PRODUCTIVITY AND EFFICIENCY OF SMALL AND LARGE FARMS IN MOLDOVA

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Abstract

The paper presents a comparative analysis of the productivity of small and large farms in Moldova based primarily on cross-section data from three farm surveys conducted by the World Bank and USAID in 2000 and 2003. The survey data are supplemented where feasible with time series from official national-level statistics. We calculate partial land and labor productivity, total factor productivity, and technical efficiency scores (using Stochastic Frontier and Data Envelopment Analysis algorithms) for the two categories of small individual farms and large corporate farms. Our results demonstrate with considerable confidence that small individual farms in Moldova are more productive and more efficient than large corporate farms. This finding is not restricted to Moldova, as a similar result has been obtained by other authors in Russia (2005) and in the U.S. (2002), where a recent study has found that an increase of farm size reduces, rather than increases, agricultural productivity. Policies encouraging a shift from large corporate farms to smaller individual farms, rather than the reverse, can be expected to produce beneficial results for Moldovan agriculture and the economy in general. The government of Moldova should abandon its inherited preference for large-scale corporate farms and concentrate on policies to improve the operating conditions for small individual farms. At the very least, the government should ensure a level playing field for farms of all sizes and organizational forms, and desist from biasing its policies in favor of large farms.

Keywords: family farms, corporate farms, comparative performance, technical efficiency, total factor productivity, agrarian reforms, transition countries.

JEL classification: D24, J24, P27, P31, P32, Q12, Q15, R14

Introduction

Moldova has made some very impressive achievements in land reform since 1998-99, when the change in the political atmosphere triggered a quantum jump in the intensity of agrarian reform efforts, primarily through the implementation of the USAID-sponsored National Land Program (Csaki and Lerman, 2002). Private (non-state) land ownership rose from practically zero in 1989 to 67% of all agricultural land in 2003 (and to an even more impressive 80% of agricultural land used by producers), and land plots were physically distributed to more than one million rural people – 30% of Moldova's population. These highly positive developments appear to have led to the tentative signs of recovery in agriculture that we observe since 2000, when the steep decline in agricultural production was arrested and both output and productivity resumed growth.

The progress with land privatization has not been fully matched by progress with individualization of agriculture – the second main facet of transition to market (Lerman et al., 2004). There has been a massive shift of agricultural land use from the traditional collective and state farms to individual farms (including the established household plots and the newly created independent peasant farms). Yet fully 50% of agricultural land in Moldova is still controlled by large-scale corporate farms that have succeeded the traditional collective and state farms. In itself, this is also a huge achievement, far surpassing the reform outcomes in Russia and Ukraine, where large corporate farms still control about 80% of agricultural land. However, this is not satisfactory compared to land use patterns in market economies, where non-family corporate farms control around 1% of agricultural land (USDA, 2004). Of course market agriculture supports a wide spectrum of organizational forms, ranging from very small part-time family units (equivalent to household plots in Moldova) to fairly large corporate farms. However, market agriculture is predominantly agriculture of family farms, not corporate farms: corporate farms are few in number and control a very small share of agricultural land. In Moldova, on the other hand, a relatively small number of large corporate farms control a much greater share of agricultural land than in established market economies, including the U.S., Canada, and the EU-15. The high concentration of land in a small number of large corporate farms, which exist alongside a very large number of small family farms, is a manifestation of the dual farm structure that Moldova inherited from the Soviet era and still retains despite the generally successful reforms (World Bank, 2006).

Although the decline of agricultural output in Moldova was arrested following the implementation of the National Land Program in 2000, agriculture contracted again in 2003 due to a combination of factors, including frost and drought, and has generally lagged behind other sectors of the economy (World Bank, 2005). This, combined with the persistence of a dual farm structure in the country, has generated renewed debate about the merits of land privatization and farm restructuring. This debate took on new urgency with the coming to power of the Communist Party in 2001. Ever since, driven by the Soviet-era ideology of economies of scale in agriculture, the government of Moldova has pushed for the re-creation of large corporate farms – agricultural enterprises – through consolidation (some would say “re-collectivization”) of privatized individual holdings (MinAg, 2005).

The farm structure conundrum has two dimensions: (a) the organizational-form dimension – individual farms versus corporate farms; and (b) the size dimension – small farms versus large farms. With regard to organizational form, world experience clearly indicates that agricultural production cooperatives are less efficient than individual farms and market-oriented corporate farms. This is suggested by the well-developed theory of cooperatives, but more importantly, this is proved by the almost total nonexistence of production cooperatives in market economies (Lerman et al., 2004, p. 47). We cannot make the same statement regarding the comparison of market-oriented corporate farms with family farms. The plain fact is that corporate farms do exist in market economies (especially in the United States and Canada, much less so in the EU-15), which proves that they are able to compete with individual farms. Furthermore, the small numbers of corporate farms that do exist in market economies appear to be even more efficient than individual farms as a group: in the United States, non-family corporate farms control 1% of agricultural land and generate close to 7% of output (USDA, 2004). In Moldova, on the other hand, the relation is reversed: corporate farms control 50% of land and generate less than 30% of output. Similarly, in Russia and Ukraine, corporate farms generate 40% of output on 80% of agricultural land. This effectively implies that in many (if not all) transition countries the large corporate farms use land less efficiently than the small individual farms. The market economies have achieved an equilibrium farm structure, which includes a mix of individual farms (the dominant majority) and corporate farms (a small minority) determined by resource availability, managerial capacity, and personal preferences of farmers and investors. A similar process can unfold in Moldova through the natural action of market forces, without government intervention and programming.

The second dimension of the farm structure conundrum involves farm sizes – small versus large. There is a voluminous literature on the farm-size effect in developed and developing countries. The results are inconclusive: there is no clear proof that large farms are more productive and more efficient than small farms. A similar result is generally obtained for the transition countries, where studies do not detect any advantage of large corporate farms relative to small individual farms (the best that can be said is that large farms are not inferior to small farms in transition countries).

