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Technical Efficiency in Russian Agriculture

by

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Chapter 14

Technical Efficiency in Russian Agriculture[1]

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For decades, Russian agriculture had had little technological progress and virtually no foreign investment, which resulted in a stable production possibilities frontier and made the sector ideally suited to production function analysis. The production function estimations reported in **Chapters 10-13** add to a series of previous studies of the input/output relationship in Russian agriculture (e.g., Clayton, 1980, 1984; Gray, 1981; Johnson and Brooks, 1983), which generally followed the same methodology. In the late 1970s and the 1980s, however, the average response production functions gave way in the economics literature to more sophisticated production analysis techniques that measured not only productivity but technical efficiency as well (Aigner, et al., 1977; Bauer, 1990). Some of the major methodological advances in applying technical efficiency analysis to individual firms were made by a joint Russian-American team in Moscow in the early 1980s (Jondrow, et al., 1982; Danlin et al., 1985), but lack of data for many sectors of the Russian economy precluded the application of this technique until the end of the decade. When the Soviet Union collapsed, the initial optimistic expectation was that many sectors of the new Russian economy could rapidly achieve both higher productivity and higher technical efficiency once market forces prevailed. Our research attempts to understand why this has not happened in Russian agriculture in terms of technical efficiency.

Technical Efficiency Framework

When measuring technical efficiency we recognize the one-sidedness of the production possibilities frontier. Farms that fail to use their inputs as efficiently as other farms fall short of the "best practice" frontier and are labeled technically inefficient. Inefficiency is measured within a sample, and so even farms that are observed to be 100% efficient among their "peers" may not be efficient compared with farms in other regions or other countries.

Several methods exist for measuring technical efficiency with the choice of method often depending on the data and the researcher's philosophical view of the importance of measurement error (Forsund et al., 1980). The various methods calculate a technical efficiency index (TE score), which measures the distance of the observed firm from a point on the production frontier. Firms lying on the production frontier are 100% technically efficient (with TE = 1), and the "inefficiency" of the remaining firms increases

[1] This is a draft chapter deriving from a BASIS/CRSP study of agricultural factor markets in Russia. The findings of the study will be published in full in Lerman, Z. (ed.): *Russia's Agriculture in Transition: Factor Markets and Constraints on Growth,* Lexington Books, Lanham, MD. Comments welcome.

with the distance from the production frontier (for a concise description of the two approaches to technical efficiency see Coelli et al., 1998).

Two methods that particularly appealed to researchers in the 1980s were stochastic frontier analysis (SFA) and data envelopment analysis (DEA). SFA is a regression-like econometric method that often assumes a Cobb-Douglas production function with constant returns to scale (CRS) and constructs a linear production frontier in the input/output space. DEA is a linear-programming technique that constructs the production frontier as a convex envelope of the observed points in the input/output space without assuming a specific functional form for the production function and thus allows variable returns to scale (VRS).

DEA and SFA also differ in their treatment of errors. DEA is a strictly deterministic technique: it ignores the error term and treats the total deviation from the production frontier as inefficiency. SFA, on the other hand, assumes that the deviations from the frontier can be split into two components: a symmetrical ("two-sided") random error with mean zero (classical white noise) and a "one-sided" inefficiency component that takes only positive values from a truncated normal distribution with a positive mean (e.g., the half-normal distribution). Such an assumption creates a classical error term with an added one-sided error term. As a result of this different treatment of the error term, none of the observed points can by definition fall outside the DEA production frontier, whereas in the SFA model some points may definitely fall outside ("above") the production frontier if their classical error term is large enough. These stray points may still have a non-zero inefficiency score, which is determined by their one-sided error component.

As DEA requires no functional form on the input/output relationship, it is used by those who believe that imposing any functional relationship on the input/output mix is too restrictive. While DEA's non-parametric approach may appear more flexible, SFA has the advantage of explicitly accounting for measurement error in the classical error term, which if not included (as in DEA) means that any measurement error is incorrectly assumed to be technical inefficiency. So there is no clear, better choice between these two methods which often results in both methods being applied to the same sample.

