Production Efficiency in Ukrainian Agiculture and the Process of Economic Reform

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Abstract

A representative sample of 49 state and collective farms in Ukraine provides data in physical units on livestock and crop production and input use for 1989-92. The changes in production efficiency for beef, pork, dairy, winter wheat, grain, and potato production, investigated using stochastic frontier methods, show declining technical efficiency in livestock production and especially low marginal contribution of labor inputs. The number of workers, size of farm, and distance from nearest city are related to efficiency in agricultural production.

Keywords: technical efficiency, panel data, economies in transition, frontier production function

PRODUCTION EFFICIENCY IN UKRAINIAN AGRICULTURE AND THE PROCESS OF REFORM

The economic reform in the countries of the former Soviet Union (FSU) has been accompanied by policy uncertainty and structural adjustment as governments have freed prices, introduced private property, and left production and distribution more to the forces of supply and demand (Csáki, 1990). In general, the reforms have resulted in an initial sharp decline in production and consumption levels and in productivity. Adjustments in agriculture have been of particular importance because of the major roles of food and agricultural subsidies during the planning era and for some countries, including Ukraine, the agricultural sector had a large share of aggregate output and labor.

Input prices in agriculture have increased sharply compared with output prices (because of both continuing state control and decreasing food demand) and have resulted in declining output levels and farm incomes (ERS, 1992). In addition, high nominal interest rates, decreased farm income, and uncertainties about the pace of the economic restructuring have reduced farm investment. Governments in the FSU have introduced short-term adjustment policies to stabilize farm income and food production and longer term initiatives to address issues related to privatization, the presence of monopolies, monetary and fiscal stabilization, enhancement of trade, and the creation of markets. There is relatively little empirical work, however, to support the restructuring and development of new agricultural policies.

There has been considerable work done on applications of frontier methods in agriculture (see Battese, 1992; Bravo-Ureta and Pinheiro, 1993; Coelli, 1995). However, very little research exists on the efficiency of agriculture in the formerly planned economies. Data have been limited, especially at the farm level. Much of the work on efficiency in agriculture has been limited to analysis of highly aggregated data (Johnson and Brooks, 1983; Koopman, 1989). A few recent studies exist that use more disaggregated data to study production efficiency (e.g., Brada and King, 1992; Johnson et al., 1994).

Although the availability of the official state and collective farm (census) data observed at the individual farm level provides a rich source of information about the process of reform, much of the input information is inadequate for production analysis; inputs, except for land and labor, are reported only in rubles. Because of the complex system of subsidies, bonuses, and other price distortions, there is considerable error introduced when researchers are forced to rely on these proxies for physical amounts of inputs. For a better understanding of technical efficiency, additional information on physical input use by agricultural ouput is required. Also, other variables, such as characteristics of the farm manager and farm management system, experience of managers and distance from supply and distribution points, can enhance the understanding of farm production efficiency (Battese and Coelli, 1992; Brock, 1994).

This paper uses farm-level data to evaluate changes in production and input use and investigates production efficiency in Ukraine's agriculture. We focus on three livestock products— beef, pork, and dairy— and three crops—winter wheat, total grain, and potatoes. Data came from a random survey of 49 state and collective farms in Ukraine during 1989-92. We take advantage of the detailed input and output data reported in physical units to evaluate changes in production efficiency and factors associated with efficiency in production during this recent period. The detail allows a unique opportunity to consider changes in Ukraine's agricultural sector.

Data and Farm Structure

A small survey of state and collective farms in Ukraine was conducted in 1992 to initiate a detailed analysis of agricultural production efficiency. The survey was designed as a random sample of state and collective farms across agro-climatic zones and was stratified by farm size. The Ukrainian Institute for Agrarian Economics (UIAE) supervised the administration of the survey. Of the original 80 farms surveyed, data for 49 from two administrative regions, Kyivska oblast and Cherkaska oblast of the mixed agro-climatic zone (the middle zone), were complete and used for this analysis. (See UIAE 1993, available from the authors, for more details on the survey.)

Descriptive Statistics

Descriptive farm-level statistics (Table 1) show the 49 farms to be representative of the region. The average farm size in 1989 was 2,470.7 hectares of agricultural land with 399 farm workers, 342 of whom were engaged in agricultural production, and 381 pensioners. The changes over the next four years were rather dramatic, although typical of Ukraine's agricultural sector. Agricultural land declined an average of 8.5 percent over the period. There was also a decline in the total number of farm and agricultural workers: down 11 percent and 12 percent. The changes in agricultural land and labor led to an increase of almost 5 percent in the ratio of agricultural land per agricultural worker. The number of pensioners increased by 2.6 percent over the period.

