Technical efficiency and farm financial management in countries in transition

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Abstract

The paper employs Data Envelopment Analysis to estimate technical efficiency combined with bootstrapping to account for statistical variability. The smoothed homogenous bootstrap and the procedure proposed by Simar and Wilson (1998 and 2000) are applied. The impact of financial exposure on efficiency variations is analysed using a Tobit model. The potential endogeneity of the financial variable with efficiency is accounted for, first, by testing for exogeneity, following Smith and Blundell (1986), and second, by applying the estimator proposed by Amemiya (1978) in the cases when exogeneity cannot be accepted. The application is to 88 livestock and 256 crop farms in the Czech Republic. The results of DEA point estimates indicate that, overall, corporate farms in the Czech Republic are more technically efficient than individual farms. The construction of confidence intervals, however, shows mixed support for this finding. The analysis of the relationship between the financial exposure and technical efficiency shows that the application of an efficient estimator increased the standard errors in comparison to the standard Tobit estimation, but did not reveal substantial differences between the two management types, in the way that both seem exposed to high agency costs.

Keywords: DEA, bootstrapping, endogeneity, financial exposure, farms, Czech Republic

JEL Classification: D24, Q12

Efficacité technique et gestion financière des exploitations agricoles dans les pays en transition

Résumé

Le papier étudie les inefficacités dues au management et l'impact des décisions financières sur la performance des exploitations dans les pays en transition. La contribution de la gestion financière à la performance des exploitations agricoles est particulièrement intéressante à étudier, puisqu'il s'agit d'une nouvelle fonction pour tous les agriculteurs des pays d'Europe Centrale. L'efficacité technique est tout d'abord estimée, par la méthode Data Envelopment Analysis (DEA) en combinaison avec une procédure de bootstrapping afin de tenir compte de la variabilité statistique. Le bootstrap homogène et la procédure proposés par Simar et Wilson (1998 et 2000) sont appliqués. Puis l'impact des décisions financières est analysé par un modèle Tobit. L'endogénéité des variables financières est prise compte, tout d'abord en testant l'exogénéité avec le test de Smith et Blundell (1986), puis en utilisant l'estimateur proposé par Amemiya (1978) dans les cas où l'exogénéité ne peut pas être acceptée. Le cas des exploitations tchèques, individuelles et collectives, spécialisées en grandes cultures et en élevage, est donné comme exemple. Les résultats d'estimation par la DEA indiquent qu'en moyenne en République Tchèque les exploitations collectives sont plus techniquement efficaces que les exploitations individuelles, mais la construction des intervalles de confiance avec le bootstrapping ne confirme pas entièrement ces conclusions. Les résultats de l'étude de l'impact des variables d'endettement sur l'efficacité technique montrent que l'application d'un estimateur efficace augmente l'écart-type en comparaison avec l'estimation par un modèle Tobit standard, mais ne révèlent pas de différences substantielles entre les exploitations individuelles d'un côté et collectives de l'autre. Les deux types d'exploitations semblent avoir à leur charge les coûts du principal (la banque) provenant de l'information imparfaite et du contrôle. Cela suggère de mettre l'accent en terme politique sur les facteurs qui peuvent réduire l'asymétrie d'information, afin de permettre une utilisation des dettes qui favorise une meilleure allocation des ressources.

Mots-clés : exploitations agricoles, efficacité, décisions financières, République Tchèque

Classification JEL : D24, Q12

Technical efficiency and farm financial management in countries in transition

"Financial structure must be taken into account in an analysis of efficiency in agricultural production."

(Whittaker and Morehart, *Agricultural Finance Review*, 1991, p 95)

1. Introduction

The paper measures the technical efficiency of farms emerging during the transition to a market economy in Central Europe. It accounts for the statistical variability of the point estimates of technical efficiency and employs bootstrapping to determine the variability of Data Envelopment Analysis (DEA) efficiency estimates. Recently Brümmer (2001) and Latruffe *et al*. (2004) considered the statistical variability in estimating technical efficiency of farms in transition countries. Latruffe *et al*. suggest that any DEA study should employ bootstrapping as standard practice, providing the sample sizes are not so large as to make it impractical.

The contribution of financial management to farm performance is particularly interesting, as this function is new for all farm managers in the countries in Central Europe. Owing to insufficient expertise, it could be assumed that financial decision-making might create inefficiencies. Relatively little general research has been done on the empirical testing of the relationship between technical efficiency and farm financial exposure (Nasr, Barry and Ellinger, 1998; Shankar *et al*., 2001) and this relationship has not been studied at all for farms in transition countries. Moreover, none of the above studies has been concerned with the potential endogeneity of the financial variable with the efficiency score. In this paper, the endogeneity is accounted for, first, by testing for exogeneity of the financial variable in a Tobit model, following Smith and Blundell (1986), and second, by applying the estimator proposed by Amemiya (1978) in the cases when exogeneity cannot be accepted.

The Czech Republic is employed as a case study country. After more than a decade of transition in the Czech Republic, questions about whether or not one organisational farm type, namely individual farms, are more efficient than other types, such as corporate structures, are still topical (for a summary of the debate see Gorton and Davidova, 2004). Moreover, there is no clear-cut evidence about whether or not the corporate farms – the successor organisations of the former state and collective farms – and the *de novo* individual farms operate under the same budget constraints.

There exist several previous studies analysing the productivity and efficiency of the Czech farms during transition (Mathijs, Blaas and Doucha, 1999; Hughes, 2000; Curtiss, 2002; Davidova *et al*., 2003). Some studies emphasise that one of the main problems of the Czech farms, particularly the corporate ones, is the high levels of debt (see, for example, Davidova *et al*., 2003). Revoltella (2001) identifies a positive relation between firm size and the stock of debt for Czech enterprises and raises the question of whether this is a result of past policies of resource allocation favouring larger units, or a reflection of the age of the firm. Therefore, there is an important issue about firms' indebtedness in the Czech context.

The paper is structured as follows. The next section summarises the theoretical and empirical approaches to the relationship between technical efficiency and financial exposure, and provides a background to the specificities of debt structure of the post-reform Czech farms. The second section explains the methodology employed and the third section describes the database. The fourth section summarises the empirical results. The last section concludes.

2. Theoretical and empirical approaches to the relationship of farm financial exposure and technical efficiency

Different theoretical frameworks lead to different hypotheses about the relationship between farms' financial exposure and technical efficiency. At the theoretical level, three main approaches have been employed in various studies (Nasr, Barry and Ellinger, 1998; Shankar *et al*., 2001), namely, agency theory; free cash flow; and credit evaluation. The agency theory approach emphasises the costs of monitoring the borrowers by lenders, costs that might be transferred to borrowers. As a result, higher indebted borrowers are also high cost, thus less efficient. The free cash flow approach originates from Jensen (1986). Relating the free cash flow concept to the agency costs in the corporate sector, the author formulates the 'control hypothesis' or the 'benefits of debt' as a motivating force for managers/firms to become more efficient. The third main approach, the credit evaluation approach, expects banks to prefer borrowers who are low risk, thus more technically efficient.