Much of the applied literature stops with the creation of a TE index while ignoring the idea that such an index really measures "gross" technical efficiency rather than the "pure" TE it purports to measure (Fare et. al, 1985). Ignoring this further distinction may be a problem when, as we do here, a "whole farm" versus "commodity by commodity" approach to farms are both being considered. Gross TE is composed of pure, scale and congestion TE with such a decomposition easily done only with the DEA method. Scale TE might be expected with Russian farms as they may be too large for a given technology. Scale TE is a "social" and not "private" inefficiency as it is outside the farm manager's control. Scale TE can be tested for by comparing TE indices generated with constant returns to scale imposed versus TE indices generated without any returns to scale assumption (Ferrier and Porter, 1991). Congestion TE can result from, for example, a regional government imposing a macroeconomic constraint on a corporate farm such as viewing the farm as an employment center rather than a profit maximizing enterprise leading to an overuse of inputs such as labor that are no longer freely disposable. Such congestion TE has been found in both market and formerly socialist countries (e.g. Reiman, 1992 and Caves et. al., 1981) with at least one study finding that congestion TE is the most likely cause of most of the inefficiency measured in a TE index such as we use here (Kemme and Neufeld, 1991). Finally, if one believes in X-inefficiency {Stigler (1976) vs Frantz (1992)}, then the TE index may contain both TE and X-inefficiency as separating the two remain problematic (Button and Weyman-Jones, 1992). Thus different levels of aggregation in sample data and the varying institutional environment in which a farm is embedded could lead to TE indexes that appear to contradict each other at different levels of aggregation with one cause being these components of TE found in the literature.

In the 1990s, the technical efficiency literature expanded again with the growing use of Z-variables in the application of SFA. Prior to the 1990s, researchers would take estimates of TE and run auxiliary or "second step" regressions on a wide range of policy variables (so-called Z-variables) that might explain the measured technical inefficiency. The newer SFA method allows for the effect of these Z-variables simultaneously with the calculation of the TE scores in a one-step procedure (e.g., Audibert, 1997; Wang and Schmidt, 2002). The method enables analysts to better link technical inefficiency to policy by explicitly including in the estimation both economic variables and other variables (e.g., institutional or sociological factors) that fall outside standard production function analysis. This one-step extension is available for SFA only, while DEA must still use two steps if Z-variables are being considered.

Technical Efficiency of Russian Farms

Prior evidence on production efficiency in Russian agriculture suggested that, coming out of the Soviet era, large corporate farms exhibited high technical inefficiency within large samples from a single region (see, e.g., Brock, 1996/1997). In other words, there was much room for improvement in farm utilization of existing inputs given a constant state of technology.

Table 14.1. Comparison of the two datasets used for technical efficiency analysis

	2003 BASIS survey	Goskomstat national dataset
Number of farms	500	Over 20,000
Type of farms	Corporate Individual	Corporate only
Time frame	One year (2002)	Panel data 1995-2002
Disaggregation options	"Total farm" Specific commodities	"Total farm" "Total farm" with classification by main commodity specialization
Output variable	Sales revenue Value of production	Sales revenue Cost of products sold

We proceeded to analyze the technical efficiency of Russian farms after more than a decade of transition using two sources of data: the 2003 BASIS survey and the Goskomstat national dataset. A schematic comparison of the two datasets is given in **Table 14.1**. The 2003 BASIS survey covered some 500 farms, whereas the Goskomstat national dataset had over 20,000 farms. The 2003 BASIS survey collected cross-section data at a single point in time (2002), whereas the Goskomstat national dataset had panel data spanning the period between 1995 and 2002. On the other hand, the Goskomstat national dataset contained data for corporate farms only, whereas the 2003 BASIS survey provided detailed information for farms of different organizational forms, both corporate and individual (subdivided in turn into peasant farms and commercially oriented household plots). Finally, the detailed survey data on inputs and outputs in the 2003 BASIS survey were disaggregated by specific commodities, whereas the Goskomstat national dataset contained "total farm" information only (with a possibility of classifying the farms by main commodity specialization).

The differences in datasets made it possible to apply DEA and SFA methods at different levels of aggregation and over time. The particularly rich vector of farm inputs in the BASIS survey allowed "total farm" analysis as well as detailed commodity-by-commodity analysis of technical efficiency of production of grain, sunflower, beef, etc. The option of classifying the corporate farms in the Goskomstat database by their main commodity specialization (i.e., farms that produce mainly grain, farms that produce mainly vegetables, farms that produce mainly pigs, etc.) naturally led to technical efficiency analysis of farms of different specializations though not at the fine commodity-by-commodity detail of the BASIS survey. We thus analyze three levels of aggregation in this study: "total farm" models and commodity-specific models at the two extremes with "total farm" models with farms classified by main commodity specialization in between. **Table 14.2** presents a schema of the various combinations implemented in our technical efficiency analysis and indicates the names of the researchers responsible for each combination.

