Policy Research Working Paper 10912

Using Satellite Imagery and a Farmer Registry to Assess Agricultural Support in Conflict Settings

The Case of the Producer Support Grant Program in Ukraine

Klaus Deininger
Daniel Ayalew Ali

WORLD BANK GROUP
Development Economics
Development Research Group
September 2024

Abstract

While cash transfers have emerged as an attractive option to minimize negative long-term impacts of conflict, the scope for targeting and assessing their impact in such settings is often challenging. This paper shows how a digital farmer registry in Ukraine (the State Agrarian Register) helped to target and evaluate such a program, using the country's $50 million Producer Support Grant in a way that largely avoided mis-targeting. The analysis applies a difference-in-differences design with panel data from 2019–23 on crop cover at the parcel/farm level for the universe of eligible farmers registered in the State Agrarian Register. The findings suggest that the program significantly increased area cultivated, although the effect size remained modest. Impacts were most pronounced near the frontline and for the smallest farmers. The paper discusses the implications in terms of a more diversified menu of support options and the scope of using the State Agrarian Register to help to implement these options, as well as lessons beyond Ukraine.

This paper is a product of the Development Research Group, Development Economics. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/prwp. The authors may be contacted at kdeininger@worldbank.org and dali1@worldbank.org.

Using Satellite Imagery and a Farmer Registry to Assess Agricultural Support in Conflict Settings: The Case of the Producer Support Grant Program in Ukraine

Klaus Deininger[1]
Daniel Ayalew Ali[1]

JEL Codes: Q10, O13, H56, R14

Keywords: Ukraine, conflict/war, food security, agricultural production, cash grants, remote sensing

1 The World Bank, 1818 H Street NW, Washington, DC, USA

The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent. Funding support from the European Union (ENI/2017/387-093 and ENI/2020/418-654) is gratefully acknowledged. We thank Denis Bashlyk, Eduard Bukin, Markiyan Dmytrasevych, Taras Gagalyuk, Ben Hell, Thea Hilhorst, Roman Hrab, Sergyi Kubakh, Nataliia Kussul, Vasyl Kvartiuk, Guido Lemoine, Daria Manzhura, Andrii Martin, Sevara Melibaeva, Roman Neyter, Oleg Nivievskyi, Martin Petrick, Irina Schuman, Andrii Shelestov, Stefan von Cramon-Taubadel, Taras Vysotskyi and Sergyi Zorya for helpful discussions and insightful comments and as well as Tania Khorzovskaya for outstanding coordination and administrative support.

Using Satellite Imagery and a Farmer Registry to Assess Agricultural Support in Conflict Settings: The Case of the Producer Support Grant Program in Ukraine

1. Introduction

The Russian Federation's invasion of Ukraine in February 2022 started a war that has to date displaced more than 8 million individuals, destroyed the productive capacity and infrastructure of vast stretches of territory, and resulted in marked decreases in agricultural productivity. To help small and medium-size farmers, who are most likely to be credit constrained, to cope with this shock, Ukraine's Ministry of Agriculture established a digital registry platform, the State Agrarian Register (SAR) in August 2022 with the goal of implementing support programs, including an EU-supported US$ 50 million Producer Support Grant (PSG) and improve farmers' ability to access markets. We use the SAR's link to administrative data from the registry of property rights and the cadaster at parcel-level to assess the targeting and impact of this program, compare results to those from a phone survey, and draw out implications for future research.

At the start of the war, most of the 2021 harvest was still in storage but traditional export routes had been blocked, requiring development of logistics through alternative and more costly overland routes. Similarly, fertilizer imports from Russia were cut off. Once immediate military challenges had been fought off, an immediate challenge was to secure market access and essential support (with reconstruction, generators, essential inputs, grain drying facilities) to many farmers in a setting with restrictions on physical movement, limited capacity, and a tradition of weak governance. While power supplies and cyber-attacks posed challenges and many doubted farmers who traditionally remained in informality to avoid taxes in a cash-based economy would be willing to abandon their anonymity, a digital registry platform emerged as the most viable solution and the SAR, interoperable with registry and cadaster, was launched by August 2022.

The PSG, which provided a cash grant to small farmers (below 120 ha) proportional to the amount of land cultivated in 2022, was one of the first programs using the SAR. Although it provides interesting qualitative insights, high rates of non-response and attrition reduced the representativeness and power of a phone survey. Combining administrative data with use of the universe of eligible SAR registrants thus provides an alternative way to explore PSG targeting and impact. As resources were made available on a first come, first served basis, analysis of impacts on area cultivated is more challenging methodologically. We use the pool of farmers whose digital application was lodged too late to be processed before PSG resources had been exhausted as a control group and use weights from entropy matching to establish comparability in observables between treatment and control. Parallel pre-trends cannot be rejected and insignificant coefficients from a placebo test allay concerns about differences in unobservables driving our results.

We find that receipt of a PSG grant of $86 per ha had a significant, though quantitatively modest, impact on area cultivated with summer crops. Interestingly, this impact was largest for farms located closest to active fighting and in the smallest size group (below 20 ha), two sub-groups with the greatest difficulty in accessing alternative sources of finance so that grant resources may have been important to bridge short-term gaps. On the other hand, the size of the grant is well below the level of demand for credit articulated in the farm survey. To help farms, especially those further from the front, diversify into higher value crops, it will be important to explore how grant resources can be used to leverage larger amounts of bank finance. This will require using the digital platform built on the SAR to reduce the transaction cost of accessing credit, including by allowing banks to validate applicant information, farmers to access technical support, and linking to other factor and output markets. Beyond the methodological contribution of this paper, further research along these lines could help to appreciate the size and incidence of benefits from a digital farm registry and the implications for public investment and cost recovery.