In this paper we present a comparative analysis of the productivity of small and large farms in Moldova based primarily on three farm surveys conducted by the World Bank and USAID in 2000 and 2003. The survey analysis is supplemented with official national-level statistics, which are used to calculate productivity measures of individual and corporate farms. Both nationally and in the available surveys, corporate farms are large farms, whereas individual farms are small farms. The two dimensions of the farm structure conundrum actually overlap for Moldova, and the organizational-form dichotomy in the national-level analysis is therefore a good proxy for the farm-size dichotomy in the analysis of the surveys. For purposes of analysis we calculate partial and total productivity measures (from both the surveys and the national statistics), as well as technical efficiency scores (from survey data only). The national statistics provide time-series data, whereas the surveys lend themselves to cross-sectional analysis. Furthermore, the national statistics include both household plots and peasant farms in the individual sector; in the analysis based on survey data we only used peasant farms as the representatives of the small-farm individual sector, because the data collected for household plots were inadequate for productivity calculations (on differences between household plots and peasant farms in Moldova, see, e.g., Lerman et al., 1998).

Our analysis demonstrates with considerable confidence that small farms in Moldova are more productive and more efficient than large farms**.** This finding is not restricted to Moldova, as a similar result was obtained in Russia (Uzun, 2005). Moreover, a recent study of U.S. farms has found that an increase of farm size reduces, rather than increases, agricultural productivity (Ahearn et al., 2002). The accumulating empirical evidence thus lends support to the "counterintuitive stylized fact [that] generally family farmers use resources more efficiently than large, commercial farmers who depend primarily on hired labor" (van den Brink et al., 2006, pp. 18-19). The discussion of the farm-structure issue suggests that the government of Moldova should abandon its preference for large-scale corporate farms and concentrate on improving the operating conditions for small individual farms. At the very least, the government should ensure a level playing field for farms of all sizes and organizational forms, and desist from biasing its policies in favor of large farms.

Partial productivity measures: changes in productivity of land and labor over time

The continuing shift of agricultural land from corporate to individual farms has produced a dramatic change in the structure of land use by agricultural producers. Particularly notable is the shrinking share of former state and collective farms and a corresponding increase in land used by the individual sector. Back in the early 1990s, corporate farms (collective and state farms at that time) controlled 90% of the agricultural land used by agricultural producers (excluding various components of reserve land). The individual sector (which consisted entirely of household plots at that time) managed the remaining 10% (**Table 1**). Since 1999-2000, the agricultural land resources are evenly divided between individual farms (which now consists of household plots and peasant farms) and large-scale corporate farms, mostly new organizational forms (joint stock companied, limited liability companies, agricultural cooperatives) with private ownership of land and assets. Each sector now controls approximately 50% of agricultural land (excluding reserve land).

The significant changes in land use have naturally affected the production structure of agriculture (**Table 1**). While the output of large collective and corporate farms declined through a complex combination of factors that included loss of land and disruption of the old economic order, the output of the individual sector (including the traditional household plots and the newly created peasant farms) has been growing (**Figure 1**). In 1998, the individual sector overtook the collective and corporate sector by volume of production. As of 2003, the individual sector, with about 50% of total agricultural land, produces more than 70% of agricultural output (**Table 1**).

Table 1. Land, output, and labor by farm type 1990-2003

	Agricultural land used by farms*			Gross Agricultural Output			Employed in agriculture		
	'000 ha	Corporate, %	Individual, %	Million lei, 2000 prices	Corporate, %	Individual, %	'000 workers	Corporate, %	Individual, %
1990	2545.8	91.5	8.5	17757	79.6	20.4	678	83.2	16.8
1991	2544.9	89.6	10.4	15749	76.3	23.7	743	75.8	24.2
1992	2509.5	89.0	11.0	13311	70.6	29.4	749	74.1	25.9
1993	2187.3	86.8	13.2	14647	62.5	37.5	730	73.1	26.9
1994	2196.6	82.7	17.3	11086	58.1	41.9	767	69.6	30.4
1995	2196.4	81.9	18.1	10293	55.5	44.5	771	69.2	30.8
1996	2191.3	78.9	21.1	9071	53.8	46.2	711	67.4	32.6
1997	2181.2	75.1	24.9	10108	54.4	45.6	684	63.2	36.8
1998	2177.8	70.1	29.9	8935	42.8	57.2	750	48.5	51.5
1999	2173.8	56.6	43.4	8184	32.8	67.2	731	33.8	66.2
2000	2146.7	47.1	52.9	7917	29.0	71.0	766	23.1	76.9
2001	2076.0	46.0	54.0	8427	28.0	72.0	764	20.7	79.3
2002	2069.2	48.7	51.3	8717	29.0	71.0	747	20.6	79.4
2003	2059.8	50.7	49.3	7535	25.0	75.0	583	23.9	76.1

*End of year data; land used by farms is agricultural land excluding the areas not allocated to agricultural producers (the state reserve, miscellaneous state lands, and part of the municipal land not allocated to agricultural producers).
Source: Statistical Yearbook of Moldova, various years; Agriculture (2004).

The discrepant shares of the individual sector in land and output can be applied to calculate the so-called relative productivity of individual farms. Taking the average sector productivity as 1.0 (with 100% of land producing 100% of output), we obtain 1.4 (=70%/50%) for the relative productivity of land used by individual farms, compared with only 0.6 (=30%/50%) for corporate farms. Already these rough calculations show that the small individual farms use their land more productively than the large corporate farms. This phenomenon has persisted since 1990, as the share of individual output has always been greater than the share of land in individual tenure (**Table 1**).

