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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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Are mega-farms the future of global agriculture?

Exploring the farm size-productivity relationship for large commercial farms in Ukraine

Abstract: With farms cultivating tens or hundreds of thousands of hectares, Ukraine is often used to demonstrate the existence of economies of scale in modern grain production. Panel data analysis for all the country's farms with more than 200 hectares 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 with more than 3,000 or 5,000 hectares at the rayon level significantly reduce subsequent exit, suggesting that land concentration reduces productivity growth. The paper draws implications for global evolution of farm structures.

Recent trends in soft commodity prices and expected increases of demand for food, fiber, and fuel derived from them 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 exploiting such opportunities. 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). Although, with ever more sophisticated technology, such claims have intuitive appeal, their empirical basis remains weak. In fact, we know of no studies that unambiguously demonstrate the existence of economies of scale in agricultural production (Byerlee and Deininger 2013).

Quite to the contrary, historically, absence of economies of scale in agricultural production have been a reason why a large literature found concentration of land under large farms to negatively affect human and economic development. Unable to compete with small producers on economical grounds, large farms often used their locally dominant position to monopolize input and output markets (Binswanger *et al.* 1995), to subvert provision of public goods such as education (Nugent and Robinson 2010, Vollrath 2009a), to undermine financial sector development (Rajan and Ramcharan 2011), and to restrict political participation (Baland and Robinson 2008). They also often lobbied for policies such as capital subsidies or trade protection to provide them with economic advantages often at high social cost (Deininger and Binswanger 1995). Concern about host country governments' limited ability or political will to reign in such non-competitive behavior is one reason for the widespread opposition by large parts of civil society and the media to the current 'rush' for investments in large-scale agriculture (Pearce 2012).

Ukraine offers unique opportunities to explore the associated issues. It is one of the 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, it lacks developed countries' farm price support or subsidy policies that have been argued to artificially depress farm sizes (Adamopoulos and Restuccia 2011). Partly as a result, 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. Variations rooted in different patterns of settlement under the czars, the intensity of purges, famine, and collectivization under communism, discovery of minerals, etc., have led to vast differences in social structure and the nature of economic activity across Ukraine’s regions. Reforms of the farm sector from 2001 allow exploring the extent to which initial differences in agrarian structure matter.

Despite their relevance for the debate on farm structures and the future of smallholder farming, the performance of Ukrainian farms has received little attention in the literature. To shed light on it, we use a large farm level panel data set for Ukraine’s commercial farm sector during the period 2001-2011. Descriptive evidence highlights significant changes in farm structure over the period: while median farm size decreased, area under farms cultivating more than 5,000 ha increased by more than 2 mn. ha or 10 percentage points . With yields for oilseed doubling, productivity and overall sector performance also improved markedly.

These data allow us to explore two types of questions, namely (i) links between productivity and farm size and (ii) impacts of initial farm structure on subsequent entry, exit and productive performance. A production function approach allows testing for the existence of economies of scale. While naïve cross sectional estimates suggest presence of significant economies of scale, such a conclusion is not robust to inclusion of farm fixed effects suggesting that superior performance of certain farms is due to location- and farm-specific attributes rather than increasing returns to scale in agricultural production. Farm- and rayon-level fixed effects can be interpreted as measures of managerial ability, or infrastructure access and land quality, respectively. Estimated magnitudes of the rayon fixed effects exceed those of farm-fixed effects, suggesting that opportunities for productivity-enhancing investment may be scant where low soil fertility and limited access to public goods and infrastructure constrain options for expansion.

Our analysis demonstrates that observed productivity growth over the period is predominantly due to the exit of less productive operators and the entry of new and more productive operators. Wide variation of initial inequality of operational farm sizes, measured as the share of area cultivated by farms greater than 3,000 or 5,000 ha, across the 472 rural rayons (districts) in our sample allows us to explore to what extent structural factors might affect productivity indirectly through an impact on the rate of entry and exit once other factors are controlled for. We find evidence of a strong negative impact of initial land concentration on subsequent exit and, to a lesser extent entry, suggesting that land concentration slows productivity growth. Quantile regressions of productivity growth suggest that productivity growth and convergence were slower in areas initially dominated by large farms. Research to identify channels for such effects to come about could help identify ways to regulate and/or monitor more effectively.

The paper is organized as follows. The next section reviews literature on the relationship between farm size and productivity, impacts of initial land ownership distribution on subsequent development, and the evolution of Ukraine's agricultural sector. Section three introduces the data and uses them to describe changes over time in productivity, area cultivated, farm size structure and profits per ha, as well as entry and exit of new firms as drivers of productivity change. Section four discusses results from estimating a production function at farm and determinants of entry and exit at rayon level. Section five concludes by drawing out policy implications and identifying areas for follow-up research.

Background and analytical issues

Whether an agrarian structure based on large farms can be economically and socially desirable hinges on two issues. One is whether new technology has changed the negative farm size-productivity relationship found in much of the traditional literature, leading to economies of scale in production for all or part of the farm size distribution. A second concern is whether, as documented in the historical literature, initial land concentration will affect subsequent economic performance and what channels might be involved. To set the stage for our study, we briefly review the literature on each of these and then highlight why Ukraine provides an interesting setting to study both phenomena.

The farm size-productivity debate

A negative relationship between farm size and output per area in non-mechanized agriculture, first noted in Russia (Chayanov 1926) and India (Bardhan 1973, Sen 1975, Srinivasan 1972), has almost become a stylized fact in the literature (Eastwood *et al.* 2010, Lipton 2009). A widely accepted explanation for this is that, as a residual claimant to profit, owner-operators (and fixed rent tenants) and their family members are more likely to exert effort than hired wage workers who, in light of the spatial dispersion of agricultural production and the ensuing requirement for adjustment to external factors, require costly supervision. While a large number of studies that rely on output rather than profit are of questionable validity (Binswanger *et al.* 1995) and part of the relationship may be due to measurement error (Lamb 2003a), empirical evidence in favor of the relationship is quite robust. It persists in the face of controls for land quality via econometric techniques (Assuncao and Braido 2007, Benjamin 1995) or detailed measurement of soil nutrients (Barrett *et al.* 2010).[i] This is consistent with the fact that, with the exception of plantation crops or industrial-style livestock operations,[ii] agriculture is dominated by owner-operated firms (Allen and Lueck 1998, Deininger and Feder 2001).[iii] Over time, firm size will adjust to allow operators income to be comparable to what they could obtain in the non-agricultural sector (Eastwood *et al.* 2010) and be affected by subsidies and policies that would reduce farm size below what would be observed in undistorted settings (Adamopoulos and Restuccia 2011).

It is often argued that, in some contexts, this relationship may no longer hold due to two factors, namely greater importance of capital inputs and new technology. Once capital inputs assume greater importance, small farmers' labor supervision advantage may be offset by their difficulty in accessing capital, insurance, or other lumpy inputs (e.g., machinery, draft animals, or management skills) for which markets may be absent or difficult to establish. In fact, most of the evidence for a negative farm size productivity relationship is from settings with little mechanization and greater relevance of capital may lead to a positive relationship instead as in Sudan (Kevane 1996), Kenya (Carter and Wiebe 1990), or Malawi and Zambia (Dorward 1999, Kimhi 2006).

Technical progress has also been shown to attenuate the negative relationship as demonstrated in post-green revolution India where it has been found to be weaker (Rosenzweig and Binswanger 1993) or absent (Carter 1984, Deolalikar 1981, Lamb 2003b). In fact, plots in India may have become too small to allow introduction of labor-saving mechanization, thus tying up large amounts of labor below opportunity cost (Foster and Rosenzweig 2010). Also, recent genetic and technological developments such as herbicide-tolerant varieties that allow zero tillage and precision agriculture that combines remote observation of crop conditions with GPS-enabled equipment can substitute capital for labor and attenuate traditional labor supervision constraints by reducing the labor intensity and number of steps in the production process (Deininger and Byerlee 2012). While the associated reduction in supervision requirements will no doubt affect development options in land-abundant agrarian economies, a key issue on which little evidence is available is whether, beyond affecting factor price ratios, it will lead to the emergence of economies of scale,.

The impact of initial land distribution on subsequent economic development

Historically, high levels of land inequality were often associated with low levels of subsequent growth (Barro 2000, Deininger and Squire 1998, Vollrath 2007). One reasons was that owners of non-competitive large farms resort to political means to ensure economic viability (Conning and Robinson 2007), e.g. by reducing supply of public goods to keep unskilled labor plentiful and cheap (Nugent and Robinson 2010). This is observed even in the United States where, during the late 19th century, high levels of land inequality at county level were associated with lower taxes and investments in public education (Vollrath 2009b) or lower levels of financial sector development (Rajan and Ramcharan 2011). This mirrors cross-sectional evidence of a negative relationship between and negative impacts of unequal asset distribution on agricultural production structure, economic outcomes, political economy, and public goods in Latin America (de Janvry 1981), India (Banerjee and Iyer 2005; Iyer 2010).[iv]

Although the coercive methods historically applied by land owners are now less viable, high levels of land concentration may still affect local competition through entry and exit dynamics. Establishing farming operations from scratch is risky, with high rates of failure even in favorable circumstances (Tyler 2011).[v] It has been argued that ways to ensure that land and other assets will be priced properly and can be transferred quickly from unsuccessful to more productive ventures will be important to ensure efficient use of scarce resources, reduce speculation, and focus economic agents' efforts on productive activities rather than lobbying (Deininger 2013). This is an important policy issue as the lack of such mechanisms in land abundant countries where high levels of investor interest has materialized may create opportunities for rent seeking and bureaucratic interference, evidence on the longer-term impact of initial farm structure that could be used as a basis for policy advice remains scant.[vi]

Evolution of Ukraine's agricultural sector

With vast areas of fertile black soils, Ukraine has traditionally been a regional breadbasket. It produced about 60% of the corn, 50% of the sugarbeet, and 40% of the wheat and sunflower seed of the former Soviet Union, even though it made up only 15% of the area, (World Bank 1995). In volatile world markets and as one of the few countries expected to benefit from climate change (Fischer et al. 2002), Ukraine's performance is likely to affect global food prices, implying a key role for the country in contributing to global food security; some do predict that Ukraine's share of global grain markets will exceed that of Argentina and Australia within a decade (Cramon-Taubadel *et al.* 2007).

In practice, the country has not always lived up to its potential. After the collapse of the FSU, land reforms that issued initially paper shares to agricultural workers transformed former collective farms into corporate structures (Csaki and Lerman 1997, Lerman *et al.* 1994). As they involved little change in the actual structure of agricultural production, their performance was disappointing (Csaki *et al.* 2004, Macours and Swinnen 2002). A 1999 Presidential Decree altered this by prescribing conversion of land shares into physical plots, thus transforming 7 million rural residents, most employees of large collective farms, into landowners[vii]. This helped output to recover from the crisis levels and, with price hikes during the 2008-2010 period, increased attractiveness of the agricultural sector and prompted high levels of export growth (Liefert *et al.* 2010). Lacking farming experience and non-land assets, most of the new farmers leased their land to corporate farms (Lerman *et al.* 2007).

