FARM FIRM MICRO-ECONOMETRIC MODELLING: EMPIRICAL EVIDENCE FROM RUSSIAN DAIRY FARMING

by

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Paper prepared for the Annual meeting of the American Agricultural Economics Association in Chicago (August 5-8)

JEL classification: Q12, P32

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Abstract

This study develops a micro econometric model of specialised dairy farms in Moscow Region using panel data over the period 1995-1998. The model is used to analyse the role of input and output subsidies in the on-farm decision making. Theoretical conditions for short term profit maximization and the fixed effect specification are not rejected by the data. Estimates of the parameters related to input and output subsidies are found to be highly significant. The effect of output subsidies on milk output supply is larger then the price effect. Output subsidies are allocated efficiently in the period 1996-1998 and inefficiently in 1995; input subsidies are allocated efficiently in 1995 and inefficiently in 1996-1998.

1. Introduction

In the past decade, Russian agriculture has passed through a major transformation process that had important effects on its development. The price liberalisation launched in 1992 diminished the role of central planning in the allocation of inputs and outputs in favour of the role of market prices. The price liberalisation was followed by privatisation and a sharp reduction in agricultural subsidies. By now it can be concluded that the privatisation has motivated the new owners to improve management practice (Sotnikov, 1998). However, the transformation created an unfavourable economic environment due to price shifts, reduction of financial support, underdevelopment of financial, supply and marketing systems. As a result, agricultural production declined by 40% between 1991-1998 and a large proportion (84,4% in 1998) of agricultural enterprises (Goskomstat, 1999) became unprofitable.

The problem of agricultural production decline in Eastern European countries has drawn the attention of many agricultural economists. Gow and Swinnen (1998), Macours and Swinnen (1999) indicate that one of the essential reasons for output decline is insufficient financing due to reduced supply of agricultural credit, market uncertainty and high inflation.

This view is supported by the outcome of a recent survey conducted by Goskomstat in 1998 showing that 78% of Russian agricultural enterprises mention lack of finance as the most limiting factor of agricultural development; 55% mention high interest rates; 48% name consumers' insolvency[1].

The lack of external financing limits the production possibilities of the agricultural enterprises. Prior to 1992, agricultural producers were granted subsidies and compensations. According to Goskomstat (1999), the average share of government annual subsidies in the total cash receipts in agriculture in 1996-1998 was about 5.5%, whereas the average share of subsidies for all sectors is approximately 3.5%. In the period 1996-1998, the share of subsidies in agriculture exceeded the share of loans, credits and other sources of external financing by 1.3% on average. Therefore, it may be expected that agricultural production is still sensitive to the level of subsidies.

The main objective of this paper is to analyse the factors influencing input and output allocation at the agricultural enterprises in Russia with a special focus on the effect of subsidies. This objective is achieved by developing a micro economic production model that incorporates subsidies and thus accounts for specific conditions of Russian agriculture. This microeconomic model is estimated on panel data of agricultural enterprises in the Moscow region over the period 1995-1998. It is assumed that agricultural enterprises in Russia are price-takers and behave as short-term profit maximisers.

Due to data limitations, empirical studies on Russian agriculture either have the character of case studies, based on data of a small number of individual farms (see e.g. Yagutkin and Godenko, 2000) or they make use of highly aggregated sector data that are available from the statistical yearbooks (e.g. Sotnikov,1998). Many publications in Russian agricultural economic journals present the results of descriptive studies based on comparison of group averages. Several micro econometric models of agricultural production have been developed for European and Northern American countries (e.g. see Moschini, 1988; Baffes and Vasavada, 1989; Shumway and Gottret, 1991; Helming *et al*, 1993; Oude Lansink and Thijssen, 1998). However, to date, no micro econometric models of Russian agricultural enterprises have been developed.

This paper contributes to the literature, first by developing a micro econometric model of Russian farms and, second by calculating the effects of input and output subsidies on input

[1] Also the respondents mentioned insufficient support from the state, critical condition of the fixed assets, high taxes and inefficient management (Goskomstat, 1999).

and output allocation in Russian agriculture. Furthermore, the micro econometric model is assessed by testing theoretical conditions (convexity and monotonicity) and by analysing price elasticities, elasticities of intensity and shadow prices of fixed inputs and subsidies.

The remainder of this article is organised as follows. Section 2 develops the theoretical model of farm production in the presence of subsidies. This is followed by the specification of the empirical models and a description of the data. The paper ends with a discussion of the results and comments.

