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"For whoever has will be given more"? Land rental decisions and technical efficiency in Ukraine

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ABSTRACT

Land rental markets had played a critical role in providing farms access to Ukraine's agricultural land before the ban on land sales was lifted in 2021. This paper examines whether rental-based land relations can promote land use by more productive farms in the context of imperfect institutions. In particular, we examine whether Ukrainian farms' decisions to rent land are linked to their agricultural ability. Utilizing a rich panel of more than 16,000 Ukrainian commercial agricultural producers for 2005–2015, we analyze demand-side determinants of participation in the land rental market. The evidence suggests that farms' total factor productivity is disconnected from their decisions to rent land. Land accumulation appears to be driven by other context-related factors, including existing local land concentration and orientation toward cash crop production. Results call for launching a land sales market and improving rental market infrastructure because these measures can align land rental prices with the value of the marginal product of land.

1. Introduction

Although optimal agricultural organization and respective land policies have been puzzling scholars for more than three decades and still present an actively debated issue, relatively little attention has been paid to a post-socialist transition context. Literature has extensively considered land markets as a mechanism for creating opportunities for land transfers from less to more productive farms and as a poverty-reducing tool (de Janvry et al., 2001; Deininger, 2003). Although land ownership is widely considered to induce investments and improve productivity (Besley, 1995; Koirala et al., 2016; Place, 2009), land sales markets are often difficult to implement with imperfect institutions. Because many transition economies are known for high transaction costs in land purchases, thin land sales markets, and credit constraints (Lerman et al., 2004), renting land is often the primary way of transferring land-use rights. In these environments, land rental markets may play an important role in enhancing agricultural efficiency because they may enable land to flow towards more efficient producers (Sadoulet et al., 2001) and provide access to land for the poor (Deininger and Binswanger, 2001). The idea is that land rental markets may minimize transaction costs of land exchange and are, thus, more efficient than other forms of land relations (Deininger et al., 2009; Deininger and Binswanger, 2001; Vranken and Swinnen, 2006). However, very little research has been conducted on how rental markets actually work in settings with imperfect institutions. Rental markets may be thin, local elites may be able to exert market power, depressing prices and accumulating land, and landowners' lack of negotiating capacity may disrupt land flow towards more capable producers. This study explores whether land rental markets contribute to an effective land exchange in a post-Soviet setting with imperfect institutions.

Existing literature on the relationship between rental decisions and agricultural ability almost exclusively focuses on farm households where non-separability and the existence of multiple income sources might facilitate access to land (Huy and Nguyen, 2019; Rahman, 2010; Tan et al., 2018). Regionally, existing studies have mainly focused on Southeast Asia and Africa. Former Soviet states differ substantially in institutional setup and land ownership patterns. In Russia, Ukraine, and Kazakhstan, former workers of collective farms received land plots as part of the de-collectivization during the 1990s. Most rent these plots out to large commercial farms instead of starting a family farm. Naturally, land rental decisions in commercial farms are expected to differ from household decisions, as there are no additional income sources, and new challenges arise with hired labor supervision and remuneration. It is unclear whether land rental markets can facilitate

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productivity-enhancing land distribution in these circumstances. We address these research gaps by examining the link between farms' ability and their propensity to rent land.

Ukraine represents an interesting case because land rental has been an almost exclusive way to access agricultural land. The reason is that by adopting the new Land Code in 2002, the Ukrainian government introduced private property rights on land, followed by an immediate moratorium forbidding land sales. Land-intensive agricultural production with large commercialized producers puts Ukraine in one group with countries with similar natural and environmental conditions as well as comparable reform paths: Russia and Kazakhstan. The Ukrainian land rental market had been in place for over two decades, leading to substantial land use concentration, giving rise to large farms operating on several hundreds of thousands of ha (Keyzer et al., 2017; Mamonova, 2015). One explanation for the emergence of large-scale farms and local land concentration could be the persistence of economies of scale in crop production and a higher return to land in large production units. However, Deininger et al. (2018) have not been able to prove that larger farms are more productive in Ukraine. This raises the question of how rental decisions are made and whether production efficiency plays a role.

The main objective of this paper is to analyze whether the Ukrainian land rental market facilitates the conveyance of agricultural land to more efficient agricultural producers. First, we review the literature on the factors affecting farmer's rental decisions. The theory suggests that the value of the marginal product of land should motivate the decision to rent land, implying that more productive farms should operate larger areas. However, initial land concentration stemming from the times of collective farming may distort this relationship. Second, we use unique farm-level panel data from Ukraine to trace the developments of the land rental market over 11 years between 2005 and 2015. Then, we estimate the determinants of participation in the land rental market for commercial agricultural producers, analyzing the connection between farms' agricultural ability and the likelihood of renting land. In doing so, we explicitly consider the initial land concentration and how large farms may exploit their advantageous position. Based on the results, we discuss the implications of the current land relations for the growth of the Ukrainian agricultural sector.

Our results do not support the hypothesis that more productive farms rent more land. Other context-related factors appear to be the drivers of rental decisions. In particular, initial rayon-level land concentration appears to generate farm size polarization with further growth of large farms and further shrinkage of their smaller counterparts. Moreover, the availability of cheap land may generate incentives for land-intensive business models focusing on large-scale cultivation of cash crops with a low added value per hectare. Finally, the growth of the agricultural sector appears to have been brought about not by the size expansion but by the entry of more productive and the exit of less productive farms.

The rest of this paper is organized in the following fashion. Section 2 articulates our literature review focusing on the efficient use of land as a production factor and initial land concentration. Section 3 provides a brief excurse of the institutional context of Ukrainian land relations. Data and methods are presented in Section 4, whereas we present the results in Section 5. Finally, Section 6 concludes and discusses the implications of our findings.

2. Conceptual framework

Our research questions are embedded in an old debate about the farm size-productivity relationship because land rental is by far the most important way of accessing land in Ukraine. An observation that large farms tend to be less productive has turned into a stylized fact with a coined term – "inverse farm size – productivity relationship" (Chayanov, 1926; Eastwood et al., 2010; Eswaran and Kotwal, 1986; Lipton, 2009). Well-known principal-agent problems of farm owners' supervision of the hired labor have been the primary explanation for the inverse size – productivity relationship (Barrett et al., 2010; Feder, 1985). However, modern technologies (e.g., precision farming) and management approaches may attenuate the effect of labor supervision challenges (Deininger and Byerlee, 2012; Rada and Fuglie, 2019). In this case, labor constraints may be relaxed, unleashing potential drivers of land accumulation if other non-land factor markets are unhindered. Because land rental markets represent a flexible way of accessing land (Sadoulet et al., 2001), they could allow new farmers to grow or contribute to land accumulation by large farms. Understanding a farmer's decision to rent land will provide a theoretical foundation for testing whether more efficient farmers rent in more land.

2.1. *Land rental decisions*

The aggregate productivity of an agricultural sector may be improved via an effective land exchange mechanism. A functional land rental market can generate a flow of land from less to more able farmers (Sadoulet et al., 2001). Underutilized land imposes opportunity costs on more able farmers and generates incentives for land exchange, putting land to the most efficient use. As a result, land rental should facilitate efficient factor allocation, improving the aggregate efficiency of land cultivation.

Basic microeconomic theory informs a farm's decision to rent land. The departure point is that a profit-maximizing farm will add units of a production factor until the factor's price equals the value of its marginal product (Dasgupta et al., 1999; Lackman, 1977). Because the value of the marginal product of land depends on the production processes, its value will be higher for the farms that use all production factors more efficiently. In other words, the decision to rent in an additional land plot depends on the farmer's ability to use it in the production process effectively. Thus, a farmer with low agricultural ability will not be able to compete in the rental market, facing high opportunity costs of holding land, which generates incentives to reduce the portfolio of rented land. Consequently, we expect farms with superior agricultural ability to rent more land. This forms a basis for our test, with the central hypothesis stipulating a positive correlation between a farm's agricultural ability and its activeness on the land rental market.

Farmer's renting decisions may be affected by other incentives if rental markets or other factor markets show imperfections. For instance, imperfect factor markets may incentivize the self-selection of business models focusing on certain crops. On the one hand, household farms facing challenges renting land and lacking alternative off-farm employment opportunities may overuse labor because they cannot adjust their farm size (Sen, 1966). Conversely, commercial farms may be in a better position to overcome land rental transaction costs, making it easier for them to expand their sizes. In this case, the marginal product of land will exceed the rental price and lead to land overutilization (Deininger et al., 2018). Relaxed constraints for larger commercial farms may incentivize less intensive cultivation. For instance, in the Chinese context, less labor-intensive grain production was found to be associated with less constrained access to land (Min et al., 2017; Qiu et al., 2020). The lower demand for labor per unit of land in grain production compared to, for instance, livestock or vegetable production allows to deal with labor shortages and/ or high supervision costs. At the same time, more mechanized production systems are expected to benefit from larger cultivated areas (Luo, 2018; Pingali, 2007). Thus, in the Ukrainian context, land-intensive business models oriented towards export crops (corn, wheat, and sunflower) should be associated with a higher land rental activity.

2.2. *Land concentration via rental markets*

Initial distribution of land on a local level may affect the transaction costs of land exchange, impeding the achievement of efficiency-enhancing distribution of land. In particular, locations with substantial amounts of land controlled by large farms may be subject to prohibitive transaction costs of land access for smaller farms or new entrants. Furthermore, renting large amounts of land may require substantial administrative capacities for managing the contracts. Thus, larger farms are typically better positioned and will have an advantage in negotiating with local landowners. As a result, new or smaller farmers may face additional costs of land access and may be disadvantaged in the competition for land access compared to larger counterparts. Additionally, farmers cultivating small areas may be excluded from local political processes (Acemoglu et al., 2004; Binswanger and Deininger, 1997). This, in turn, may limit their political influence on the decision-making of local authorities with respect to land distribution. For instance, influential farms may have an advantage in renting state-owned agricultural land[1] due to their superior bargaining power relative to their small counterparts.

Large farms may also have incentives to cement their dominant position and expand their rented land if the land prices are lower than the value of the plots' marginal product. The logic is that several dominant land users may be able to deter potential entrants (Balmann et al., 2021; Martinelli, 2014). A situation when a few farms control a substantial share of land may discourage smaller farms from renting in land within this particular location because of limited rental options. For instance, dominant farms may strategically rent specific plots, increasing the costs of land consolidation for potential entrants (Hartvigsen, 2015) or play a role of price leaders (Graubner et al., 2021), making renting land within a given region unattractive.

