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Impact of the Russian Invasion on Ukrainian Farmers' Productivity, Rural Welfare, and Food Security

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Abstract

Data from 2,251 small and medium-size farms for 2021 and 2022 show that area reductions in response to the Russian invasion of Ukraine remained limited. However, worsening terms of trade reduced farm profitability, implying that 46 percent of farms had a negative cash flow and 54 percent (67 percent in the 50–120 hectare group) were credit constrained in 2022, implying that longer term effects may be more adverse. Total factor productivity varies significantly across size groups but is not significantly different between formal and informal farms in the same size group. This suggests that limited transferability of land use rights that are disproportionately used by smaller farms may be one reason for low productivity. Improving transferability of land, digital access to markets, and mortgage lending could thus trigger investment and growth in higher value products by small and medium-size farms to solidify Ukraine's comparative advantage in agriculture and improve rural living conditions in the context of reconstruction.

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Impact of the Russian Invasion on Ukrainian Farmers' Productivity, Rural Welfare, and Food Security

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1. Background and motivation

With a total agricultural area of close to 45 million ha of very fertile land,[1] Ukraine has long been a major breadbasket and exporter of agricultural commodities. Beyond causing immediate hardship and triggering a large exodus of displaced people, the Russian Federation's military invasion of Ukraine and the economic blockade of its Black Sea export routes have also led to sharp increases in grain prices (von Cramon-Taubadel 2022) and raised concern about global food security. While fears of such consequences have eased somewhat with partial opening of maritime export routes in the context of the UN-brokered grain deal, there is little doubt that the war and associated political changes will profoundly affect Ukraine's farm sector and rural areas.

To better understand impacts on the welfare of Ukraine's farm population as well as the profitability, food supply, and prospects for future development of the country's agriculture sector, this paper reports results from a survey of small and medium sized farms for the 2021 and 2022 agricultural seasons. We aim to answer three questions: First, has the invasion created an imminent threat of decapitalization that might permanently undermine the rural economy's capacity to invest including in human capital? Second, how have area cultivated, profitability, crop choice, and level of market participation been affected by the war overall, what are the underlying mechanisms, and how do war effects vary across farm size group and regions? Third, what is the extent of informality in Ukraine's agriculture sector and how do productivity and war impact differ between farms in the formal and informal sectors?

On the first issue, studies show that, if it forces households to liquidate assets to survive, exposure to conflict can have persistent effects, beyond short term impacts on food security (George *et al.* 2020; Muriuki *et al.* 2023) or agricultural output (George *et al.* 2021). In Colombia, violence led households to shift to activities with lower but less risky returns and, in the extreme, revert to subsistence (Arias *et al.* 2019). While direct effects may be of temporary nature only (Miguel & Roland 2011), violence can have long term effects if it is associated with refugee flows via forced displacement (Ibanez *et al.* 2022), reduces households' investment in human capital (Büttner *et al.* 2022), leaves residues such as land mines (Arcand *et al.* 2015), or is used as cover for opportunistic land holding expansion by elites (Tellez 2022). Adverse long-term impacts of violence via human capital accumulation are documented for Nigeria's 1967–1970 Civil War

[1] Ukraine's agricultural land endowment is larger than the agricultural area of France (18 million ha), Germany (12 million ha) and Poland (11 million ha) combined.

(Akresh *et al.* 2023) and Colombia's mid-20th century 'La Violencia' that slowed structural transformation via occupational choices by individuals who experienced violence in school or pre-school age (Fergusson *et al.* 2020).[2] Conflict can affect those not directly exposed if households adjust their behavior (Tapsoba 2023) or asset portfolios (Rockmore 2020; Sinha *et al.* 2022) in anticipation.

Our survey shows that, in Ukraine, the war triggered a marked drop in expectations for the future, but social safety nets and non-agricultural income sources held up. Ukraine's comparative advantage in agriculture contributed to continued strong fundamentals in the sector; in fact, instead of divesting assets, most farmers expressed interest in expanding their holdings by leasing or purchasing land through markets.[3] Farmers' perceived priorities focus on better access to output markets and protection against rapidly worsening terms of trade.

Regarding the second question, estimates on the extent to which direct war-related actions have affected area cultivated vary widely partly because 2021 yielded a record harvest so that any direct comparisons that fail to adjust for weather or for potential substitution would tend to overestimate war effects.[4] Moreover, conflict can affect economic activity indirectly, e.g., by reducing trust (Korovkin & Makarin 2023), increasing mobility and trade cost to force input substitution (Amodio & Di Maio 2018), reducing interaction (Couttenier *et al.* 2022), or lowering project returns (de Roux & Martinez 2021). Impacts may thus be felt well beyond the areas directly affected by war and conflict (Federle *et al.* 2022).

The farm survey data analyzed here shows that any direct war effect on area cultivated was eclipsed by large increases in prices for imported inputs that affect all farmers together with changes in labor cost that vary across regions in line with labor availability. Together with marked drops in output prices and reduced market participation, high input prices reduced farmers' profitability and liquidity, an outcome most pronounced but not limited to areas affected directly by conflict.

Finally, a distinguishing feature of Ukraine's agriculture sector is that many producers remain informal (Nivievskyi *et al.* 2021). While there has been considerable progress on characterizing and quantifying informality (Ohnsorge & Yu 2021) and its correlates in terms of financial development (Capasso *et al.* 2022) and other development outcomes (Ulyssea 2020), the debate on the direction of causality remains largely open. If informal firms are less productive than formal ones (Nguimkeu 2022), they will be unable to compete (La Porta & Shleifer 2014) or afford fixed formalization fees. If this is the case, informal firms

[2] Short-term health outcomes may also be affected (Akresh *et al.* 2011), especially close to the location of violent events (Akresh *et al.* 2022).
[3] Due to egalitarian distribution of land when large holdings were privatized and a moratorium on land sales that was only lifted recently, most Ukrainian households own and rent out land. To the extent that rental contracts can adjust, better agriculture sector performance could thus provide broad-based benefit via higher land values.
[4] USDA's April 2023 USDA/WASDE report projects wheat production in Ukraine at 21.0 million tons, a drop of 12.1 million tons compared to previous years (see https://www.usda.gov/oce/commodity/wasde/wasde0423.pdf), much higher than what is estimated by the EU (Ben Aoun *et al.* 2022). As Deininger *et al.* (2023) show, some of the difference between estimates may be due to different geographical domains. A clarification of methodological assumptions will be desirable.

offered subsidized registration (Benhassine *et al.* 2018) would fall back into informality, a notion supported by a number of randomized trials from Latin America or South Asia (Bruhn & McKenzie 2014). If, on the other hand, entry barriers or other factors reducing the benefits of formality apply only to a subset of firms, eliminating these could set off large gains in terms of competition, output, and wages for skilled labor (Ulyssea 2018).

We contribute to this debate in two ways. First, to measure the size of informality in the agriculture sector, we make use of the fact that informal farms operate unregistered land to combine our sample frame with estimates of agricultural crop cover based on satellite imagery. We find that 14.5 mn. ha, or about 32% of the 45.7 mn. ha of Ukraine's cultivated area, is operated informally. Although informal farms are smaller, their total factor productivity (TFP) is indistinguishable from that of formal enterprises of comparable size, suggesting that, rather than productivity differences, either other barriers to farm entry (Deininger *et al.* 2018) or factors affecting the benefits from formalization for specific farms may have precluded formalization.

One candidate for such barriers is restrictions on transferability and inheritance to rights of 'permanent use' of land that was given to emergent farms in the early 2000s. As use rights are concentrated with the smallest farms, such restrictions could partly explain variation in TFP across farm size groups. Moreover, although they can be transferred to a legal entity established by the original assignee, such personal rights would not survive the death of the original assignee, reducing the benefits from formalization and incentivizing farms with larger shares of land in use rights to remain informal. Exploring this in greater detail is an important area for follow-up research with potentially far-reaching implications for Ukraine's future development.

The paper is structured as follows. Section 2 provides conceptual and methodological background by discussing evidence of the aggregate impact of the invasion and details of constructing the sample frame and ways to infer the size of the informal sector. Section 3 provides evidence from our data at household and farm level for 2021 and 2022 to show how asset positions and factor market participation changed with the invasion. Section 4 provides evidence on how direct and indirect war effects changed land allocation, profitability, and productivity by farm size. Section 5 concludes and draws out policy implications.

2. Motivation and context

This section discusses studies that assessed the impact of the Russian invasion of Ukraine on agricultural exports and global food security, the channels through which such impacts could come about, and the micro data underpinning such estimates. It highlights how representative farm level data can complement existing data sources and, by providing information on economic factors at a more granular level, informs estimates of negative conflict impacts and ways to try and minimize them.

2.1 Aggregate evidence on the effects of the invasion

Given the historically strong integration of Ukraine as well as Russia into global commodity markets,[5] the Russian invasion of Ukraine, in February 2022, together with the economic blockade of its export routes through the Black Sea, resulted in a spike of grain prices and led to major concerns about effects on global food security. A key reason was the economic blockade of Ukraine's main seaborne export routes via the Black Sea that limited Ukraine's ability to generate export revenue and forced a costly shift to overland routes with much lower capacity but high physical and transaction costs. The 'grain deal' agreed under the auspices of the UN in July 2022 and extended twice since then, allows a limited quantity of grain to be exported from Ukraine through the port of Odessa, albeit at higher cost and risk than before the invasion.[6] Yet, while it may have avoided food insecurity in countries heavily dependent on Ukrainian imports (FAO 2022a), higher transaction cost of this export route may translate into lower prices for farmers in Ukraine.

Trade models have been used to highlight likely impacts of different conflict scenarios on global wheat markets, especially for African countries (Balma *et al.* 2022), the resilience of the global food system (Ihle *et al.* 2022), or countries that have historically been characterized by heavy reliance on wheat imports from Ukraine (e.g., the Arab Republic of Egypt, Türkiye, Mongolia, Georgia, and Azerbaijan). A global model drawing on satellite imagery for different scenarios concludes that, even in the most optimistic case, reductions in welfare and shortages of food and energy are likely unless production gaps are compensated by increased production elsewhere (Lin *et al.* 2023). One concern has been that countries could use the crisis as a pretext for adopting protectionist policies (Ben Hassen & El Bilali 2022) that, while possibly yielding political benefits in the short term, could create negative externalities that would make achieving global food security more difficult (Glauben *et al.* 2022).

The results of macro models depend significantly on the quality and granularity of the data used which are often derived from satellite imagery or household surveys. Remotely sensed imagery allows to identify changes in crop cover over time and separate direct conflict effects due to active fighting, mining, explosion of ordnance, heavy vehicle movement, and deliberate burning of agricultural fields from indirect ones at a granular level. Kussul *et al.* 2023 infer direct effects for 2-week intervals since the start of the war using satellite imagery and interpretation by means of machine learning as well as manual classification.[7]

Using this information together with a 4-year panel (2019-2022) of cropped area for 10,125 village councils aggregated up from the field level, points to an area reduction of slightly less than 1 mn. ha (or 10%), well

[5] Ukraine accounts for 10% of world trade in wheat, 42% trade in sunflower oil, and 16% of maize.
[6] In March 2023, 3.5 million tons of grain and oilseed crops were exported through the Black Sea, adding to 2.8 million tons exported via rail, road, and river, bringing the total amount of crops exported in the 2022/23 marketing year to 44.7 million tons about 70% of the potential of 64 million tons (84% grain and 16% oilseeds), comprising the 2022 harvest as well as stocks that had been in storage in February 2022.
[7] High resolution imagery is needed to detect craters from ordnance explosion, a measure correlated with presence of unexploded munitions (Duncan *et al.* 2023).

below those provided by aggregate models (Deininger *et al.* 2023).[8] Moreover, less than one-fifth of the total effects is attributable to direct conflict-induced field damage while the remainder comes about through indirect effects, including damages to the electricity grid and logistics infrastructure including road transport and grain elevators (Khoshnood *et al.* 2022); limited availability of key inputs including fuel, labor, and agro-chemicals; and reduced demand as a result of higher cost for transport and marketing.

To link data on area cultivated and yield to welfare and prices or profitability, surveys at household or farm level are needed. Household surveys conducted by FAO highlight the importance of home production on garden plots dating from Soviet time as a safety net to increase resilience (FAO 2022b). In a nation-wide survey of 5,230 rural households, drops in income were reported by 55% of respondents, especially for IDPs. For the population who are not displaced three salient characteristics emerge, namely (i) 25% of the surveyed rural population reported reducing or stopping agricultural production due to the war; (ii) 72% of crop and 64% of livestock producers reported increased production costs; and (iii) more than half and around 20% of respondents reported spending more than 50% and 75% of their total expenditure on food, respectively (FAO 2022c).

