CASE STUDY

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Are Mega-Farms the Future of Global Agriculture?

Exploring the Farm Size-Productivity Relationship for Large Commercial Farms in Ukraine*

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ABSTRACT

With farms cultivating tens or hundreds of thousands of hectares, Ukraine's example is often used to demonstrate the existence of economies of scale in modern grain production. Panel data analysis for all the country's farms above 200 ha in 2001-2011 suggests that higher yields and profits are due to unobserved factors at rayon (district) and farm level rather than economies of scale. Productivity growth was driven not by farm expansion but by exit of unproductive and entry of more efficient farms. Higher initial shares of area under farms above 5,000 ha at rayon level significantly reduce subsequent exit and entry, suggesting that excessive land concentration reduces productivity growth in the long run. Implications for global evolution of farm structures are drawn out.

BACKGROUND

Recent trends in soft commodity prices and expected increases in demand for food, fiber, and fuel has led to a revival of interest in agricultural production and agrarian structure. Earlier, evidence of superior economic performance of owner-operated farms and the drawbacks of a highly unequal distribution of land assets provided the basis for near-unanimous support of smallholder-based strategies as the most effective way of expanding agricultural production. Now, influential voices argue that increasing returns to scale in agricultural production – partly resulting from new technology – could make reliance on large commercial farms a viable development path for land-rich countries (Collier and Venables 2011).

Whether an agrarian structure based on large farms can be economically and socially desirable hinges on two issues. One is whether the new technology has changed the negative farm size-productivity relationship found in much of the traditional literature, leading to economies of scale in production. A second concern is whether initial land concentration will affect subsequent economic performance and what channels may be involved.

Ukraine provides an interesting setting to study both phenomena. With vast areas of fertile black soils, Ukraine has traditionally been a regional breadbasket. It is one of few countries that have seen rapid expansion of large farms using modern technology and management over the last decade. While tax and quota policies may favor larger farms, Ukraine lacks farm price support and subsidy policies of developed countries that arguably depress farm sizes artificially (Adamopoulos and Restuccia 2011). It is home to some of the largest farms on earth and has seen considerable land concentration; the country's 40 largest agri-holdings are estimated to control 4.5 million ha or 13.6% of cultivated area (Lissitsa 2010), a fact interpreted by supporters of large scale agribusiness as evidence of such farms' superior economic performance. There are also vast differences in social structure and the nature of economic activity across Ukraine's regions. The land reforms of 1999-2001 allow exploring the extent to which initial differences in agrarian structure matter.

DESIGN

The basis for our empirical work is a depersonalized data collected annually from 2001 to 2011 by Ukraine's State Statistics Committee (through form 50SG) for the universe of roughly 10,000 large commercial farms in the country each year. We construct consistent series for area cultivated and output value in 2010 US$, from crop production for 11 crops and cost of key inputs. We restrict our sample to farms above 200 ha as they were not affected by any changes in reporting requirements. Over the whole period, we have 89,736 observations for a panel of 16,191 farms registered outside cities.

These data allow exploring two types of questions: (i) links between productivity and farm size and (ii) impacts of initial farm structure on subsequent entry, exit, and productive performance. The wide variation in initial inequality of operational farm sizes are measured as the share of area cultivated by farms greater than 5,000 ha, across the 472 rural rayons (districts). Using this measure, we explore the extent to which structural factors affect productivity indirectly by having an impact on the rate of entry and exit once other factors are accounted for. We use a farm-level production function to investigate the presence of economies of scale and rayon-level analysis to identify the initial land concentration effect.

DESCRIPTIVE EVIDENCE

Detailed panel data illustrate three features of agricultural development in Ukraine over 2001-2011. First, yields grew rapidly after 2006, with sunflower, corn, and soybean yields almost doubling, prompting a marked shift to oilseeds (Table 1). Second, the transformation of agricultural sector was more due to new entry than to existing farm growth. Most entrants cultivated farms 1,000-3,000 ha in size, which are large by European standards but not super-large. Finally, although land sales have not been allowed, there was massive concentration of operational holdings via land rental agreements: area farmed by units above 10,000 ha expanded by more than 2 mn. ha (or 10% of the total) in the 2006-11 period.

