PRODUCTION ORGANIZATION AND EFFICIENCY DURING TRANSITION: AN EMPIRICAL ANALYSIS OF EAST GERMAN AGRICULTURE

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ABSTRACT

Farm restructuring is expected to improve efficiency in transition economies. With data from former East Germany we compare the efficiency of family farms and partnerships with large-scale successor organizations of the collective and state farms (LSOs). Our efficiency analysis, using parametric and non-parametric techniques, shows that LSOs display lower technical efficiency than family farms and partnerships, but that this difference is small and declining during transition, mainly as a result of structural changes in agriculture. Family farms are less scale efficient than partnerships and LSOs. Partnerships are superior to all other organizational forms regardless of the measuring technique used.

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I. INTRODUCTION

An important issue in the economic transition in Central Europe is the restructuring of production organizations and its impact on productivity and efficiency. A key issue in the literature is whether so-called *de novo* firms will be more efficient than restructured former state and collective enterprises facing hard budget constraints in a competitive environment.[1] In agricultural production, these *de novo* firms are typically family farms or small associations of family farms. The former collective and state farms which have not been liquidated, have typically been transformed into either a "private cooperative" or a joint stock company (Swinnen, Buckwell and Mathijs, 1997). We will refer to both organizations as "large-scale successor organizations" (LSOs).

Two factors have an important – and opposite – effect on the relative efficiency of these various organizations in agricultural production: labor transaction costs and scale economies. First, LSOs are expected to display lower levels of technical efficiency because of their inherent problems in solving principal-agent problems in labor contracting related to the difficulties of linking effort in production to income (Schmitt, 1993). As a result, individuals in these production organizations have more incentive to shirk. This problem is due to the difficulty of metering effort in production (Alchian and Demsetz, 1972) – which is particularly stringent in agriculture because of its biological and sequential nature and spatial dimensions (e.g., Brewster, 1950; Binswanger and Rosenzweig, 1986). Family farms are more efficient in this regard because family members maximize family welfare rather than individual welfare and hence face no incentive to free ride, so that the costs of monitoring and controlling labor effort are lower (Carter, 1984). Based on these theoretical observations – and the domination of family farms in most OECD countries' agriculture – several authors have concluded that family farms are superior organizations in agricultural production (Pollak, 1985; Schmitt, 1991).

Second, scale economies would favor the largest organizations. However, many studies suggest that there are no increasing returns to farm size in production beyond what can be captured by the family farm both in developing (Berry and Cline, 1979; Hayami and Ruttan,

[1] See for example the special issue of the *Journal of Comparative Economics* edited by Ben-Ner, Brada and Neuberger (1993) for a comprehensive overview of the issues and Brada, King and Ma (1997) for an analysis of enterprise efficiency in Hungary and the Czech Republic.

1985) and in developed countries (Kislev and Peterson, 1991; Peterson, 1997). Advantages of cooperation and economies of scale do exist in output marketing, input purchasing, credit and information provision and risk management. In many countries these scale economies are captured by marketing and credit cooperatives. However, in a transition economy where cooperative frameworks limited to input purchasing, credit negotiation and output marketing are typically absent, these ‘intrinsic’ scale advantages may provide important advantages to LSOs and may offset their transaction cost disadvantages, at least during the transition period (Carter, 1987; Machnes and Schnytzer, 1993; Deininger, 1995). Moreover, some argue that state and collective farms performed poorly not because of their intrinsic problems, but because of extrinsic problems, such as bureaucratic controls and extractive external environments (Johnson, 1983; Putterman, 1985). This result would imply that LSOs will be able to survive and compete as production organizations even after the transition is over.

Empirical evidence on the relative efficiency of large-scale (sometimes cooperative) and small-scale (mostly family farms) organizations is rather scarce and is limited to earlier reforms in socialist countries in East Asia and to pre-reform comparisons in those Central European countries where private farms were important during Communism. The studies show that institutional reform had a large positive impact on agricultural growth in China (McMillan et al., 1989; Lin, 1992) and in Vietnam (Pingali and Xuan, 1992). Evidence for Central Europe is limited to pre-1989 comparisons of small-scale family farms and large-scale collective (or state) farms in Poland and Yugoslavia. Boyd (1987a,b) shows that both in Poland and Yugoslavia there is no difference in technical efficiency between state farms and private farms. Improved techniques based on frontier estimates yield ambiguous results: they confirm Boyd’s results for Poland (Brada and King, 1993), but Hofler and Payne (1993) reject them for Yugoslavia. Brada and King conclude that indeed “it is the environment of socialized agriculture rather than the socialized nature of farms that leads to the poor performance of the agricultural sector in Eastern Europe and the former Soviet Union” (p. 54).