While these figures illustrate the breadth and depth of war impacts, disaggregated data on small and medium scale farm production is important to understand the extent to which the invasion may deplete the productive capacity of rural areas and to design responses on the continuum between humanitarian and productive support to maintain and expand productive capacity, diversification, and employment opportunities in rural areas. This is particularly relevant as experts agree that a significant part of Ukraine's agriculture sector operates in informality, but little is known on either its size or the nature and profitability of its operations.

2.2 Sample construction and level of informality

To obtain information on changes in welfare, production, and productivity in the small and medium farm sector between 2021 and 2022, a nation-wide phone survey of such farms in areas controlled by Ukraine, was conducted in cooperation with the Ministry of Agricultural Policy and Food (MAPF), from October to December of 2022.[9] The original intent was to construct a sample frame using data from the State Statistics Service of Ukraine (SSSU), complemented with the company registry. However, these sources cover only registered legal entities. To capture informal farms that, based on expert estimates, cultivate 32% of Ukraine's agricultural area (Nivievskyi *et al.* 2021), a decision was taken to use the State Agrarian Registry (SAR) as a sample frame instead.

[8] https://downloads.usda.library.cornell.edu/usda-esmis/files/3t945q76s/cc08jp14g/cr56p755q/wasde0822.pdf
[9] The survey was implemented by the Kyiv International Institute of Sociology (KIIS) with financial support from the European Commission.

The SAR is an electronic registry, established in August 2022, with the objective of transferring support to small and medium farmers in a transparent yet expeditious way. Farmers can sign up at the SAR website (https://www.dar.gov.ua/) using their electronic signature and provide a minimum of personal information including a bank account to which any resource transfers can be made, irrespectively of their legal status, i.e., registered legal entity, family-owned business (FOP), or individual. The system gathers information for all land parcels to which the farmer has registered rights from the registry of rights and the cadaster and adds information on the farm from several other official registries.[10] Information in SAR can be used by MAPF or any authorized entity to advertise or implement programs in support of the agriculture sector and to interact electronically with potential participants. Farmers can take any actions required digitally rather than by filling paper forms, including uploading scanned documents, photos, or providing authorization for providers of certain services to access specific types of personal information stored on the system.

The SAR simplifies program implementation by providing reliable information from official registries and providing an incentive to ensure the currency of these; simplifying the process of program application by eliminating the need for repeated filling of paper forms; and leveling the playing field and increasing competition in factor markets by creating a basis of potential clients to which service providers or banks can market their services. Use of the SAR to implement an EU-supported producer support grant (PSG) as well as other programs,[11] facilitated rapid sign-up, especially by small and medium scale farms, many of which had been in the informal sector before.

As the survey was launched in the second half of October, we set Oct. 15, 2022, as the cut-off date to construct the sample frame by dropping farms without any registered land or a valid phone number. Table 1 provides comparison of the resulting sample frame with the 2020 all registered farms survey (Form 29) of SSSU by farm size category (<50, 50-120, 120-500 and > 500 ha). Panels A and B of table 1 presents a simple comparison of number of establishments and total area cultivated of the two frames. Panels C and D draw out implications for informality in areas controlled by Ukraine (ACUs) and areas affected by conflict (AACs) by comparing, for each of these, the area cultivated by farms that are included in our and SSSU's frame or in either of these frames separately to identify the area cultivated informally (i.e., by farms that are neither included in Form 29 nor the SAR).

[10] For example, the SAR automatically gathers information on any outstanding debts to the state (which would legally disqualify them from receiving state support) and on farmers' registered livestock from the animal registry and the government plans to add information from other registries, including the mortgage registry and the registry of court cases, in the near future.

[11] The PSG that targeted to farmers who cultivated less than 120 ha provided a cash grant equivalent to US$100 for each hectare of land cultivated during the 2022 agricultural season in non-conflict affected areas. Information from the SAR was first used to establish whether the farmer was below the 120 ha threshold. After subtracting land parcels registered in the farmers' name located in conflict affected areas, maps with registered parcel boundaries were used to cross-check cultivation status against a crop map elaborated based on remotely sensed imagery to compute the total grant amount. The € 50 mn. available under the program had been fully disbursed by Nov. 2022 and an evaluation that aims to compare differences over time in parcels by successful as compared to unsuccessful PSG applicants is currently underway. Beyond this, several donors are using the system to implement programs such as provision of short-term grain storage, delivery of seeds, fertilizer, or critical capital equipment (generators).

Panel A of table 1 shows that our frame includes 75,571 farmers, more than double the 36,184 in the Form 29 survey as used by SSSU. Of these, 21% are legal entities, 11% FOPs, and 68% individuals overall with the latter concentrated in the farm size class below 50 ha of which 82% are individuals and 9% each FOPs and legal entities. Legal entities dominate for larger farm size classes, making up 58%, 76%, and 97% of those in the 50-120, 120-500, and > 500 ha group, respectively. Coverage in terms of farm numbers by the SAR is better than that of Form 29 for the below 120 ha group (with 3.8 and 1.1 times the number of farms in the < 50 and 50-120 ha) but worse above 120 ha with SAR containing only 0.62 and 0.44 times the number of operations in the 120-500 and the >500 ha group, respectively.

Table 1 panel B illustrates that the farms covered by Form 29 and SAR cultivate 27.85 and 11.6 million hectares, respectively with 25% of Form 29 area in ACUs and 25% in AACs. While they comprise less than a quarter of the number of registered farms, legal entities operate more than 90% of the area registered in SAR overall (33%, 64%, 83%, and 97% of area in the <50, 50-120, 120-500, and > 500 ha groups, respectively). The total area registered in SAR amounts to 42% of the area in Form 29 at the national level and 150%, 127%, 67%, and 37% of which in the <50, 50-120, 120-500, and > 500 ha groups, respectively.[12]

To quantify the extent of informality in Ukraine's agriculture sector, we use crop maps for 2020 elaborated using the methodology described in Kussul *et al.* (2017); Shelestov *et al.* (2017), and Shelestov *et al.* (2020) to identify the total area cultivated with crops in 2020 and then compare this area to what is covered by Form 29 as well as SAR.[13] Table 1 panels C and D highlight that, based on these maps, Ukraine's total cultivated area amounts to 45.73 million ha, 33.87 mn ha in ACUs and 11.86 mn ha in AACs. With 27.8 mn. ha (21 mn ha in ACUs and 6.8 mn ha in AACs), SSSU's Form 29 thus covers 61% of the country's cultivated area in 2020, leaving an estimated 39% of cultivated area in informality.

Using enterprise IDs to match farms between SAR and Form 29 suggests that 7.5 mn ha nationally (6.4 mn. ha in ACUs and 1.1 mn ha in AACs) is cultivated by farms included both in SAR and Form 29 while 3.36 mn. ha, almost all in ACUs, are registered in SAR only. This suggests that in the 3-month period from Aug. 12 to Oct. 15, 2022, registration in SAR reduced the amount of land cultivated informally by 3.36 mn. ha or about 7% of the total. Still, 14.5 mn. ha, more than the total agricultural area of Poland or Germany, are cultivated by farmers that are neither part of SSSU's sample frame nor registered in SAR, implying that this land is not reflected in any official statistics.

[12] As a plausibility check, we compare mean farm sizes between Form 29 and SAR. For the above 50 ha group, average farm size in SAR is 803 ha compared to 934 ha and 999 ha for ACU and AAC, respectively, in Form 29 and the corresponding figures for farms greater than 500 ha are 2,834, 2,255, and 2,137 ha, respectively, for SAR and Form 29 in ACUs and AACs.

[13] As area cultivated in 2022 is likely to have been affected by the conflict and to avoid bias that might arise from the fact that 2021 was an exceptional year with very favorable growing conditions, we use both satellite imagery and Form 29 data from 2020. Area cultivated excludes forest, bare land, wet land, water, and areas with artificial (built up) cover.

3. Data and descriptive statistics

Household data show that, although continued access to non-agricultural incomes, access to public social support and the scope to draw on informal safety nets provided short-term support, the war led to a dramatic drop in long-term perspectives. In the agriculture sector, continued high demand for renting in or buying land together with low willingness to sell land points to strong sectoral fundamentals. Size-biased access to credit that is reinforced by traditional agricultural subsidy policies may, however, limit access to working capital finance even for investments that would be advantageous in the short term and, together with a complete lack of long-term finance, may limit farmers' ability to take advantage of opportunities for long term investment and diversification into higher value crops in due course.

3.1 Sample, household characteristics, coping strategies, and conflict effects

To obtain the sample that could form the basis for a phone-based farm survey, we exclude conflict affected areas and define four farm size strata (< 50 ha, 50-120 ha, 120-500 ha, and > 500 ha) for a stratified random sample.[14] To assess representativeness, panel A of table 1 compares median and mean farm size between SAR and Form 29, the frame currently used by SSSU, in each stratum, pointing towards a near perfect match in the 50-500 ha category, no difference in the median for farms in the > 500 ha category (but better coverage of large farms in Form 29) and a much better coverage of small farms in SAR as compared to official statistics. A graphical representation of the sample's geographic coverage in figure 1 shows it covers most of the rayons in areas not affected by conflict but coverage is scant in the East and the North.[15]

At the farm level, the survey asked about total output and market participation as well as input costs for key inputs (hired labor; fertilizer and chemicals; machinery and fuel) by crop. If respondents could not provide information by crop, inputs were recorded at a more aggregate level. For owner-operated farms (82%), information on household composition, key income sources, and coping mechanisms is also included. As far as possible, questions were asked for before and after invasion or the 2022 and the 2021 cropping season. In tables 2-6, we present information by region (columns 2-6) and farm size group (columns 7-10).

Key data on household composition in table 2 suggest that Ukraine's small and medium farm owners are about 50 years old, well educated, and linked to banks as well as the internet.[16] The head almost always has a bank account, higher than secondary education in 89% of cases, and a Facebook account in 67% of farms.

[14] To allow use of the sample as a basis for evaluating the PSG cash grant, farms in the below 120 ha category are split equally into PSG applicants and non-applicants.

[15] Appendix table 1 shows that, with less than 21% of the sampled farms resulting in a successful interview (66% in the first, 22% in the second, and 12% in the third attempt), non-response (45%) and refusal rates (34%) were high. As indicated there, large part of the non-responses can be attributed to war conditions with cellphones out of range or power the most frequent reason.

[16] The high level of digital literacy might be accelerated by the shift towards digital service provision associated after the invasion. As opening a bank account is one of the most expeditious ways of obtaining an electronic signature for individuals who do not yet have one, the share of heads with a bank account may be biased upwards though this does not apply to other household members.

Some 72% and 67% of farm households have multiple bank or Facebook accounts. War-related damage to land or structures were experienced by 8% or 4% of respondents overall, being most prevalent in the East (26% and 15%), followed by the North (21% and 11%) and the South (10% and 5%) in line with the incidence of hostilities.

While outmigration of an entire household would not be captured in the survey but instead result in a non-response, family members migrated within or beyond the oblast in 8% or 9% of cases, respectively. The rate of beyond-oblast migration is highest in the East (18%), followed by the South (11%). With 46% indicating that they could get informal support up to a mean of US$7,311, an amount that ranges from $4,145 for the below 50 ha farm size group to $12,141 for farm households cultivating more than 500 ha, informal safety nets remain common. This is consistent with studies showing that exposure to war violence increases local cooperation (Bauer *et al.* 2016) and changes individual behavior to be more altruistic, risk-seeking, and with higher discount rates that affect savings and investments decisions (Voors *et al.* 2012).

To assess if households would use additional cash for consumption, working capital, investment, or savings, respondents were asked on how they would use a hypothetical small (US$200) or large ($5,000) amount won in the lottery. Data in table 2 show that working capital was by far the most frequent response, accounting for 56% of valid responses for the small and 69% for the large amount, especially for farms below 500 ha.[17] It was followed by investment (20%) for the $5,000 amount and consumption (24%) for the small amount of $200. The propensity to invest a larger cash windfall was highest for farms greater than 500 ha, possibly suggesting that this farm size group was better able to deal with working capital shortages than smaller farms (Deininger *et al.* 2023).

Table 3 provides summary statistics on income sources, attitudes, and coping mechanisms in 2021 (panel A) and 2022 (panel B) to assess changes over time. The number of adult household members (2.6) remains roughly the same in both years with close to 2 adult members working in agriculture either full-time (1.45) or part-time (0.62). About 54% of farms had permanent employees, a share that increased from 18% and 45% for those in the below 50 and the 50-120 ha class, respectively, to 82% and 98% in the 120-500 and the above 500 ha class with a concomitant increase in the number of employees from 1, 1.15, and 4.5 to almost 50 for the largest farms.