We contribute to three strands of literature. First, a large body of literature shows that real-time use of administrative data can greatly improve targeting and effectiveness of public programs. Examples include use of biometric IDs to identify beneficiaries (Muralidharan *et al.* 2016), transfer of cash that is coordinated with actual implementation (Banerjee *et al.* 2020), or use of administrative data to solicit user feedback to help monitor public service providers (Muralidharan *et al.* 2021). Our finding that, even in a conflict environment where accountability and capacity have traditionally been limited, verifiable data from official sources can help transparently target benefits to groups that have been underserved in the past adds to this literature. It reinforces the notion that, especially in crisis or conflict settings, non-traditional data sources including mobile phone data can help target support (Aiken *et al.* 2021).

Building on studies showing spatial data can be used to enforce land use regulations (Assuncao *et al.* 2019) or certify supply chains' environmental sustainability (Heilmayr *et al.* 2020; Moffette *et al.* 2021), including establishing links to public support (Assunção et al. 2020),[1] we also show that, if combined with remotely sensed imagery, cadastral data can be used beyond targeting to evaluate the impact of specific programs, something that has proven to be more difficult for mobile phone data (Aiken *et al.* 2023). In Ukraine's case, the ability to access a reasonably complete cadaster was a distinct advantage as setting up the spatial data on which to run a farm registry during war time was impossible.

A second topic is the digitization of agriculture. While digital technology, including equipment-mounted sensors that are now routinely used by large farms (Deines et al. 2021), improved productivity (Chancellor 2023) by increasing input use efficiency and reducing uncertainty (Khanna 2021), high fixed costs imply

[1] Refer to Moffette and Gibbs (2021), Carlson *et al.* (2018), Lee *et al.* (2020), and Pacheco *et al.* (2020) for a discussion of challenges and impacts. Merkus (2024) shows that effective enforcement can be beneficial for economic growth.

this technology comes with strong economies of scale. Use of digital technology to reduce trade and transaction costs, including those related to identifying partners, negotiating a deal, proving compliance with standards, and logistics (Jouanjean 2019), while not without challenges (Zant 2024), can be more size neutral. It offers the opportunity to improve market access (Huang *et al.* 2022), resilience (Guo *et al.* 2023), and reduce risk or credit constraints (van Campenhout 2022).[2] Low marginal cost of disseminating and accessing advice digitally has also been shown to increase uptake (Abate *et al.* 2023; Mohammed and Abdulai 2022) and willingness to pay (Hidrobo *et al.* 2022b). Yet, efforts to establish nation-wide farmer registries in countries as diverse as the Philippines (Reyes and Mina 2017),[3] India,[4] Kenya,[5] Guinea, Mali, and Niger (Ba *et al.* 2019) have struggled to take off or be maintained.

Our paper shows that, from an IT perspective, a viable farm registry can be put together rather quickly and that even small farmers who have traditionally remained informal will sign up if they see tangible benefits. Beyond grants, farm registries provide opportunities to link small farmers to markets and data to allow them to access services—from technical advice to insurance—that are otherwise limited to much larger farms. The ability to realize these opportunities depends on public action beyond the upfront investment to establish a registry to ensure the information it contains is current and reliable, something that will be achieved in Ukraine through a requirement that all state support be channeled through the SAR platform and its use as the basis for an EU-type integrated administration and control system (IACS), and regulation to govern data access. As the impact of new technology is sensitive to implementation (Muralidharan *et al.* 2023), this creates opportunities of great interest to other developing countries.

Third, a large and growing body of literature shows that weather-induced fluctuations in agricultural yields, the frequency of which is likely to increase with climate change, can trigger persistent conflict (Harari and La Ferrara 2018). Conflict in turn can lead households to reduce human capital investment (Akresh et al. 2023; Büttner et al. 2022) and, by modifying their assessment of risk (Federle et al. 2022), influence activity choice (Arias et al. 2019; Fergusson et al. 2020), trust (Korovkin and Makarin 2023), social interaction (Couttenier et al. 2022), and long-term economic outcomes (Chiovelli et al. 2021; Ibanez et al. 2022). By reducing households' vulnerability to shocks, cash transfers can thus lessen conflict risk (Fetzer 2020) and increase resilience (Agwu 2023).[6] Survey-based evidence on the effect of transfers for farmers in conflict settings is more limited: in the Republic of Yemen, where conflict increased child malnutrition, cash

[2] Whether or not this is size neutral is an actively discussed issue, a combination of digital new actors and public action, can improve access for all (Birner *et al.* 2021) (Reinhardt 2023) and involves challenges (Finger 2023).
[3] A complete overhaul of the Filipino farmer registry (https://www.pna.gov.ph/articles/1218397) has yet to produce tangible results.
[4] Refer to https://agristack.gov.in/#/ and https://www.nic.in/products/fruits/.
[5] Refer to https://www.kalro.org/kiamis/ and https://www.fao.org/kenya/news/detail-events/fr/c/1630294/.
[6] Premand and Rohner (2024) show that in Nigeria, beyond reducing conflict through an increase in poor households' opportunity cost for fighting, transfers created incentives for looting that increased conflict. Digital transfers can and are less likely to be intercepted by rebel groups than public cash transfers that are transmitted via analog means (Ghorpade 2020).

transfers alleviated negative nutritional impacts (Ecker *et al.* 2023), and both in cash and in-kind transfers helped households switch to activities with higher return and liquidity needs or risk (Schwab 2019). In Mali, exposure to conflict also reduced use of conventional inputs by farmers, an effect that was partly reversed via cash transfers (Sessou and Henning 2024). Cash transfers fostered investment in profitable endeavors beyond subsistence for men but also affected marital migration of women (Hidrobo *et al.* 2022a).