As a result, competition for land based on efficiency considerations may be hindered, generating misallocation of land and labor. Small farms may be stuck with insufficient land rental possibilities, whereas large counterparts may use their political and strategic position to expand cultivated areas further. Because Ukrainian large farms emerged on the basis of the former collective farms (Swinnen and Vranken, 2007), their dominant position may had been attained exogenously, giving rise to initial inequality in rented land distribution. If average rental prices are far below the marginal product of land,[2] we expect all types of farms to compete for land. However, because of the lower transaction costs, we expect farms with a dominant position in the local rental market to reinforce their position and rent in more land. On the other hand, smaller farms failing to compete with larger counterparts may shrink or exit agricultural production, contributing to farm size polarization. With increasing land concentration, we expect a self-selection process where each remaining farm's market and political power is expected to increase, and thus farms might rent in more land. Thus, we hypothesize that farms located in regions with relatively unequally distributed land should rent in more land.

3. Land relations in Ukraine

After the collapse of the Soviet Union, Ukraine set the course for liberal land reforms in the early 1990s but then got trapped in the transition period. Fig. 1 demonstrates the evolution of the major legislative initiatives. The first important milestone that signified the launch of the land reform was the 1995 Presidential Decree[3] which launched the distribution of the so-called "conditional land shares" (CLS) – stakes in the former collective farms. Employees of collective farms and certain groups of the rural population were eligible to receive CLS. Later on, the 1999 Presidential Decree[4] gave a chance to the CSL holders to convert their shares into physical plots (Lerman et al., 2007), subsequently creating ca. 7 million land owners, who owned 27.6 million ha. However, the institutions necessary for establishing a market-based exchange of ownership titles were not developed then. The 2002 Land Code that paved the way for new land relations in Ukraine could be considered a major breakthrough because it clearly defined property rights related to agricultural land. However, the subsequently adopted Moratorium on land sales took away the basic right of the landowners to sell land. Initially planned as a temporary measure, the Moratorium has been prolonged ten times since its adoption. Only in 2020, the Ukrainian parliament adopted a law stipulating the launch of a restricted sales market in 2021.

In the meantime, access to land for agricultural producers was almost exclusively based on land rental. Land rental prices were formed based on a so-called 'normative monetary value' of land, a reference value artificially set based on soil quality and expected revenues. Several observers claim that the 'normative monetary value' of land was set way below the value of the marginal product of land and that the gap increased over the years (Kvartiuk and Herzfeld, 2019; Nivyevskyy, 2019; Nivyevskyy and Nizalov, 2016). Apart from being low, Kuns (2017) suggests that land prices were often paid in the form of agricultural produce. Ukrainian landowners were disadvantaged because of their low bargaining power and, thus, their ability to exert upward pressure on prices. Rental prices below the value of the marginal product of land incentivize land accumulation and lead to overutilization of this production factor (Deininger et al., 2018). In addition, we observe anecdotal evidence of illegal expropriation of land and hostile overtakes. The combination of low prices and tenure uncertainties generates the incentives for business models of export-oriented annual crop cultivation on large areas (Kvartiuk and Herzfeld, 2019). These institutional settings have contributed to the emergence of Ukraine as one of the world's leading producers and exporters of grains and oilseeds (Keyzer et al., 2017).

Within these institutional settings, three major types of agricultural producers emerged in Ukraine: agricultural enterprises (including state enterprises), individual farms, and households. Fig. 2 breaks down land use by each type of agricultural producer and by land-use type (owned vs. rented). We see that commercial farming on owned land is rare. A light grey color represents the small amount of land owned by individual farms and agricultural enterprises that managed to acquire small areas before the 2002 sales ban. Importantly, households predominantly farm on owned land and account for ca. 4.3 million small agricultural producers that cultivated about 15.7 million ha (43.1 % of the total agricultural land) in 2016. They mainly produce for subsistence consumption, orienting excess to the local markets. The State Statistics Service of Ukraine (SSSU) estimated that households accounted for 38.7 % of the value of agricultural crops produced in 2016. Despite the households' significant role in Ukrainian agriculture, this study focuses on commercial agricultural producers: individual farms and agricultural enterprises.

Family farming has been promoted in Ukraine to facilitate the commercialization of the households that rented land in addition to what they owned. For this purpose, individual farms were defined by the law in 2003[5] and have been granted preferential conditions on establishment, taxation, and access to land. Individual farms have been gaining importance and reached 4.4 million ha in total land use in 2016 (12 % of the total agricultural land), represented by about 32,000 producers. They farm predominantly on rented land (89 % of the total land used by this category).

[1] Roughly a quarter of all agricultural land was owned by the Ukrainian state as of 2016.

[2] We explain why that is the case in the Ukrainian context in Section 3.

[3] Decree of the President of Ukraine No. 720/95 from 08.08.1995 "On the order of distribution of lands transferred to a collective ownership of agricultural enterprises and organizations".

[4] Decree of the President of Ukraine No. 1529/99 from 03.12.1999 "On urgent measures for accelerating the reforms in agricultural sector of the economy".

[5] Law No. 973 from 19.06.2003 "On individual farming".

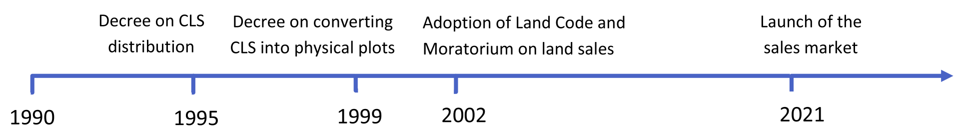


Fig. 1. Timeline of the major milestones in the Ukrainian land reform.

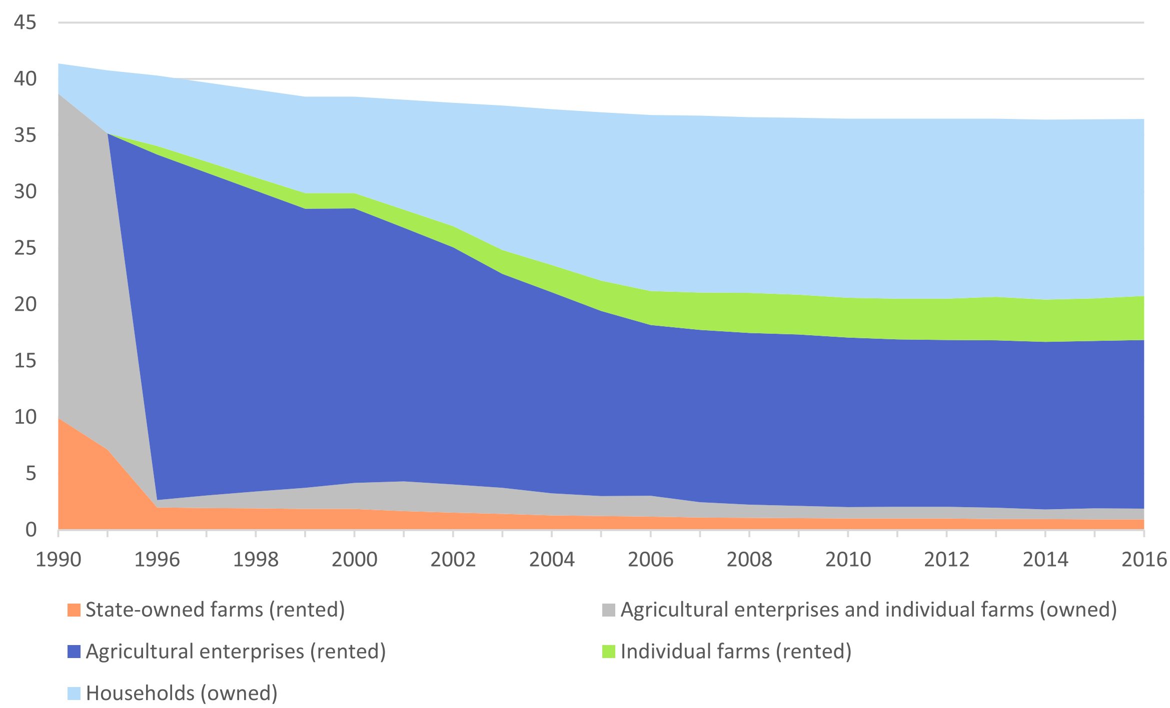


Fig. 2. Distribution of land use by farm types. Source: SSSU (2017).

Agricultural enterprises represent legal entities typically run by hired managers and often owned by individuals not directly involved in agriculture or by the state. Many of these enterprises were created on the basis of former collective farms but almost exclusively operated on land rented from the CLS holders: they owned only 1.5 % (200,000 ha) of the total land in 2015. The share of land operated by enterprises declined after restructuring but stabilized in the mid-2000s. As of 2016, they account for roughly 16.3 million ha or 47 % of the total agricultural land while being represented by 9796 legal entities.

A distinctive feature of Ukrainian agriculture is a relatively large operational scale in comparison to the rest of the world. Ukraine hosts some of the largest agricultural enterprises in the world. The average utilized land per farm amounts to 460 ha but the largest farms operate up to 500,000 ha (Deininger et al., 2018). A substantial share of land is used by agricultural enterprises between 500 ha and 4000 ha in size, which likely represent enterprises organized around former collective farms. In addition, many farms are affiliated with a central holding forming multibranch farms – so-called 'agriholdings' (Deininger et al., 2018; Graubner et al., 2021). Apart from better managerial and administrative capacities, these farms typically enjoy better access to credit and other forms of outside capital, contributing to substantial land concentration with total land holdings spanning up to half a million ha. Enterprises operating more than 10,000 ha account for 17.7 % of the cultivated land (SSSU, 2017). Because the majority of these farms inherited CLS-land from collective farms (Lerman et al., 2007), land concentration was a given condition across Ukraine in the early 2000s. Thus, the unequal initial distribution of land, which generated political and market power for large farms, in combination with low rental prices may have contributed to extreme land concentration outcomes.

4. Data and methods

4.1. Data

To test our hypotheses outlined above, we use a unique farm-level panel dataset covering the period from 2005 to 2015. Data has been collected annually by the State Statistics Service of Ukraine (SSSU). Observations are sampled from farms registered as legal entities, irrespective of farm type, and exceeding one out of five size thresholds defined by SSSU.[6] Approximately 8000 farms are covered by the sample each year accounting for 17 million ha of agricultural land (48 % of all agricultural land). Overall, our sample covers 16,950 agricultural enterprises and individual farms distributed across 625 rayons[7] (districts) of Ukraine, which produce about half of the domestic agricultural output. This makes it a unique data source for medium- and large-scale enterprises in Ukraine.[8] However, it is important to note that this dataset

[6] Survey participation thresholds remained stable between 2005 and 2015. In general, any legal-entity producing agricultural commodities has been sampled if it were qualifying for any of the following thresholds: size above 200 ha; number of full-time workers above 20; number of livestock above 50 heads of cattle, or swine or sheep or 500 for poultry; or annual revenue above 150 thousand UAH per year (ca. 6000 USD in 2020)

[7] SSSU's standard reporting form "50SG" covers from 85 % in 2005 to 95 % in 2015 of land operated by all agricultural enterprises (state and privately owned) as well as 79–60 % of land operated by individual farms registered as legal entities (based on data from (SSSU, 2017)).