There was little change in the share of farms with members obtaining resources from off-farm wage (94%) or self-employment (62%). In fact, average monthly income (or revenue) dropped only slightly by about 9% for the former (from $253 to $231) and 7% (from $288 to $269) for the latter. The drop in wage or self-employment income was most pronounced in the South (with 14% and 15%) and East (13% and 6%).

[17] Unambiguous answers were provided by 94% of respondents for the large and 72% for the small amount.

To assess changes in overall expectations due to the invasion, respondents were asked to rank their personal situation as well as that of the country, respectively, on a scale from 1 to 10, both before and after the invasion. Figures in table 3 point towards a marked drop in both from 7.34 and 7.15 to 3.66 and 3.24, respectively and with a drop of more than 4 points in both categories, it was most dramatic in the East.

Social assistance programs including pensions emerge as a key coping mechanism with 32% having a member who received on average US$69 per month before the invasion. The share of recipients of such assistance increased by 7 percentage points to 39% during the war; albeit, with a slight decrease in the average amount received, highlighting the continuity in government functioning. This expansion was particularly pronounced in the South where the share of households with at least one social assistance recipient increased by 14 percentage points to 47%. Compared to public support, remittances were received by only 4% in 2021 and 5% in 2022, an increase driven by the South where the share of remittance recipients increased from 3% to 6%.

3.2 Asset ownership and factor market participation

In terms of farm characteristics, table 4 highlights that virtually all (84%) farmers lease land at an annual lease price of about US$103.7/ha.[18] This is more than three times the lease price that prevailed in 2015,[19] suggesting that reforms that improved tradability of land and increased competitiveness of land markets significantly improved small landowners' welfare. Across farm size groups, amounts of lease payments are the lowest (US$86/ha) in the smallest farm size group and the highest (US$117) in the more than 500 ha category.

To gauge economic prospects in agriculture, respondents were asked if they would be interested to either lease in more land at the current lease price or buy or sell land at a price they could name. In contrast to general pessimism about the future as documented above, responses point towards strong fundamentals in the agriculture sector despite the war: 85% of farmers (from 80% in the South to 87% in the Center) indicated they would like to lease more land at the current lease price; for farms above 50 ha, this share is well above 90%.

In addition to strong demand for leasing land, farmers are also eager to buy land, with 78% indicating they would like to buy land (56%, 86%, and 89% in the < 50 ha, 50-500 ha, and 500 ha group, respectively). Interestingly, the price farmers report to be willing to pay (US$1,432 per ha on average, ranging from $1,353 for those in the < 50 ha group to $1,548 in the > 500 ha group) are in a narrow band slightly above

[18] Only farmers in the below 50 ha group pay, with US$87.7/ha, significantly lower leases. This may be attributable to greater prevalence of informal arrangements in this group or to respondents including land that has been transferred to them by the state for permanent use in the 'leased' category.
[19] See https://kse.ua/wp-content/uploads/2022/06/eng_jan2022_land_monitoring.pdf; http://www.kse.org.ua/en/research-policy/land/governance-monitoring/yearbook-2016-2017/.

the post-war market price (of $1,369) for agricultural land (Deininger & Ali 2023), pointing towards broad awareness of market conditions after the 2021 opening of sales markets for agricultural land.

Compared to the near-universal desire to buy more land, only 3% are willing to sell land, a share highest in the <50 ha farm size group (6%) and zero for farms in the > 500 ha category. The mean proposed sales price, $3,142 (ranging from $4,787 in the > 50 ha group to $1,206 in the 120-500 ha group), is mostly above what potential buyers are willing to pay, consistent with a strong endowment effect (Zhu *et al.* 2021) and highlighting that, with strong fundamentals, agricultural land continues to be a promising investment.

As a proxy for farms' capital stock, information was obtained about ownership and current value of tractors and mechanical equipment. With 84% (82%, 88%, and 72% in the < 50 ha; 50-500 ha, and > 500 ha groups, respectively) of sampled farms owning tractors, a significant share of large and small farmers rely on machine rental services. The per ha value of equipment ranges between US$610 and US$680 for all size groups, except the < 50 ha one ($1,213), possibly due to indivisibilities and frictions in markets for rental services.

Data on credit market participation suggests that access to credit is limited and biased in favor of larger farms: 55% of farmers overall—34% in the < 50 ha group vs. 84% in the above 500 ha group ever accessed credit. While 2.3 years passed since the average credit recipient obtained her last loan, the average farm in the > 500 ha class received its last loan 9 months ago (0.78*12), i.e., in the 2022 production season after the invasion. This compares to a gap of 4.8 and 2.9 years for farms in the below 50 and the 50-120 ha class. With an average loan size of US$200,000 at a nominal interest rate of 5.4% that is likely to reflect interest rate subsidies provided by the government's 5-7-9 program,[20] loan terms were more favorable for larger farms than for smaller ones. The latter, if they cold access credit at all, received amounts of US$7,028, US$17,597, and US$53,418 at rates of 11.5%, 8.3%, and 7% for the <50, 50-120, and 120-500 ha group, respectively. Such size bias is inherent to the way in which the interest rate subsidy program is currently administered.[21]

The data also show that, except for loan recipients in the smallest farm size group, 21% of which borrowed for purposes other than working capital—most likely to smooth consumption in an emergency—virtually all the credit received went to short-term working capital loans. If the ability to use agricultural land as collateral for investment, backed by longer-term credit, to diversify into higher value-added agriculture is

[20] For a description of the program, see https://www.kmu.gov.ua/en/news/uriad-rozshyryv-prohramu-5-7-9-na-pidpryiemstva-zruinovani-pid-chas-viiny; for the design https://www.kmu.gov.ua/en/news/oleksij-goncharuk-uryad-zapustiv-programu-dostupnih-kreditiv-5-7-9-pid-rekordno-nizkij-vidsotok#:~:text=The%20State%20Program%20%22Affordable%20Loans%205%2D7%2D9%25,Ukrainian%20micro%20and%20small%20enterprises; https://ukraineinvest.gov.ua/news/22-11-22/ and https://www.kyivpost.com/post/8003 for figures for November 2022 and possible impacts.

[21] As the current program structure requires producers to obtain a loan first and then provides a portfolio-based interest rate subsidy, it will do little to increase credit access beyond those who have been able to secure loans in the past.

to be realized, focusing subsidies on market imperfections and changes in the way government supports credit access by farmers are likely to be needed.[22]

We define farmers who indicate that they would want to borrow but did not receive a loan in 2022 as credit constrained. Table 4 shows that 54% of farmers overall fall into this category but that there is significant variation across farm size groups: credit constraints are most binding for farms in the 50-120 ha category, more than two-thirds (67%) of whom are credit constrained by this measure. With 46% and 33% in the 120-500 and the > 500 ha group, the share of constrained producers is much lower at larger farm sizes due to better credit access. With only 62% interested in borrowing, lower demand is the main reason for lower incidence of credit constraints in the < 50 ha group. Improved access to credit for smaller farms could thus make a significant contribution to leveling the playing field.

Although 91% indicate that they would welcome technical support, access to advisory services is, with 18% overall, of which about half is provided by government and the remainder by other farmers or non-profits (with little difference across farm size categories), more limited than credit access. To identify priorities for public sector engagement in the current situation, farmers were asked to name the most important areas for government action. Credit (15%) is in third place, after measures to reduce high input prices (29%) and improve access to output markets (25%) take first and second place. To identify reasons for this, we turn to changes in output and input prices as well as overall production and the agriculture sector's terms of trade after the Russian invasion.

4. Production outcomes

Although limited war impacts on area cultivated highlight the resilience of Ukraine's agriculture sector, higher output and lower input prices worsened terms of trade that, together with declining participation in output markets, led 50% of farms to experience a negative cash flow in 2022. While direct damage reduced productivity by 12%, indirect war effects decreased it by between 30% in the South and 7.5% (marginally significant) in the West. TFP increased slightly with size but does not differ between formal and informal farms, making identification or removal of factors that keep farmers in informality an important area for future research and policy.

4.1 Changes in land use and economic outcomes

Evidence on production outcomes, in terms of area devoted to main crops for the 2021 and 2022 cropping seasons, is displayed in table 5 using the same structure as table 3. For sampled farms (i.e., the farming population outside the AACs), between 2021 and 2022, cultivated area increased by 7%, from 346 to 371

[22] Such changes will need to be complemented by regulation to reduce the transaction costs of posting or foreclosing on collateral pledged for loans in case of default.

ha per farm. This is in line with evidence from remote sensing that suggests that (i) cultivated area decreased less than implied by aggregate estimates; and (ii) in areas such as the North, farmers were able to plant summer crops on fields where 2022 winter crops were damaged or destroyed during the early phases of the war. The magnitude of the increase in area planted was similar across all farm size groups, though there are regional differences with area cultivated dropping by 9% in the East and increasing by 12% in the Center.

Data for crops cultivated in the 2022 season point towards a shift from grains to oilseeds such as soybean and rapeseed (+42% and +22%, respectively, both from a modest base) or sunflower (+18%) compared to 2021. These crops either require less fertilizer or can sustain short-term lack of fertilization better due to a deep root system and often also are processed locally, lowering transport cost for output marketing. Maize and barley area decreased by 10% and 3%, respectively while wheat area increased by 4%. Contrary to what is reported from household surveys (FAO 2022b), area under 'other' crops (buckwheat, rye, beets, potatoes, etc.) decreased by 3% overall, mainly in the largest farm size group (-15%), a decrease balanced by increases of 17% and 30% for the 50-120 and the 120-500 ha class and in the South (+36%). Regional disaggregation also suggests the shift out of maize is driven by the North which, together with the Center, also saw a large increase in area cultivated with sunflower, soybean, and rapeseed. [23]

While changes in crop mix across regions could possibly be observed using remote sensing (and linked to farm size categories if there is a complete cadastral map linked to the registry), only survey data can provide economic information on costs, prices received, input and output market participation, profit, and cash flow. To obtain such information, the survey collected data on the cost of hired labor, purchased inputs (fertilizer, pesticides, and other chemicals for crop protection), and machinery services by crop for the 2021 and the 2022 agricultural season. In several cases, respondents instead provided total input cost or total cost of machinery services and purchased inputs either by crop or for all crops grown by the farm.[24] If inputs are reported at farm rather than crop level, we apportion them across crops using crop area as a weight.

As respondents provided consistent information only on output prices, we rely on a survey of community leaders and local dealers' adverts, complemented by completed auctions for machinery services on the Prozorro sales platform, to compute regional prices for fertilizer, fuel, machinery services, and labor in 2021 and 2022.[25] Appendix table 2 shows that at the national level, prices for fertilizer more than doubled, those for diesel increased by 90%, and those for machinery services by 31%. Wages increased by 25% on average, with differences across regions (no increase in the North vs. 75% in the South).

[23] See the discussion of regression evidence in table 7 below.
[24] To separate different categories of input costs in cases where costs were reported in total, we use median cost shares in the sample as follows: If non-labor inputs are reported jointly, purchased material inputs (i.e., fertilizer and other chemicals) and machinery services account for 64% and 36% of the total, respectively. If labor and non-labor inputs are reported jointly, they account for 15% and 85% of the total, respectively.
[25] Prices are for ammonium nitrate and urea for fertilizer and the cost of harvesting and ploughing/soil preparation for wheat and maize, respectively, for machinery services.

Figures in table 6 illustrate that, valuing per hectare output for the 6 main crops at market prices implies a monetary output value of US$872 in 2021 but only US$571 in 2022, a 34% reduction (see appendix table 3 for corresponding information at crop level). Valuing 2022 output at 2021 prices suggests that this figure comprises a 19% decline in real output/ha and a 15% drop in real output prices that is likely to be linked to higher transport cost. Transport cost also contributed to an increase in the cost of purchased inputs (fertilizer and chemicals, machinery, fuel, and hired labor) from an equivalent of US$154/ha to US$184/ha, despite a drop of real input quantity by almost 40%. Together, this resulted in a drop of revenue net of purchased inputs by almost 50%, significantly reducing farmers' ability to pay for fixed factors (family labor, capital depreciation, land rent, entrepreneurial risk).