A few studies focus on the relationship between financial exposure and technical efficiency during some critical stages of farm adjustment to new economic conditions. For transition economies, Sotnikov (1998) hypothesises a negative relationship between financial exposure and technical efficiency, as highly indebted farmers may not have access to credit for working capital and, consequently, cannot apply the necessary technological processes on time. This is consistent with the study of transition of New Zealand farms from a state of higher protection to more market exposure (Paul, Johnston and Frengley, 2000). According to the authors' adjustment hypothesis, farmers with lower financial exposure would adjust more easily to the change and would therefore be more efficient.

The hypotheses derived by the three main theoretical approaches, mentioned above, have been tested by Nasr, Barry and Ellinger (1998) and Shankar *et al*. (2001). Nasr, Barry and Ellinger use a non-parametric frontier to estimate the efficiency of Illinois grain farms from 1988 through 1994, and a Tobit model to explain the variations in efficiency scores. They did not find a significant relationship between the debt to assets ratio and efficiency scores. During the second estimation, when the authors excluded the farmer's age variable, included year dummies and replaced the debt to assets ratio with the current debt to assets ratio, they found a positive relationship supporting Jensen's (1986) free cash flow concept. Shankar *et al*., using the stochastic frontier approach in an application to a panel of dairy farms in England and Wales over the period 1984-1997, found that an increase in various debt ratios decreased the level of efficiency. Therefore, their findings did not support the free cash flow hypothesis but were consistent with the agency costs and adjustment hypotheses, although they acknowledged that the latter might be less adequate for English farms as they have not had to adjust to such dramatic policy changes as the New Zealand farms.

Other empirical approaches must also be mentioned. Färe, Grosskopf and Lee (1990) use a non-parametric approach to construct expenditure constrained and unconstrained profit function for 82 Californian rice farms. They examine two types of profit losses, first, those resulting from expenditure constraint (financial inefficiency) and, second, those generated by the inability to achieve the maximum potential profit given the actual expenditure. When the actual efficiency was estimated across expenditure constrained and unconstrained farms, the conclusion was that financially constrained farms performed better, explained by possible overcapacity in the unconstrained group. Weersink, Turney and Godah (1990) found a negative relationship between the debt to assets ratio and total technical efficiency in a regression employing 23 variables to explain technical efficiency of dairy farms in Ontario. They argue that a high ratio may be related to overcapitalisation and that the higher level of debt may constrain a farmer's allocation decisions and, thus, negatively affect efficiency.

The situation in the Czech Republic is specific from the point of view of the so-called ‘transformation debts’ inherited by some of the successors of the former state and collective farms. In general, corporate farms have more liabilities than individual farms. However, a high proportion of these debts stems from the reform process itself. The producer co-operatives have non-bank long-term liabilities to the owners of co-operative assets who received shares during the land reform process but decided not to farm individually and to leave their land and their shares of non-land assets within the new co-operatives. The limited liability companies are indebted to the state as they acquired assets from the former state farms. The outstanding reform debts impede the further access of corporate farms to commercial loans and thus the further use of debt. However, the co-operatives did not begin to pay back their debts to asset owners until 2000 and the limited liability companies pay very little interest on their loans from the state, so they exhibit low financial stress (Davidova *et al*., 2003). This is not the case of the *de novo* individual farms and some joint stock companies created post-reform as they have to pay their debts to the commercial lenders on tight schedules. This specific situation of farms in transition countries gives grounds for proposing that the relationship between the financial exposure and technical efficiency might be different for the corporate farms, on the one side, and *de novo* individual farms, on the other.

3. Methodology

3.1. Efficiency measurement

DEA is used for estimating technical efficiency in combination with bootstrapping to account for statistical variability. DEA constructs a non-parametric frontier over data points, so that the observations lie on or below the frontier (for more details see Charnes, Cooper and Rhodes, 1978; Färe, Grosskopf and Lovell, 1994; Thiele and Brodersen, 1999). DEA is a deterministic method and makes no assumptions about the distribution of the underlying data. Deviation from an estimated frontier is interpreted purely as inefficiency. The total efficiency score (estimated under constant returns to scale) can be decomposed into a pure technical efficiency score (estimated under variable constant returns to scale) that relates to management practices, and a scale efficiency score (the residual).

The study employs an input oriented single-output multi-input farm level model using Farm Accountancy Data Network (FADN) data. Total output in value is used as the single output variable. Four inputs are included: utilised agricultural area (UAA) in hectares (ha) as a land factor; annual work units (AWU) as a labour factor; depreciation plus interest as a capital factor; and the value of intermediate consumption as a variable input factor. Value units are expressed in Czech Koruna (CZK). Four frontiers are estimated, one for each specialisation, livestock and crop, and each management form, individual and corporate farms. The underlying assumption is that the production technology is different for different specialisations and legal forms. Mathijs, Blaas and Doucha (1999) also estimate a DEA frontier that is specific to each specialisation, but common to the organisational types.

The accuracy of DEA results may be affected by sampling variation. The impact of sampling noise on efficiency estimates is now receiving increasing attention within the DEA literature. Sampling variability may lead to input-oriented efficiency estimates biased towards higher scores (i.e. towards one) if the decision-making units (DMU) that determine the frontier are not contained in the sample (Brümmer, 2001). The robustness of DEA point estimates could be evaluated by construction of confidence intervals employing bootstrapping. The rationale of applying bootstrapping is that it enables an approximation to the true sampling distributions of any parameter of interest to be obtained (Brümmer, 2001). The bootstrapping procedure relies on simulating the sampling distribution by mimicking the data generating process (DGP), which in this case is the process of generating the efficiency scores. Simar and Wilson (1998) note the difficulty in providing an estimate of the bootstrap sampling distribution which is bounded by [0,1]. In order to smooth the empirical distribution, they propose a smoothed bootstrap. It is provided by a modified version of the Gaussian kernel density estimate, where the bandwidth parameter h determines the amount of smoothing that is applied to the data. In the present analysis, 95 per cent confidence intervals are constructed using bootstrapping. The smoothed homogenous bootstrap and the procedure proposed by Simar and Wilson (1998 and 2000) are applied, as presented in Appendix 1. The homogenous bootstrap approach is chosen, as it is assumed that the inefficiency distribution is independent over the sample. The bandwidth parameters are chosen according to the normal reference rule (Simar and Wilson, 2000) and 2,000 bootstrap iterations are performed.