Table 14.2. Schematic classification of technical efficiency calculations

Models	Dataset	Organizational type	DEA	SFA
"Total farm"	2003 BASIS survey	Corporate farms	Lerman	Lerman
		Individual farms	Lerman	Lerman
"Total farm" with different commodity specialization	Goskomstat national database	Corporate farms (two individual years)	Uzun	--
Commodity models	2003 BASIS survey	Corporate farms	Grazhdaninova	Brock, Grazhdaninova

"Total Farm" Analysis Using the 2003 BASIS Survey

The "total farm" approach using the 2003 BASIS survey made it possible to evaluate technical inefficiency of corporate farms on their own and also to analyze separately corporate farms, independent peasant farms, and household plots in a pooled sample. The analysis led to a comparison of the technical inefficiency of these distinct organizational types—something not often done in the literature. Of the three organizational types analyzed, household plots appear to have the highest mean technical efficiency using either SFA or DEA methods. This is quite interesting given that one cause of inefficiency may be poor management or a lack of a sense of ownership in the results of the farm.

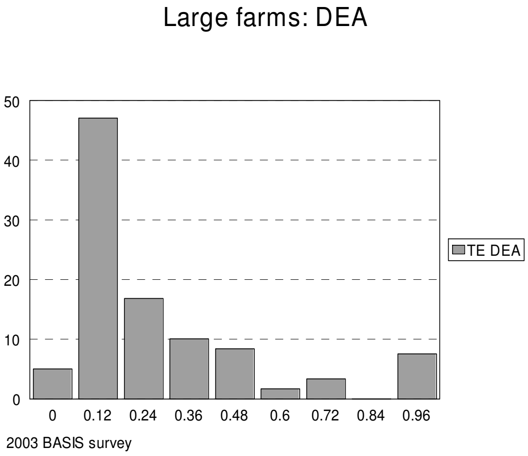
"Total farm" technical efficiency was analyzed using both DEA and SFA methods (see Coelli et al. (1998) for the description of the software used). The technical efficiency of corporate farms was estimated on a sample of 119 observations with all nonmissing values. The value of agricultural production (aggregating crops and livestock) was used as the output variables; the inputs included agricultural land in use (hectares), number of workers engaged in agricultural activities, input costs (in rubles), and value of farm fixed assets.

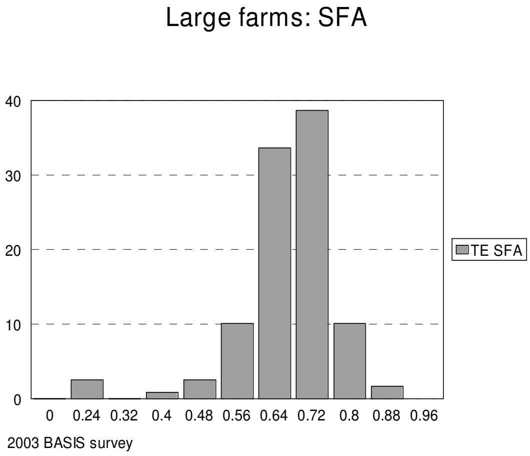
Table 14.3. Technical efficiency scores for large farms in the 2003 BASIS survey

	Mean (*n*=119)	Rostov (*n*=54)	Ivanovo/Nizhnii Novgorod (*n*=65)
DEA -- CRS	0.18	0.23*	0.14
DEA – VRS	0.28	0.34*	0.23
SFA – w/out regional factor	0.67	--	--
SFA – with regional factor	0.62	0.70*	0.56

*Difference statistically significant at 5%.

DEA (in both constant and variable return to scale specifications) suggests a large amount of technical inefficiency among corporate farms with mean TE scores in the 0.2-0.3 range. The SFA results yield a much higher mean efficiency in the 0.6-0.7 range (**Table 14.3**). The difference is visualized quite dramatically in **Figures 14.1 and 14.2**, which show the distributions of the efficiency measures produced by the two methods. While the SFA scores are bunched relatively close to the efficiency frontier (where TE = 1), the DEA scores are strongly shifted toward the lower tail of the distribution, characterizing a very high degree of inefficiency.





The literature suggests the differing results for SFA and DEA could be due to the different treatment of measurement error in the two methods **(see above)**. The SFA results obtained with the 2003 BASIS survey sample are similar to mean technical efficiency found on large Russian farms a decade earlier (Brock, 1996/1997), which would support the idea of a largely unrestructured corporate farm management (e.g., Liefert, 2001) even after a decade of reforms in other sectors.