2. Theoretical model

The dual short term profit function approach allows for modeling multiple input demand and multiple output supply and forms the base of the theoretical model in this study. Key assumptions in this model are that farm enterprises are maximising short term profit, subject to a convex technology, given quantities of fixed inputs and given prices of outputs and variable inputs. The latter assumption implies that farm enterprises are price takers in markets of inputs and outputs. The assumption of profit maximisation is supported by results of a survey implemented in 1997-1998 in Nizhny Novgorod and Orel regions (Uzun *et al.*, 1999). About 87% of farm managers responded that they are pursuing the strategy of surviving, where 55% explicitly named profit maximisation (loss minimisation) as their goal. In our opinion, the surviving strategy can be modelled as loss minimisation strategy (profit maximisation) under the constraints of keeping the employees and farm assets.

The short-term profit function is assumed to be non-decreasing in output prices, non-increasing in input prices, convex and linearly homogeneous in prices, continuous and twice differentiable (Chambers, 1988) and takes the following form:

$$\pi_h(\mathbf{v}, \mathbf{z}_{1h}, \mathbf{z}_{2h}) = \max_{\mathbf{q}_h}\{\mathbf{v}\mathbf{q}_h \mid \mathbf{z}_{1h}, \mathbf{z}_{2h}\} \equiv \mathbf{v}\mathbf{q}_h \tag{1}$$

Here h is a farm index, π is profit, $\mathbf{q}$ is a vector of netputs (non-negative for outputs and non-positive for inputs) with corresponding positive netput prices $\mathbf{v}$. Profit may be both positive and negative. $\mathbf{z}_{1h}$ and $\mathbf{z}_{2h}$ are vectors of fixed inputs and gross subsidies, respectively. The subsidies may have a pure wealth effect without altering the production decisions or they may have a reallocation effect and play a similar role as prices. The amount of gross subsidies is linked to quantities of inputs and outputs at the level of an individual farm. Therefore, the role of subsidies is similar to the role of prices. Subsidies could be accounted for in the profit function by including the subsidy rate (per unit of output or input). However, subsidy payments often come with a long delay and are uncertain[2]; moreover annual gross payments partly reflect payments for production in the preceding year. Therefore, it was decided to include the observed *amount of gross subsidies*, rather than the *subsidy rate* in the profit function. In what follows, vectors $\mathbf{z}_{1h}$ and $\mathbf{z}_{2h}$ are combined in one vector $\mathbf{z}_h$.

A system of input demand and output supply functions is derived from the profit function using Hotelling's lemma:

$$\frac{\partial \pi_h(\mathbf{v}, \mathbf{z}_h)}{\partial \mathbf{v}_i} = \mathbf{q}_{ih} \tag{2}$$

The shadow prices of fixed inputs $\mathbf{s}_h(\mathbf{v}, \mathbf{z}_h)$ are determined as the first derivative of the profit function to fixed input quantities:

$$\frac{\partial \pi_h(\mathbf{v}, \mathbf{z}_h)}{\partial \mathbf{z}_h} = \mathbf{s}_h \tag{3}$$

The shadow price is equal to the market price when the fixed input is freely disposable and the producer is maximising profit.

3. Empirical specification

This section develops the empirical model of Russian agricultural enterprises. Oude Lansink and Thijssen (1998) mentioned four approaches to selecting functional forms. The majority of studies follows the strategy of estimating several functional forms chosen *a priori* and then discriminate among them upon theoretical conditions (convexity, monotonicity, invariance, etc.) and plausibility of the estimation results (significance of the coefficients, their

[2] Zaiko (1999) has studied the economic performance of 20 agricultural enterprises located in the Moscow region and found that, in 1995-1996 these enterprises received about 48% from the granted level of subsidies.

sign, price elasticity). Literature on microeconomic modelling suggests the use of flexible functional forms[3] since they do not impose arbitrary restrictions on the underlying technology. Commonly used flexible functional forms are the Symmetric Normalised Quadratic (SNQ) and Normalised Quadratic (NQ). These functional forms allow for both positive and negative profits and for imposing convexity in prices globally. However, the NQ functional form has a serious disadvantage compared to the SNQ, i.e. the estimates of the NQ depend on the choice of the *numeraire* (Diewert and Wales, 1987; Shumway and Gottret, 1991; Boots, 1999). Therefore, this study uses the SNQ as a functional approximation for the profit function.