3.2. Tobit model, exogeneity test and application of an efficient estimator

The study is focused on investigating management rather than scale inefficiencies. For this reason, the pure technical inefficiency score is chosen as the independent variable in the analysis of factors explaining the efficiency differences. Because the efficiency distribution is censored at one, the Tobit model is preferred (Chilingerian, 1995). Greene (1993) argues that it is more convenient to have data censored at zero and Chilingerian (1995) uses the inefficiency score as a dependent variable computed as follows: *inefficiency score = (1/efficiency score) – 1*. In this case, the inefficiency distribution is censored at zero. The same approach is followed in this study. A Tobit model is estimated for each of the four sub-samples (livestock/crop, individual/corporate).

Based on previous research of farm efficiency in developing and transition countries, a number of variables are considered to be possible in the explanation of the variations in farm efficiency scores.

(i) Financial variables: debt to assets ratio, showing the leverage of the farm, i.e., the long-term capital position; current ratio (current assets/current liabilities), indicating the liquidity of the farm, i.e., the farm's ability to convert assets into cash quickly and to meet its operational needs; a ratio of interest plus rentals to total output that is indicative of the financial stress of the farm caused by repayments of loans and rents.

(ii) Size variable: UAA for crop farms and livestock units for livestock farms[1].

(iii) Technology proxies: ratios of capital to labour and land to labour.

(iv) Integration in the factor markets: shares of hired labour in total labour input and of rented land in UAA. These shares are not included in the corporate farms' models as they are nearly 100 per cent for all observations.

(v) In addition to these continuous variables, four regional and two legal form dummies are used. The Czech Republic is divided into five large agri-environmental regions. Hughes (2000) labels these as maize, sugar beet, cereal, potato, and mountainous-forage with the maize region being the most favourable for farming and the mountainous-forage region the least. Regional dummies are employed as proxies for environment characteristics (DREG1, DREG2, DREG3 and DREG4) with region 5, mountainous-forage, used as a reference. For the corporate farms, the two dummies are DLTD for limited companies and DJSTOCK for joint stock companies, with co-operatives used as a reference group.

As the main interest is on the financial management of the farms and its implications for efficiency, the financial variables are of central importance. The main methodological

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[1] European Union FADN conversion coefficients are used to convert the average number of animals to livestock units according to the category of animal.

problem is the potential endogeneity in the sense that banks, for example, might lend mainly to efficient firms (credit evaluation approach). The test and estimation procedure followed in the study are explained below.

Tobit model specification

The Tobit model to estimate is defined by equations (1) and (2).

$$y_t = \begin{cases} y_t^* & \text{if } y_t^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

$$y_t^* = Y_t\beta + X_{et}\gamma + u = Z_t\delta + u \tag{2}$$

where y* denotes the dependent variable (inefficiency score), Y is the variable that is potentially endogenous (financial variable), X_e are the exogenous variables (listed previously in (ii) to (v)), β and γ are vectors of parameters to be estimated, u is an error term, Z = [Y,X_e], δ' = [β',γ'], the subscript *t* represents the values for the *t*-th observation.

Test of exogeneity of Y

Smith and Blundell (1986) propose a test for exogeneity of an explanatory variable in a Tobit model. Their method follows two steps. In the first step, the endogenous variable is estimated with ordinary least squares over a set of instruments and the exogenous variables of the Tobit model, as defined in (3).

$$Y_t = X_{it}\Pi_i + X_{et}\Pi_e + V_t = X_t\Pi + V_t \tag{3}$$

where X_i denotes additional exogenous variables (instruments), Π_i and Π_e are vectors of parameters to be estimated, V is an error term, X = [X_i,X_e], Π' = [Π_i',Π_e'].

In the second step, the predicted residual from (3), $\hat{V}$, is included as an additional explanatory variable in (2). Thus, the following Tobit model is estimated:

$$y_t = \begin{cases} y_t^* & \text{if } y_t^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

$$y_t^* = Y_t\beta + X_{et}\gamma + \hat{V}_t\rho + \varepsilon_t \tag{4}$$

where $\hat{V}_t = Y_t - X_t\hat{\Pi}$ with $\hat{\Pi}$ the least squares estimator of Π, ρ is a parameter to be estimated, ε is an error term.

The exogeneity test is used to test the following null hypothesis:

H_0: exogeneity of Y

$\Leftrightarrow$ H_0: $\hat{V}$ has no explanatory power

$\Leftrightarrow$ H_0: $\rho = 0$.

Thus, it is a test of the significance of the coefficient ρ. If H_0 is accepted, Y is exogenous and the standard Tobit model, defined by (1) and (2), is estimated. If H_0 is rejected, Y is endogenous and an alternative model for estimating the parameters of interest (vector δ) has to be used.

Efficient estimation of δ if exogeneity of Y is rejected

The estimator $\hat{\delta}$ used here is the estimator proposed by Amemiya (1978). Newey (1987) proved that this estimator is an efficient one. The method relies on applying the generalised least squares to the relationship between the Tobit model's structural parameters δ, given by (2), and its reduced form parameters α, given by (5) below:

$$y_t{}^* = X_t \alpha + v_t \tag{5}$$

or equivalently

$$y_t{}^* = X_t \alpha + \hat{V}_t \lambda + \psi_t \tag{6}$$

where α and λ are parameters to be estimated, ψ and v are error terms.

The structural parameters δ are, therefore, estimated by applying generalised least squares to the relationship defined by (7) below:

$$\hat{\alpha} = \hat{D}\delta + \eta \tag{7}$$

where $\hat{\alpha}$ is the maximum likelihood estimator of α from the Tobit model defined by (1) and (6), $\hat{D} = [\hat{\Pi}, I_e]$ with I_e such that $X_e = X\, I_e$ and $\hat{\Pi}$ the least squares estimator of Π from equation (3), η is an error term.

The detailed formula of the estimator $\hat{\delta}$, calculated with this method, and of its covariance matrix are given in Appendix 2.

Smith and Blundell's test of exogeneity is performed by using Baum's procedure written for STATA (Baum, 1999). The parameters δ are estimated with Amemiya's method. The STATA procedure set out by Harkness (2000) is used for the computation. The instruments (X_i) are chosen following Rajan and Zingales (1995). They use four variables as potential determinants of financial variables: a size variable, the natural logarithm of the revenues from sales; the tangibility of assets, calculated as a ratio of fixed to total assets; a current profitability variable, represented by returns to assets; and a proxy for growth opportunities, the market-to-book value.[2] In this study, the size proxy is the value of total output in natural logarithm. The ratio of fixed to total assets is included as farm tangibility. For the current profitability, a farm specific cost-revenue ratio is constructed. Revenue includes proceeds from sales of agricultural products including net current subsidies, the value of non-marketed output (usually substantial in transition economies), and the proceeds from other activities. Costs include labour, land, capital (depreciation and interest) and intermediate consumption. A variable for growth is not used in the model.