Regional effects were explored by separating out the agriculturally rich southern province of Rostov. In all instances, the TE scores for Rostov were higher than for the agriculturally less endowed provinces of Ivanovo and Nizhnii Novgorod (**Table 14.3**; the differences were statistically significant). The regional factor was included as a Z-variable in SFA, allowing simultaneous one-step estimation of the TE scores with regional effects. In DEA the regional variable was included as a dummy in second-step regression.

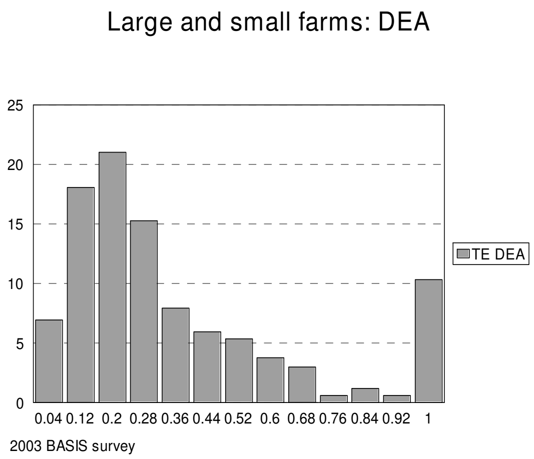
For the analysis of the three organizational forms—large corporate farms, peasant farms, and household plots—in a pooled sample we had to use sales revenue, and not the value of farm production, as the output variable. This was inevitable because the data on the value of production in small individual farms turned out to be totally unreliable in the survey.[2] The vector of input variables included five inputs: agricultural land, number of agricultural workers, input costs (in million rubles), machinery (number of pieces adjusted for quality), and livestock (standard head). The selection of these variables maximized the number of valid observations: DEA, n=504 (non-logged) and SFA, n=499 (logged) out of 567 farms in the database.

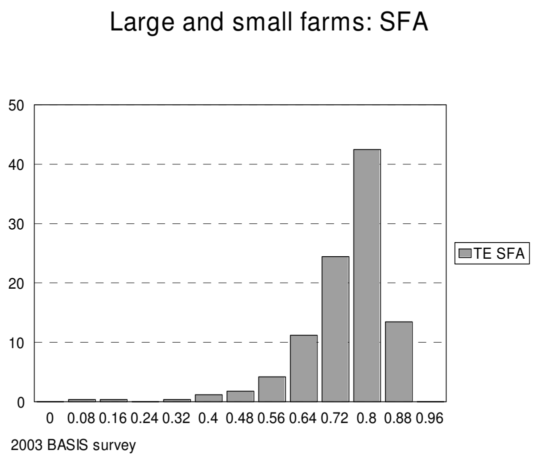
Table 14.4. Technical efficiency scores for farms of different organizational forms in the 2003 BASIS survey

	Mean (*n*=499)	Corporate farms (*n*=121)	Peasant farms (*n*=211)	Household plots (*n*=167)
SFA*	0.745	0.736	0.699	0.811
DEA VRS	0.357	0.339	0.276	0.472

*With region and organizational form as Z factors.

The technical efficiency scores are presented in **Table 14.4**. Both the SFA and the DEA scores are significantly different across all three organizational forms (although for DEA some simultaneous pairwise tests fail to distinguish significant differences between corporate and peasant farms). The efficiency ranking by SFA scores and by DEA scores with variable returns to scale (DEA VRS) is Household plots > Corporate farms > Peasant farms. The small household plots thus appear to be the most productive by all methods, while peasant farms are least efficient.





The frequency distributions of SFA and DEA efficiency scores for all 500 farms (large and small) are presented in the two histograms in **Figures 4.3 and 4.4**. The SFA scores show the classical bunching near 1 (although the mode at 0.80 is relatively far

[2] Uzun also had to use sales revenue in his analysis of all "large" farms in Russia (see below): this is the only output variable in the Goskomstat databases.

from 1 by "Western standards"). The DEA scores, on the other hand, show a pathological reverse pattern with the mode at 0.20.

"Total Farm" Analysis Using the National Database

In addition to estimating technical efficiency from the data of the 2003 BASIS survey, we had the opportunity to calculate farm efficiency from the Goskomstat national database of all corporate farms in Russia. Common wisdom suggests that farm productivity may vary depending on specialization. We accordingly classified the corporate farms by a simple sequential technique. First, the corporate farms were divided into three groups depending on the dominant component of their agricultural sales (crop farms, livestock farms, and other farms). The crop farms were in turn classified into three groups: those with predominance of grain and technical crops in their sales ("grain farms"); those with predominance of potatoes and vegetables ("vegetable farms"); and other crop farms. The livestock farms were divided into four groups by the main commodity contributing to their sales: cattle farms, pig farms, poultry farms, and other livestock farms. The number of farms in each specialization category is shown in the first column in **Table 14.5**. The TE scores were calculated for farms in each specialization category separately using input-oriented DEA with variable returns to scale.[3] 1995 and 2002 were compared to get a picture of efficiency changes over time.

