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DISCUSSION PAPER

Institute of Agricultural Development in Central and Eastern Europe

TECHNICAL AND ECONOMIC EFFICIENCY OF RUSSIAN CORPORATE FARMS: THE CASE OF THE MOSCOW REGION

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ABSTRACT

The research focus of the paper is to distinguish allocative and technical inefficiencies on Moscow region corporate farms. DEA specifications with both monetary and technical objective functions are applied. Reduced costs and sensitivity analyses are used to identify fixed inputs constraining either allocative or technical efficiency. To decrease heterogeneity and allow for the accessibility to different technologies of a given farm, the farms are grouped with respect to the set of outputs they produce. Thus, as a result of an unstable market environment, it is shown that allocative inefficiency causes 65-100 % (depending on the group) of total inefficiency in 2002 and 60-96 % in 1999. As for technical inefficiency, in 1999 its major source was the lack of liquidity (30-48 %) and other resources; in 2002 it was the lack of fodder (up to 37 %), liquidity (up to 31 %) and sown area (48 % in one of the groups). The role of insufficient management in regional farming inefficiency is evaluated as being much lower than many earlier studies suggest.

JEL: D24, Q12, C14

Keywords: Technical inefficiency, allocative inefficiency, Data Envelopment Analysis, Moscow region, transitional economy.

ZUSAMMENFASSUNG

DETERMINATNTEN DER TECHNISCHEN UND ÖKONOMISCHEN EFFIZIENZ VON LANDWIRTSCHAFTLICHEN BETRIEBEN IN RUSSLAND: DER OBLAST MOSKAU

In dem Diskussionspapier wird eine Unterscheidung zwischen allokativer und technischer Effizienz landwirtschaftlicher Betriebe in der Region Moskau vorgenommen. Hierzu werden DEA-Modelle mit technischen und ökonomischen Zielfunktionen spezifiziert. Mit Hilfe von Sensitivitätsanalysen werden Inputs identifiziert, die zu allokativer und technischer Ineffizienz führen. Um die Heterogenität in der Stichprobe zu reduzieren und um die Verfügbarkeit von Technologien für die landwirtschaftlichen Betriebe besser abbilden zu können, werden die Unternehmen entsprechend ihrer Produktionsstruktur gruppiert. Die Ergebnisse zeigen, dass – je nach Gruppen – die allokative Ineffizienz in den Jahren 1999 und 2002 zwischen 60 und 100 % der gesamten Ineffizienz erklärt. Dies deutet darauf hin, dass das unzureichende Management von größerer Bedeutung ist, als frühere Studien vermuten lassen. Die Hauptursache für die technische Ineffizienz war 1999 das Fehlen liquider Mittel. Im Jahr 2002 waren neben der Liquidität, die Verfügbarkeit von Futtermitteln und die Saatfläche die Inputs, die für die Ineffizienz verantwortlich waren. Der Anteil der bindenden Restriktionen betrug in den einzelnen Gruppen bis zu 31 %, 37 % und 48 % bei den genannten Faktoren.

JEL: D24, Q12, C14

Schlüsselwörter: Technische Ineffizienz, Allokative Ineffizienz, Data Envelopment Analysis, Region Moskau, Transformationsländer.

Резюме

Факторы технической и экономической эффективности российских сельскохозяйственных предприятий: На примере Московской области

Цель исследования – соизмерение резервов, обусловленных адаптацией к рынку и использованием технологического потенциала, в сельскохозяйственных организациях Московской области. Применённые модели основаны на методе инкапсуляции данных, решаются по технологическому и стоимостному критериям. Для выявления ресурсов, дефицит которых снижает показатели эффективности адаптации к рынку и (или) технологической эффективности, использован анализ чувствительности и двойственных оценок. Для снижения гетерогенности и учёта доступности технологий исследуемым хозяйствам их совокупность разбита на группы по набору реализуемых видов продукции. Показано, что в 2002 г. 65-100 % (в зависимости от группы хозяйств) резервов повышения экономической эффективности объясняется недостаточной адаптацией к рынку (в 1999 – 60-96 %) по причине нестабильной рыночной конъюнктуры. Резервы роста технологической эффективности в 1999 г. были связаны с дефицитом ликвидности (30-48 % объёма резервов) и других ресурсов, в 2002 – с ограниченностью кормов (до 37 %), ликвидности (до 31 %) и посевов (48 % в одной из групп). Роль неудовлетворительного управления в неэффективности сельхозорганизаций региона оказалась значительно меньше, чем это представлялось во многих предшествующих публикациях.

JEL: D24, Q12, C14

Ключевые слова: Технологическая эффективность, эффективность адаптации к рынку, метод инкапсуляции данных, Московская область, переходная экономика.

CONTENTS

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1 INTRODUCTION

After more than a decade of transition to a market system, the objective nature of transitional problems in Russian agriculture has at last been widely acknowledged. Researchers' attention is now being drawn to economic, rather than political causes of existing problems.

Mainstream economic studies of Russian agriculture have shifted from merely understanding the situation to regular monitoring it to provide systematic advice to politicians. This monitoring requires methodological approaches that are uniform and easily understandable, yet powerful enough to address a wide range of practical questions of agricultural policy. The most common question of this type is 'What problem causes business failures in the sector'.

The long-term problems of Russian agriculture will probably require politicians' future attention with no regard to the depth and achievements of the transitional process. Among these are unfavourable natural conditions and low land price (GATAULIN et al., 2003); the underdevelopment of necessary state institutions and market infrastructure (UZUN, 2005), especially of the land market (LERMAN and SHAGAIDA, 2005); severe competition with other branches of the economy for capital and qualified labour (SVETLOV, 2003); a burden of social problems (UZUN et al., 1999); lack of managerial and technological skills (SEROVA, 2000; SEDIK et al., 1999); an unstable political and legal environment (*ibid.*)

The problems that are listed above are complemented with short-term problems, which should be monitored on a regular basis. Among them there is the lack of short-term capital (SVETLOV, 2003; EPSTEIN and TILLACK, 1999), machinery (ZINCHENKO, 2001), labour (in terms of quantity), high-breed livestock, etc. Under the conditions of a perfect market, such problems are solved automatically by the adjustment of prices and supply. But actual agricultural markets are far from perfect and can require political attention when a problem persists. For this reason, a good system of agricultural policy should include a subsystem facilitating the regular monitoring of factors which hamper agricultural production.

The aims of this paper are:

- To develop and test a methodology for monitoring factors that limit agricultural production efficiency at the regional level.
- To identify the set of factors that currently constrain the efficiency of agricultural production.

The set of research questions is:

a) How to identify and measure the constraining factors of economic efficiency in its allocative and technical aspects?

b) What are the constraining factors of production efficiency on the Moscow region's corporate farms?

c) How do these factors change over time?