[8] For the years 2014–2015, no data is available for the territories occupied by the Russian Federation: Crimea and part of territories of the Donbass region.

does not include small producers that do not pass the minimum criteria for being included in the sampling population set by SSSU. Furthermore, it is an unbalanced panel with relatively high attrition where only 24 % of farms are present each year (see Appendix A for further details). Available variables include standardized farm management information and performance statistics. It contains data on farms' expenditures on inputs, produced crops, and livestock as well as volumes and values of sales in each calendar year. Specifically, the input data distinguishes between land area, labor in full-time equivalent (FTE), and expenditures on land rent, hired labor, seeds, fertilizers, petrol, services, machinery, and other items.[9] We deflated all monetary data to the 2018 price level using the Consumer Price Index (CPI) and then converted the values into US dollars.

To ensure data consistency and to narrow the scope of the analysis, we restrict the dataset in a number of ways. First, we focus on farms that specialize in crop production, restricting the sample to the farms that meet both of the following criteria in each year a farm is present in the sample: 1) a share of costs related to crop production in their total costs is greater than 25 % and 2) operational size is above 5 ha.[10] Moreover, as we are interested in changes in rented land, we exclude all the farms that appeared in the panel only once (those farms that existed for one year or were qualified to be covered by the survey only once).

Table 1 presents the descriptive statistics. The first observation is that between 2005 and 2015, the average amount of owned land decreased and rented land increased for all types of producers except for the state farms that continued relying on the cultivation of state-owned land. Importantly, the average farm size increased for all categories of producers. Secondly, we observe considerable growth in land concentration. Observing the Herfindahl-Hirschman Index (HHI) of the land used within a given rayon,[11] we see a moderate country-wide increase from 0.22 to 0.31 throughout our panel. Fig. 3 highlights the spatial differences in land concentration and their changes over the decade. Main regions of grain production stretching from the south through the center and to the northeast of Ukraine experienced moderate levels of land concentration. On the other hand, agricultural land appears to be more concentrated in the north-western and western regions. These patterns largely coincide with the operation domains of large farms. Moreover, we observe signs of the business models' re-orientation towards large-scale grain production. First, enterprises appear to have substantially increased the shares of corn, soybeans, and oilseeds at the expense of barley, sugar beets, and oats. These grains have been among the major export commodities during 2005–2015.

Because the SSSU collects the data on a calendar year basis, volumes of crops sold in each specific year are rarely the same as the production levels. Consequently, the amount of output sold may be higher or lower compared to the actual production. In addition, there may be a potential bias due to the transfer pricing of crop output within vertically integrated crop-livestock farms. We follow Deininger et al. (2018) in dealing with these challenges and calculate the values of the produced crops in 2018 USD for each farm based on the median crop prices at the rayon level and individual farms' production quantities.

Examining the data on farms' performance reveals clear differences between the three types of agricultural producers. Although farms' output per ha increased considerably on average across all farm types, these gains are less pronounced for state enterprises. Their level of output per ha was only half of the respective value for agricultural enterprises in 2015 although it also grew roughly 50 % during the decade of 2005–2015. These differences are also traceable in the cost structure, indicating that state-owned agricultural enterprises are fundamentally different from other types of producers. Total production costs went up 2.7 times for all farm types, whereas state farms experienced only a 1.4-fold increase. This may reflect the fact that the managers of state farms may utilize outdated technologies due to a lack of investments. For instance, state farms spent three times less on fertilizer per ha in 2015, and petrol costs almost did not change and were only 50 % of the level of other farm types. Importantly, although the land rental prices almost tripled for all farm types, state farms, on average, paid only 19 % of the average rental prices in 2005 and 12 % in 2015. This illustrates their competitive advantage in accessing cheaper state-owned land.

4.2. Methodology

Following our theoretical framework, we aim to explain agricultural producers' participation in the Ukrainian land rental markets. In particular, our goal is to test whether producers with better agricultural ability tend to rent in more land. This will help understanding whether current land relations stimulate a flow of land toward more efficient agricultural producers.

First, we explain the amount of land rented by each farm i $Rental\_final_i$ in the last period where it is observed in the sample. Our key explanatory variable is a measure of the farm i's initial agricultural ability α_init_i at the time of its first appearance in the sample. In line with our first hypothesis, we expect it to be positive should more productive farms rent more land. In addition, we include the initial area of land owned ($Owned\_init_i$), the level of initial land concentration in rayon j $HHI\ init_{ij}$ at the time when the farm entered our panel, and other farm-specific characteristics as a vector of control variables X_i:

$$Rental\_final_i = \beta_0 + \beta_1 \alpha\_\mathrm{init}_i + \beta_2 Owned\_init_i + \beta_3 HHI\_init_j + \beta_4 X_i + \varepsilon_i \quad (1)$$

As the rented area at the end of the observation period for each farm falls in an interval between zero and infinity, we utilize Tobit regressions.[12] We minimize the risk for endogeneity between the rented land and the farms' economic performance because we explain the final land rental with the initial agricultural ability estimated at the time of the farms' entry into the sample. This ensures that in most cases, we have large lags. The same logic is applied to our proxies for land concentration and owned land.

Second, we explain the changes in land use over the observed period between 2005 and 2015.[13] To achieve that, we construct a new dependent variable for the model represented by Eq. 1: the difference in rented land area between the last and the first farm-specific observation following the year of the production function estimation $\Delta Area_i = Area\_final_i - Area\_initial_i$. Note that the difference in rented land excludes the year used to calculate agricultural ability to minimize endogeneity. The variable $\Delta Area_i$ captures only land use changes achieved through rental markets, excluding land sales, which was prohibited at the time. In addition, we estimate this model separately for several subsamples: farms with decreased and increased utilized land as well as for farms that stayed during the whole period, exited, and entered the land market. We expect that in the sample of the farms with decreasing land use more productive farms demonstrate a smaller decline in their land

[9] As there is no information on capital and machinery per se, we assume machinery costs being approximated by the annual amortization expenditures. Land costs are only recorded for the crops production, while the livestock production contains records of the feed costs.

[10] Records on farms smaller than 5 ha may be biased because of measurement errors considering SSSU's sampling strategy outlined above.

[11] We follow the literature and define HHI as the sum of the squared shares of the land users in a given rayon. As a result, it ranges from zero to one. Because owned agricultural land represents only roughly one tenth of the land used, we focus on the concentration of the land used.

[12] In the Ukrainian context, farms typically do not rent out land as they have miniscule amounts of owned land according to the data of State Service for Geodesy, Cartography, and Cadaster. Thus, we cannot observe renting out patterns which represents left-censoring of our dependent variable at zero.

[13] We use the last period for which data is available for those farms that exited the panel.

Table 1
Descriptive statistics.

	All farm types		Agricultural enterprises		Individual farms		State farms	
	2005	**2015**	**2005**	**2015**	**2005**	**2015**	**2005**	**2015**
Output per ha at rayon med. prices* (2018 USD)	242.8	623.4	245.8	650.8	230.3	483.4	193.1	326.5
	(212)	(488)	(211.4)	(504.1)	(170.3)	(320.8)	(255.5)	(257.4)
Total utilized land, ha	2156.2	2230.8	2148.6	2231.1	1949.5	2084.5	2672.3	2890.7
	(2432.8)	(4758.7)	(2484.2)	(5021.7)	(1561.7)	(1657.4)	(2084.4)	(4578.6)
Owned land, ha	176	94.5	93.3	28.7	49.4	31.5	2532.4	2740.6
	(823.4)	(877.3)	(598.5)	(313)	(208.8)	(160.8)	(2067.3)	(4600.8)
Rented land, ha	1980.2	2136.3	2055.3	2202.4	1900	2052.9	139.9	150.1
	(2395.3)	(4714.4)	(2450.3)	(5021)	(1562.7)	(1651)	(539.1)	(467.1)
Labor, average number of full-time workers	101.3	47.4	100.6	48.7	73.1	30.7	162.9	78.9
	(116.8)	(112.9)	(116.5)	(119.2)	(64.8)	(31.9)	(157.6)	(108.9)
Land concentration at rayon (HHI)	0.221	0.305	-	-	-	-	-	-
	(0.238)	(0.297)						
Total costs*, 2018 USD per ha	175.9	486.6	176.7	503.1	170.5	425.6	166.7	229.3
	(417.3)	(1783)	(433.2)	(1909.4)	(124.2)	(437.8)	(258.2)	(180.3)
Labor costs*, 2018 USD per ha	27.3	33.8	26.6	34.9	24	24.2	46.7	33.2
	(127.4)	(172.9)	(130.6)	(185.1)	(23.2)	(37.7)	(125.9)	(59)
Petrol costs*, 2018 USD per ha	30.9	57.5	30.9	58.4	33.2	57.7	28.9	32.6
	(23.3)	(381.4)	(23.4)	(409.8)	(20.1)	(31.6)	(25.6)	(25.7)
Seed costs*, 2018 USD per ha	20.4	57	20.6	59	21.1	52.1	16.1	19.9
	(22.4)	(181.4)	(22.4)	(183.8)	(16.3)	(187.3)	(27)	(18)
Fertilizer costs*, 2018 USD per ha	23.8	91.8	24.3	94	23.8	92.2	13.3	27.1
	(39.9)	(113.4)	(41.2)	(116.5)	(24.5)	(93.7)	(19.7)	(42.2)
Machinery/capital costs*, 2018 USD per ha	22.7	57.4	22.3	58.2	24.8 (27.8)	61.6 (98)	27.8 (43.5)	22.6 (30.2)
	(55.7)	(129.3)	(57.3)	(134.5)				
Service costs*, 2018 USD per ha	18.9	92.3	19.1	96.2	13	64.2	20.6	75.7
	(56.8)	(513.1)	(58.4)	(550.4)	(41.7)	(78.8)	(31.8)	(87.8)
Other costs**, 2018 USD per ha	31.9	96.8	32.8	102.5	30.6	73.5	13.2	18.2
	(153.6)	(638.5)	(160.9)	(685.8)	(22.6)	(57.4)	(34.5)	(28.7)
Land rental price, 2018 USD per ha	22.2	58.2	22.5	60.9	20.7	50.6	4.3	6.8
	(63.6)	(363.2)	(58.3)	(390.1)	(138.5)	(27.6)	(17.8)	(24.3)
Wheat share in harvested area, %	37	31.5	36.9	31.1	35.6	33.1	40.1	35.3
	(15.1)	(16.8)	(15.1)	(16.9)	(14)	(15.2)	(16.1)	(15.8)
Oilseeds share in harvested area, %	18.2	26.9	18.2	26.4	20.5	32	15.8	26.3
	(14.5)	(17.2)	(14.5)	(17.2)	(14.8)	(15.7)	(13)	(18.5)
Corn share in harvested area, %	6.2	17.9	6.4	18.9	6.1	12.4	3.3	8.7
	(10)	(19.9)	(10.3)	(20.5)	(7.7)	(13.5)	(4.2)	(14.1)
Soybean share in harvested area, %	2.2	10.2	2.2	10.6	1.7	7.5	2.1	7.3
	(6.1)	(15.9)	(6.2)	(16.1)	(4.1)	(13.8)	(5.6)	(15.7)
Barley share in harvested area, %	19.1	8.2	19	7.6	19.8	11.3	20.9	12.4
	(10.9)	(9.6)	(11)	(9.5)	(9.9)	(9.8)	(11.2)	(9.8)
Sugar share in harvested area, %	3.7	1.3	3.8	1.4	3.6	0.5	2	0.6
	(6.8)	(4.9)	(6.9)	(5.2)	(6.3)	(2)	(4.3)	(2.8)
Rye share in harvested area, %	0	0.6	0	0.6	0	0.3	0	1.6
	(0)	(4)	(0)	(4.1)	(0)	(1.9)	(0)	(6)
Oat share in harvested area, %	2.9	0.6	2.9	0.5	2.2	0.4	3.4	2.6
	(6.8)	(2.8)	(6.8)	(2.8)	(5.6)	(1.5)	(7.3)	(5.2)
Number of observations	6136	7034	5594	6088	328	776	214	170