In all models, the output variable was the cost of products sold, including crop sales, livestock sales, and nonagricultural sales. Arable land, number of workers, and balance-sheet value of productive assets were used as the inputs.

Table 14.5. TE scores of corporate farms with different commodity specializations 1995, 2002 (estimated by the DEA method from the Goskomstat national database)

Farm specialization	Number of farms	TE (mean)	St. dev.	% of farms		
				TE > 0.9	TE > 0.7	TE< 0.3
	(1)	(2)	(3)	(4)	(5)	(6)
Grain and technical crops						
1995	1,249	0.39	0.19	4	7	37
2002	1,296	0.24	0.21	4	5	77
Potatoes and vegetables						
1995	448	0.44	0.25	9	17	37
2002	298	0.47	0.30	15	23	36
Pigs						
1995	365	0.59	0.24	15	24	20
2002	198	0.64	0.26	23	32	15
Poultry						
1995	770	0.51	0.25	11	21	22
2002	541	0.51	0.28	16	25	28

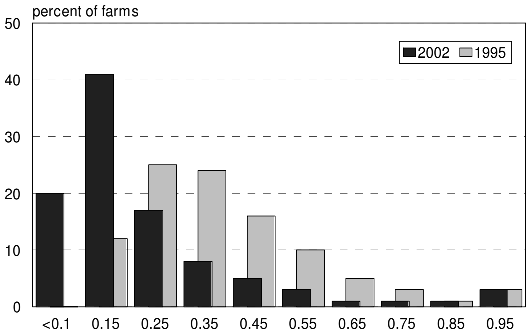
Table 14.5 shows the TE scores for farms of different specializations in 1995 and 2002. In addition to the mean scores, the table also presents information about the most

[3] The calculations were carried out using the EMS software (http://www.wiso/ini-dortmund/de/LSFG/schttl/ems)

efficient and the least efficient farms. The full distributions of corporate farms by TE scores in different specialization categories are shown in **Figures 14.5-14.8**.

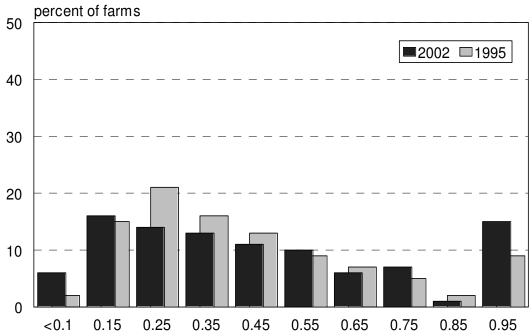
Table 14.5 shows the TE scores for farms of different specializations in 1995 and 2002. In addition to the mean scores, the table also presents information about the most efficient and the least efficient farms. The most efficient farms are those with TE > 0.9 (column 4), or less restrictively those with TE > 0.7 (column 5); these farms are close to the efficiency frontier, where technical efficiency reaches its maximum value 1. The least efficient farms lie far from the production frontier and have TE < 0.3 (column 6). The full distributions of corporate farms by TE scores in different specialization categories are shown in **Figures 14.5-14.8**.