In addition, macro-economic instability and volatile sectoral policies dented incentives to invest in much-needed physical and human capital formation. For a long time, reforms moved in a stop- and go mode with far-reaching and progressive moves followed by regressive measures. Fundamental policy issues, e.g. whether to lift a moratorium on land sales, have been debated inconclusively for years without substantive impact on legislative proposals.[viii] Price controls, export taxes, quotas, and support to 'infant industries' such as livestock channeled large rents to few players, creating a danger of entrepreneurs shifting attention from increasing productivity to preserving rents and preventing new entries that could make markets more competitive.

In-depth analysis to help inform Ukrainian and global policy debates remains scant. One study pointing towards superior technical efficiency by large farms (Lissitsa and Odening 2005) is based on a limited sample (92 enterprises in 4 rayons close to Kiyv) during the pre-2000 period that appears structurally quite different from current conditions. A 2005 survey finds higher profits for peasant compared to corporate farms -though no significant differences in total factor productivity (Lerman *et al.* 2007)- but does not reconcile this with expansion by super-large farms. While credit market imperfections have been identified as a key constraint to needed investment in new technology (Zinych and Odening 2009), this is not translated into differences in capital costs.

Data and descriptive evidence

Detailed panel data illustrate three features. First, yields grew rapidly after 2006, with sunflower-, corn-, and soybean-yields almost doubling, prompting a marked shift to oilseeds. Second, transformation of the agricultural sector was due more 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 are not allowed, there was massive concentration of operational holdings; area farmed by units above 10,000 (20,000) ha expanded by more than 2 (1.5) mn. ha (or 10% of the total) in the 2006-11 period. This suggests that either capital constraints or other factors prevented growth of medium sized farms.

Data sources and overall changes in regional productivity characteristics

The basis for our empirical work is data collected annually for the years 2001 to 2011 by Ukraine's State Statistics Committee (through form 50SG) for the universe of the about 10,000 large commercial farms in the country. The unit of observation is the legal entity rather than the physical production unit. For sizes below 5,000 ha, both are usually identical. Beyond this size, a single legal entity may operate multiple farms and if interest is in production, we need to adjust for this.[ix] Also, agri-holdings -often established to access capital from outside Ukraine through a public offering- may comprise multiple legal entities. Without more detailed information on whether an enterprise is part of a larger agri-holding, it will be difficult to account for how this may affect capital access. Questionnaires are administered by mail with non-respondents having to pay a fine. Experts also note that incentives for over- or under-reporting balance each other as responses are used as basis for taxes as well as subsidies.

Questionnaire and reporting requirements changed slightly over time.[x] We can, however, construct a consistent series for area cultivated and output value, in 2010 US dollars, from crop production for 11 crops and cost of key inputs including labor, fertilizer, seed, fuel and energy, agricultural services, and capital depreciation.[xi] As farms above 200 ha were not affected by the changes in reporting requirements, we restrict the sample to these farms -who together cultivate close to 20 million hectares- to avoid bias.[xii] We limit attention to crop production as data on livestock production are noisy.[xiii] Discarding farms that appear in the survey only once provides us with 92,324 observations from a total of 16,724 panel farms. The sample restricted to the farms registered outside the cities includes 89,736 for a panel of 16,191 farms.

Changes in the yields of specific crops, prices, and structure of output as summarized in table 1 point to major increases in yields of sunflower, soybean, corn, and sugar beet (from 0.9 to 1.9, 1.1 to 1.9, 3.3 to 5.9 and 19.7 to 32 t/ha, respectively) at the national level, compared to stagnation or decrease for wheat and barley (3 to 3.1 and 1.8 to 1.7 t/ha), with differences depending on regions' comparative advantage. Reinforced by price changes -in particular a sharp increase in sunflower prices between 2001 and 2011- value shares of specific commodities changes significantly: Output shares for wheat and barley decreased from 41% and 15% in 2001 to 26% and 10% in 2011 while those for corn, sunflower increased from 3%, 7%, and 0 to 15%, 26%, and 5%, respectively. In the aggregate, this implied a shift in output value from more than three quarters in grain (82% of the mean farm's area in the West) in 2001 to much greater reliance on oilseeds (13% in the first and 31% in the second period). The shift was most pronounced in the East where in 2011 50.5% vs. 46.4% of the mean farm's area are cultivated with grains and oilseeds, respectively. It is accompanied by a reduction in root crops (from 8.5% to 3.2%) and an increase in fruits and vegetables (3% to 4%).

Yield growth and shifts in output composition prompted far-reaching changes in agrarian structure. As table 2 illustrates, area cultivated by our sample farms decreased from 21 mn. ha in 2001 to 15 mn. ha in 2006 before recovering to some 18 mn. ha in 2011.[xiv] 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, a decline most pronounced in the East and the South where median size dropped by more than 1,000 ha from 2,671 to 1,668 ha and 2,502 to 1,432 ha, respectively. Interestingly, in 2011, all farms in the sample that had at some point cultivated more than 100,000 ha operated areas (142,014, 135,741, 115,651, and 54,452 ha) well below the peak they had attained in 2008.[xv]

While initial farm structure differed across regions -more than 50% of land was in ‘small’ farms below 1,000 ha in the West while in the East almost 50% were above 2,000 (see figures 1.1 and 1.2)- inequality grew significantly throughout with the Gini of the operational farm size distribution shifting from 0.32 to 0.47. The almost 5-fold increase in area on farms above 10,000 ha, from 0.65 mn. ha in 2001 to 3.4 mn. ha in 2011, was a key factor underlying this trend.[xvi]

Variation across farm size groups

Table 3 provides evidence of profitability (panel A) and structural transformation (panel B) across farm size groups. Mean profit per ha, US$ 31 overall, was, close to zero in the first period but increased to US$ 74 after 2006, with the value of output per ha more than doubling (from US$ 179.6 to 367), while costs rose by 60% (from US$ 184 to 309) over the same period. The marked increase in the intensity of purchased input use between the pre-and post-2006 period together with a drop in the number of workers (from 4.1 to 2.3 per ha – Table 4) suggests a shift towards a more input-intensive mode of production, a notion supported by the fact that daily wages more than doubled (from US$ 3.3 to 7.3). In the first period, profits for farms below 1500 ha were indeed negative and very small. By contrast, they increased markedly, partly due to higher oilseed prices, ranging from US$ 47.3 for those below 500 ha to US$ 85.0 for farms above 5000 ha in the period after 2006.

Reductions in employment and intensity of labor use narrowed the gap in labor intensity between the largest and the smallest farms: while the smallest farms used 6.71 workers per 100 ha at a wage of US$ 3.28 (vs. 2.67 at a wage of US$ 4.28 on the largest farms) in 2001, this decreased to 3.3 and 1.8 workers, respectively (at wages of US$ 5.1 and 8.6) by 2011. This was accompanied by a decrease of hired labor's cost share from 17.9% to 12.7 and a decline in the cost share of land from 17.0 to 11.4% (Table 3C). Both before and after 2006, profit per ha was lowest in the West and highest in the South (US$ -16 and 48 and 11 and 83, respectively).

There was divergence in the extent to which fertilizer and machinery were used across farm size classes: in the first period, the mean cost share for fertilizer was 12.0% for the smallest vs. 10.3% for the largest, increasing to 12.6% on average in the second period (11.7% vs. 14.9% for smallest vs. largest). Very large farms seem to have become more energy efficient, reducing use of this input in the second period to 14.5% (vs. 19.4% for the smallest group).

Kernel-weighted nonparametric regressions illustrate the evolution of output values and costs with farm size. Figure 2 presents these for log of crop value and cost per ha (indicated by solid and dashed lines, respectively), together with the 95% confidence interval for each. Noting that profits are the vertical distance between output and input cost, we note that, if all periods are lumped together, 'small' farms up to almost 2,000 ha made losses. Data on cost and output per ha for pre- and the post-2006 periods in figures 2.1 and 2.2 suggests that in the first period, profitability was limited, most farms lost money, and few super-large farms existed. After 2006, profitability improved and some entities cultivated more than 150,000 ha. Output, costs and profit per ha are precisely estimated up to a farm size of 10,000 ha but confidence bands widen thereafter. Profits are maximized at farm sizes of 2,000 to 3,000 ha, although output per ha peaks at 30,000 to 50,000 ha. This casts doubt on the notion that superior productive performance was the main driver of the expansion of super-large farms.

Entry and exit as main drivers of productive performance

Table 3 shows that attrition was high; more than 80% of sample farms either exited (42%) or entered (40%; 28% of stayers and 12% of churners) during the period and only 17.3% remained in the sample throughout.[xvii] Table 4 displays levels of productivity by farms in the initial sample that either stayed there or exited and new entrants, those who remained in the sample until 2011 and 'churners' who exited before then. Entry and exit seem close linked to productive performance; the 42% incumbents who exited had negative profits per ha (US$ -11.3), compared to US$ 35 for the 17.3% who stayed and US$ 65.5 for the 40% who entered (US$ 94.1 for the 28% who did so permanently and US$ -2.7 for the 12% of churners). Entrants had higher cost (e.g. US$ 289 vs. US$ 146 for exiters and US$ 259 for stayers), suggesting use of more input-intensive technology. This is consistent with successful entrants employing less than average labor in both periods (3.35 workers per 100 ha vs. 4.14 on average in period 1 and 1.81 vs. 2.28 in period 2).

While noticeable, differences in per ha profits in the first period (-15.7 for churners and -12.5 for exiters to 6.7 for stayers and 7.4 for entrants who stayed) were less pronounced than in the second period when 56% of incumbents with an average per ha profit of US$ 77.5 stayed, 20% (with per ha profits of US$ 15.8) exited, and 24% (with profits of US$ 96.1 per ha) entered, 21% (enjoying a profit of US$ 107 per ha) staying until 2011. Compared to the increase in per ha cost, mean initial area operated by entrants decreased over time, from 1,950 h in the first to 1,445 ha in the second period. 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 and motivates detailed analysis.

Econometric evidence

We use a farm-level production function to explore the presence of economies of scale and factor market imperfections, and rayon-level data to identify the initial land concentration effect. Some interesting results were produced. First, once rayon- or farm-level fixed effects are accounted for, the production technology exhibits constant returns to scale but imperfections exist in markets for land, agricultural services, and capital assets. Second, initial land concentration affected subsequent performance: a higher share of land cultivated by farms above 3,000 or 5.000 ha at rayon level in 2001 is associated with lower levels of exit and, for the above 5,000-ha share, entry overall and for each of the years separately and productivity growth.