The theoretical contribution of the paper is a microeconomic framework which aims to identify and measure the constraining factors of economic and technical efficiency, allowing levels of aggregation as low as data permit. This framework benefits from:

- Data envelopment (CHARNES et al., 1978) representation of technological sets;
- Using both monetary and technical objective functions;

- The adoption of elements of sensitivity analysis technique (in particular, assuming a resource to be abundant) to provide a wider view of scarcity of a resource than is achievable with shadow prices analysis.

The empirical contribution finds that in 2002, short-term capital lost its position as the most important constraining factor of efficiency on agricultural corporate farms in the Moscow region; it was replaced with a bundle of problems including a lack of machinery, labour and even land. All this indicates an important change: Many resources have become scarce, and thus market resource allocation can now be expected to become effective indeed.

2 THEORETICAL FRAMEWORK

Many researchers emphasize the advantages of non-parametric estimation techniques. Among the non-parametric approaches, the Data Envelopment Analysis (DEA) developed by CHARNES et al., (1978), has occupied one of the topmost positions. This approach is based on a linear programming (LP) representation of the production frontier.

The basic assumption of this approach is that the production possibilities of a homogenous sample of firms can be represented by a linear combination of actual farm-level technologies observed within this sample. The key idea of the DEA is that the location of a firm outside a production frontier indicates that the firm is experiencing a specific problem that does not hamper the activities of firms located on the frontier. In many studies identification is done by means of regression analyses of efficiency scores. However, in many cases the LP-represented production frontiers can be directly used for this kind of analysis. This follows from the two issues related to DEA applications described below.

First, efficiency scores are sometimes discussed as being ‘high’ or ‘low’, although a universal scale is not possible and ‘low’ scores might often be more a result of a misspecified model than of actual under-utilization of available technological knowledge. An instructive example is SEDIK et al., (1999), where widespread ‘low’ efficiency scores are interpreted as evidence of bad management. Actually, the large variance of efficiency scores might also be explained by the fact that many ‘non-efficient’ farms suffer from resource constraints which are not explicitly considered by the DEA model specification, while in the ‘efficient’ ones these constraints are not binding. Such a situation is quite expectable in transitional markets which lack certain institutions, infrastructure and motivations.

Second, in addition to efficiency measures, DEA models can produce plenty of analytical information such as shadow prices, scenario analyses, sensitivity tests outcome, etc. This information is used fruitfully in many studies (e.g. VALDMANIS, 1992; SIMAR and WILSON, 1998; KUOSMANEN et al., 2005) yet, to the best of our knowledge, not in studies of Russian agriculture.

In this respect, we hereafter use the approach based on an LP representation of production frontier that is similar to that applied in DEA. Contrary to other DEA applications to Russian agriculture (SEDIK et al., 1999; and OUDE LANSINK et al., 2003), we use both technical and monetary objective functions in order to approach both allocative and technical efficiency[1]. Following the above-formulated idea about the possible reason for low efficiency scores, we include constraints reflecting those resources that are most commonly reported as efficiency-constraining in BEZLEPKINA (2004), EPSTEIN and TILLACK (1999) and ZINCHENKO (2001). Finally, we apply shadow prices and sensitivity analyses to identify the most restrictive resources.

[1] In the forthcoming paper of GRAZHDANINOVA and LERMAN (2005) the same approach is used.

A short-run profit maximizing[2] firm (a farm in our case) can be represented, in a general way, as a mathematical programme

$$P^* = \max_{\mathbf{x},\mathbf{y}}(P |\, P = \mathbf{vy} - \mathbf{wx},\ \mathbf{y} \in Y(\mathbf{x})), \quad (1)$$

where P^* is an optimal profit, **w** and **v** are non-negative vectors of average input and output prices, and **x** and **y** are non-negative vectors of inputs and outputs, respectively. $Y(\mathbf{x})$ is a set of outputs that are possible when inputs **x** are given.

Assuming free disposability and convexity, the set $Y(\mathbf{x})$ can be represented by linear combinations of inputs and outputs as follows:

$$P^* = \max_{\lambda,\mathbf{x},\mathbf{y}}(P \,|\, P = \mathbf{vy} - \mathbf{wx},\ \mathbf{y} \le \mathbf{B\lambda},\ \mathbf{A\lambda} \le \mathbf{x} \le \mathbf{a}), \quad (2)$$

In this presentation λ is an optimal vector of intensities of the technologies; $A = (a_{mi})$ is a non-negative input matrix consisting of all available farms input vectors; $B = (b_{ni})$ is a non-negative output matrix consisting of all available farms output vectors; a is a non-negative vector of available amounts of inputs. This vector is assumed to consist of:

- Limiting values for those inputs that cannot be adjusted to profit-maximising levels considering an ad hoc defined time horizon, i.e., for fixed inputs;
- Infinitely large values for other (variable) inputs.

The foremost outcome of the model is P^*, which is always greater than or equal to actual profit observed on the farm. The closeness of P^* to actual profit indicates that the farm uses the resources represented by the model in an efficient way, perfectly utilizes technological knowledge and does not have hidden constraints hampering its economic efficiency with respect to explicit constraints. Otherwise, the case is one of the following:

- Poor utilization of technological knowledge (i.e., managerial failures);
- Implementation of investment projects that temporarily take some resources out of the production process;
- Presence of other constraints to be identified. These comprises of the omission of barely discernable scarce fixed inputs, managerial problems on the farm a. o. m.

With respect to the aim of our study, this model can also be used as a source of shadow prices of fixed inputs. Under a perfectly-functioning market and good management, shadow prices are expected to be close to market prices. Closeness should exist over time. This allows us to exclude that efficiency is a random phenomenon. Considerable differences between shadow prices and **w** can be conditioned by insufficient resource management. If this is not the case, then a shadow price below market price indicates, commonly, that in the given time horizon, the market fails to sweep out the excess amount of input or that the market is 'overheated' (the latter can be distinguished by widespread, large and relatively uniform gaps between shadow and market prices throughout the analysed sample of farms). An opposite relation between market and shadow prices indicates the failure of the market to deliver necessary quantities of the resource within an available time frame. Zero shadow prices indicate abundant resources that are underutilized, either due to scarcity of other resources, which is expected to be overcome in future, or as a result of market or managerial failure.

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[2] Hereafter the term 'profit' always means the short-term profit.

The analytical significance of shadow prices is widely known; nevertheless, they characterize only a local situation in a vicinity of an optimal production programme. Deeper analysis requires addressing the question regarding the amount of existing shortages of a particular resource with respect to other available resources. For this purpose, the sensitivity analysis is applied. An element of vector **a** corresponding to a scarce fixed input is replaced with an infinitely large value simulating an abundant resource. The increase of profit indicates the opportunity of profitability growth (therefore, of increasing efficiency of other fixed inputs) by increasing the amount of that fixed input. The model also yields the necessary adjustment of the resource.

Problem (2) is very useful for performance analysis. If the solution is outside the frontier, then, in order to identify the reason, it is possible to decompose the observed lack of performance into its components by means of imposing additional restrictions to (2). For instance, the following restrictions can be imposed:

a) All inputs are fixed at their actual values;

b) Outputs are fixed as to the actually-observed structure;

c) $\lambda' 1 = 1$, where 1 is a vector of ones.