Notes: Standard deviations are given in brackets. For all variables (except for "Land concentration at rayon, (HHI)") means and standard deviations are weighted by the farm size. * variables are denominated per hectare of land use (owned and rented). ** Variable "Other costs" includes the costs of access to land.
Source: Authors' calculations based on the SSSU data.

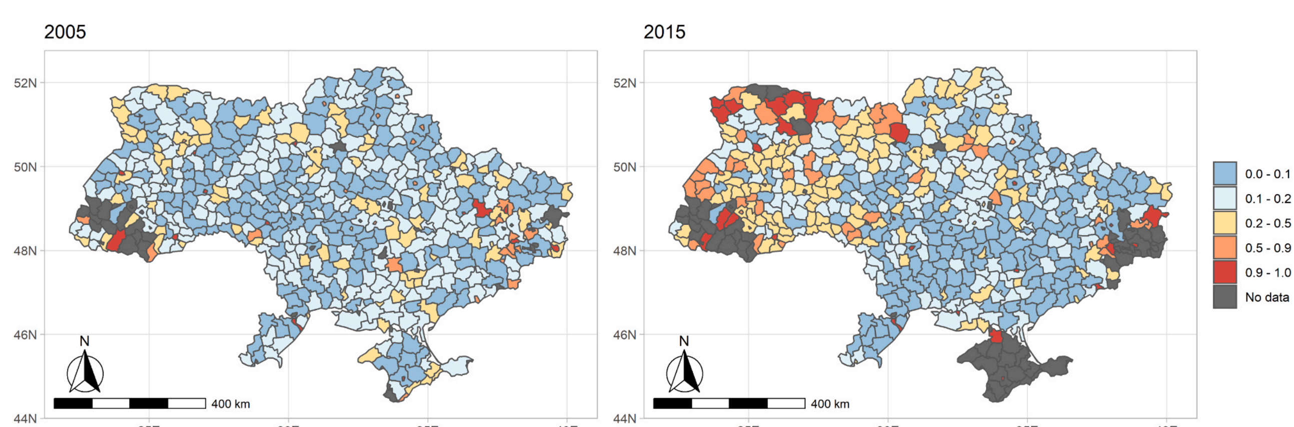


Fig. 3. Spatial distribution of land concentration (HHI index) at the rayon level.

holdings (i.e., positive sign of β_1 because the dependent variable is negative for this sub-sample). On the other hand, more able farms should also grow more in the sample with farms that experienced an increase in farm size (i.e., positive sign of β_1). Moreover, exit-entry analysis should provide clues about the factors influencing the decisions to enter, exit, or stay on the rental market.

Naturally, the key to this analysis is to estimate unobservable agricultural ability α_i. We employ three different approaches to estimate abilities. First, we follow Schmidt and Sickles (1984) in calculating a farm-specific fixed effect (within transformation) using panel regression (FE). Second, we calculate technical efficiency scores based on the Stochastic Frontier Analysis (SFA) with time-invariant efficiency scores distributed according to the truncated normal distribution following (Battese and Coelli, 1992). Third, we derive Total Factor Productivity (TFP) from the Solow residual of the pooled-OLS production function (Deininger et al., 2009; Deininger and Jin, 2005; Schmidt and Sickles, 1984). To calculate each of the above, we estimate a Cobb-Douglas production function of the following general form:

$$Y_{it} = \gamma + \beta X_{imt} + \delta Z_{\text{int}} + \alpha_i + \varepsilon_{it} \quad (2)$$

where Y_{it} – is the log of the value of crop output of the farm i in time t; X_{imt} – is the vector of logs of m input costs used by farm i in time t; Z_{int} – is the vector of the n control variables such as reverse dummy variables for zero input use following (Battese, 1997), linear trend, and crop-year specific dummy variables indicating that a given crop was produced on the farm. With the FE or SFA estimators, we derive α_i which is a time-invariant, farm-specific fixed effects or inefficiencies, respectively. Then we transform SFA inefficiencies into technical efficiencies ($e^{-\alpha_i}$), which we use as a first proxy for agricultural ability. FE estimates represent another proxy for the ability. Finally, in the specification with pooled cross-sections, farm-specific TFP is calculated as $TFP_i = \sum_t \varepsilon_{it}/n_i$, where n_i is the number of years that the farm is present in the sample, and is used as an alternative proxy for agricultural ability. All these parameters are estimated along with the coefficients $\gamma, \beta,$ and δ.

5. Main results

5.1. Estimating agricultural ability

Before estimating the model with the determinants of land rental, it is informative to examine the results of the model with the production function estimations (Table 2). Models (1) to (3) in Table 2 estimate the abilities on a time-invariant subsample of farms pooled from their first year of their appearance in the panel to avoid endogeneity issues in our main estimations below. Models (4)-(5) exploit the whole variation of the panel and estimate the production functions based on the whole sample. Because we deal with an unbalanced panel with 38.6 % of the farms present during the whole sample (see Appendix A for details on panel structure), it is important to consider the farms entering and exiting during our period. Thus, we estimate the efficiencies for the "entrants" at the time of their first appearance in the sample. To ensure the robustness of our results, we compare our estimates with those obtained from a balanced panel (see Appendix B) which appear to be very similar.

All the coefficients of the input costs show the expected signs and are statistically significantly different from zero, predicting the output with relatively high explanatory power. We find land to be the most important production factor with an elasticity ranging from 20.1 % for the OLS to 23.1 % for FE estimation. These figures are way above the average share of land rental expenditures in total costs (12.6 %). Models (4)-(6) suggest that these figures increased further over time. This indicates an uncompetitive allocation of land as we would observe a closer match

Table 2
Production function estimations.

	First year			Whole sample		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	OLS	FE	SFA	Pooled OLS	FE	SFA
Utilized land (ha)	0.226***	0.231***	0.233***	0.232***	0.343***	0.268***
	(0.021)	(0.022)	(0.038)	(0.004)	(0.006)	(0.009)
Labor costs	0.043***	0.041***	0.051**	0.067***	0.064***	0.09***
	(0.010)	(0.010)	(0.018)	(0.002)	(0.003)	(0.003)
Seeds costs	0.186***	0.187***	0.192***	0.162***	0.142***	0.156***
	(0.013)	(0.014)	(0.019)	(0.003)	(0.003)	(0.019)
Fertilizers costs	0.134***	0.134***	0.132***	0.129***	0.100***	0.116***
	(0.007)	(0.008)	(0.014)	(0.002)	(0.002)	(0.003)
Petrol costs	0.154***	0.148***	0.141***	0.113***	0.080***	0.086***
	(0.012)	(0.013)	(0.019)	(0.003)	(0.003)	(0.014)
Machinery/capital costs	0.053***	0.053***	0.056***	0.050***	0.034***	0.048***
	(0.007)	(0.007)	(0.014)	(0.002)	(0.002)	(0.003)
Services costs	0.091***	0.092***	0.094***	0.100***	0.089***	0.107***
	(0.005)	(0.006)	(0.010)	(0.002)	(0.002)	(0.002)
Other costs	0.100***	0.100***	0.099***	0.139***	0.109***	0.127***
	(0.011)	(0.011)	(0.018)	(0.002)	(0.003)	(0.003)
Linear trend				0.102***	0.082***	0.086***
				(0.002)	(0.002)	(0.002)
Constant	1.267		2.313***	0.310***		0.732***
	(0.862)		(0.360)	(0.025)		(0.055)
Scale elasticity	0.987***	0.987**	0.999**	0.993***	0.961***	0.997***
	(0.0097)	(0.0101)	(0.0234)	(0.0023)	(0.0051)	(0.0053)
N	11,710	11,710	11,710	80,245	80,245	80,245
Adj. R^2 / % total variance due to inefficiency (SFA)	0.842	0.798	57.3 %	0.877	0.571	68.2 %
Mean Technical Efficiency (st. dev.)			0.632			0.7066
			(0.148)			(0.165)

Note: p-values are * < 0.05; ** < 0.01; *** < 0.001. Clustered, heteroscedasticity, and autocorrelation robust standard errors (Arellano, 1987) are presented in the parenthesis for pooled OLS and FE specifications, while regular standard errors are reported for the SFA. All continuous dependent and independent variables are in logarithmic form; input costs are expressed in thousands of constant 2018 USD; reverse dummy variables are used for compensating zero input use following Battese (1997). Multiple crop-specific dummy variables are introduced to control for the crop composition at the farm level each year. Model (2) utilizes rayon fixed effects because each farm is observed only once.
Source: Authors' calculations based on the SSSU data.

between these values otherwise (Dobbelaere and Mairesse, 2013). Interestingly, labor has a very low contribution to the output in all three specifications, which is reflected by the share of labor in the cost structure. This suggests that business models focusing on cash crops' cultivation heavily rely on non-labor production factors where land represents the most important production factor. Finally, various material inputs have a substantial contribution to output. The models (1)-(3) estimated on the first year are similar to the models (4)-(6) estimated on the whole panel sample, suggesting robustness of the results. Obtained agricultural abilities across the three approaches are also close to each other (correlation coefficients: 0.90–0.97), suggesting a high robustness of the estimations.

Estimation results suggest that returns to scale are close to constant. Estimated scale elasticities vary between 0.988 and 1.002. Although in most of the models, we cannot reject the hypothesis that the scale elasticity is different from one. Scale elasticities in models (4) and (5) are significantly different from one suggesting minimal diminishing returns to scale.