Across farm size groups, 2022 output value is, with US$471, lowest in the below-50 ha size class and highest, with $704, for those above 500 ha. As large farms also spent more on purchased inputs (despite reducing spending in real terms), net revenue is, with US$380/ha, marginally higher for farms in the 50-120 ha group than for those above 500 ha (US$368/ha), followed by the 120-500 ha group (US$345/ha). Although these trends are similar across regions, output value and net revenue are least affected in the West, possibly due to better access to external markets, where output value decreased from US$962 to US$738 and net revenue from US$735 to US$496 which is more than double the value in the East (US$217), 59% above that of the North (US$311), and 36% above the level in the Center (US$364).

The above figures assume all output produced is sold in the market, as was largely the case in the 2021 season when, except for 15% in the smallest farm size group, virtually all farms participated in output sales markets and sold on average 83% of their output.[26] Compared to 2021, the share of producers who sold (or planned to sell) in the market dropped by 17 percentage points from 94% to 77% and the share of the harvest sold from 83% to 57%, a 26 percentage point drop. To illustrate potential impact of worsening market access on farmers' cash on hand, we subtract the cost of purchased variable inputs from actual sales revenue to obtain cash on hand. The challenges posed by worsening terms of trade to farmers' liquidity are highlighted by the fact that this measure of cash dropped from US$432/ha in 2021 to -US$26/ha in 2022. Moreover, while 10% of farmers had negative cash on hand in 2021, this share increased to 46%% in 2022 (51% in the South and West and 56% for the largest farm group).

To summarize patterns by region and farm-size group and account for exogenous shock of war damage, we regress variables of interest in both years on an indicator variable of whether the farm's land or structures were damaged by war-related fighting in 2022, an interaction between region or farm size group, and a 2022 dummy. Results for area, yield, a dummy for output market participation, the share of total output

[26] To the extent that farmers stored the 2021 harvest and were planning to sell it after February, they may have been affected by the intervention.

value sold, the amount spent on inputs, net revenue, cash flow, a dummy for having had a negative cash flow, and the share of cropped area devoted to oilseeds are summarized in table 7.

Beyond reducing cropped area and monetary output by 12.4% and 11.1%, exposure to direct war-related damages did not affect any of the variables considered here. Other than for reductions due to war damage, area cultivated in 2022 was not significantly different from 2021. Output value per ha dropped by between 37.5% in the South and 14.4% in the West over the two periods while the year effect is not significantly different from zero across farm size groups once regional effects are controlled for. Market participation at the extensive margin decreased by about 15% in the East and the North and for the below-50 ha size category, and 12%, 10%, and 9% in the West, Center, and South, respectively. It also decreased by more than 30% at the intensive margin in all regions—from 37% in the East to 31% in the North—again no additional variation across farm size groups. Real input value dropped by between US$184 and US$154 across regions but increased by US$112 for the smallest farm size group and US$80 for those in the 50-120 ha farm size category.

Stark declines are also visible for farm net revenue per hectare which declined between US$356 in the West and US$452 in the North and cash flow, which dropped by between US$819 in the North and US$556 in the South, an effect that was less pronounced for farms in the below-50 ha group. The share of farms with negative cash flow increased by between 53% in the East, 46% in West and Center and 47% in the North. We also note that in line with descriptive statistics, the share of area cropped with oilseeds increased by 11% in the North.

4.2 Levels and changes in productivity

While the above evidence points towards direct war effects on area cultivated and indirect effects war-induced changes in the intensity of input use, net revenue, and cash flow, inferences on productivity require a production function estimate in per-hectare terms. Indexing farms by *i* and time by *t*, we use a farm fixed effects regression of the form

$$Y_{it} = \alpha_i + \boldsymbol{S}_{it}\boldsymbol{\beta} + \boldsymbol{X}_{it}\boldsymbol{\gamma} + \boldsymbol{RT}_i\boldsymbol{\delta} + \boldsymbol{\lambda_t} + \varepsilon_{it}, \quad (1)$$

where Y_{it} is the value of output per ha, α_i is a farm fixed effect, $\boldsymbol{S}_{it}$ an indicator of whether the farm's land or structures sustained war-related damage in 2022, $\boldsymbol{X}_{ij}$ is a vector of the monetary value of inputs (labor, chemicals, machinery) used by farm *i* in period *t*;[27] $\boldsymbol{RT}_i$ is an interaction between region and the 2022 war period; ε_{ij} is a random error term; and $\alpha, \boldsymbol{\beta}, \boldsymbol{\gamma}$ and $\boldsymbol{\delta}$ are parameters to be estimated.

[27] To convert the stock of family and hired labor as well as machinery into a service flow, we assume that (i) full-time family and permanent farm workers spend on average 240 days per year on agricultural activities while part time family workers spend half of that time and their wages are equal to those of casual workers; (ii) tractors and equipment depreciate linearly over a 10-year lifespan with a 36% salvage value; and (iii) for the cases where inputs are aggregated across crops, imputed values are apportioned using crops' area share.

Results for (1) are in cols. 7 and 8 of table 8, complemented by those from the OLS version from the 2021 and 2022 cross sections (in cols. 1-4) and the combined sample using OLS (cols. 5 and 6). In all cases, direct damage from the war is estimated to reduce productivity by about 12%. Indirect war effects differ across regions with point estimates of 29% in the South, 20%, 11%, and 9% in the Center, East and North and 7.5% (significant at 10%) in the West. Coefficients on land, labor, fertilizer, and machinery are highly significant in the OLS regressions, with point estimates of between 0.094 and 0.111 for land, 0.029 and 0.045 for labor, and 0.072 or 0.056 for fertilizer and machinery, respectively. Only fertilizer is significantly different from zero (with a coefficient of 0.051) in the fixed effects regression.

Farm fixed effects α_i net of rayon fixed effects provide a measure of farmers' total factor productivity (TFP). Figure 2 which plots estimated TFP against cultivated area highlights great dispersion in productivity levels and modest increases in productivity with size.[28] Results from regressing TFP on farm size categories and an indicator variable for formal registration provide two insights. First, differences in TFP across farm size groups are statistically significant, most notably a large gap of 14-20 percentage points between the smallest farm size category and the next (50-120 ha). Differences between subsequent categories are much smaller with gaps of 4 and 5-7 points, respectively, between the 50-120 and the 120-500 ha as well as the 120-500 and > 500 ha category.[29] Second, registered farms' TFP is not different from that of informal ones overall (table 9, col. 2) or in the same size group (table 9, col. 3). If formality is not associated with differences in TFP, it will be of interest to identify—and possibly affect through policy—factors that differ systematically between formal and informal farms and that may, by affecting either the cost of the benefits from formalization, may be a reason for farms to stay in informality. A model suggests that identifying and eliminating such factors could eliminate deadweight losses and in doing so increase competition, aggregate production, and skilled formal sector wages (Ulyssea 2018).

Restrictions on land given to small farms in the 1990s or early 2000s for 'permanent use' under favorable conditions but, until 2022,[30] without mechanisms to acquire ownership rights to such land or transfer it to others, are one candidate. As they are non-transferrable and assigned to individuals, they will not survive the death of the original assignee.[31] creating tenure insecurity that is likely to reduce incentives for land-attached investments. Moreover, as most of these rights were assigned 2-3 decades ago, such restrictions

[28] Appendix table 4 tabulates mean and dispersion of TFP overall and separately for legal entities and 'informal' farms. While TFP increases and dispersion decreases with size, for the 50-500 ha categories, the hypothesis of levels and dispersion of TFP being equal between formal and informal farms cannot be rejected.

[29] Note that credit constraints are estimated to decrease TFP for 50-120 ha farms by 5 points, an estimate that is significant at 10%.

[30] Short-term (1 year) leases of land operated under permanent use rights were allowed in March 2022. Legislation adopted in November 2022 provides citizens and legal entities with the right to permanently use a land plot of state or communal property to buy the corresponding land without land auctions. The purchase of agricultural land plots is carried out at a price equal to the normative monetary value of the land plot (UAH 27,500/ha) and the buyer has the right to opt for paying for the land in 10 equal instalments that are indexed to inflation.

[31] Formally, in case of death, land will revert to the community or state, the tenure while village councils can-and have in some cases-provided permanent use rights to the assignee's heirs, they are under no obligation to do so.

may prevent many of the original recipients from formally exiting farming and transferring their land to younger farmers able to make better use of it and mechanisms to ensure such transfer will be important.

As smaller farms rely disproportionately on land held under use rights, high levels of tenure insecurity and limited investment incentives for land held under permanent use could be a plausible explanation for the low levels of TFP by farms below 50 ha. Using the cadastral designation of land can provide a quick check and suggests that 58% of land by farms below 20 ha and 36% for those below 50 ha, as compared to 20% for farms in the 50-120 ha class, is for 'personal farming' rather than 'commercial agriculture', a difference that is significant at 1% in both cases. Making use rights more transferable, possibly by helping the smallest farm size group acquire full ownership rights to the land they farm thus seems to have potential to boost Ukraine's future development by increasing the welfare of this group, competitiveness of the land market, land-related investment and use of land as collateral, as well as the amount of local land tax receipts.

5. Conclusion and policy implications

This paper aimed to complement existing studies by assessing impacts of Russia's invasion of Ukraine on agricultural performance and food supply based on a micro-level economic data and by including informal farms, a segment of Ukraine's agriculture sector that is often overlooked in official statistics. Two findings are noteworthy. First, our data show that surveyed farmers kept their cultivated area in 2022 almost unchanged, a sign of farmers' resilience. At the same time, worsening terms of trade for agriculture led to a precipitous regionally differentiated decline in farm profitability and productivity. Monitoring changes in planted area for winter as well as summer crops in 2023 based on satellite imagery will be important to identify the extent to which such changes in profitability triggered longer-term adjustments like decapitalization. Second, our data suggest that, especially with the country undergoing a significant crisis, an exclusive focus on (large) farms that are formally registered risks permeating old biases and in doing so tilting the playing field against potential sources of dynamism in rural areas that will be needed if Ukraine is to emerge from the war with a more diversified rural economy that focuses on high value crops in addition to grains and oilseeds. Three implications are particularly relevant:

First, efforts to improve factor and output market competitiveness will be essential to prevent war-induced problems of market access and logistics being exacerbated by exercise of market power and efforts to curtail competition. Ukraine's success in facilitating competitive electronic procurement and transfer of rights to state assets including land via e-auctions (Deininger *et al.* 2022) together with the advances made in setting up the SAR and using it to disburse emergency productive cash support to small farmers during the war, suggest MAPF is well placed to quickly work with input suppliers, output traders, banks, and crop insurance providers, to explore how SAR can be used as an electronic platform to increase competitiveness and reduce risk, including via forward contracts, even at a time of war.

Second, our data suggest productivity of farms below 50 ha is low in part due to investment disincentives and transferability restrictions associated with land under permanent use rights, they also show that informal farms are as productive as formally registered ones and that productivity differences between farmers of different size groups above 50 ha are much narrower than policy makers seem to believe. The rapid growth of SAR registrations suggests that farmers will come out of the shadows if doing so provides benefits. Measures to expand this into a digital marketplace and facilitate land transfers and boost mortgage lending using land as collateral, including greater transferability of land given under rights of permanent use rights could thus have a transformative effect by setting in motion a wave of investment and growth in higher value products by small and medium-sized farms to solidify Ukraine's comparative advantage in agriculture and improve rural living conditions.

Finally, evidence-based decision-making to help the country address the unprecedented current challenges and maximize economic potential and public accountability during reconstruction requires that quality farm survey data like the ones analyzed here will need to be provided regularly, ideally by the country's State Statistics Service (SSSU) including better coverage of the entire farm size spectrum, and in ways that can be linked to data from other sources. To move in this direction, there is a need to amend the legal basis for agricultural statistics to be in line with global best practice in terms of harnessing satellite imagery, computerized data entry, and dissemination of micro-data for analysis without sacrificing confidentiality. An expeditious move towards such a framework would allow alignment with EU membership requirements and help make information collected by SSSU more representative of Ukraine's farm sector, timelier, and more meaningful for policy decisions to navigate the profound war-induced challenges to the country's economic and social fabric in a way that is based on evidence rather than ideology and encourages participation and input by all stakeholders.