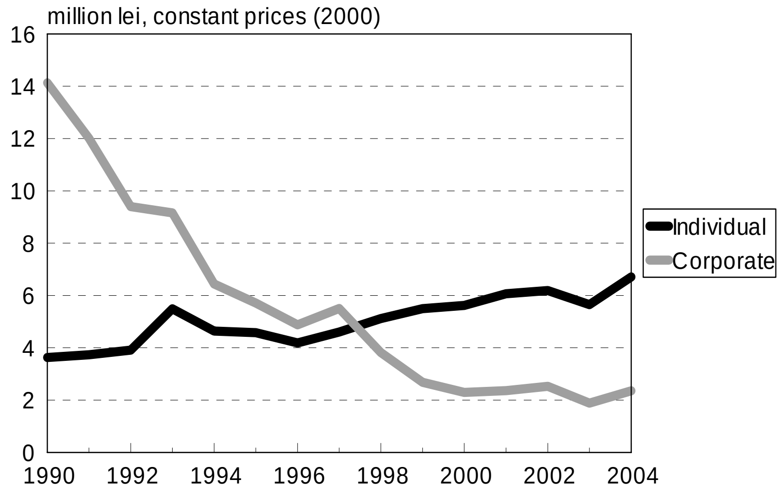

Figure 1. Gross agricultural product for individual and corporate farms 1990-2004.
Source: Statistical Yearbook of Moldova 1999, 2004.

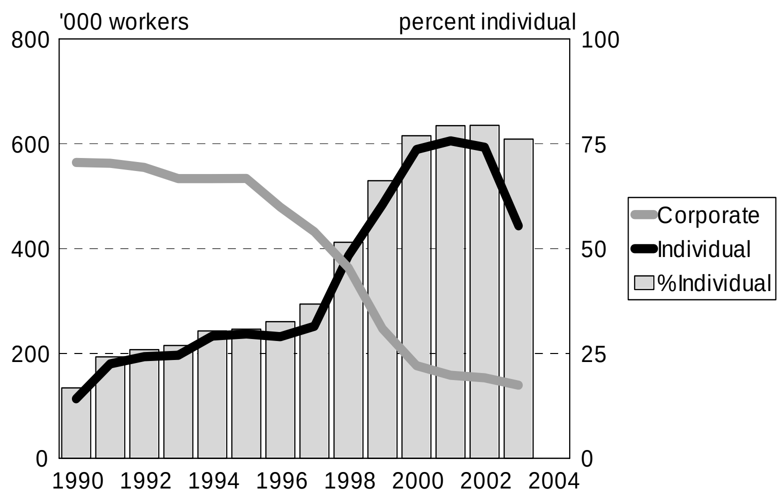

Figure 2. Agricultural employment in individual and corporate farms: thousands of workers (solid curves) and share of individual farms in agricultural employment (bars). Agricultural employment includes self-employed individuals.
Source: Agriculture (2004); number of employed in individual farms calculated as the difference between total number of employed and number of employed in corporate farms.

Agricultural labor is the second main resource that affects the performance of the agricultural sector. The total number of employed in agriculture (including hired labor, members of cooperatives and shareholder farms, and self-employed) remained fairly stable at 700,000-

750,000 between 1990 and 2002 (**Table 1**; the reported number of employed in agriculture dropped by more than 20% in 2003, but the reasons for this may be purely technical and forthcoming revisions will hopefully clarify the situation). Yet the steady overall picture of agricultural employment hides dramatic changes in farms of different types (**Figure 2**). The agricultural labor in corporate farms decreased precipitously, especially between 1995 and 2001, while that in individual farms increased sharply, especially after 1996, following the influx of agricultural land into the individual sector. In farms of both types the changes in agricultural labor use are strongly correlated with the changes in agricultural land use (the coefficient of correlation is greater than 0.95 for 1990-2003). The opposite employment trends in corporate and individual farms have resulted in a sharp increase of the share of agricultural labor in the individual sector – from 25% in the early 1990s to more than 75% in 2000-2003 (**Table 1**).

Table 2. Land and labor productivity for corporate and individual farms

Year	Productivity of land, '000 lei/ha		Productivity of labor, '000 lei/worker	
	Corporate	Individual	Corporate	Individual
1990	6.1	16.8	25.0	32.0
1991	5.3	14.2	21.3	20.8
1992	4.2	14.2	16.9	20.2
1993	4.8	18.9	17.2	27.9
1994	3.5	12.2	12.1	19.9
1995	3.2	11.5	10.7	19.3
1996	2.8	9.0	10.2	18.1
1997	3.4	8.5	12.7	18.3
1998	2.5	7.9	10.5	13.2
1999	2.2	5.8	10.9	11.4
2000	2.3	4.9	13.0	9.5
2001	2.5	5.4	14.9	10.0
2002	2.5	5.8	16.5	10.4
2003	1.8	5.5	13.5	12.7
Ave 1990-2003	3.4*	10.1*	14.7	17.4
Ave 1990-1996	4.3*	13.8*	16.2*	22.6*
Ave 1997-2003	2.4*	6.3*	13.1	12.2

*The differences between corporate and individual farms significant at $p < 0.1$ by both parametric and non-parametric tests.
Source: Calculated from **Table 1**.

Given the value of agricultural output in constant 2000 lei (**Table 1**), we can calculate the partial productivity of land and labor in absolute terms. The results are presented in **Table 2**. The productivity of land and the productivity of labor decrease over time in both corporate and individual farms. However, despite the similar trends, the productivity of individual farms is generally higher than the productivity of corporate farms. The land productivity of individual farms is higher in each and every year between 1990 and 2003. The labor productivity is higher in 11 of the 14 years: the exception is the period 2000-2003, when the labor productivity of corporate farms increased due to signs of increasing output (**Figure 1**) combined with continuing decrease of labor in these years (**Figure 2**).