Version (a), compared to the solution of (2), allows a researcher to measure profitability loss due to suboptimal input structure caused by either managerial or market failures. Version (a+b) collapses in a classical output-oriented DEA problem that is used for technical efficiency analysis, as the solution no longer depends on prices, and, compared to (a), identifies profitability losses due to non-optimal output allocation. Version (a+b+c) captures scale effects.

In the two latter versions, shadow prices are scarcely useful for analytical purposes. However, the opportunities of efficiency growth can be identified and measured by sensitivity analysis, i.e., by releasing fixed input constraints.

3 Data

This study uses data of the registry of the Moscow region corporate agricultural farms, which was provided by the Federal Service of State Statistics of Russian Federation (ROSSTAT). The registry includes data from the annual statistical reports of those entities classified by ROSSTAT as corporate agricultural firms. The data cover farm profitability, gross and net inputs and outputs in kind (except aggregated inputs and outputs) and in a monetary measure, detailed data about subsidies, total amount of bank credits, overdue credits, and accounts payable and receivable (total and overdue). Data of 2002 and 1999 were available. Market entry and exit caused that an unbalanced panel data set had to be used in the calculations. The year 1999 has been chosen as a basis for comparison for two reasons:

a) As the first year after the financial crisis of 1998, it opens a period of relatively stable ‘playing-by-the-rules’ on agricultural and financial markets. Hence, the results of the analysis are expected not to be significantly affected by changes in the economic and political environment;

b) This provides the opportunity to compare with the conclusions derived in SVETLOV (2001).

Russian transitional agriculture is in the course of adjusting production to the changing price system under the pressure of a great lack of capital. In these circumstances, in order to ensure consistency of our study with the basic assumption of DEA, formulated in Section 2, subpanels were formed that are homogeneous in terms of their output sets. Thereafter, we call a *production pattern* a set of non-zero outputs of a farm. In other words, it is assumed that if a farm does not sell e.g. milk, then milk production technologies are absolutely inaccessible to this farm in the time horizon of our study. Each sub-panel defines a specific technological set. The analysis covers only those sub-panels which include at least 10 farms in each of the two years. The 6 sub-panels which satisfy these conditions are characterized in Table A1 (see Appendix). Some descriptive statistics of these data are presented in Table A2.

4 EMPIRICAL MODEL

The empirical model originates from the theoretical model from Section 2, with restriction (a) imposed:

$$R_i^* = \max_{\lambda,\mathbf{y}} (R \mid R = \mathbf{v}_i\mathbf{y},\ \mathbf{y} \le \mathbf{B\lambda},\ \mathbf{A\lambda} \le \mathbf{a}_i)\,. \tag{3}$$

The notations are: R_i^* is the optimal amount of sales in the farm i; $\mathbf{v}_i$ is a non-negative vector of average output prices for farm i; $\mathbf{y}$ is a non-negative vector of outputs; $\boldsymbol{\lambda}$ is a non-negative vector of technology intensities; $\mathbf{A} = (a_{mi})$ is a non-negative input matrix; $\mathbf{B} = (b_{ni})$ is a non-negative output matrix; $\mathbf{a}_i$ is a non-negative vector of actual inputs on farm i (that is, the i-th column of $\mathbf{A}$); i is a farm index; m is an input index; n is an output index.

Under the condition that the farm uses the best technologies and maximizes its profit (which in case of constant inputs is equivalent to maximising revenue), problem (3) enables calculation of the i-th farm revenue taking the actual amount and structure of inputs as given. Comparison of the modelled indicators of financial efficiency against actual indicators reveals the amount of reserves. Analysis of shadow prices identifies the factors constraining financial efficiency growth.

To calculate the attainable level of revenue under the conditions of free availability of input j (for instance, from a farm's own storage) and fixed availability of other inputs, the problem

$$R_{im}^* = \max_{\lambda,\mathbf{y}} (R \mid R = \mathbf{v}_i\mathbf{y},\ \mathbf{y} \le \mathbf{B\lambda},\ \mathbf{A}^m\boldsymbol{\lambda} \le \mathbf{a}_i^m) \tag{4}$$

should be solved. This is obtained from theoretical model (2) with the imposed restriction (a) and omitted constraint on the input m. In (4) $\mathbf{A}^m$ is the matrix which is similar to $\mathbf{A}$ but has the line m omitted; $\mathbf{a}_i^m$ is derived from $\mathbf{a}_i$ in the same way. The specification (4) is used for all inputs except sources of production costs financing.

Omitting a constraint implies that the fixed input is available for free and production costs do not grow because of its increased usage. When dealing with the input 'sources of financing of production costs', the assumption of unchanged production costs implies that the additional sources are not used. This renders the procedure senseless. For this reason, in this specific case we assume that a higher input necessarily result in larger costs (for instance, a farm urgently obtains a resource at a higher price in order to prevent skipping an important technological operation). To formally represent this assumption, the problem (4) is replaced by the following one:

$$R_{im}^* = \max_{\lambda,\mathbf{y},c} (R \mid R = \mathbf{v}_i\mathbf{y} - c,\ \mathbf{y} \le \mathbf{B\lambda},\ \mathbf{A}^m\boldsymbol{\lambda} \le \mathbf{a}_i^m,\ \mathbf{a}_m\boldsymbol{\lambda} \le a_{mi} + c), \tag{5}$$

where m relates only to the input 'sources of production costs financing', $\mathbf{a}_m = (a_{mi})$, and c represents additional production costs (excluding depreciation costs).

The problem

$$k_i^* = \max_{k,\lambda} (k \mid \mathbf{a}_i \ge \mathbf{A\lambda},\ k\mathbf{b}_i \le \mathbf{B\lambda}),\ \ R_i^{**} = k_i^*\mathbf{v}_i\mathbf{b}_i\,, \tag{6}$$

where $\mathbf{b}_i = (b_{ni})$ and k is an output growth ratio, facilitates splitting overall inefficiency measured by problem (3) into two parts: Technological inefficiency $R_i^{**} - R_i$ and allocative inefficiency caused by inadequate market adaptation $R_i^{*} - R_i^{**}$, where R_i is are actual returns of farm i. This problem follows from (2) by imposing restrictions (a+b) described in Section 2. That is, it has the form of an ordinary output-oriented DEA model.

Finally, the problem

$$k_{im}^{*} = \max_{k,\lambda}(k \mid \mathbf{a}_i^m \geq \mathbf{A}^m\boldsymbol{\lambda},\ k\mathbf{b}_i \leq \mathbf{B}\boldsymbol{\lambda}),\ \ R_{im}^{**} = k_{im}^{*}\mathbf{v}_i\mathbf{b}_i, \tag{7}$$

has the same purpose as (4) regarding technical efficiency. That is, it captures an impact of a particular input on the technical efficiency level of a farm and is obtained from (6) by releasing one of the input constraints.

