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An Examination of Economic Efficiency of Russian Crop Output in the Reform Period

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Abstract

This paper examines economic efficiency of Russian corporate farms for 1995-98. Economic efficiency declined over the period, due to declines in both technical and allocative inefficiency. According to the average technical efficiency scores, Russian agricultural production could improve from 17 to 43 percent according to DEA and SFA analysis, respectively. The efficiency scores show that Russian agriculture presently uses relatively too much fertilizer and fuel and too little land and labor. Russian agriculture inherited machinery-intensive technology from the Soviet era, which may be inappropriate given the relative abundance of labor in the post-reform environment. Investment constraints have prevented the replacement of old machinery-intensive technology with labor intensive technology.

Keywords: Russia, economic efficiency, agricultural reform

An Examination of Economic Efficiency of Russian Crop Output in the Reform Period

1. Introduction

When reform of the agricultural sector in Russia began in 1992, many analysts predicted that farmers would become profit maximizers and, consequently, improve the productivity and efficiency of their operations. After an initial dip in agricultural production, therefore, Russian agriculture was supposed to recover significantly. This recovery in agricultural production has yet to materialize.

Russian agriculture's failure to respond to reform is reflected in measures of the relative efficiency of crop production in state and collective farms. One recent study of technical efficiency in Russian agriculture showed that the average farm's performance in terms of technical efficiency has declined compared to the best domestic practice (Sedik et al., 1999).¹ The decline in technical efficiency was explained by such factors as self-sufficiency efforts, competing private plot output, and the share of state subsidies in revenues.

The goal of this study is to measure the economic efficiency of corporate farms in Russia for 1995-98.² Measurements of economic efficiency reflect the ability of producers to achieve both technical efficiency (maximizing the physical production relationship between input and output) and allocative efficiency (cost-minimization). This will allow at least two important questions to be addressed. One question is, how much could farm performance be improved if all farms in Russia were to adopt the best domestic practice? A related question is, which input

¹ Technical efficiency examines the maximum physical relationship of output and input.

² The period 1995-98 is analyzed because it takes advantage of the most recently available data and because it is a period of price stability.

markets suffer from the greatest distortions? Given the answer to the second question, it should be possible to focus in on the input markets where reform is most needed in order to help Russian farms emulate the best domestic practice. The evidence presented in this paper suggests that there is much room for improving economic efficiency, using a domestic best practice standard, and that the magnitude of the input market distortions are in some cases quite severe.

An important caveat for interpreting economic efficiency of Russian agriculture concerns the measurement of prices in Russia. Allocative efficiency measures depend on the accuracy of the prices used. It is possible that the prices used in the study are measured poorly or that market prices do not accurately reflect producers' opportunity costs. The first problem does not appear to be serious.³ However, the second problem suggests that the cost-minimizing bundle implied by market prices may not correspond to the producer's true cost-minimizing bundle. Consequently, a true cost-minimizing producer may be found to be allocatively inefficient when market prices are used to measure allocative efficiency. In such cases, cost-minimizing producers would be expected to consistently over- or under-utilize inputs. This latter problem is perhaps more relevant in Russian agriculture, because it is known *a priori* that there are non-market incentives to overuse certain inputs in Russian agriculture that are not fully represented in their market price.

For example, the results in this paper suggest that farm managers could improve their allocative and economic efficiency by using more appropriate (labor-using) machinery, given the change in relative input prices. However, given the current low level of farm-level reform in Russia – such as the poorly functioning credit market – it is unlikely that farm managers are able to invest in machinery appropriate for the new market-oriented input mix. If that is the case, it

³ Goskomstat, the Russian statistical agency, estimated the prices used in this study by asking a sample of 10 percent of all corporate farms in Russia what their prices and expenditures were on their inputs.

may be rational for them to use the old Soviet input mix, if that mix is appropriate for the technology they inherited from the Soviet regime.

Thus, this study takes the approach of interpreting allocative efficiency scores as a measure of the degree of input market distortions *faced by cost-minimizing producers*, rather than as a measure of producers' ability to minimize costs.⁴ This approach is reinforced by the aggregate level data used in this analysis, which would seem to favor this type of interpretation.

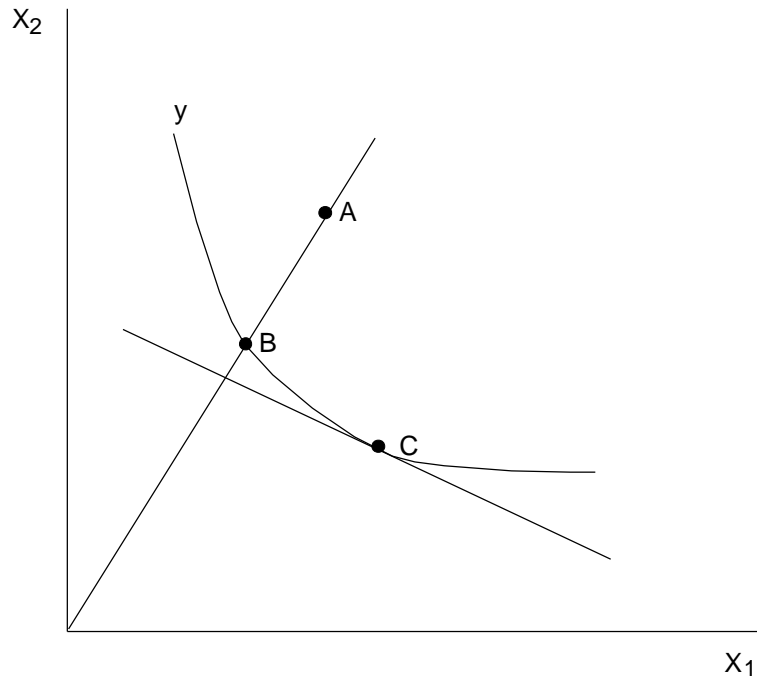
This paper is organized as follows. Section 2 presents the methodologies that are used to estimate economic and allocative efficiency. The data used in the estimation are discussed in Section 3. The results are presented and discussed in Section 4. Section 5 concludes the paper by highlighting how much corporate farm performance could be improved and reviewing input market distortions.