The land productivity of individual farms is statistically significantly higher than that of corporate farms.[1] The difference in labor productivity, on the other hand, is not statistically significant, although the mean for the entire period 1990-2003 is observed to be higher for individual farms (**Table 2**). In other transition countries we also observe that the productivity of land is higher for individual farms, but the productivity of labor is actually higher for corporate farms. For Moldova the labor productivity of corporate farms is indeed higher in the later subperiod 1997-2003, but again the difference is not statistically significant (**Table 2)**. Thus, the two partial productivity measures for land and labor do not give a consistent picture: while land productivity is definitely higher for individual farms, the results for labor productivity are ambiguous (and furthermore do not fit the results in other transition countries, where labor productivity is typically lower for individual farms). To resolve the ambiguity, we have to

[1] A caveat is in order in connection with land productivity calculations: the land data cover all of Moldova, including the breakaway provinces in Transnistria (for the entire period 1990-2003); the agricultural output data are reported for Moldova without Transnistria (since 1995). To correct for the resulting bias, we recalculated the land productivity using the agricultural land series without Transnistria since 1995 (a rough approximation due to lack of authoritative data for Transnistria). The new results did not differ much from the original numbers: the mean productivity of land for corporate farms increased from 3.4 to 3.7, and that for individual farms from 10.1 to 10.2

calculate a measure of Total Factor Productivity (TFP), which is the ratio of total output produced (in money units) to the total bundle of inputs used (also in money units). TFP calculations using various databases are presented in the following sections.

A feature that clearly emerges from **Table 2** is the general decline of agricultural productivity since 1990 for farms of all types. The ongoing reforms have not produced significant productivity improvements after the initial shock. The labor productivity index constructed for the entire agricultural sector (combining both corporate and individual farms – **Figure 3**, thick black curve) shows signs of slight recovery after 2000, when the reforms accelerated during the implementation of the National Land Program. The labor productivity index bottomed out in 2000 at 40% of 1990, increasing to 50% of 1990 in 2003.

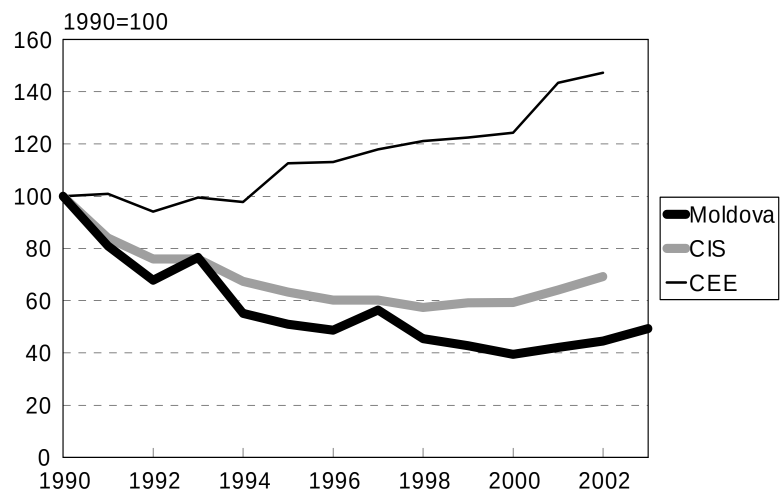

Figure 3. Agricultural labor productivity for Moldova, CIS, and CEE (index numbers, percent of 1990). Source: Authors' calculations based on Table 2 for Moldova, CIS (2004) for CIS, and country statistical yearbooks for CEE.

This pattern for Moldova is not different from the pattern observed for the CIS countries as a group, where agricultural labor productivity declined up to 1998 and showed slight signs of recovery thereafter (**Figure 3**, thick gray curve). However, the productivity loss in Moldova was initially greater than the CIS average, largely due to the political deadlock that prevented decisive implementation of reforms (Lerman et al., 1998; Csaki and Lerman, 2002), and the recent recovery still lags behind the average, due in large part to undeveloped and distorted markets for products and factors (World Bank, 2005). The productivity recovery in Moldova is attributable to the reported gains in agricultural production since 2000 (see **Table 1**), which in turn appear to be associated with the intensification of land reform after the introduction of NLP.

The behavior of agricultural labor productivity over time in Moldova and CIS is totally different from what we observe in Central Eastern Europe, where labor productivity has been increasing since 1994 through a combination of dramatic reduction of agricultural labor (at least in some countries) and a certain (though by no means dramatic) growth in agricultural output (**Figure 3**, thin black curve). In established market economies, such as the United States, Canada, and the European Union, agricultural labor productivity shows a steady growth over time as agricultural employment shrinks while output grows due to technological change. Thus, USDA data show that between 1990 and 1999 agricultural labor in U.S. farms decreased by 4% while agricultural output increased by 20%, producing an increase of 24% in agricultural labor productivity (USDA, 2000). The CEE countries in fact matched this productivity growth during the corresponding period, while CIS dropped to 60% of the 1990 level and Moldova's productivity declined even more to an abysmal 40% of the 1990 level (see **Figure 3**).

Total Factor Productivity

Partial productivity measures reflect the use of a single input (land or labor) taken separately. They often present an ambiguous picture, as some farms may have a higher productivity of land (say) and a lower productivity of labor. The ambiguity is resolved by switching from partial productivity to total factor productivity (TFP), which is calculated as the ratio of the value of output to the aggregated cost of input use. In the absence of market prices for valuing the cost of inputs (such as the price of land), TFP can be determined by estimating a production function and then using the estimated input coefficients as the weights to calculate the value of the bundle of inputs (for an application of this approach to 12 former Soviet republics see Lerman et al., 2003). The ratio of the observed output to the estimated bundle of inputs is the TFP.[2]

In principle, the production function can be estimated for any number of observed inputs. In practice, the physical data available for land and labor (area in hectares and number of workers, respectively) are usually much more reliable and consistent than the accounting figures for other factors of production, such as the cost of purchased inputs and the value of fixed assets. Due to the technical considerations of data reliability and availability, we have decided to estimate two-input production functions with land and labor as the explanatory variables for the aggregated value of output. This decision may be justified by the observation that in the economic productivity literature TFP is typically calculated assuming only two inputs: capital and labor (see, e.g., Jones, 1998, pp. 41-42, or the extensive productivity tables for Canada and the U.S. in CSLS, 2005). In our two-input production functions, land alone is a proxy for capital, as we ignore the extremely deficient cost data on farm machinery and buildings.