In the empirical specification of the profit function consistent with (1), two outputs (milk q_1, other output q_2), two variable inputs (fodder q_3 and other variable input q_4) and five fixed inputs (labour z_1, arable land z_2, fixed capital z_3, output subsidy z_4, input subsidy z_5)[4] are distinguished. Exogenous netput (positive for outputs, negative for inputs) prices are v_1-v_4.

The SNQ profit function for farm h in each time period t takes the form:

$$\begin{aligned}\pi_{ht} = \sum_{i=1}^{4}\eta_{ih}v_{it} + \frac{1}{2}\left(\sum_{k=1}^{4}\lambda_k v_{kt}\right)^{-1}\sum_{i=1}^{4}\ \sum_{j=1}^{4}\alpha_{ij}v_{it}v_{jt} + \\ \frac{1}{2}\left(\sum_{k=1}^{4}\lambda_k v_{kt}\right)\sum_{i=1}^{5}\ \sum_{j=1}^{5}\beta_{ij}z_{iht}z_{jht} + \sum_{i=1}^{4}\ \sum_{j=1}^{5}\varphi_{ij}v_{it}z_{jht}\end{aligned} \qquad (4)$$

The intercept of farm h in equation i is denoted by η_{ih}. Symmetry is imposed by requiring $\alpha_{ij}=\alpha_{ji}$, $\beta_{ij}=\beta_{ji}$ for all i and j. Linear homogeneity in prices is imposed by the term $\sum_{k=1}^{K}\lambda_k v_{kt}$,

where λ_k is the average share of netput k in total costs plus revenue, so $\sum_{k=1}^{K}\lambda_k = 1$, where $K\in I$

(Kohli, 1993; Boots *et al*, 1997). The term $\sum_{k=1}^{K}\lambda_k v_{kt}$ can be interpreted as a price index with

fixed weights λ.

Corresponding netput equations are derived using Hotelling's Lemma:

[3] According to Chalfant (1984), flexibility provides the first- and second-order partial derivatives of an unknown function at some point ('local flexibility'). The locally flexible functional form is usually a quadratic expression.

$$q_{iht} = \eta_{ih} + \left(\sum_{k=1}^{4} \lambda_k v_{kt} \right)^{-1} \sum_{j=1}^{4} \alpha_{ij} v_{jt} - \frac{1}{2} \lambda_i \left(\sum_{k=1}^{4} \lambda_k v_{kt} \right)^{-2} \sum_{i=1}^{4} \sum_{j=1}^{4} \alpha_{ij} v_{it} v_{jt} + \frac{1}{2} \lambda_i \sum_{i=1}^{5} \sum_{j=1}^{5} \beta_{ij} z_{iht} z_{jht} + \sum_{j=1}^{5} \varphi_{ij} z_{jht} \quad (5)$$

Furthermore, the shadow prices of fixed input j on farm *h* in year *t* (s_{jht}) are derived as:

$$s_{jht} = \sum_{i=1}^{4} \varphi_{ij} v_{it} + (\sum_{k=1}^{4} \lambda_k v_{kt}) \sum_{i=1}^{5} \beta_{ij} z_{iht} \quad (6)$$

The shadow price of input *j* is equal to the market price when the input is freely disposable and the producer is maximising profit over input *j*.

A derivation of uncompensated price elasticities E_{ij} and elasticities of intensity for the fixed inputs E_{iCj} from the parameters of the Symmetric Normalized Quadratic profit function can be found in Oude Lansink and Thijssen (1998). Elasticities of intensity indicate the relation between netputs and fixed inputs. The elasticities of intensity of outputs correspond to short-run production elasticities when farms can adjust all variable inputs and outputs to their optimal level (Higgins, 1986). Uncompensated price elasticities can be used to classify the netputs into substitutes and complements.

4. Data and estimation

Panel data of large-scale specialised dairy farms in the Moscow Region are obtained from a sample of Russian farms collected by the state statistical committee from the farms' annual statistical reports. The sample of specialised dairy farms includes farms for which the share of marketable milk production takes more than 70% of total revenues. The balanced panel set that is used for estimation contains 380 observations on 95 farms over the period 1995-1998. On these farms, on average 79.2 % of revenues comes from milk and 10.4% from beef production. The shares of other livestock production (egg production, pig production) and arable farming (potato, cereals, vegetables and other) are 3.6% and 6.8%, respectively.

Variable inputs are purchased feed (e.g. concentrates) and other variable input (con-

[4] Only four years are available from the data set. In order to avoid linear dependence between netput prices, the number of netputs should not exceed the number of years.

sisting of energy, fuel, seeds, veterinary service, chemicals, material for reconstruction and other). Outputs are milk and other output (cattle meat, pig meat, poultry meat, eggs, cereals, potato, vegetables). Implicit quantities of variable inputs (outputs) are obtained as the ratio of costs (revenues) and Tornqvist price indices.

