Supply Response of Ukrainian Agriculture

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Abstract

This study explores the impact of technical inefficiency on agricultural supply functions in Ukraine. Two models using a system of output supply and input demand equations were evaluated in this research: one without inefficiency included in the model and another with inefficiency included. A likelihood ratio test found that the model with inefficiency included was the preferred model in this case. Incorporation of inefficiency into the model increased output supply elasticities and did not dramatically change input demand elasticities. The own-price elasticities for grains, sugar beets, sunflowers, and potatoes showed inelastic positive signs that were statistically significant. The own-price input demands were negative and also inelastic; however, only fertilizer and fuels were statistically significant.

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1. Introduction

Ukraine undertook significant changes in its economic system in the early 1990s, such as restricting state interference in economic activity, reducing subsidies to the agricultural sector, and liberalizing trade. During this period agricultural output declined dramatically. However, some positive changes were noticeable. Among these changes were a reduction of inflation levels, relative stability of the national currency, and increased personal incomes. With all these changes, prices in the Ukrainian agricultural sector were stabilizing. In 1997, for example, prices on agricultural commodities increased by 5 percent compared to the previous year; in 1998 this indicator was ten percent (Puhachov, 2000). Changes in prices of industrial products used by farmers were similar. By 1997-99, the price dynamics in Ukraine stabilized somewhat.

The transition period to a free market economy was characterized by policy and institutional reforms. The effect of these reforms on the determinants of crop and livestock supply is unknown and determined by specific-country circumstances. This study attempts to analyze supply response of Ukrainian crop production during the period of price and trade liberalization, land privatization, and the development of a financial system. This research attempts to measure basic free market behavior in an economy in transition from a socialist to a capitalist structure with consideration of technical inefficiency, which has been found to be widespread in Ukrainian agriculture (Jensen et al., 1996; Murova et al., 2000).

The goal of this study is to estimate agricultural supply functions in Ukraine, with and without technical inefficiency incorporated in the models. In most previous research, efficiency is maintained by assumption. By relaxing this assumption in a profit function framework, two important questions are addressed: Is the supply function misspecified without technical efficiency incorporated? If so, how much of an impact does inefficiency have on supply elasticities for different crops? The model with technical inefficiency incorporated will be shown to be the preferred model, but its impact on supply parameters varies by commodity.

This study is organized as follows. Section 2 derives a theoretical supply model that incorporates technical inefficiency, discusses efficiency measurement. Section 3 describes the Ukrainian crop data used in estimation and discusses some important empirical issues related to the data. Section 4 presents the results of the supply models, without and with technical inefficiency incorporated. Section 5 concludes by reviewing the main results.

2. Methodology

There are a few different approaches to estimating supply functions. A traditional approach has been to estimate supply function in the tradition of Nerlove (1958). His model analyzed the supply response of the US farmers for cotton, corn, and wheat for 1909-32.[1] Nerlove used the least-squares technique on the following reduced form equation:

$$Q_t = \pi_0 + \pi_1 P_{t-1} + \pi_2 Q_{t-1} + \pi_3 Q_{t-2} + \pi_4 Z_t + \pi_5 Z_{t-1} + v_t, \qquad (1)$$

where:

Q_t – total value of observed output;
P_{t-1} – observed price for a given commodity in the t-1 period;
Q_{t-1}, Q_{t-2} – total value of output lagged by one and two periods;
Z_t – relevant and observable variable;
π_i – structural coefficients;
v_t – residual term.

[1] Empirical studies of agricultural supply functions in this tradition were surveyed for various commodities worldwide by Askari and Cummings (1976).

In this research, different models were used based on the values of the coefficient of expectations, lagged price, and lagged acreage by one or two years.

More recent work generally has used duality theory to derive a system of supply equations from the indirect profit function (Chand and Kaul, 1986; Shumway and Lim, 1993). This type of model has been extended recently to examine the effects of technical inefficiency on supply for crops in Russia (Arnade and Trueblood, 2000). This paper closely follows this latter paper. Two models are considered: one model without technical efficiency and the other with technical efficiency. These models are derived below.