Production function estimates

We use the data to estimate a standard Cobb-Douglas production function of the form:

$$Y_{it} = \zeta + \beta \boldsymbol{X}_{imt} + \gamma \boldsymbol{X}_{imt} * \mathrm{D}_{mt} + \alpha_{ij} + \varepsilon_{it} \qquad (1)$$

where Y_{it} is monetary output by farm i in year t, $\boldsymbol{X}_{imt}$ is a vector of inputs m used by i, D_{mt} is a dummy for the time period after 2006, α_{ij} is a farm-specific fixed effect for farm i located in rayon j, ε_{it} is an white noise error term, and ζ, β, and γ are coefficient vectors to be estimated. Note that α_{ji} can be decomposed into two components, a rayon-level effect $\hat{\alpha}_j = (\sum_i \hat{\alpha}_{ij}) / n_j$ that proxies for conditions such as road or market infrastructure, soil quality, and other largely time-invariant rayon-level factors and a farm-fixed effect obtained by subtracting $\hat{\alpha}_j$ from $\hat{\alpha}_{ij}$ that provides an estimate of ability by each sample farm (Deininger and Jin 2005).

Table 5 reports results for the close to 90,000 observations not registered in towns for the naïve cross section (col. 1) and specifications with rayon (col. 2) and farm fixed effects (col. 3).[xviii] The bottom panel highlights that equality of the coefficients in both periods is strongly rejected, supporting the notion of a structural break. Elasticities of seeds, agricultural services, and to a lesser extent fertilizer and fuel/energy were higher in the second period than the first one while those for land and labor were lower, pointing towards a more technology- intensive modality of production.

Adding up coefficients on conventional factors of production allows us to test for returns to scale. 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 the second period, in line with the notion of market imperfections that could be overcome only by very large size in the early post-liberalization stages. Addition of rayon-level fixed effects significantly reduces this estimate (to 1.06 and 1.02 in the pre-and post-2006 period, respectively) although the hypothesis of constant returns is still rejected. 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% in both periods. This near-disappearance of 'economies of scale' once rayon and farm fixed effects are controlled for implies that large farms' emergence or prevalence may be explained by a combination of three factors, namely (i) large farms' use of superior management skills;[xix] (ii) their location in rayons better endowed with key factors such as soil quality or infrastructure; and (iii) benefits from the ability to vertically integrate beyond the production stage, deal with factor market imperfections, and possibly exercise market power. Which of these factors is most important will have implications for policy.

Separating out farm- and rayon-specific fixed effects allows comparing relative magnitudes of location-specific factors vs. farm-specific management. Plots of kernel-weighted nonparametric regressions of these two parameters against operated farm size in figure 3 provide two insights. First, as expected if farm-level fixed effects proxy for managerial ability as an indivisible factor, better managers operate larger farms. Also, the absolute magnitude of rayon-level effects exceeds that of farm-fixed effects for farms above about 1500 ha. In other words, large farms locate in rayons with more favorable endowments and the size of benefits from the associated location-specific rents exceeds those from managerial efficiency. For ‘smaller’ farms (200 to 1,500 ha), rayon-level effects have a quantitatively smaller impact on productivity than the managerial ability of their operators.

The spatial distribution of rayon fixed effect presented in figure 4 provides an additional insight. The highest region-specific productivity shocks are observed in the central part of Ukraine, which roughly corresponds to the distribution of the soil fertility. As the rayon fixed effect comprise both soil fertility and the effect of infrastructure, studying of their relative contribution requires further attention.

If markets work, any input’s marginal value product will equal its price or its factor share the coefficient on this input in the production function (Dobbelaere and Mairesse 2013). While more detailed data and study would be required to assess the underlying factors, use of production function estimates to test for the functioning of factor markets in this way provides some insights (table 5, column 4 and 5). It suggests that labor markets are reasonably competitive. However, land rents remain significantly below the marginal product, possibly making it rational to accumulate large amounts of land without being able to use it most efficiently.[xx] Fertilizer and services’ cost shares are above these factors’ marginal product. This could be due to non-competitive markets for services, failure to provide them in a timely manner, or high cost of credit being added to such factors. They could affect productivity in the longer term if, as a consequence, farmers apply fewer nutrients than they take off via crops and thus drive down long-term soil fertility. It is observed, however, that the size of imperfections on several input markets has decreased over time. The only deterioration in market functioning is observed in the market for seeds. Results are robust to inclusion of other controls (e.g. producers of livestock, producers of agricultural services) and to the functional form (the trans-log function produces similar results for the sample average).[xxi]

Displaying farm fixed effects separately for those who entered, exited, and remained in the sample in fig. 5 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. Descriptive data support this, suggesting that, while entrants located in more favorable rayons, farm-specific effects have a larger impact than rayon endowments throughout (e.g. means are 0.12 vs. 0.06 for all and 0.17 vs. 0.09 for permanent entrants and medians 0.13 vs. 0.10 and 0.16 vs. 0.12, respectively). In other words, entrants on average increased production by 12 or 17 percentage points, above the mean fixed effect of 0.08% for the above 5,000 ha farm size group.

Structural determinants of entry, exit, and productivity change

The apparent importance of entry and exit warrants analysis of the extent to which these processes are driven by structural determinants beyond the individual farm. To explore this, we conduct analysis at the rayon level using the 470 agricultural rayons (excluding towns) to explore if initial land concentration affects subsequent structural change by estimating:

$$X_{it} / Y_{it} = \alpha + \beta_1 \boldsymbol{S}_i + \beta_2 \boldsymbol{FF}_i + \beta_3 \boldsymbol{S}_i * F_i + \beta_4 \boldsymbol{RF}_i + D_t + \varepsilon_{it} \quad (2)$$

where X_{it} or Y_{it} is the share of the agriculturally cultivated area that was released from production through exit or occupied by new entrants in rayon *i* at time *t*. Entry or exit may be 'permanent', i.e. between the endpoints of our sample, or temporary.[xxii] As our main interest is to find out whether, after controlling for endowments and initial productivity of large and small farms, the level of entry and exit was affected by initial large farm presence, we include as other controls S_i, the share of area in rayon *i* initially cultivated by farms above 5,000 or 3,000 ha, FF_i, and F_i, the mean levels of rayon *i*'s initial productivity for all farmers and farms with more than 5,000 and 3,000 ha, respectively as proxied by the fixed effect from the production function, and RF_i the rayon-level fixed effect to control for differences in productive endowments. The initial period is 2001/02 and annual regressions also include year dummies (D_t).

Descriptive statistics for the relevant variables are displayed in table 6. With national initial cultivated area of 19.06 mn. ha, the average rayon had an area of somewhat above 400 km^2 of which 36% and 13% were initially occupied by farms greater than 3,000 or 5,000 ha. This aggregate conceals variation across regions: in the East and the South, more than 60% and 25% of land were under farms greater than 3,000 and 5,000 ha, respectively, compared to less than 10% and 2% in the West and 33% and 10% in the North. Except in the West (-0.15). Initial efficiency levels were closer, with between -0.08 and -0.1 for all regions. In fact, inter-regional differences in initial efficiency were more pronounced between farm size groups: farms above 5,000 ha were most productive in the West (0.04 compared to -0.03 for farms above 3,000 ha) and least productive in the East (-0.09 or -0.08). There are also differences between initial rayon-level fixed effects with the West having the least (-0.24) and East and

South (0.10 and 0.11) the most favorable endowments (see figure 5 for a rayon productivity map).

Some abandonment of cultivated area is visible from the fact that, in the average rayon, the share of area released via exit (0.54) exceeded that occupied by new entrants (0.38). The South, where 47% vs. 43% of area was subject to permanent entry or exit, with an additional 12% of churners, is the only exception. The bottom panel of table 6 also illustrates that entry and exit followed distinct time profiles; while exit was highest in initial reform years, with more than 10% of the area cultivated by large farms, it tapered off to slightly below 2% towards the end of the period. With up to about 8% of rayon area overall (and 11% or 12% in the East and South) brought under new production in 2007, entry peaked during the 2007/08 commodity price boom.

Table 7 reports regression results for aggregate (panel A) and annual (panel B) rayon-level area subject to entry or exit with dependent variables being rayon area shares exited from production permanently (col. 1) or overall (col. 2) and brought in production permanently (col.3) or totally (col. 4). In each case, regression results for shares of farms above 5,000 and 3,000 ha are reported in the top and bottom panels.

For exit, the coefficient of interest, i.e. the share of area initially cultivated by large farms, is negative and significant at 5% or 1% throughout. In other words, controlling for initial levels of productivity for all farms, the relevant large farm group, and the rayon overall, initial concentration of farmland at rayon level negatively affected the amount of area made available by existing operators going out of business over the period. Coefficients on 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. Coefficients on rayon fixed effect are significant and positive, suggesting that, other things equal, competition for land is stronger in productive as compared to marginal rayons. The interaction between the share of area under large farms and these farms' productive efficiency is negative and highly significant, in line with the notion that, other things equal, higher levels of initial productivity by large farms will be associated with lower levels of exit. Beyond coefficients' statistical significance, the magnitude of the estimated effects implies they are meaningful economically: having had an additional 10% of a rayon's area under farms above 5,000 ha or 3,000 ha is predicted to reduce subsequent exit by 2.7 and 4 percentage points, respectively. The difference of 0.54 between West and East in the initial share of farms above 3,000 ha would thus be predicted to explain between a fourth and a third (15% or 22%) of the observed difference in permanent and temporary exit (54% and 69%). Qualitatively very similar results are obtained from regressions with the annual rate of exit as dependent variable in panel B. The effect of initial land concentration on subsequent exit seems remarkably robust and inclusion of year dummies significantly improves R^2s, most clearly (from 0.22 to 0.36) in the case of permanent exit.

Though surprisingly similar in qualitative terms, regressions for area newly occupied by entrants are different from those for exit in two respects: First, the point estimate on the share of area above 3,000 ha, though still negative, loses significance in most cases, suggesting that barriers to entry require higher levels of concentration (or collusion by fewer very farms). Second, the interaction between large farms' area share and their initial level of productivity is insignificant, consistent with the notion that, if area shares are controlled for, large farms' initial productivity does not affect entry. Further research into the channels through which such an effect could materialize, in particular imperfections in markets for key factors, would be of great interest.

To the extent that they affect entry and exit, pre-existing structural differences should also impact overall productivity. Regressing changes in monetary output on a subset of the variables included in equation (2) produces three types of insights (table 8).[xxiii] First, holding other factors constant, higher levels of initial land concentration indeed reduce subsequent productivity growth, with the size of point estimates fairly similar across categories. Second, 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 productivity growth are higher in rayons that are more productive.