TE scores of grain farms: DEA



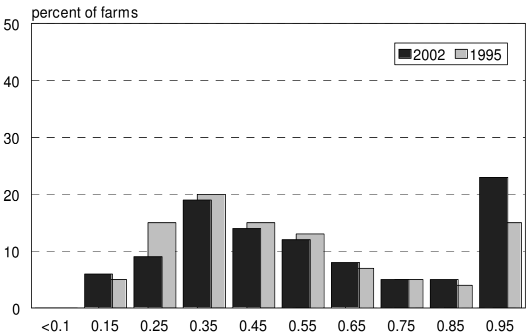
Goskomstat national database

TE scores of vegetable farms: DEA



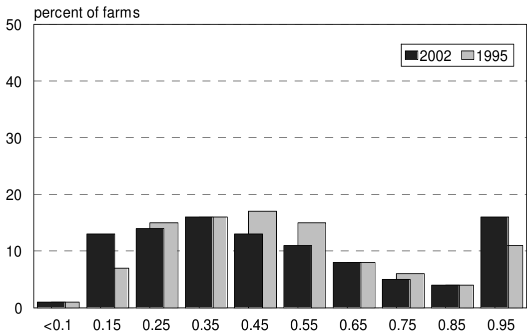
Goskomstat national database

TE scores of pig farms: DEA



Goskomstat national database

TE scores of poultry farms: DEA



Goskomstat national database

We see from **Table 14.5** and from the distributions in **Figures 14.5-14.8** that corporate farms show a high variability by technical efficiency. For most vegetable and poultry farms (about 60%) the TE scores are below 0.5. Pig farms are relatively more efficient, with TE scores below 0.5 for only one-third of the farms. Inefficiency is quite high for farms that produce grain and technical crops. For these farms the distribution of TE scores has a high peak at TE = 0.1-0.2 and nearly 80% of grain farms have TE < 0.3. The bulk of grain farms are thus quite inefficient, and furthermore their inefficiency increased markedly between 1995 and 2002 (see column 6 in **Table 14.5**).

The other distributions in **Figures 14.6-14.8** follow a clear bimodal pattern. A substantial proportion (up to 20%) of vegetable, poultry, and pig farms lie close to the efficiency frontier with TE > 0.9 (see **Table 14.5 and Figures 14.6-14.8**). However, a wide chasm separates these highly efficient "leaders" from the bulk of the farms, for which the second peak occurs far from the efficiency frontier at TE around 0.2-0.4. The TE distribution in Russia sharply differs from the standard distributions observed in established market economies, where most farms are bunched in a strong peak near the efficiency frontier.

As noted previously, grain farms became much less efficient over time: their mean TE score dropped from 0.39 in 1995 to 0.24 in 2002. For other farms, the mean TE score did not change much, although this has been accompanied by increased polarization: both the percentage of most efficient farms (TE > 0.9) and the percentage of most inefficient farms (TE < 0.3) increased between 1995 and 2003 (see **Table 14.5**).

Commodity Models Using the 2003 BASIS Survey

The wide variety of microeconomic data gathered in the 2003 BASIS survey presented an opportunity for analyzing detailed commodity-specific models by SFA and DEA methods at a level of disaggregation that is quite unique. In this section we present the results obtained by the SFA method for two crops (grain and sunflower) and by the DEA method for a wider range of crop and livestock commodities covered in the survey.

The SFA method was applied to two specific commodities—grain and sunflower, which were chosen to get a highly disaggregated production function with the output and the main inputs measured in physical units (rather than monetary values).[4] The output is the quantity of each commodity produced by the corporate farms in the survey. The inputs include land, labor, fertilizer, fuel, seeds, and machinery—all expressed in physical units as allocated to each crop. The capital stock is adjusted for age (to reflect differences in quality) and the use of physical units for tractors and harvesters avoids problems with how farmers do depreciation accounting. Additional dummy variables were included for the weather, farm creation date (Soviet or post-Soviet), and location. The weather is not incorporated in the classical error term, but is explicitly included in the production function as reported by the farmers. The production function is about as close to a truly microeconomic production function of a specific commodity as one is likely to get for any farm. Importantly, because of the level of disaggregation, issues of output mix and capital stock mix that arise at a higher level of aggregation do not apply here. This detailed production function is then further enhanced by incorporating a range of Z-variables that might influence technical efficiency (distance from regional center, entitlement to subsidies, wage payment by task or by time, etc.).

Mean technical efficiency is found to be similar to the literature and to "total farm" findings reported in **Tables 14.3 and 14.4**, with grain production having a mean TE score of 0.80 and sunflower 0.65. Farms that are relatively more profitable and farms that did not exist in Soviet times are found to be more efficient than other farms in the sample. Distance from an oblast center does not impact on a farm's TE score, indicating that poor rural infrastructure may not be a constraint on farm performance with these

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[4] The analysis was carried out using the standard Frontier 4.1 software (see Coelli et al., 1998).

two crops. How workers are paid also impacts on the efficiency of grain production: farms that pay workers by task and not a fixed salary are observed to be more efficient. It seems that, even if a farm cannot radically restructure, there may still be efficiency gains if the method of labor payment is changed alone, though more research beyond this small sample would be needed to support this conclusion. Clearly the TE index should be used as one of several measures of farm performance beyond those reported to tax authorities.

As expected, different regions had significantly different technical efficiency scores with the southern region of Rostov having slightly higher overall technical efficiency. This regional effect is consistent with the "total farm" result reported in **Table 14.3**. Farms that were profitable in the Soviet era had higher technical efficiency in the transition era possibly because this indicates better connections to suppliers or simply financial strength of the farm. Farms that specialized in a particular output or actively acquired land had higher technical efficiency as well—again suggesting this might proxy for better managed and simply actively managed farms. Finally, wage arrears negatively impacted on technical efficiency as hypothesized using Z variables.