TFP from national-level time-series data

The national-level database for Moldova contains information on the value of agricultural output (in constant 2000 lei) and the quantities of two main inputs: agricultural land and agricultural labor. These data are available for 14 years 1990-2003 for individual and corporate farms separately (see **Table 1**). Unfortunately, our attempt to estimate a two-input production function of Moldovan agriculture from these data has failed due to relative shortness of the time

[2] For a calculation of TFP as the ratio of output to the accounting cost of inputs see Dudwick et al. (2005), Table 5.

series: the coefficients of both land and labor turned out statistically not significant. To get a qualitative picture of TFP changes over time despite the failure of rigorous estimation, we assumed a conventional Cobb-Douglas production function with stylized factor shares of 0.7 for land and 0.3 for labor (these are the factor shares that we consistently obtained in production functions estimated using various farm surveys in Moldova – see **Table 6** below). **Figure 4** presents the TFP results calculated with these land and labor weights. The TFP for individual farms (household plots and peasant farms combined) is higher than for corporate farms over the entire period 1990-2003. The respective means for 1990-2003 are 11.5 for individual farms and 4.4 for corporate farms (the difference is statistically significant).

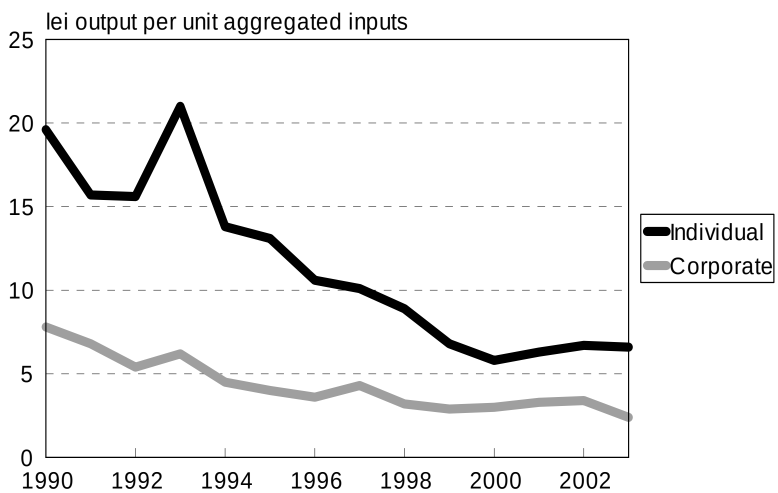

Figure 4. Total factor productivity for individual and corporate farms 1990-2003 (inputs from **Table 1** aggregated using hypothetical factor shares of 0.7 to land and 0.3 to labor).

TFP from survey data

To substantiate these simulated findings, we turned to the data collected in various farm surveys in Moldova since 2000. These surveys provide fairly large samples that allow reliable estimation of production functions. Yet the survey data are inherently cross-sections observed at a certain point in time and do not generate the time-series perspective afforded by national-level statistics.

Extensive data for small and large farms are available from four surveys: the World Bank 2003 survey conducted as part of a cross-country study of reform impacts; the USAID-sponsored survey of corporate farms carried out in 2003 by the Private Farmers' Aid Program (PFAP); the PFAP 2003 survey of individual farms; and the World Bank 2000 survey conducted as part of the preparation work for the World Bank Moldova Agricultural Strategy. The sample structure of the four surveys is shown in **Table 3**. General analyses of these surveys can be found in Dudwick et al. (2005) for the WB 2003 survey, Muravschi et al. (2004) for the two PFAP 2003 surveys, and Lerman (2001) for the WB 2000 survey.

Table 3. Structure of recent farm surveys in Moldova

	Small individual farms	Large corporate farms	Large individual farms
WB 2003 survey	176	22	--
PFAP 2003 surveys	1,166	521	--
WB 2000 survey	170	84	96

Table 4 presents the size characteristics and the partial productivity measures for small and large farms in the four surveys. While the large farms as a group are substantially larger than the small farms by all measures – output, land, and labor, the partial productivities show a mixed picture:

(a) The partial productivity of land (output per hectare) is higher for small individual farms than for large corporate farms;

(b) The partial productivity of labor (output per worker) is lower for small individual farms than for large corporate farms;

(c) The number of workers per hectare is much higher in small individual farms than in large corporate farms (the "labor sink" effect of individual farms).

These results are on the whole consistent with national-level findings since 2000 (**Table 2)**. We will now attempt to resolve the ambiguity in partial productivity measures by calculating total factor productivities (TFP) for the two groups of farms.

Table 4. Size characteristics and productivity measures for small and large farms: survey data (per fam averages)

	WB 2003 survey		PFAP 2003 surveys		WB 2000 survey	
	Small farms (individual)	Large farms (corporate)	Small farms (individual)	Large farms (corporate)	Small farms (individual)	Large farms (corporate and individual)
Number of observations	176	22	1,166	521	170	180
Ag land (ha)	4.48	971	4.02	918	5.7	533
Workers	4.51	332	6.27	150	1.6	43.7
Ag output ('000 lei)	25.8	3,230	25.3	2,038	75.4	1,642
Output/ha (lei)	6,765	2,745	9,535	2,085	6,414	3,145
Output/worker (lei)	6,857	17,135	5,145	17,824	55,304	54,393
Workers/ha	1.42	0.26	3.25	0.19		

Note: All differences between small and large farms are statistically significant at $p = 0.1$ (except the differences in productivity of labor – output/worker – in the WB 2000 survey).