However, all these studies suffer from two important remaining methodological flaws. First, since they all use parametric estimation techniques, their results are highly sensitive to the specified functional form of the production function. Second, parametric estimations do not allow to estimate the scale efficiency of organizations. The use of non-parametric techniques to calculate technical and scale efficiency therefore provides useful complementary information. For example, Piesse, Thirtle and Turk (1996) complement their parametric estimations with non-parametric calculations to show that in the Slovenian dairy sector private farms display higher technical efficiency but lower scale efficiency than cooperatives. Unfortunately, their analysis is limited to the period 1974-1990. Post-reform efficiency studies are still unavailable, mainly due to the absence of reliable and consistent data on the performance of different organizational forms in Central European agriculture since 1989.

This paper presents the first analysis – to our knowledge – of differences in efficiency between different farm organizations *after* the 1989 reforms in Central Europe.[2] East German data are used since German statistics are the most consistent and reliable in a former Communist economy presently available. Our analysis shows that in former East Germany, LSOs display lower levels of technical efficiency than partnerships and family farms, but that this difference is small and declining during transition. Our results also indicate that family farms are less scale efficient than both partnerships and LSOs, and that farms organized as partnerships are the most efficient organizational form regardless of the measuring technique used. Because of the unique conditions of East German agriculture as a result of the unification and the subsequent integration into the Common Agricultural Policy of the European Union, one should be cautious to generalize any findings based on the East German experience to other transition economies.

The paper is organized as follows. Section 2 presents the data used for the empirical analysis. While technical efficiency is estimated using parametric efficiency measures in section 3, non-parametric measures of technical and scale efficiency are calculated in section 4. The results of these calculations are tested in a fifth section. Section 6 discusses the results and formulates some hypotheses. Section 7 concludes the paper.

II. DATA

Data for the analyses are taken from the official German statistics on annual production and input use by three farm categories from 1991/92 to 1994/95 and are averages of panel data (Agrarbericht, 1996). Data are also available according to farm specialization (crops or livestock). All calculations are based on a single aggregate output and three conventional inputs: land, labor and capital. As a proxy for production, we use agricultural output, Y, i.e. the production value in German Marks (DEM) deflated by the consumer price index (OECD,

[2] Many qualitative and theoretical analyses are available. For former East Germany, see e.g. the debate between Peter and Weikard (1993) and Beckmann, Schmitt and Schulz-Greve (1993) on the relative efficiency

1996). LAND is cultivated land in hectares. LABOR is the number of annual work units ('Arbeitskräfte'). CAPITAL is the sum of the value of buildings, machinery and livestock in DEM deflated by the consumer price index.[3]

Table 1 displays the relative importance of each of these organizations and their average size in terms of cultivated land in East Germany during transition. Table 2 summarizes the descriptive statistics of the sample which is used for our analysis.

1. *Family farms* ('Einzelunternehmen'). The category of family farms, or 'sole proprietors', includes farms worked and managed by a single household. The economic size of the farms varies from less than 40,000 DEM to more than 100,000 DEM Standard Farm Income ('Standardbetriebseinkommen'). The importance of these family farms increased from 13 percent of total cultivated land in 1992 to 21 percent in 1995. The average size of the farms in the sample is 199 ha for crop farms and 81 ha for farms specialized in animal products and is higher than the average size of the population (45-48 ha). On average, family farms in the sample employ between 1.4 and 2.8 labor units.

2. *Partnerships* ('Personengesellschaften'). Most partnerships were established as new enterprises (Beckmann and Hagedorn, 1997). They typically result from the collaboration of only a few people (they employ about 5 labor units on average) which in many cases are family related. Partnerships differ from companies and cooperatives because they have unlimited liability (as do family farms). The main reason of their establishment was to overcome the difficulties single family farms face in getting access to credit given increasing capital needs (Welschof, 1995).[4] Their evolution is parallel with that of family farms. Partnerships covered 14 percent of total cultivated land in 1992 and 22 percent in 1995. The partnerships in the sample have on average 250-534 ha of land, which is comparable in size to the overall average.

3. *Legal entities* ('juristische Personen'). This category includes both farms organized as cooperatives and as joint stock companies. Both types of farms are characterized by limited

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of production organizations. Beckmann and Hagedorn (1997) provide a more general overview of structural change in East German agriculture.