Table 1: Sample frame compared to national statistics

	Total	Farm size in ha			
		< 50	**50-120**	**120-500**	**> 500**
Panel A: No. of farms & median/average farm size					
Total Form 29	36,184	16,138	5,401	7,144	7,501
ACUs %	78.9	82.0	79.7	76.2	74.0
AACs %	21.1	18.0	20.3	23.8	26.0
Total SAR	75,571	61,705	6,127	4,444	3,295
….Legal Entities %	20.8	9.0	58.4	76.3	97.1
FOPs %	11.2	9.3	28.2	21.1	2.0
Individuals %	68.0	81.7	13.4	2.7	0.8
Ratio SAR/F29	2.09	3.82	1.13	0.62	0.44
Median farm size, SAR	6.65	4.92	74 .99	206.60	1307.9
Med. farm size, Form 29	68.57	24.00	77.09	241.00	1298.6
Avg. farm size SAR	154.0	9.75	88.70	283.11	2802.5
Avg. farm size Form 29	777.7	25.07	79.43	264.67	3393.0
Panel B: Area cult. (mn. ha)					
Total Form 29	27.85	0.40	0.43	1.89	25.14
ACUs %	75.4	79.8	79.5	75.9	75.3
AACs %	24.6	20.2	20.5	24.1	24.7
Total SAR	11.64	0.60	0.54	1.26	9.23
….Legal Entities %	90.5	33.0	63.9	82.8	96.9
FOPs %	4.4	13.6	25.5	15.3	1.1
Individuals %	5.1	53.4	10.7	1.9	2.0
Ratio SAR/F29	0.42	1.49	1.27	0.67	0.37
Panel C: Informality (ACUs)					
Area cult. 2020 (mn. ha)	33.87				
F29 overlapping (mn. ha)	6.42	0.09	0.20	0.67	5.46
F29 non-overlap (mn. ha)	14.59	0.23	0.14	0.76	13.45
SAR only (mn. ha)	3.14	0.43	0.24	0.28	2.20
Informal (mn. ha)	9.71				
Panel D: Informality (AACs)					
Area cult. 2020 (mn. ha)	11.86				
F29 overlapping (mn. ha)	1.09	0.01	0.02	0.08	1.00
F29 non-overlap (mn. ha)	5.75	0.08	0.07	0.38	5.23
SAR only (mn. ha)	0.22	0.02	0.03	0.05	0.12
Informal (mn. ha)	4.80				

Source: Own computation from SAR, 2020 Form 29 data from SSSU and crop maps based on satellite imagery for 2020 as discussed in the text.

Note: In panels C and D, ACU is areas controlled by Ukraine and AAC are areas affected by conflict. Region is not reported in the SAR for 1,629 farms cultivating a total of 39,735 ha.

[a] Area cultivated 2020 is based on satellite imagery.

Table 2: Basic farm characteristics by region and farm size group

	Total	Center	North	South	East	West	<50	50-120	120-500	>500
Household characteristics										
Lives in village[a]	0.70	0.70	0.62	0.71	0.68	0.76	0.77	0.71	0.64	0.64
Hh qnr applied[a]	0.82	0.85	0.74	0.84	0.81	0.78	0.94	0.91	0.75	0.52
Male farm owner	0.75	0.76	0.85	0.64	0.82	0.77	0.61	0.82	0.80	0.83
Age of owner	48.97	49.21	47.65	50.31	49.24	46.92	49.14	49.02	48.09	50.11
Education < secondary	0.01	0.01	0.01	0.02	0.00	0.02	0.02	0.01	0.00	0.00
Secondary education	0.10	0.09	0.10	0.13	0.16	0.07	0.14	0.09	0.09	0.01
Education > secondary	0.89	0.90	0.89	0.85	0.84	0.91	0.83	0.90	0.91	0.99
Owner has bank account	0.96	0.95	0.96	0.95	0.98	0.97	0.92	0.97	0.98	0.99
Other member w. bank acct	0.72	0.71	0.71	0.77	0.68	0.69	0.71	0.73	0.78	0.60
Owner has FB account	0.67	0.66	0.65	0.69	0.64	0.71	0.64	0.68	0.70	0.66
Other member w. FB acct	0.64	0.64	0.63	0.65	0.65	0.63	0.63	0.67	0.69	0.46
War impact & coping strategies										
War damage to land[a]	0.08	0.03	0.21	0.10	0.26	0.03	0.03	0.06	0.13	0.18
War damage to structures[a]	0.04	0.01	0.11	0.05	0.15	0.01	0.02	0.02	0.06	0.09
Member migrated out in oblast	0.08	0.08	0.10	0.06	0.09	0.10	0.06	0.09	0.07	0.07
Member migrated beyond oblast	0.09	0.08	0.07	0.11	0.18	0.08	0.10	0.09	0.08	0.08
Could get informal support	0.46	0.45	0.44	0.48	0.48	0.48	0.46	0.50	0.44	0.32
if yes, amount (US$)	7,311	7,505	9,922	5,461	9,276	6,260	4,145	7,735	10,490	12,141
$ 200 lottery: Consumption	0.17	0.14	0.20	0.18	0.20	0.21	0.18	0.15	0.17	0.19
$ 200 lottery: Working capital	0.40	0.39	0.42	0.44	0.39	0.39	0.46	0.42	0.34	0.26
$ 200 lottery: Investment/savings	0.15	0.17	0.14	0.13	0.15	0.15	0.15	0.13	0.17	0.23
$ 5,000 lottery: Consumption	0.10	0.09	0.09	0.11	0.14	0.08	0.15	0.08	0.07	0.06
$ 5,000 lottery: Working capital	0.65	0.64	0.66	0.69	0.57	0.61	0.67	0.69	0.63	0.43
$ 5,000 lottery: Investment/saving	0.19	0.20	0.17	0.17	0.23	0.22	0.19	0.16	0.20	0.35
No. of obs. (farms)	2,251	1,059	316	464	124	288	619	790	501	341

Source: Own computation from MAPF/WB/EU small producer survey.

Note: Answers marked by [a] were answered by all farms while the remainder is only for the 82% owner-operated farms that answered the household section of the questionnaire.

Table 3: Household composition, income sources & coping mechanisms by region and farm size group

	Total	Center	North	South	East	West	<50	50-120	120-500	>500
Panel A: 2021										
Income sources/attitudes										
No. adult household members	2.60	2.58	2.53	2.61	2.43	2.82	2.61	2.63	2.69	2.28
…. # working full-time in agric.	1.45	1.49	1.36	1.41	1.43	1.51	1.43	1.51	1.61	1.09
…. # working part- time in agric.	0.62	0.61	0.67	0.59	0.48	0.67	0.83	0.67	0.44	0.30
Had permanent employees (y/n)	0.54	0.53	0.64	0.44	0.66	0.55	0.18	0.45	0.82	0.98
… if yes, how many?	9.02	7.68	14.92	3.39	13.28	14.94	1.05	1.15	4.56	49.34
Member w. non-agr. job (y/n)	0.94	0.96	0.94	0.90	0.95	0.94	0.87	0.96	0.98	0.98
if yes, avg. mthly income	253	255	269	240	284	237	217	256	269	314
Member self-emp. in non-ag (y/n)	0.62	0.64	0.69	0.57	0.72	0.57	0.34	0.71	0.83	0.8
if yes, avg. mthly income	288	286	297	282	316	281	246	284	293	349
Personal situation (1-10)	7.34	7.39	7.36	7.29	7.31	7.21	6.84	7.37	7.55	7.81
Country situation (1-10)	7.15	7.22	7.06	7.16	7.02	7.04	6.88	7.24	7.21	7.34
Coping mechanisms										
Member received social assistance	0.32	0.30	0.30	0.33	0.33	0.37	0.36	0.32	0.28	0.22
if yes, avg. monthly (US$)	69.0	72.7	64.6	67.4	61.2	66.1	64.5	70.3	76.9	65.5
Member received remittances	0.04	0.04	0.02	0.03	0.07	0.07	0.04	0.05	0.04	0.02
if yes, avg. monthly receipt	75.2	81.0	92.6	61.7	88.0	66.1	48.6	88.0	84.2	92.6
Panel B: 2022										
Income sources/attitudes										
No. adult household members	2.59	2.57	2.52	2.61	2.41	2.80	2.59	2.62	2.69	2.27
…. # working full-time in agric.	1.47	1.50	1.44	1.41	1.37	1.55	1.47	1.55	1.58	1.07
…. # working part- time in agric.	0.63	0.64	0.56	0.61	0.52	0.76	0.89	0.71	0.45	0.18
Had permanent employees (y/n)	0.55	0.54	0.68	0.44	0.61	0.57	0.20	0.46	0.81	0.98
… if yes, how many?	8.78	6.99	14.63	3.27	11.16	16.90	0.96	1.16	4.53	48.01
Member w. non-agr. job (y/n)	0.93	0.94	0.93	0.89	0.93	0.94	0.85	0.95	0.98	0.98
if yes, avg. mthly income	232	234	254	207	246	233	198	222	256	311
Member self-emp. in non-ag (y/n)	0.62	0.64	0.69	0.56	0.7	0.58	0.34	0.71	0.8	0.82
if yes, avg. mthly income	269	270	281	238	296	282	229	254	279	349
Personal situation (1-10)	3.66	3.67	3.69	3.61	3.27	3.88	3.52	3.57	3.89	3.81
Country situation (1-10)	3.24	3.25	3.19	3.29	2.83	3.36	3.20	3.22	3.25	3.34
Coping mechanisms										
Member received social assistance	0.39	0.34	0.39	0.47	0.39	0.42	0.42	0.39	0.37	0.29
if yes, avg. monthly (US$)	66.4	69.6	60.5	62.1	54.7	75.2	63.0	69.4	70.8	53.4
Member received remittances	0.05	0.05	0.02	0.06	0.04	0.05	0.05	0.04	0.06	0.03
if yes, avg. monthly receipt	74.1	76.5	84.9	61.0	92.6	84.2	54.3	89.2	77.2	86.8
No. of obs. (farms)	2,251	1,059	316	464	124	288	619	790	501	341

Source: Own computation from MAPF/WB/EU small producer survey.

Table 4: Factor market participation by region and farm size group

		By region					By farm size			
	Total	**Center**	**North**	**South**	**East**	**West**	**<50**	**50-120**	**120-500**	**> 500**
Land market										
Leases land	0.84	0.85	0.84	0.82	0.84	0.84	0.72	0.87	0.87	0.85
if yes, lease paid ($/ha)	105.34	110.24	107.16	92.54	96.65	107.96	85.62	105.16	108.38	117.02
Wants to lease more (y/n)	0.85	0.87	0.86	0.80	0.84	0.84	0.71	0.89	0.89	0.94
Wants to buy land (y/n)	0.78	0.80	0.82	0.70	0.82	0.76	0.56	0.86	0.85	0.89
if yes, price ($/ha)	1,432	1,483	1,355	1,340	1,353	1,512	1,353	1,440	1,413	1,548
if yes, med. price ($/ha)	1,111	1,388	1,111	1,111	1,111	1,111	1,111	1,250	1,111	1,389
Wants to sell land (y/n)	0.03	0.03	0.04	0.03	0.05	0.05	0.06	0.02	0.03	0.00
if yes, selling price ($/ha)	3,142	4,627	1,369	1,728	1,852	3,254	4,787	1,848	1,206	
if yes, med. Price ($/ha)	1,111	1,389	1,111	1,111	1,111	1,111	2,500	1,806	1,111	
Assets										
Area cultivated (ha)	418.06	339.87	822.50	289.66	467.01	445.07	20.36	86.68	256.49	2,118.21
Own tractor/equip	0.84	0.84	0.84	0.86	0.78	0.86	0.82	0.88	0.88	0.72
if yes, value ($)	187,991	183,610	268,727	149,566	198,787	167,105	21,033	64,220	179,167	785,646
.. if yes, value/ha ($)	774.79	787.09	835.41	551.16	705.56	1023.28	1212.75	672.42	680.82	609.29
Credit markets										
Ever received credit	0.55	0.56	0.57	0.51	0.58	0.54	0.34	0.49	0.69	0.84
if yes, years since last	2.29	2.28	1.96	2.82	2.01	2.07	4.78	2.85	1.57	0.78
size (US$)	75,709	62,469	149,683	45,655	74,600	89,671	6,946	17,547	53,253	253,041
interest rate	7.59	7.71	7.36	7.28	9.69	6.96	11.47	8.31	7.04	5.44
used for working capital	0.94	0.93	0.95	0.94	0.92	0.91	0.79	0.95	0.97	0.98
Would want to borrow	0.78	0.79	0.83	0.72	0.78	0.81	0.62	0.84	0.84	0.89
if yes, amount	140,530	116,669	188,375	130,829	148,939	184,438	34,508	74,299	128,475	446,956
interest rate	6.08	6.18	6.76	5.32	6.55	5.84	5.20	5.89	6.64	6.75
Credit constrained?	0.54	0.54	0.55	0.53	0.62	0.50	0.56	0.67	0.46	0.33
Support received/needed										
Got advisory service (y/n)	0.18	0.19	0.20	0.14	0.13	0.20	0.14	0.19	0.19	0.22
if yes, from Gov't	0.49	0.50	0.49	0.44	0.50	0.49	0.41	0.48	0.53	0.53
Would want more TA	0.91	0.90	0.92	0.92	0.94	0.93	0.88	0.93	0.90	0.93
Priorities for gov't to										
… regulate input prices	0.29	0.30	0.24	0.31	0.24	0.30	0.34	0.28	0.26	0.25
… procurement/markets	0.25	0.27	0.26	0.24	0.24	0.23	0.24	0.26	0.25	0.26
… provide credit	0.15	0.14	0.17	0.15	0.14	0.15	0.12	0.16	0.16	0.16
… tax reduction	0.12	0.11	0.12	0.13	0.14	0.10	0.11	0.10	0.12	0.15
No. of obs. (farms)	2,251	1,059	336	464	124	268	619	790	501	341

Source: Own computation from MAPF/WB/EU small producer survey.