Yield growth and shifts in output composition prompted far-reaching changes in agrarian structure. As Table 1 illustrates, the area cultivated by sample farms decreased from 21 mn. ha in 2001 to 15 mn. ha in 2006 before recovering to 18 mn. ha in 2011. While average national farm size increased from 2,061 to 2,305 ha, the median area farmed decreased, from 1,625 to 1,429 ha. Inequality grew significantly with the Gini of the operational farm size distribution shifting from 0.32 to 0.47. The almost 5-fold increase in area of farms above 10,000 ha during this period was a key factor underlying this trend.

Data on cost and output per ha for pre- and post-2006 periods in Figures 1.1 and 1.2 suggest that in the first period, profitability was limited and few super-large farms existed. After 2006, profitability improved, with profits maximized at farm sizes of 2,000 to 3,000 ha. This casts doubt on the notion that superior productive performance was the main driver of the expansion of super-large farms.

Table 2 displays levels of productivity by farms in the initial sample that either stayed or exited and new entrants. Entry and exit seem closely linked to productive performance; the incumbents who exited had negative profits per ha (US$ -11.3), compared to US$ 35 for stayers and US$ 65.5 for entrants. Entrants had higher cost, suggesting use of more input-intensive technology. This is consistent with successful entrants employing less than average labor in both periods.

Compared to the increase in per ha cost, mean initial area operated by entrants decreased over time from 1,950 ha to 1,445 ha. The fact that their size in both periods was quite small casts further doubt on the validity of the narrative of relentless farm growth driven by economies of scale.

Table 1: Overall Changes in Yields of Major Crops (kg/ha)

	2001	2006	2011
Corn	3,305	3,298	5,892
Soybean	1,081	1,060	1,914
Sunflower	942	1,424	1,948
Changes in Farm Structure			
Area cultivated (mn ha.)	20.59	15.19	17.61
Avg. farm size (ha)	2,061	2,222	2,305
Median farm size (ha)	1,625	1,630	1,429
Land Gini	0.316	0.352	0.473
Area under farms > 10,000 ha	654,755	1,338,368	3,437,111
Maximum farm size (ha)	88,032	88,751	142,014

Source: Own computation from Form 50.

RESULTS

Two sets of main analytical results were produced. First, once rayon- or farm-level fixed effects are accounted for, the production technology exhibits constant returns to scale. Second, initial land concentration affected subsequent performance: a higher share of land cultivated by farms above 5,000 ha at rayon level in 2001 is associated with lower levels of exit and entry and productivity growth.

Table 3 reports results for the nearly 90,000 observations for the naïve cross section (col. 1) and specifications with rayon (col. 2) and farm fixed effects (col. 3). While cross sectional estimates point towards significant increasing returns to scale in the first period, when a doubling of inputs is predicted to be associated with a 1.17 increase in output, the corresponding figure was much lower (1.06) in