First, Färe and Primont determined that the distance function is homogenous of degree of *-1/k* in outputs if the technology is homogenous of degree *k* (Färe et al., 1994):

$$\gamma^{-(1/k)} = D(y,x) = D\,(\gamma y,\, x) \qquad (4)$$

where D(·) is the distance function, *y* a vector of outputs, and *x* a vector of inputs. Duality of the cost function and distance function is considered here. This duality is expressed as:

$$C(y,w) = \min wx \text{ s.t. } D(y,w) = 1 \qquad (5)$$

Färe established that the distance function is equal to the inverse of the technical inefficiency measure θ (Färe et al., 1990). Thus, the cost minimization problem can be written as:

$$C(y,w) = \min wx \text{ s.t. } D(y,w) = 1/\theta \qquad (6)$$

$$\min wx \text{ s.t. } \theta\, D(y,x) = 1 \qquad (7)$$

$$\min wx \text{ s.t. } D(\, \theta^{-k}\, y,\, x) = 1 \qquad (8)$$

The efficiency measure is one of the parameters of a distance function homogeneous to the degree -*k*. Because of the duality of the cost and distance function and the fact that the distance function is homogenous of degree *-1/k* in outputs, if the technology is homogenous of degree *k*, the previous expression can be rewritten as $C(\theta^{-k} y, w) = \theta^{-1} C(y,w)$.

The profit maximization problem, then, can be written as:

$$\text{Max}_y\ p_i y_i - \theta^{-1} C(y_i, w_i). \tag{9}$$

The first order conditions of this profit maximization function are:

$$p_i = \theta^{-1} \partial C/\partial y_i, \text{ or} \tag{10}$$

$$\theta p_i = \partial C/\partial y_i. \tag{11}$$

The profit function at the optimal output level will be:

$$\Pi^* (\theta p_i, w_i) = \max p_i y_i^* - \theta^{-1} C(y_i^*, w_i), \tag{12}$$

where y* is the optimal output level. This model differs from the model without inefficiency included. In this model, inefficiency enters the profit function with output prices multiplied by inefficiency.

In order to implement the model specified above, technical efficiency scores need to be computed and a functional form for the supply function has to be specified. There are two well-established approaches for measuring technical efficiency: data envelopment analysis (DEA) and stochastic frontier analysis (SFA).[2] The DEA is a programming approach, whereas SFA uses econometric techniques. This study uses the DEA approach in order to obtain technical efficiency scores through nonparametric methods, which can be used in subsequent econometric analysis without resorting to sequential econometric estimation.[3]

DEA can be used with an input or with an output orientation. In this study, estimation of static technical efficiency was estimated using direct primal data and output orientation. With the output orientation, a producer's level of input is held fixed, so that technical efficiency (θ) is measured as a ratio of observed output to the maximum level of output to reach the frontier ($1 \leq \theta \leq \infty$).

Computationally, the output orientation technical efficiency score for producer *i* under constant returns to scale (CRS) was attained by solving the following linear programming problem:

$$F(x_i, y_i \mid C) = \max_{\theta, z} \theta \quad \text{s.t. } \theta y_i \leq zM$$
$$zN \leq x_i$$
$$z_i \geq 0 \ (\forall i),$$

where

x_i input for the producer i,
y_i output for producer i,
θ efficiency score,
z an activity intensity variable,
M is an i x m matrix of outputs for a set of producers i,
N is an i x n matrix of inputs for a set of producers i.

The F(·) notation represents Farrell's definition of technical efficiency (Farrell, 1957).

For the supply function, the following quadratic model is considered:

$$\Pi = \Pi((\theta * p), w) = \sum B_i \theta p_i + \sum B_i w_i + \sum B_{ij} \theta^2 p_i p_j + \sum B_{il} w_i w_l$$
$$+ \sum B_{ik} \theta p_i w_k + \sum \gamma_{il} \theta p_i \, Ld + \sum \gamma_{il} \, w_i \, Ld . \qquad (13)$$

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[2] These approaches are summarized in Coelli, Rao, and Battese (1998).
[3] A separate but related paper estimates and compares technical efficiency with both approaches (Murova et al., 2000). These findings are discussed later in the results.