To explore the relationship between farm size and the three measures of a farm's ability further, we use Loess smoothing depicted in Fig. 4.[14] Across the plots based on different efficiency proxies, we see a slight increase in the efficiency up to the size of 1000–1500 ha with a consequent slight decrease as we move along the x-axis. For farms larger than 10,000 ha, the variance is too large to draw any meaningful conclusions about the farm size vs. efficiency relationship. Because the SFA model assumes a stochastic nature of the frontier analysis, the confidence intervals of the green line plotted based on SFA estimations are narrower compared to the lines based on FE and pooled OLS estimates. Therefore, we rely on the SFA measures of technical efficiency as an approximation of a farm's ability in our further analysis.

We observe substantial spatial variation in our agricultural ability proxies. The average technical efficiency is 70.7 % of the possible production level (standard deviation - 16.5 %). Fig. 5 presents the spatial distribution of the efficiency scores on the rayon level at the beginning and at the end of our sample (the choropleth map is based on deciles of respective distributions for comparability reasons). We observe a cluster of high efficiency in the eastern parts which were hindered by the Russian military invasion in 2014. Although we see some efficiency improvements in the southern regions, the central parts with the most intensive agricultural production do not show signs of improvement.

5.2. Determinants of land rental

Table 3 presents the estimations of the determinants of land rental. Most importantly, we find the coefficients of the initial agricultural ability to be negative and significant across all the specifications. This implies that more efficient farms tend to rent in less land in the last observed period, and conversely, those farms that rent in more land appear to be less efficient. Quantitatively, this means that a farm with a 10 % higher agricultural ability throughout our period was likely to end up with 141.1 ha less rented land on average. Our finding is precisely the opposite of what we would expect in a well-functioning land rental market where more able farms should rent in more land. In particular, rental-based land relations in Ukraine up until 2015 appear to have facilitated a flow of land toward less efficient agricultural producers.

Testing our hypothesis related to land concentration, we find that initial regional land distribution matters for further farming modes. Thus, farms that were operating in a rayon with a high degree of land concentration in 2005 were more likely to have rented more land at the end of the observation period. The effect appears to be relatively large, as a 10 % increase in the HHI index with respect to a reference rayon is associated with 132.6 ha more rented land in the last observed year. We also find that the coefficient of the interaction term between rayon land concentration and agricultural ability does not differ from zero in a statistical sense.

Initially owned land appears to be positively associated with the land rented at the end of the observation period, contrary to our expectations and the results of similar studies (e.g., Deininger and Jin, 2005; Vranken and Swinnen, 2006). Owned land was most typically held in the form of the CLS, representing negligible amounts compared to the rented areas. As the farm grows, it may be better positioned to attract CLS from the individuals in its vicinity. As a result, we may observe a complementarity between the CLS and rented land.

A farm's legal form appears to play a significant role in its activity in the land rental market. We find the coefficients of the dummy for an individual farm to be positive and statistically significant, suggesting that this type of producer was more likely to accumulate land at the end of the observation period compared to the agricultural enterprises, which are accounted for in the intercept. We observe an opposite picture with the dummy for state farms, which appears to exert a persistent negative effect throughout the specifications. This implies that state enterprises tend to rent less land than their private counterparts

Our evidence suggests that farm size expansion is closely associated with the focus on cash crops cultivation. Most of the coefficients of the variables reflecting the percentage of area cultivated with these crops are positively and significantly related to the dependent variable. For instance, an additional 10 % of land initially allocated for corn was associated with ca. 365.1 ha more rented land at the end of the period. Similarly, 10 % more land allocated for wheat in 2005 is associated with ca. 60.6 ha of additionally rented land in 2015. This means that agricultural enterprises cultivating crops that are suitable for exports were more likely to rent in more land. This is in line with our hypothesis about annual export-oriented crop cultivation driving farm expansion via land rental markets.

5.3. Determinants of changes in land rental

We now examine the factors that may impact the changes in land rental explicitly considering the types of farms during the observed period. In particular, we divide the sample into subsamples according to the following criteria: farms that stayed over the whole period, exited, and entered the land market (Table 4). We use the same explanatory variables as in Table 3 above. As three interaction terms are present in the model, we also estimate marginal effects for each regressor at the mean of the corresponding interaction terms.

Our estimations do not reveal convincing evidence of rental markets facilitating the flow of land towards more efficient farmers as the coefficients of the agricultural ability are insignificant in most of the specifications. Among the farms that operated during the whole period of 2005–2015 (stayers), more able ones were more likely to rent in more land. Moreover, those stayers that cultivated corn and sugar beets appear to have been typical export-oriented farms operating large areas as the coefficients of the shares of respective crops are positive, significant, and large in magnitude. These farms, often restructured from collective farms, inherited substantial land rental contracts. In contrast, more efficient entrants rented less land on average, suggesting higher production intensity or difficulties in accessing land. Notably, for the entrants, we find the coefficient of the interaction term between the ability and land concentration to be negative and significant implying that they were more productive in the areas with higher land concentration.

If farms' efficiency drives their land rental decisions, we should observe this in the subsamples with shrinking and growing farms in a more pronounced way. We thus re-estimated our models on the subsamples with farms that grew and shrank by at least 5 % and 25 % (Table 5). However, marginal effects of agricultural ability do not demonstrate significant effects. In contrast, initial land concentration appears to exert a polarizing effect: farms with decreasing land holding

[14] All the smoothers are based on full-sample estimations with the exception of the initial technical efficiency.

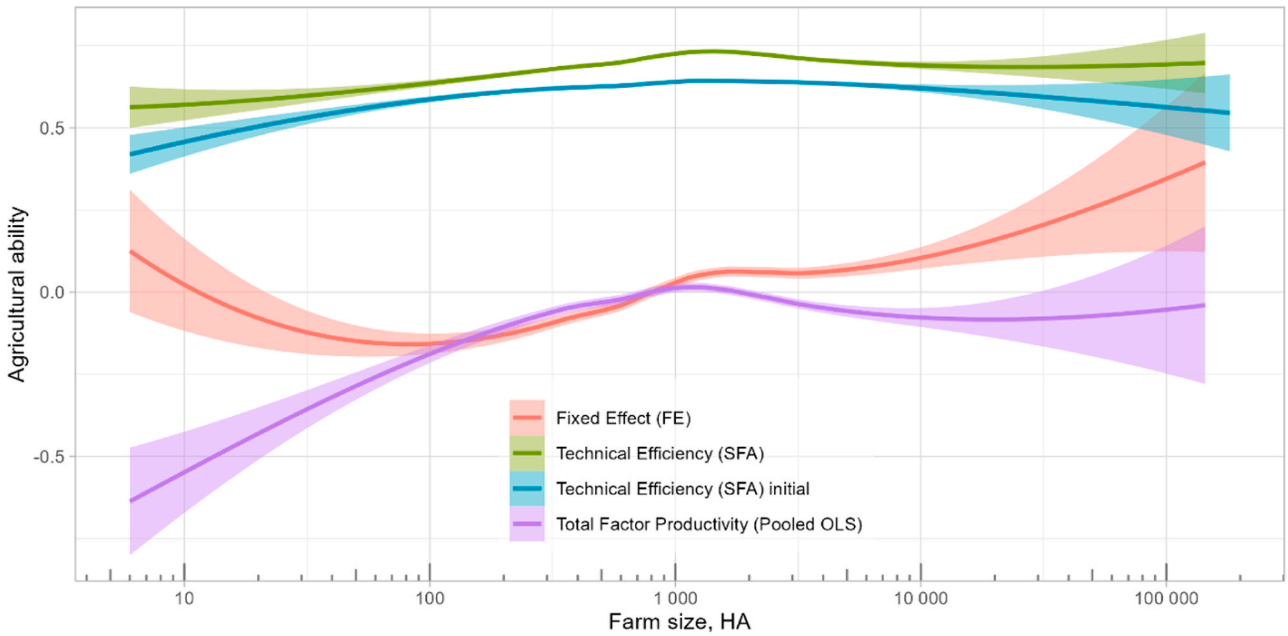


Fig. 4. Relationship between estimated agricultural ability and farm size (Loess smoothers).

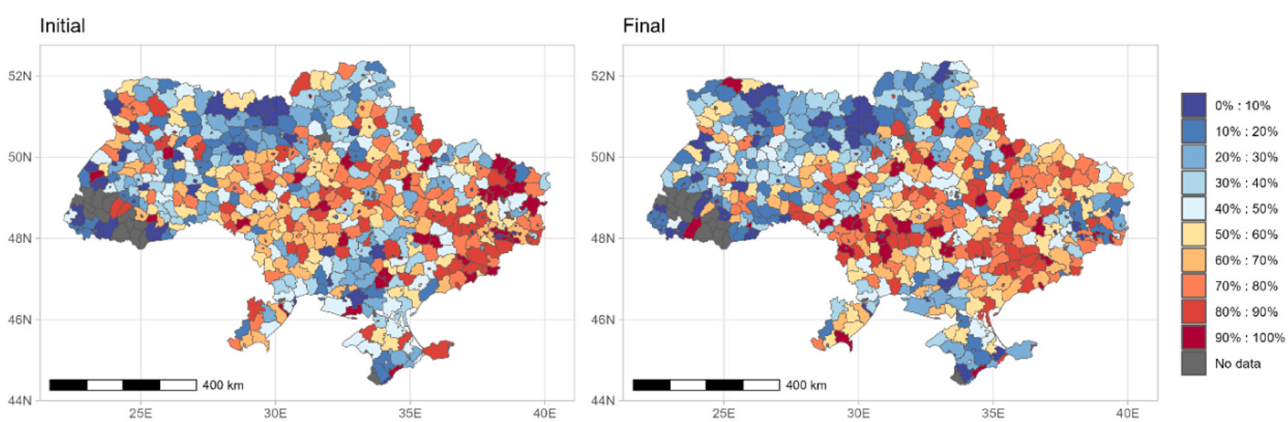


Fig. 5. Initial (left) and final (right) average rayon efficiency scores based on deciles of their distributions.

trends decreased the amount of rented land more, and farms with growing land holdings were growing faster in the rayons with higher land concentration. We observe the negative and significant marginal effects of the HHI index for the subsamples with farms that shrank at least by 5 % and positive and significant marginal effects of the farms that grew by at least 5 %. The former could be explained by shrinking farms that face competition from larger enterprises that may possess a certain degree of market power in a given rayon. We interpret the latter arguing that farms on a growing path could compete with large farms by expanding their size as well. Interestingly, the coefficients of the shares of corn and sugar beets suggest that cultivation of these crops is associated with large rented areas. In addition, we find that the interaction term between agricultural ability and land concentration is negative and significant for the sample with shrinking farms suggesting that land concentration mitigated the effect of agricultural ability accelerating the reductions in operational land. In sum, the evidence suggests that initial land distribution matters: initial land concentration is associated with further shrinkage of the declining farms and growth of the ones that expand their land holdings.