For all four sub-samples, three pairs of models are presented and discussed in turn. The only difference between them is in the type of the financial variable included: the debt to assets ratio, the current ratio and the financial stress ratio respectively. Each pair contains the standard Tobit estimation and the alternative estimation to account for endogeneity of the financial variable. In the model with the current ratio not all individual farms were included because 76 crop and 18 livestock farms did not have short-term liabilities and therefore the current ratio was not relevant.

4. Description of data

The study draws data from the 1999 Czech FADN dataset. The initial set included 1,087 farms. After checking for missing or inconsistent data the useable sample was reduced to 753 farms. From these 753 farms, two sub-samples are constructed depending on whether farms specialise in crop or livestock, defined here as farms for which at least 65 per cent of the value of total agricultural output comes from crop or livestock. The extracted livestock sub-sample contains 88 farms and the crop sub-sample, 256 farms. The farms are also split according to

[2] The hypotheses behind this are that the larger firms tend to be more profitable as well as less likely to go bankrupt; firms with greater tangibility have more collateral available; more profitable firms tend to rely less on debts since they generate larger earnings for self-finance; and the increase in growth opportunities leads to an increase in the agency costs of debt.

their management form into individual and corporate sub-samples. The individual farms are the most numerous group, 274 in all. They account for 86 per cent of the crop and 60 per cent of the livestock farms. The summary statistics of the variables of interest for the sample farms are presented in Table 1.

The sample farms are located in different agri-environmental regions. Within the sub-samples, no individual livestock farm is located in the maize region and no corporate crop farm in the mountainous-forage region. For this reason, in the Tobit models, region 4, potato, is used as a reference for the corporate crop farms instead of region 5, mountainous-forage.

<< Table 1 about here >>

5. Empirical results

5.1. Technical efficiency: comparison of point and interval estimates

DEA point estimates, presented in Table 2, reveal that, contrary to some theoretical expectations related to transaction costs, overall, corporate farms are more totally technically efficient than individual farms. This is consistent with Hughes' (2000) Total Factor Productivity (TFP) findings for the Czech Republic. The main efficiency differences between individual and corporate farms appear in livestock production, where the corporate farms are much more efficient (total technical efficiency scores 0.55 and 0.83 respectively). The differences in average efficiency estimates between the two farm types in crop production are small (average total technical efficiency scores of 0.67 for the individual crop farms and 0.69 for the corporate crop farms). By specialisation, among individual farms crop farms are on average more totally technically efficient (score of 0.67) than livestock farms (score of 0.55). Among corporate farms, the opposite is true (0.69 for crop farms and 0.83 for livestock farms). In terms of pure technical and scale efficiency the relations between the two specialisations are the same as in the case of the total technical efficiency.

<< Table 2 about here >>

The confidence intervals of the efficiency scores, constructed with bootstrapping, are wide (Table 3). This is particularly the case for the individual livestock farms, for which the width of intervals is on average 0.3. This finding proves a high statistical variability of the efficiency estimates and suggests that farms might be less efficient than estimated with DEA. Similarly wide intervals were found for a sample of farms in Poland (Latruffe *et al*., 2004). Both

Brümmer (2001) and Latruffe *et al*., found that the interval width varies considerably over the samples.

<< Table 3 about here >>

Table 4 reports the lower and upper bounds of the DEA total technical efficiency scores' confidence intervals as an average for each sub-sample. For example, individual livestock farms might be able to decrease the input use by 82 per cent (lower bound of 0.18), while the average reduction revealed by the point estimates is 45 per cent (mean efficiency of 0.55). However, the interval results appear to confirm the superiority of one or other specialisation indicated by the point estimates. It seems that amongst individual farms, crop farms are on average more total technically efficient than livestock farms, as the mean upper bound for the livestock farms (0.50) is strictly less than the mean lower bound for crop farms (0.51). The same reasoning can be applied to confirm the superiority of corporate livestock farms over the corporate crop farms. However, there is no clear-cut evidence about the superiority of corporate over individual farms as a whole. Whilst confirmed in the case of the livestock specialisation, it is subject to doubt for crop farms, as the lower and upper bounds of the individual and corporate crop farm sub-samples are fairly similar.

<< Table 4 about here >>

5.2. Factors accounting for technical efficiency variations

The results for the three pairs of models, including in turn the debt to assets ratio, the current ratio and the financial stress ratio, are presented in Table 5. As the dependent variable is the inefficiency score, the parameters with negative signs indicate sources of efficiency and *vice versa*.

In Table 5, Model 1, exogeneity of debt to assets variable was rejected for crop farms, both individual and corporate. Correcting for endogeneity by applying Amemiya's (1978) estimator increased the standard errors and revealed a statistically significant relationship with inefficiency scores for corporate crop farms (Table 5, Model 1), which was not present when the standard Tobit was applied (Table 5, Model 1a). Overall, the debt to assets ratio is negatively related to technical efficiency, with statistical significance for individual livestock and corporate crop farms at the 10 per cent level, and for corporate livestock farms at the 1 per cent level. A significant negative relationship with technical efficiency was also detected when financial stress was used as a financial variable (Table 5, Model 3), with the strongest relationship for the individual crop farms (significant at the 1 per cent level). In the three cases when exogeneity of the financial variable was rejected, the use of an efficient estimator helped to assess the significance of the financial stress as an explanatory factor of efficiency, which was not present when the standard Tobit estimation was applied (Table 5, Model 3a).

The above results do not support the credit evaluation hypothesis.[3] They support the agency costs and adjustment hypotheses. It is argued that the latter is more relevant to the Czech context where dramatic policy changes have taken place during the transition to a market economy. Despite the preliminary expectations, so far the estimation results do not indicate any differences in the direction of the relationship between farm capital structure and efficiency scores for individual farms, on the one hand, and for corporate, on the other. Such differences were detected when the effect of liquidity (current ratio) was analysed (Table 5, Model 2). When the efficient estimator was applied, the results show that the higher current ratio (thus more current assets in relation to current liabilities) is beneficial for the technical efficiency of individual farms, whilst the lower the ratio (thus more current debt available in respect to current assets) has a positive effect on the technical efficiency of the corporate crop farms (no significant relationship for the corporate livestock farms). In the case of the corporate crop farms, the results support the cash flow concept. The negative implications of the current liabilities on the efficiency of individual farms of both specialisation could be explained by the agency costs theory, proposing that these agency costs are much higher for the small and dispersed individual farms than for the co-operatives and other farm companies. Davidova and Latruffe (2003) also propose that in reality debt in individual farms is often used for non-productive purposes, which is another sign of the difficulties the new managers face with the management of financial resources.