The restructuring of farms seems mostly due to growth of individual subsidiary plots of state and collective farm members and to the appearance of independent private farms, which started to emerge after 1990 (World Bank, 1994; UIAE, 1992). The decrease in the working population on the farms can be attributed to young people leaving farms and going into cities and retired workers remaining on the farms. This tendency started long before the break-up of the Soviet Union and is mentioned, for example, in recent sector reports by the World Bank (1994) and the UIAE (1992). The UIAE (1992) reports that the rural population of the two administrative regions represented in the data declined by more than 22 percent from 1970 to 1990.

Productivity Indicators

Tables 2 and 3 show the production and input use in livestock and crop production in the survey data. Compared with productivity calculations in other countries, Ukraine shows relatively greater feed use in all areas of livestock than that of European Union countries, although Ukraine was more efficient than many other FSU countries (World Bank, 1994).

Within Ukraine, farms were provided technological coefficients for input use and output, based on the scientific norms or recommendations of specialists (UIAE, 1994). These recommendations targeted higher yields in crop production and higher output per animal in livestock production. There was no profit/cost efficiency taken into account. We compared the reported numbers to the technological norms to evaluate average efficiency and quality of the data.

The technological coefficients for livestock are reported in Table 2. For beef, the data from the surveyed farms showed production declined over the four years by about 23 percent and herd size decreased by 5 percent. The input use was similar to use reported in aggregate Ukraine data for the region (World Bank, 1994). The labor and feed use did not differ significantly from the technological norms (coefficients). The reported labor use in beef production was somewhat higher; however, reported feed use stayed lower than that prescribed (varying from 11.3 to 12 as opposed to the norm of 12.7 tons/ton of output).

Pork production declined an average of 27 percent over the four-year period, and this was accompanied by a large change in the input use rate: herd size, feed, and machinery all declined, and labor use increased by about 20 percent. These changes are consistent with other unpublished numbers for Ukraine. The data show that the farms used considerably more labor per ton of production than technological norms. The farms also used more feed than the technical recommendations (11 to 12 tons/ton of output, as opposed to 9.2 tons/ton of output as prescribed).

The average decline in milk production was about 27.6 percent and this was accompanied by similar declines in feed and machinery and smaller declines in herd size, land,[1] and nearly stable labor use. Labor and feed use followed the same pattern as beef, relative to the norms: labor use was greater than the technological coefficients and increased by 43 percent over the period; feed use per ton of production stayed below the norm of 1.65 tons/ton of production.

The trends in crop production were similar to those in livestock production as shown in Table 3. On average, total grain production declined by 35 percent over the four years; however, the area under grains declined by only 12 percent. The area under grains relative to total agricultural land remained relatively stable and constituted slightly less than 50 percent of the farms' total agricultural land. The greatest decline in inputs application was for fertilizer, down 37.8 percent; chemicals, down 28.7 percent; and manure, down 26.3 percent. Other inputs showed large declines as well. Smaller declines occurred in application of fuel and seeds. The change in labor use was in the opposite direction and rather dramatic: total labor application increased by more than 70 percent over the four years.

Winter wheat constituted slightly less than one-half the area under grains. The trends in production and input use were very similar to those for total grain: the decline in production of 39.6 percent was accompanied by a moderate decline in land of 10.4 percent, an increase in labor application, and a decline in other input use, in percentages similar to those for grains.

Changes in potato production followed the same general pattern as for grains: a 38.3 percent decline in production accompanied by a decline in fertilizer application and smaller declines in other inputs. Labor use increased by only 14.9 percent.

Technological map coefficients for winter wheat and potatoes were available in input use per hectare. Labor use per hectare in winter wheat production was below the norm of 30 man-hours per hectare in 1989 and increased to 38.2 man-hours per hectare in 1992. Fertilizer application has been much above the 140 kilograms/hectare for winter wheat. In 1989 it was 250.3 kilograms per hectare, its use declined in 1992, with 185.7 kilograms per hectare, although this level of application was still above the norm. The same general pattern of input use in winter wheat production could be seen for fuel and lubricants and chemicals application: use of these inputs declined over the four years but remained above or near the norms. The only input, consistently below the available norms, was manure: its application declined from 7.8 to 6.7 tons per hectare with the norm of 10 tons per hectare. This pattern of input application reflects the well-recognized importance of wheat production in Ukraine and preferred supply and delivery of inputs for wheat production.

The pattern of input use in potato production differs substantially. Labor use in 1989 was much higher than the norm : 393.3 versus 228 man-hours per hectare. The number fluctuated over the years and reached a level of 413.7 in 1992. Use of other inputs was below the norms and declined over the four years: for fertilizer, only 174.3 kilograms per hectare were applied in 1992, with the norm of 294 kilograms per hectare; in the same year, manure use was 15.5 tons per hectare, with the norm of 52 tons per hectare; only about one-half the norm for fuel and lubricants was applied. The pattern for potatoes indicates the complementary status of potato production: because of almost nonexistent marketing opportunities, all farms had to produce potatoes to feed residents, even if relatively small amounts of inputs, other than labor, were available. Labor with relatively low productivity in potato production (e.g., students and city workers recruited for potato harvesting) may have contributed to the extremely high labor use per hectare in potato production.[2]

In sum, the survey data showed declines both in livestock and crop production over the four years and declines in input use, except for labor, accompanied the fall in production. In percentage terms the declines in crop production were larger than those in livestock production; the increase in labor application was smaller in livestock production than that in crop production. The decline in manure application in crop production is of about the same magnitude as the decline in livestock production. This result supports the hypothesis of availability as the major determinant of input use.