2. Methodology

Recent studies of efficiency have their roots in the seminal article by Farrell (1957). Farrell made a distinction between technical efficiency, allocative efficiency, and economic efficiency. Technical efficiency (TE) refers to the ability to achieve the maximum physical relationship between output and inputs. Allocative efficiency (AE) refers to the ability to achieve cost minimization for a given output level. Economic efficiency (EE) refers to the combined effect of technical and allocative efficiency.

⁴ The approach taken here closely mirrors that used in an environmental economics study, in which allocative efficiency results using shadow prices were interpreted more as a reflection of market distortions rather than cost-minimizing ability (Bhattacharyya et al., 1994).

Fig. 1 - Relationship between technical, allocative and economic efficiency



These ideas are illustrated in Figure 1. Point A is technically inefficient since it is located on the interior of the production isoquant for output level y^0 ; that is, the same output could have been achieved with fewer inputs (x_1 and x_2), given the best practice frontier. Point B is technically efficient since it is on the isoquant for output y^0 ; however, this point is not allocatively efficient since it is not a cost minimizing point, like point C. Since point C is both technically efficient and allocatively efficient, it is economically efficient.

Generally speaking, an input-oriented approach to measuring efficiency will yield three sets of inputs: 1) The observed set, \mathbf{x}^0 ; 2) The technically efficient set, \mathbf{x}^{te} ; and 3) The economically efficient set, \mathbf{x}^e . The cross products of these input sets with the input price vector \mathbf{w} yields the costs of the observed, technically efficient, and economically efficient input set, respectively. These costs can then be used to devise measures of technical, allocative, and economic efficiency:

$$\begin{aligned}
(1) \quad & TE = \mathbf{w}'\mathbf{x}^{te} / \mathbf{w}'\mathbf{x}^o \\
(2) \quad & AE = \mathbf{w}'\mathbf{x}^e / \mathbf{w}'\mathbf{x}^{te} \\
(3) \quad & EE = \mathbf{w}'\mathbf{x}^e / \mathbf{w}'\mathbf{x}^o (= AE * TE)
\end{aligned}$$

There have been two main approaches used to measure efficiency, discussed in more detail below: the parametric approach known as stochastic frontier analysis (SFA) and a nonparametric approach, data envelopment analysis (DEA). Both approaches are implemented and the results compared.

It should be pointed out that most empirical studies have estimated technical efficiency or cost efficiency, but not both.⁵ Studies of allocative efficiency are relatively uncommon for a few reasons. The most formidable obstacle appears to be practical: examining overall economic efficiency requires a comprehensive database on output, input, and prices. Another problem, usually associated with micro level data, is the lack of price variation that results when producers face common regional prices, which makes econometric estimation difficult.⁶

These obstacles are not considered a problem for the present study for the following reasons. Regarding the availability of data, this study uses a comprehensive database on output, inputs, and prices for Russian agriculture in the reform period. The micro-level data issue is not a problem because the study is regional in nature; that is, corporate farms that are spatially separated in a large country are examined.

⁵ In fact, the vast majority of efficiency studies have focused on technical efficiency (for recent surveys, see Seiford, 1996 and Berger and Humphrey, 1997). A few of the studies examining both technical and allocative efficiency include Schmidt and Lovell (1979); Kopp and Diewert (1982); Ferrier and Lovell (1990); Evenson and Bravo-Ureta (1994); Xu and Jeffrey (1998); and Sharma et al (1999). This study most closely follows the study by Evenson and Bravo-Ureta (1994), but the comparisons are limited given the institutional issues raised in this article.

⁶ Other theoretical estimation problems are discussed in more detail below.

Parametric approach. We follow a standard methodology for using parametric techniques to estimate technical, allocative, and economic efficiency.⁷ The primary parametric approach is the stochastic frontier approach (SFA) (Aigner, Lovell, and Schmidt, 1977; Meeusen and van den Broek, 1977). Here, one specifies and econometrically estimates a farm's production function:

$$(4) \quad y_i = f(\mathbf{x}_i; \beta) + e_i$$

If the error term, e_i , is found to be nonspherical, it is decomposed into a pure noise component, v_i , and an efficiency component, u_i . The expression of technical efficiency relies on the value of the unobservable u_i , which must be predicted. These predictions are obtained by deriving the expectation of the appropriate function of u_i conditional on the observed value of v_i - u_i (Jondrow et al., 1982; Battese and Coelli, 1988, 1992). Assumptions must be made about the shape of the efficiency score distribution. The most commonly used distributions have been the half-normal (Aigner, Lovell, and Schmidt, 1977) and truncated normal (Stevenson, 1980), although the gamma distribution also has been recommended (Greene, 1980). For panel data models, there have been a few different proposals about how to model inefficiency patterns over time (Cornwell, Schmidt and Sickles, 1990; Kumbhakar, 1990). This study uses the exponential time model proposed by Battese and Coelli (1995).

Some economists have proposed estimating allocative efficiency with a system of equations econometric approach, where factor demand equations are estimated simultaneously with the cost equation. There are two main objections to this approach: 1) the solutions require numerical search methods, which are not readily available in most econometric software

⁷ See Kopp and Diewert (1982), Ureta and Rieger(1991), Bravo-Ureta and Evenson (1994), Sharma et al. (1999)

programs; and 2) the issue of how to treat the errors terms (including allocative efficiency effects) in the cost function and the error terms in the factor demand equations has not been adequately addressed. Rao, Battese and Coelli (1998) recommend the single equation approach, assuming the modeling assumptions are appropriate and there are suitable data available. This is the approach taken in this study.