The technical efficiency of production for a wider range of commodities—both crop and livestock—was also estimated using input-oriented DEA models with variable returns to scale (VRS)[5]. Input-oriented estimation is more appropriate than the output-oriented alternative because one of the objectives of the study is to determine the efficiency of input use for the production of a given output and find ways to optimize input use. The impact of external factors on technical efficiency was then estimated by second-step regression analysis as the use of Z-variables in a one step procedure is not available in DEA.

Table 14.6. Technical efficiency scores (TE) of corporate farms for selected commodities (estimated by the DEA method)

	TE (mean)	St. dev.	TE > 0.9, % of farms	TE > 0.7, % of farms	TE< 0.3, % of farms
Grain	0.77	0.23	39	64	2
Sunflower	0.71	0.24	35	49	2
Beef 1*	0.64	0.29	31	44	17
Beef 2*	0.78	0.26	54	64	6
Milk 1*	0.65	0.24	25	37	2
Milk 2*	0.82	0.22	55	69	1
Beef +milk 1 **	0.78	0.20	42	59	0
Beef +milk 2 **	0.88	0.16	65	80	0
Pork 1*	0.75	0.28	50	63	6
Pork 2*	0.88	0.18	67	79	0

*See notes on Models 1 and 2 in Table 3.

**Two-output DEA models (beef and milk). Without fattening operations, the inputs are shared by the two outputs.

Table 14.6 presents the TE scores for specific commodities. The high mean technical efficiency scores and the high frequency of "best practice" technologies in the sam-

[5] The DEA program used in this study has been developed by Aleksandr Usol'tsev on the basis of standard linear programming algorithms published in the literature. The work has been carried out at the Analytical Centre for Agri-Food Economics in Moscow as part of the BASIS Russia project.

ple limit the potential impact that can be expected from the adoption of "best practice" technologies by the inefficient farms. Thus, the adoption of "best practice" technologies will increase the production of beef by 22%-36% (Model 2 and Model 1, respectively). Results here suggest a disaggregate analysis of the sample reveals much more technical efficiency than a "whole farm" approach using the BASIS or Goskomstat data, which might seem contradictory. However, differences in coverage (120 farms in three oblasts in the sample-based analysis versus 1,200 farms in 75 oblasts in the national-level analysis), the definition of both input and output variables used, and the idea of "gross" versus "pure" TE discussed above suggest such differences should not be surprising at all. Indeed, the differences can be utilized to focus on where the farm might improve its operations with much more attention perhaps focused on how the farm management operates across commodities with issues such as the mix of output and equipment on the farm overall.

The results of Model 1 for livestock products (in these models, animal feed is expressed in feed units) shed some light on the differences between farms near the efficiency frontier (those with TE > 0.9) and the highly inefficient farms with TE < 0.4. For the high-efficiency farms, the share of purchased feed is relatively high. It is 19% for the beef model, 14% for the milk model, and 10% for the pork model. For the low-efficiency farms, the respective purchased feed shares are 2.6%, 2.0%, and 3.4%. The mean share of purchased feed for all corporate farms in the sample is 7%. Purchased feed is mainly high-quality concentrated feed, whereas feed from own production is basically hay, pasture grasses, or low-quality concentrated feed. The farms at the efficiency frontier, using a high proportion of purchased feed in the ration, probably optimize the ration by analyzing the market price of feed, the cost of on-farm production, and the value of the end product. The inefficient farms, using a small proportion of purchased feed in their ration, probably follow the strategy of cost minimization for purchased inputs because of financial constraints.

The relationship of the DEA technical efficiency scores with various external factors, such as farm size, location, or financial conditions, may be determined in second-stage regression. **Table 14.7** shows the estimation results for such a regression model. Many factors that a priori were expected to affect the technical efficiency proved to be not statistically significant and are not shown in **Table 14.7**. Thus, the farm size (measured by hectares of land used) does not have a statistically significant effect on technical efficiency. State subsidies and borrowing of any kind do not affect technical efficiency (however, very few farms in the sample provided information on these variables). The managerial qualification variable expressing knowledge of tax laws, lease payments, and land allocation procedures is not statistically significant in the model. The land utilization ratio (i.e., the share of land actually used in agricultural production) does not affect technical efficiency. It is quite possible that keeping agricultural land in the farm's possession without cultivating it is the most efficient strategy under the present circumstances because of complex alienation procedures and high transaction costs.