Tornqvist price indices (see Coelli, 1999) are calculated for the aggregated output and input categories. The price indices vary over years but not over farms, implying differences in the quality and composition of inputs and outputs are reflected in the quantity. The descriptive statistics of the variables are presented in Table II.1 of Appendix II.

Fixed inputs are: labour, sowed land (hereafter referred to as 'land'), capital, subsidies for outputs and subsidies for inputs. The farms' social policies might result in a strategy of keeping the workers on the farm (hidden unemployment) and pay employees in kind. The strategy of keeping employees on the farm is accounted for by treating labour as a fixed input. Labour is measured as the number of agricultural workers on the farm. The land property rights are currently under development in Russia. There is a temporary limitation on land transactions and the land market is still underdeveloped, first, due to low land productivity, second, due to very high transaction costs. Therefore, land is treated as a fixed input. Separate values for machinery and buildings were only available for the years 1997-1998. Since imputation by regression for 1995-1996 produced bad results, the book value of total fixed capital invested in machinery and buildings is used in the profit function. The book value of capital is measured at the beginning of a year and is measured in Roubles of 1995. The level of gross subsidies for outputs and inputs is calculated as the sum of subsidies or compensations for different products reported by the farm within a year.

Convexity in prices of the profit function is satisfied if the Hessian matrix of second order price derivatives is positive semidefinite. Following Diewert and Wales (1987), Ball (1988) and Moschini (1988), we will test for convexity by estimating the matrix of second order price derivatives in its Cholesky factorisation[5]. Convexity is satisfied if all Cholesky values D_{ii} are nonnegative.

The availability of panel data is explicitly taken into account, by assuming that each farm has a farm-specific intercept in the netput equations (fixed effect model (Baltagi, 1995)). The farm specific intercepts reflect variation in farm specific characteristics such as soil, climate and managerial and farm worker capabilities. Estimation of the fixed effect model is en-

[5] Symmetric square matrix **A** can be represented in the non-linear factorisation **A= L D L'**, where **L** is a unit lower triangular matrix and **D** is a diagonal matrix whose elements are the Cholesky values (Ball, 1988).

abled by transforming all variables prior to estimation, thereby avoiding direct estimation of the farm-specific intercepts (i.e. the deviation of each observation from the average over time per farm is used during estimation, see Hsiao (1986)). Farm-specific effects are computed after estimation (see Appendix I). The system of netput equations (5) is estimated with additive error terms. Error terms are assumed to correlated across equations, which is accounted for by employing Iterative Seemingly Unrelated Regression (ITSUR) estimation method. The fixed effect data transformation and estimation are performed using SAS statistical software (release 6.12).

5. Results

In this section, the results of the estimation of the Symmetric Normalised Quadratic are discussed. Price elasticities and elasticities of intensity are presented and regularity conditions are assessed.

We tested for the convexity in prices of the profit function by estimating (5) in the Cholesky factorisation). This condition is satisfied because the null hypothesis that the Hessian matrix is positive semidefinite is not rejected (see table II.2 for the Cholesky values). Monotonicity was assessed for each observation and each netput and is satisfied for all 380 observations except for other outputs in two observations. Since theoretical conditions (monotonicity and convexity) are not violated, it may be concluded that the data support the assumption that the farms in the sample are maximizing short run (variable) profit.

The estimation results of the unrestricted model, i.e. the model without convexity in prices imposed, are presented in Appendix II (Table II.2). The t-values indicate that 44% of the parameters are significant at the critical 5% level and 51% are significant at the critical 10% level. It can be also seen that the percentage of significant parameters related to cross products of prices, α_{ij} is smaller than the average: four out of ten coefficients are significant at the critical 5% level. This may be due to the use of year-specific prices that reduces the price variation in the data (see Oude Lansink, 2000) and the very short time series that was available (4 years).

A farm specific intercept was estimated for each farm and each netput (95 farms and four netputs gives 380 farm-specific intercepts). 58% of the farm-specific intercepts are significant at the critical 5% level and 64% at the10% level. The joint significance of the farm-specific intercepts is tested using an F-test and it is found that the null hypothesis (i.e. all farm-specific intercepts are jointly zero) is rejected at the critical 5% level. The R^2 for the equations of milk output, other output, feed and other variable inputs are respectively 0.97, 0.83, 0.93 and 0.87.