Given the estimate of the production function and the efficiency component u_i , the observed output of farm i , y_i , can be filtered for noise by subtracting the efficiency component from the technically efficient output, $f(\mathbf{x}_i; \beta)$:

$$(5) \quad y_i^o = y_i - v_i = f(\mathbf{x}_i; \beta) - u_i.$$

Since the Cobb-Douglas production function was found to be an appropriate representation of the technology, the optimal input use ratios of a cost-minimizing farm are independent of output. This property can be used to calculate the technically efficient input set by substituting y_i^o for output in the factor demand equations, $x^*(y, w)$, and using shadow prices derived from the observed input ratios. The dual cost function is then used to derive the economically efficient input set (with observed prices, rather than shadow prices).

Nonparametric approach. The nonparametric approach known as data envelopment analysis (DEA) was developed by Charnes, Cooper and Rhodes (1978). Allocative efficiency is calculated by solving the mathematical programming problems that estimate technical efficiency and cost efficiency, then using the relationship in equation (3), $AE = EE/TE$. Technical efficiency under constant returns to scale assumption and an output orientation is estimated by solving the following program:

$$\begin{aligned}
(6) \quad TE = F^0(x, y \mid C) = \text{Min}_{\theta, z} \theta \text{ s.t.} \\
\theta y \leq zM \\
zN \leq x_i \\
z_i \geq 0
\end{aligned}$$

Economic efficiency is calculated by solving the following linear programming problem:

$$\begin{aligned}
(7) \quad EE: \\
\text{Min. } \lambda, x_i^* \quad wX^* \text{ s.t.} \\
\lambda Y \geq y_i \\
x_i^* \geq \lambda X \\
\lambda \geq 0
\end{aligned}$$

There have been a few studies comparing the parametric and nonparametric approaches (Ferrier and Lovell, 1990; Bravo-Ureta and Rieger, 1990; Neff et al., 1993; Hjalmarsson et al., 1996). The advantages and disadvantages to each approach are well known. SFA allows one to obtain parameter values and statistical significance levels, and separate random noise from efficiency levels. However, SFA is criticized sometimes for requiring an arbitrary specification of the functional form and efficiency distribution. DEA relaxes the specification assumptions, but is often criticized for confusing random noise with efficiency levels.

3. Data

The analysis focuses on data on crop production and input use from corporate farms at the oblast level.⁸ The data are divided by the number of corporate farms per region in order to model a representative farm of each oblast.⁹ The data are available only for corporate farms, although the Russian statistical agency Goskomstat has recently begun paying more attention to private household farming. Private household farming in 1998 accounted for 57.3 percent of the value of total agricultural output in Russia, although private farms used only 5.4 percent of the total available agricultural land. The implications of the obvious productivity advantage of private versus corporate farming in Russia will be discussed in the conclusions.

The data used to estimate efficiency come from statistical publications of Goskomstat and the Russian Ministry of Agriculture. The data are available for 70 oblasts, representing four calendar years of data, from 1995 to 1998. It should be noted that the high inflation of the early reform period was largely under control for the study period. Month-on-month inflation was brought under 5 percent for the first time in July of 1995, and was relatively stable until the August 1998 financial crisis.

Output was measured as the value of crop output in real 1983 rubles.¹⁰ For the input quantities, land was measured in thousands of hectares of “cropland sown under crops,” adjusted for quality (Goskomstat, 2000).¹¹ Labor was measured as mandays used in crop production.

Goskomstat no longer separates out labor expenditures on crops and livestock, so the proportion

⁸ The term *oblast* is used to refer to the roughly 70 oblasts, krajs, and republics that are the administrative regions of Russia, roughly equivalent to states or provinces. We deliberately avoid the term “region,” which can be confused with economic regions, which are the 8 (formerly 11) subdivisions of the Russian Federation (each containing several oblasts), and *rayony*, which are the equivalent of counties.

⁹ Ideally, farm-level data should be used to measure efficiency, although in this instance farm-level data is not available. Many macro-level efficiency studies assume the existence of a representative consumer, firm, or farm, which is consistent with the approach used here.

¹⁰ Unfortunately, this is the latest available constant price output measurement available for the study.

¹¹ The quality adjustment was proxied as the pre-reform ratio of the oblast’s average grain yield to the national average grain yield. This measurement was compared with the “bal” agroclimatic measurements and shown to be highly correlated.

of expenditures on labor was estimated using the ratios calculated by Sedik et al. (1999) for 1995. Fertilizer and oil products were measured in thousands of tons, estimated by dividing total expenditures on fertilizer and oil by their unit cost (Goskomstat, 1999). Machinery was calculated as the product of the total tractor fleet and the average depreciation rate from 1995 through 1999 to represent tractors “consumed” in production (Russian Ministry of Agriculture, 1998).

Land prices were derived as a result of the parametric analysis discussed in the results section. Wages were provided by the Russian Ministry of Agriculture (1998). Fertilizer, oil, and tractor prices were available from price indices publications (Goskomstat, 1999). Goskomstat estimated the prices used in this study by asking a sample of 10 percent of all agricultural enterprises in Russia what their prices and expenditures were on their inputs during the year in question.