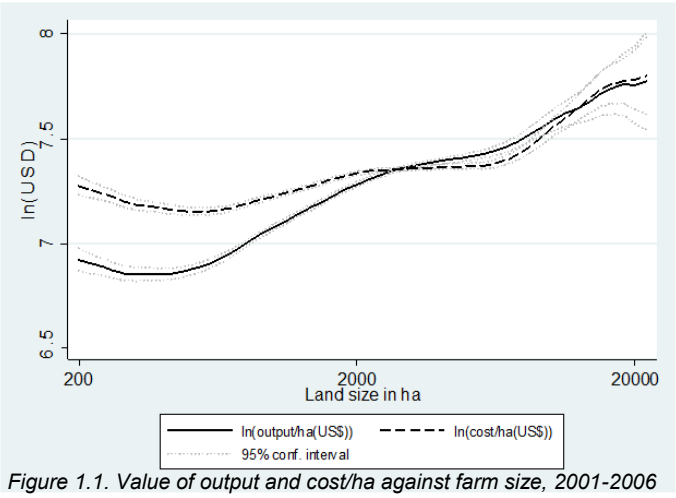

Figure 1.1. Value of output and cost/ha against farm size, 2001-2006

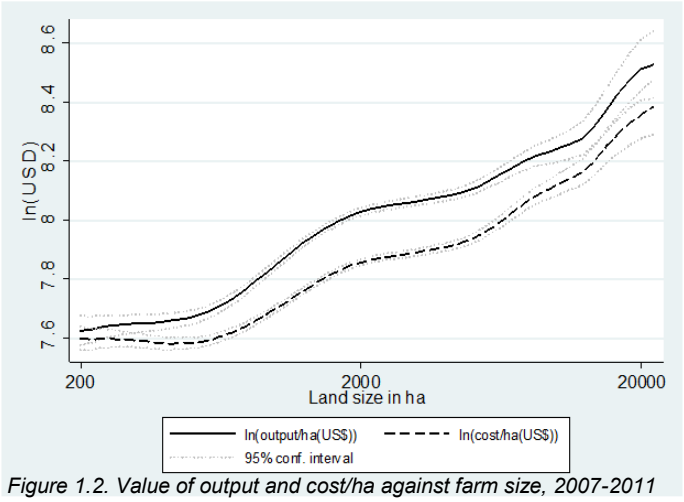

Figure 1.2. Value of output and cost/ha against farm size, 2007-2011

Table 2: Descriptive Statistics by Type of Exit and Entry

	Period	All	Exits	Stayers	Entrants
Profit/ha (US$)	2001/11	27.7	-11.3	35.3	65.5
	2001/06	-2.4	-12.5	6.7	1.6
	2007/11	69.8	15.8	77.5	96.1
Output/ha (US$)	2001/11	250.4	134.3	294.3	354
	2001/06	179.6	126.1	203.8	239.1
	2007/11	367.1	232.7	393.9	415.2
Cost/ha (US$)	2001/11	222.7	145.5	259	288.5
	2001/06	182	138.6	197.1	237.4
	2007/11	297.3	216.9	316.4	319.1
Area at start (ha)	2001/11	1911	1829	2627	1688
	2001/06	2036	1801	2363	1950
	2007/11	2017	1488	2453	1445
Workers per 100 ha	2001/11	3.36	4.28	3.61	2.29
	2001/06	4.14	4.34	4.34	3.45
	2007/11	2.28	2.7	2.34	1.81

Source: Own computation from form 50SG

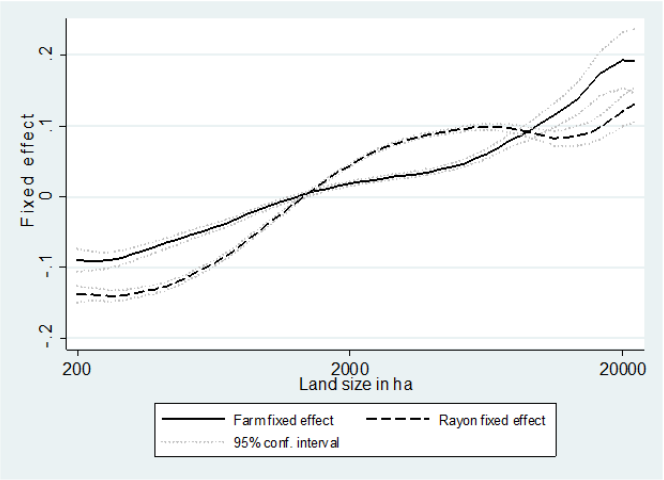

Figure 2. Farm and rayon fixed effects by farm size (cities & rayon centers excluded), 2001-2011

the second period. This is in line with the notion that market imperfections could only be overcome by very large sizes in the early post-liberalization stages. Once farm-fixed effects are included to account for unobserved differences in managerial ability, the hypothesis of constant returns to scale can no longer be rejected at 10% statistical significance level in both periods. This near-disappearance of 'economies of scale' implies that large farms' emergence or prevalence may be explained by a combination of three factors: (i) large farms' use of superior management skills; (ii) their location in rayons better endowed with key factors (e.g. soil quality, infrastructure); and (iii) benefits from the ability to vertically integrate beyond the production stage, deal with factor market imperfections, and possibly exercise market power.