TFP by dummy variable estimation

Differences in TFP between categories of farms can be captured by estimating appropriate production functions with a dummy variable for different farm types. If the dummy coefficient for type A farms is found to be greater than for type B farms, this implies that type A farms produce a greater value of output at any given bundle of inputs and essentially means that type A farms have higher TFP than type B farms. This procedure enables us to assess *differences* in TFP without actually calculating the TFP in *absolute values*.

Simple two-input Cobb-Douglas production functions, relating the aggregated value of output to agricultural land and agricultural labor, were estimated for two datasets: the WB 2003 survey on its own (198 farms classified into small and large) and the pooled dataset combining the WB 2003 survey with the PFAP survey of corporate farms (521 additional observations on large corporate farms).[3] The two-input production functions were first estimated for both datasets without dummy variables (Models 1 and 1P in **Table 5**). In both samples, the coefficients of the two factors of production (land and labor) summed to less than 1, and the difference from 1 was statistically significant at $p = 0.10$. The production function thus shows *decreasing* returns to scale: large (corporate) farms produce less per unit of inputs in the margin than small (individual) farms (and this result is statistically significant).

Table 5. Estimation of Cobb-Douglas production function for large and small farms: WB 2003 survey and pooled sample

Dependent variable: value of output (lei)	Model 1 coefficients	Model 1P coefficients	Model 2 coefficients	Model 2P coefficients
Explanatory variables:				
Land (ha)	0.60	0.58	0.69	0.75
Labor (workers)	0.30	0.39	0.31	0.33
Farm type (dummy): large farms relative to small farms	--	--	-0.58	-0.84
Sum of input coefficients	0.90	0.97	n.a.	n.a.
R^2	0.770	0.911	0.773	0.917
Number of observations	198	719	198	719
Estimation sample	WB survey	Pooled	WB survey	Pooled

Note: Models 1 and 2 estimated using the WB 2003 survey; models 1P and 2P estimated using the pooled data set with the WB 2003 sample augmented by large corporate farms from the PFAP 2003 survey.

This conclusion is strengthened and quantified by estimating the same two-input production function with a dummy variable for large (corporate) and small (individual) farms (Models 2 and 2P in **Table 5**). The intercept for large farms (relative to small farms) is negative, which means that at each level of inputs (land and labor) large corporate farms attain lower output than small individual farms (the negative coefficient was statistically significant at $p = 0.10$). The mathematics of the Cobb-Douglas production function translates the negative dummy variable coefficient of -0.58 obtained in the 2003 survey into a difference of 45% in output between corporate and individual farms for each bundle of inputs ($1 - \exp(-0.58) = 1 - 0.55 = 0.45$). In the pooled sample, the gap is even greater (57%).

[3] We decided not to pool the 1,166 individual farms from the PFAP sample with the rest because their large number would overwhelm the much smaller WB 2003 sample.

TFP calculated from production function coefficients

The estimated production function provides another technique for calculating the TFP in absolute values for different groups of farms. As we move from the small individual farms to the large corporate farms, the agricultural product increases, but so do the land endowment and the labor force per farm (see **Table 4**). The production function is a mathematical relationship that links the increase in agricultural product with the increase in aggregated input use. The inputs are aggregated by applying the weights (or factor shares) from the corresponding production function to specific values of the inputs (land and labor in our case). TFP is calculated as the aggregated value of output divided by the aggregated value of inputs. This differs from the partial productivity measures, in which the aggregated value of output is divided by the quantity of a single input (land or labor).

Table 6. Regression coefficients and input weights in production functions estimated for three samples

	WB 2003 survey (n = 198)	PFAP individual farms (n = 1166)	PFAP corporate farms (n = 521)	WB 2000 survey (n = 268)
Estimated coefficients:				
Ag land	0.6007	0.5247	0.8150	0.6305
Workers	0.2993	0.1865	0.3068	0.2325
Sum of coefficients	0.90	0.71	1.12	0.86
R^2	0.77	0.40	0.84	0.89
Input weights:				
Ag land	0.67	0.74	0.73	0.73
Workers	0.33	0.26	0.27	0.27

Note: The estimated coefficients are significantly different from zero (p< 0.01); all sums of coefficients significantly different from 1.

Table 6 presents the estimated production function coefficients and the weights used in TFP calculations. Two features are worth highlighting in these numbers. First, in all two-input production functions agricultural land accounts for around 70% of input use and labor for 30% (see the rows for input weights). These results have suggested the specific weights applied to the synthetic analysis of national time series at the beginning of this section (see **Figure 4**). Second, mixed samples of individual and corporate farms (WB 2003 and WB 2000) as well as the sample of pure individual farms (PFAP) reveal *decreasing* returns to scale (the sum of the estimated coefficients is significantly less than 1). Corporate farms taken on their own (PFAP sample of corporate farms) reveal *increasing* returns to scale (the sum of the estimated coefficients is significantly greater than 1). These issues are discussed in some detail in a separate section.

The mean TFP values obtained by this method for small and large farms in the four survey samples are presented in **Table 7**. Small individual farms attain consistently higher TFPs than large corporate farms. The differences are statistically significant at $p = 0.1$. The TFP calculations thus eliminate the ambiguity between the partial productivities of land and labor for large and small farms and conclusively show that small farms use their resources more productively than large farms.[4] This finding is consistent with the indication of decreasing returns to scale in the production function.