On the other hand, most models show a positive association between enlargement of holdings and technical efficiency. Farm enlargement (a yes/no variable that indicates if the farm has added new agricultural land to its holdings) is statistically significant in both crop and livestock production models. Farm enlargement not only represents expansion of the sown area, but it is also an indicator of management quality.

As suggested by a priori considerations, wage arrears have a negative effect on technical efficiency (in half the commodity models). If this factor is accepted as a proxy for financial health, we conclude that financially ailing farms are less efficient than the rest. This factor is also closely connected with management quality. The absence of wage arrears and good financial health reflect highly qualified management.

Table 14.7. Factors that influence technical efficiency*

Factor	Grain	Sunflower	Beef 1	Beef 2	Milk 1
Ivanovo regional factor	–0.134		–0.337	–0.296	–0.279
Distance from oblast capital				0.243	
Augmentation of farm holdings	0.122			0.321	0.281
Wage arrears	–0.017				–0.022
Pre –reform status (profitable)		0.298			0.214
Crop specialization			–0.496	–0.613	–0.777
Controlling packet of shares	–0.175				
Surplus labor					

Factor	Milk 2	Beef+ milk 1	Beef+ milk 2	Pork 1	Pork 2
Ivanovo regional factor	–0.294			–0.492	–0.284
Distance from oblast capital		0.134			
Augmentation of farm holdings	0.298		0.167	0.267	
Wage arrears	–0.017	–0.018			–0.025
Pre –reform status (profitable)	0.185		0.171		
Crop specialization	–0.613	–0.533	–0.343	–1.179	–0.485
Controlling packet of shares					
Surplus labor			0.002		

* **Table 14.7** shows only the factors that are statistically significant at 10% level in one of the commodity models.

The impact of management structure is also reflected by the farms' pre-reform status. Farms that were profitable in the pre-reform period demonstrate higher technical efficiency in some models. The existence of a controlling packet of shares, which a priori led us to expect greater efficiency due to more effective control of the majority owner over management, is not statistically significant in most models, perhaps because of the very small number of farms with a controlling packet in the sample.

Livestock producers that add crops to their product mix are less efficient in all commodities. The regional factor has a statistically significant effect: farms in Ivanovo Oblast are the least efficient and Rostov farms are the most efficient in the sample. Distance from the oblast capital in general does not have a statistically significant effect on technical efficiency. The existence of surplus labor does not affect the technical efficiency of corporate farms either.

Conclusions and Further Research

Russian farms, like farms in other countries, reveal a variety of technical inefficiency results across commodities and many types of inputs. Technical efficiency scores can be used in conjunction with standard performance measures (e.g., reported profit, which unfortunately is prone to being manipulated for tax purposes) to fully understand how

Russian farms are doing. Because Russian farms are generally not very specialized, our unique commodity-by-commodity results deserve special attention. Assigning various inputs to the production that they actually are used for without getting lost in aggregate measures needs to be done over time and in other regions to more fully understand how Russian agriculture is performing. While farms may be able to achieve best practice on the current frontier, that frontier is stagnant and not shifting out (technological progress) which is a major inhibitor to growth.

Enough technical inefficiency has been found in this study to stimulate further research in other regions and comparison papers where Russian farms as well as similar farms from other countries might be included in the same sample. The latter research would support a trend in the comparative economics literature towards looking at cross-country regressions to better understand institutional issues and other cross-country differences on performance. Russian farm data combined with, say, U.S. farm data in a single sample carefully controlling for location would seem to be one avenue to go down to better understand Russian farm performance. Adding another transition economy such as Ukraine would enrich the analysis further and lead to some interesting policy recommendations. Throughout this comparative analysis, our results using household plots and small farms should be incorporated to test for the influence of farm size and sense of ownership on technical efficiency across regions and countries. We know Russian household plots are relatively productive and have found limited evidence for them being relatively more efficient, but much more research would be needed to be conclusive about an optimal size for a Russian farm by crop or livestock type.

The cross-sectional nature of the survey data rules out panel analysis of technical efficiency over time. Further research might use the Goskomstat database to carefully construct a panel microeconomic dataset including the farms used in the project. While it is clear that agriculture did not become suddenly highly efficient after the freeing of prices in the early 1990s, technical inefficiency may be declining slowly over time, or conversely it may be increasing in the aftermath of the 1998 financial crisis. Only time-series analysis can answer this question. Finally, the impact of other variables on technical efficiency such as location would be much better understood if the impact is examined over time as well as space.

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