Price elasticities based on the SNQ profit function estimates are calculated at the sample mean and can be found in Table 1.

Table 1. Uncompensated price elasticities at the sample mean (t-statistics in parentheses[6])

	Price of:			
	Milk	Other output	Feed	Other input
Milk	0.369	-0.058	0.005	-0.345
	(2.04)	(-0.38)	(0.06)	(-1.70)
Other output	-0.227	0.402	0.186	-0.321
	(-0.38)	(0.48)	(0.59)	(-0.42)
Feed	-0.006	-0.058	-0.546	0.535
	(-0.06)	(-0.59)	(-6.21)	(2.97)
Other input	0.282	0.067	0.359	-0.682
	(1.70)	(0.42)	(2.97)	(-2.39)

The price elasticities in Table 1 show that milk and other outputs are substitutes, although the relation is not significant at the critical 5% level. Also it can be seen that feed and other inputs are substitutes. All own price elasticities except for that of other outputs are significant at the critical 5% level. The overall small size (in absolute terms) of the own price elasticities suggests that the outputs and variable inputs are price inelastic. The low price responsiveness of supply and demand of dairy farms in Moscow Region in 1995-1998 can be explained from the fact that price is only one of the factors affecting the level of agricultural production. Boots et al. (1997) also detected low price elasticities for Dutch dairy farms over the period 1972-1992. The own price elasticities found by Boots et al. (1997) for milk (0.26), other outputs (0.22), feed (-0.40) and other inputs (-0.28) are similar in size compared to the own price elasticities found in our study.

[6] T-statistics were calculated using the following formula for variances: $\sigma^2 = \mathbf{f'}\,\mathbf{\Omega}\,\mathbf{f}$, where **f** is a vector of partial derivatives of the variance function with respect to the parameters of the estimated profit function. $\mathbf{\Omega}$ is a covariance matrix of the estimated parameters (see Rao, 1973).

Table 2. Elasticities of intensity at the sample mean (t-statistics in parentheses)

	Labour	Land	Capital	Output Subsidy	Input Subsidy
Milk	0.319	0.292	0.019	0.943	-0.024
	(2.83)	(2.46)	(14.57)	(38.50)	(-1.00)
Other output	0.607	0.270	0.008	-0.181	0.177
	(0.75)	(0.27)	(0.07)	(-0.84)	(1.76)
Feed	0.367	0.156	-0.156	0.071	-0.053
	(3.44)	(1.39)	(-7.61)	(2.55)	(-2.95)
Other input	0.313	0.177	-0.110	0.084	-0.040
	(2.35)	(1.23)	(-5.02)	(2.57)	(-1.92)

Elasticities of intensity shown in Table 2 give the effect of increases in the quantities of fixed inputs and subsidies on quantities of variable inputs and outputs. The elasticities of intensity of milk (other outputs) can be considered as production elasticities of fixed inputs given that all variable inputs and all outputs can be adapted freely to the optimal level at the same time. Approximately 60% of the elasticities of intensity is significantly different from zero at the critical 5% level. Labour and land are complements of feed and other inputs, whereas capital is found to be a substitute for these variable inputs. Output supply and input demand are mostly affected by variations in labour, whereas variations in capital have small but overall significant effects on variable inputs and outputs. The elasticity of milk output with respect to output subsidy is close to unity and 2.5 times greater than the own milk price elasticity. This implies that outputs are more responsive to subsidy signals than to market signals. The impact of input subsidies on input demand is much smaller.

Results in Table 2 also show that on specialised dairy farms the output subsidies increase milk production and decrease production of other outputs. Therefore, on specialised dairy farms, output subsidies provide an incentive for (further) specialisation in milk. Input subsidies have the opposite effect: they decrease demand for inputs, increase production of other outputs and decrease production of milk. However, it should also be noted that the size of the elasticities of input subsidies is smaller than the size of the elasticities of the output subsidies and that most elasticities of input subsidies are not significant.