Technical Efficiency

A stochastic frontier analysis was conducted to estimate farm *technical efficiency*. These results can be of value in linking efficiency to management systems and in characterizing the factors associated with changes in productivity. These are among the first estimates of technical efficiency for both *livestock and crop* production in Ukraine. The magnitudes of the production function and efficiency estimates do not differ much from other estimates of the crop sector derived by using a different data set (and dependent on ruble valuation of several inputs) (see Johnson et al., 1994). As expected with individual farm data, the efficiency estimates are lower than estimates made with aggregate data (Koopman, 1989).

The Model and Estimation

For the analysis, a fully parametric stochastic frontier approach was used. The model employed is that of Battese and Coelli (1992). The general form of the time-varying technical efficiency model with the Cobb-Douglas function is

$$\log Y_{it} = \beta_o + \sum_{j=1}^{n} \beta_j \log X_{jit} + \beta_{n+1} d + v_{it} - u_{it},$$

$$u_{it} = \{\exp[-\eta(t-T)]\} u_i,$$

where the subscripts i and t refer to the i^{th} farm and the t^{th} time period. Y represents the production per animal for livestock production or production per hectare for crops (metric tons); X_j, j = 1, ..., n, are input variables where n is the number of inputs.

The inputs used in the analysis of livestock production are labor per animal (man-hours), machinery per animal (hours), land devoted to feed per animal (hectares), and feed per animal (metric tons). For winter wheat and grain the list includes four inputs: labor per hectare (man - hours), manure per hectare (kilograms), chemicals per hectare (kilograms), and fuel per hectare (liters). Three inputs were used in the analysis of potato production: labor per hectare, manure per hectare, and tractors per hectare (hours). The variable d (d = 1, 2, 3, 4) represents the linear effect of year; β are unknown parameters; v is statistical noise; $u \geq 0$ represents the shortfall of output from the frontier; and T = 4 is the number of time periods. The linear time trend was included to account for technological and other changes over time, independent of changes in technical efficiency captured by the parameter η.

We chose a Cobb-Douglas production function and not any other less parsimonious form because, as Maddala (1979) notes, the measurement of technical efficiency is quite insensitive to the choice of functional form of production because this property is related to shifts of the isoquants rather than their shapes. Constant returns to scale in the production function were assumed because of the degrees of freedom problem originating from the small sample. And, constant returns to scale had been found in earlier estimates for Ukraine (Johnson et al., 1994) and Russia (Skold and Popov, 1990).

The random noise variables v_{it} are assumed to be normally distributed with mean 0 and variance σ_v^2 and are taken to be independent for all firms and time periods. The second random disturbance term, u_i, is assumed to be a nonnegative truncated normal random variables from a distribution with mean μ and variance σ^2. Parameter $\gamma = \sigma^2 / (\sigma_v^2 + \sigma^2)$ measures the share of total variation of the errors attributable to the variation in technical efficiency. The technical efficiency $TE_{it} = \exp(-u_{it})$ for the ith firm at the tth time was estimated as described in Battese and Coelli (1992).

Estimators for firm technical efficiency can be obtained with the maximum likelihood method. We used a program developed by Coelli (1992) called FRONTIER (Version 2.0) that computes the maximum likelihood estimates by iteratively maximizing a nonlinear function of the unknown parameters in the model subject to constraints.

Results

Technical efficiency was estimated for three livestock products: pork, beef, and milk, and for three crops: total grain, winter wheat, and potatoes. The parameters of interest are the output elasticities, the time trend coefficient, γ, μ, η, and the yearly mean technical efficiencies (Tables 4 and 5). All of the nonzero elasticity estimates are significantly different from zero, with the exceptions of herd size in livestock production and land in crop production (for which testing was not done), and where marked "ns." The output elasticity of herd size was calculated as one minus the sum of the elasticities of labor, machinery, land, and feed. The output elasticity of land in crop production was calculated similarly, as one minus the sum of other output elasticities.

Output elasticities for labor were found to be very small: insignificantly different from zero for winter wheat and potatoes, 0.092 for pork, 0.082 for grains, and zero for beef and milk production. These results indicate that farms use labor in production to the point that its marginal product is zero or near zero. A similar result was found by Brock (1994) for Russian data in a multiproduct framework. In general, mean technical efficiency declined in livestock production, and the efficiency change in crop production was not significantly different from zero.