The list of outputs can be found in Table A1 in the Appendix. The following 10 inputs are included: Sown area; meadows and pastures; agricultural workers; sources of production costs financing; fodder; cows; sows; sheep and goats; fixed assets used in agricultural production; spare parts.

Usage of sown area as an input instead of arable land is due to the fact that even efficient farms in the Moscow region often underexploit arable land. In turn, this approach may induce other problems as the sown area constraint may capture the effect of other constraints: The decision about sown areas is made with respect to availability of other inputs, which appear to be actual limiting factors. However, if there are only a few farms where the sown area constraint is binding, this problem can be ignored.

The ‘spare parts’ variable is used as a proxy for machinery. However, a lack of spare parts may indicate the lack of financing rather than the lack of machinery. Identifying the reason requires to check the constraint on sources of production costs financing. If this constraint is not binding lack of spare parts indicates lack of machinery. Otherwise, no unambiguous conclusion is possible.

5 Results

The data of Table 1 suggests that, despite ten years having passed after the origination of market reforms, agricultural production again calls for restructuring. The relatively favourable farming sector price system that was set up after the financial crisis in August 1998 has already receded into the past. As a result, the need to adjust production to market challenges, which was quite significant in 1999, became even greater by 2002 in all groups. Farms lack time to make investments in the required structural adjustments in a persistently changing market conjuncture. The farms that are worst adapted to the market belong to the most numerous groups, I and II; these farms do not produce pork and vegetables.

Technical efficiency of all groups but VI improved during this period. In addition, the farms utilize existing technological opportunities quite satisfactory and hidden constraints appear not to be very hampering. Moreover, the increase of overall inefficiency was mainly caused by a poor adaptation to the market.

Table 1: Opportunities to increase efficiency on Moscow region corporate farms

	Groups (production patterns)					
	I	II	III	IV	V	VI
Year 2002						
Sales Profitability*, %, actual	-29.7	-27.9	-4.2	-3.3	-5.0	-25.0
modelled	2.3	12.5	19.9	14.2	-0.5	-18.3
Loss due to inefficiency	32.0	40.4	24.1	17.5	4.6	6.7
- Due to technical inefficiency	7.8 (24.4 %)	2.5 (6.2 %)	4.2 (17.5 %)	0.0 (0.0 %)	0.0 (0.0 %)	2.3 (34.8 %)
- Due to allocative inefficiency	24.2 (75.6 %)	37.9 (93.8 %)	19.9 (82.5 %)	17.5 (100.0 %)	4.6 (100.0 %)	4.4 (65.2 %)
Year 1999						
Sales Profitability*, %, actual	-6.4	-7.4	13.5	4.4	24.7	-5.4
modelled	27.2	16.8	30.7	16.4	34.1	0.8
Loss due to inefficiency	33.6	24.1	17.3	12.0	9.4	6.1
- Due to technical inefficiency	10.2 (30.3 %)	9.7 (40.0 %)	4.2 (24.4 %)	0.4 (3.7 %)	2.3 (24.3 %)	1.1 (17.3 %)
- Due to allocative inefficiency	23.5 (69.7 %)	14.5 (60.0 %)	13.1 (75.6 %)	11.6 (96.3 %)	7.1 (75.7 %)	5.1 (82.7 %)

Source: Authors' calculations based on solutions of models (3) and (6).

Notes: The table presents weighted averages across the patterns. The weights are the sales values.

*) Short-term profit per cent of revenue (depreciation is not included in costs).

As for 1999, the resource that farms were most commonly short of was financing of production costs (Groups I-III, the most numerous). This result is justified by the data of Table 2 and is complementary with SVETLOV (2001). In 2002 the situation was different. Source of production costs financing appeared to be the most widespread constraint in Group II and (together with spare parts) in Group IV. In Group VI and especially in Group III, the lack of sown area is noticeable. This was hardly observed in 1999, when it was very problematic for farms to finance sowing. To conclude, corporate farms and the rural financial system are, step-by-step, overcoming the most difficult problem of the previous ten years, which was the shortage of short-term capital. Since then, the demand for raising production intensity by means of investing in fixed production assets is a characteristic feature of the present situation in the region, although the lack of short-term capital is still evident.

Shortages of different resources influence economic efficiency differently. The lack of production costs financing and of fodder, both of which are caused by the shortage of turnover assets, were the most noticeable in 1999, but the amount of inefficiency they commonly caused was not found among the largest (Table 3). They dominated only in Group III, while in other groups fixed assets, sown area and especially the number of sow were found to be more restrictive constraints. The lack of sows was largely reduced during the interceding three years, which indicates the proper reaction of farm managers to market signals.

Table 2: Share of farms facing a lack of the given fixed input, % to the number of farms in the group

Inputs	Groups on production patterns					
	I	II	III	IV	V	VI
Sown area	**21.67** 7.14	**20.37** 33.33	**89.66*** 28.13	**—** 10.00	**25.00** 28.57	**50.00** —
Meadows and pastures	**23.33** 9.52	**7.41** 7.02	**20.69** 31.25	**33.33** —	**58.33** 50.00	**50.00** 64.71
Agricultural workers	**40.00** 7.14	**1.85** 29.82	**13.79** 6.25	**33.33** 10.00	**58.33** 64.29*	**—** 17.65
Sources of production costs financing	**20.00** 88.10*	**72.22*** 84.21*	**48.28** 71.88*	**41.67*** 40.00	**16.67** 21.43	**—** 17.65
Fodder	**46.67** 45.24	**7.41** 45.61	**—** 21.88	**16.67** 40.00	**—** —	**30.00** 70.59*
Cows	**20.00** 19.05	**3.70** 24.56	**13.79** 28.13	**—** 30.00	**33.33** 7.14	**30.00** 52.94
Sows	**—** —	**—** —	**—** —	**8.33** 30.00	**—** 7.14	**10.00** 35.29
Sheep and goats	**—**	—	—	**8.33**	—	**50.00**
Fixed assets used in agricultural production	**56.67** 26.19	**1.85** 42.11	**48.28** 34.38	**16.67** 60.00*	**66.67*** 50.00	**80.00*** 58.82
Spare parts (a proxy for machinery)	**60.00***	**46.30**	**62.07**	**41.67***	**58.33**	**10.00**

Source: Authors' calculations based on solutions of models (5) (sources of production costs financing) and (4) (the rest of inputs).

Notes: * Upper figure relates to 2002, while lower relates to 1999.
In 1999 there were no farms lacking sheep and goats.
In 1999 the model misses the constraint on spare parts due to an absence of source data.
Asterisks mark the highest value in a group for the given year.