Conclusions and policy implications

Our study touches on 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 for this environment. Instead, large farms' superior performance appears to be due to unobserved rayon- and farm-specific attributes that include access to infrastructure and managerial skills. Decomposition of farm-and rayon- fixed effects to assess the underlying factors in more 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 -

most though not all below 3,000 ha- at a later date (mostly 2007-2009), emerge as key drivers of higher agricultural productivity. The large and robust negative effect of the share of land initially held by large farms on the magnitude of subsequent exit and entry suggests that initial agrarian structure can affect development in the long term. Efforts to explore the underlying economic and political channels in greater detail, will be of great interest analytically. They may help identify instruments 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 many other countries seeking to promote rapid agricultural growth through establishment of large farms rather than models that productively involve local populations.

Even without such decomposition, the implications for policy are clear and far-reaching: Instead of -unrealistically- hoping for gains in efficiency just by establishing large farms (as would be the case with economies of scale), it appears that complementary public goods and the ability to create, attract, and retain agronomic and managerial talent have driven the improvements in productivity of Ukraine's large farm sector observed during the period. Beyond Ukraine, governments' ability to establish infrastructure to attract qualified private actors and maintain a policy environment to prevent skilled managers from going elsewhere will likely be a key factor to allow putting large tracts of apparently un- or underutilized land to productive use.

Table 1. Overall Changes Yields, Output Shares, and Prices 2001 to 2011, by Region

	Year	Total	West	East	North	South
		Panel A: Yields of major crops (kg/ha)				
Wheat	2004	2950	2594	3048	3259	3098
	2006	2354	1972	2293	2581	2705
	2011	3155	3543	3045	3042	3076
Corn	2004	3305	3024	2834	3827	3119
	2006	3298	3776	2216	4072	2396
	2011	5892	6334	4431	7433	3723
Barley	2004	1830	1594	1619	2138	1970
	2006	1595	1362	1403	1799	1798
	2011	1675	1796	1321	1641	1880
Soybean	2004	1081	1021	952	1080	1353
	2006	1060	1124	797	1137	989
	2011	1914	1675	1518	2079	2127
Sunflower	2004	942	813	929	962	991
	2006	1424	1226	1475	1505	1361
	2011	1948	1827	2160	2159	1614
Sugarbeet	2004	19746	19076	20118	20199	21820
	2006	24855	23654	21698	28071	20857
	2011	32042	32230	23569	35831	41562
		Panel B: Key crops' shares in output value (%)				
Grain	2001	0.803	0.820	0.722	0.831	0.792

	2006	0.679	0.740	0.556	0.711	0.620
	2011	0.582	0.666	0.485	0.632	0.541
Oilseed	2001	0.065	0.006	0.196	0.043	0.117
	2006	0.181	0.075	0.353	0.154	0.265
	2011	0.353	0.222	0.485	0.310	0.394
Root crops	2001	0.106	0.157	0.057	0.118	0.020
	2006	0.104	0.159	0.061	0.123	0.017
	2011	0.035	0.084	0.015	0.047	0.003
Fruit & vegetable	2001	0.026	0.017	0.026	0.008	0.071
	2006	0.051	0.026	0.030	0.059	0.097
	2011	0.043	0.029	0.015	0.055	0.063
Wheat	2001	0.414	0.381	0.411	0.378	0.545
	2006	0.305	0.332	0.306	0.259	0.334
	2011	0.260	0.294	0.269	0.177	0.315
Corn	2001	0.028	0.018	0.032	0.046	0.016
	2006	0.051	0.030	0.046	0.089	0.029
	2011	0.148	0.151	0.108	0.282	0.036
Barley	2001	0.152	0.137	0.160	0.151	0.181
	2006	0.171	0.145	0.167	0.181	0.206
	2011	0.095	0.080	0.076	0.066	0.151
Sunflower	2001	0.065	0.006	0.196	0.043	0.117
	2006	0.132	0.018	0.339	0.094	0.222

	2011	0.261	0.060	0.466	0.200	0.317
		Panel C: Producer prices for key crops (US$/kg)				
Wheat	2001	0.139	0.159	0.119	0.141	0.111
	2006	0.120	0.126	0.111	0.119	0.115
	2011	0.155	0.161	0.152	0.158	0.148
Corn	2001	0.176	0.167	0.194	0.144	0.235
	2006	0.122	0.136	0.126	0.112	0.124
	2011	0.150	0.154	0.148	0.146	0.159
Sunflower	2001	0.246	0.253	0.251	0.240	0.246
	2006	0.213	0.230	0.214	0.208	0.210
	2011	0.387	0.382	0.387	0.389	0.387
No. of obs	2001	9992	3901	1517	2781	1793
	2006	6835	2301	1086	2120	1328
	2011	7639	1565	1631	2288	2155

Source: Own computation from Form 50.

Table 2. Changes in Farm Structure 2001 to 2011, by Region

	Year	Total	West	East	North	South
Area cultivated	2001	20.59	4.95	4.65	5.84	5.16
(mn ha.)	2006	15.19	3.02	3.45	4.76	3.97
	2011	17.61	3.14	4.07	5.79	4.61
Avg. farm size (ha)	2001	2061	1268	3063	2099	2879
	2006	2222	1311	3172	2245	2987
	2011	2305	2005	2498	2529	2138
Median farm size (ha)	2001	1625	1118	2671	1864	2502
	2006	1630	991	2484	1716	2432
	2011	1429	1112	1668	1490	1432
Land Gini	2001	0.316	0.304	0.337	0.299	0.352
	2006	0.352	0.371	0.343	0.353	0.324
	2011	0.473	0.505	0.453	0.472	0.466
Area under farms	2001	654,755	34,887	313,842	109,704	196,323
> 10,000 ha	2006	1,338,368	167,050	491,190	387,288	292,840
	2011	3,437,111	781,618	655,626	1,468,147	531,720
Area under farms	2001	255,572	-	191,426	64,146	-
> 20,000 ha	2006	583,714	41,720	261,433	196,375	84,186
	2011	2,009,043	335,687	424,593	1,035,412	213,351
No. of farms	2001	40	3	15	6	16
> 10,000 ha	2006	73	10	24	21	18
	2011	155	45	24	56	30

No of farms	2001	7	0	5	2	0
> 20,000 ha	2006	16	1	6	7	2
	2011	47	11	7	24	5
Maximum farm size	2001	88032	12443	88032	35500	18247
(ha)	2006	88751	41720	88751	45491	46000
	2011	142014	45485	142014	135741	82710

Source: Own computation from Form 50.

Table 3: Key Characteristics of Panel Farms by Initial Farm Size

	Period	All	Size in ha						
			200-500	500-1000	1000-1500	1500-2000	2000-3000	3000-5000	>5000
A. Per ha output/cost (US$)									
Profit/ha	2001/11	31.32	6.75	23.56	34.22	30.95	38.33	40.40	54.49
	2001/06	-0.17	-36.14	-12.62	-0.21	2.98	11.19	14.79	23.79
	2007/11	73.95	47.31	71.54	83.41	73.67	79.96	80.30	84.99
Output/ha	2001/11	268.50	275.35	237.79	257.15	267.97	273.45	277.51	351.94
	2001/06	184.24	174.31	158.17	176.99	187.65	196.61	200.45	226.79
	2007/11	382.54	370.90	343.39	371.62	390.69	391.26	397.57	476.28
Cost/ha	2001/11	237.18	268.60	214.23	222.92	237.02	235.11	237.11	297.45
	2001/06	184.41	210.45	170.79	177.20	184.67	185.43	185.65	203.00
	2007/11	308.54	323.59	271.85	288.22	317.02	311.30	317.27	391.28
B. Sample composition (%)									
Stayed from beginning	2001/11	0.173	0.048	0.095	0.138	0.181	0.255	0.316	0.333
	2001/06	0.358	0.195	0.261	0.344	0.363	0.419	0.468	0.502
	2007/11	0.559	0.265	0.533	0.510	0.616	0.714	0.768	0.734
Incumbents exited in …	2001/11	0.424	0.328	0.450	0.444	0.438	0.457	0.428	0.314
	2001/06	0.415	0.502	0.505	0.424	0.379	0.390	0.347	0.276
	2007/11	0.198	0.281	0.268	0.187	0.181	0.138	0.116	0.104

Entered & staid	2001/11	0.283	0.453	0.316	0.289	0.255	0.212	0.178	0.269
	2001/06	0.171	0.203	0.163	0.174	0.200	0.146	0.148	0.193
	2007/11	0.213	0.401	0.172	0.263	0.177	0.141	0.096	0.148
Churned	2001/11	0.119	0.171	0.140	0.129	0.126	0.076	0.078	0.085
	2001/06	0.057	0.101	0.070	0.057	0.057	0.045	0.037	0.029
	2007/11	0.030	0.053	0.027	0.041	0.027	0.008	0.020	0.014
No. of farms	2001/11	16724	2076	3381	3419	2368	2726	1973	781
No. of obs.	2001/11	92324	8167	16400	18336	13829	16989	13265	5338
	2001/06	53095	3782	9073	10631	8196	10312	8123	2978
	2007/11	39229	5014	7853	7245	5200	6299	4855	2763

Source: Own computation from form 50SG.

Table 4. Descriptive Statistics by Type of Exit and Entry

	Period	All	Exits	Stayers	Entrants	Entrants who churn	Entrants who stay
Profit/ha (US$)	2001/11	27.7	-11.3	35.3	65.5	-2.7	94.1
	2001/06	-2.4	-12.5	6.7	1.6	-15.7	7.4
	2007/11	69.8	15.8	77.5	96.1	19.7	106.7
Output/ha (US$)	2001/11	250.4	134.3	294.3	354.0	214.0	412.7
	2001/06	179.6	126.1	203.8	239.1	158.6	265.9
	2007/11	367.1	232.7	393.9	415.2	246.1	438.7
Cost/ha (US$)	2001/11	222.7	145.5	259.0	288.5	216.7	318.6
	2001/06	182.0	138.6	197.1	237.4	174.4	258.5
	2007/11	297.3	216.9	316.4	319.1	226.4	332.0
Area at start (ha)	2001/11	1911	1829	2627	1688	1562	1741
	2001/06	2036	1801	2363	1950	1606	2064
	2007/11	2017	1488	2453	1445	1363	1457
End area	2001/11	1824	1396	2525	1973	1504	2170
	2001/06	1856	1440	2203	2068	1485	2262
	2007/11	2090	1359	2524	1689	1390	1730
Workers per 100 ha	2001/11	3.36	4.28	3.61	2.29	3.08	1.96
	2001/06	4.14	4.34	4.34	3.45	3.75	3.35
	2007/11	2.28	2.70	2.34	1.81	1.74	1.81
Wage per day	2001/11	4.70	2.68	6.32	6.13	4.52	6.80
	2001/06	3.28	2.47	3.58	4.31	3.35	4.63

	2007/11	7.26	4.94	8.18	7.04	6.24	7.15
No. of farms	2001/11	16724	7094	2898	6732	1991	4741
	2001/06	12937	5364	4628	2945	738	2207
	2007/11	9894	1962	5529	2403	293	2110
No. of obs	2001/11	92324	30281	31432	30611	6660	23951
	2001/06	53095	17313	27613	8169	1857	6312
	2007/11	39229	4589	27318	7322	655	6667