[3] Since output and capital are expressed in monetary terms, our results may be sensitive to differences between family farms and LSOs in how assets are valued and how they react to policy changes.

[4] For example, dairy farms face high capital needs to finance the purchase of milk quota.

liability. Most of these farms were created from former cooperative farms – the so-called 'Landwirtschaftliche Produktionsgenossenschaften' (LPGs) – whereas the majority of partnerships were established as new enterprises. We refer to this category as large-scale successor organizations (LSOs) of the LPGs. The data do not allow disaggregation between companies and cooperatives, such that our conclusions will apply to LSOs in general. Both companies and cooperatives are transformed LPGs. In fact, 40 percent of the LPGs have been eliminated, whereas 60 percent has been transformed into one of the legal forms provided by West German Law. Out of the 60 percent of LPGs that have not been liquidated by 1992, 49 percent were transformed into cooperatives, 41 percent into companies and 13 percent into partnerships (Beckmann and Hagedorn, 1997). The share of LSOs in total cultivated land decreased steadily from 73 percent in 1992 to 57 percent in 1995. The average size of LSOs in the sample exceeds that of the population considerably. Moreover, it must be indicated that cooperatives are generally larger than companies. LSOs employ about 50 labor units on average.

III. ESTIMATING TECHNICAL EFFICIENCY USING PARAMETRIC METHODS

Frontier estimation

A production organization is technically efficient if it produces on the boundary of the production possibilities set, that is, it maximizes output with given inputs and after having chosen technology. This boundary or frontier is defined as the best practice observed within the sample. Deviations from the frontier reflect the intensity of resource use, i.e. since production inputs are not measured in technical productivity units and effort determines both labor productivity and the intensity and intelligence with which non-labor inputs are used, any variation in the intensity and effort with which firms utilise observed inputs, are reflected in variation in technical efficiency (Carter, 1984, p. 830).

We will analyze the technical efficiency of different organizations by comparing the observed output of a certain activity k[5], Y_k, produced using land, labor and capital, to an 'efficient' output level, $\tilde{Y}_k$, located on the frontier production function. This frontier contains

[5] Activities can be different farms at a certain point of time, a particular farm at different points in time, or a combination of both.

the maximum output levels given certain input bundles. The ratio of observed output to efficient output is then the level of technical efficiency for activity k, $e_k = Y_k / \tilde{Y}_k$. We will first estimate this frontier in a standard, parametric way. More specifically, following Lin (1992), Hofler and Payne (1993), Piesse, Thirtle and Turk (1996) we use a Cobb-Douglas specification, because the available data do not contain sufficient information to permit the estimation of more sophisticated functional forms. The estimates thus derived are the so-called Timmer measures of technical efficiency.[6]

The production function frontier can be either stochastic – i.e. the frontier can be subject to statistical noise – or deterministic – i.e. the frontier is fixed. We will first investigate whether to use a stochastic or a deterministic frontier for the efficiency estimation. The stochastic frontier can be written as follows:

$$(1) \qquad \ln(\tilde{Y}) = \tilde{\alpha}_1 + \tilde{\alpha}_2 T_{92/93} + \tilde{\alpha}_3 T_{93/94} + \tilde{\alpha}_4 T_{94/95} + \tilde{\beta}_A \ln(LAND) + \tilde{\beta}_L \ln(LABOR) + \tilde{\beta}_K \ln(CAPITAL) + \tilde{v} - \tilde{u}$$

where $\tilde{\alpha}_1$ denotes the intercept for 1991/92; the T's are dummy variables for each year (1 for that year, 0 for other years), and the $\tilde{\beta}$'s are the production elasticities at the frontier. The time dummies are included to account for yearly shifts of the frontier. The error term is decomposed into a two-sided error term which is normally distributed, $\tilde{v} \sim N(0, \sigma_v^2)$, and represents statistical noise, and a one-sided error term $\tilde{u} \geq 0$ which follows a half-normal distribution with mean μ and variance σ_u^2 and represents technical inefficiency. The stochastic frontier is estimated using the maximum likelihood technique of LIMDEP following Aichner, Lovell and Schmidt (1987).