Earlier studies used satellite data on night lights (Chiovelli et al. 2018), complemented by vegetation indices (Ben Yishay et al. 2024), to assess the impact of landmine clearance on economic activity at a granular level. Ours is to the best of our knowledge the first study that relies on administrative and remotely sensed data jointly to analyze short-term farm-level effects of an intervention in near real time in a setting where an ongoing conflict makes other forms of data collection very challenging to implement. Our ability to identify average effects that were not be detected in a survey as well as heterogeneity of such effects across locations and fam size groups suggests that use of administrative data can usefully complement traditional approaches to data collection in the agriculture sector, as noted also by Yacoubou Djima and Kilic (2024).

In Ukraine's context, some simple administrative measures such as storing historical registry information and ensuring applications for and final award of other types of support are recorded in SAR can help to improve the quality of estimates, and regulation to govern and implement such measures is already under preparation. Improved collection of training data beyond the country's five main crops could help to expand the range of outcome variables considered while donors could help ensure that future programs are designed in a way that makes them more amenable to impact evaluation.

The rest of the paper is structured as follows. Section 2 documents the context of Ukraine's agriculture and PSG implementation modalities. Section 3 provides details on war effects and PSG access based on phone survey data. Section 4 expands on this by using administrative and remotely sensed information to assess targeting quality and program impact on area cultivated with summer crops in the 2023 season, directly after resources were received. Section 5 concludes with implications for policy and research.

2. Context and setting

Given its turbulent history of collectivization and famine in the first half of the 20th century and privatization at the beginning of the 21st century, Ukraine's agricultural sector is distinctly different from what is found in other European countries. Coming at a time of reforms to improve transparency and create preconditions for a functioning and socially inclusive market economy, the war triggered by the invasion led to a severe disruption of agricultural of grains and oilseeds, major damage to the stock of physical capital, and unprecedented population displacement. To help address some of the resulting challenges and adopt key elements of EU policy, the government established the digital SAR registry platform, using it to implement the EU-supported producer support grant targeted to small farmers (< 120 ha) among many others.

2.1 Ukraine's agricultural sector

With more than 40 million ha of some of the most fertile agricultural land globally, Ukraine has traditionally been a key global supplier of agricultural commodities, especially sunflower oil, maize, and wheat. Before the war, agriculture contributed about 10% to GDP and 42% of the country's exports. The sector's structure was shaped by de-collectivization in the early 2000s when some 7 million landowners were provided with land shares of about 4 ha each. Some 20 million ha of Ukraine's agricultural land is farmed by formalized large farms, often firms with links to foreign capital markets (Deininger *et al.* 2018) that lease land from owners. About 12 million ha is estimated to be cultivated by small and household farms many of which lack the resources to register formally and may also not be covered by the country's agricultural statistics. In 2002, about 9.2 million ha was state or communal land and an unknown share of this land was 'privatized', often in non-transparent ways that imposed significant losses to the public (Nivievskyi 2020). The country has one annual growing season with winter crops (wheat, rye, barley, rapeseed) sown in fall, summer crops (barley, maize, sunflower, soybean) in the spring and harvest from July to November.

In 2019 and 2020, Ukraine enacted far-reaching land governance reforms including allowing sales of agricultural land through the stepwise lifting of a moratorium on such transactions that had been in place since 2001. This was expected to allow use of land as collateral for credit to deepen domestic capital markets and, in the agricultural sector, support diversification, , especially by smallholder producers, away from land- and capital-intensive bulk commodities with little value or employment added. Complementary institutional reforms included measures to (i) improve transparency and data access as well as quality via digital interoperability; (ii) improve public land management by transferring ownership to local governments and requiring all lease rights to public land to be done through electronic auction; and (iii) establish a partial credit guarantee facility to ease access to financial markets by small producers.

While some of these measures had shown positive effects,[7] the war started by Russia's invasion in February 2022 profoundly affected economic and social outcomes in three ways. First, the blocking of low-cost avenues for grain exports via Ukraine's Black Sea ports and the need to shift to more expensive alternatives negatively affected Ukraine's comparative advantage in exporting bulk agricultural commodities with possibly far-reaching effects on long-term prospects and profitability of Ukraine's agriculture (Wilson *et al.* 2024) For example, for wheat, Ukrainian producers are estimated to have lost $1.4 billion in producer surplus (Devadoss and Ridley 2024), while Russia sustained at most modest losses or may even have gained

[7] The mandatory shift from centralized in-person to fully electronic auctions run by local authorities for any transfer of use rights to public land instantaneously increased lease prices by 175% (Deininger *et al.* 2023b).