Source: Own computation from form 50SG

Table 5. Cobb Douglas Production Function Estimates

	Log of output (in USD)		
	Pooled OLS	**Rayon FE**	**Farm FE**
Log(Area)	0.212***	0.236***	0.341***
	(0.016)	(0.015)	(0.013)
Log(Area)*post 2006	-0.048***	-0.020	-0.050***
	(0.018)	(0.015)	(0.015)
Log(Labor)	0.222***	0.189***	0.168***
	(0.009)	(0.007)	(0.006)
Log(Labor)*post 2006	-0.137***	-0.104***	-0.051***
	(0.010)	(0.009)	(0.008)
Log(Seed)	0.154***	0.163***	0.139***
	(0.009)	(0.007)	(0.006)
Log(Seed)*post 2006	0.091***	0.069***	0.049***
	(0.014)	(0.013)	(0.010)
Log(Fertilizer)	0.117***	0.121***	0.073***
	(0.005)	(0.004)	(0.003)
Log(Fertilizer)*post 2006	0.012**	0.010**	0.015***
	(0.006)	(0.005)	(0.004)
Log(Capital depreciation)	0.072***	0.066***	0.066***
	(0.006)	(0.004)	(0.004)
Log(Capital depreciation)*post 2006	0.041***	0.014**	-0.004
	(0.007)	(0.006)	(0.006)

Log(Fuel and energy)	0.319***	0.240***	0.162***
	(0.012)	(0.009)	(0.007)
Log(Fuel and energy)*post 2006	-0.104***	-0.061***	0.006
	(0.014)	(0.012)	(0.011)
Log(Other – agricultural services)	0.076***	0.048***	0.043***
	(0.004)	(0.003)	(0.002)
Log(Other – agricultural services)*post 2006	0.029***	0.049***	0.042***
	(0.005)	(0.004)	(0.004)
Observations	89,736	89,736	89,736
R-squared	0.860	0.828	0.607
Sum of coefficients period 1	1.171***	1.062***	0.991
Sum of coefficients period 2	1.056***	1.019***	0.999
No of rayons/farms		480	16,191
Joint test of interaction (F-value)	80.41***	60.15***	32.68***

Note: Standard deviations in brackets; Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Deviation from 1 is tested for the sum of coefficients

Table 6. Incidence of Entry and Exit, Overall and by Year

		Region			
	Total	West	East	North	South
Total area (million ha)	19.056	4.456	4.268	5.569	4.763
Share of area init. under farms > 3000 ha	0.358	0.087	0.623	0.332	0.608
Share of area init. under farms > 5000 ha	0.134	0.019	0.256	0.096	0.271
Initial productivity all farms	-0.109	-0.148	-0.086	-0.098	-0.080
Initial productivity farms > 3000 ha	-0.065	-0.025	-0.094	-0.065	-0.073
Initial productivity farms > 5000 ha	-0.053	0.037	-0.080	-0.013	-0.078
Rayon fixed effect	-0.030	-0.238	0.095	0.041	0.107
Share of permanent exit	0.541	0.637	0.504	0.526	0.433
Share of permanent entry	0.382	0.276	0.434	0.412	0.470
Share of total exit	0.689	0.808	0.614	0.697	0.548
Share of total entry	0.538	0.452	0.550	0.596	0.593
Share of area exiting by year					
2002	0.150	0.156	0.162	0.149	0.130
2003	0.114	0.107	0.119	0.126	0.105
2004	0.084	0.089	0.082	0.076	0.087
2005	0.064	0.094	0.050	0.052	0.042
2006	0.049	0.068	0.047	0.045	0.024
2007	0.028	0.045	0.019	0.024	0.012
2008	0.019	0.027	0.007	0.022	0.010
2009	0.016	0.022	0.007	0.015	0.015

2010	0.020	0.031	0.012	0.018	0.010
Share of area entering by year					
2002	0.025	0.011	0.031	0.032	0.034
2003	0.027	0.014	0.040	0.029	0.033
2004	0.039	0.017	0.042	0.056	0.048
2005	0.030	0.020	0.024	0.033	0.047
2006	0.039	0.037	0.033	0.032	0.057
2007	0.084	0.046	0.122	0.086	0.109
2008	0.075	0.077	0.094	0.069	0.064
2009	0.036	0.031	0.026	0.042	0.044
2010	0.029	0.024	0.023	0.032	0.038

Table 7. Rayon-Level Regressions for Aggregate Entry and Exit Overall and Annual

	Share of area exiting		Share of area entering	
	permanent	**churn**	**permanent**	**Churn**
	Panel A: Entry & exit over entire period (2002-2011)			
Init. share of cult. area > 5000 ha	-0.273***	-0.360**	-0.315**	-0.385**
	(-2.665)	(-2.423)	(-2.294)	(-2.509)
Initial productivity	-0.797***	-1.104***	-0.503**	-0.596***
	(-5.408)	(-5.163)	(-2.537)	(-2.696)
Init. share > 5000 ha *	-0.701***	-0.841**	-0.145	-0.188
productivity of these farms	(-2.745)	(-2.271)	(-0.422)	(-0.490)
Rayon fixed effect	0.270***	0.583***	0.774***	0.994***
	(4.303)	(6.409)	(9.196)	(10.571)
Observations	472	472	472	472
R-squared	0.222	0.219	0.246	0.253
Init. share of cult. area > 3000 ha	-0.279***	-0.403***	-0.156	-0.246*
	(-3.216)	(-3.197)	(-1.324)	(-1.870)
Initial productivity	-0.615***	-0.883***	-0.456**	-0.487**
	(-3.914)	(-3.869)	(-2.136)	(-2.046)
Init. share > 3000 ha *	-0.787***	-0.917***	-0.183	-0.390
productivity of these farms	(-3.644)	(-2.923)	(-0.625)	(-1.192)
Rayon fixed effect	0.278***	0.599***	0.782***	1.003***
	(4.422)	(6.569)	(9.177)	(10.555)
Observations	472	472	472	472

R-squared	0.233	0.229	0.240	0.250
	Share of area exiting		**Share of area entering**	
	permanent	**churn**	**permanent**	**churn**
	Panel B: Annual rates of entry & exit			
Init. share of cult. area > 5000 ha	-0.025**	-0.033**	-0.031**	-0.037**
	(-2.172)	(-2.346)	(-2.362)	(-2.469)
Initial productivity	-0.072***	-0.099***	-0.058***	-0.083***
	(-4.346)	(-4.935)	(-3.040)	(-3.799)
Init. share > 5000 ha *	-0.064**	-0.077**	-0.004	-0.012
productivity of these farms	(-2.240)	(-2.201)	(-0.112)	(-0.312)
Rayon fixed effect	0.024***	0.053***	0.073***	0.101***
	(3.440)	(6.127)	(9.034)	(10.883)
Observations	5,187	5,187	5,187	5,187
R-squared	0.359	0.279	0.126	0.148
Init. share of cult. area > 3000 ha	-0.025***	-0.037***	-0.013	-0.020
	(-2.610)	(-3.086)	(-1.188)	(-1.511)
Initial productivity	-0.055***	-0.079***	-0.051**	-0.072***
	(-3.102)	(-3.656)	(-2.503)	(-3.065)
Init. share > 3000 ha *	-0.072***	-0.084***	-0.024	-0.040
productivity of these farms	(-2.963)	(-2.824)	(-0.851)	(-1.248)
Rayon fixed effect	0.025***	0.054***	0.074***	0.101***
	(3.507)	(6.239)	(8.984)	(10.823)
Observations	5,187	5,187	5,187	5,187

R-squared	0.360	0.280	0.126	0.148

Note: Region dummies and constant included in all regressions but not reported.

Table 8. Evidence of Convergence in Productivity at Rayon Level by Quintiles

	Percentile				
	10th	**25th**	**50th**	**75th**	**90th**
Init. share > 3000 ha	-0.481***	-0.543***	-0.581***	-0.557***	-0.598***
	(-3.951)	(-7.910)	(-8.190)	(-7.758)	(-6.619)
Initial productivity	-0.522***	-0.649***	-0.659***	-0.747***	-0.830***
	(-4.792)	(-7.151)	(-9.103)	(-5.715)	(-8.913)
Init. share > 3000 ha	-0.283	-0.233	0.111	-0.056	-0.108
* productivity	(-0.437)	(-0.933)	(0.269)	(-0.152)	(-0.340)
Rayon fixed effect	1.372***	1.214***	0.983***	0.698***	0.876***
	(4.812)	(5.353)	(7.974)	(2.806)	(5.389)
Init. share > 5000 ha	-0.363***	-0.432***	-0.405***	-0.402***	-0.492***
	(-2.771)	(-4.550)	(-2.816)	(-3.530)	(-4.733)
Initial productivity	-0.414***	-0.530***	-0.569***	-0.553***	-0.785***
	(-2.629)	(-9.506)	(-7.695)	(-5.970)	(-14.095)
Init. share > 5000 ha	0.448	0.149	0.685	0.156	0.117
* productivity	(0.857)	(0.292)	(1.054)	(0.277)	(0.234)
Rayon fixed effect	0.977***	0.847***	0.628***	0.314**	0.671***
	(4.076)	(4.983)	(4.767)	(2.463)	(4.770)

Note: t-statistics in parentheses based on bootstrapped standard errors: *** p<0.01, ** p<0.05, * p<0.1