As follows from the empirical specification, the indicators which show a lack of sources of production costs financing are not directly comparable to those of other resources. Yet this does not hinder us from observing the general tendency, displayed by both Table 3 and Table 2, that inefficiencies caused by a lack of financing are being reduced and replaced by those resulting from the lack of fixed assets, land and labour force. In 2002, the greatest inefficiencies in Groups I, II and V are observed for machinery, since returns appear to be sensitive to spare parts expenses rather than to total production expenses. However, in order to recover such large revenue reserves, the spare parts expenses should be 9.5, 1.9 and 2.1 times larger, respectively, than at present (refer to Table A4 in the Appendix). Naturally, this is not realistic and indicates a very large difference in the technologies applied on farms with the same production. The conclusion is that the step-by-step expansion of machinery and corresponding technological improvements is a promising path for the long-term development of corporate farms. Shadow prices in problem (1) also lead to the conclusion that an additional rouble of spare parts expenses (caused by additional machinery input) is repaid in the corresponding groups by 15.0, 12.8 and 17.3 roubles of additional sales (Table A3 in the Appendix).

Table 3: Additional returns [a)] per hectare of agricultural land in the case of free access to the given input, roubles

Inputs	Groups on production patterns					
	I	II	III	IV	V	VI
Sown area	**10.39** 0.57	**51.98** 18.62*	**312.97*** 6.37	**—** —	**3.53** 0.45	**8.41*** —
Meadows and pastures	**20.79** 4.97	**14.78** 2.43	**29.64** 28.35	**—** —	**0.36** 95.74	**—** 2.43
Agricultural workers	**19.90** 0.75	**—** 5.78	**0.69** 0.07	**44.56** 14.76	**97.51** 74.39	**—** —
Sources of production costs financing	**0.93** 2.80	**29.34** 6.85	**22.56** 32.44*	**32.98*** 1.09	**—** 3.72	**—** —
Fodder	**22.24** 12.58	**1.77** 4.52	**—** 2.96	**11.02** 10.08	**—** —	**—** 6.61
Cows	**3.89** 2.80	**16.31** 0.45	**1.06** 9.44	**—** 3.02	**—** 2.80	**5.55** 9.89
Sows	**—** —	**—** —	**—** —	**6.37** 49.12*	**—** 100.76*	**3.91** 24.34*
Sheep and goats	**—**	**—**	**—**	**12.50**	**—**	**2.08**
Fixed assets used in agricultural production	**31.98** 25.38*	**—** 1.66	**150.99** 14.13	**1.38** 40.55	**—** 77.46	**0.71** 9.60
Spare parts (a proxy for machinery)	**50.98***	**69.60***	**188.37**	**5.69**	**116.18***	**—**

Source: Authors' calculations based on solutions of models (5) (sources of production costs financing), (4) (the rest of inputs) and (3).

Notes: * Upper (bold) figures relate to 2002, while lower relate to 1999.

In 1999 there were no farms lacking sheep and goats.

In 1999 the model misses the constraint on spare parts due to an absence of source data.

Asterisks mark the highest value in a group for the given year.

a) $R^*_{im} - R^*_i$.

Farms in Groups III and VI can benefit from the expansion of sowings (2.8 and 1.6 times, respectively) and farms in Group IV from higher labour input (by 34 %). But, as Table A3 suggests, shadow prices of sown area in Groups III and VI are small (5,160 and 3,120 roubles per hectare). Thus, even a small variation of yields or costs can reduce these figures to zero. The shadow price of an additional worker in Group IV is 194,000 roubles: The margin of the wages is 16,000 roubles per month. So farms that are short of labour can benefit from attracting workers through increased wages, as this figure is much higher than the actual average wages, which amount to 4,500 thousand roubles per month. Alternatively, this margin can be used as a tool for stimulating labour discipline and qualification growth in order to intensify the use of existing labour resources.

Due to a lack of information about resource prices, we cannot derive the conclusion about market equilibrium by comparing them against shadow prices. However, the shadow price of dairy cows displayed noticeable changes in 2002 compared to 1999: First, they grew (except Groups IV and VI); second, their variation, though still large, contracted, suggesting that market forces continuously shift cow allocation among farms to an equilibrium point, which is characterised with equal shadow prices of the same resource in different farms. An increased shadow price of agricultural workers in five groups and relatively small differences between groups suggest that the level of underdevelopment in the agricultural labour market is decreasing.

Shadow prices of sources of production costs financing are, except Group VI, larger than the average interest rate in the Russian economy, which was 0.393 in 1999 and 0.179 in 2001 (this number for 2002 is not yet available). A large gap is to be expected due to high risks and the low solvency of corporate farms (see e.g. UZUN, 1999; EPSTEIN and TILLACK, 1999), but it also indicates the lack of political incentives to overcome this problem. The situation is reversed for fixed assets: Shadow prices suggest apparent overinvestment in most groups. However, the actual reason is the gap between the book and fair market value of fixed assets mentioned by many researchers (see e.g. UZUN (1999)). Thus, the level of fixed assets shadow prices is hardly informative, unlike their change, which shows definite efficiency growth despite the lack of capital needed to adjust their structure and their extremely low liquidity.

We are unable to analyse the spare parts shadow prices in the same way (by comparing them against interest rates), because they are used as a proxy. A unitary growth of spare parts expenses in our model is assumed to be conjoined with the corresponding growth of machinery value. Thus, per unit of machinery, the shadow prices would be significantly lower. The true rate cannot be approached by means of available data.

Table 4: Influence of inputs on technical efficiency on the Moscow region's corporate farms

Inputs	Increase of technical efficiency in case of free input[a)], %, in the group:					
	I	II	III	IV	V	VI
Sown area	0.40 (-0.49)	0.21 (-0.79)	2.25* (2.25)	— (—)	— (—)	— (—)
Meadows and pastures	0.51 (0.51)	1.33 (0.81)	1.44 (1.24)	— (—)	— (—)	— (-0.82)
Agricultural workers	0.77 (0.55)	— (-0.28)	— (-0.02)	— (—)	— (—)	— (—)
Sources of financing of production costs	1.88 (-3.99*)	1.22 (-2.49*)	0.97 (-2.34*)	— (-2.72*)	— (-0.44)	— (-0.20)
Fodder	1.89* (0.57)	1.46* (-1.53)	0.75 (-1.72)	— (—)	0.60 (-0.26*)	— (-0.04)
Cows	1.74 (-0.82)	0.63 (-0.56)	0.28 (-0.56)	1.17* (1.17)	— (—)	— (—)
Sows	0.12 (0.12)	— (—)	— (—)	— (—)	— (-0.38)	— (-1.08)
Fixed assets used in agricultural production	0.60 (-0.27)	0.49 (0.08)	0.30 (0.14)	— (—)	— (-0.75)	— (-2.35*)
Spare parts (a proxy for machinery)	1.78	1.31	1.42	—	0.71*	4.04*
Average technical efficiency measure	**90.27** (6.00)	**96.01** (8.46)	**95.35** (2.29)	**98.66** (0.27)	**100.00** (3.83)	**100.00** (1.48)

Source: Authors' calculations based on solutions of models (7) and (6).