Excluding statistical noise from specification (1) yields the deterministic frontier:

$$(2) \qquad \ln(\tilde{Y}') = \tilde{\alpha}_1' + \tilde{\alpha}_2' T_{92/93} + \tilde{\alpha}_3' T_{93/94} + \tilde{\alpha}_4' T_{94/95} + \tilde{\beta}_A' \ln(LAND) + \tilde{\beta}_L' \ln(LABOR) + \tilde{\beta}_K' \ln(CAPITAL) - \tilde{u}'$$

[6] See Timmer (1971) for more detail.

where all coefficients and variables have the same interpretation as in (1), except for the error term which contains only a one-sided negative error term $\tilde{u}'$. We estimated the deterministic frontier using corrected ordinary least squares (COLS) (Greene, 1980; Russel and Young, 1983; Piesse, Thirtle and Turk, 1996).[7] It involves first the estimation of the average production function, $\ln(\overline{Y})$, which is characterized by an intercept α_1, by means of OLS:

$$(3) \qquad \ln(\overline{Y}) = \alpha_1 + \alpha_2 T_{92/93} + \alpha_3 T_{93/94} + \alpha_4 T_{94/95} + \beta_A \ln(LAND) + \beta_L \ln(LABOR) + \beta_K \ln(CAPITAL) + v$$

where the β's are the production elasticities of the different inputs and v denotes statistical noise. To yield the frontier the production function thus estimated is shifted upwards with intercept $\tilde{\alpha}_1$, so that the observation with the largest positive residual lies on the frontier:

$$(4) \qquad \ln(\tilde{Y}) = \tilde{\alpha}_1 + \alpha_2 T_{92/93} + \alpha_3 T_{93/94} + \alpha_4 T_{94/95} + \beta_A \ln(LAND) + \beta_L \ln(LABOR) + \beta_K \ln(CAPITAL),$$

that is, the new intercept equals $\tilde{\alpha}_1 = \alpha_1 + v_{max}$ where v_{max} is the largest positive error and is considered to be the most efficient observation. This approach assumes that the slope parameters of the average production function and the frontier are the same.

The results of both estimations are summarized in table 3. All coefficients are statistically significant at the one percent level, except for the intercept and the coefficient for labor, which is negative but does not differ significantly from zero. Table 3 suggests further that the stochastic frontier does not differ significantly from the deterministic frontier. The variance of the one-sided error term was much higher (0.016) than the variance of the two-sided error term ($2\ 10^{-10}$). Therefore, the results of the stochastic estimation hardly differ from the results of the deterministic estimation. This is not surprising since we use average data. As both approaches yield similar results, we calculate efficiency measures based on the deterministic frontier. We also estimated the deterministic frontier without dummies for each year. The estimated coefficients are presented in the last column of table 3. This approach yields a positive coefficient for labor and will be used for the calculation of the efficiency measures.

[7] Another method is to use programming techniques.

Any interpretation of efficiency measures will have to take into account that any shifts of the frontier during transition will now show up in the efficiency estimations.

Efficiency calculation

Technical efficiency measures are calculated for the individual observations by subtracting the largest positive residual from all residuals setting the error term of the most efficient observation equal to zero. Exponentiation gives the relative efficiency of each observation as a percentage of the most efficient one. The results of these calculations are in table 4.

In crop production, partnerships (84.0) turn out to be more efficient than family farms (79.5) and LSOs (69.4). The same pattern can be observed in livestock production, albeit that the difference between family farms (81.9) and LSOs (79.7) is much smaller now. In crop production, technical efficiency decreases over time in all types of farms, but considerably more in family farms (-9.1) and partnerships (-5.2) than in LSOs (-0.4). The differences are greater in livestock production: technical efficiency of partnerships and family farms decreases with about 20 percentage points, while LSOs show a slight increase in technical efficiency (+2.4). Finally, it can be observed that the difference in technical efficiency between partnerships and family farms on the one hand and LSOs on the other hand is greater in crop production (+14.7 and +10.1 respectively) than in livestock production (+7.9 and +2.2 respectively).

Discussion

Some of these results are remarkable, but before trying to explain and interpret these results, we discuss some problems with the model specifications and some methodological refinements to improve and decompose the efficiency calculations.

The approach used for our estimations and efficiency calculations is the same as the one used by Hofler and Payne (1993) and Piesse, Thirtle and Turk (1996). However, this approach has two important problems. First, parametric analysis involves the choice of a specific production function and using observable production behavior to estimate the underlying parameters. In order not to impose *a priori* restrictions, flexible functional forms can be used for estimation (e.g., quadratic, translog and generalized Leontief forms), but results are still sensitive to the particular parametric functional form chosen. Moreover, the choice of a particular functional form implies that one has *a priori* information on the actual form. Since this kind of information is mostly absent, methods that do not rely on the strict parametric assumptions are preferred (Chavas and Cox, 1995). Second, parametric estimations do not allow the decomposition of total efficiency in technical and scale efficiency.