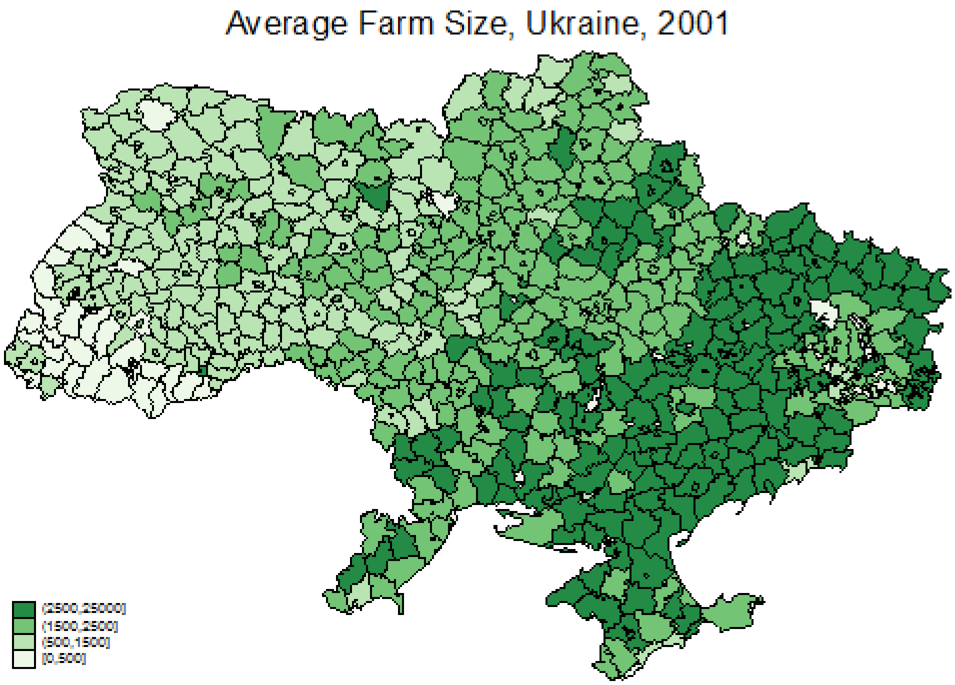

Figure 1.1: Average farm size (ha) by rayon, 2001

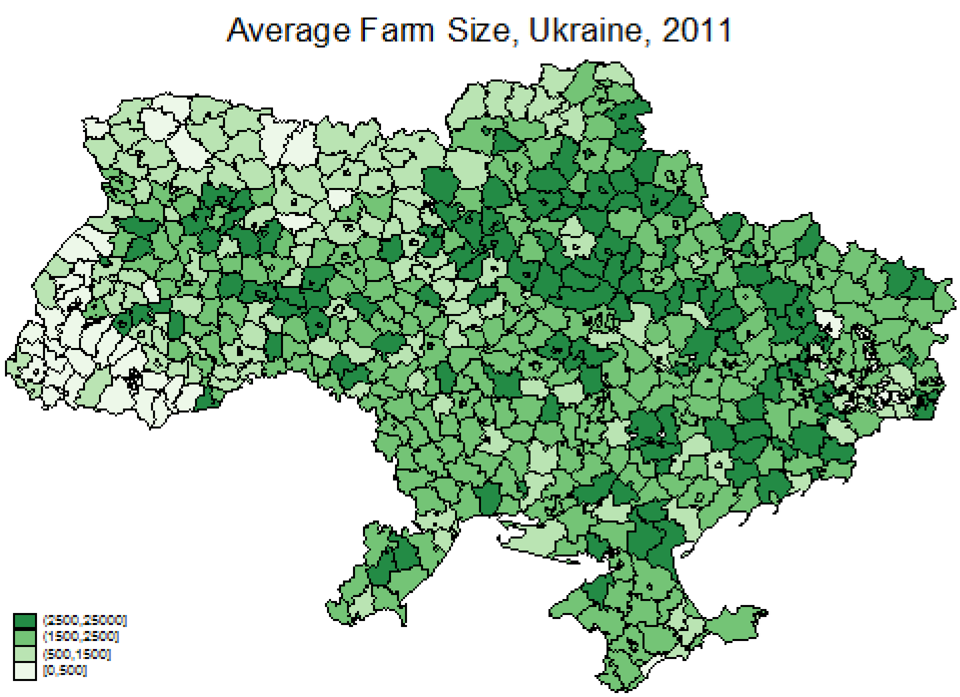

Figure 1.2: Average farm size (ha) by rayon, 2011

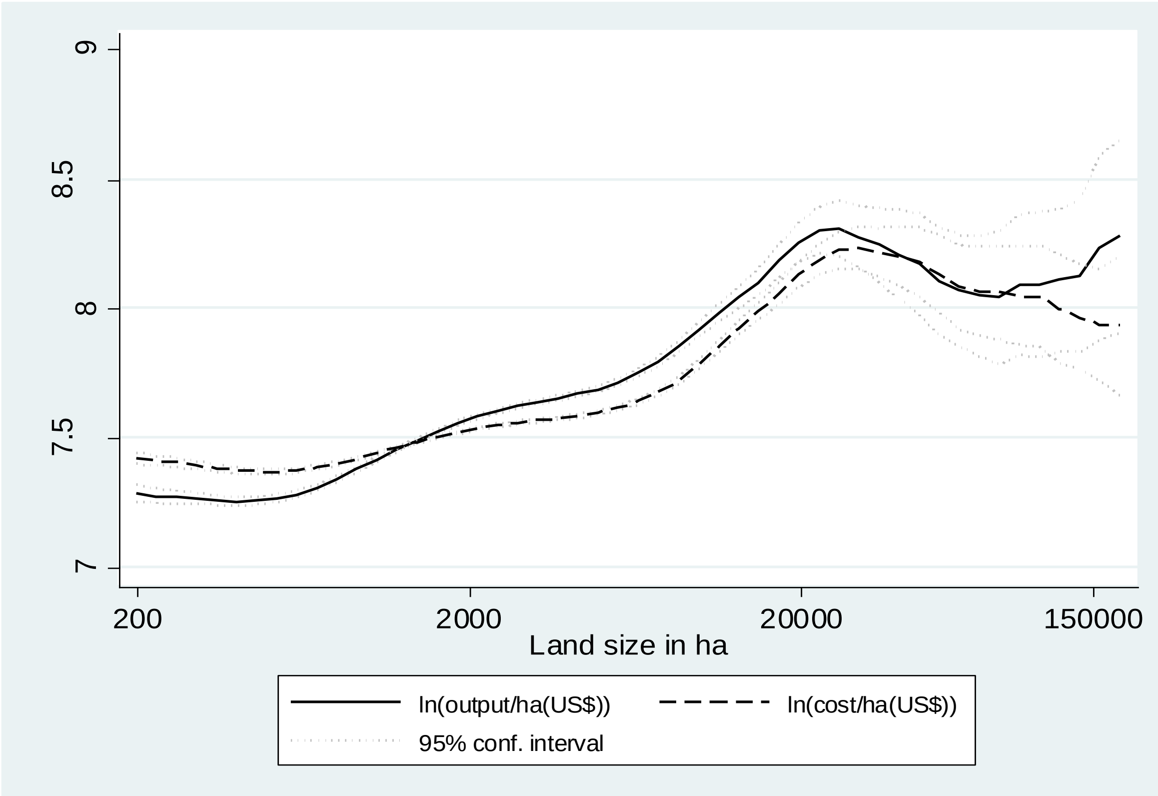

Figure 2: Value of output and cost/ha against farm size, 2001-2011

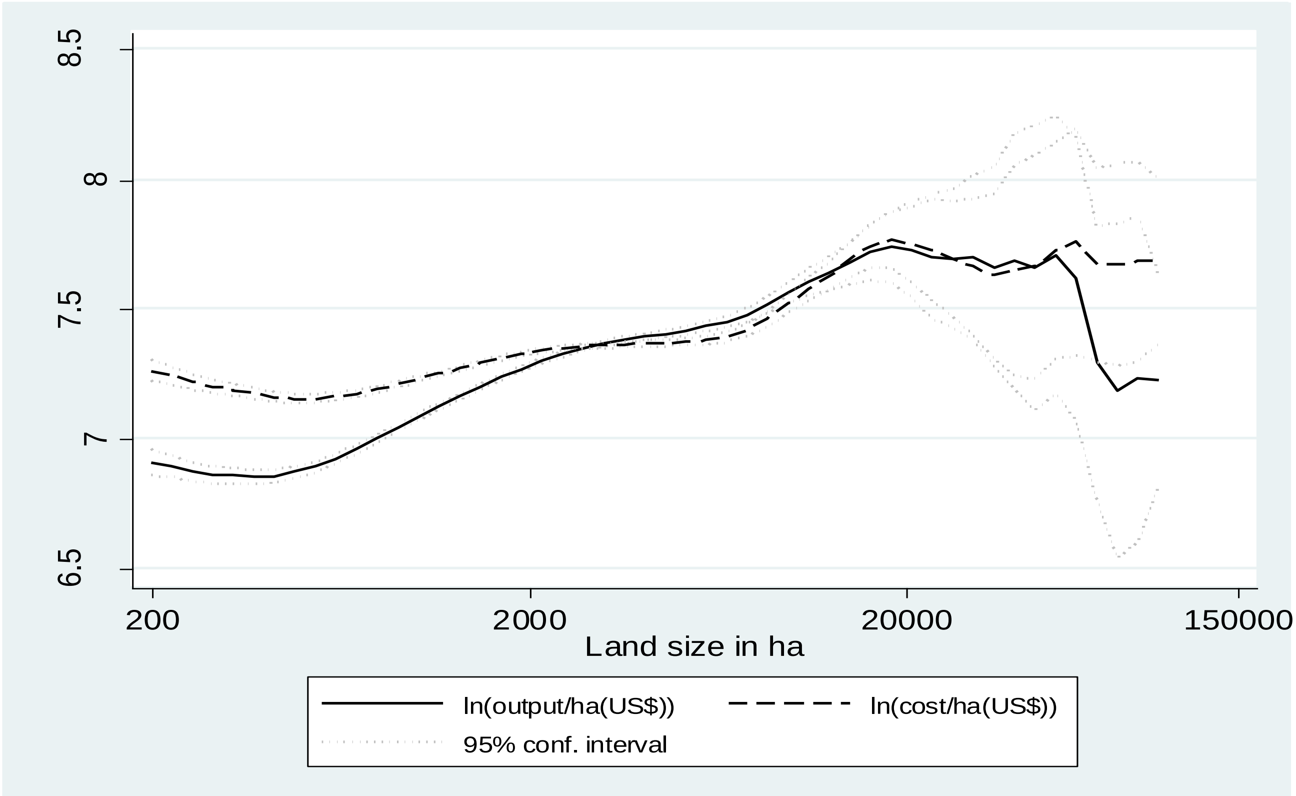