Separating out farm- and rayon-specific fixed effects allows comparing relative magnitudes of location-specific factors vs. farm-specific management. Figure 2 shows that if farm-level fixed effects proxy for managerial ability as an indivisible factor, better managers operate larger farms. In addition, the absolute magnitude of rayon-level effects exceeds that of farm-fixed effects for farms above roughly 1,500 ha. In other words, large farms locate in rayons with more favorable endowments and benefits from the associated location-specific rents exceed those from managerial efficiency.

Displaying farm fixed effects separately for those who entered, exited, and remained in the sample in Figure 3 illustrates the contribution of entry and exit to productivity dynamics. Entry appears to be a key determinant of structural change as efficiency of incumbents who remained in the sample first-order dominates that of exiters while itself being first-order dominated by permanent (though not all) entrants.

As to the long-term land concentration effect, Table 4 reports regression results for rayon-level area subject to entry or exit. The dependent variables are rayon area shares exited from production permanently (col. 1) or overall (col. 2) and brought in production permanently (col.3) or totally (col. 4). Initial levels of farm-level productivity are very significant and negative throughout, in line with the notion that exit was less likely in rayons where farms were more productive to start with. The magnitude of the estimated land concentration effects is economically significant: an additional 10% of a rayon's area under farms above 5,000 ha is predicted to reduce subsequent exit by 2.7 and entry by 3.2 percentage points, respectively. The higher the productivity of farms above 5,000 ha, the lower the share of land vacated by exiters.

Regression results for areas newly occupied by entrants are different from those for exit in the following respect. The interaction between large farms' area share and their initial level of productivity is insignificant, consistent with the notion that, if area shares are accounted for, large farms' initial productivity does not affect entry.

To the extent that they affect entry and exit, pre-existing structural differences should also have an impact on the overall productivity measured as crop output per hectare. As seen in Table 5, holding other factors constant, higher levels of initial land concentration indeed reduce subsequent

Table 3: Cobb Douglas Production Function Estimates

	Log of output (in USD)		
	Pooled OLS	Rayon FE	Farm FE
Area	0.212***	0.236***	0.341***
Area*post 2006	-0.048***	-0.02	-0.050***
Labor	0.222***	0.189***	0.168***
Labor*post 2006	-0.137***	-0.104***	-0.051***
Seed	0.154***	0.163***	0.139***
Seed*post 2006	0.091***	0.069***	0.049***
Fertilizer	0.117***	0.121***	0.073***
Fertilizer*post 2006	0.012**	0.010**	0.015***
Fuel and energy	0.319***	0.240***	0.162***
Fuel and energy*post 2006	-0.104***	-0.061***	0.006
Other – agricultural services	0.076***	0.048***	0.043***
Other – agricultural services*post 2006	0.029***	0.049***	0.042***
Observations	89,736	89,736	89,736
Sum of coefficients period 1	1.171***	1.062***	0.991
Sum of coefficients period 2	1.056***	1.019***	0.999

*Note: Statistical significance is indicated by the following: ***p<0.01, **p<0.05, *p<0.1. Deviation from 1 is tested for the sum of coefficients.*

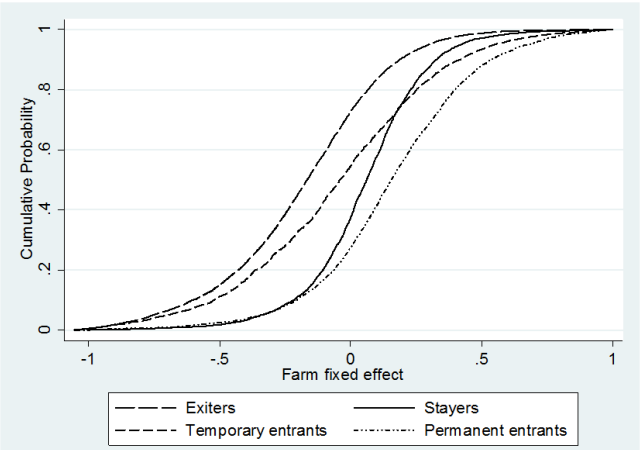

Figure 3. Farm fixed effect by nature of entry / exit

Table 4: Rayon-level Regressions for Aggregate Entry and Exit (2002-2011)