Two observations indicate the possibility of a misspecification of the production function: first, the coefficient of labor is negative both for the stochastic and the deterministic estimation, and second, the sum of coefficients is equal to 1.21 and 1.18 for the stochastic and the deterministic frontier respectively, indicating that increasing returns to scale is the dominating feature of the observations in the sample. Introducing a slope dummy in (3) for LSOs on the coefficient for LAND considerably increases the coefficient for labor to 0.35, while decreasing the other coefficients. The sum of coefficients is near 1 for LSOs, while it is still larger than 1 for family farms. These results indicate that there may exist more than one frontier and that family farms display increasing returns to scale, while LSOs display constant returns to scale.

However, as pointed out by Brada and King (1993), the different coefficients thus estimated may well reflect differences in input use, rather than differences in production technology. Pooling tests based on asymptotic likelihood comparing restricted and unrestricted specifications confirm that data for family farms and partnerships on the one hand and LSOs on the other hand can be pooled.[8] We thus share the view of Brada and King and have calculated the efficiency measures based on a restricted specification. Nevertheless, because the sample is dominated by family farms and partnerships (32 of the 44 observations), estimations will be biased towards family farms and partnerships, such that the efficiency measures for LSOs is likely to be underestimated. We will therefore use non-parametric calculations in the next section to improve the measurement of technical efficiency and to calculate scale efficiency.

IV. ESTIMATING TECHNICAL AND SCALE EFFICIENCY USING NON-PARAMETRIC METHODS

[8] A test for pooling data involves the estimation of a restricted (no intercept and slope dummies) and an unrestricted production function and the calculation of the log-likelihood ratios of each specification. The significance of the difference between the log-likelihood ratios can then be evaluated using the χ^2-distribution. The χ^2 statistics for introducing individual slope variables (5.24 for land, 3.86 for labor, 4.20 for capital and 4.30 for the intercept) all lie between the critical χ^2 values at the 95 and 99 percent confidence levels (3.84 and 6.63, respectively).

A non-parametric test is not a statistical test, but checks a set of inequalities which guarantee the existence of a production function that can rationalize a set of data in the context of the hypothesis of some behavioral goal (in general, profit maximization or cost minimization). It compares observed production behaviour with the situation that satisfies the producer's behavioral goal. The comparison can be made both in terms of quantities (inputs and outputs) and values (revenue, profit and cost).

Methodology

As in Färe, Grosskopf and Lovell (1985), we assume that production is characterized by a non-parametric piecewise-linear technology, so that simple linear programming techniques can be used. We further assume strong disposability of outputs and inputs. Estimating the non-parametric deterministic frontier, expressed in terms of minimizing input requirements, allows to calculate both a measure of pure technical efficiency given scale (E_p) – that is, the non-parametric Farrell measure of technical efficiency[9] – and of scale efficiency (E_s). We use Färe, Grosskopf and Lovell's definition of scale efficiency: an input-output combination is scale efficient if it corresponds to the combination that would arise from a zero profit long-run competitive equilibrium situation.

An input efficiency measure refers to the maximum possible proportional reduction in all inputs. Total input efficiency can be estimated by solving the following linear program for each activity k allowing only for constant returns to scale:

$$(5) \qquad \begin{aligned} &\min_{\lambda,z} \lambda \\ \text{s.t.} \quad & z\,Y \geq Y_k \\ & z\,X \leq \lambda\,X_k \\ & z \geq 0 \end{aligned}$$

where Y_k denotes the output of activity k, X_k is a vector of inputs employed by activity k, and z is a vector of k intensities that characterizes each activity. To calculate the pure technical input efficiency measure the restriction that the sum of intensities be equal to one is added to the previous program to allow for constant and non-constant returns to scale:

[9] See Farrell (1957). This technique is also called "Data Envelopment Analysis" (DEA). Only radial measures of technical efficiency are calculated. One should keep in mind that such measures allow only for equiproportionate reduction of inputs or equiproportionate expansion of outputs.

(6) $$\min_{\lambda,z} \lambda$$
$$\text{s.t.} \quad zY \geq Y_k$$
$$zX \leq \lambda X_k$$
$$z \geq 0$$
$$\sum_{i=1}^{k} z_k = 1.$$

Scale efficiency can then be calculated by dividing total efficiency by pure technical efficiency, $E_s = E_t/E_p$. Finally, to identify the source of scale inefficiency the star-technical efficiency (E_P^*) is calculated for the scale inefficient activities using the following linear program that only allows for non-increasing returns to scale:

(7) $$\min_{\lambda,z} \lambda$$
$$\text{s.t.} \quad zY \geq Y_k$$
$$zX \leq \lambda X_k$$
$$z \geq 0$$
$$\sum_{i=1}^{k} z_k \leq 1.$$

An activity exhibits increasing returns to scale if $E_P^* < E_p$ and decreasing returns to scale if $E_P^* = E_p$. Of course a scale efficient activity by definition exhibits constant returns to scale.