(Rose *et al.* 2023). Long-term impacts will depend on the extent and speed with which low-cost transport routes can be restored. Second, 5.3 million individuals are estimated to have been internally displaced in the first three weeks of the war alone (Leasure *et al.* 2023) and overall displacement, including international migrants, of more than 8 million or 20% of the country's pre-war population (Adema *et al.* 2023). This curtailed labor availability and reduced the economy's human capital stock (Egert *et al.* 2023). While many out-migrants may have left with an intention to return, such return becomes less likely the longer they stay and get settled in host communities. Finally, the war affected agricultural production directly by creating damage to the capital stock relevant for agriculture (Khoshnood *et al.* 2022), destruction of standing crops or war damages of agricultural fields (Kussul *et al.* 2023) that, as in the case of mining or unexploded ordnance (Duncan et al. 2023), may reduce productive capacity in the long term or in a way that is costly to restore. Damages to the agricultural capital stock are estimated at US$ 10.3 billion, 57% is for machinery, 18% for storage facilities, and the remainder for outputs, inputs, and crops or livestock (Neyter et al. 2024) out of a total of US$ 152 billion (World Bank 2024).

2.2 The PSG program and the SAR platform

Building on legal foundations created by the 2020 reforms, the government, via the Ministry of Agricultural Policy and Food (MAPF), established the State Agrarian Registry (SAR) in August 2022 and expedited its roll-out as a platform that would allow digital interaction between farmers and state organs and accredited users in the private sector. One objective was to establish a digital tool to overcome the informational and institutional barriers that, in the past, made it difficult for credit constrained small and medium farmers to access state support.[8] A second objective was to reduce leakage to intermediaries by transferring support directly into beneficiaries' bank accounts. To allow this, all farmers, irrespective of their formal status a (i.e., a registered legal entity, a family farming business (FOP), or as individual) can use their electronic signature to sign up at the SAR website (https://www.dar.gov.ua/) without charge, thus avoiding the transaction cost and bureaucratic hurdles associated with registration as a legal entity. To assess the extent to which these objectives were achieved, MAPF, with EU support, asked the World Bank to conduct an independent evaluation of the PSG program and provided access to necessary data.

In the sign-up process, SAR gathers owner details from the State Registry of Property Rights and parcel details from the land cadaster for all land parcels to which the farmer has registered rights. This allows the government to establish, in rudimentary form, all the elements used by integrated administration and control systems (IACS) operational in EU countries.[9] It also helps establish the SAR as a trusted source of

[8] It has been argued that traditional ways of transferring state support in Ukraine had little economic justification, were non-transparent, and, by *ex post* subsidizing interest rates for farmers who have already taken out loans, have little economic justification and offer no additionality. For example, refer to https://voxukraine.org/en/the-new-agricultural-support-system-in-ukraine-who-really-benefits.

[9] The IACS is used to manage, monitor and control all area or animal-based common agricultural policy (CAP) interventions (such as direct payments interventions and area and animal-based rural development interventions). It consists of several digital interconnected databases,

information specific data from which can, with data owners' consent, be accessed by accredited private parties for their own purposes.[10] This makes it easier for banks to evaluate credit applications or for advisory service providers to tailor crop management advice to the specific conditions prevailing on a farmer's fields, leveling the playing field between large and small farms and encouraging farmers to fix discrepancies between reality and formal records.[11]

Supported by a call center to assist with application processing, more than 86,000 producers had signed up to SAR by end 2022 with a total of 150,000 farmers registered by June 2024. This is much larger than the total of some 40,000 agricultural producers in the sample frame used by the national statistics office. The ability to quickly and unbureaucratically communicate with farmers made SAR the instrument of choice for implementing a broad array of programs to increase the agriculture sector's resilience, e.g., via in-kind provision of seeds, fertilizer, generators, or plastic tubes for on-field grain storage, often by specific donors.

The EU-supported Producer Support Grant (PSG) program, the largest program implemented on SAR thus far, transferred a total € 50 million as an unconditional cash grant to small producers, defined as cultivating more than 1 and less than 120 ha or owning between 3 and 100 cows, via a land- or a livestock sub-program on a first-come first served basis.[12] The land program, which is the focus of our analysis,[13] paid farmers UAH 3,100 (about US$ 86) for each hectare of land that was (i) formally registered in the applicant's name; (ii) located outside of conflict affected areas; and (iii) declared to have been cultivated in 2022. It aimed at providing working capital support to prevent decapitalization or liquidation of small and medium farms in response to the hardship inflicted by the war. Implementation was swift: applications for the full amount of grants available had been received by November 15, 2022, leading to closure of the application process about two months after the program had been launched and disbursement of money to beneficiaries once administrative formalities had been completed 6-8 weeks after applications had been closed.

including (i) a land parcel identification system (LPIS) is used to identify all agricultural land parcels; (ii) a geo-spatial application (GSA) that allows beneficiaries to visually indicate the areas for which they apply for aid; (iii) the area monitoring system (AMS) that is used to observe, track and assess agricultural activities using remotely sensed data; and (iv) a system to identify beneficiaries.

[10] Farmers can carry out the required actions digitally rather than by filling paper forms, including uploading scanned documents and photos or providing authorization for providers of certain services to access specific types of personal information stored on the system.

[11] 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. The government plans to add information from other registries, including the registry of court cases, in the near future. Development of SAR has been supported by the World Bank and the EU.

[12] Funds were transferred from the EU to the state budget and implemented as a standard state support program with responsibility for administration and cross-checking delegated to the farmer support fund of Ukraine. To support sign-up and applications, a call center was established and, between Aug. 12 when the SAR was launched and Dec. 31, 2022, received 26,197 calls. The SAR has also been used to manage distribution of short-term grain storage by FAO, for distribution of various type of emergency support, and for follow-up programs to support recovery. The latter include US$ 50 million out of a US$ 320 million grant combined with a US$ 230 million loan under the World Bank's ARISE project. SAR is also planned to be used as the platform for farmers to apply for partial credit guarantees to be provided by an independent agency that is jointly capitalized with recourses from the World Bank and the EU.