	Share of area exiting		Share of area entering	
	permanent	churn	permanent	churn
Init. share of cult. area > 5000 ha	-0.273***	-0.360**	-0.315**	-0.385**
Initial productivity	-0.797***	-1.104***	-0.503**	-0.596***
Init. share > 5000 ha *productivity	-0.701***	-0.841**	-0.145	-0.188
Rayon fixed effect	0.270***	0.583***	0.774***	0.994***
Observations	472	472	472	472
R-squared	0.222	0.219	0.246	0.253

*Note: Region dummies and constant included in all regressions but not reported; Statistical significance is indicated by the following: ***p<0.01, **p<0.05, *p<0.1.*

productivity, with the size of estimated effect fairly similar across categories. Also, while the negative coefficient on initial productivity points towards convergence of productivity levels across farms, there is greater dispersion in the bottom of the distribution as compared to the top. Finally, levels of individual productivity are higher in rayons with positive productivity shocks (e.g. better infrastructure).

Table 5: Evidence of Convergence in Productivity at Rayon Level by Quintiles

	Percentile				
	10th	25th	50th	75th	90th
Init. share > 5000 ha	-0.363***	-0.432***	-0.405***	-0.402***	-0.492***
Initial productivity	-0.414***	-0.530***	-0.569***	-0.553***	-0.785***
Init. share > 5000 ha * productivity	0.448	0.149	0.685	0.156	0.117
Rayon fixed effect	0.977***	0.847***	0.628***	0.314**	0.671***

*Note: Statistical significance is indicated by the following: ***p<0.01, **p<0.05, *p<0.1.*

CONCLUSION

Our study contribute to two strands of literature. First, we extend evidence on the farm size-productivity relationship, which hitherto has been largely restricted to labor intensive technologies in relatively land-scarce environments, to a setting with abundant land and capital-intensive technology. The hypothesis of economies of scale in agricultural production is rejected even in this environment. Instead, large farms' superior performance appears to be due to unobserved rayon- and farm-specific attributes. Decomposition of fixed effects to assess the underlying factors in detail will be a key area for follow-up research.

Second, concerning the literature on transition and agrarian structure, our findings suggest that a causal interpretation of the temporal coincidence of Ukraine's productive recovery with the growth of mega-farms may be a fallacy. Instead, exit of inefficient farms during the early years of reform and the space this created for entry of more efficient ones emerge as key drivers of higher agricultural productivity. It implies that reduction in entry/exit barriers in agriculture may be a viable development strategy. The large and robust negative effect of the share of land initially held by large farms on subsequent exit and entry suggests that the initial agrarian structure can affect development in the long term. Efforts to explore the underlying economic and political channels in detail may help identify ways to close productivity gaps and foster greater convergence across Ukraine's regions. Beyond Ukraine, the evidence of land concentration causing negative externalities holds lessons for policy makers in other countries seeking to promote rapid agricultural growth.

From a methodological perspective, the study shows that the dearth of studies to guide policy-making in Ukraine is not due to absence of data but the lack of capacity to process and link available information. Addressing this gap could help support research on a number of key topics including an exploration of the extent to which smaller farms' growth is hampered by factor market imperfections (and how they can be over-come); land valuation and the extent to which there is an under-investment in long-term agricultural assets (incl. soil fertility); and the links between agricultural and non-agricultural growth at rayon level. This could help inform the debate on the future of agricultural development and land markets in Ukraine to base policy proposals on empirical evidence rather than ideology or corporate interests.

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*Full text of report is available at: http://go.worldbank.org/A5D4SB2IU0

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