From Hoteling's Lemma, the 5 output supply equations are:

$$y_i = B_i\,\theta + \sum B_{ik}\,\theta\,w_k + \sum B_{ij}\,\theta^2\,p_j + \gamma_{il}\,\theta\,Ld + u_i \qquad (14)$$

The 3 input demand equations are:

$$-\,x_i = B_i + \sum B_{il}\,w_l + \sum B_{ik}\,\theta\,p_i + \gamma_{il}\,Ld + v_i \qquad (15)$$

In these equations, y_i is the output quantity, x_i is the input quantity, p_j is the output price, w_k is the input price, *Ld* is the planted acreage, and u_i and v_i are the error terms for output supply and input demand equations. Land is treated as a fixed input. This system of eight equations is estimated using iterative seemingly unrelated regression (SUR) to account for potential correlation between the error terms.

Prices are normalized by the price of labor, thus imposing the homogeneity restriction and addressing any inflation problems. The own-price elasticities are derived using the following formula:

$$b_{ii} = B_{ii} * (p_i / y_i), \qquad (16)$$

where:

B_{ii} – i-th coefficient of the i-th equation;
p_i – output price of the i-th crop, calculated at mean levels;
y_i – output quantity of the i-th crop, calculated at mean levels.

Cross-price elasticities are estimated using:

$$b_{ij} = B_{ij} * (p_j / y_i), \qquad (17)$$

where:

B_{ij} – i-th coefficient of the j-th equation;
p_j – output price of the j-th equation;
y_i – output quantity of the i-th crop.

3. Data

Panel data were collected from sources published by the Ukrainian Ministry of Statistics. Data for 25 Ukrainian oblasts (equivalent to states or provinces) were collected for the period from 1993-1996. The data used in this study include the corporate and the private sectors of Ukrainian agriculture. Since input and output prices are lagged by one year, the time period is reduced to 1994-96. Quantities and price data were collected for 5 outputs (grains, sugar beets, sunflowers, potatoes, and vegetables) and three inputs (fertilizers, electricity, and fuel). Also, planted acreage for each oblast was used.

These data are summarized in Table 1. The prices of sunflowers, potatoes, and vegetables were quite similar for this time period, with sunflowers being the most expensive crop. However, the largest crop produced during the years 1994-96 was for grains (wheat, barley, rye, oats, millet, rice, and buckwheat), followed closely by sugar beets.

There are two important data-related issues that merit discussion: cross-sectional versus time series data and aggregation issues. On the first matter, Rao's survey of the literature on agricultural supply functions in developing countries found very different estimates were obtained when time series data were used compared to cross-sectional data (Rao, 1989). One of his conclusions was that time series estimates were generally lower than cross-sectional estimates, but there is substantial variation across commodities and levels of aggregation.[4] This study uses a panel database that is relatively short in time series (T = 4) and large in cross-sectional observations (N = 25).

The other problem of aggregation also is important. In this case, oblast (state) level data are used. Other researchers have recognized this problem previously, yet in many instances

[4] Of course, other methodological factors are important, too, such as the treatment of country-specific factors relating to technology, risk, farm size, economic structure and macroeconomic constraints.

aggregate data were used to estimate supply response models. Shumway and Lim used national data to estimate output supply and input demand elasticities for different functional forms of a profit function (Shumway and Lim, 1993). Shumway and Alexander estimated output supply and input demand equations for 10 regions of the United States using regional data (Shumway and Alexander, 1988). Moreover, aggregate data are also used in many other areas of economic analysis. For instance, agricultural productivity indexes are frequently calculated at the state or national level (e.g., Chambers and Pope, 1996). Aggregate data arguably reduce the noisy random variation associated with firm-level data. Thus, research on supply response commonly use aggregate data while imposing or testing firm-level theoretical assumptions.

4. Results

The technical efficiency scores were computed using the DEAP software program and are reported in Table 2. The average DEA scores fluctuated year to year, but displayed an upward trend over 1991-94 and then declined until 1996 (data before 1994 not shown in table).[5] Average technical efficiency scores decreased from 0.836 in 1994 to 0.751 in 1996. Vinnitskaya, Volinskaya, and Ivano-Frankovskaya oblasts exhibited the highest increase in technical efficiency compared to other oblasts (28 percent, 20 percent, and 1 percent, respectively). Krimskaya, Donetskaya, and Odesskaya oblasts showed the largest decrease in technical efficiency during this time period. Oblasts in the Ukrainian heartland had relatively high average technical efficiency score improvements.