Notes: * The figures in brackets are the changes to 1999, in points. A dash represents no influence (no change).
In 1999, the model misses the constraint on spare parts due to an absence of source data.
The asterisks mark the constraint with the highest impact on efficiency (for instance, the asterisk at -0.26 means that the year 1999 the increase of 0.6 - (-0.26) = 0.86 was the greatest in Group V.

a) Mean value without weighting.

Shadow prices of meadows and pastures are mostly higher than that of sown area because of the large production expenses on arable lands. As follows from SVETLOV (2003), excess costs on arable lands are often caused by delayed financing, which causes technological failures. Better financing is expected to shorten losses and to allow the use of arable land to its full capacity. This results in higher opportunity costs of arable land. Our findings show that the growth of shadow prices of sown area from 1999 to 2002 is quite common, which supports these expectations.

Although technical inefficiency plays a minor role in the problems of farm businesses in the Moscow region, it is still of both scientific and practical interest. As expected, the less numerous the group, the higher the efficiency score. The scores presented in Table 4 (except the last line) are the differences between average k_{in}^* and k_i^* obtained from problems (7) and (6). The last line contains average efficiency scores obtained from problem (6).

In 1999, technical efficiency, similar to allocative efficiency, suffered primarily from the lack of short-term finance (Groups I through IV). In Group V, the factor that most hampered technical efficiency was the deficit of fodder, which originated in the same problem of shortage of short-term assets (Group V). In the three largest groups, wider liquidity sources can remove 30 % (Group II) to 48 % (Group III) of existing technical inefficiency, which is not large for transitional agriculture, where it is partially caused by successfully operating farms having some resources frozen in projects under construction. Moreover, easier access to fodder can also decrease technical inefficiency in these groups by 8 to 36 %. Increasing the cow population removes 10 to 16 % of technical inefficiency.

The analysis of year 2002 suggests that in Groups I and II, fodder took the leading position, with up to 19 % and 37 %, respectively, of total technical inefficiency. Short-term finance lost its leading position but remained influential at 19 % and 31 %, respectively. In Group III, we observe a novel situation: The topmost constraint to technical efficiency is now sown area, whose lack causes 48 % of technical inefficiency. The reason is that farms of this group can access vegetable growing technologies. However, this interesting finding, when considering Russia's limited market capacity, rather suggests overuse of other resources (in particular, labour and fixed assets other than machinery) with respect to the most efficient technologies. Remarkably, the sown area also strongly limits returns in this group in 2002 (Tables 2 and 3). Group IV lacks cows in terms of technical efficiency, while its returns are mostly affected by short-term finance. Technical efficiency in the other groups is constrained by machinery.

6 CONCLUSIONS AND DISCUSSION

The study has demonstrated the capabilities of DEA as a tool for identifying constraints hampering efficiency increases. This addresses the first research question formulated in Section 1. With respect to the second research question, this study provides a means of identifying constraining factors of both production and technical efficiency and provides a set of measures regarding the frequency and severity of these factors. For the third research question, the most important constraining factors are the lack of machinery and of turnover assets, and particularly of sources of production costs financing (whose influence and frequency are decreasing). The shortage of land area and workers are also noticeable.

Our study supports the results of other studies (OUDE LANSINK et al., 2003; SEDIK et al., 1999) which stress managerial failures and conservative agricultural policies in Russia, to a very limited extent. The essential source of ineffective resource allocation, according to our findings, is an unstable market. Management reacts to market changes, as a rule, in an appropriate way, even if constrained with financial difficulties and with natural restrictions following a protracted cycle of agricultural production. In an institutional sense, our study shows the insufficiency of the agricultural financial system regarding the requirements and specificity of agricultural production, despite the many positive changes in this sphere.

On the other hand, conforming to GRAZHDANINOVA and LERMAN'S (2005) opinion about the absence of noticeable technical inefficiencies, it should be noted that utilising at least these small reserves of raising efficiency can sometimes transform farming to a profitable enterprise, as Table 1 displays. As for allocative inefficiency, it is found to be a continuous problem of the Moscow region corporate farms.

The methodological framework applied to this study suggests that it is not wholly correct to attach estimated technical inefficiency only to scale and allocation problems, which in turn relate to either management or institutional failures. Very often the reason is that the technological set appears to be significantly more complex than represented by the model. Hence, the farms may appear in unequal positions with respect to the omitted particularities of the technology that can be brought to light by means of sensitivity analysis. In particular, our study gains from the explicit accounting for sources of production costs financing as a specific resource, whose lack could cause unexplained inefficiency in a data envelopment model omitting any liquidity constraint.

This study shows the importance, among the various options for solving the social and economic problems of rural society, of the following actions:

- Stabilisation of market conjuncture;
- Support for restructuring production;
- Stimulating growth of agricultural workers' wages.

Demand for programs supporting the accumulation of turnover assets by corporate farms, which is noticed in SVETLOV (2003), remains; however, the focus of attention should be moved to the increasing technological level of production by means of accessing more machinery.

Newly-emerging shortages of sown areas is a positive finding. If this tendency persists, it would allow for the transition from declarations to deeds in the field of establishing a truly functioning agricultural land market.

Numerous inputs and outputs can be the source of the superfluity of degrees of freedom mentioned in COELLI (1998). Taking this into account, we still believe that this problem is less hampering to the results than omitting or aggregating some technological constraints, because this practice automatically leads to the increased variation of efficiency scores and to the incapability of explaining the variation in economic terms. In the case of numerous inputs and outputs, we expose the estimates to a risk of a random error, which does not have a definite direction, thus allowing the results to be interpreted as ‘the best of accessible knowledge’. On the contrary, reducing the number of inputs and outputs in the model affects the scores of farms constrained in the omitted resources in opposite directions than those of unconstrained farms.

The comparison of 2002 to 1999 is not completely convincing, because the specifications of the 1999 and 2002 models are different due to data availability constraints. In particular, in 2002 the effect of sources of production costs financing might be partially captured by the spare parts constraint, while in 1999 the situation might be inversed. More comprehensive data could yield conclusions which differ in some details from those presented above.

The reliability of the conclusions also suffers from the increased number of binding constraints on sown area in 2002: Refer to the discussion in Section 4 on usage of sown area instead of arable land area in the applied model. In 2002 this constraint was binding in 90 % of the farms in Group III and in 50 % of the farms Group VI. This may indicate a biased estimations especially overrating the impact of additional land and underrating the effect of other resources like machinery, and sources of production costs financing. In other groups, underestimation is also possible, but, due to the existence of a representative subset of farms not constrained in sown area, it is unlikely that the existing effects of resources on revenue or technical efficiency could not be recognized.

The analysis of additional returns is valid only under the assumption that a farm appears to have some ‘unused storage’ of the resources and thus do not pay to obtain it. The exception is the sources of production costs financing, for which such an assumption is meaningless and, for this reason, not made. This is reflected by problem (5) of the empirical model specification. Hence, the amount of inefficiency caused by the sources of financing is not comparable to other inefficiency amounts approached in this study, unless the latter consider the costs for obtaining them. This has not been done because of difficulties in measuring these costs. In other words, the inefficiency amount attached to financing sources, which is given in Table 3, is underestimated compared to the inefficiency amount attached to other inputs.