Note: As discussed in the text, a farm is considered credit constrained in 2022 if it indicated that it would want to borrow but did not have access to credit in this year. Area cultivated at the farm level reported for 2022.

Table 5: Area allocation and changes in aggregate crop mix

	Total	Center	North	South	East	West	<50	50-120	120-500	>500
Panel A: 2021										
Average area cult. (ha)	346.46	269.29	676.69	248.54	438.45	410.76	21.52	77.93	225.19	1713.87
% of farmers cultivating										
… wheat (ha)	0.70	0.67	0.58	0.76	0.81	0.77	0.53	0.71	0.78	0.81
… barley (ha)	0.30	0.28	0.15	0.46	0.33	0.24	0.22	0.29	0.33	0.41
… sunflower (ha)	0.59	0.64	0.55	0.70	0.71	0.18	0.38	0.60	0.68	0.76
… maize (ha)	0.46	0.56	0.66	0.20	0.42	0.33	0.25	0.46	0.52	0.72
… soybean (ha)	0.24	0.27	0.28	0.01	0.12	0.59	0.16	0.28	0.25	0.30
… rapeseed (ha)	0.10	0.08	0.07	0.11	0.01	0.23	0.00	0.05	0.12	0.33
… other (ha)	0.19	0.14	0.28	0.11	0.18	0.39	0.13	0.16	0.22	0.29
Total area grown with										
… wheat (ha)	176,082	61,484	29,619	42,179	19,128	23,672	3,029	15,569	31,615	125,869
… barley (ha)	34,175	12,326	2,533	14,496	2,025	2,795	986	3,595	7,405	22,189
… sunflower (ha)	171,289	74,257	37,624	29,469	17,483	12,456	2,945	14,364	27,197	126,783
… maize (ha)	172,414	68,517	71,189	4,752	6,714	21,242	1,651	11,401	20,846	138,516
… soybean (ha)	48,211	13,042	18,631	105	2,098	14,335	1,088	5,487	6,984	34,652
… rapeseed (ha)	33,570	7,913	4,490	7,830	490	12,847	0	766	3,997	28,807
… other (ha)	29,117	8,858	11,853	2,574	1,168	4,664	544	2,824	5,542	20,207
Panel B: 2022										
Average area cult. (ha)	370.70	301.35	716.61	261.69	400.48	436.18	22.60	83.67	242.02	1832.09
% of farmers cultivating										
… wheat (ha)	0.75	0.74	0.60	0.82	0.89	0.79	0.56	0.78	0.83	0.88
… barley (ha)	0.32	0.32	0.15	0.49	0.32	0.26	0.22	0.30	0.38	0.45
… sunflower (ha)	0.65	0.70	0.66	0.75	0.71	0.21	0.40	0.69	0.75	0.80
… maize (ha)	0.48	0.60	0.63	0.22	0.38	0.39	0.25	0.50	0.55	0.73
… soybean (ha)	0.30	0.34	0.37	0.01	0.12	0.64	0.19	0.33	0.30	0.38
… rapeseed (ha)	0.12	0.10	0.10	0.13	0.02	0.27	0.01	0.07	0.15	0.38
… other (ha)	0.21	0.16	0.32	0.13	0.21	0.42	0.15	0.18	0.25	0.31
Area/farm grown with										
… wheat (ha)	183,742	65,695	29,231	40,966	23,887	23,963	3,072	16,116	32,644	131,910
… barley (ha)	33,119	12,581	2,416	13,855	1,376	2,891	863	3,691	6,922	21,643
… sunflower (ha)	201,675	88,306	59,642	30,983	10,955	11,789	3,096	16,282	31,800	150,497
… maize (ha)	154,938	70,159	53,187	5,693	5,660	20,239	1,607	10,481	18,841	124,009
… soybean (ha)	68,504	19,754	24,823	477	947	22,503	1,502	6,750	9,238	51,014
… rapeseed (ha)	41,068	11,366	5,977	11,295	983	11,447	70	1,354	4,677	34,967
… other (ha)	28,331	7,870	11,042	3,501	1,046	4,872	549	3,310	7,207	17,265
No. of obs. (farms)	1,919	915	260	408	112	224	476	693	460	290

Source: Own computation from MAPF/WB/EU small producer survey

Note: Data are for the balanced panel of farms that report cultivating any crop in both the 2021 and 2022 agricultural seasons.

Table 6: Output and input prices and cash flow

	Total	Center	North	South	East	West	<50	50-120	120-500	>500
Panel A: 2021										
Output value (US$/ha)	872.0	903.7	815.1	1,051.6	661.3	962.4	704.1	866.3	907.2	1,084.6
Input cost (US$/ha)	154.03	153.04	153.80	200.92	124.44	166.98	110.96	140.36	189.67	261.76
Net revenue (US$/ha)	670.4	706.3	656.5	790.0	506.2	735.1	563.7	710.9	692.5	778.2
Sold anything in market	0.94	0.94	0.97	0.95	0.96	0.90	0.84	0.96	0.98	1.00
… if yes, % of value	0.83	0.84	0.85	0.81	0.83	0.80	0.83	0.85	0.85	0.77
Cash flow (US$/ha)	432.2	487.2	376.1	532.9	331.7	276.1	401.5	431.3	442.6	481.6
% w. negative cash flow	0.10	0.09	0.09	0.15	0.09	0.17	0.12	0.08	0.11	0.13
Panel B: 2022										
Output value (US$/ha)	571.3	595.7	498.1	680.2	384.5	738.6	471.4	565.8	591.3	704.4
… at 2021 price ($/ha)	704.8	735.1	688.9	864.8	468.2	855.9	576.2	698.9	732.3	870.0
Input cost (US$/ha)	183.61	187.02	171.19	226.47	153.76	187.36	149.05	169.51	222.21	260.91
… real input value ($/ha)	94.88	94.04	81.83	124.50	82.42	97.36	77.08	87.12	115.63	134.75
Net revenue (US$/ha)	345.9	363.5	311.5	417.8	216.6	496.0	294.2	379.6	345.3	368.0
Sold anything in market	0.77	0.78	0.76	0.75	0.80	0.71	0.58	0.80	0.85	0.89
… if yes, % of value	0.57	0.57	0.57	0.58	0.59	0.50	0.69	0.55	0.57	0.51
Cash flow (US$/ha)	-25.6	-30.3	-18.9	-36.2	-6.6	-38.3	89.1	8.1	-99.5	-188.6
% w. negative cash flow	0.46	0.43	0.46	0.51	0.47	0.51	0.40	0.43	0.50	0.56
No. of obs. (farms)	1,714	852	213	367	89	192	413	632	419	250

Source: Own computation from MAPF/WB/EU small producer survey

Note: Cash flow is defined as the value of output sold minus cost of purchased inputs

Table 7: Regression (area/yield etc.) for main crops

	Area	Output value (US$/ha)	Market participation	Share sold	Input	Net revenue	Cash flow	Negative cash flow	Share of area with oilseeds
Central # 2022	0.032	-0.237***	-0.096***	-0.318***	-154.089***	-425.184***	-680.161***	0.460***	0.044
	(0.051)	(0.034)	(0.032)	(0.037)	(24.701)	(45.034)	(139.359)	(0.076)	(0.028)
East # 2022	-0.073	-0.170**	-0.158**	-0.371***	-159.596***	-422.076***	-630.566***	0.531***	0.025
	(0.069)	(0.069)	(0.074)	(0.069)	(39.537)	(66.861)	(149.905)	(0.123)	(0.047)
North # 2022	-0.036	-0.192***	-0.150***	-0.311***	-183.705***	-451.522***	-819.191***	0.478***	0.113***
	(0.068)	(0.047)	(0.047)	(0.053)	(32.468)	(61.006)	(152.796)	(0.103)	(0.043)
South # 2022	-0.026	-0.375***	-0.085**	-0.322***	-155.485***	-380.965***	-556.685***	0.513***	-0.005
	(0.054)	(0.044)	(0.041)	(0.047)	(25.644)	(46.814)	(130.939)	(0.087)	(0.036)
West # 2022	0.079	-0.144***	-0.124**	-0.316***	-178.273***	-356.133***	-616.454***	0.462***	0.036
	(0.067)	(0.040)	(0.050)	(0.052)	(32.230)	(54.478)	(184.906)	(0.105)	(0.038)
< 50 ha # 2022	0.054	0.065	-0.153***	0.035	111.805***	117.286**	271.982*	-0.092	-0.002
	(0.057)	(0.046)	(0.047)	(0.048)	(26.207)	(49.686)	(138.623)	(0.086)	(0.042)
50-120 ha # 2022	0.066	0.016	-0.056	-0.049	78.871***	69.108	169.584	-0.070	0.013
	(0.054)	(0.037)	(0.037)	(0.041)	(26.275)	(46.584)	(136.112)	(0.081)	(0.030)
120-500 ha # 2022	0.051	0.026	-0.021	-0.014	70.529**	46.797	60.736	-0.007	0.043
	(0.057)	(0.039)	(0.039)	(0.044)	(27.617)	(49.472)	(145.668)	(0.087)	(0.032)
Structure or land affected by war	-0.124**	-0.111**	0.007	0.015	-11.703	-45.517	-34.700	0.082	-0.026
	(0.062)	(0.054)	(0.052)	(0.054)	(23.629)	(45.629)	(96.038)	(0.089)	(0.039)
Constant	4.376***	6.682***	0.942***	0.767***	249.480***	569.715***	402.366***	0.140***	0.390***
	(0.008)	(0.007)	(0.007)	(0.007)	(3.094)	(6.481)	(12.908)	(0.012)	(0.006)
No. of farms	3,428	3,358	3,288	3,006	2,710	2,460	2,168	2,172	3,422
R-squared	0.977	0.826	0.657	0.710	0.813	0.803	0.712	0.677	0.678

Note: Main crops include wheat, barley, rapeseed, maize, sunflower and soybean. The dependent variables in cols. 1 and 2 are in natural logs. The dependent variable in col. 2 is real farm output of these crops at the 2021 prices per ha of cultivated land. The dependent variable in col. 5 is the real value of hired labor and machinery services as well as purchased material inputs per ha deflated at 2021 regional level fertilizer prices. The dependent variable in col. 6 is nominal value of output minus value of hired labor and machinery services and purchased material inputs per ha. The dependent variable in col. 9 is the share of the farm's cultivated area devoted to oilseeds. All regressions include farm fixed effects. The sample is restricted to the balanced panel based on valid observations the dependent variable in the respective column. Robust standard errors clustered at farm level in parentheses: * significant at 10%, ** significant at 5% and *** significant at 1%.

Table 8: Production function regressions

	2031		2022		2021 and 2022 combined			
					OLS		Farm fixed effects	
Land (ha)	0.081***	0.114***	0.080***	0.114***	0.077***	0.095***	-0.031	0.014
	(0.009)	(0.012)	(0.011)	(0.014)	(0.008)	(0.010)	(0.032)	(0.039)
Affected by war			-0.111**	-0.122**	-0.098*	-0.114**	-0.129**	-0.122**
			(0.055)	(0.053)	(0.055)	(0.055)	(0.050)	(0.051)
Labor (US$/ha)		0.063***		0.068***		0.034**		0.019
		(0.016)		(0.019)		(0.014)		(0.033)
Fertilizer (US$/ha)		0.081***		0.084***		0.069***		0.050**
		(0.017)		(0.018)		(0.015)		(0.021)
Machinery (US$/ha)		0.065***		0.055***		0.056***		0.029
		(0.015)		(0.018)		(0.017)		(0.022)
Central # Year 2022					-0.184***	-0.137***	-0.232***	-0.197***
					(0.020)	(0.021)	(0.018)	(0.023)
East # Year 2022					-0.196***	-0.118***	-0.152***	-0.114**
					(0.043)	(0.044)	(0.055)	(0.058)
North # Year 2022					0.010	0.031	-0.120***	-0.088**
					(0.042)	(0.042)	(0.039)	(0.043)
Southern # Year 2022					-0.602***	-0.486***	-0.332***	-0.285***
					(0.031)	(0.034)	(0.031)	(0.036)
West # Year 2022					0.007	0.042	-0.123***	-0.072*
					(0.049)	(0.050)	(0.037)	(0.039)
Constant	6.322***	5.165***	6.092***	5.012***	6.341***	5.497***	6.803***	6.134***
	(0.043)	(0.136)	(0.049)	(0.146)	(0.040)	(0.118)	(0.138)	(0.332)
No. of farms	954	954	959	959	1,913	1,913	1,913	1,913
R-squared	0.073	0.170	0.055	0.133	0.221	0.270	0.278	0.289

Note: Regressions are for monetary yield from main crops (wheat, barley, rapeseed, maize, sunflower and soybean) per hectare using the balanced panel of farms cultivating any crop in the 2021 and 2022 cropping season. Robust standard errors clustered at the farm level in parentheses: * significant at 10%, ** significant at 5% and *** significant at 1%. All regressions include farm fixed effects.