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[5] The companion paper to this study explores the interpretation of this finding in greater detail (Murova et al., 2000). In short, the results suggest that positive reform forces (price and trade liberalization, enterprise privatization) had a greater impact on technical efficiency than the negative forces (start-stop land privatization efforts, slow reforms in labor and credit markets, erratic policy

The SHAZAM econometrics computer program was used to estimate the profit function. The supply elasticities for the model without technical efficiency included are reported in Table 3. The statistical significance of the reported elasticities represents the statistical significance of the respective coefficients. Coefficients and their t-ratios for this model are given in Table 5. The coefficients of the own-price elasticity for this model were statistically significant for grains, sugar beets, sunflowers, potatoes, fertilizers, and fuel.

The own-price elasticities for outputs were positive and statistically significant, with the exception of grains and vegetables. These elasticities exhibited inelastic long run supply relationships, which is consistent with previous research. For example, the elasticity of grains came out to be 0.1063. This can be compared to Shumway and Lim's estimate of U.S. grains' own-price elasticity of 0.24. They used data for the years 1974-1982 and assumed a generalized Leontief functional form.

The own-price elasticity for sugar beets was estimated to be 0.0839. A somewhat larger elasticity of 0.1747 was found for sunflowers. The own-price elasticity for potatoes was 0.4375. Potatoes were more price-responsive than the other crops. This crop was the most critical commodity during this period in Ukraine, as it served a food-rationing role during this difficult transition period. In Shumway and Lim's study, the own-price elasticity for crops was 0.42. Thus, these estimates are generally lower in comparison to the previous estimates.

The own-price elasticities for input demands have the appropriate signs, but their magnitudes were considerably lower than the magnitudes for output supply elasticities. The own-price elasticity for fertilizer was statistically significant and equal to –0.0035. The coefficients for both electricity and fuels were not statistically different from zero. These inputs

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changes). This finding might seem surprising at first, but the aggregate data suggest it is accurate. Output declined, but inputs contracted even faster, particularly for labor and fertilizers.

were not price responsive, which intuitively make sense in this Ukrainian model. At this time, the government was trying to reduce producers' risk by organizing different credit programs and by requiring producers to market grains through the state by offering stable prices. This interference likely contributed to inelastic input demand.

The second model included the inefficiency measure. Table 4 displays elasticities and Table 6 their respective coefficients and their t-ratios. The results from this model show that the own-price elasticity estimates increase relative to the first model. In this case, the elasticities for grains and vegetables are statistically significant. The own-price elasticity is 0.2041 for grains, 0.2065 for sugar beets, 0.3147 for sunflowers, and 0.5280 for potatoes. The own-price elasticity for vegetables had an unexpected negative sign, –0.3861. This anomalous result can be explained by the degradation and absence of technology, and by the return to manual labor in the production of vegetables. Also, many consumers were unable to afford this commodity group at high market prices, so they grew vegetables on their private plots or simply excluded vegetables from their diet.

The own-price elasticity for input demands increased in absolute value terms as well. The values of these new estimates are very close to the estimates from research on US agricultural production elasticities (Shumway and Lim, 1993). The statistical significance of the respective coefficients of the own-price elasticities did not change in this model.

Incorporating inefficiency changed the cross-price relationships between outputs. In this model, the cross-price signs of grains, sugar beets, sunflowers, and potatoes indicated that they were substitutes. Inefficiency increased the absolute value of the own-price elasticity of fertilizer and reduced in absolute value the own-price elasticity of fuel. The cross-price relationships between inputs did not change.

A likelihood ratio test was used to examine the hypothesis that the model without technical efficiency is preferred to the model with technical efficiency. The null hypothesis of the model without inefficiency included was rejected in favor of a model in which inefficiency was included. The test value 43.6 exceeded the critical value of 5.99 at the 95 percent confidence interval for two degrees of freedom. Thus, the model with inefficiency was the preferred model in this case.

5. Conclusions

This study has explored the impact of technical inefficiency on agricultural supply functions in Ukraine. The first issue that was examined was whether the supply models were misspecified if they did not allow for technical inefficiency. Two systems of input demand and output supply equations were evaluated in this research: one without inefficiency included and another with inefficiency included. The solutions to both systems of equations produced useful results. However, a likelihood ratio test found that the model with technical inefficiency was the preferred model in this case.