[13] The 'cow program' would provide UAH 3,600 (equivalent to US$ 120 at the time of program formulation) for each head of cattle registered in the farmers' name in the government's Animal Registry and confirmed to be still alive. While the government had concerns that fear of becoming visible to the state for taxes would prevent individuals and FOPs from registering in SAR, sign-up data show that those fears were largely unfounded.

Whether farms have less than 120 ha of agricultural land registered in their name in non-conflict areas is easily verifiable.[14] Those that have more land registered may be eligible if they did not cultivate all their land in 2022. Although in the PSG program, area cultivated was based on farmers' declaration, with random checks only, it can be easily verified by overlaying parcel boundaries from the public cadastral map with publicly available crop maps although technical challenges of quickly establishing real time interoperability between registries did not allow doing so in this case.[15]

Appendix table A1 provides information on disbursement under the PSG land window for the universe of beneficiaries. The program paid a total of 35.1 US$ million in grants to 21,050 farmers. Of these, 73% had an area smaller than 20 ha, 15% were from 20 to 50 ha in size, and 12% had between 50 and 120 ha. As the grant was proportional to area, those in the three groups received 24%, 27% and 49% of total resources respectively. Of the farms receiving PSG support, 20% were organized as legal entity, 12% as sole proprietorship (FOP), and 68% as unincorporated individuals, receiving 50%, 22%, and 28% of resources, respectively. Table 1 displays the same figures for 19,660 beneficiary farms in the regression sample used for subsequent analysis.[16]

3. Farm-level effects of the war and PSG access

Survey data, together with market price information, show that, while total area cultivated was remarkably resilient to the war, profits per ha for Ukraine's traditional agricultural export crops halved due to lower output and higher input prices, though land prices suffered only modest declines. High levels of unsatisfied credit demand are one factor limiting small producers' ability to respond to the associated relative price changes by diversifying into higher value crops. The PSG per-ha grant provides working capital rather than investment support and was indeed used in this way by most recipients, though survey data provide no conclusive evidence on its targeting or impact.

3.1 War effects

For descriptive analysis of how PSG resources help to better deal with war impacts, we use data from two rounds of a nationwide phone survey of small and medium-scale farmers conducted by MAPF.[17] specifically for this purpose. Using all producers registered in SAR by October 15, 2022, as a frame, the sample was stratified by whether or not an application for PSG had been lodged by this date and by four

[14] Location of fields in areas outside of the government-maintained list of conflict-affected locations is verifiable from parcels' cadastral numbers.
[15] Due to restricted interoperability with the registry of rights, the amount of PSG funds obtained was based on farmers' declaration of total area cultivated rather than on automatically aggregating total cultivated area from the parcels to which the farm had registered rights. Fully automated controls are expected to be hard-coded in future versions of the SAR software.
[16] Reasons for excluding farms were that (i) some or all of the parcel shapefiles needed for overlays with crop cover data was missing for 605 farms; (ii) 530 farms were excluded as they did not cultivate summer crops but only winter crops and pastures in the 2019 to 2023 period; (iii) although they received grants only for the area located in non-conflict areas, 227 farms also had registered parcels in the conflict zone, making them quite different from the rest; and (iv) 28 farms had 2022 cultivated area in excess of the 120 ha cutoff.
[17] The survey was implemented by the Kyiv International Institute of Sociology, with financial support from the European Commission, under the guidance of the World Bank in collaboration with the School of Economics.

farm size classes (<20 ha; 20-50 ha; 50-120 ha, and > 120 ha). As there were no PSG applicants with more than 120 ha, this yielded a total of 7 strata. See Deininger *et al.* (2024) for a more detailed discussion of the sampling procedure, including a comparison to the official statistical database.

Data were obtained by phone in two waves in winter 2022/23, when information on the 2021 and 2022 agricultural seasons was collected, and in winter 2023/24, collecting data for the 2023 agricultural season, providing a three-year panel with data from before and during the war for the same farms. As might be expected in a setting where trust is low, the population has been traumatized by conflict, and mobile connectivity or electricity are frequently disrupted, levels of nonresponse and attrition were unfortunately very high: out of a total sample of more than 10,000 sample farms, only 2,500 valid responses were obtained in the 2022 round and only about half of these could be traced and provided answers in 2023.[18]

To assess whether selective non-response may have resulted in bias, we can use data for all SAR registrants to check for variables that might increase the likelihood of a valid survey response by running a probit regression for whether a survey response was obtained. Results from doing so in appendix table A2 show that, with a marginal effect of 0.18 having applied for programs other than PSG is by far the most important predictor of a positive response to the survey, followed by being organized as a FOP (marginal effect of 0.13), having applied for PSG (0.10), and considering an application for credit (0.07).[19] Once these factors are controlled for, proximity to the front, as indicated by a dummy for being located within 50 km from the frontline, does significantly affect the likelihood of a positive survey response.