Table 3. Average shadow prices of fixed inputs and subsidies in 1995-1998 (t-statistics in parentheses)

Year	Labour	Land	Capital	Output Subsidy	Input Subsidy
1995	-0.230	0.236	0.111	1.265	-0.296
	(-0.90)	(0.97)	(2.92)	(2.12)	(-0.40)
1996	-0.660	-0.310	0.258	-1.297	2.731
	(-2.59)	(-1.27)	(6.78)	(-2.18)	(3.66)
1997	-0.538	-0.447	0.383	-1.488	2.373
	(-2.11)	(-1.84)	(10.07)	(-2.50)	(3.18)
1998	-0.418	-0.448	0.425	-1.281	2.220
	(-1.64)	(-1.84)	(11.17)	(-2.15)	(2.98)

Shadow prices of fixed inputs and subsidies are given in Table 3. It can be seen that shadow prices of the year 1995 substantially differ from those in the period 1996-1998. Analysis of profitability of the farms in the sample shows that 40% of the dairy enterprises became unprofitable after the year 1995. Negative shadow prices for labour and arable land indicate that these fixed inputs are overused by dairy farms. The average price of renting one hectare of arable land in Moscow Region is not known from the official statistics. According to our expectations, the price of renting should be approximately equal to the gross margin (revenue minus variable costs) per hectare. The gross margin is approximated as the profit/loss per hectare of arable land[7], which is calculated from the data as 0.27, -0.35, -0.30 and -0.23 million roubles of 1995. The shadow price of capital is expected to be around 0.15 (interest, depreciation and maintenance) and is found to be below this value in 1995 and well above this value in the years 1996-1998. The difference between the shadow value of capital and 0.15 is not significant in 1995 and is significant in the period 1996-1998. This indicates that specialised dairy farms are under-capitalised since 1996. The increasing value for the shadow price of capital indicates that the degree of under-capitalisation increases over time.

Input and output subsidies are allocated optimally among inputs and outputs when the shadow prices of these subsidies are minus one. Results in Table 3 show that output subsidies are well above minus one in 1995 and smaller than minus one thereafter. The difference be-

[7] These values are corrected for the consumer price index to allow for a comparison.

tween the average shadow price of output subsidies and minus one is significant (at 5%) in 1995 and not in the period 1996-1998. This implies that allocative efficiency of output subsidies has improved after the deterioration of farm profitability after 1995, i.e. output subsidies are allocated optimally in the period 1996-1998 and not 1995. The input subsidies show the opposite development. In 1995, the shadow price of input subsidies is negative and not significantly different from minus one (at 5%); in the period 1996-1998 it is positive and significantly different from minus one. This implies that the allocative efficiency of input subsidies has worsened following the fall in farm profitability after 1995.

6. Conclusions

In this paper a microeconomic model of specialised dairy farms in Russia is developed in order to analyse their economic behaviour and the allocative effects of input and output subsidies. The model is estimated on panel data of specialised dairy farms in the Moscow region over the period 1995-1998.

Results show that convexity in prices is not violated, whereas monotonicity is violated for less than one percent of the observations. Therefore, necessary conditions for the hypothesis that the farms in the Moscow region are maximising short-run profit are not violated.

Price elasticities show that output supply and input demand have small responses to own price changes. Milk and other outputs are found to be substitutes, as are feed and other inputs. Output and input subsidies have a significant effect on supply of outputs and demand for variable inputs, indicating that they play an important role in decision making on Russian dairy farms. The elasticity of milk production to output subsidies is larger than the elasticity to milk prices. Furthermore, it is found that output subsidies encourage specialisation in milk production, whereas input subsidies encourage diversification to other outputs. Shadow prices of land and labour show a dramatic fall after 1995 that is explained by the fall in farm profitability. Shadow prices of fixed inputs indicate that land and labour are overused, whereas capital is, on average underused on the farms in the sample. Shadow prices of subsidies show that output subsidies are allocated *efficiently* after 1995, i.e. after profitability dropped dramatically. Input subsidies are allocated *inefficiently* after the drop in farm profitability.

Specialised dairy farms in the Moscow region account for approximately 30% of the total number of large operating agricultural enterprises. Other large enterprises are specialised in livestock production or combine crop and livestock production (mixed specialisation). A natural extension of this study is to apply the micro economic modelling framework that was adopted in this paper to other large-scale farms. Another extension of the modelling framework in this paper is to account for credit constraints and uncertainty about revenues due to delayed payments by processing firms (e.g. dairy plants).

Acknowledgements

We gratefully acknowledge the financial support by the Mansholt Graduate School (Wageningen University, the Netherlands) provided for the research on which this paper is based.

References

Baffes, J. and U. Vasavada (1989). On the choice of functional forms in agricultural production analysis. *Applied Economics*, **21**, 1053-1061.

Ball, V.E. (1988). Modelling supply response in a multiproduct framework. *American Journal of Agricultural Economics*, **70**, 813-825.

Baltagi, B.H. (1995). *Econometric analysis of panel data*. Chichester: Wiley.