The second issue concerned the impact of technical inefficiency on the supply function model. Incorporation of inefficiency increased the output supply elasticities, but did not affect the input demand elasticities very much. The own-price elasticities for output supply for grains, sugar beets, sunflowers, and potatoes showed inelastic positive signs that were statistically significant. The magnitudes of the elasticities in the model with inefficiency included were close to those estimated for crops in U.S. agriculture. This outcome showed that perhaps the forces of the free market economy are beginning to operate in Ukraine in the midst of reforms, despite a certain degree of chaos in the implementation of these reforms.

The own-price input demands were negative and also inelastic; however, only fertilizer and fuels were statistically significant. The magnitudes of the elasticities were very small. This very low price responsiveness suggests that barriers to functioning free markets were still prevalent. The low response may be due to very high prices of inputs, especially fuel, and to shortages of these inputs in the markets during 1994-96.

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Table 1 - Data Summary for 25 Ukrainian Oblasts for the Period 1994-96

Variable	Unit	Mean	Std. Dev.	Min	Max
Profit	Billion grivnia	11,500	14,200	3.52	95,300
Price of labor	Grv/1000 mandays	4,222,219	5,898,658	3,172	16,160,826
Price of fertilizer	Grv/1000MT	136	178	0.078	597
Price of electricity	Grv/1000Kwh	23.9	51.3	0.069	326
Price of fuel	Grv/1000MT	12	18	0.007	85
Price of grains	Grv/1000 MT	2,921.9	3,934	0.1	10,046
Price of sugar beets	Grv/1000 MT	900	2,411	0.0	16,607
Price of sunflowers	Grv/1000 MT	6,401	10,366	0.2	38,188
Price of potatoes	Grv/1000 MT	6,041	6,293	13	20,640
Price of vegetables	Grv/1000 MT	6,202	5,326	11	19,152
Quantity of labor	1000 mandays	6,586	3,010	1,571	14,837
Quantity of fertilizer	1000 MT	97	101	6.9	453
Quantity of electricity	1000 Kwh	120,820	75,881	0	363,667
Quantity of fuel	1000 MT	98	48	0	211
Quantity of grains	1000 MT	1,253	563	197	2,469
Quantity of sugar beets	1000 MT	1,068	1,002	0	3,981
Quantity of sunflowers	1000 MT	87	105	0	390
Quantity of potatoes	1000 MT	658	401	46	1,687
Quantity of vegetables	1000 MT	160	89	52	463
Quantity of land	1000 ha.	1,630	604	442	2,546
Efficiency score	Score	0.759	0.162	0.384	1.00

Table 2 – DEA-C Technical Efficiency Scores by Oblast in Ukraine for 1994-96

	1994	1995	1996
Autonom. Rep. Krim	0.830	0.753	0.449
Cherkasskaya	0.919	0.780	0.741
Chernovetskaya	0.849	0.765	0.741
Chernigovskaya	1.000	0.689	1.000
Dnepropetrovskaya	0.895	0.762	0.833
Donetskaya	1.000	0.787	0.633
Hersonskaya	0.447	0.510	0.454
Hmelnitskaya	0.684	0.668	0.521
Ivano-Frankovskaya	0.993	0.766	1.000
Kievskaya	1.000	0.642	0.978
Kirovogradskaya	0.956	0.921	0.779
Kharkovskaya	0.816	0.744	0.845
Luhanskaya	0.608	0.503	0.588
Lvovskaya	0.906	0.699	0.930
Nikolaevskaya	0.940	0.651	0.728
Odesskaya	0.612	0.673	0.384
Poltavskaya	0.919	0.823	0.781
Rovenskaya	0.829	0.545	0.824
Sumskaya	0.769	0.557	0.692
Ternopolskaya	0.709	0.620	0.548
Vinnitskaya	0.787	0.824	1.000
Volinskaya	0.836	0.548	1.000
Zhitomirskaya	0.713	0.834	0.651
Zakarpatskaya	1.000	0.629	1.000
Zaporozskaya	0.875	0.645	0.666
Average	0.836	0.694	0.751

Table 3 - Output Supply and Input Demand Elasticities for 25 Ukrainian Oblasts Without Efficiency, 1994-9