Table 9: Regression of farm TFP on farm size, formality, and credit constrained status

Farm size <50 ha	0.908***	0.909***	0.884***
	(0.016)	(0.019)	(0.026)
Farm size 50-120 ha	1.043***	1.046***	1.086***
	(0.012)	(0.020)	(0.027)
Farm size 120-500 ha	1.085***	1.087***	1.076***
	(0.015)	(0.021)	(0.037)
Farm size >=500 ha	1.155***	1.162***	1.126***
	(0.023)	(0.030)	(0.109)
Legal entity		0.003	
		(0.017)	
Credit constrained		-0.005	
		(0.016)	
Farm size <50 ha * Legal entity			0.056
			(0.038)
Farm size 50-120 ha * Legal entity			-0.010
			(0.025)
Farm size 120-500 ha * Legal entity			-0.011
			(0.036)
Farm size >=500 ha * Legal entity			0.052
			(0.108)
Farm size <50 ha * Credit constrained			0.017
			(0.032)
Farm size 50-120 ha * Credit constrained			-0.053*
			(0.027)
Farm size 120-500 ha * Credit constrained			0.040
			(0.033)
Farm size >=500 ha * Credit constrained			-0.042
			(0.052)
No. of farms	941	918	918
R-squared	0.952	0.952	0.953

Note: Dependent variable is farm TFP (i.e., exponential of farm fixed effects extracted from col. If of table 8 after purging village fixed effects). A constant term is not included in all the specifications. The equality of farm size coefficients in cols. 1 and 2 between any category and the greater than 500 ha category is rejected at 1% level. Standard errors clustered at the farm level in parentheses: * significant at 10%, ** significant at 5% and *** significant at 1%.

Figure 1: Geographical distribution of sample

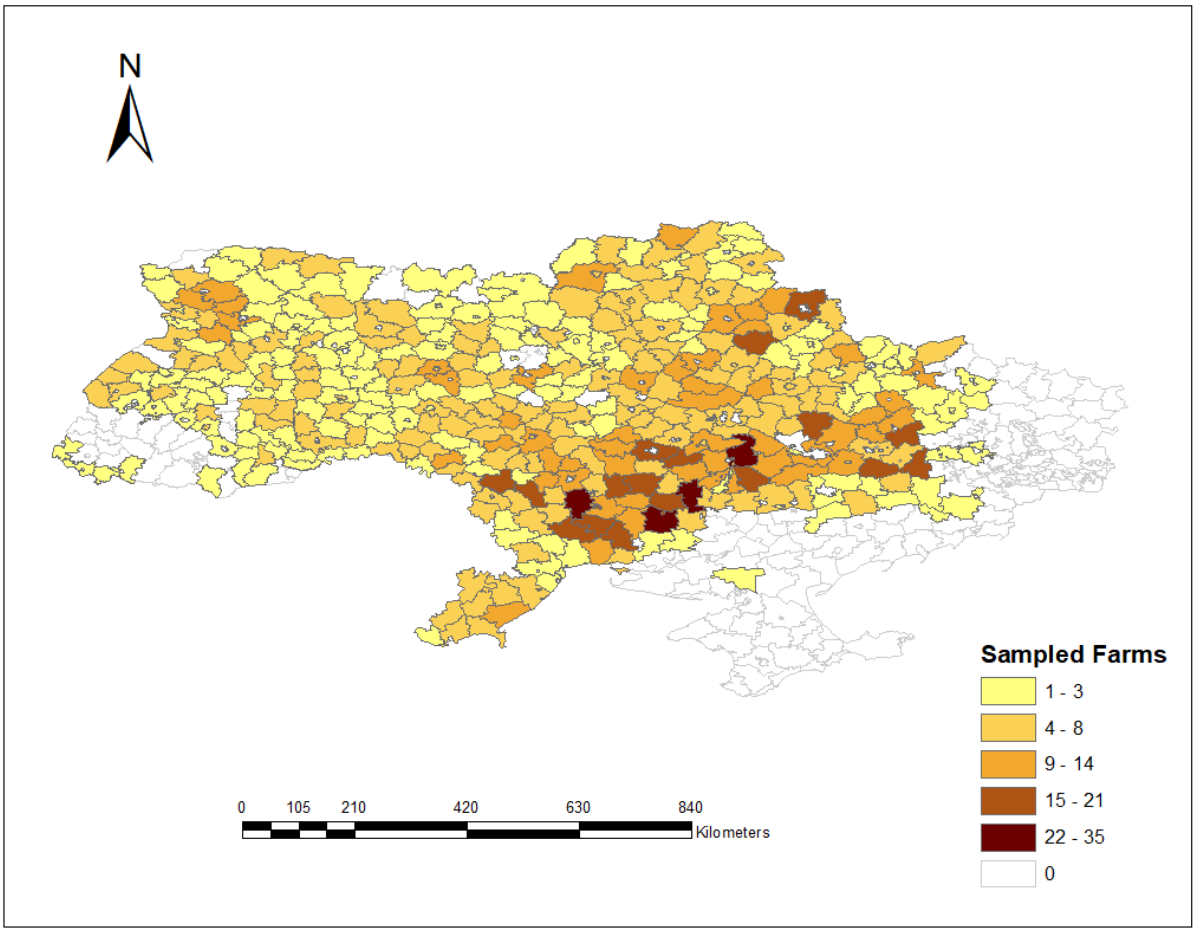
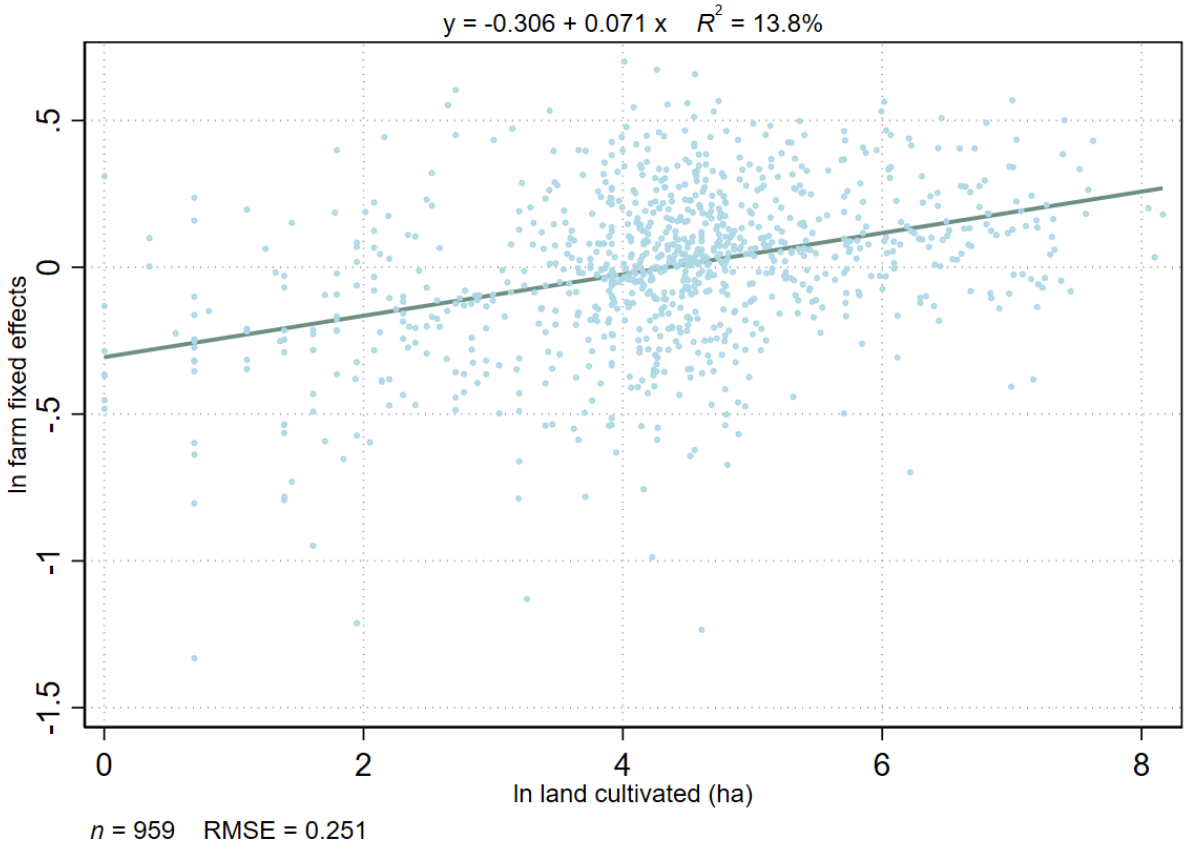


Figure 2: Plot of farm-level productivity against farm size



Note: Farm fixed effect (net of rayon fixed effects) is extracted from the regression of output/ha in col. 8 of table 8.

APPENDIX TABLES:

Appendix table 1: Response rate by farm size

	Total	Farm size category			
		< 50	**50-120**	**120-500**	**> 500**
Sampled farms	11,756	2,383	4,609	2,743	2,021
Farms contacted	10,982	2,302	4,174	2,626	1,880
No response (%)	45.76	50.26	47.22	43.18	40.59
Refusal (%)	33.76	27.89	30.43	37.43	43.19
Interviewed (%)	20.49	21.85	22.35	19.38	16.22
… 1st attempt (%)	66.13	68.39	67.52	68.17	54.75
… 2nd attempt (%)	22.22	20.48	22.51	22.20	24.26
> 2 attempts (%)	11.64	11.13	9.97	9.63	20.98

Note: Categories coded as non-response include 'cellphone out of range/not reachable' (4,536 cases), 'no answer', 'enterprise closed or did not operate in 2022', 'respondent moved abroad', 'non-response due to security', and 'not relevant contact'.

Appendix table 2: Prices for key farm inputs, 2021 and 2022

	National	Regional				
		Center	North	South	East	West
Panel A: 2021						
Fertilizer price (US$/50kg)	15.57	15.45	15.28	15.91	15.28	15.94
Diesel (US$/liter)	0.78	0.78	0.78	0.78	0.79	0.79
Machinery services (US$/ha)	37.52	35.42	31.85	30.56	28.65	61.15
Daily wage (US$/day)	11.55	13.89	12.50	7.98	12.36	11.03
Panel B: 2022						
Fertilizer price (US$/50kg)	40.17	38.90	40.28	40.42	38.19	43.06
Diesel (US$/liter)	1.49	1.48	1.49	1.49	1.50	1.48
Machinery services (US$/ha)	49.23	45.30	39.18	42.03	39.76	79.88
Daily wage (US$/day)	14.38	15.30	12.50	13.89	16.32	13.89

Source: Survey of community leaders and local dealers' adverts, complemented by completed auctions for machinery services on the Prozorro sales platform. Prices are for ammonium nitrate and urea for fertilizer and the cost of harvesting and ploughing/soil preparation for wheat and maize, respectively, for machinery services. Wages are for agricultural labor.