4. Results

To reiterate an important point, farm-level data are not available, so aggregate data were divided by the number of farms to model a representative farm of each oblast. Allocative inefficiency due to actual “incompetence,” if unbiased, will tend to cancel out in aggregate data. The representative firm modeled here can be viewed, then, as one that minimizes costs according to the incentives it faces. The resulting allocative efficiency scores are measures of the extent to which the representative firm’s incentives differ from the market prices used in the measure. To the extent that market prices are measured accurately, the “allocative efficiency” score is in fact a

measure of the distortions in agricultural input markets. The individual distortion scores still represent the degree to which a farm's costs could be reduced if the distortions were removed.

The study of allocative efficiency, which requires input prices, faces an important methodological issue in Russia. There are no land markets in Russia, and consequently no land prices.¹² Shadow land prices can be calculated in the parametric context by appealing to duality theory, if the Cobb-Douglas production function is a good representation of Russian agricultural technology. After estimating the translog production function, restricting it to the Cobb-Douglas function did not result in a significant loss of fit.¹³ Shadow land prices were derived by using the dual Cobb-Douglas cost function, the prices of other inputs and y_i^0 , and by assuming that the amount of land used was efficient. The resulting shadow land prices are shown in table 4. These prices were used in the nonparametric approach.

For the SFA model, the Cobb-Douglas frontier production function was estimated by the FRONTIER (4.1) software program (Battese and Coelli, 1996). The program uses the Battese and Corra (1977) technique that replaces the error variances s_v^2 and s_u^2 with $s^2 = s_v^2 + s_u^2$ and $\gamma = s_u^2 / (s_v^2 + s_u^2)$ (note $\gamma \in [0, 1]$). The closer γ is to one, the more error variance is attributable to inefficiency; if γ is zero and statistically significant, then an OLS model would be appropriate. The program estimates technical efficiency under the half-normal distributional assumption with maximum likelihood techniques. This assumption of a zero mean can be tested with an estimated parameter μ ; if this parameter is statistically significant and nonzero, then the half-normal distribution may be centered away from zero. The program assumes that technical

¹² There have been several attempts to pass land reform legislation in Russia since the reform era began. The effort has largely stalled in recent years, despite a decree signed by President Yeltsin to legalize purchases and sales of land, although the use of land for collateral is still forbidden. Essentially, there is no meaningful agricultural land market at this time.

¹³ Restricting the cross-product of input coefficients to zero resulted in a chi-squared statistic of 15.76, with 15 degrees of freedom. Rejection of the restriction requires a statistic greater than 22.31 at the 10 percent level.

efficiency grows or decays exponentially; that is $u = u_i \exp(-\eta(t-T))$, where η is a parameter to be estimated. The normal error term is assumed to be independently, identically distributed (i.i.d.) as $v \sim N(0, s^2)$; the inefficiency terms u_i are also assumed to be i.i.d. as $N(\mu, s^2)$ but are truncated from the left at zero.

The frontier Cobb-Douglas production function that was estimated was the following (see Table 1 for details):

$$(9) \quad \ln y_i^{te} = -2.67 + 0.47 \ln x_i^1 + 0.49 \ln x_i^2 + 0.01 \ln x_i^3 + 0.06 \ln x_i^4 + 0.05 \ln x_i^5$$

where the x_i^j are land, labor, fertilizer, energy and machinery for $j = 1, \dots, 5$, respectively, and y_i^{te} is the technically efficient production given the x_i^j .

The corresponding cost function, from which we calculate the allocative efficiency scores, is:

$$(10) \quad \ln C(w, y^*) = 34.18 + 0.44 \ln w_1 + 0.45 \ln w_2 + 0.01 \ln w_3 + 0.06 \ln w_4 + 0.04 \ln w_5 + 0.92 \ln y^*$$

**Table 1 -- Estimates of the Stochastic Frontier Cobb-Douglas Production Function
(standard errors in parentheses)/1**

<u>Variable/Input</u>	<u>Coefficient</u>
Constant	-2.673 (0.338) ***
Land	0.472 *** (0.058)
Labor	0.493 *** (0.109)
Fertilizer	0.010 (0.017)
Oil Products	0.062 (0.047)
Tractors	0.047 (0.134)
Sigma^2	0.135 *** (0.033)
Gamma	0.738 *** (0.049)
Mu	0.630 *** (0.133)
Eta	-0.011 (0.025)
Log Likelihood Function	-13.73
LR test (with 3 restrictions)	144.86

*** - Significant at the 1 percent level of significance

/1 Sigma^2, Gamma, Mu, and Eta are coefficients related to the efficiency measure and are explained in the text

It should be noted that these results show that the return to scale is 1.08. A statistical test of the returns to scale showed they were not significantly greater than one.¹⁴

Rather than deriving economic efficiency measures from the price data and trying to decompose it into technical and allocative efficiency (using a procedure described by Kumbhakar, 1997), we take advantage of the duality properties of the Cobb-Douglas production function and derive allocative efficiency measures directly from the production function that results from the technical efficiency measurement. Allocative efficiency scores can be measured for each region by dividing the minimum cost of producing y_i^o , $w'x^e$, by the technically efficient cost, $w'x^{te}$.

To calculate allocative efficiency measures in this way, an estimate of land prices is needed. Since the underlying Cobb-Douglas production function was found to be suitable and data are available on the prices of other inputs and output levels, it is possible to derive the price that would induce a cost-minimizing producer to choose the amount of land actually used. Since the producers in question are assumed to be in fact cost-minimizers, the only disadvantage to this approach is the above-mentioned disparity between market prices and the producers' true opportunity costs. However, in our view, using the shadow prices derived in this way is better than assuming an arbitrary price for land or assuming that land is quasi-fixed.