Table 7. TFP (lei per aggregated unit of inputs)

	Small (individual) farms	Large (corporate) farms	Large-to-small ratio
WB 2003 survey	6,426	4,745	0.74
PFAP surveys	7,424	3,464	0.47
WB 2000 survey	8,420	4,010	0.48

The conclusions of the dichotomized productivity comparison between large and small farms in **Table 7** were strengthened by checking the relationship of TFP with farm size as a continuous variable (measured in hectares of agricultural land). This analysis was carried out only in the WB 2000 survey, where individual farms span the entire spectrum of farm sizes and are not limited to the small-size range as in the other samples (the corporate farms in this sample are all in the large-size range). Consistently with the previous findings, TFP decreases with

[4]Our results for the relative TFP of corporate and individual farms are not too far from the result of Dudwick et al. (2005), who calculate the TFP as the ratio of the value of output to the accounting value of total costs. The TFP of corporate farms in Dudwick et al. (Table 5) is 30% of the TFP for individual farms, whereas our results give around 45% (by dummy variable analysis for the WB 2003 sample and by input aggregation for the pooled sample).

increasing farm size (see the regression line for TFP in Figure 5; the relationship is highly significant). These results corroborate the previous conclusion of decreasing returns to scale.

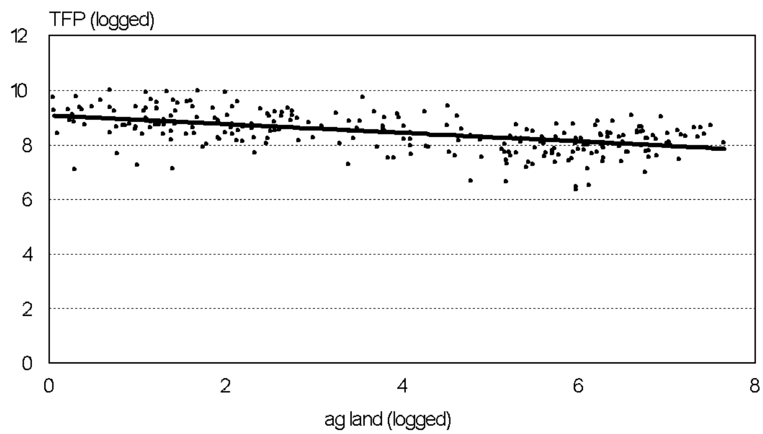

Figure 5. Total factor productivity versus farm size for individual and corporate farms combined (WB 2000 survey).

Our findings that TFP is higher for small farms (**Table 7**) and that TFP decreases with increasing farm size (**Figure 5**) are reinforced by recent results for U.S. farms (Ahearn et al., 2002). Using a time series of labor and capital in U.S. farms for 1978-1996, the researchers have found that an increase of farm size reduces, rather than increases, agricultural productivity (as measured by TFP). "This suggests that on average a type of diseconomies of size is operating [in U.S. farms]" (ibid., p. 20).

Technical Efficiency of Small and Large Farms

Our approach to total factor productivity has relied on estimation of production functions. As noted above, production function estimation with farm-type dummy variables is a standard econometric technique for assessing the relative productivity of different organizational forms without actually calculating absolute TFP values. A different approach that focuses on farm efficiency (rather than TFP) relies on the construction of production frontiers (not production functions). A production frontier is the locus of efficient or “best attainable” points, i.e., points where the maximum output is achieved for every given bundle of inputs, or alternatively every given output is achieved by the consumption of a minimum bundle of inputs. The production-frontier approach provides an alternative view that generally reinforces the TFP results obtained with production functions.

The production frontier is constructed on the basis of available empirical data, and the efficient points are the “best attainable” in the sample, not in the entire conceivable population. Once the production frontier has been constructed, the technical efficiency of each farm is calculated by measuring its relative distance from the frontier. Points on the frontier are technically efficient; their distance from the frontier is 0, and their technical efficiency (TE) score is 1. As the distance of a particular point from the frontier increases, its TE score decreases. Each TE score is a number indicating the output that a particular farm achieves with a given bundle of inputs as a fraction (or a percentage) achieved by the “best performer” with the same bundle of inputs. For a comprehensive discussion of technical efficiency and the methodology of constructing production frontiers see Coelli et al. (1998).

Stochastic Frontier Analysis (SFA) is a production frontier technique that is conceptually close to production function estimation. This is an econometric method that starts with the production function and then iteratively shifts it outward by a certain algorithm until a production frontier is obtained. The actual observed points generally fall below the frontier (in this sense they are inefficient). The deviation of the observed points from the frontier also contains a random error component because of which some points may actually fall above the estimated frontier (if the error component exceeds the estimated inefficiency component). The

TE scores are calculated by taking the ratio of the actual output of each farm (adjusted for random errors) to the stochastic frontier output for the corresponding bundle of inputs. A detailed description of the SFA algorithm and its comparison with an alternative deterministic algorithm (DEA – Data Envelopment Analysis, which assigns the total deviation from the frontier to inefficiency), can be found in Coelli et al. (1998).

Table 8. TE scores obtained by Stochastic Frontier Analysis (SFA) for 2003 surveys

	WB 2003 survey (n = 198)	Pooled database (n = 719)
Corporate	0.46* (n = 22)	0.67# (n = 543)
Individual	0.64* (n = 176)	0.70# (n = 176)

*Difference statistically significant at p = 0.10 by parametric *t*-test and nonparametric Wilcoxon test.
#Difference statistically significant at p = 0.10 by nonparametric Wilcoxon test only.

Table 8 presents the mean TE scores obtained for farms of different types in the WB 2003 sample and in the pooled sample augmented with 512 corporate farms from the PFAP survey. Small individual farms achieve higher TE scores than large corporate farms (the difference is statistically significant in both samples). This indicates that the small individual farms on average utilize the two inputs (land and labor) more efficiently than the large corporate farms: for any given bundle of inputs the small farms produce on average more than the large farms. These results are consistent with the TFP results obtained by production function analysis: small farms are more productive in the production function paradigm and more efficient in the production frontier paradigm.

Evidence of Increasing Returns to Scale among Corporate Farms: Isolating the Organizational Form Effect

So far we have been looking at datasets with two clearly differentiated groups of farms: small individual farms (generally farms with less than 50 hectares) and large corporate farms (technically farms with more than 50 hectares, but in practice managing hundreds and thousands of hectares on average). Given this dichotomy, we obtained evidence of decreasing returns to scale and clear proof of higher total factor productivity in small individual farms.