Boots, M., A.Oude Lansink and J. Peerlings (1997). Efficiency loss due to distortions in Dutch milk quota trade. *European Review of Agricultural Economics*, **24**, 31-46.

Boots, M.G. (1999). Micro-economic analysis of alternative policies for Dutch dairy farming. Dissertation. Wageningen Agricultural University.

Chalfant, J.A. (1984). Comparison of alternative functional forms with application to agricultural input data. *American Journal of Agricultural Economics,* **66**, 216-220.

Chambers, R.G. (1988). *Applied production analysis*, Cambridge University Press.

Coelli, T., D.S.P Rao, G.E. Battese (1999). *An introduction to efficiency and productivity analysis*. Kluwer Academic Publishers.

Diewert, W.E. and T.J. Wales (1987). Flexible functional forms and global curvature conditions. *Econometrica*, **55**, 43-68.

Goskomstat (1999). *Rossiiskyi Statisticheskyi Ezhegodnik* [Russian Statistical Yearbook, *in Russain*]. Moscow.

Gow, H.R. and J.F.M. Swinnen (1998). Agribusiness Restructuring, Foreign Direct Investment, and Hold-Up Problems in Agricultural Transition. *European Review of Agricultural Economics*, **25**(3), 331-350.

Helming, J, A. Oskam and G. Thijssen (1993). A micro-economic analysis of dairy farming in the Netherlands. *European Review of Agricultural Economics*, **20** (3), 343-363.

Higgins, J (1986). Input demand and output supply on Irish farms – A micro economic approach. *European Review of Agricultural Economics,* **13**, 477-493.

Hsiao, C. (1986). *Analysis of panel data*. Cambridge, Cambridge University Press.

Kohli, U. (1993). A symmetric normalised quadratic GNP function and the US demand for imports and supply of exports. *International Economic Review,* **34**, 243-255.

Macours, K. and J.Swinnen (1999). Causes for output decline in economic transition: The case of central and Eastern European agriculture. Paper presented at the IX EAAE Congress 1999, Warsaw, Poland.

Moschini, G. (1988). A model of production with supply management for the Canadian agricultural sector. *American Journal of Agricultural Economics,* **70**, 318-329.

Oude Lansink, A. and G. J. Thijssen (1998). Testing among functional forms; an extension of the Generalised Box-Cox formulation, *Applied economics,* **30**, 1001-1010.

Oude Lansink, A.G.J.M. (2000). Productivity growth and efficiency measurement: a dual approach. *European Review of Agricultural Economics,* **27** (1), 59-73.

Rao, C. (1973). *Linear statistical inference and its applications*. Wiley, New York.approach.

Shumway, C.R. and P.E. Gottret (1991). Numeraire choice in normalised quadratic functional choice. *Applied Economics,* **23**, 1597-1602.

Sotnikov S. (1998). Evaluating the effects of price and trade liberalization on the technical efficiency of agricultural production in a transition economy: The case of Russia. *European Review of Agricultural Economics,* **25**, 412-431.

Thijssen, G.J. (1992). Micro-econometric models of Dutch dairy farms. *Wageningen Economic Studies*, **25**, Wageningen.

Uzun V.Ia. et al. (1999). Sotsial'no-ekonomicheskii analiz rezul'tatov reorganizatsii sel'skokhoziaistvennykh predpriiatii (Sociological and economic analysis of the outcome of agricultural enterprises reorganisation). Moscow, Entsiklopedia rossiiskikh dereven' (in Russian).

Yagutkin, S., L.Godenko (2000). Reservy antikrizisnogo upravleniya. *Ekonomika sel'skogo khozyaistva Rossii,* [Reserves of anticrisis management, *Economy of Russian agriculture*, in Russian], **3**, 28-29.

Zaiko, N.S. (1999). Ekonomicheskiye metody obosnovaniya upravlencheskikh resheniy po zemlepol'zovaniuy sel'skokhozyaistvennykh predpriyatii [Economic methods of decision making about land use at the agricultural enterprises, *in Russian*], dissertation, Moscow Timiryazev Agricultural Academy.

Appendix I: Farm specific effects

The farm specific effects α_{ih} can be calculated in the following way for the SNQ:

$$\alpha_{ih} = \overline{q}_{ih} + \frac{1}{2}\lambda_i \sum_{i=1}^{4} \sum_{j=1}^{4} \tilde{\alpha}_{ij} \overline{w}_i \overline{w}_j - \sum_{j=1}^{4} \tilde{\alpha}_{ij} \overline{w}_j$$
$$- \frac{1}{2}\lambda_i \sum_{i=1}^{5} \sum_{j=1}^{5} \tilde{\beta}_{ij} \overline{z}_{ih} \overline{z}_{jh} - \sum_{j=1}^{5} \tilde{\varphi}_{ij} \overline{z}_{jh}$$

Where $\overline{w}_i = \left(\frac{v_i}{\sum_{k=1}^{4} \lambda_k v_{kt}} \right)$ is the farm-specific average value of the normalised prices.