The results for other groups of variables show that the increase in size (measured in livestock units) is positively related to the efficiency score for the individual livestock farms (Table 5, Model 1). Due to the fact that these farms emerged after the start of the transition process, and that the factor markets in Central Europe are still underdeveloped, they might not yet have managed to reach an efficient size. The availability of land per unit of labour has also a positive impact on efficiency of all types of individual and corporate farms (at different levels of significance for different sub-samples). The effects of the other technology proxy and the

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[3] As Nasr, Barry and Ellinger (1998) note, whilst the relationship between the current debt to assets ratio and technical efficiency is a test of the free cash flow concept, the relation between total debt to assets ratio and efficiency scores is more indicative of the credit evaluation concept.

variables used to indicate integration in the factor markets are either negative or insignificant. Location in the regions with better agri-environmental conditions for farming has a positive effect on the efficiency of individual crop and corporate livestock farms. In Models 2 and 3 in Table 5 there are some differences in the sign of the coefficients and the significance of the relationship in comparison to Model 1. However, in all three models size is an important variable for increasing the technical efficiency of the individual livestock farms.

<< Table 5 about here >>

6. Conclusions

The paper measures the technical efficiency of farms emerging during transition to a market economy in the Czech Republic. It accounts for the statistical variability of the point estimates of technical efficiency and employs bootstrapping to determine the variability of DEA efficiency estimates. The analysis of the factors that may explain the variability in efficiency focuses on the contribution of financial management to farm performance.

The results of DEA point estimates indicate that, overall, corporate farms in the Czech Republic are more technically efficient than individual farms. The construction of confidence intervals, however, shows mixed support for the efficiency superiority of corporate farms. Whilst the livestock corporate farms continue to be more efficient when the statistical variability is accounted for, the evidence for the crop farms is not conclusive. This supports Latruffe *et al*.'s (2004) conclusion that, if possible, bootstrapping should routinely be used with DEA estimates in order to avoid reaching misleading conclusions.

The analysis of the relationship between the financial exposure and technical efficiency requires cautious treatment, as exogeneity of the financial variable with the efficiency scores cannot always be confirmed. In the present analysis, exogeneity was rejected for individual and corporate crop farms in the model employing debt to assets as a financial variable (Model 1), for individual farms of both specialisation when the current ratio was used (Model 2) and for individual crop and livestock, and corporate crop farms when the financial stress was included in the model (Model 3). The application of an efficient estimator increased the standard errors in comparison to the standard Tobit estimation. The corrected estimations help assess the importance of financial variables as potential explanatory factors for efficiency. For example, testing for exogeneity might help explain the failure of Nasr, Barry and Ellinger (1998) to detect any impact of the debt to assets ratio on efficiency.

With regard to Czech farm structures, although the indebtedness of the corporate farms has been high on the political agenda in the Czech Republic, particularly in view of the viability of these farms in an enlarged Union, the analysis did not detect substantial differences in the relationship of the financial exposure to technical efficiency between the two management types. Both seem exposed to high agency costs. Therefore, factors that can decrease information asymmetry, which is one fundamental reason for the high agency costs, might prove to be beneficial for the use of debt in the direction of better resource allocation.

Appendix 1: Bootstrap procedure

(i) With the smoothed bootstrap, an estimate of the original DEA efficiency scores (denoted as $\hat{\theta}_i$ for the i-th farm) for i=1,…,N, is obtained, with N the number of farms in the sample. A random sample of the original size (N) is drawn from this smooth estimate, and is denoted $\theta_{i,b}*$ for i=1,…,N.

(ii) For i=1,…,N, a pseudo data set of $(x_{i,b}*, y_{i,b}*)$ is constructed, where y_i* is the original output level $y_{i,b}* = y_i$, and $x_{i,b}*$ is the constructed pseudo input level $x_{i,b}* = (\hat{\theta}_i/\theta_{i,b}*)x_i$, with y_i and x_i respectively the original output and input vectors of the *i*-th farm.

(iii) A new DEA efficiency score is calculated for each farm by taking the pseudo data as a reference, i.e. the following program is solved for i=1,…,N (constant returns to scale case):

$$\min_{\lambda,\hat{\theta}_{i,b}*} \quad \hat{\theta}_{i,b}* \tag{8}$$

$$\text{subject to} \qquad -y_i + Y_b*\lambda \geq 0$$

$$\hat{\theta}_{i,b}*x_i - X_b*\lambda \geq 0$$

$$\lambda \geq 0$$

where λ is a N$\times$1 vector of constants.

(In case of variable returns to scale, the constraint N1'λ = 1 is added, where N1 is a N×1 vector of ones.)

(iv) Steps (i) to (iii) are repeated B times to yield a set of B new DEA efficiency scores $\hat{\theta}_{i,b}*$ for b=1,…,B and i=1,…,N.

From this procedure the construction of confidence intervals can be based on bootstrap percentiles (Simar and Wilson, 1998). However, the DEA estimators need to be corrected for bias and this introduces additional noise (Simar and Wilson, 2000). Simar and Wilson (2000) propose a procedure that automatically corrects for bias. For a $(1-\alpha)$ per cent confidence interval, it starts from the following probability:

$$\Pr(-a_\alpha \leq \hat{\theta}_i - \theta_i \leq -b_\alpha) = 1 - \alpha \tag{9}$$

where θ_i denotes the real efficiency score of the *i*-th farm.

Since the distribution $(\hat{\theta}_i - \theta_i)$ can be approximated by the distribution $(\hat{\theta}_i * - \hat{\theta}_i)$, a_α and b_α can be estimated with the following probability:

$$\Pr(-\hat{a}_\alpha \leq \hat{\theta}_i * - \hat{\theta}_i \leq -\hat{b}_\alpha) = 1 - \alpha . \tag{10}$$

Finding $\hat{a}_\alpha$ and $\hat{b}_\alpha$ involves sorting the values $(\hat{\theta}_{i,b} * - \hat{\theta}_i)$ for b=1,…,B in increasing order and then deleting the $(\alpha/2) \times 100$-percent of the elements at either end of the sorted list. $-\hat{a}_\alpha$ and $-\hat{b}_\alpha$ are equal to the end points of the truncated array, with $\hat{a}_\alpha \leq \hat{b}_\alpha$. Thus, the estimated $(1-\alpha)$ per cent confidence interval for the efficiency θ_i of the *i*-th farm is:

$$\hat{\theta}_i + \hat{a}_\alpha \leq \theta_i \leq \hat{\theta}_i + \hat{b}_\alpha . \tag{11}$$