The PFAP database taken on its own (without pooling with the WB 2003 survey) provides 512 observations of large corporate farms only. The coefficients of the production function estimated for this sample of large corporate farms are 0.81 for land and 0.31 for labor. They sum to more than 1, and the difference from 1 is statistically significant at $p = 0.01$ (see **Table 6**). The production function thus shows *increasing* returns to scale within the sample of corporate farms. This result is consistent with previous findings for corporate farms in Russia, where several researchers have observed increasing returns to scale specifically among corporate farms (Uzun, 2002; Epshtein, 2003, 2005).

The TFP calculations were repeated for the PFAP sample of corporate farms considered on its own. Here, we keep the farm type constant (corporate farms) and examine the TFP scores as a function of farm size. The coefficient of correlation between the TFP scores of corporate farms and land (taken as a continuous variable) is positive (0.2) and statistically significant at $p < 0.01$. This implies that for corporate farms TFP indeed increases with farm size.

To visualize the results more clearly, we additionally classified the 521 corporate farms in the PFAP survey into three size groups (up to 500 hectares, between 500 and 2000 hectares, more than 2000 hectares). The productivity of land clearly increases with farm size, whereas the productivity of labor does not. Total factor productivity calculated by aggregating land and labor with appropriate weights from the production function shows a definite increase with farm size (all pairwise differences in TFP are statistically significant by standard simultaneous comparison tests). This behavior is illustrated in **Table 9**.

The TFP results were verified by carrying out Stochastic Frontier Analysis for the PFAP sample of corporate farms and testing for significant differences in TE scores across the three size categories. The mean TE scores by size group are presented in **Table 10**. The lowest TE score is observed for the smallest corporate farms with up to 500 hectares; the highest TE score is observed for the largest corporate farms with more than 2,000 hectares. These results were found to be highly significant by standard simultaneous pairwise-comparison methods.

Table 9. TFP of corporate farms by land size categories: PFAP 2003 survey

	<500 ha (1)	500-2000 ha (2)	>2000 ha (3)
Number of farms	238	225	58
Land productivity (output/ha, lei)	1,927	2,162	2,430
Labor productivity (output/worker, lei)	18,660	16,580	19,219
TFP (lei per unit of aggregated inputs)	3,162	3,603	4,167

Table 10. TE scores obtained by Stochastic Frontier Analysis for the PFAP sample of corporate farms (*n*= 521)

Farm size category	SFA scores
<500 ha	0.64*
500-2000 ha	0.76*
>2000 ha	0.84*

On balance, we do find evidence of increasing returns to scale in the homogeneous sample of corporate farms, while farms in a larger mixed sample of different types (both individual and corporate) on the whole show decreasing returns to scale. The different behavior may be understood if we recall that in our samples scale is a proxy for farm type. Small farms are typically individual farms, and they do better than large corporate farms not necessarily because of a size effect, but because of an organizational form effect: individual farms outperform corporate farms. This conclusion is consistent with general theoretical arguments on comparative performance of different organizational forms (see, e.g., Allen and Lueck, 2003) and with the stylized facts described by van den Brink et al. (2006).

Conclusion

The large corporate farms in Moldova are a carryover from the Soviet era. The Soviet agricultural ideology was driven, among other factors, by expectations of economies of scale. This ideology is still deeply implanted in the minds of many agricultural decision makers in the country, regardless of their dedication to market economy principles. It is also at the root of the persistent complaints about fragmentation of agricultural holdings in the process of privatization and the need to achieve consolidation by transition to large cooperatives or corporations. Yet the policy makers in Moldova should realize that all attempts to preserve large-scale corporate structures in former Soviet republics (whether as agricultural cooperatives or as new corporations with market-sounding names) have not produced any positive results. The Russian and Ukrainian dream of "horizontal transformation", making persistently inefficient corporate farms suddenly efficient, apparently does not work. On the contrary, it is the three small countries that resolutely abandoned the large-scale structures and made a clean shift to small-scale individual agriculture – Armenia, Georgia, and Azerbaijan – that demonstrate the most impressive recovery record among the CIS countries in recent years. Moldova has much in common with these three small, densely populated countries, much more than with Russia and Ukraine, and the Moldovan policy makers will do well to study the experience with small farms in Armenia, Georgia, and Azerbaijan.

Comparison of farm structure in Moldova and the EU-15 (as representatives of a market economy) shows that Moldova is characterized by much greater land concentration in large farms than any of the EU-15 countries. Even in countries most similar to Moldova, such as Portugal and Greece, the large-farm sector controls a much smaller proportion of land and small farms achieve much greater dominance. To move closer to the farm-structure pattern typical of market economies, Moldova should allow land to flow from large corporate farms to small individual farms, rather than in the opposite direction. This will reduce the concentration of land in large farms, while at the same time increasing the share of land controlled by the small individual farms, and thus bring Moldova in closer conformity with the market pattern of land concentration. At the same time it may correct, at least partially, one of the two manifestations of land fragmentation in Moldova: the average size of the very small individual farms will increase somewhat as they acquire more land at the expense of large corporate farms. More importantly, it should also result in increased agricultural productivity.

Fragmentation of holdings due to land privatization and the advisability of implementing administrative measures to encourage consolidation and re-creation of large-scale corporate farms are at the center of the ongoing policy debate in Moldova. Our results show convincingly that small individual farms in Moldova achieve higher productivity and efficiency than large corporate farms – a result which is obtained also in other countries (see, e.g., Uzun (2005) for Russia and Ahearn et al. (2002) for the United States). Therefore policies encouraging a shift from large corporate farms to smaller individual farms, rather than the reverse, can be expected to produce beneficial results for Moldovan agriculture and the economy in general.

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