Table A4 provides reason to believe that the classification of farms by production pattern based on sales does not always result in homogeneous sub-panels. Hence, it is reasonable to try classifying farms by either actual production (with no regard to sales) or by both production and sales (to capture the availability of both production and marketing facilities). Another approach to be considered is ignoring very small sales when defining production patterns. The idea of using cluster analysis in order to form homogenous sub-panels was rejected because its output is sensitive to the measurement of variables. In order to achieve sensible results, it is advisable that all the variables used for cluster analysis have the same measurement, or some weighting value for each variable be identified. This is not provided in our case. However, the final conclusion regarding the applicability of cluster analysis to grouping farms for the purposes of profitability and efficiency analysis should be made after tests on the sensitivity of group composition to changing variable measurements.

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APPENDIX

Table A1: Groups of the Moscow region's corporate farms

Number of sub-panel (production pattern)	Farms selling:									Number of farms	
	Cereals	Potatoes	Vegetables	Other crop production	Beef	Pork	Milk	Other animal production*)	Non-agricultural production	1999	2002
I	+			+	+		+	+	+	42	60
II	+	+		+	+		+	+	+	57	54
III	+	+	+	+	+		+	+	+	32	29
IV	+	+	+	+	+	+	+	+	+	10	12
V		+	+	+	+		+	+	+	14	12
VI	+	+		+	+	+	+	+	+	17	10

Source: Authors' calculations based on data from ROSSTAT.

Notes: *) Animal production excluding meat, poultry, dairy milk, wool and eggs.
The farms of the six sub-panels do not produce wool or eggs.

Table A2: Descriptive statistics of groups (minimal, average, maximal values and variance coefficient)

Variables	1999						2002					
	I	II	III	IV	V	VI	I	II	III	IV	V	VI
Sown area	0 2547.6 9136 63.2	333 2526.3 5982 45.2	612 2341.9 4404 42.5	575 2216.0 5464 61.3	5 1297.1 3753 89.1	1758 2906.8 4628 30.8	0 2595.6 5242 42.8	640 2770.6 9257 54.8	644 2331.9 4651 42.9	589 3009.8 4636 41.8	70 1150.8 2888 71.5	0 2346.9 4574 50.8
Meadows and pastures	0 847.4 2593 76.8	0 637.4 2205 77.2	0 610.0 1769 64.6	281 923.9 2197 76.8	0 991.3 3267 98.4	0 604.3 1761 66.9	0 598.3 1761 73.5	0 792.5 4611 95.4	0 759.3 2296 65.4	272 1232.9 3211 77.8	77 984.5 3305 104.5	94 716.5 1388 46.7
Agricultural workers	45 206.6 677 55.7	41 170.0 677 63.1	42 318.2 880 56.3	42 266.4 585 57.5	43 309.4 910 82.3	63 270.9 415 34.3	29 148.2 508 53.6	42 183.8 700 62.4	25 233.0 513 47.0	52 360.2 707 60.7	41 310.7 1041 100.2	63 182.6 288 43.1
Sources of financing of production costs	1523 13602.6 74632 86.7	2566 11144.5 72283 109.5	1995 20283.8 62042 64.7	1395 16492.0 41013 74.9	1514 20049.5 70250 108.3	4662 19117.4 50755 60.2	3137 22406.8 93902 70.2	3244 32968.7 226103 104.0	3736 39218.3 110437 56.5	6097 66662.3 138160 63.0	8546 47732.1 145760 94.1	5553 31126.4 96192 86.1
Fodder	565 5261.4 31625 96.2	510 4183.3 26853 105.9	633 5714.9 14323 66.2	168 4120.4 9171 68.8	503 5803.3 24364 105.9	1283 8537.4 27240 81.1	727 8300.8 25686 70.1	1359 11585.5 89351 119.9	712 10868.0 26333 56.3	1704 18429.3 46995 67.9	1847 12840.3 52923 110.9	1463 11769.8 47090 114.1
Cows	85 712.4 2861 68.1	80 517.3 1262 52.0	93 683.9 1520 56.8	11 665.4 1000 54.8	93 620.3 2131 86.1	52 771.6 1689 57.7	74 568.2 1233 50.7	84 660.2 3200 80.9	66 594.3 1458 50.0	164 839.6 1850 57.6	60 553.3 2476 121.0	196 539.5 1134 61.8
Sows		0 1.2 50 648.1		0 10.7 55 157.1	0 0.4 5 374.2	0 335.5 2087 153.2				0 50.5 260 147.7		0 170.0 1002 185.3
Fixed assets used in agricultural production	1144 63722.6 247115 74.8	11734 47216.5 101102 50.4	5167 79211.5 266566 62.7	27378 87139.1 228905 83.8	4263 50279.9 149990 87.1	36496 84530.2 272089 69.6	0 55500.5 147305 59.9	9220 65488.2 310167 96.2	4145 86768.4 255185 68.9	23543 121019.9 246937 56.7	17347 94722.7 271903 85.2	25778 78687.1 180853 60.9
Spare parts (a proxy for machinery)	…	…	…	…	…	…	0 1492.3 6388 96.1	50 2487.1 31318 180.8	38 2661.4 9171 86.6	140 4284.7 15419 103.5	296 2764.4 12803 131.3	197 1997.9 5198 81.6
Cereals	2 3183.1 40559 215.9	3 1132.0 9011 166.9	4 1770.3 15522 171.3	37 1005.5 2820 100.8		42 3088.5 14806 132.0	2 5128.1 56711 210.4	3 9075.8 52988 147.5	18 5044.9 19385 114.3	5 5222.4 27164 172.3		565 10037.8 35968 131.7
Potatoes	5 2784.9 45109 239.9		72 6191.8 39067 150.1	729 5893.2 28815 147.2	158 4890.0 37241 194.0	9 3842.6 20419 144.1		7 4557.4 43968 206.1	18 7844.1 59980 193.0	297 16757.3 51629 107.4	16 3394.3 20373 168.1	185 2715.1 8106 96.5
Vegetables			19 21383.5 137345 147.7	87 11372.0 88643 242.4	53 34513.1 201373 175.0				25 28607.2 151195 149.9	65 40356.6 201831 179.5	10 30646.7 147976 156.8	
Other crop production	1 222.1 2457 193.7	1 1300.5 50934 603.3	2 1385.8 13525 229.1	5 863.1 3764 168.2	1 710.1 5141 197.9	2 179.7 524 88.4	1 935.3 42022 583.6	1 426.1 4590 206.1	5 2857.7 34036 278.2	2 1387.6 10743 215.3	1 10503.3 87036 233.0	5 219.2 889 127.9
Beef	16 689.2 3655 102.7	17 1183.5 26299 338.8	6 376.0 1450 98.1	32 588.4 2245 114.6	7 571.6 2515 144.6	70 875.8 3480 102.4	4 837.9 4320 84.0	4 962.7 7421 121.1	88 797.9 2756 74.7	2 786.7 3246 119.9	14 944.4 5684 162.8	170 998.1 2555 75.3
Pork				1 19.5 36 65.3		1 1451.2 9527 165.2				1 61.6 490 220.5		4 1150.7 9712 263.3
Milk	1015 21272.5 148346 108.6	755 13563.4 52076 78.5	208 19023.6 56801 80.8	58 14730.5 38104 81.3	124 23610.9 118773 125.9	1198 25297.7 77249 80.2	609 20575.7 60324 69.8	89 27613.7 196287 115.1	855 23608.1 71933 69.9	340 27688.7 62419 77.0	79 23718.8 148989 179.0	4491 18637.9 44349 80.3
Other animal production*)	5 480.7 2409 108.5	14 1562.2 22176 299.8	3 2046.2 24308 233.4	64 1773.5 7431 131.0	14 796.1 3782 144.7	26 1315.7 10091 186.7	17 1527.8 27017 284.3	3 1366.8 17271 234.4	13 1247.8 10347 155.8	156 9636.8 38595 127.1	121 2531.3 17517 194.9	127 3940.5 21056 181.3
Non-agricultural production	13 726.7 12122 228.2	11 418.7 2828 132.2	2 1985.4 8386 110.0	138 1825.8 6083 133.8	18 1710.2 11042 178.6	9 649.2 4538 173.1	2 714.6 3472 117.9	2 1726.7 24372 234.2	36 2848.8 23698 176.7	14 7879.3 23379 95.8	123 3373.3 20191 162.7	23 1402.6 6238 128.9
Sales	0 3691.1 10405 48.0	0 3736.1 8487 48.9	0 3309.5 6176 42.8	872 3446.4 7698 54.4	22 2489.4 5507 67.9	2074 4012.4 7022 36.1	724 17276.9 74415 84.8	1601 25770.4 210074 125.3	5651 37644.1 120899 81.6	2453 64543.0 194899 89.8	3669 45439.8 173888 116.4	4644 25388.8 93351 103.4
Arable land area	0 2843.7 9131 54.8	0 3098.7 6282 47.4	0 2699.5 5693 46.4	591 2522.5 5501 51.8	22 1498.1 4028 80.7	1806 3408.1 5696 34.1	0 3095.0 6082 44.7	0 2983.8 9570 55.0	912 2629.7 5693 43.0	600 3442.4 5501 40.7	655 1510.3 3058 55.5	1980 3069.9 5194 33.3