Appendix 2: Alternative estimator in case of endogeneity

Amemiya's (1978) generalised least squares estimator $\hat{\delta}$ is given by the following formula (Newey, 1987):

$$\hat{\delta} = (\hat{D}'\hat{\Omega}^{-1}\hat{D})^{-1}\hat{D}'\hat{\Omega}^{-1}\hat{\alpha} \tag{12}$$

where

$$\hat{D} = [\hat{\Pi}, I_e]$$

with

I_e such that $X_e = X\, I_e$

$\hat{\Pi}$ the least squares estimator of Π from equation (3);

$$\hat{\Omega} = \left(\hat{J}^{-1}\right)_{\alpha\alpha} + \hat{\sigma}^2\left(\frac{X'X}{N}\right)^{-1} \tag{13}$$

with

$\left(\hat{J}^{-1}\right)_{\alpha\alpha}$ the standard covariance matrix of the maximum likelihood estimators of the Tobit model defined by (1) and (6),

N the number of observations,

$X = [X_i, X_e]$,

$$\hat{\sigma}^2 = \frac{1}{(N-K)}\sum_{t=1}^{n}\left[\hat{V}_t\left(\hat{\lambda}-\hat{\beta}\right)\right]^2, \tag{14}$$

K the dimension of X,

$\hat{V}_t$ the residual from the estimation of (3) ($\hat{V}_t = Y_t - X_t\hat{\Pi}$),

$\hat{\lambda}$ the estimator of λ obtained by applying maximum likelihood to the Tobit model defined by (1) and (6),

$\hat{\beta}$ the estimator of β obtained by applying maximum likelihood to the Tobit model defined by (1) and (4);

$\hat{\alpha}$ is the estimator of the reduced form parameters α obtained by applying maximum likelihood to the Tobit model defined by (1) and (6).

The covariance matrix M is given by (Newey, 1987):

$$M = (\hat{D}'\hat{\Omega}^{-1}\hat{D})^{-1} \tag{15}$$

where

$\hat{D}$ and $\hat{\Omega}$ are defined above.

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Table 1: Summary statistics for the sample farms according to specialisation and organisational form

Variables	Mean	Standard deviation	Minimum value	Maximum value	Mean	Standard deviation	Minimum value	Maximum value
Individual farms	Livestock farms (53 farms)				Crop farms (221 farms)			
DEA model								
Total output (000 CZK)	3,750	5,506	226	25,784	2,807	4,438	114	33,076
Land (ha)	142	257	10	1,400	144	195	15	1,562
Labour (AWU)	4.68	7.03	0.92	40.95	3.20	4.47	0.07	35.00
Capital[a] (000 CZK)	570	818	20	4,798	462	855	3	6,190
Intermediate consumption (000 CZK)	2,937	4,829	201	30,427	1,972	2,855	141	22,789
Tobit model								
Debt to assets ratio	0.30	0.34	0	1.74	0.17	0.24	0	1.53
Current ratio	174.9	302.2	0.4	1,498.0	615.5	2,159.5	0.2	14,445.3
Financial stress ratio	0.032	0.039	0	0.201	0.054	0.071	0	0.490
Livestock Units	86.3	135.3	6.2	727.2	-	-	-	-
Capital[a] / Labour (000 CZK/AWU)	128	101	9	456	149	206	2	1563
Land / Labour (ha/AWU)	28	17	8	93	60	54	4	486
Share of hired labour (%)	24	34	0	100	21	31	0	97
Share of rented land (%)	65	33	0	100	68	30	0	100

Variables	Mean	Standard deviation	Minimum value	Maximum value	Mean	Standard deviation	Minimum value	Maximum value
Corporate farms	Livestock farms (35 farms)				Crop farms (35 farms)			
DEA model								
Total output (000 CZK)	43,727	30,262	6,948	127,951	43,313	34,132	3,652	131,928
Land (ha)	1,480	721	220	3,084	1,498	836	424	3,952
Labour (AWU)	78.87	54.63	12.00	253.00	60.59	38.17	13.00	140.23
Capital[a] (000 CZK)	6,063	4,159	1,336	19,186	5,623	3,742	821	14,953
Intermediate consumption (000 CZK)	31,998	19,296	4,073	73,892	26,088	17,562	4,928	73,454
Tobit model								
Debt to assets ratio	0.49	0.40	0.05	2.20	0.73	0.44	0.04	2.18
Current ratio	4.3	2.9	0.4	13.7	6.3	7.3	0.3	29.3
Financial stress ratio	0.040	0.043	0	0.197	0.034	0.028	0	0.117
Livestock Units	65.0	33.8	5.6	195.2	-	-	-	-
Capital[a] / Labour (000 CZK/AWU)	85	38	41	197	96	40	42	199
Land / Labour (ha/AWU)	23	13	4	67	29	16	12	70
Share of hired labour (%)	100	0	100	100	100	0	100	100
Share of rented land (%)	99	2	89	100	98	6	70	100

[a] Interest plus depreciation

Table 2: Descriptive statistics of technical efficiency

Farm specialisation and form		Mean	Standard deviation	Minimum	Share of farms with efficiency score of 1 (%)
		Total technical efficiency			
Individual	Livestock	0.55	0.16	0.29	3.8
	Crop	0.67	0.18	0.21	6.3
Corporate	Livestock	0.83	0.15	0.55	25.7
	Crop	0.69	0.22	0.34	8.6
		Pure technical efficiency			
Individual	Livestock	0.73	0.18	0.40	18.9
	Crop	0.76	0.19	0.21	18.1
Corporate	Livestock	0.90	0.12	0.57	37.1
	Crop	0.87	0.16	0.52	31.4
		Scale efficiency			
Individual	Livestock	0.77	0.17	0.35	3.8
	Crop	0.88	0.13	0.29	6.3
Corporate	Livestock	0.92	0.09	0.70	25.7
	Crop	0.80	0.20	0.35	8.6

Table 3: Width of efficiency estimates' confidence intervals

Farm specialisation and form		Width for total technical efficiency	Width for pure technical efficiency
Individual	Livestock	0.32	0.33
	Crop	0.14	0.19
Corporate	Livestock	0.15	0.18
	Crop	0.17	0.22

Table 4: Total technical efficiency estimate and confidence intervals bounds: means

Farm specialisation and form		Estimate	Lower bound	Upper bound
Individual	Livestock	0.55	0.18	0.50
	Crop	0.67	0.51	0.65
Corporate	Livestock	0.83	0.67	0.81
	Crop	0.69	0.49	0.66

Table 5: Determinants of pure technical inefficiency

Model 1: Alternative estimation correcting for endogeneity; financial variable-debt to assets ratio