In beef production, the estimated elasticity of machinery was 0.538. The largest decline in input use was also in machinery: 21.13 percent. The labor elasticity was zero, and feed and land use elasticities were relatively small. Both the time trend and efficiency change coefficients were negative, and a joint test that they equal zero was rejected at the 5 percent level. For beef production, mean technical efficiency steadily declined slightly over the four years from 0.606 in 1989 to 0.599 in 1992.

For milk production, the highest elasticity estimated among inputs was for feed: 0.515. As in beef production, the labor elasticity was zero and both the time trend and efficiency change coefficients were negative and jointly significant at the 5 percent level. Mean technical efficiency declined over the four years from 0.748 in 1989 to 0.714 in 1992.

The estimates for pork production were the most difficult to obtain. There may have been some problems in the measurement of inputs, especially related to feed use. The data on land and feed use in pork production were highly correlated; therefore, only feed data were used in estimation. That means the feed elasticity reported (0.259) captures the effect of both land and feed in production. The estimated elasticity of 0.647 for machinery is rather high. This may be because the largest decline in input use was for machinery. The linear time trend coefficient was negative, but the change in efficiency over time was positive. Testing that the linear time trend and the change in efficiency over time were both zero was rejected at the 5 percent level. Mean technical efficiency was about 0.34 and increased from 1989-91, then declined in 1992.

Winter wheat represented an average of 54 percent of total production of grain and utilized about 44.5 percent of the total land under grain. As expected, the production function estimates for grain and winter wheat do not differ much. Output elasticities for labor were low, and for winter wheat, estimated to be not statistically different from zero. The highest elasticity among inputs was for fuel: 0.484 for grain and 0.356 for winter wheat. This elasticity presumably reflects the contribution of machinery inputs into production; in fact, for all three crops, data on fuel and machinery utilization (in hours) were highly correlated. Elasticities for manure and chemicals were similar, in the range of 0.14 to 0.20. In potato production, again the labor elasticity was not statistically different from zero. The highest output elasticity obtained (though insignificant) was for tractors: 0.213.

The time trend was negative and significantly different from zero for all three crops. The hypothesis that $\eta = 0$ and $\mu = 0$ cannot be rejected for all three crops, suggesting that efficiency was not significantly changing over time. Mean technical efficiencies were relatively high compared with livestock production: 0.86 for grain and wheat and 0.725 for potatoes.

Factors Associated with Relative Efficiency

To better understand the relative efficiency in production and factors associated with relative efficiency, several types of analyses were conducted. These included comparison of rank correlations, and comparison of farms at the tails of the efficiency distribution.

Rank Correlations

First, to compare relative efficiency rankings of the farms in different products, Spearman rank correlation coefficients were computed. As expected, the highest rank correlation is between grain and winter wheat efficiency, 0.81. Another correlation, highly positive and significantly different from zero, exists between the grain and potatoes efficiency rankings, 0.47, and between the grain and milk rankings, 0.48 ($\alpha = .01$).

The correlation between the pork and beef rankings (0.29) was smaller but significantly different from zero; the correlation between pork and beef (0.21) was insignificant at the 5 percent level. Other correlations were positive and statistically significant at $\alpha = .20$ (potatoes and wheat, wheat and milk, pork and milk, pork and beef). These results indicate that farms more efficient in one product tend to be more efficient in other types of production. The results also suggest that general farm-specific characteristics should be associated with relative efficiency.

Analysis of the "Tails" of the Efficiency Distribution

The analysis of the "tails" is summarized in Table 6 for the five and ten most efficient farms and the five and ten least efficient farms. For all the types of production analyzed, the more efficient farms were larger in terms of the total number of workers and the number of agricultural workers. Though no relationship between the total agricultural land and relative technical efficiency could be seen, the more efficient farms were relatively more abundant in labor resources as the number of farm workers per hectare of agricultural land shows. These farms were better able to hold their labor force, as well; the percentage decline in both the total number of workers and the number of agricultural workers was smaller for the more efficient farms than for the less efficient farms. Particularly in grain production, the total number of workers declined by 8 percent and the number of agricultural workers declined by 3.8 percent for the five most efficient farms. For the five least efficient farms, total workers declined by 18.6 percent and agricultural workers by 16.6 percent.

The least efficient farms seemed to have a relatively large number of pensioners compared with to the number of workers. This ratio, together with another similar characteristic, the ratio of the number of pensioners to the number of agricultural workers, was negatively related to efficiency. In sum, the more efficient farms were undergoing smaller changes over the four years than the less efficient farms. In addition to the decline in workers, the percentage decline in agricultural land seemed to be smaller, and the percentage increase in the ratio of pensioners to total workers was smaller for the more efficient farms than that for the less efficient ones.