Land rental decisions appear to be independent of the legal forms except for the state-owned farms. We did not find statistical differences between individual farms and agricultural enterprises. However, state farms that exited or decreased cultivated area were renting substantially less land at the end of the period in comparison to agricultural enterprises. Preferential access to state-owned land may reduce the incentives to rent in privately owned land. Finally, it is worth noting that neither of the interaction terms between the legal forms and our key explanatory variables are significant.

The exit of less productive farms and entry of more efficient ones appear to be an important mechanism of aggregate productivity growth. Fig. 6 shows the distribution of the efficiency scores for the farms observed during the whole period (“stayers”), the ones that exited at some point (“exiters”), and the ones that entered the land market (“permanent entrants”).[15] We see that the “entrants” are substantially more productive than the “exiters”. The “stayers” demonstrate a much wider distribution of efficiency scores. In addition, comparing the distributions of initial and final efficiency scores (see Appendix C for further details), we see that neither category of the farms changed their efficiency substantially. Finally, we correlate rayon-level average initial agricultural ability and land concentration with the rayon shares of land

[15] The farms that entered temporarily are not displayed but their efficiency scores are very close to the “exiters”.

Table 3
Tobit estimations of the determinants of land rented.

	(1)	(2)	(3)	(4)
Coefficients:				
Area owned (ha)	0.889***	0.889***	0.888***	0.888***
	(0.027)	(0.027)	(0.027)	(0.027)
Initial agricultural ability (SFA efficiency score)	−1411.404***	−1477.838***	−1135.295**	−1198.961**
	(256.328)	(266.895)	(365.067)	(373.979)
Initial land concentration in a rayon (HHI)	1326.040***	1328.980***	2315.234*	2321.944*
	(279.224)	(279.206)	(971.958)	(973.075)
Individual farms (1 – yes, 0 – no)	285.317*	−144.843	283.257*	−123.489
	(121.730)	(680.703)	(121.741)	(680.988)
State farm (1 – yes, 0 – no)	−7832.373***	−8744.516***	−7832.650***	−8763.204***
	(316.275)	(1258.112)	(316.313)	(1257.188)
Individual farms * Agricultural ability		653.176		617.742
		(1014.578)		(1015.113)
State farm * Agricultural ability		1503.903		1534.122
		(1995.551)		(1993.827)
Initial land concentration at rayon (HHI) *Agricultural ability			−1612.474	−1617.671
			(1517.321)	(1518.778)
Initial share of land under wheat	605.803*	610.943*	606.160*	611.393*
	(245.608)	(245.621)	(245.578)	(245.590)
Initial share of land under rye	1012.065	1012.940	1012.949	1013.966
	(669.044)	(669.114)	(668.990)	(669.063)
Initial share of land under barley	128.421	137.868	131.647	141.052
	(288.060)	(288.184)	(288.059)	(288.180)
Initial share of land under corn	3651.150***	3661.208***	3662.393***	3672.298***
	(310.918)	(311.080)	(311.085)	(311.237)
Initial share of land under oats	−898.959	−881.781	−901.019	−883.665
	(522.712)	(523.301)	(522.702)	(523.282)
Initial share of land under oilseeds	839.608**	843.037**	847.808**	851.232**
	(278.812)	(278.833)	(278.909)	(278.928)
Initial share of land under soybeans	1467.380***	1469.462***	1477.228***	1479.369***
	(359.419)	(359.413)	(359.523)	(359.517)
Initial share of land under sugar beets	6123.340***	6128.426***	6102.018***	6107.366***
	(602.372)	(602.450)	(602.691)	(602.759)
Intercept	645.348*	679.609*	473.051	505.351
	(328.593)	(330.748)	(366.590)	(369.033)
Marginal effects				
Initial agricultural ability (SFA efficiency score)	−1411.404***	−1370.120***	−1368.604***	−1327.951***
	(256.328)	(259.986)	(259.478)	(262.956)
Land concentration in a rayon in 2005 (HHI)	1326.040***	1328.980***	1302.257***	1305.703***
	(279.224)	(279.206)	(280.113)	(280.079)
Individual farms (1 – yes, 0 – no)	285.317*	265.490*	283.257*	264.585*
	(121.730)	(125.961)	(121.741)	(125.958)
State farm (1 – yes, 0 – no)	−7832.373***	−7799.745***	−7832.650***	−7799.449***
	(316.275)	(318.407)	(316.313)	(318.436)
Log-likelihood	−108,233.8	-−108,233.2	−108,233.2	108,232.6
Number of independent variables	52	54	53	55
Number of observations	11,679	11,679	11,679	11,679

Note: p-values are * < 0.05; ** < 0.01; *** < 0.001. Standard Errors are reported in parenthesis. Marginal effects are evaluated for selected variables at mean values of the corresponding interaction terms and using the delta method for estimating the standard errors.
As control variables, we use oblast dummies as well as dummies that take a value of 1 if a farm existed in each year from 2005 to 2015.
Source: Authors' calculations based on the SSSU data.

under "exiters" following Deininger et al. (2018). Estimations (see Appendix D) show that in rayons with higher initial aggregate efficiency, we can expect lower shares of land under "exiters" at the end of the period, suggesting that inefficient farms were more likely to exit. Conversely, the higher rayon-level agricultural ability may had encouraged the farms to stay.

Entrants that are, on average, more efficient appear to substitute their less efficient counterparts. Fig. 7 demonstrates the shares of entrants in 2015 by rayons. We observe fewer entries in the most efficient areas (central Ukraine) and more entries in the north-western parts of the country. The Russian invasion in 2014 clearly discouraged entry into the eastern areas and Crimea. In sum, more efficient farms appeared to substitute the ones that exited without challenging the incumbents.

6. Conclusion

This paper has addressed the question of whether rental-based land relations can facilitate the efficiency-enhancing distribution of land in a setting with imperfect institutions. Most of the related literature so far has either focused on household producers (Vranken and Swinnen, 2006) or smallholder farms (Deininger and Jin, 2005; Huy and Nguyen, 2019; Min et al., 2017). This study contributes to the emerging literature that focuses on larger commercial agricultural producers within the setting of highly constrained sales markets (Deininger et al., 2018; Kvartiuk and Petrick, 2021).

Results of the econometric analyses utilizing unique farm-level data from Ukraine suggest that rental-based land relations fail to generate flows of land towards more efficient agricultural producers (farms with higher agricultural ability). Instead, we observe empirical evidence that less efficient farms rented in more land between 2005 and 2015. These findings challenge the idea of Sadoulet et al. (2001) and Deininger (2003) that rental markets may be a flexible option for land relations in a setting with imperfect institutions. In fact, we find precisely the opposite: competitive allocation of land via rental markets fails. In particular, land accumulation transpires not due to the superior performance of the respective farms but due to other possible factors. Land prices below the

Table 4
Estimations of the changes in rented land by status.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
chnical efficiency distr	Full sample OLS	Full sample OLS	Stayers OLS	Stayers OLS	Exited OLS	Exited OLS	Entered OLS	Entered OLS
Coefficients								
Area owned initial (ha)	0.042	0.041	0.147	0.149	1.213***	1.212***	−0.023	−0.027
	(0.024)	(0.024)	(0.085)	(0.085)	(0.057)	(0.057)	(0.032)	(0.032)
Initial agricultural ability (SFA efficiency)	−118.207	49.683	1247.113*	1468.661	441.056	390.270	−916.662*	−24.346
	(247.766)	(365.165)	(613.761)	(908.895)	(285.736)	(436.232)	(460.739)	(674.844)
Initial land concentration in a rayon (HHI)	243.759	1146.235	2505.190***	2489.224	−490.627	−866.726	−147.488	3382.284
	(280.547)	(997.282)	(701.319)	(2872.442)	(332.357)	(1417.371)	(527.630)	(1860.545)
Individual farms (1 – yes, 0 – no)	61.159	42.914	30.625	2045.319	187.789	140.816	10.876	558.306
	(124.606)	(618.156)	(298.994)	(2025.010)	(187.378)	(982.854)	(212.049)	(1630.400)
State farm (1 – yes, 0 – no)	18.999	−1879.692**	−175.335	928.764	−2199.858***	−1749.143*	217.826	153.062
	(216.145)	(720.060)	(409.066)	(1628.436)	(252.871)	(815.428)	(690.900)	(4516.244)
Share of corn in total crops[1]	533.320	536.858	7416.752***	7373.654***	−791.336	−808.090	2508.381*	−280.598
	(321.181)	(321.519)	(908.357)	(909.711)	(572.369)	(574.512)	(1263.118)	(572.213)
Share of sugar beets in total crops[1]	2448.001***	2427.004***	5417.683***	5450.891***	976.565	947.898	−311.036	2568.531*
	(598.171)	(599.063)	(1197.109)	(1197.943)	(659.156)	(661.836)	(571.520)	(1263.378)
Individual farms * Agricultural ability		−311.161		−3001.429		67.530		558.306
		(1025.756)		(2982.104)		(1493.807)		(1630.400)
State farm * Agricultural ability		161.009		−1766.438		−735.220		153.062
		(1331.995)		(2531.043)		(1266.171)		(4516.244)
Initial land concentration in a rayon (HHI) *Agricultural ability		−1550.647		47.117		598.145		−5517.661*
		(1523.518)		(4320.769)		(2205.890)		(2789.727)
Intercept	2.955	−258.060	−3108.292***	−3236.472***	193.647	249.942	93.757	−447.401
	(309.931)	(383.579)	(755.671)	(867.373)	(354.017)	(428.536)	(2974.143)	(2990.610)
Marginal Effects								
Agricultural ability (SFA efficiency)	−118.207	−195.824	1247.113*	1247.512*	441.056	451.974	−916.662*	−763.785
	(247.766)	(255.313)	(613.761)	(621.953)	(285.736)	(288.166)	(460.739)	(479.527)
Initial land concentration in a rayon (HHI)	243.759	154.804	2505.190***	2520.297***	−490.627	−489.120	−147.488	−111.533
	(280.547)	(282.510)	(701.319)	(704.771)	(332.357)	(333.021)	(527.630)	(528.178)
Individual farms (1 – yes, 0 – no)	148.212	70.433	52.772	65.945	187.789	183.447	10.876	−32.235
	(118.986)	(130.097)	(114.626)	(301.259)	(187.378)	(188.880)	(212.049)	(225.907)
State farm (1 – yes, 0 – no)	42.160	25.605	−175.335	−236.163	−2199.858***	−2213.285***	217.826	181.467
	(214.736)	(221.233)	(409.066)	(419.828)	(252.871)	(254.247)	(690.900)	(717.540)
Number of observations	9646	9646	3068	3068	1905	1905	3468	3468
Adjusted R2	0.009	0.012	0.051	0.052	0.267	0.266	0.021	0.022

Notes: p-values are * < 0.05; ** < 0.01; *** < 0.001. Standard Errors are present in parenthesis. Marginal effects are evaluated for selected variables at means of the corresponding interaction terms. The Delta method is used for estimating the standard errors. [1]Note that we do not present the results for the variables with insignificant coefficients due to space limitations. However, the specifications are identical to the ones in Table 3.
Source: Authors' calculations based on the SSSU data.

marginal product of land (in the absence of a functional sales market) may encourage land accumulation and not cultivation intensification. Furthermore, pre-existing land concentration may generate bargaining power for large farms and a respective ability to put downward pressure on rental prices. We find that in rayons with a higher land concentration, the remaining farms tend to grow, pushing out smaller counterparts. Large farms may be exercising market and bargaining powers in accessing rented land outcompeting small enterprises in negotiating rental contracts. As a result, initial land concentration may further exacerbate the degree of land concentration in a given rayon. Finally, we find that farms specializing in cash crops tend to rent in larger areas of land. These enterprises have land-intensive business models oriented at cultivating annual crops with the final aim of export. The relatively cheap access to land via rental markets generates incentives to expand operational land and not to invest in land use intensification, which locks farms in a situation with relatively low yields.