Appendix table 3: Production outcomes by crop

	Total	Center	North	South	East	West	<50	50-120	120-500	>500
Panel A: 2021										
Produced wheat	0.63	0.61	0.77	0.52	0.70	0.68	0.48	0.64	0.74	0.72
Area (ha)	103.30	84.82	128.44	144.98	108.76	112.94	10.88	30.62	84.10	385.56
Yield of wheat (t/ha)	4.28	4.42	4.16	4.78	3.52	4.75	3.72	4.13	4.38	4.92
Price of wheat ($/t)	170.59	167.11	162.97	180.77	171.93	177.52	146.77	160.46	178.31	192.92
Sold wheat (y/n)	0.90	0.90	0.95	0.90	0.94	0.79	0.72	0.92	0.95	0.95
if yes, share of harvest sold	0.87	0.88	0.93	0.86	0.86	0.87	0.87	0.89	0.89	0.82
Input cost	158.47	155.75	139.60	191.06	149.02	170.96	117.65	148.07	190.17	203.09
Net revenue	535.34	552.43	551.06	652.23	423.51	584.53	485.74	543.01	529.06	609.72
Produced barley	0.27	0.26	0.30	0.13	0.41	0.23	0.19	0.26	0.31	0.36
Area (ha)	49.56	41.43	41.36	56.25	63.02	47.15	8.12	16.61	49.40	146.72
Yield of barley (t/ha)	3.76	3.87	3.15	4.09	3.50	4.16	3.05	3.58	3.81	4.59
Price of barley ($/t)	145.03	140.50	131.94	162.22	145.87	163.10	120.58	133.04	156.57	162.53
Sold barley (y/n)	0.84	0.85	0.73	0.64	0.94	0.67	0.56	0.90	0.91	0.87
if yes, share of harvest sold	0.87	0.88	0.80	0.74	0.87	0.92	0.82	0.85	0.89	0.90
Input cost	136.11	134.59	107.14	121.97	136.89	171.50	107.43	118.10	149.56	225.21
Net revenue	388.35	408.88	330.44	424.04	342.71	489.83	340.92	398.86	393.89	425.80
Produced sunflower	0.52	0.57	0.65	0.47	0.63	0.14	0.30	0.54	0.63	0.68
Area (ha)	108.99	90.84	128.79	156.97	96.40	313.26	17.38	33.99	83.85	376.57
Yield of sunflower (t/ha)	2.38	2.41	2.32	2.79	2.08	2.78	2.06	2.34	2.39	2.69
Price of sunflower ($/t)	441.06	442.19	409.51	452.18	433.96	512.88	396.04	415.63	455.21	494.12
Sold sunflower (y/n)	0.95	0.92	0.96	0.98	0.98	1.00	0.93	0.95	0.97	0.93
if yes, share of harvest sold	0.92	0.93	0.95	0.92	0.90	1.00	0.94	0.92	0.95	0.86
Input cost	154.06	154.17	141.53	203.61	128.81	230.93	120.98	122.62	180.71	242.52
Net revenue	845.63	868.25	823.78	1,036.91	697.61	1,094.86	751.97	850.55	825.38	971.54
Produced maize	0.41	0.50	0.38	0.55	0.19	0.27	0.21	0.41	0.49	0.64
Area (ha)	141.37	108.72	101.69	240.88	66.41	289.24	14.39	31.84	80.93	428.69
Yield of maize (t/ha)	7.28	7.25	5.27	8.17	6.10	8.27	5.93	7.14	7.24	8.03
Price of maize ($/t)	162.65	162.40	138.54	172.33	151.45	169.52	144.28	151.80	162.64	182.57
Sold maize (y/n)	0.92	0.92	0.75	0.93	0.92	0.93	0.82	0.92	0.92	0.95
if yes, share of harvest sold	0.88	0.90	0.86	0.86	0.90	0.82	0.90	0.92	0.90	0.81
Input cost	219.39	196.77	219.53	304.47	153.45	308.64	147.83	169.47	270.32	314.82
Net revenue	915.36	920.93	613.87	1,115.42	691.44	992.01	763.55	984.60	862.97	955.90
Produced soybeans	0.22	0.24	0.10	0.25	0.01	0.49	0.14	0.25	0.24	0.27
Area (ha)	74.46	49.56	97.67	114.40	58.33	99.42	14.39	29.57	60.19	259.08
Yield of soybeans (t/ha)	2.44	2.40	2.43	2.36	1.58	2.58	2.36	2.40	2.38	2.70
Price of soybeans ($/t)	389.49	378.46	403.22	378.46	277.78	415.61	340.51	374.48	400.24	434.65
Sold soybeans (y/n)	0.89	0.89	1.00	0.91	0.50	0.90	0.94	0.89	0.92	0.83
if yes, share of harvest sold	0.90	0.91	0.97	0.84	1.00	0.93	0.93	0.90	0.93	0.87
Input cost	135.44	113.75	270.92	179.40	172.22	145.72	96.27	121.38	123.31	272.00
Net revenue	749.15	736.24	607.50	636.79	179.63	868.51	742.68	750.03	751.75	752.68
Produced rapeseed	0.09	0.07	0.01	0.06	0.10	0.18	0.00	0.05	0.12	0.29
Area (ha)	175.47	110.32	490.00	236.32	192.24	218.93		21.78	81.49	282.52
Yield of rapeseed (t/ha)	2.74	2.65	2.60	3.27	2.45	2.79		2.55	2.57	2.89
Price of rapeseed ($/t)	465.56	445.44	476.36	488.30	471.56	476.22		446.54	448.92	484.81
Sold rapeseed (y/n)	0.99	0.98	1.00	1.00	0.95	1.00		1.00	0.97	0.99
if yes, share of harvest sold	0.98	0.99		0.98	0.97	0.97		1.00	0.99	0.96
Input cost	285.24	227.42	589.57	342.48	254.00	333.55		301.72	285.99	272.35
Net revenue	946.34	890.36	650.72	1,054.44	804.10	1,065.59		924.06	890.02	1,005.38

Source: Own computation from MAPF/WB/EU small producer survey

Appendix table 3 (cont.): Production outcomes by crop

	Total	Center	North	South	East	West	<50	50-120	120-500	>500
Panel B: 2022										
Produced wheat	0.73	0.71	0.88	0.58	0.82	0.77	0.56	0.76	0.82	0.86
Area (ha)	100.93	85.31	121.86	150.30	97.36	111.30	10.59	30.88	81.84	375.12
Yield of wheat (t/ha)	3.52	3.56	3.64	4.09	2.62	4.48	3.05	3.41	3.52	4.17
Price of wheat ($/t)	128.94	122.76	102.81	132.93	134.69	152.76	106.63	115.93	136.31	156.48
Sold wheat (y/n)	0.57	0.57	0.56	0.53	0.65	0.49	0.40	0.57	0.61	0.69
if yes, share of harvest sold	0.66	0.66	0.67	0.67	0.69	0.59	0.76	0.65	0.69	0.61
Input cost	204.22	208.56	160.14	230.12	174.90	250.99	170.69	192.53	230.06	251.52
Net revenue	214.69	201.81	213.38	251.10	157.83	357.85	215.48	219.71	191.94	242.39
Produced barley	0.31	0.31	0.31	0.14	0.46	0.26	0.22	0.29	0.37	0.43
Area (ha)	45.81	38.02	35.48	62.50	55.95	45.98	8.18	16.13	43.08	137.44
Yield of barley (t/ha)	3.20	3.38	3.09	3.73	2.57	3.99	2.76	3.15	3.05	3.86
Price of barley ($/t)	113.39	106.66	103.13	131.49	111.95	153.36	90.66	102.25	116.67	141.95
Sold barley (y/n)	0.54	0.52	0.45	0.54	0.64	0.38	0.37	0.56	0.61	0.53
if yes, share of harvest sold	0.79	0.77	0.61	0.95	0.81	0.73	0.80	0.76	0.82	0.77
Input cost	155.53	154.74	145.56	161.83	151.60	180.41	130.68	140.57	172.54	216.68
Net revenue	178.07	190.85	92.66	257.58	129.02	342.38	177.30	186.22	169.18	171.46
Produced sunflower	0.63	0.68	0.70	0.64	0.73	0.20	0.36	0.68	0.75	0.79
Area (ha)	117.70	98.24	136.13	181.67	94.11	376.43	16.70	33.77	92.51	411.40
Yield of sunflower (t/ha)	1.87	1.98	2.02	2.04	1.42	2.34	1.53	1.86	1.87	2.08
Price of sunflower ($/t)	364.79	365.24	330.75	366.53	372.06	382.52	345.50	354.37	368.11	391.48
Sold sunflower (y/n)	0.68	0.71	0.71	0.67	0.61	0.70	0.68	0.63	0.72	0.72
if yes, share of harvest sold	0.78	0.76	0.76	0.77	0.84	0.91	0.92	0.81	0.73	0.71
Input cost	174.00	176.82	140.91	253.05	139.38	200.66	127.59	151.49	205.44	239.46
Net revenue	460.79	507.08	513.39	447.60	346.61	591.82	396.21	488.39	429.72	501.97
Produced maize	0.47	0.59	0.38	0.61	0.22	0.36	0.26	0.48	0.55	0.73
Area (ha)	134.22	110.15	83.00	191.20	75.90	283.28	14.24	31.28	72.63	409.75
Yield of maize (t/ha)	5.78	5.64	5.46	7.09	3.27	7.38	4.66	5.52	6.01	6.34
Price of maize ($/t)	136.17	127.36	119.10	145.53	150.85	156.93	115.33	123.28	137.99	157.66
Sold maize (y/n)	0.66	0.65	0.58	0.65	0.75	0.66	0.59	0.63	0.69	0.69
if yes, share of harvest sold	0.79	0.81	0.81	0.74	0.79	0.79	0.87	0.82	0.77	0.75
Input cost	280.61	261.09	360.24	382.89	154.78	340.43	205.42	218.81	354.99	372.05
Net revenue	449.63	433.18	179.41	606.31	320.97	627.86	382.77	516.51	364.13	472.58
Produced soybeans	0.29	0.32	0.11	0.35	0.02	0.60	0.18	0.32	0.31	0.38
Area (ha)	83.76	56.99	113.50	94.95	80.00	126.71	14.54	30.91	69.77	295.85
Yield of soybeans (t/ha)	2.05	1.96	2.32	2.16	1.47	2.17	1.85	1.90	2.20	2.39
Price of soybeans ($/t)	333.14	331.43	347.06	346.63	333.33	326.94	300.93	319.97	341.12	368.82
Sold soybeans (y/n)	0.60	0.60	0.83	0.61	0.50	0.57	0.49	0.59	0.65	0.63
if yes, share of harvest sold	0.77	0.81	0.85	0.76	0.01	0.70	0.91	0.78	0.74	0.69
Input cost	176.69	158.96	250.32	222.17	177.08	182.00	156.94	169.59	169.69	247.11
Net revenue	471.76	451.33	463.97	430.47	281.25	545.76	438.46	457.71	510.40	519.12
Produced rapeseed	0.12	0.10	0.02	0.09	0.14	0.23	0.01	0.07	0.15	0.38
Area (ha)	181.63	126.59	935.00	283.11	184.05	189.95		22.41	78.54	295.59
Yield of rapeseed (t/ha)	2.76	2.68	4.81	3.30	1.86	3.05		2.47	2.41	3.04
Price of rapeseed ($/t)	391.44	369.30	473.17	419.13	382.02	407.03		350.87	356.64	432.03
Sold rapeseed (y/n)	0.88	0.82	1.00	0.95	0.86	0.95		0.89	0.97	0.84
if yes, share of harvest sold	0.93	0.95		0.88	0.92	0.92		0.96	0.94	0.90
Input cost	275.45	232.79	143.52	253.93	310.66	313.38		262.90	331.12	245.09
Net revenue	723.33	641.72	1,942.96	775.82	390.07	934.77		759.87	507.48	854.81

Source: Own computation from MAPF/WB/EU small producer survey

Appendix table 4: Distribution of farm TFP by farm size and ownership type

Size group	Total			Legally registered farms			Informal farms		
	TFP		No.	TFP		No.	TFP		No.
	Mean	CV	obs.	Mean	CV	obs.	Mean	CV	obs.
<50 ha	0.908	0.266	226	0.951	0.255	49	0.896	0.268	177
50-120 ha	1.043	0.218	375	1.045	0.216	183	1.042	0.221	192
120-500 ha	1.085	0.225	240	1.078	0.221	166	1.100	0.234	74
>=500 ha	1.155	0.184	100	1.158	0.187	95			
Total	1.033	0.238	941	1.068	0.221	493	0.995	0.253	448

Note: As discussed in the text, informal farms are either operations run by individuals or by FOPs. For legally registered farms, mean farm TFP in the less than 50 ha, 50-120 ha and 120-500 ha category is statistically different from the mean TFP in the greater than 500 ha category at 1%. For informal farms, mean farm TFP in the less than 50 ha category is statistically different from that of 120-500 ha category at 1% while the equality of mean TFP between 50-120 ha and the 120-500 ha category can only be rejected at 10%.

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