Analysis of the "tails" of the efficiency distribution also provides an explanation of how the more efficient farms have managed to keep their working population better than the less efficient farms. The more efficient farms had a lower share of agricultural workers in the total number of workers. And, the ratio of production expenditures to total farm expenditures seems to be smaller for the more efficient farms. What is included in nonproduction expenditures was not defined, however; nor was there any information on the characteristics of the nonagricultural workers. These numbers suggest, for example, that the more efficient farms spent more (of both money and labor) on processing and marketing their production. Alternatively, the more efficient farms may have provided more social services to the people living on the farms. In any case, the more efficient farms provided some nonagricultural production jobs and in this way may have retained working people on the farms. Another variable, the distance from the nearest city, is also consistent with this explanation. The more efficient farms tend to be located farther from cities. This advantage in location may have allowed the farms to compete better with cities for workers.

The positive relationship between the distance from a city and relative efficiency might have another explanation as well. More energetic workers from rural communities located closer to cities could commute to jobs in these cities, thus lowering the average skill/effort level of the available agricultural labor on these farms. In addition, the farms located closer to cities had easier access to the less productive (in agricultural tasks) city workers and students recruited for harvest time. In this way, relative efficiency would be related to the distance to city through its effect not only on the number, but also on the quality of the farm=s productive labor.

The more efficient farms remained more stable in production over the four years: they experienced smaller percentage declines in area planted and production of crops, and smaller percentage declines in herd size. The pattern of labor substitution for other inputs differed, however, between crops and livestock. For livestock, both labor utilization per animal in 1989 and the percentage increase in labor use per animal were smaller for the more efficient farms than for the less efficient ones. Labor use per ton of production was smaller in beef and milk production for the more efficient farms than that for the less efficient ones. Labor use per ton of production grew for both categories of farms, but grew less rapidly for the more efficient farms. These results suggest that in livestock production, the more efficient farms exercised relatively more capital-intensive input use as opposed to the relatively more labor intensive input mixes of the less efficient farms.

For crops, however, the pattern of comparative input use between less and more efficient farms differed from that of livestock. In wheat production, high labor utilization per hectare seemed to be positively related to technical efficiency. In addition, in grain and potato production, the percentage increase in labor utilization per hectare was higher for the more efficient farms than that for the less efficient farms.

Use of other inputs can be compared for specific products. For beef, the comparative analysis shows that the more efficient farms had herds two times larger in size and over the four year period cut their herd size less than the less efficient farms. Feed use did not vary much across the farms. The more efficient farms used less machinery, had more land under feed in total, but used less land per ton of production.

In milk production, the pattern of input use is similar to that for beef: the least efficient farms used on average twice as much machinery and land and about 1.4 times more feed per ton produced than the five most efficient farms. Farms did not differ much in average herd size.

The comparison of "tails" in pork production suggests that the more efficient farms were much larger; they had herd sizes more than four times as large as those of the less efficient farms. The pattern of input use differed significantly between the more and less efficient farms. The major difference was in labor use: both types of farms used approximately the same labor per ton of production in 1989 (about 645 man-hours per metric ton of production). By 1992, the more efficient farms increased labor use by only 8.84 percent on average per farm, whereas the less efficient farms increased labor use by 170 percent on average. Also, there was a difference in machinery use. The more efficient farms used about four times fewer machinery hours per ton of production than the less efficient farms.

The input use per hectare, winter wheat and grain production in general had a higher relative efficiency associated with smaller application of fertilizer and manure, and higher application of seeds and chemicals per hectare.

In potato production, the more efficient farms put more land in potato production both in absolute numbers and relative to total farm agricultural land. That suggests some support to the hypothesis that larger and more specialized operations were better at achieving technical efficiency in potato production. Labor use per hectare in potato production increased over the four years for the more efficient farms: by 134 percent for the five most efficient farms versus a decline of 7 percent for the five least efficient farms. Although the five most efficient farms began the period with smaller labor use per hectare, as a result of such a large increase, the labor use per hectare in 1992 became larger for the most efficient farms. Manure, tractor, and seed use per hectare were all negatively related to the technical efficiency.

Conclusions and Implications

Although the analysis was for a relatively small sample of farms, the data are very similar to numbers for the aggregate data reported by the World Bank and the Ukrainian Agricultural Economics Institute. The detail provided by the data source allowed the improved analysis of productivity. The steady decline in farm size between 1989 and 1992 in terms of land and workers was accompanied by a larger steady decline in the production of pork, beef, milk, winter wheat, grain, and potatoes. The shift in the proportion of inputs used as output declined is identified here. Herd size, feed, and machinery use fell for the three livestock products. Labor use declined for milk at rates smaller than for the other inputs, but increased for pork and beef.

For crops, fertilizer, chemicals, manure, fuel, and seeds application fell, but labor use increased by as much as 70 percent, on average, in grain production. This substitution among major inputs towards labor can be explained by the changes in relative prices of these inputs and the relative abundance of labor inputs throughout the period. Although the estimated frontier production functions are characterized by especially low marginal contribution of labor inputs, the marginal cost of labor to the farm/firm may have been very low (or near zero) in this period.