	Grains		Sugar Beets		Sunflower		Potatoes		Vegetables		Fertilizer		Electricity		
Grains	0.1063		-0.0027		-0.0133		-0.0067		0.0142		-0.0001		>0.0001		>0.
Sugar beets	-0.0102		0.0839	**	-0.0156		-0.0078		0.0167		-0.0001		>0.0001		>0.
Sunflower	-0.1248		-0.0264		0.1747	*	-0.0955		0.2037		-0.0017		>0.0001		>0.
Potatoes	-0.0166		-0.0035		-0.0451		0.4375	**	0.2705		-0.0002		>0.0001		>0.
Vegetables	-0.0681		-0.0144		-0.1852		0.0784		-0.0754		-0.0009		>0.0001		>0.
Fertilizer	-0.6450		0.0311		-0.1010		1.0200		-0.2196		-0.0035	*	>0.0001		-0.
Electricity	-0.0920		0.0275		0.1380		0.0690		-0.1470		0.0012		>0.0001		>0.
Fuel	-0.1130		0.0337		0.1690		0.0847		-0.1808		0.0015		>0.0001		>0.

* Significant of the respective coefficients at the 10 percent level.
** Significant of the respective coefficients at the 1 percent level.

Table 4 - Output Supply and Input Demand Elasticities for 25 Ukrainian Oblasts With Efficiency, 1994-96

	Grains		Sugar Beets		Sunflower		Potatoes		Vegetables		Fertilizer		Electricity		F
Grains	0.2041	*	-0.0026		-0.0209		0.0082		0.0055		-0.0001		>0.0001		>0.0
Sugar beets	-0.0100		0.2065	**	-0.0246		0.0096		0.0064		-0.0001		>0.0001		>0.0
Sunflower	-0.1224		-0.0415		0.3147	*	0.1170		0.0786		-0.0008		>0.0001		>0.0
Potatoes	-0.0163		-0.0055		0.0552		0.5279	**	0.0104		-0.0001		>0.0001		>0.0
Vegetables	-0.0668		-0.0226		0.2268		0.0303		-0.3861	*	-0.0004		>0.0001		>0.0
Fertilizer	-0.5970		0.0461		-0.1470		1.7800		-0.9376		-0.0059	**	>0.0001		>0.0
Electricity	-0.1280		0.0269		0.2170		-0.0846		-0.0569		0.0006		>0.0001		>0.0
Fuel	-0.1570		0.0330		0.2660		-0.1040		-0.0698		0.0007		>0.0001		>0.0

* Significant of the respective coefficients at the 10 percent level.
** Significant of the respective coefficients at the 1 percent level.

Table 5 - Values of the A_{ij} Coefficients of the Model Without Technical Inefficiency, 1994-96

	Coef.	s.e.	t-stat.	
A1	16,311.0	8,963.5	1.8197	*
A11	5,815.2	3,037.0	1.9148	*
A12	-2,496.9	1,195.9	-2.0879	*
A13	1,321.1	722.8	1.8278	*
A14	7,357.4	2,197.5	3.3481	*
A15	-1,165.2	1,622.8	-0.7180	
A16	525.4	553.5	0.9492	
A17	-18,751.0	4,057.0	-4.6219	*
A18	2,849.3	2,570.6	1.1084	
A19	-62.0	8.6	-7.2504	*
A2	-76,283.0	35,801.0	-2.1308	*
A22	1.0	1.0	1.0000	
A23	-214.0	99.3	-2.1551	*
A24	1,302.6	1,793.2	0.7264	
A25	-1,276.8	1,295.3	-0.9857	
A26	-886.6	498.8	-1.7775	*
A27	-1,575.4	2,209.6	-0.7130	
A28	2,371.5	2,546.1	0.9314	
A29	-28.3	18,267.0	-0.0015	
A3	26,728.0	13,346.0	2.0027	*
A33	521.8	280.6	1.8594	*
A34	242.1	1,118.3	0.2165	
A35	-2,099.9	729.5	-2.8787	*
A36	-98.2	267.6	-0.3671	
A37	-979.2	2,514.8	-0.3894	
A38	962.1	1,720.0	0.5594	
A39	-41.2	6.9	-5.9554	*
A4	-8,785.9	3,552.9	-2.4729	*
A44	5,607.0	4,761.8	1.1775	
A45	3,209.2	2,670.8	1.2016	
A46	868.5	1,042.4	0.8332	
A47	-20,858.0	5,247.4	-3.9749	*
A48	-3,100.6	2,384.6	-1.3003	
A49	747.2	26.0	28.7620	*
A5	3,279.2	1,706.6	1.9215	*
A55	34,506.0	7,512.9	4.5929	*
A56	-2,073.4	1,273.8	-1.6277	
A57	10,844.0	6,662.1	1.6277	
A58	-1,857.1	1,108.4	-1.6755	
A59	520.0	69.8	7.4512	*
A6	-36,632.0	18,922.0	-1.9359	*
A66	811.3	442.8	1.8322	*
A67	-4,218.0	1,750.5	-2.4096	*
A68	-42.6	392.9	-0.1084	
A69	83.0	11.7	7.0716	*
A7	23,467.0	11,192.0	2.0968	*
A77	54,367.0	11,036.0	4.9264	*
A78	8,196.5	3,188.3	2.5708	*
A79	283.4	37.0	7.6648	*
A8	-34,843.0	16,432.0	-2.1204	*
A88	-1,608.4	2,365.3	-0.6800	
A89	108.8	10.0	10.8884	*