Source: Authors' calculations based on data from ROSSTAT.

Notes: Missing data are displayed as ellipses.

*) Animal production excluding meat, poultry, dairy milk, wool and eggs.

Table A3: Average shadow prices*) of inputs in problem (3), roubles×1,000

Inputs	**Groups on production patterns**					
	I	**II**	**III**	**IV**	**V**	**VI**
Sown area, per hectare	**2.51**	**13.58**	**5.16**	**—**	**21.39**	**3.12**
	2.94	2.51	4.72	1.74	3.19	—
Meadows and pastures, per hectare	**25.75**	**5.31**	**18.68**	**5.60**	**13.65**	**23.74**
	25.78	54.62	29.39	—	13.32	3.49
Agricultural workers, per person	**65.71**	**54.68**	**38.88**	**193.97**	**86.62**	**—**
	21.63	33.33	26.66	97.83	48.29	2.97
Sources of production costs (excluding depreciation) financing, per thousand roubles	**0.68**	**1.04**	**1.07**	**1.10**	**0.72**	**—**
	0.91	0.92	1.41	1.17	0.94	0.50
Fodder, per thousand roubles	**2.15**	**3.20**	**—**	**1.13**	**—**	**1.84**
	2.90	0.52	1.35	1.46	—	1.35
Cows, per animal	**24.61**	**74.38**	**18.23**	**—**	**14.80**	**11.34**
	12.70	2.72	18.10	16.31	48.67	13.35
Sows, per animal**)	**—**	**—**	**—**	**>0**	**—**	**>0**
	—	—	—	>0	>0	38.65
Sheep and goats, per productive animal**)	**—**	**—**	**—**	**>0**	**—**	**13.37**
Fixed assets used in agricultural production, per thousand roubles	**0.25**	**0.18**	**0.62**	**0.45**	**0.08**	**0.04**
	0.33	0.04	0.23	0.09	0.40	0.08
Spare parts, per thousand roubles	**14.99**	**12.79**	**7.06**	**8.15**	**17.25**	**3.95**

Source: Authors' calculations.

Notes: Upper (bold) figures relate to 2002, while lower relate to 1999.

In 1999 there are no farms lacking sheep and goats.

In 1999 the model misses the constraint on spare parts due to the absence of source data.

*) Mean value without weighting (mathematical expectation of technical efficiency measure for a random farm chosen from the corresponding data set).

**) Notation '>0' replaces very large values justified with only one farm having very few animals (for instance, the farm in Group IV that has a non-zero shadow price has only one sow), which has no actual economic sense. In other farms in the group, the corresponding constraint is not bound.

Table A4: Average lack of resources on a farm, %

Inputs	Groups on production patterns					
	I	II	III	IV	V	VI
Sown area, per hectare	28.19 13.70	37.32 13.70	**277.29** —	— —	**532.41** 44.76	60.73 74.72
Meadows and pastures, per hectare	161.88 99.92	**700.15** 26.77	238.89 114.87	— —	273.26 **280.77**	— 20.91
Agricultural workers, per person	31.64 14.08	— 24.60	5.26 5.54	33.78 12.26	297.71 71.86	— 1.48
Sources of production costs (excluding depreciation) financing, per thousand roubles	17.39 10.85	29.64 35.98	27.87 35.56	26.21 20.60	— 9.17	— —
Fodder, per thousand roubles	23.98 19.81	13.60 26.68	— 46.63	27.70 62.06	— —	— 28.45
Cows, per animal	15.85 **107.51**	51.98 27.81	5.19 24.62	— 120.61	— 25.42	26.16 66.49
Sows, per animal	— —	— —	— —	72.93 **294.22**	— —	**136.35** **821.87**
Sheep and goats, per productive animal	—	—	—	37.45	—	18.19
Fixed assets used in agricultural production, per thousand roubles	106.84 85.85	— **185.18**	107.62 **139.60**	2.57 52.62	— 65.01	9.88 236.83
Spare parts, per thousand roubles	**948.22**	91.23	253.73	**156.99**	210.70	—

Source: Authors' calculations based on solutions of models (5) (sources of production costs financing), (4) (the rest of inputs) and (3).

Notes: Upper figures relate to 2002, while lower relate to 1999.

Bold font indicates the largest lack per group in the corresponding year.

In 1999 there are no farms lacking sheep and goats.

In 1999 the model misses the constraint on spare parts due to the absence of source data.

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