Large farm sizes do not contribute to aggregate production efficiency growth in Ukraine. We find that although farms grew between 2005 and 2015, their agricultural ability did not improve. New efficient farms that entered the market in combination with the exit of less efficient appear to had driven aggregate efficiency improvements in the Ukrainian agricultural sector. These findings are in line with Deininger et al. (2018).

Our results could be extended to a range of countries with comparable institutional settings with Russia and Kazakhstan being the first candidates. While in Ukraine land sales were prohibited until 2021, Russian and Kazakhstani farms face high transaction costs of purchasing land, which motivates them to rely on rental markets (Petrick, 2015; Petrick et al., 2011; Uzun and Lerman, 2017). All three countries have experienced a substantial land concentration by large farms. Kvartiuk and Petrick (2021) find that rental markets did not facilitate the flow of land towards more efficient commercial producers in Kazakhstan, challenging the idea of land relations exclusively based on land rental.

Our results suggest general policy implications. Ukrainian land relations before the launch of the land sales market in 2021 may have locked the agricultural sector in a trap of low value-added per hectare. We provide evidence that farms' decisions to rent in agricultural land were not based on agricultural ability considerations. This may had been due to the fact that land rental prices were below the value of the marginal product of land (Deininger et al., 2018; Kuns, 2017). As a result, farms were incentivized to accumulate relatively cheap land, which stimulated business models based on large cultivated areas and low value-added per ha. A more competitive allocation of land as a key production factor would reduce the incentives to expand land holdings. This could be achieved by improving the supporting institutions facilitating a transparent and competitive rental market (e.g., better quality and interoperability of land registries, higher transparency of land auctions) and by introducing a land sales market that would allow the formation of market-based land prices. The launch of the land sales market in 2021 was expected to facilitate the flow of agricultural land towards more productive farmers in Ukraine. Future research is required to check whether the 2021 reforms facilitate rental price formation based on the economic value of land and thus better align the incentives of agricultural producers to rent land with the value of the marginal

Table 5
Estimations of the changes in rented land with growth/decline sub-samples.

	>5 % decrease OLS (1)	>5 % decrease OLS (2)	>25 % decrease OLS (3)	>25 % decrease OLS (4)	> 5 % increase OLS (5)	>5 % increase OLS (6)	> 25 % increase OLS (7)	> 25 % increase OLS (8)
		Coefficients:						
Area owned initial (ha)	−0.001 (0.022)	−0.004 (0.022)	0.310*** (0.068)	0.298*** (0.068)	0.925*** (0.142)	0.936*** (0.143)	0.730*** (0.186)	0.740*** (0.187)
Initial agricultural ability (SFA efficiency)	−207.850 (323.765)	539.882 (479.254)	−875.413 (537.659)	354.724 (771.375)	−670.173 (613.149)	−588.631 (931.992)	−1370.025 (996.042)	−181.010 (1561.920)
Initial land concentration in a rayon (HHI)	−901.108* (370.328)	2085.240 (1436.846)	−966.325 (590.630)	3802.577 (2193.919)	1409.918* (709.207)	1266.859 (2435.490)	2052.020 (1155.572)	5378.811 (4203.275)
Individual farms (1 – yes, 0 – no)	−2.513 (175.948)	29.022 (1094.798)	−122.939 (353.445)	−140.949 (2190.487)	−147.371 (291.689)	−788.130 (2296.186)	−138.921 (509.487)	1394.392 (2754.812)
State farm (1 – yes, 0 – no)	856.847 (478.789)	1191.602 (1856.311)	620.394 (728.090)	1156.253 (2915.335)	−2798.193** (941.456)	−4511.202 (5274.475)	−3160.255* (1225.740)	−455.149 (4319.116)
Share of corn in total crops[1]	−2335.723*** (459.993)	−2336.151*** (460.229)	−4904.217*** (816.900)	−4904.385*** (816.657)	2626.258*** (725.591)	2604.087*** (726.945)	3416.739** (1110.394)	3395.897** (1112.676)
Share of sugar beets in total crops[1]	297.120 (800.480)	285.647 (800.743)	−1845.187 (1370.431)	−1890.293 (1370.087)	5807.305*** (1388.078)	5804.341*** (1400.488)	8738.491*** (2215.232)	8673.894*** (2217.312)
Individual farms * Agricultural ability		−51.601 (1602.362)		10.106 (3214.137)		−788.130 (2296.186)		−2240.919 (3919.389)
State farm * Agricultural ability		−585.302 (2994.977)		−854.886 (4598.894)		−4511.202 (5274.475)		−4438.087 (6831.282)
Initial land concentration in a rayon (HHI) *Agricultural ability		−4729.199* (2196.985)		−7531.286* (3336.698)		225.522 (3617.528)		−5131.642 (6219.056)
Intercept	−183.683 (457.386)	−660.539 (510.487)	−336.047 (758.214)	−1084.895 (829.699)	−139.983 (926.930)	−190.624 (1043.076)	−54.764 (1463.335)	−890.208 (1697.111)
		Marginal Effects						
Agricultural ability (SFA efficiency)	−207.850 (323.765)	−116.857 (329.309)	−875.413 (537.659)	−727.591 (544.186)	−670.173 (613.149)	−698.364 (632.852)	−1370.025 (996.042)	−1280.211 (1021.324)
Initial land concentration in a rayon (HHI)	−901.108* (370.328)	−932.250* (370.597)	−966.325 (590.630)	−960.972 (590.397)	1409.918* (709.207)	1411.911* (709.543)	2052.020 (1155.572)	2052.685. (1156.553)
Individual farms (1 – yes, 0 – no)	−2.513 (175.948)	−3.902 (185.296)	−122.939 (353.445)	−134.557 (376.097)	−147.371 (291.689)	−118.719 (304.349)	−138.921 (509.487)	−58.083 (536.602)
State farm (1 – yes, 0 – no)	856.847 (478.789)	818.147. (492.952)	620.394 (728.090)	615.536 (732.844)	−2798.193** (941.456)	−2987.006** (967.693)	−3160.255* (1225.740)	−3331.741** (1259.503)
Number of observations	4586	4586	2613	2613	2732	2732	1628	1628
Adjusted R2	0.080	0.081	0.127	0.128	0.058	0.058	0.066	0.065

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard Errors are present in parenthesis. Marginal effects are evaluated for selected variables at means of the corresponding interaction terms. The Delta method is used for estimating the standard errors. [1]Note that we do not present the results for the variables with insignificant coefficients due to space limitations.
Source: Authors' calculations based on the SSSU data.

product of land in the production process.

CRediT authorship contribution statement

Thomas Herzfeld: Writing – review & editing, Resources. **Eduard Bukin:** Visualization, Validation, Software, Formal analysis, Data curation. **Vasyl Kvartiuk:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

Herewith I declare no financial or other conflict of interest in the production of and/or research associated with the manuscript ""*For whoever has will be given more"? Land rental decisions and technical efficiency in Ukraine*".

Data availability

The authors do not have permission to share data.

Appendix A. Panel structure of the sample

Years of presence in the sample	Type of presence	Number of farms	% of all farms	Number of observations	% of all observations
11	Continuous[a]	2826	24.0 %	31086	38.6 %
10	Continuous	312	2.6 %	3120	3.9 %
10	Interrupted[b]	201	1.7 %	2010	2.5 %

(*continued on next page*)

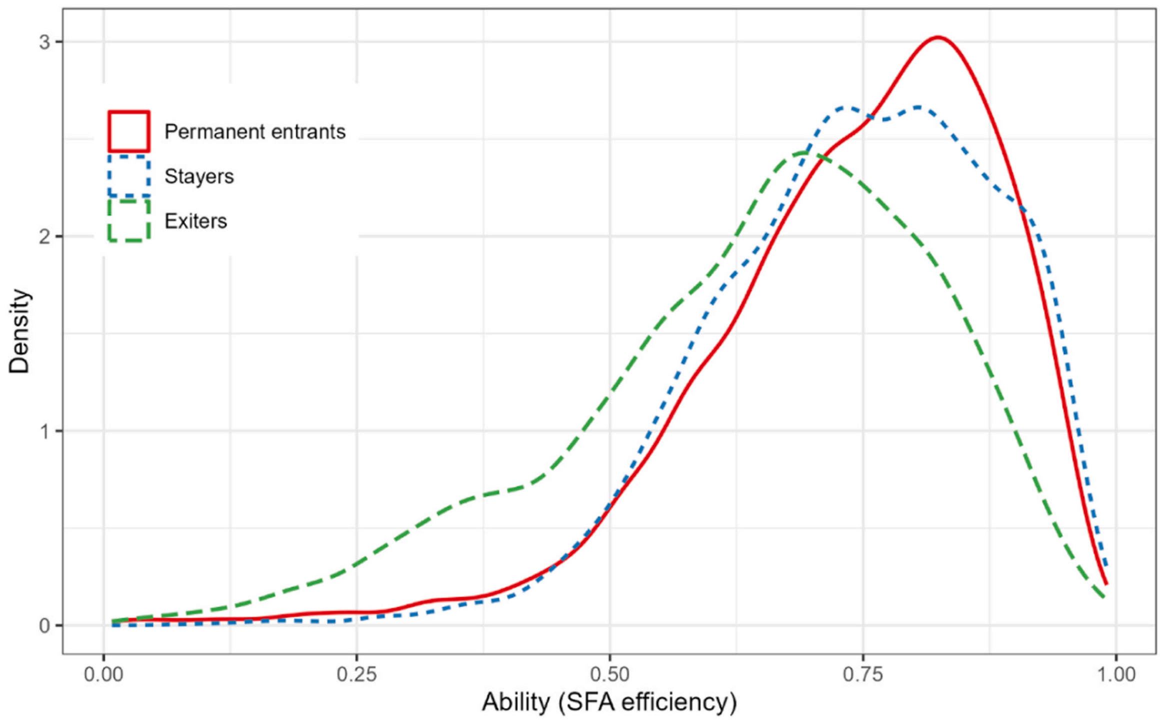


Fig. 6. Farms' efficiency scores distribution depending on the status.