Results

To allow for comparison with the parametric calculations, the non-parametric efficiency measure for each observation is calculated using the whole data set rather than the observations of the same year. The results are summarized in table 4. Note that a comparison of parametric and non-parametric efficiency measures can only be done in relative terms since the reference point differs for both approaches: the best-practice frontier is defined differently for the Cobb-Douglas specification than for the non-parametric method.

Contrary to the parametric estimations, there is not much difference in technical efficiency between family farms (97.7), LSOs (97.6), and partnerships (97.3) in crop production. However, family farms are considerably inferior in terms of scale efficiency (82.1), compared to LSOs (93.2) and especially partnerships (99.9). As a result, the low levels of total efficiency of family farms are due to their high levels of scale inefficiency. The source of this inefficiency are increasing returns to scale, that is, family farms are too small. Also LSOs specialized in crops are scale inefficient, but this time due to decreasing returns to scale: they are too large. In livestock production, partnerships (99.1) outperform both family farms and LSOs. Family farms (94.9) display higher levels of technical efficiency than LSOs (91.9), but again, family farms suffer from scale inefficiency (86.4) because they are too small. Partnerships and LSOs have equal scale efficiency in livestock production. Livestock farms are in general more scale efficient than crop farms. Also, the difference in technical efficiency between family farms and partnerships on the one hand and LSOs on the other hand is more important for livestock farms than it is for crop farms.

There are important changes in technical efficiency measures during transition. Technical efficiency decreases in family farms, both in crop and livestock production. However, the decrease is largest in livestock production. The results are different for partnerships and LSOs. Partnerships specialized in crop production show a decrease in technical efficiency, while livestock farms remain the same. LSOs show an increase in technical efficiency, which is larger for livestock production than for crop production. Before interpreting these results, we test whether the observed differences, both between different production organizations and during transition, are significant.

V. THE IMPACT OF PRODUCTION ORGANIZATION ON EFFICIENCY

To test whether the differences in efficiency are significant, we use the parametric and non-parametric results in a multiple regression analysis. For this, we applied a logistic transformation on the efficiency data, i.e. for each activity k, the total, technical and scale efficiency measure, e_k, is transformed into

(8) $$E_k = \ln [1/(1-e_k)].$$ [10]

We then estimated the following equation for each efficiency measure

[10] When a measure was equal to one, it was replaced by the value 0.9999.

(9) $E_k = b_o + b_1$ LSO + b_2 PARTNERSHIP + b_3 TREND + b_4 TREND*LSO

where LSO is a dummy equal to 1 for LSOs and 0 otherwise, PARTNERSHIP is a dummy equal to 1 for partnerships and 0 otherwise, TREND assumes the values 0, 1, 2 and 3 for the respective years and TREND*LSO is an interaction term indicating how the estimation for LSO changes in time. The interaction term TREND*PARTNERSHIP was found to be statistically insignificant.

The results of these four estimations are summarized in table 5. The following conclusions can be drawn.

- Partnerships and family farms display higher technical efficiency than LSOs, but technical efficiency significantly decreases during transition for family farms and partnerships, while it significantly increases for LSOs.

- Both LSOs and partnerships display significantly higher levels of scale efficiency than family farms, while there seems to be no statistically significant time trend in scale efficiency.

- Total efficiency is significantly higher for partnerships than family farms and LSOs. There is no statistically significant difference in total efficiency between family farms and LSOs.

- The non-parametric measures of technical efficiency were higher on average, and showed less difference between organizations, than the parametric measures of technical efficiency.

VI. DISCUSSION AND HYPOTHESES

Technical efficiency

Our analysis supports the hypothesis that family farms and partnerships (mostly working with family labor) have an advantage in agricultural production because of lower labor transaction costs. This is reflected (a) in higher technical efficiency of both partnerships and family farms vis-à-vis LSOs, and (b) in the fact that the difference in technical efficiency is especially important in livestock production. Livestock production is more labor intensive and therefore more affected by labor effort problems.