To appreciate the impact of the war on sample farms, table 2 displays, for farms participating in both survey years, changes between 2021 or 2022 and 2023 in area cultivated and profitability as well as factor use, credit market participation (actual and desired), and perceptions.[20] Panel A suggests that, while mean area cultivated remained approximately constant, physical yields for key crops decreased by between 6% (for rapeseed) and 21% (maize or sunflower) in the first war year but returned close to pre-war levels in 2023. This display of resilience notwithstanding, revenue per hectare decreased by 34% between 2021 and 2022 to US$714 with a further decline to US$597 (or 56% of the 2021 level) in 2023. With an increase of 26% in input costs over 2021 levels in 2022, this led profits per hectare to drop by 60%, from US$778 to US$313. The share of output sold to the market decreased from 78% to 68% in 2022 and remained 20 percentage points below

[18] Two-thirds of the nonresponses were due to inability to reach the relevant contact, in most cases because phone lines were unreachable or disconnected or the enterprise had gone out of business whereas one-third was due to refusal. A probit model with baseline covariates suggests that the likelihood of non-response is much lower among PSG beneficiaries (-25%), applicants to other programs (-48%), those hoping to access credit (-17%), or FOPs (-30%) is much lower than for the rest of the sample. Respondents' status, perceived personal situation, experience of direct war damages, and region did not affect response rates, but larger farms were significantly less likely to respond.

[19] Respondents may reason that responding to the survey could increase their chances of receiving support.

[20] As these are farm-level differences, there is no need to apply weights.

the share attained in 2021 in 2023. While lower input prices led profits to recover to US$397/ha in 2023, this was only 54% of the 2021 level.

Price data in appendix table A3 reinforce this narrative by illustrating that (i) output prices for main crops almost halved in 2022; (ii) with unit transport cost increasing by 48% over pre-war levels in 2022, prices for imported fertilizers more than doubled and those for other inputs increased markedly directly after the invasion; (iii) prices for locally produced services or inputs increased markedly in 2022 but largely returned to within 10% of their pre-war levels by 2023; and (iv) output prices for all crops except soybean declined further from their 2022 levels in 2023, resulting in a modest rebound of farm profitability.

Panel B of table 2 uses survey data to support the notion that price changes are the main channel through which the war affected agricultural outcomes in our sample. About 8% of respondents suffered direct damage to structures or land through the war. The number of family members working full-time on farms which had remained unchanged between 2021 and 2022 increased by about 30% from 2022 to 2023, from 1.5 to 2, and 0.72 to 0.89, with a 24% increase in part-time workers from 0.72 to 0.89, though the number of permanent employees did not change. The share of those receiving public support fluctuated between 32% and 40% with only marginal fluctuations in the amount received per household. While respondents' subjective rating of their situation had dropped sharply from 2021 to 2022, it improved slightly since then.

Despite the drop in profitability, data on land prices and intentions to expand operated area suggest that fundamentals in agriculture remain favorable as compared to the alternatives: lease prices remained largely unchanged, partly because contracts are long term and may be difficult to renegotiate. Although the share declined slightly, from 85% in 2022 to 79% in 2023, more than three in four farmers indicate they want to lease more land at the current lease price if conditions return to normal. With 74%, down from 79% in 2022, interest in buying land, at a per hectare price almost unchanged from 2022 (US$ 1,473 in 2023 vs. 1,540 in 2022), remains high. While credit rationing was widespread, the share of those able to access credit declined only slightly, from, 25% in 2022 to 22% in 2023 although average loan size decreased from $ 84,689 in 2022 to $ 70,755 in 2023 and the interest rate increased significantly, from 4.6% to 8.8%.

3.2 PSG access

Table 3 panel A compares farm characteristics in 2022 and 2023 for PSG eligible survey respondents (i.e., those cultivating less than 120 ha) who did (columns 1 and 2) and did not (columns 6 and 7) receive a grant, respectively.[21] Both groups seem largely similar in terms of endowments and trends regarding labor and machinery, mirroring general trends observed earlier in terms of satisfaction and access to markets for land

[21] Appendix table A4 presents summary statistics by PSG participation and eligibility criteria while appendix table A5 replicates table 3 by restricting only to farms located within 50 km from the frontline, suggesting the figures are comparable to national ones.

and capital with about two thirds being interested in accessing a loan but only 15% of PSG recipients an 10% of non-recipients being able to access a much diminished amount of credit (from almost $ 40,000 to slightly above 20,000 per loan) at an interest rate that was almost double what had been charged in 2022.

In 2023, respondents were also asked about their interest in loans for working capital or investment at the prevailing interest rate (of 5%). About 40% of PSG recipients and non-recipients are interested in a loan with a desired mean loan size of about $ 33,600 (with a median of $ 16,400) for working capital loans and $ 84,800 (with a median of $ 54,700) for investment loans which translates into about $ 510/ha for working capital and $ 1700/ha for investment loans for all but the smallest farm size group. The $ 89 received on average via the PSG amounts to less than 20% or 10% of expressed demand for working or investment credit, respectively. Demand for grants with a 25% matching component is, with 63%, significantly higher, especially in the 20-120 ha group, implying that a matching component could possibly serve as a useful tool to separate between loan demand for consumption smoothing and for investment. For PSG recipients, table 3 panel B suggests more than 98% of resources received was reported to have been used as working capital for crop or livestock production (88% and 11%, respectively) and only 1% reporting to have used the resources for investment.

If access to PSG (and survey response) were random, the double difference Δ_{PSG}-$\Delta_{Non\text{-}PSG}$ between values in 2023 and 2022 for PSG participants and non-participants, would provide an estimate of the program effect. Results of a t-test for Δ_{PSG}-$\Delta_{Non\text{-}PSG} = 0$ reported in column 8 suggest that none of the other variables show a significant difference. To avoid potential bias from selective responses to the survey, we use cadastral data for the universe that is available for the universe of eligible SAR registrants to check if receipt of a PSG grant affects this variable.