Average efficiency declined over the period for beef and milk (and for pork, in 1992). In livestock production the most efficient farms used relatively less labor and machinery, and tended to substitute feed and machinery inputs for labor to a lesser extent than was done by the less efficient farms. In crop production the average efficiency remained stable over the period. In winter wheat and grain production, the more efficient farms applied relatively less fertilizer, manure, and more seeds and chemicals. In potato production, the more efficient farms specialized in potato production and increased labor use over the four years relatively more than the less efficient farms.

We found that relative efficiency rankings of the farms in different products were in general positively correlated. And relative technical efficiency seems to be positively related to the success of the farms in keeping their productive labor on the farms. The more efficient farms lost fewer workers over the four years, just as they had in the past. One possible way the farms keep young people from leaving is through the development and provision of nonagricultural jobs on the farms. There is some evidence that the more efficient farms were located farther from alternative sources of employment. Whether age and experience of the farm manager affect relative efficiency is something to be investigated further.

Ukraine=s economic and political environment are still very much in transition, although the rate of change in input prices appears to be slowing. The results of the analysis of technical efficiency in selected major agricultural products indicate that the efficiency in livestock, especially, has fallen during the period and is quite low. At the same time, the more efficient farms show an ability to substitute among available inputs to achieve their relatively higher level of output. Also, the more efficient farms seem to better utililize labor, both in agricultural and nonagricultural activities.

Except for potato production, there is no strong evidence that specialization will improve productivity in the agricultural sector. In fact, evidence that more efficient farms are efficient in all of their productive activities suggests that other factors, such as the availability and access to inputs, distribution channels for output, organization of nonagricultural activities, including processing activities, or managerial skill, would contribute to improved productivity in the agricultural sector. The development of infrastructure to support improved distribution and availability of inputs is likely to be important to achieving improved efficiency. This would include investment in roads, processing and distribution services, and continued development of value adding activities on the farms.

Table 1. General farm level indicators[a]

Indicator	Units of Measurement	Number of Farms	1989	1990	1991	1992	% change 1989-92
Distance to city	km	49				37.9 (18.23)	
Age of manager	years	49				46.49 (8.26)	
Experience of manager	years	48				25.08 (7.6)	
Agricultural land	hectares	49	2470.73 (927.73)	2423.65 (909.3)	2311.88 (831.11)	2237.99 (799.54)	-8.54 (9.5)
Total farm workers	number	49	399.31 (130.1)	390.12 (127.96)	371.88 (123.87)	347.98 (124.79)	-12.86 (9.85)
Agricultural workers	number	49	342.24 (108.3)	329.69 (106.95)	316.96 (105.68)	301.45 (105.33)	-11.41 (12.59)
Ratio of agricultural workers to total farm workers	number	48	0.854 (0.05)	0.847 (0.05)	0.854 (0.05)	0.869 (0.05)	1.96 (6.25)
Agricultural land per agricultural worker	hectares	49	7.332 (1.78)	7.458 (1.81)	7.374 (1.51)	7.568 (1.67)	4.81 (15.82)
Share of agricultural land under grains	number	44	0.478 (0.05)	0.478 (0.06)	0.481 (0.05)	0.460 (0.06)	-3.45 (9.95)
Pensioners	number	49	381.27 (145.53)	382.31 (147.41)	387.49 (152.29)	390.24 (151.77)	2.58 (10.68)
Ratio of pensioners to total farm workers	number	49	0.964 (0.22)	0.989 (0.24)	1.048 (0.25)	1.141 (0.30)	19.02 (17.62)
Ratio of pensioners to agricultural workers	number	49	1.127 (0.27)	1.168 (0.27)	1.231 (0.30)	1.312 (0.33)	17.92 (20.20)
Ratio of production expenditures to total farm expenditures	number	45	0.938 (0.06)	0.939 (0.21)	0.898 (0.11)	0.792 (0.16)	-15.12 (19.33)

[a]All the indicators reported are average per farm, the numbers in parentheses are the standard deviations
Source: UIAE Survey of Ukrainian farms

Table 2. Farm-level livestock production productivity indicators[a]