Table 2 shows the economic, technical and allocative efficiency scores of the SFA and DEA approaches. According to the technical efficiency estimates, inputs could be reduced on average from 17 percent (according to the DEA analysis) to 43 percent (according to the SFA analysis). Since the returns to scale are not significantly different from one, the increase in

¹⁴ In contrast with earlier results (Sedik, et. al., 1999). The production function in Sedik, et al., did not model a representative farm but simply used aggregate data, so the increasing returns to scale they found is related to the amount of agricultural production in each oblast, rather than the scale of agricultural production of a representative farm.

output that could be expected from using the same amount of inputs would be the same.

Furthermore, according to the allocative efficiency estimates, for the same output target, costs could be reduced from 28 percent to 42 percent (DEA and SFA results, respectively).

It is interesting to compare the technical efficiency scores to those of Sedik et al. (1999). Their study showed that technical efficiency declined from 1993 to 1995. The new data shows that this trend may be slowing down but has not yet been reversed.

The technical and allocative efficiency scores are both equally good predictors of economic efficiency, and are also correlated with each other.¹⁵ Regions that have high technical efficiency scores tend to have high allocative efficiency scores as well. Thus Novosibirsk, not known for its enthusiasm for reform, has relatively high technical and allocative efficiency scores (recall that the data being analyzed are for corporate farms, not private farms or plots). Nizhnyj Novgorod, in contrast, is considered highly reform-oriented, but never exceeds a ranking of 54th in allocative or technical efficiency scores. The low efficiency scores in Nizhnyj Novgorod may simply reflect a neglect of corporate farming in favor of more efficient private farming.

¹⁵ For example, in a regression of TE and AE scores against EE scores for 1998, the R^2 was 0.9 and 0.8, respectively. The correlation of TE and AE scores in 1998 was 0.64.

Table 2 -- Summary of SFA and DEA scores		
	SFA	DEA
Technical efficiency		
1995	0.58	0.86
1996	0.57	0.84
1997	0.57	0.80
1998	0.57	0.83
Allocative efficiency		
1995	0.62	0.70
1996	0.57	0.72
1997	0.56	0.72
1998	0.56	0.73
Economic efficiency		
1995	0.37	0.61
1996	0.34	0.60
1997	0.33	0.58
1998	0.33	0.61

Market Share Results

As mentioned above, it is possible to use the efficient cost shares to diagnose problem areas in input markets. Table 3 shows that the regions that performed the best were those that had the highest cost shares in land and labor, and the lowest cost shares for fertilizer, oil products, and tractors.

The results show that Russian agriculture does not reflect the relative abundance of labor with respect to machinery. Russian agriculture inherited a capital-intensive technology from the Soviet era. In order to employ more labor-intensive technology, it is probably necessary for much of the inherited machinery to be replaced. Unfortunately, the poor financial performance of Russia's agricultural sector, as well as the poor performance of the Russian credit market in general, has discouraged investment. The inability to invest in new technology may be one of the main distortions in the input markets that keep farms from using the cost-minimizing

(relatively labor-intensive) input bundle. However, there are other possible distortions that are explored in detail in the following section.

Table 3 -- Comparison of cost shares between most and least allocatively efficient regions (according to SFA analysis)					
Item	Land	Labor	Fert.	Energy	Tractors
Optimal cost shares	0.44	0.45	0.01	0.06	0.04
1995					
10 most efficient oblasts	0.26	0.37	0.03	0.24	0.09
10 least efficient oblasts	0.09	0.24	0.02	0.51	0.14
1996					
10 most efficient oblasts	0.25	0.31	0.05	0.27	0.12
10 least efficient oblasts	0.07	0.23	0.05	0.48	0.17
1997					
10 most efficient oblasts	0.25	0.35	0.05	0.22	0.13
10 least efficient oblasts	0.08	0.21	0.06	0.45	0.21
1998					
10 most efficient oblasts	0.25	0.38	0.07	0.21	0.10
10 least efficient oblasts	0.07	0.21	0.06	0.40	0.26

Fuel. The main source of allocative inefficiency in the Russian agricultural sector is the large cost share of fuel consumption. According to the dual cost function derived from the production function, the efficient cost share of fuel consumption for Russian agriculture on average is 6 percent, while the actual share of energy consumption in 1998 (when the cost share of fuel was the lowest) averaged 32 percent. It may be that the Russian tractor fleet inherited from the Soviet Union is not fuel-efficient (largely due to poor maintenance, see tractor discussion below).

Another source of excessive fuel consumption may be the tendency to pay workers in kind, either explicitly, through direct in-kind payments, or implicitly, by allowing workers to steal agricultural inputs for their own use. A survey of enterprises by the Russian Economic Barometer reveals that payments in kind during this period were only 2 percent of employees'

total remuneration. However, the REB survey does not indicate the share of in-kind payments in total remuneration among enterprises that use it. Furthermore, no survey of Russian agricultural enterprises has investigated the extent of input theft by employees. Perhaps further research would shed some light on this issue.

Finally, what may seem to be “excessive” fuel consumption may be a result of stockpiling fuel for barter. For example, the price list on one tractor factory’s website at one point stated that prices were negotiable and barter transactions would be considered, with food products and fuel the most desirable barter products.¹⁶

Tractors. The high cost share of fuel in Russian agriculture may result from fuel-inefficiency of Russian tractors. However, a new Byelorussian tractor has about the same, if not better in some instances, fuel consumption performance as a new western tractor.¹⁷ Russian tractors may nevertheless be less fuel-efficient because they are poorly maintained. In 1998, one tractor testing laboratory tested the reliability of 92 tractors produced by 9 different foreign and domestic factories.¹⁸ The study concluded that Russian tractors break down much more often than their Western counterparts, while spare parts availability for the Western tractor manufacturers was much better.¹⁹ Not only is the spare parts market for agricultural machinery

¹⁶ The Cheliabinsk tractor factory, <http://chtz.chelyabinsk.ru/prais.html>. In 2000, the web site was changed to state that only cash or checks will be accepted.