4. Assessing PSG impacts on area cultivated and targeting

Cadastral parcel data, together with satellite-based crop maps, suggest that, despite incentives to overstate cultivated area, targeting rules were largely adhered to. A difference in differences design that leverages the timing of program implementation using 5 years of panel data on area cultivated with agricultural crops by the universe of PSG-eligible SAR registrants suggest the program had significant, albeit modest benefits the incidence of which was concentrated among small producers near the frontline.

4.1 Data and evidence on targeting

Overlaying cadastral data for all parcels to which a farm has registered rights with public crop maps (available at https://ukraine-cropmaps.com/) for winter and summer seasons separately,[22] allows us to

[22] Crop maps had been produced under the EU/WB program to 'Improving Transparency of Land Governance in Ukraine'. Refer to (Kussul *et al.* 2022) for the methodology and recent applications. Land registered in the name of the owner but rented out informally could, in principle, have been falsely reported as self-cultivated and counted towards the owners' eligibility but was considered not to be significant enough to matter.

compute, for each farm, the area cultivated with winter and summer crops annually from 2019 to 2023.[23] Comparing cropped area before and after receipt of program funds between PSG recipients and eligible SAR registrants who did not receive PSG resources then can provide an estimate of program impact.

To illustrate the locations of farms in our data, we use the centroid of all parcel centroids as a proxy for the farm's location. Figure 1 panel A shows the map for all farms registered in SAR with a size below 120 ha. Successful applicants in blue and unsuccessful ones in yellow. Areas with yellow dots only correspond to conflict-affected zones identified by Government that were not eligible to benefit from PSG. Excluding these provides us with a sample of 43,003 farms (19,660 treated and 23,343 control) that cultivate land exclusively in non-conflict affected areas. Panel B of figure 1 maps these farms, illustrating that, apart from conflict zones, they cover Ukraine's entire territory.

Data on registered area and crop cover can be used to assess targeting of PSG resources in two ways, namely by identifying if (i) farms that cultivated more than 120 ha (or that did not cultivate at all) received PSG grants and (ii) self-declared area matches with the total area of parcels to which farmers have a registered right that are cultivated. Table 4 illustrates that of 20,445 farms with parcel data (including those with land in conflict areas), 31 had zero cultivated area based on satellite imagery while 46 had registered and cultivated area greater than 120 ha implying that, based on remotely sensed data, they would not have been eligible to receive PSG resources. Also, with 19.15 ha, mean self-reported area is 0.33 ha larger than what was obtained using remote sensing. Despite a strong incentive to over-report area cultivated, this suggests mis-targeting was rather limited, especially if compared to widespread reports about irregularities in earlier farm support programs in Ukraine.

4.2 Methodology and results

To estimate the impact of subsidy receipt on area cultivated, we use the fact that applicants were informed about the status of their application in November 2022 and the money was transferred in December 2022 or January 2023. As this was too late to affect decisions about the area to be planted to winter crops in the 2023 agricultural season, PSG receipt would only affect area decisions for summer crops, allowing us to use a difference-in-differences design with 2023 as the outcome variable. Formally, indexing farms by *i* and time by *t*, we use a farm fixed effects regression of the form

$$Y_{it} = \alpha_i + PSG_i * Post + \boldsymbol{X}_{it}\boldsymbol{\gamma} + \lambda_{\boldsymbol{t}} + \varepsilon_{it} \tag{1}$$

where Y_{it} is the area cultivated with summer crops in *t*, α_i is a farm fixed effect; PSG_i is an indicator variable that equals one if farm *i* participated in the PSG program and zero otherwise; *Post* indicates timing after the

[23] As historical registry records are not accessible, we are able to observe when farmers acquired rights to parcels they currently cultivate and can make adjustments accordingly (implicitly assuming that the last recorded right is the current one and that registration created a new right rather than extending or renewing an existing one), we cannot adjust for rights that were transferred out.

PSG program had been implemented in 2023; $\boldsymbol{X}_{ij}$ is a vector containing levels and squares of weather variables including total precipitation, GDD (>5°C), and the number of days with zero precipitation during planting and growing seasons as well as winter crop area to allow for substitution effects between winter and summer crops that was found important elsewhere (Deininger *et al.* 2023a); λ_t is a time fixed effect that varies with farm size category (< 20, 20-50, and > 50 ha); and ε_{it} is an error term. To explore heterogeneity of potential program effects, we also interact PSG_i*$Post$ with categorical variables for farms' size category (<20, 20-50, and >50 ha), distance to the front (< 50 km, 50-100 km, and >100 km);[24] and legal status (legal entity FOP, or individual).

Table 5 presents descriptive statistics for the regression sample of 19,660 PSG recipients (in panel A) and 23,343 eligible non-recipients (in panel B), overall (column 1) and by farm size (columns 2 to 4), and legal status (columns 5-7). The first two rows in each panel provide the total area of parcels (or agricultural parcels) to which the registrant has a registered right. With an average area of registered land close to 20 as compared to about 9 ha for non-participants, successful PSG participants are larger (12% as compared to 3% cultivating more than 50 ha) and more likely to be organized as a legal entity (19.2% vs. 6.2%) or FOP (12.7% vs. 7,7%) than the control. Overlaying cadastral with crop map information suggests farmers in treatment and control cultivated 96% and 99% of their registered area, respectively, in the pre-war years (2019-2021); the war triggered a marked decline of cultivated area to 93% or 91%, respectively, in 2022 that was partly but by no means fully reversed in 2023. On average, successful applicants received the equivalent of $1,668 ($962 and $ 6,206 for farms below or above a registered area of 50 ha, respectively) via the PSG program.