Here the notation is similar to (1-3). Tildes denote the estimates of the models and bars denote the averages over time per farm. It is assumed that the average of the reminder disturbance per farm, that is the part of the error term which is not farm-specific, is zero (Boots *et al.*, 1997; Baltagi, 1995).

Appendix II: Data and estimation results

Table II.1 Description of data set of dairy farms

Variable	*Dimension/base year*	*Sym-bol*	*Period: 1995-1998* *Observations: 380* *Number of farms:95*	
			Mean	Standard deviation
Price indices				
Milk	Base year 1995	v_1	0.908	0.081
Other output	Base year 1995	v_2	0.971	0.066
Feed	Base year 1995	v_3	1.144	0.125
Other input	Base year 1995	v_4	0.983	0.015
Quantities				
Variable input				
Milk output	10^6 roubles of 1995	q_1	2.650	2.512
Other output	10^6 roubles of 1995	q_2	0.637	0.529
Feed	10^6 roubles of 1995	q_3	-1.727	1.108
Other input	10^6 roubles of 1995	q_4	-2.993	1.777
Fixed input				
Labour	10^2 number of workers in agriculture	z_1	2.300	1.012
Arable land	10^3 Hectares	z_2	2.542	1.194
Capital	10^7 roubles of 1995	z_3	3.059	3.375
Output subsidies	10^6 roubles of 1995	z_4	0.278	0.321
Input subsidies	10^6 roubles of 1995	z_5	0.138	0.215

Table II.2 Parameter estimates of the SNQ function and estimated t-values (corrected for fixed effects*)

Parameter	Value	t-value	Parameter	Value	t-value
α_{11}	1.494	2.04	φ_{11}	0.501	2.84
α_{12}	-0.221	-0.38	φ_{12}	0.485	2.60
α_{13}	0.017	0.06	φ_{13}	-0.022	-1.03
α_{14}	-1.290	-1.70	φ_{14}	0.619	2.10
α_{22}	0.366	0.48	φ_{15}	-0.068	-0.64
α_{23}	0.143	0.59	φ_{21}	0.211	2.87
α_{24}	-0.288	-0.42	φ_{22}	0.114	1.64
α_{33}	1.143	6.21	φ_{23}	-0.009	-0.90
α_{34}	-1.303	-2.97	φ_{24}	-0.507	-3.53
α_{44}	2.881	2.39	φ_{25}	0.921	5.41
β_{11}	-0.186	-0.72	φ_{31}	-0.134	-1.04
β_{12}	-0.106	-0.64	φ_{32}	0.045	0.33
β_{13}	0.012	0.42	φ_{33}	0.053	3.35
β_{14}	0.394	0.66	φ_{34}	-0.745	-2.59
β_{15}	-0.100	-0.14	φ_{35}	1.001	3.15
β_{22}	-0.171	-0.99	φ_{41}	-0.197	-0.87
β_{23}	0.040	1.94	φ_{42}	0.018	0.08
β_{24}	-0.457	-1.11	φ_{43}	0.056	2.11
β_{25}	0.569	1.05	φ_{44}	-1.363	-2.72
β_{33}	-0.014	-1.88	φ_{45}	1.372	2.34
β_{34}	0.500	3.40	D_{11} **	1.449	1.98
β_{35}	-0.628	-3.40	D_{22}	0.267	0.41
β_{44}	2.823	1.72	D_{33}	1.068	4.65
β_{45}	-6.150	-3.20	L_{12}	-0.112	-0.35
β_{55}	7.908	2.51	L_{13}	0.014	0.08
			L_{23}	0.475	0.51

* Since the intercept is not included when using a typical regression package, correction of the standard errors should be done by multiplying them by the following coefficient:

$\left(\frac{N*G-K}{N*G-H*G-K}\right)^{\frac{1}{2}}$, where N is the total number of observations, G is the number of equations in which fixed effect is included, K is the number of estimated parameters and H is the number of farms (Baltagi, 1995).

** Values L_{12}- L_{23} and D_{11}-D_{33} obtained from the Cholesky decomposition and derived from the estimation of the non-linear system of netput equations.