	Individual farms		Corporate farms	
	Livestock	Crop	Livestock	Crop
Constant	0.45 **	3.58 ***	0.73 ***	-0.83 *
	(0.22)	(0.77)	(0.21)	(0.50)
Size variable [a]	-2.53 E-3***	0.33 E-3	-1.47 E-3	0.24 E-3 **
	(0.84 E-3)	(0.35 E-3)	(1.20 E-3)	(0.12 E-3)
Ratio capital/labour	2.26 E-3 ***	1.27 E-3	-1.37 E-3	0.73 E-3
	(0.59 E-3)	(0.83 E-3)	(1.05 E-3)	(2.09 E-3)
Ratio land/labour	-10.44 E-3 ***	-4.52 E-3 ***	-8.73 E-3 *	-12.94 E-3 *
	(4.15 E-3)	(1.66 E-3)	(4.78 E-3)	(7.98 E-3)
Share of hired labour	3.54 E-3 *	0.05 E-3	-	-
	(1.99 E-3)	(3.11 E-3)		
Share of rented land	4.20 E-3 **	8.57 E-3 **	-	-
	(2.01 E-3)	(3.74 E-3)		
Debt to assets ratio	0.31 *	-2.54	0.36 ***	0.80 *
	(0.19)	(1.68)	(0.10)	(0.49)
DLTD	-	-	-0.25 **	0.10
			(0.11)	(0.18)
DJSTOCK	-	-	-0.03	0.47
			(0.08)	(0.31)
DREG1	-	-3.73 ***	-0.38 **	0.35
		(0.90)	(0.16)	(0.50)
DREG2	-0.52 ***	-3.41 ***	-0.43 ***	0.33 *
	(0.18)	(0.82)	(0.13)	(0.21)
DREG3	-0.18	-3.31 ***	-0.38 ***	0.07
	(0.17)	(0.83)	(0.11)	(0.25)
DREG4	-0.25	-3.00 ***	-0.47 ***	-
	(0.19)	(0.82)	(0.13)	
H_0: exogeneity	accepted	rejected *	accepted	rejected **

*,**,*** : 10%, 5%, 1% significance. E-3: 10 power –3. Standard errors into brackets.

[a] UAA for crop farms, livestock units for livestock farms.

Model 1a: Standard Tobit estimation; financial variable-debt to assets ratio (Re-estimated models in comparison to Model 1 in italic)

	Individual farms		Corporate farms	
	Livestock	*Crop*	Livestock	*Crop*
Constant	0.45 **	*2.68 ****	0.73 ***	*-0.35*
	(0.22)	*(0.38)*	(0.21)	*(0.31)*
Size variable [a]	-2.53 E-3***	*0.11 E-3*	-1.47 E-3	*0.15 E-3 **
	(0.84 E-3)	*(0.26 E-3)*	(1.20 E-3)	*(0.09 E-3)*
Ratio capital/labour	2.26 E-3 ***	*0.16 E-3*	-1.37 E-3	*0.73 E-3*
	(0.59 E-3)	*(0.23 E-3)*	(1.05 E-3)	*(1.75 E-3)*
Ratio land/labour	-10.44 E-3 ***	*-3.01 E-3 ****	-8.73 E-3 *	*-8.21 E-3*
	(4.15 E-3)	*(1.02 E-3)*	(4.78 E-3)	*(6.13 E-3)*
Share of hired labour	3.54 E-3 *	*-3.65 E-3 ***	-	-
	(1.99 E-3)	*(1.57 E-3)*		
Share of rented land	4.20 E-3 **	*3.84 E-3 ****	-	-
	(2.01 E-3)	*(1.32 E-3)*		
Debt to assets ratio	0.31 *	*-0.09*	0.36 ***	*0.19*
	(0.19)	*(0.18)*	(0.10)	*(0.21)*
DLTD	-	-	-0.25 **	*0.19*
			(0.11)	*(0.24)*
DJSTOCK	-	-	-0.03	*0.16*
			(0.08)	*(0.19)*
DREG1	-	*-2.69 ****	-0.38 **	*0.24*
		(0.41)	(0.16)	*(0.41)*
DREG2	-0.52 ***	*-2.42 ****	-0.43 ***	*0.28*
	(0.18)	*(0.37)*	(0.13)	*(0.12)*
DREG3	-0.18	*-2.30 ****	-0.38 ***	*0.08*
	(0.17)	*(0.37)*	(0.11)	*(0.23)*
DREG4	-0.25	*-2.04 ****	-0.47 ***	-
	(0.19)	*(0.38)*	(0.13)	

*,**,*** : 10%, 5%, 1% significance. E-3: 10 power –3. Standard errors into brackets.

[a] UAA for crop farms, livestock units for livestock farms.

Model 2: Alternative estimation correcting for endogeneity; financial variable-current ratio

	Individual farms		Corporate farms	
	Livestock	Crop	Livestock	Crop
Constant	0.89 ***	2.95 *	0.89 ***	-0.20
	(0.33)	(1.70)	(0.25)	(0.21)
Size variable [a]	-2.31 E-3 ***	0.37 E-3	-0.55 E-3	0.11 E-3
	(0.62 E-3)	(0.87 E-3)	(1.37 E-3)	(0.08 E-3)
Ratio capital/labour	3.28 E-3 ***	-1.13 E-3	-2.19 E-3 *	-0.30 E-3
	(0.63 E-3)	(1.08 E-3)	(1.24 E-3)	(1.73 E-3)
Ratio land/labour	-4.92 E-3	-3.54 E-3	-12.41 E-3 **	-5.85 E-3
	(4.90 E-3)	(3.11 E-3)	(5.78 E-3)	(5.24 E-3)
Share of hired labour	-1.61 E-3	-7.74 E-3	-	-
	(2.28 E-3)	(5.91 E-3)		
Share of rented land	5.78 E-3 ***	6.48 E-3	-	-
	(2.17 E-3)	(5.06 E-3)		
Current ratio	-0.77 E-3 **	-0.68 E-3 *	12.16 E-3	15.70 E-3 *
	(0.37 E-3)	(0.40 E-3)	(14.05 E-3)	(9.02 E-3)
DLTD	-	-	-0.04	0.28 *
			(0.12)	(0.15)
DJSTOCK	-	-	-0.16 *	0.09
			(0.09)	(0.16)
DREG1	-	-1.58	-0.23	0.23
		(1.98)	(0.18)	(0.38)
DREG2	-0.86 ***	-2.26	-0.37 **	0.22
	(0.32)	(1.65)	(0.16)	(0.16)
DREG3	-0.58 **	-1.82	-0.32 **	0.10
	(0.30)	(1.69)	(0.13)	(0.21)
DREG4	-0.88 ***	-2.15	-0.44 ***	-
	(0.31)	(1.74)	(0.15)	
H_0: exogeneity	rejected *	rejected ***	accepted	accepted

*,**,*** : 10%, 5%, 1% significance. E-3: 10 power –3. Standard errors into brackets.

[a] UAA for crop farms, livestock units for livestock farms.