A_{ij} coefficient, where i - is the equation number and j – is the variable number in the equation. For j: 1-fertilizer, 2-electricity, 3-fuel, 4-grains, 5-sugar beets, 6-sunflowers, 7-potatoes, 8-vegetables, 9-land.

* Significant at the 10 percent level.

Table 6 - Values of the A_{ij} coefficients of the model with technical inefficiency, 1994-96

	Coef.	s.e.	t-stat.			Coef.	s.e.	t-stat.	
A1	23651.0	7617.3	3.1049	*	**A39**	-38.7	7.8	-4.9518	*
A11	9775.2	3237.3	3.0196	*	**A4**	-12914.0	4327.3	-2.9843	*
A12	-1201.1	401.5	-2.9919	*	**A44**	29953.0	13399.0	2.2355	*
A13	241.9	89.2	2.7106	*	**A45**	2680.6	6073.0	0.4414	
A14	6808.0	2528.9	2.6921	*	**A46**	2735.7	1290.9	2.1193	*
A15	-1728.4	2030.8	-0.8511		**A47**	-15523.0	8354.7	-1.8580	*
A16	763.5	797.2	0.9578		**A48**	-6938.8	5904.5	-1.1752	
A17	-32671.0	14365.0	-2.2743	*	**A49**	918.3	38.0	24.1739	*
A18	12165.0	7291.5	1.6684		**A5**	4544.7	1515.9	2.9981	*
A19	-64.6	7.4	-8.7793	*	**A55**	84884.0	28385.0	2.9905	*
A2	-92451.0	30800.0	-3.0016	*	**A56**	-4120.7	1957.8	-2.1048	*
A22	1.0	1.0	1.0000		**A57**	19028.0	5362.1	3.5486	*
A23	-191.2	67.3	-2.8424	*	**A58**	-3338.3	1792.4	-1.8625	*
A24	1810.8	3017.7	0.6001		**A59**	658.2	98.7	6.6711	*
A25	-1252.0	1626.3	-0.7699		**A6**	-25153.0	8333.0	-3.0185	*
A26	-1394.1	709.9	-1.9638	*	**A66**	1461.2	754.9	1.9357	*
A27	1930.0	2397.1	0.8051		**A67**	-5788.8	1838.1	-3.1494	*
A28	915.4	2676.9	0.3419		**A68**	-68.3	565.5	-0.1208	
A29	-19.2	18.1	-1.0659		**A69**	88.4	9.4	9.4570	*
A3	-32543.0	11015.0	-2.9544	*	**A7**	27398.0	9031.8	3.0335	*
A33	450.9	147.0	3.0667	*	**A77**	65602.0	20812.0	3.1521	*
A34	-45.6	1665.5	-0.0274		**A78**	13006.0	6116.6	2.1263	*
A35	-2799.7	1113.5	-2.5144	*	**A79**	359.6	50.4	7.1315	*
A36	-220.3	398.0	-0.5537		**A8**	-39922.0	12985.0	-3.0744	*
A37	-2641.2	3641.1	-0.7254		**A88**	-8233.8	4158.1	-1.9802	*
A38	3023.2	2679.7	1.1282		**A89**	131.0	8.8	14.9230	*

A_{ij} coefficient, where i - is the equation number and j – is the variable number in the equation. For j : 1-fertilizer, 2-electricity, 3-fuel, 4-grains, 5-sugar beets, 6-sunflowers, 7-potatoes, 8-vegetables, 9-land.

* Significant at 10 percent level.