Figure 2.1: Value of output and cost/ha against farm size, 2001-2006

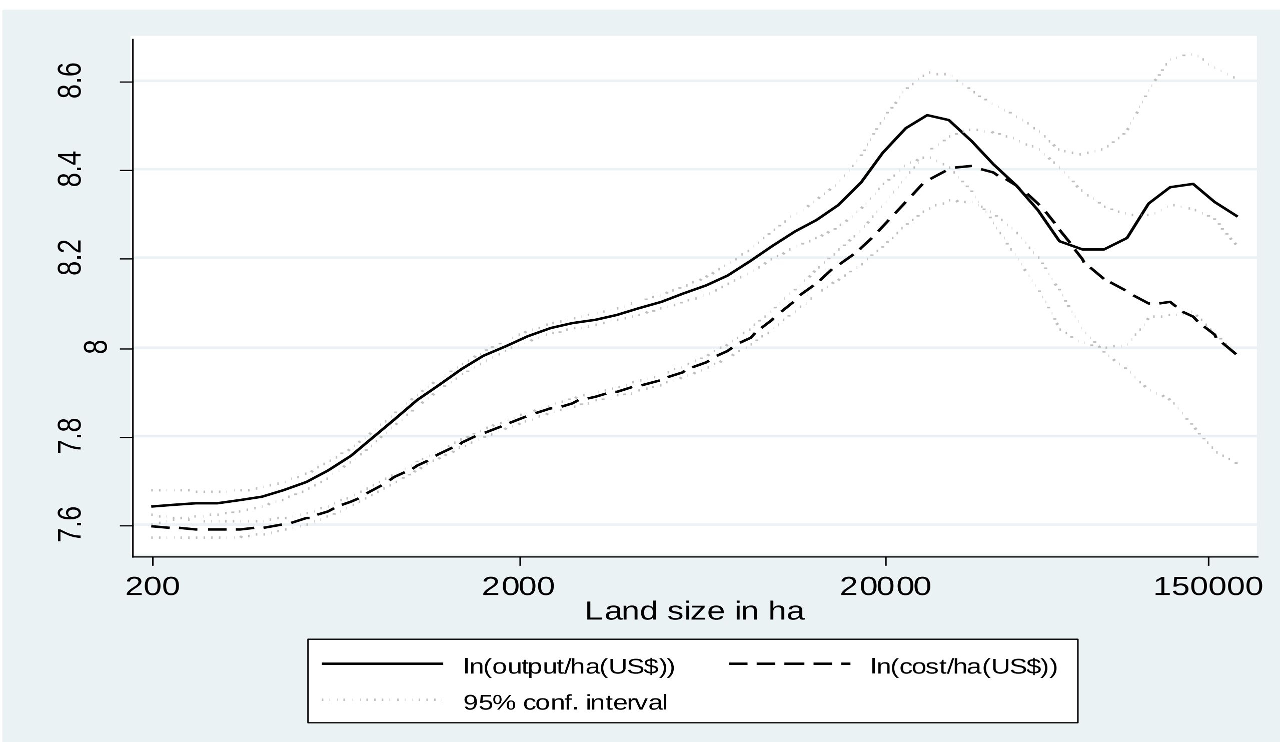

Figure 2.2: Value of output and cost/ha against farm size, 2007-2011

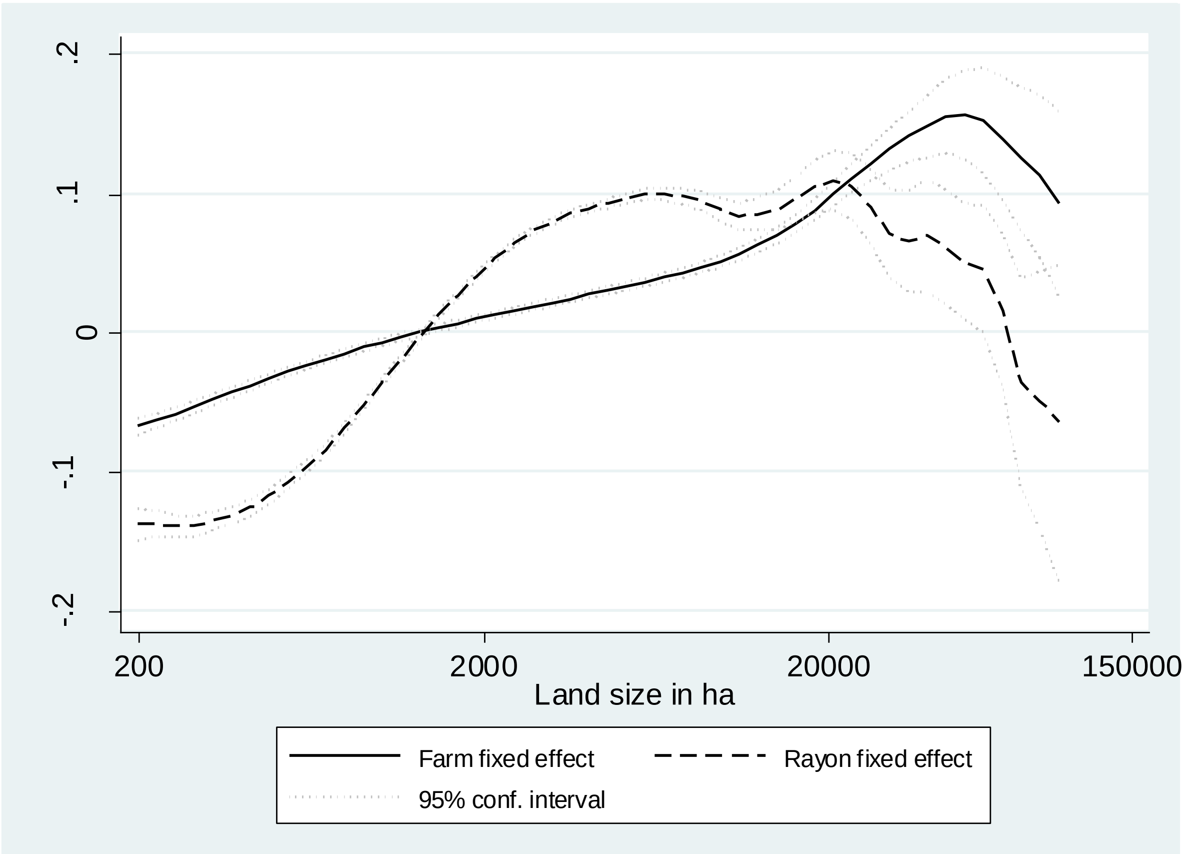

Figure 3: Farm and rayon fixed effects by farm size (cities & rayon centers excluded), 2001-2011