Indicator	1989	1992	% change 1989 -92 (percent)	1989	1992	% change 1989 -92 (percent)	1989	1992	% change 1989-92 (percent)
	Beef			Milk			Pork		
Production (tons)	157.86	114.17	-23.31	1689.6	1105.45	-27.61	97.82	53.81	-27.02
Herd size	909.11	802.74	-5.09	509.57	463.15	-3.49	1037.81	790.93	-17.38
Labor (1000 man hours)	66.36	63.64	1.12	126.9	116.6	-0.02	42.54	37.51	21.04
Feed (metric tons)	1753.79	1272.1	-18.8	2475.07	1642.55	-26.33	907.44	567.31	-18.67
Machinery (hours)	1966.67	1496.24	-21.13	7079.61	5442.69	-17.41	1153.27	635.64	-21.38
Land (hectares)	994.22	740.04	-0.24	938.67	817.77	-5.67	216.24	183	8.43
Input use per ton of production									
Labor (man hours per ton)[b]	487.09	681.26	46.59	79.92	111.34	43.15	614.95	1273.59	113.52
Feed (tons per ton)[c]	11.44	12	7.11	1.43	1.47	3.07	10.86	11.53	12.18
Machinery (hours per ton)	14	14.18	3.27	4.18	4.72	14.51	11.7	12.29	5.87
Land hectares per ton)	6.14	8.42	37.47	0.63	0.85	38.36	2.75	3.86	55.41

[a] The number of farms was 47 except for pork which was 43 for this table. All the indicators reported are average per farm.

[b]Technological map norms were 524, 687, and 123 man hours per ton of production in pork, beef, and milk production respectively. However, the data in the survey is defined as direct labor used as opposed to total, direct labor represents about 64% of the total. Thus the technological map norms for the direct labor are 386,440, and 80 man hours per ton of production in pork, beef, and milk production respectively. Direct labor is labor used directly in production of the product. Total labor may include labor used in other related activities such as machinery repair, production of feed, etc.

[c] Technological map norms were 9.2, 12.7, and 1.65 tons per total in pork, beef, and milk production (UIAE, 1994).

Source: UIAE Survey of Ukrainian farms

Table 3. Farm-level crop production productivity indicators[a]

Indicator	1989	1992	% change 1989-92 (percent)	1989	1992	% change 1989 -92 (percent)	1989	1992	% change 1989 -92 (percent)
	Grain			Winter Wheat			Potatoes		
Yield (tons per hectare)	4.3	3.1	-26.0	5.3	3.6	-31.8	12.6	8.6	-28.1
Production (tons)	4936.5	3183.2	-35.1	2786.5	1677.3	-39.6	155.1	97.8	-38.3
Land (hectares)	1172.9	1020.3	-12.1	536.1	477.3	-10.4	12.4	10.5	-9.0
Labor (1000 man hours)	28.84	26.88	70.5	15.62	17.67	58.5	4.47	4.51	14.9
Fertilizer (tons)	281.8	178.1	-37.8	136.7	90.22	-34.2	3.14	2.03	-34.1
Manure (tons)	9109	6485	-26.3	4371	3352	-24.3	217	140	-26.7
Chemicals (kilograms)	7611.0	4319.1	-28.7	3356.3	2284.4	-30.1	222.7	215.9	-8.6
Fuel (1000 liters)	131.3	103.3	-19.6	60.33	48.67	-17.8	2.21	1.77	-16.6
Seeds (tons)	243.8	201.5	-15.2	112.2	97.0	-13.0	33.6	28.0	-10.2
Input use per hectare:									
Labor (man hours per hectare)[b]	23.8	34.8	93.1	28.8	38.2	76.7	393.3	413.7	27.8
Fertilizer (kilograms per hectare)[c]	242.2	175.7	-28.8	250.3	185.7	-25.8	243.0	174.3	-30.0
Manure (tons per hectare)[d]	7.60	6.39	-16.4	7.83	6.74	-14.7	17.9	15.5	-18.4
Chemicals (kilograms per hectare)[e]	6.5	5.2	-19.0	6.4	5.0	-21.6			
Tractor (hours per hectare)							19.7	20.1	0.4
Fuel (liters per hectare)[f]	111.7	102.0	-8.4	112.3	102.7	-8.2	167.4	155.4	-7.3
Seeds (tons per hectare)	0.2	0.2	-3.4	0.2	0.2	-2.8	2.8	2.8	-0.7

[a]The number of farms was 44 for wheat, 41 for grain, and 38 for potato production. All the indicators reported are average per farm.
[b]Technological map norms for labor use were 30 man-hours per hectare for winter wheat, 228 man-hours per hectare for potatoes.
[c]Technological map norms for fertilizer were 140 kg/hectare for winter wheat, 294 kg/hectare for potatoes.
[d]Technological map norms for manure were 10 tons/hectare for winter wheat, 52 tons/hectare for potatoes.
[e]Technological map norm for chemicals was 5.15 kg/hectare for winter wheat.
[f]Technological map norms for fuel were 90 litres/hectare for winter wheat, 320 litres/hectare for potatoes.
Source: UIAE Survey of Ukrainian farms.