¹⁷ Based on a comparison of five Byelorussian tractors to western tractors of similar horsepower. Data are from OECD tractor tests carried out in the 1990s by the Nebraska Tractor Test Laboratory (2000). In 1999, specialists of the North-Caucas Machine Testing Station compared the “Don-2600” of the Rostov tractor factory “RostSel’Mash” with Case’s “Case-2366” under Russian harvesting conditions. They found that the “Don” produced 18.8 tons of grain per hour, using 2.26 liters of diesel per ton, with losses of 2.02 percent. The “Case” tractor produced 16.3 tons of grain an hour, using 2.34 liters of fuel per ton, with losses of 2.34 percent.

¹⁸ The study was conducted by the Center for Scientific and Technical Cooperation for the Testing of Agricultural Machinery. This study focused on the number of breakdowns the machines experienced, rather than yield and fuel consumption. The study reported the price paid for the tractors, the frequency of breakdowns, and the primary reasons for the breakdowns. The best performing Russian tractor broke down an average 7.5 times over a period of two years. The worst performing Western tractor, the “Mega-208” from the German company “Klaas” broke down an average 1.8 times over the same period.

¹⁹ The workers of the machine testing stations “have over the years noticed the same flaws in the construction of Russian combines: bad welding, low reliability of the cooling system, belts, and especially ball bearings. Not one

in Russia underdeveloped, but agriculture officials complain that the scarcity of agricultural machinery forces Russian farmers to cover much more land in their tractors and combines than their western counterparts, leading to excessive wear and tear. This may also lead to poorly maintained tractors that are fuel inefficient.

Labor. Studies of the labor market for Russian agriculture point out the excess labor extant in that industry (for example, Kapeliushnikov and Aukutsionek, 1995). However, the present study claims that the efficient regions are the ones that spend the largest share of their costs on labor, which seems counterintuitive. How can these two conflicting claims be reconciled?

While it is true that there is redundant labor on agricultural enterprises, the same is true for almost all of the inputs used in Russian agriculture. A firm that is technically inefficient is one that could reduce all inputs and maintain the current output. The allocative inefficiency scores, which suggest that the cost efficient regions are those with high cost shares of labor, do not address the *overall* use of inputs. Rather, the AE scores address the optimal *mix* of inputs. Thus, when the AE scores indicate that the cost-minimizing mix of inputs has a relatively high share of labor, it is effectively indicating that the use of other inputs could be decreased relatively more than the use of labor (in this case, energy and fertilizer). The high cost share of labor indicated by the AE score does not necessarily imply that productivity will improve by hiring more workers.

At times, laborers persist in showing up at their jobs even when they have not been paid for as much as six months. This indicates that the labor market is relatively rigid. Some of the

producer has organized a repair service for its combines. At the same time, ... the German company 'Klaas' has already established a repair service in Novosibirsk. The American firm 'Case' has created a technical center in Omsk." From the new Russian "Inter-regional Grain Trading System" website, <http://www.mtszerno.ru/grain/docs/analit/combine.html>

rigidity of the Russian labor market can be explained by the peculiarities of the housing market, where a large proportion of apartments remained unprivatized. In regions where privatization of housing has not occurred, the supply of privatized housing is restricted, increasing the costs of finding a new dwelling. In a recent study of labor mobility, Brown (1997) found that regions with low rates of apartment privatization have lower overall labor mobility (migration in and out of the region).

Another source of labor market rigidity is proposed in a study by Friebe and Guriev (1999), who contend that labor rigidity in the Russian Federation can be explained by deliberate practices of Russian enterprises. They claim that the use of payments in kind that cannot be monetized, like medical services and vacation facilities, allows firms to retain workers in spite of attractive alternatives elsewhere. Regions that use relatively more in-kind compensation would have relatively low incomes and lower labor mobility.

Land. As mentioned above, there is no land market in Russia. Until the Russian Duma passes a reformed Land Code, Russia's policy towards land is governed by a decree passed by President Yeltsin that legalizes the purchase and sale of land, although not the use of land as collateral. The version of the Land Code passed by the Duma in December of 1996 does not allow the purchase and sale of land for agricultural use. President Yeltsin rejected this version of the code in July of 1997, which led to an impasse. Vladimir Putin, the current President of Russia, has stated that he considers land reform a high priority, but has never described his position on the issue. At the time of this writing, the land issue remains unresolved.

Table 4: Shadow land prices, adjusted for land quality

in dollars	1995	1996	1997	1998	Quality ¹
Russia	13.54	14.02	13.84	8.65	N/A
<u>Northern District (2)</u>	<u>26.43</u>	<u>26.22</u>	<u>23.22</u>	<u>15.46</u>	<u>0.75</u>
<u>Northwest District (2)</u>	<u>28.90</u>	<u>25.87</u>	<u>27.25</u>	<u>18.08</u>	<u>0.84</u>
<u>Central District (2)</u>	<u>20.15</u>	<u>19.37</u>	<u>18.12</u>	<u>11.98</u>	<u>1.11</u>
<u>Volga-Vyatka District (2)</u>	<u>11.11</u>	<u>11.58</u>	<u>11.50</u>	<u>7.32</u>	<u>0.96</u>
<u>Central Black Earth District (2)</u>	<u>12.22</u>	<u>11.39</u>	<u>11.08</u>	<u>7.32</u>	<u>1.49</u>
<u>Povolzhsky District (2)</u>	<u>16.37</u>	<u>15.92</u>	<u>16.43</u>	<u>9.67</u>	<u>0.94</u>
<u>North Caucasian District (2)</u>	<u>9.21</u>	<u>11.75</u>	<u>11.78</u>	<u>7.34</u>	<u>2.08</u>
<u>Urals District (2)</u>	<u>12.39</u>	<u>13.71</u>	<u>13.36</u>	<u>8.03</u>	<u>0.79</u>
<u>Western-Siberian District (2)</u>	<u>13.35</u>	<u>14.97</u>	<u>14.88</u>	<u>9.38</u>	<u>0.83</u>
<u>Eastern-Siberian District (2)</u>	<u>9.49</u>	<u>8.14</u>	<u>7.53</u>	<u>4.83</u>	<u>0.91</u>
<u>Far East District (2)</u>	<u>34.37</u>	<u>24.02</u>	<u>24.51</u>	<u>13.67</u>	<u>0.80</u>
<u>Kaliningrad</u>	<u>7.16</u>	<u>5.71</u>	<u>4.97</u>	<u>3.40</u>	<u>1.40</u>