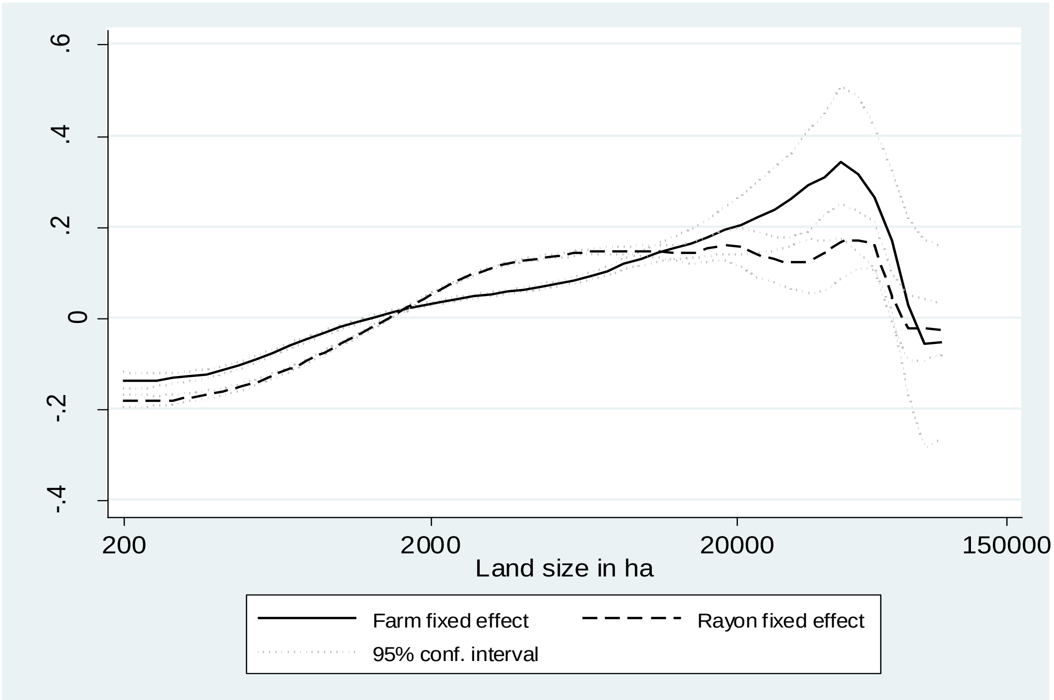

Figure 3.1: Farm and rayon fixed effects by farm size, 2001-2006

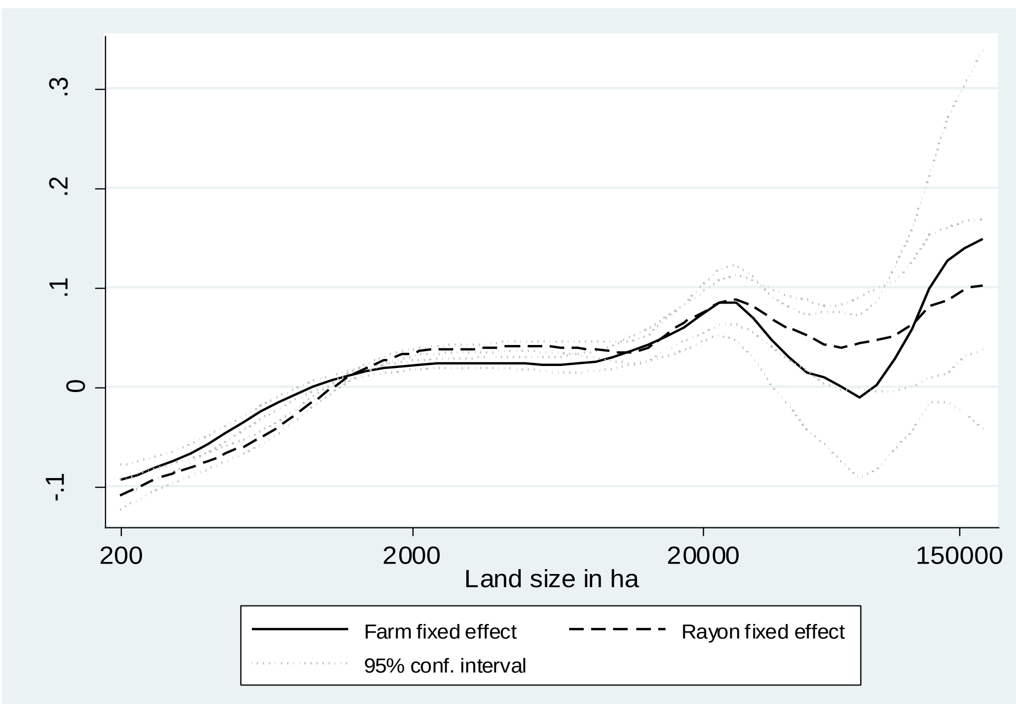

Figure 3.2: Farm and rayon fixed effects by farm size, 2007-2011

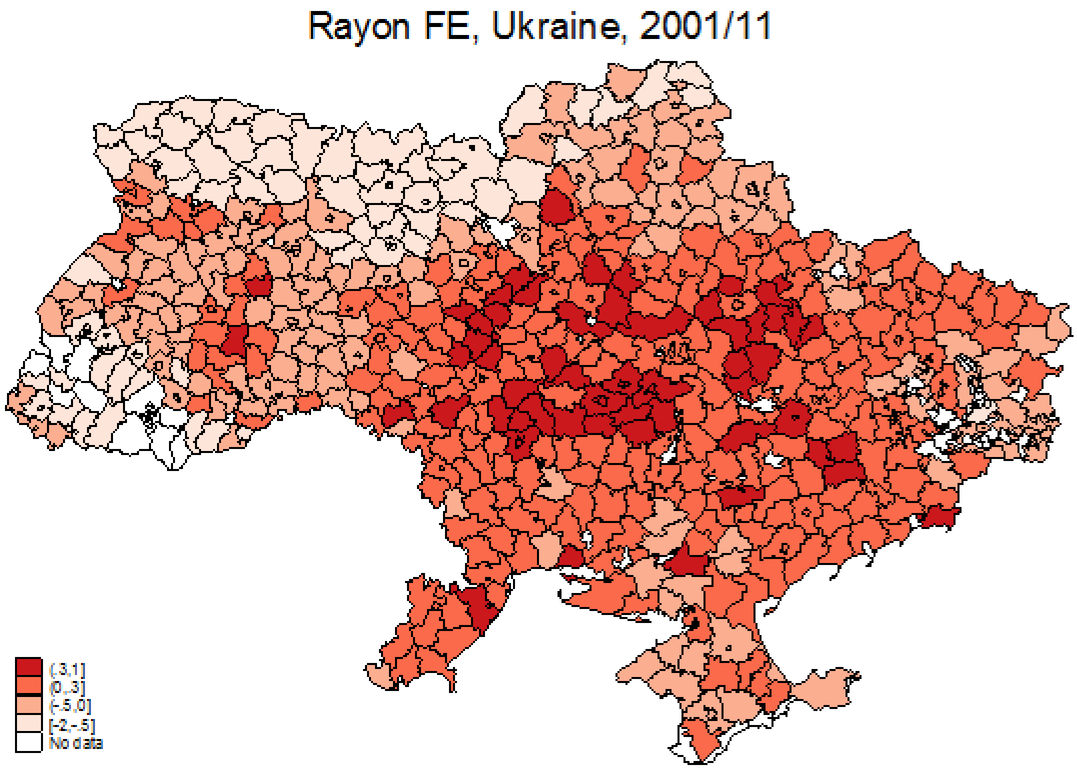

Figure 4: Rayon fixed effects distribution, 2001-2011

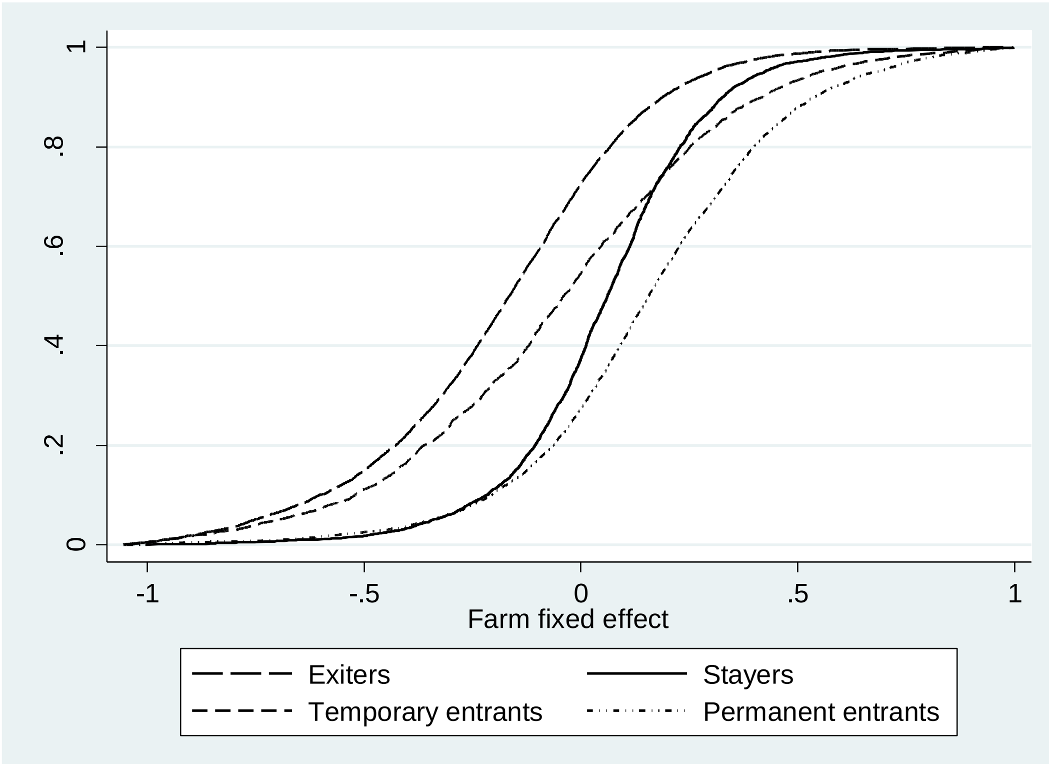

Figure 5: Farm fixed effect by nature of entry/exit

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[i] Use of GPS, though not without challenges, suggests that indeed farmers' area estimates being biased (Calogero *et al.* 2011)

[ii] A well-known exception to the advantages of owner-operated units of production over those relying on wage labor is in perishable plantation crops, where economies of scale in processing may be transmitted to production (Binswanger and Rosenzweig 1986). Limited seasonality and scope for year-round employment facilitate labor supervision and management, similar to specialized stall-fed livestock operations in industrial countries which, as a result, moved from family farm to corporate types of farming (MacDonald 2011).

[iii] As of end 2009, only seven publicly listed farming companies existed worldwide, 3 in South America and 4 Ukraine and Russia (Deininger *et al.* 2011a). This contrasts with a highly concentrated industry structure in agricultural processing and inputs due to high levels of fixed costs (e.g. for R&D or processing units) that give rise to economies of scale below a certain operational size.

[iv] Channels for such effects to come about include credit market imperfections in the presence of indivisible investments (Aghion and Bolton 1997, Galor and Zeira 1993); wealth-induced limitations on households' ability to voice concerns in politics (Bourguignon and Verdier 2000); and willingness/ability to supply local public goods (Cardenas 2003).

[v] Failures include the "bonanza farms" in the US in 1860-1900 (Drache 1964), Brazilian rubber plantations by Henry Ford in the 1920s (Grandin 2009), and efforts in the 1960s to establish large-scale agriculture in the Lakeland Downs of Australia's far Northeast (Rogers 2008).

[vi] Many countries have laws that preclude transfers of land among individuals and instead require these to be mediated by the state (Deininger *et al.* 2011b). In fact, efforts in Ukraine to establish a 'land bank' with pre-emptive right to land purchases go in the same direction.

[vii]A ban on sales of agricultural land (moratorium) was established in 2001 making the rental market the only instrument for land transfer among cultivators.

[viii] The 2012 draft "Law on Land Market" is the country's 5th attempt to lift the current moratorium on land sales since 2005. Although there is broad consensus about the need to establish secure property rights to land to encourage investment, there was agreement that the Draft Law was worse than the status quo resulting in its withdrawal (Lapa 2011) and a decision has now been postponed until 2016.

[ix] As we know the locality where firms are registered, one way of adjusting for this is to exclude from the analysis entities registered in towns. However, as discussed below, inclusion or exclusion of these farms does not affect our results in any substantive way.

[x] In terms of coverage, reporting requirements were relaxed in 2004 and in 2007. The choice of 200 ha as cut-off consistently excludes farms that dropped out later due to changes in reporting requirements. Substantive changes in the questionnaire include (i) disaggregation of area by crop from 2004; (ii) disaggregation of inputs by crop and inclusion of data on taxes and subsidies in 2007; (iii) addition of factor prices in 2010.

[xi] The survey includes information only on wage payments, implying that inputs by family workers who do not receive a wage are not recorded. Although this is unlikely to be a big issue at the farm sizes considered here, it will need to be taken into account in interpreting our results.

[xii] The survey focuses on legal entities rather than physical production units and has to be filled by farms that either have (i) a land area of 200 ha or more; (ii) at least 50 units of cattle, pigs, or goats; (iii) at least 500 units of poultry; (iv) at last 20 permanent employees; or (v) at least UAH 150,000 UAH (19,000 USD) revenue from sales of agricultural commodities or services.

[xiii] Part of the reason is that higher levels of vertical integration in and subsidies to the livestock industry imply greater use of transfer pricing and under- or over-reporting of output and profits for tax purposes. The focus on crops only does not affect our main estimates, largely because of the inclusion of farm fixed effects (results are available on request).

[xiv] The pattern of recovery was differentiated across regions: While the North fully returned to the amount of area cultivated in 2001, two thirds (2 mn. ha) of the national decline occurred in the West, which hardly recovered post-2006, and the remainder was equally distributed between East and South (0.5 mn. ha each).

[xv] The largest farm in the sample started out in 2007 with an area of 181,263 ha but had shrunk to 115,651 ha in 2011. The second farm started out with 145,129 ha in 2007 and expanded to 147,753 ha in 2008 but cut back to 142,014 ha in 2011. Farm three started out with 25,222 ha in 2006, expanded to 156,426 ha in 2010 and shrank to 135,741 ha in 2011. Farm four started with 10,446 ha in 2001, expanded to 113,147 ha in 2008, and then decreased to 54,452 ha in 2011.

[xvi] The number of farms above 10,000 ha increased from 40 in 2001 (with the largest one farming 88,032 ha) to 155 in 2011 (the largest farming 142,014 ha). Most concentration occurred in the period after 2006 when area cultivated by farms above 10,000 ha farms increased by more than 2 mn ha. The relative increase in the number and area under large farms was highest in the West and the North where there had been only 3 and 6 farms above 10,000 ha and none or 2 above 20,000 ha in 2001.

[xvii] Only 2,898 of the 9,992 incumbent farms in 2001 (or 19% of the entire sample) survived until 2011. By contrast, 41% of incumbent sample farms exited before 2011, 31% entered after 2001 but stayed until 2011, and 9% churned, i.e. entered after 2001 but exited before 2011. While turnover was larger in the first period when only 36% of farms made it to the end as compared to the second when 56% did so, fluctuation is biggest for the smaller farms: in the below 500 ha category, only some 20% of the sample (vs. 50% in the above 5000 has class) remained from 2001 to 2006 and 27% (vs. 73% in the above 5000 has class) from 2007 to 2011.

[xviii] As equality of elasticities across periods is rejected throughout, we only report the specification with interactions to conserve space.

[xix] It is important to get the causality right: It is not that growth makes farms more efficient but it is that efficient managers operate large farms.

[xx] Data on leases would be needed to distinguish the extent to which this is a result of farmers being locked into long-term leases concluded when agriculture was still very unprofitable or limited competition at local level.

[xxi] Results are available upon request.

[xxii] Permanent entrants are those who entered the sample after 2001 and were present in 2011 whereas 'permanent exiters' are defined as those present in 2001 who had exited by 2011. Temporary entrants and exiters include those who entered after 2001 but exited before 2011.

[xxiii] Quantile regressions are used to avoid results being unduly affected by outliers.