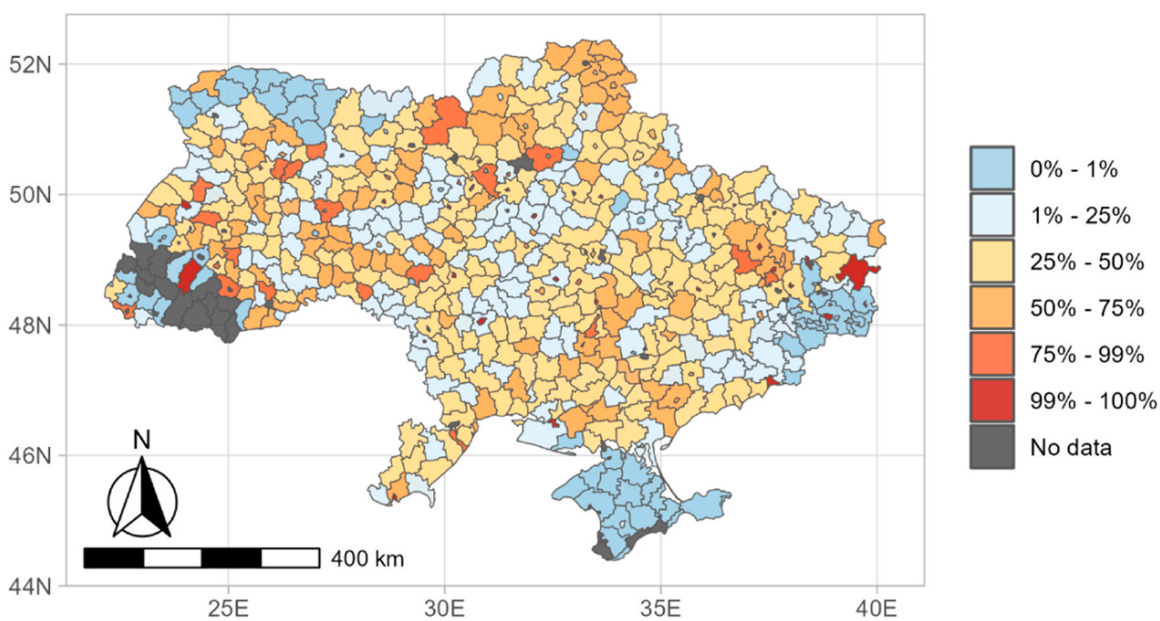


Fig. 7. Spatial distribution of the rayon shares of land occupied by entrants in 2015.

(*continued*)

Years of presence in the sample	Type of presence	Number of farms	% of all farms	Number of observations	% of all observations
9	Continuous	1231	10.4 %	11079	13.7 %
9	Interrupted	107	0.9 %	963	1.2 %
8	Continuous	823	7.0 %	6584	8.2 %
8	Interrupted	117	1.0 %	936	1.1 %
7	Continuous	631	5.4 %	4417	5.5 %
7	Interrupted	114	1.0 %	798	1.0 %
6	Continuous	717	6.1 %	4302	5.3 %
6	Interrupted	124	1.1 %	744	0.9 %
5	Continuous	704	6.0 %	3520	4.4 %
5	Interrupted	112	1.0 %	560	0.7 %

(*continued on next page*)

(*continued*)

Years of presence in the sample	Type of presence	Number of farms	% of all farms	Number of observations	% of all observations
4	Continuous	759	6.4 %	3036	3.8 %
4	Interrupted	139	1.2 %	556	0.7 %
3	Continuous	986	8.4 %	2958	3.7 %
3	Interrupted	156	1.3 %	468	0.6 %
2	Continuous	1618	13.7 %	3236	4.0 %
2	Interrupted	103	0.9 %	206	0.2 %
Total		**11780**	**100.0 %**	**80579**	**100.0 %**

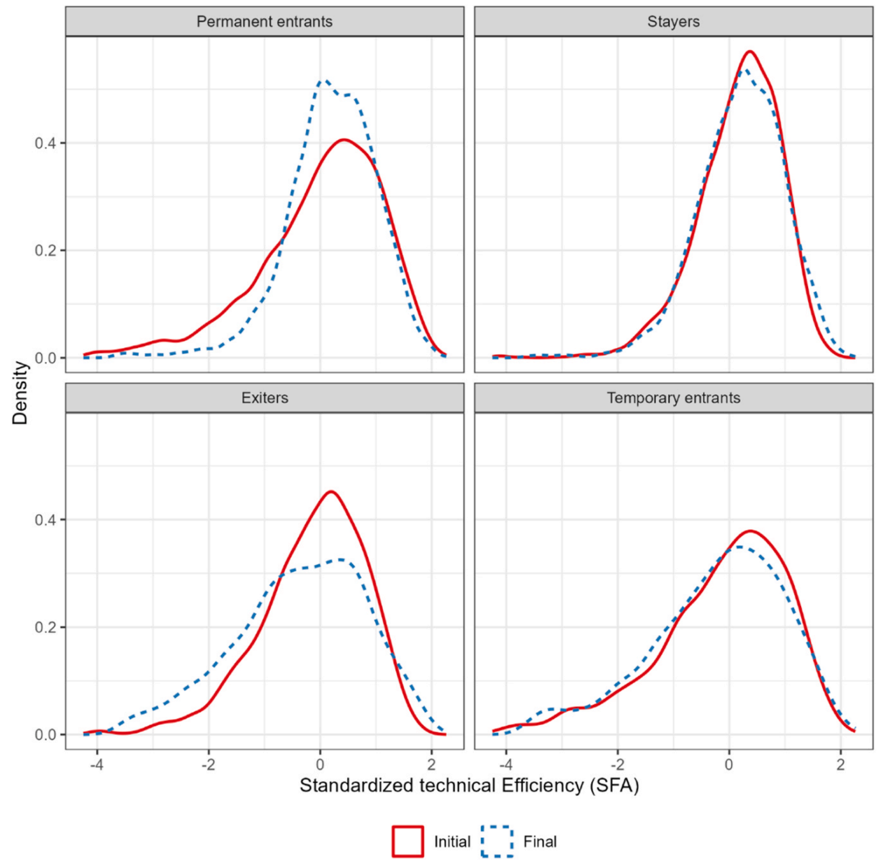
Notes: If a farm was present in the sample for less than 11 years, it means it was missing for one or more years of analysis, contributing to the unbalanced structure of the sample.
[a] ***Continuous*** appearance means that farms were present in the sample for a certain number of years in a row.
[b] ***Interrupted*** appearance means that such farms were not continuously present in the sample, i.e. a farm was present in the sample for 6 years and absent from the sample for 2 years between 2007 and 2014.

Appendix B. Production function estimation on the balanced panel

Variables	Pooled OLS	FE	SFA
Utilized land (ha)	0.234***	0.366***	0.313**
	(0.005)	(0.009)	(0.114)
Labor costs	0.083***	0.059***	0.074**
	(0.003)	(0.005)	(0.028)
Seeds costs	0.156***	0.137***	0.145***
	(0.005)	(0.005)	(0.039)
Fertilizers costs	0.139***	0.103***	0.117**
	(0.003)	(0.003)	(0.042)
Petrol costs	0.082***	0.075***	0.075
	(0.005)	(0.005)	(0.080)
Machinery/capital costs	0.069***	0.045***	0.056*
	(0.003)	(0.003)	(0.024)
Services costs	0.074***	0.070***	0.076***
	(0.002)	(0.002)	(0.020)
Other costs	0.146***	0.114***	0.122***
	(0.003)	(0.004)	(0.028)
Linear trend	0.063***	0.075***	0.068
	(0.004)	(0.004)	(0.063)
Crop-specific dummy variables	…	…	…
Constant	0.795***		0.074
	(0.039)		(0.061)
Scale elasticity	0.983 (SE = 0.0033, F Stat = 25.175, p-val < 0.01)	0.968 (SE = 0.0075, F Stat = 18.09, p-val < 0.01)	0.977 (SE = 0.081, χ^2 Stat = 0.1, p-val = 0.773)
Number of observations	31069	31069	31069
R^2 adjusted / % total variance due to inefficiency (SFA)	0.889	0.637	17.9 %
Log likelihood	−16,478.3	−8938.2	−13,343.9
F Statistic / LR test (SFA)	1417.634*** (df = 176; 30892)	326.534*** (df = 176; 28067)	6046.1*** (df = 167; 169)
Mean Technical Efficiency (standard deviation)			0.598
			(0.128)
Total variance - σ^2 (SE)			0.180 (0.047)
Inefficiency variance in total variance - (γ) (SE)			0.375 (0.084)

Note: *Significant at 0.1; **Significant at 0.05; ***Significant at 0.01. Clustered, heteroscedasticity and autocorrelation robust standard errors (Arellano, 1987) are presented in the parenthesis for Pooled OLS and FE specifications, while regular standard errors are reported for the SFA. All continuous dependent and independent variables are in logarithmic form; costs are expressed in thousands of constant 2018 USD; reverse dummy variables are used for compensating zero input use following Battese (1997). Multiple crop- and year-specific dummy variables are introduced to control for the crop composition at the farm level each year.
Source: Authors' calculations based on the SSSU data.

Appendix C. Standardized distributions of initial and final efficiency scores depending on the farms' status in the sample.



Note: Technical efficiency distributions are standardized with the help of the a standard normal distribution with a zero mean and standard deviation of 1. This allows compatibility of these distributions as they are estimated based on different samples.

Appendix D. Rayon-level estimations of the shares of land freed by "exiters"

	Share of land under exiters
Coefficients	
Agricultural ability (rayon-level mean)	−1.164***
	(0.345)
Initial land concentration in a rayon (HHI)	−0.763*
	(0.310)
Agricultural ability (rayon-level mean) * Initial land concentration in a rayon (HHI)	0.718
	(0.489)
Intercept	1.066***
	(0.221)
Marginal effects	
Agricultural ability (rayon-level mean)	−0.978***
	(0.251)
Land concentration in a rayon in 2005 (HHI)	−0.309***
	(0.058)
Number of independent variables	4
	88
Number of observations	605

Notes: *p<0.1; **p<0.05; ***p<0.01. Standard Errors are present in parenthesis. Marginal effects are evaluated for selected variables at means of the corresponding interaction terms. The Delta method is used for estimating the standard errors.
Source: Authors' calculations based on the SSSU data.

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