However, our analysis also indicated that the differences in technical efficiency between LSOs on the one hand and family farms and partnerships on the other hand are smaller than would be expected based on theories that explain the "optimality of the family farm" because of transaction costs in labor contracting Schmitt (1991, 1993). Moreover, the difference in average technical efficiency declined substantially when transition progressed and farms restructured, and was insignificant by 1995/96. The change in technical efficiency during transition is negative for family farms and partnerships and positive for LSOs. These changes are due to the restructuring of East German agriculture during transition, and partly to the statistical phenomenon of using averages.

Following the privatization and transformation legislation, most members of large-scale LPGs either stayed in an LSO or established a *de novo* family farm or partnership. Since we measure the average technical efficiency of each type of farm, the dynamics of the restructuring changes the technical efficiency of both LSOs and family farms. Several LSOs were liquidated during transition, and in the first place those LSOs with the worst performance, either because individual farmers were more likely to leave the worst performing LSOs or simply because they went bankrupt. This liquidation process by itself improved the *average* efficiency of the remaining LSO. In combination with improved management, forced by changing constraints and incentives, and organizational restructuring of the remaining LSOs, the average efficiency of the LSOs increased.

More generally, this observation of declining differences in technical efficiency is consistent with Mathijs and Swinnen's (1996) model of farm restructuring in Central Europe. In their model, the establishment of family farms is driven by individuals who decide to leave the LSO if they can improve their income by starting up a family farm. The first group of individuals to leave the LSO is the group with the highest outside over inside labor productivity ratio (OIPR), defined as the ratio of the average labor productivity of a family farm started up by an individual over the average labor productivity of the LSO. The initial difference in labor productivity between LSOs and family farms is largest in the beginning of transition. The group of individuals who leave the LSO in a second phase are those with the second highest OIPR (which is the highest OIPR left in the LSO in the second phase). When they leave the

LSO and start up a family farm, the average labor productivity of family farms decreases and the difference in average labor productivity between LSOs and family farms declines.

Scale and total efficiency

The analysis shows that both LSOs and partnerships have considerably higher scale economies than family farms in both livestock and crop production. Total efficiency of LSOs is even higher than that of family farms because the lower technical efficiency is more than offset by higher scale efficiency. Partnerships turn out to be the most efficient production organizations because they combine the advantages of low transaction costs with family labor and low hired labor input with optimal scale economies. Both parametric and non-parametric calculations support this conclusion.

It should be emphasized that the efficiency differences with LSOs are considerably smaller than the literature typically assumes and has predicted, and that the difference is further declining during transition. While further research is required to provide a conclusive answer, our analysis suggests that the main reason for the pre-reform inefficiency of the collective farms was the socialized economic environment, rather than the intrinsic problems of large-scale farming. This preliminary conclusion provides support for the hypothesis of Johnson and Putterman, who argued that it is the environment which determines the relative performance of organizations – an hypothesis which was proven by Brada and King for Polish agriculture in 1960-74. Future research based on farm level data should also analyze whether differences in efficiency exist between cooperatives and joint stock companies within the LSO group.

Parametric versus non-parametric calculations

Finally, to what extent differ our conclusions based on whether a parametric or non-parametric estimation technique was used? The non-parametric Farrell measures of technical efficiency were higher on average, and showed less difference between organizations, then the parametric Timmer measures of technical efficiency. This is because of two reasons. First, the parametric method is sensitive to the distribution of the observations it tries to model. Since the parametric frontier takes a partnership as the most efficient observation, LSOs are found to be relatively more inefficient than in reality. This explains why the parametrically estimated differences in technical efficiency between family farms, partnerships and LSOs are larger than those estimated by a non-parametric technique, where technical efficiency is not compared with a single fixed observation, but rather with more efficient observations with comparable input mix. Second, the non-parametric procedure forms the convex hull of the observations, such that the non-parametric frontier closer embraces the data than the parametric frontier.

In summary, because parametric estimation of efficiency measures requires the *a priori* specification of a functional form and because it does not allow to decompose efficiency into scale and technical efficiency, non-parametric calculation of efficiency measures are preferable.

VII. CONCLUSION

In this paper we have estimated a stochastic and deterministic production frontier and we have used non-parametric techniques to calculate the technical and scale efficiency of family farms, partnerships and the large-scale successor organizations (LSOs) of the East German collective farms (LPGs). Our results indicate that LSOs display lower levels of technical efficiency than partnerships and family farms. Although this confirms the thesis that family farms and partnerships deal better with the agency-managerial problems that arise as a result of the difficult metering of effort in agricultural production than LSOs, the difference in technical efficiency is small and declining in time. Moreover, family farms are scale inefficient compared to both partnerships and LSOs, because they are still too small to exhaust all scale economies. Farms organized as partnerships are superior to all other organizational forms regardless of the measuring technique used.