(1) For brevity, we omit prices that are not adjusted for quality. They can be calculated by multiplying the price in question by the quality adjustment coefficient.

(2) District averages are weighted by quality adjusted land endowment.

5. Conclusions

This study attempts to address two main questions: 1) If all farms in Russia were to adopt the best domestic practice, what improvement in farm performance would result? 2) According to the allocative efficiency measures, which input markets suffer from the greatest distortions?

According to the technical efficiency estimates, inputs could be reduced on average from 17 percent (according to the DEA analysis) to 43 percent (according to the SFA analysis). Since the returns to scale are not significantly different from one, the increase in output that could be expected from using the same amount of inputs would be the same. Furthermore, according to the allocative efficiency estimates, for the same output target, costs could be reduced from 28 percent to 42 percent (DEA and SFA results, respectively).

The largest distortion effecting input use is probably Russian farms' inability to secure credit to replace their labor-saving machinery with labor-intensive machinery (due to the poor financial performance of the agricultural sector and the credit market). This means that farms often find they will perform better by implementing the old machinery-intensive Soviet agricultural practices rather than responding to market incentives, which would require emphasizing labor-intensive practices.

All inputs were found to contribute to low allocative efficiency, reflecting markets that function poorly. The main source of allocative efficiency was the large cost share of oil products. The high cost share of fuel implies that Russian farmers purchased more than the efficient proportion of fuel compared to other inputs. Fuel is an ideal barter tool and the large purchases of fuel may have been used to finance other input purchases, and to pay laborers in

kind. However, it is also true that Russian agricultural machinery is less fuel-efficient than western machinery, due to poor maintenance and the lack of a market for spare parts.

It should be noted that the data used in this study was available only for corporate farms. The Russian government has only recently started to publish data on peasant (i.e. private) and family (private plot) farming. This reflects a bias of the Russian government towards large scale, machinery-intensive farming, a bias that was shared by the Soviets. The results of this study show that the machinery-intensive nature of corporate farming may be inappropriate, given the current low cost of labor relative to machinery and fuel. Private plot farming is by its nature more labor-intensive, so should be a more cost-effective way to produce crops. Given the proper institutional reforms to allow for more factor mobility, private plot farming over time might evolve into large-scale, capital-intensive agriculture.

One oft-quoted statistic of Russian agriculture is that private plot farming provides more than 50 percent of the value of all agricultural production in Russia, while using less than 10 percent of all available arable land. What is misleading about this figure, however, is that some of the inputs used in the private plots were pilfered from corporate farms where the owner of the private plot works. Further research may be needed to explore the extent to which private plot farming in Russia is more cost-efficient than corporate farming. This in turn raises another issue of whether it is in fact appropriate to consider private plot and corporate farming separately, or whether they should be considered collectively, since private plot holders get some of their inputs from the “mother” farm.

REFERENCES

- Aigner, Dennis, Lovell, C.A. Knox, and Schmidt, Peter (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics* **6**, 21-37.
- Battese, George (1992). A Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics. *Agricultural Economics* **7**, 185-208.
- Battese, George and Coelli, Tim (1996). FRONTIER 4.1 computer software program. University of New England, Centre for Efficiency and Productivity Analysis.
- Battese, George and Corra, Greg S. (1977). Estimation of a Production Frontier Model: With Application to the Pastoral Zone of Eastern Australia. *Australian Journal of Agricultural Economics* **21**, 169-79.
- Bauer, Paul W. (1990). Recent Developments in the Econometric Estimation of Frontiers. *Journal of Econometrics* **46**, 39-56.
- Berger, Allen N. and Humphrey, David (1997). Efficiency of Financial Institutions: International Survey and Directions for Future Research. *European Journal of Operational Research* **98**, 175-212.
- Bhattacharyya, Arunava, Parker, Elliott and Raffiee, Kambiz (1994). An Examination of the Effect of Ownership on the Relative Efficiency of Public and Private Water Utilities. *Land Economics* **70**(2), 197-209.
- Bravo-Ureta, Boris E. and Rieger, Laszlo (1990). Alternative Production Frontier Methodologies and Dairy Farm Efficiency. *Journal of Agricultural Economics* **41**, 215-226.
- Brooks, Karen and Lerman, Zvi (1994). Land Reform and Farm Restructuring in Russia. Washington, DC: World Bank Discussion Paper 233.
- Brown, Annette (1997). The Economic Determinants of Internal Migration Flows in Russia During Transition. Davidson Institute Working Paper Series #89.
- Charnes, Abraham, Cooper, William W., and Rhodes, Edwardo (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research* **2**, 429-444.
- Coelli, T., P. Rao, and G. Battese (1998). *An Introduction to Efficiency and Productivity Analysis*. Boston: Kluwer Academic Publishers.