Model 2a: Standard Tobit estimation; financial variable-current ratio (Re-estimated models in comparison to Model 2 in italic)

	Individual farms		Corporate farms	
	Livestock	*Crop*	Livestock	Crop
Constant	*0.83 ****	*2.89 ****	0.89 ***	-0.20
	(0.31)	*(0.58)*	(0.25)	(0.21)
Size variable [a]	*-2.47 E-3 ****	*0.18 E-3*	-0.55 E-3	0.11 E-3
	(0.66 E-3)	*(0.32 E-3)*	(1.37 E-3)	(0.08 E-3)
Ratio capital/labour	*3.23 E-3 ****	*-0.18 E-3*	-2.19 E-3 *	-0.30 E-3
	(0.56 E-3)	*(0.32 E-3)*	(1.24 E-3)	(1.73 E-3)
Ratio land/labour	*-2.75 E-3*	*-3.40 E-3 ***	-12.41 E-3 **	-5.85 E-3
	(4.19 E-3)	*(1.42 E-3)*	(5.78 E-3)	(5.24 E-3)
Share of hired labour	*0.05 E-3*	*-5.01 E-3 ****	-	-
	(1.89 E-3)	*(2.01 E-3)*		
Share of rented land	*5.14 E-3 ****	*4.73 E-3 ****	-	-
	(1.90 E-3)	*(1.70 E-3)*		
Current ratio	*-0.28 E-3*	*-0.02 E-3*	12.16 E-3	15.70 E-3 *
	(0.18 E-3)	*(0.02 E-3)*	(14.05 E-3)	(9.02 E-3)
DLTD	-	-	-0.04	0.28 *
			(0.12)	(0.15)
DJSTOCK	-	-	-0.16 *	0.09
			(0.09)	(0.16)
DREG1	-	*-3.04 ****	-0.23	0.23
		(0.62)	(0.18)	(0.38)
DREG2	*-0.95 ****	*-2.60 ****	-0.37 **	0.22
	(0.30)	*(0.55)*	(0.16)	(0.16)
DREG3	*-0.67 ***	*-2.39 ****	-0.32 **	0.10
	(0.28)	*(0.56)*	(0.13)	(0.21)
DREG4	*-0.92 ****	*-2.23 ****	-0.44 ***	-
	(0.29)	*(0.59)*	(0.15)	

*,**,*** : 10%, 5%, 1% significance. E-3: 10 power –3. Standard errors into brackets.

[a] UAA for crop farms, livestock units for livestock farms.

Model 3: Alternative estimation correcting for endogeneity; financial variable-financial stress ratio

	Individual farms		Corporate farms	
	Livestock	Crop	Livestock	Crop
Constant	0.62 *	-0.44	0.79 ***	-0.49
	(0.35)	(1.31)	(0.24)	(0.34)
Size variable [a]	-2.88 E-3 ***	-0.58 E-3	-0.28 E-3	0.09 E-3
	(1.03 E-3)	(0.64 E-3)	(1.26 E-3)	(0.10 E-3)
Ratio capital/labour	1.14 E-3	-1.17 E-3 *	-2.94 E-3 **	-2.64 E-3
	(1.11 E-3)	(0.63 E-3)	(1.30 E-3)	(2.97 E-3)
Ratio land/labour	-21.38 E-3 **	-4.32 E-3 **	-8.64 E-3	7.15 E-3
	(9.30 E-3)	(2.11 E-3)	(5.39 E-3)	(9.98 E-3)
Share of hired labour	3.00 E-3	0.23 E-3	-	-
	(3.10 E-3)	(3.91 E-3)		
Share of rented land	6.18 E-3 **	-2.16 E-3	-	-
	(3.21 E-3)	(3.52 E-3)		
Financial stress ratio	13.65 *	18.05 ***	1.77 **	14.01 *
	(7.83)	(5.37)	(0.89)	(8.05)
DLTD	-	-	-0.06	0.03
			(0.11)	(0.21)
DJSTOCK	-	-	-0.17 *	0.22
			(0.09)	(0.23)
DREG1	-	0.19	-0.17	-0.17
		(1.30)	(0.18)	(0.56)
DREG2	-0.65 **	0.33	-0.32 **	0.11
	(0.29)	(1.21)	(0.15)	(0.23)
DREG3	-0.51	0.67	-0.26 **	-0.25
	(0.33)	(1.26)	(0.11)	(0.33)
DREG4	-0.23	1.22	-0.37 ***	-
	(0.29)	(1.35)	(0.14)	
H_0: exogeneity	rejected **	rejected ***	accepted	rejected **

*,**,*** : 10%, 5%, 1% significance. E-3: 10 power –3. Standard errors into brackets.

[a] UAA for crop farms, livestock units for livestock farms.

Model 3a: Standard Tobit estimation; financial variable-financial stress ratio (Re-estimated models in comparison to Model 3 in italic)

	Individual farms		Corporate farms	
	Livestock	*Crop*	Livestock	Crop
Constant	*0.44 *** *(0.22)*	*-2.57 **** *(0.38)*	0.79 *** (0.24)	*-0.23* *(0.23)*
Size variable [a]	*-2.47 E-3 **** *(0.89 E-3)*	*0.09 E-3* *(0.26 E-3)*	-0.28 E-3 (1.26 E-3)	*0.11 E-3* *(0.08 E-3)*
Ratio capital/labour	*2.16 E-3 **** *(0.61 E-3)*	*0.09 E-3* *(0.21 E-3)*	-2.94 E-3 ** (1.30 E-3)	*0.09 E-3* *(1.78 E-3)*
Ratio land/labour	*-10.24 E-3 *** *(4.19 E-3)*	*-3.01 E-3 **** *(1.02 E-3)*	-8.64 E-3 (5.39 E-3)	*-3.37 E-3* *(5.86 E-3)*
Share of hired labour	*3.91 E-3 ** *(2.01 E-3)*	*-3.69 E-3 *** *(1.55 E-3)*	-	-
Share of rented land	*4.86 E-3 *** *(2.04 E-3)*	*3.51 E-3 **** *(1.28 E-3)*	-	-
Financial stress ratio	*1.90* *(1.52)*	*0.43* *(0.55)*	1.77 ** (0.89)	*2.59* *(2.40)*
DLTD	-	-	-0.06 (0.11)	*0.16* *(0.15)*
DJSTOCK	-	-	-0.17 * (0.09)	*0.10* *(0.16)*
DREG1	-	*-2.58 **** *(0.41)*	-0.17 (0.18)	*0.11* *(0.40)*
DREG2	*-0.55 **** *(0.19)*	*-2.32 **** *(0.37)*	-0.32 ** (0.15)	*0.21* *(0.16)*
DREG3	*-0.20* *(0.18)*	*-2.19 **** *(0.37)*	-0.26 ** (0.11)	*-0.01* *(0.23)*
DREG4	*-0.21* *(0.19)*	*-1.93 **** *(0.39)*	-0.37 *** (0.14)	-

*,**,*** : 10%, 5%, 1% significance. E-3: 10 power –3. Standard errors into brackets.

[a] UAA for crop farms, livestock units for livestock farms.

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