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Table 1: Average farm size in hectares agricultural land and share in total agricultural land of different organizations in East Germany, 1992-1995

		1992	1993	1994	1995
Sole proprietorships	average size share	46 ha 13 %	45 ha 18 %	48 ha 20 %	46 ha 21 %
Partnerships	average size share	626 ha 14 %	511 ha 18 %	469 ha 21 %	449 ha 22 %
Cooperatives	average size share	1,537 ha 44 %	1,265 ha 39 %	1,218 ha 36 %	1,164 ha 34 %
Companies	average size share	1,006 ha 29 %	892 ha 26 %	823 ha 24 %	772 ha 23 %

Source: Beckmann and Hagedorn (1997)

Table 2: Descriptive statistics of enterprise data in the sample (average of 1991/92-1994/95)

	Output thousand DM	Land ha	Labor units	Capital thousand DM
Family farms				
Crops	370	199	2.10	431
Livestock	214	81	1.87	429
Partnerships				
Crops	1,101	534	4.94	931
Livestock	728	250	4.56	998
LSOs				
Crops	5,085	2,073	45.99	4,601
Livestock	5,542	1,566	59.86	5,790

Source: Own calculations based on Agrarbericht (1996)

Table 3: Parametric frontier estimation with ln(Y) as dependent variable

	Stochastic frontier		Deterministic frontier			
			With time dummies		Without time dummies	
Intercept	1.04	(0.6)	1.46	(1.7)*	2.81	(2.8)***
Time dummies						
$T_{92/93}$	–0.19	(–5.2)***	–0.12	(–3.4)***		
$T_{93/94}$	–0.22	(–6.2)***	–0.16	(–4.3)***		
$T_{94/95}$	–0.24	(–5.9)***	–0.17	(–4.6)***		
Inputs						
ln(LAND)	0.67	(19.4)***	0.62	(16.5)***	0.63	(13.2)***
ln(LABOR)	–0.12	(–1.2)	-0.07	(–1.4)	0.02	(0.3)
ln(CAPITAL)	0.66	(5.0)***	0.63	(8.6)***	0.51	(5.9)***
Sum of coefficients	1.21		1.18		1.16	
Adjusted R^2	-		0.997		0.995	
Nr. of observations	44		44		44	

t-values in parentheses; statistical significance is indicated at the *** 1, ** 5 and * 10 percent level.

Table 4: Parametric and non-parametric efficiency measures

	Parametric frontier	Non-parametric frontier		
		Total efficiency	Technical efficiency	Scale efficiency
Four year average				
Family farms				
Crops	79.5	80.2	97.7	82.1
Livestock	81.9	82.0	94.9	86.4
Partnerships				
Crops	84.0	97.2	97.3	99.9
Livestock	87.6	99.0	99.1	99.9
LSOs				
Crops	69.4	91.0	97.6	93.2
Livestock	79.7	91.8	91.9	99.9
Last - first year				
Family farms				
Crops	–9.1	–1.7	–2.2	+0.1
Livestock	–20.1	–5.2	–6.6	+0.6
Partnerships				
Crops	–5.2	–3.2	–3.1	–0.1
Livestock	–21.1	–0.1	0.0	–0.1
LSOs				
Crops	–0.4	–0.6	+3.1	–3.6
Livestock	+2.4	+7.6	+7.7	–0.1

Source: Own calculations

Table 5: Regression on total, technical and scale efficiency

	Parametric	Non-parametric		
	technical efficiency	**total efficiency**	**technical efficiency**	**scale efficiency**
Intercept	2.33 (6.9)***	2.22 (3.9)***	6.51 (8.4)***	1.97 (4.0)***
LSO	-0.45 (-0.7)	1.35 (1.3)	-2.98 (-2.1)**	4.21 (4.6)***
PARTNERSHIP	1.20 (2.7)**	4.74 (6.4)***	2.39 (2.4)**	6.19 (9.6)***
TREND	-0.51 (-2.99)***	-0.47 (-1.6)	-1.32 (-3.4)***	-0.18 (-0.7)
TREND*LSO	0.32 (1.0)	0.53 (1.0)	1.97 (2.6)**	-0.12 (-0.3)
Adjusted R^2	0.235	0.494	0.253	0.719
Nr. of observations	44	44	44	44

t-values in parentheses; statistical significance is indicated at the *** 1, ** 5 and * 10 percent level.