Table 4. Stochastic frontier analysis of livestock production, farm level panel data, Ukraine, 1989-1992

	Beef	Milk	Pork
Estimated coefficients:			
Intercept	-1.706	-0.176	-1.479
Herd size	0.075	0.089	0.002
Labor	0	0	0.092
Machinery	0.538	0.333	0.647
Land	0.192	0.063	0
Feed	0.195	0.515	0.259
Time trend	-0.024	-0.014	-0.055
μ	0.521	0.337	1.106
η	-0.0086	-0.051	0.02
γ	0.942	0.787	0.946
Mean technical efficiency:			
1989	0.6059	0.7481	0.3331
1990	0.6035	0.7371	0.3364
1991	0.601	0.7258	0.3496
1992	0.5986	0.7141	0.3456
Mean percentage change of technical efficiency	-1.37	-4.72	7.06
Number of farms in the panel per year	47	47	45

Table 5. Stochastic frontier analysis of crop production, farm-level panel data, Ukraine, 1989-92

	Grain	W. Wheat	Potato
Estimated coefficients:			
Intercept	-2.604	-1.847	1.490
Labor	0.082	0.041^{ns}	0.119^{ns}
Land	0.1	0.273	0.511
Manure	0.161	0.195	0.157^{ns}
Chemicals	0.173	0.135	–
Fuel	0.484	0.356	–
Tractors	–	–	0.213^{ns}
Time trend	-0.091	-0.118	-0.210
γ	0.678	0.625	0.465
Mean technical efficiency	0.863	0.861	0.725
Number of farms in the panel per year	41	44	38

Table 6. Efficiency and selected farm characteristics for Ukrainian agriculture

Indicator[a]	Beef	Milk	Pork	Grain	W. Wheat	Potato
1 Distance to the nearest city, kilometers	+	•	+	+	+	•
2 Agricultural land in 1989	+	–	+	–	–	+
3 Percentage change in agri. land, 1989-92	•	+	–	+	+	+
4 Total number of workers in 1989	+	+	+	+	•	+
5 Farm workers per hectare in 1989	–	+	+	+	+	+
6 Percentage change in total workers, 1989-1992	+	+	+	+	+	+
7 Number of agricultural workers in 1989	+	+	+	+	•	+
8 Percentage change in agr. workers, 1989-1992	+	+	+	+	+	+
9 Ratio of agr. workers to total workers in 1989	•	–	–	–	–	–
10 Percentage change in ratio of agr. workers to total workers, 1989-1992	–	–	•	+	•	–
11 Ratio of pensioners to total workers in 1989	•	+	–	–	–	•
12 Percentage change in ratio of pensioners to total workers, 1989-1992	–	–	–	–	–	–
13 Ratio of production expenditures to total farm expenditures in 1989	–	–	–	–	–	+
14 Percentage change in ratio of production to total farm expenditures, 1989-1992	+	•	–	+	–	+

[a]Notation:

+ means that the average of the indicator for the 5 most efficient farms is greater than that computed for the 5 least efficient farms and the average of the indicator for the 10 most efficient farms is greater than that computed for the 10 least efficient farms;

– means that the average of the indicator for the 5 most efficient farms is smaller than that computed for the 5 least efficient farms and the average of the indicator for the 10 most efficient farms is smaller than that computed for the 10 least efficient farms;

• means that neither “+” nor “–“ could be assigned.

Table 6. (continued)

Indicator[a]	Beef	Milk	Pork	Grain	W. Wheat	Potato
15 Percentage change in production, 1989-92	+	–	–	+	+	+
16 Percentage change in herd size, 1989-92	+	+	+			
17 Labor use per animal in 1989	•	–	–			
18 Percentage change in labor use per animal, 1989-92	–	–	–			
19 Percentage change in labor use per ton of production, 1989-92	–	–	–			
20 Inputs per ton of production in 1989:						
labor	–	–	+			
feed	–	–	+			
machinery	–	–	–			
land	–	–	+			
21 Percentage change in area planted, 1989-92				+	+	•
22 Percentage change in labor use per hectare, 1989-92				+	–	+
23 Inputs per hectare in 1989:						
labor				•	+	•
fertilizer				–	–	–
manure				–	–	–
chemicals				•	+	
fuel				+	•	+
tractors						–
seeds				+	+	–

[a]Notation:

+ means that the average of the indicator for the 5 most efficient farms is greater than that computed for the 5 least efficient farms and the average of the indicator for the 10 most efficient farms is greater than that computed for the 10 least efficient farms;

– means that the average of the indicator for the 5 most efficient farms is smaller than that computed for the 5 least efficient farms and the average of the indicator for the 10 most efficient farms is smaller than that computed for the 10 least efficient farms;

• means that neither "+" nor "–" could be assigned.

ENDNOTES

1. For beef and milk production land is defined as land under feed crops. For pork production land is defined as land under grains.

2. For potato production, it is possible that reporting error in inputs use could have biased all the data for inputs uniformly across farms. For example, inputs used for other purposes may have been written off through the winter wheat account because of the preferred status of wheat production in the centrally planned economy. By the same reasoning, higher actual use of inputs other than labor in potato production might be not shown in the data.

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