- Cornwell, Christopher, Schmidt, Peter, and Sickles, Robin (1990). Production Frontiers with Cross-Sectional and Time-Series Variation in Efficiency Levels. *Journal of Econometrics* **46**, 185-200.
- Evenson and Bravo-Ureta (1994). Efficiency in Agricultural Production: The Case of Peasant Farmers in Eastern Paraguay. *Agricultural Economics* **10**, 27-37.
- Färe, Rolf, Grosskopf, Shawna, and Lovell, C.A. Knox (1994). *Production Frontiers*. Cambridge, Great Britain: Cambridge University Press.
- Farrell, Michael J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society Series A*, General 125 Part 2: 252-267.
- Ferrier, Gary D. and Lovell, C.A. Knox (1990). Measuring Cost Efficiency in Banking: Econometric and Linear Programming Evidence. *Journal of Econometrics* **46**, 229-245.
- Friebel, Guido and Guriev, Sergei (1999). Why Russian Workers Do Not Move: Attachment of Workers Through In-Kind Payments. Davidson Institute Working Paper Series #283.
- Gaddy, Clifford, and Ickes, Barry (1998). To Restructure or Not to Restructure: Informal Activities and Enterprise Behavior in Transition. Mimeo, Pennsylvania State University. <http://econ.la.psu.edu/~bickes/ickres.htm>
- Gomulka, Stanislaw (1985). Kornai's Soft Budget Constraint and the Shortage Phenomenon: A Criticism and Restatement. *Economics of Planning* 19: 1-11.
- Goskomstat of Russia, *Agriculture in Russia 2000*, Moscow, Russia.
- Goskomstat of Russia, *Price Indices of Prices Received and Purchased Inputs and Services by Corporate Farms, January – December 1996*. Moscow, Russia.
- Goskomstat of Russia, *Price Indices of Prices Received and Purchased Inputs and Services by Corporate Farms, January – December 1997*. Moscow, Russia.
- Goskomstat of Russia, *Price Indices of Prices Received and Purchased Inputs and Services by Corporate Farms, January – December 1998*. Moscow, Russia.
- Goskomstat of Russia, *Price Indices of Purchased Inputs and Services by Corporate Farms, January – December 1999*. Moscow, Russia.
- Greene, William (1980). Maximum Likelihood Estimation of Econometric Frontier Functions. *Journal of Econometrics* **13**, 27-56.
- Hjalmarsson, L., Kumbhakar, S., and Heshmati, A. (1996). DEA, DFA, and SFA: A Comparison. *Journal of Productivity Analysis* **7**, 303-327.

- International Monetary Fund (2000). *International Financial Statistics (March 2000)*. Washington, DC: International Monetary Fund.
- Kapeliushnikov, R., and Aukutsionek, S. (1995). Labor Market in 1994. *Russian Economic Barometer* 4.
- Kopp, J. and Diewert, W.E. (1982). The Decomposition of Frontier Cost Function Deviations into Measures of Technical and Allocative Efficiency. *Journal of Econometrics* **19**, 319-31.
- Kornai, Janos (1985). Gomulka on the Soft Budget Constraint: A Reply. *Economics of Planning* **19**, 49-55.
- Kumbhakar, Subal C. (1997). Modeling Allocative Inefficiency in a Translog Cost Function and Cost Share Equations: An Exact Relationship. *Journal of Econometrics* **76** (1-2), 351-56.
- Kumbhakar, Subal C. (1990). Production Frontiers, Panel Data, and Time-Varying Technical Inefficiency. *Journal of Econometrics* **46**, 201-211.
- Meeusen, Wim and van den Broeck, J. (1977). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. *International Economic Review* **18**, 435-444.
- Nebraska Tractor Test Laboratory (2000). Test results obtained by correspondence. Lincoln, Nebraska.
- Neff, D., Garcia, P., and Nelson C. (1993). Technical Efficiency: A Comparison of Production Frontier Methods. *Journal of Agricultural Economics* **44**, 479-489.
- Raiser, Martin (1997). *Soft Budget Constraints and the Fate of Economic Reforms in Transition Economies and Developing Countries*, Kieler Studien No. 281. Tübingen: J.C.B. Mohr (Siebeck).
- Russian Ministry of Agriculture, *Agro-Industrial Complex of Russia 1998*. Moscow, Russia.
- Schmidt, P. and Lovell, C.A.K. (1979). Estimating Technical and Allocative Inefficiency Relative to Stochastic Production and Cost Frontiers. *Journal of Econometrics* **9**, 343-66.
- Scott, Chris (1990). Soft Budgets and Hard Rents: A Note. *Economics of Planning* **23**, 117-127.
- Sedik, et al. (1999) Corporate Farm Performance in Russia, 1991-95: An Efficiency Analysis. *Journal of Comparative Economics* **27**, 514-533.
- Sharma, K., Leung, P., and Zaleski, H. (1999). Technical, Allocative and Economic Efficiencies in Swine Production in Hawaii: A Comparison of Parametric and Nonparametric Approaches. *Agricultural Economics* **20**, 23-35.

- Sieford, Lawrence (1996). Data Envelopment Analysis: The Evolution of the State of the Art (1978-1995). *Journal of Productivity Analysis* **7**, 99-137.
- Stevenson, Rodney (1980). Likelihood Functions for Generalized Stochastic Frontier Estimation. *Journal of Econometrics* **13**, 57-66.
- United Nations (1995). *Energy Statistics Yearbook*. New York, United Nations.
- U.S. Department of Agriculture (1999). *Farm Business Economics Report, 1996*. Washington, DC: U.S. Department of Agriculture, Economic Research Service, ECI-1997.
- Xu, Xiaosong and Jeffrey, Scott (1998). Efficiency and Technical Progress in Traditional and Modern Agriculture: Evidence from Rice Production in China. *Agricultural Economics* **18**, 157-65.