To improve comparability between treatment and control, we use entropy matching on first and second moments for all regressions variables to re-weight observations in the control sample, making them more comparable to those in the treatment. Appendix table A6 shows that, after re-weighting, normalized differences between farms that received and that did not receive PSG payment are negligible throughout and well below the rules of thumb considered in the literature. Figure 2 graphically illustrates mean values of our outcome variable (area cultivated with summer crops) for treatment and controls in the pre-and post-intervention period, respectively using entropy weights. The null hypothesis of parallel linear trends in the pre-treatment period cannot be rejected at the 5% level although values diverge after PSG became available.

4.3 Results and robustness check

Results, overall (column 1) and with heterogeneous effects by distance to the closest administrative unit affected by conflict (referred to as the 'front line'), farm size, and formality of organization (columns 2-4)

---

[24] For purposes of this analysis, we use the centroid of all parcel centroids as a proxy for the location of the farm.

are displayed in table 6. Receipt of PSG resources is estimated to have increased 2023 summer crop area significantly although with 0.17 ha, i.e., less than 2%, estimated effect size remains modest.

Regressions point to heterogeneity in three respects. First, PSG support seems to have been most effective within 50 km of the 'front', defined as the border to ineligible conflict-affected areas, where the estimated coefficient increases to 0.743 while coefficients on PSG access in areas mor distant from the front remain insignificant. PSG impacts also seem to vary by farm size and organization: Program grants are estimated to have been highly significant impact (coefficient of 0.081) for the smallest farm size group who may be most constrained in terms of accessing other sources of support and marginal (coefficient of 0.71, significant at 10%) for the largest farm size group. Estimated PSG impacts are highly significant for FOPs (coefficient of 0.38) while being less significant (0.09, significant at 5%) for small and marginally significant for farms in the 50-120 ha category (0.317, significant at 10%).

The timing of PSG resource disbursement in December of 2022 allows us to use the area cultivated with winter crops as a placebo treatment to check if there are any unobserved differences between the two groups that may have affected outcomes independently from the receipt of PSG funds. To do so, we run (1) replacing Y_{it} with area under winter crops and in $\boldsymbol{X}_{ij}$, include weather variables and their squares for three (planting, dormancy, and growing) instead of two phases of plant development, and set the cut-off for GDD at 0°C instead of 5°C. Table 6 shows all coefficients in the relevant regressions are insignificant, suggesting that treatment and control groups were not affected differently by the war in other systematic ways.

5. Conclusion and policy implications

We find that mandatory use of a farmer registry with a spatial element allows not only quick implementation and transparent targeting of cash transfers in a conflict setting with low administrative capacity and a long history of endemic corruption, but also use of satellite imagery to assess farm-level impacts on aspects of land use that can be observed remotely.

While we find a positive overall impact of the support to bridge working capital gaps, estimated effects are modest overall and largest close to the frontline and for the smallest farm size group. Beyond showing the usefulness of evaluating interventions in real time using administrative data, this suggests that, even with an ongoing conflict, needs and the most effective responses may differ by location and farm type. A similar package of working capital support may be appropriate close to the frontline and possibly even in areas officially classified as affected by hostilities. In areas farther from the frontline, working capital support as provided under PSG may be insufficient to offset the drop in grain and oilseed profitability and use of grant resources to leverage access to investment credit may offer farms in the size group targeted by the PSG a better chance to diversify into higher value products in line with their factor endowments. Combined with greater private sector use of SAR information, this could help to show how Ukraine's farmers can capitalize on earlier reforms to transform the challenges posed by war and invasion into an opportunity for a more diverse and resilient agricultural sector.

Table 1: Volume of approved PSG land program applications by region and farm size

	Number of successful applicants				Amount	Area per farm			
	Total	**<20 ha**	**20- 50 ha**	**> 50 ha**	**($ mn.)**	**Total**	**<20 ha**	**20- 50 ha**	**> 50 ha**
Total	19,660	14,313	2,953	2,394	32.480	19.5	6.5	35.2	77.7
Panel A: By region									
Center	9,194	6,026	1,689	1,479	18.325	23.5	7.0	35.0	77.8
North	1,503	949	306	248	3.114	24.4	6.6	36.4	78.0
South	4,828	3,994	523	311	6.215	15.2	7.4	35.7	80.1
West	4,135	3,344	435	356	4.827	13.8	4.5	34.5	75.4
Panel B: By organizational form									
Individual	13,340	12,270	845	225	9.225	8.2	5.5	30.7	66.3
FOP	2,519	1,185	695	639	7.279	34.1	9.8	35.1	78.1
Legal entity	3,801	858	1,413	1,530	15.976	49.6	15.9	37.9	79.3

Source: Own computation based on PSG records.

Note: The total number of approved and paid applicants under the land program were 21,050 farms. Data reported in this table is only for 19,660, i.e., the number of PSG beneficiary farms used in the regression analysis after data cleaning.

Table 2: Changes in use of outputs and inputs as well as farm profitability, 2021–23

	2021	2022	2023	Δ21-22	Δ21-23
Panel A: Area cultivated & profitability					
Area cultivated (ha)	216.8	215.1	226.5	-0.01	0.04
Rapeseed yield (t/ha)	2.71	2.55	2.68	-0.06	-0.01
Maize yield (t/ha)	7.05	5.58	6.72	-0.21	-0.05
Sunflower yield (t/ha)	2.36	1.86	2.23	-0.21	-0.06
Soybeans yield (t/ha)	2.45	2.05	2.42	-0.16	-0.01
Wheat yield (t/ha)	4.25	3.45	4.03	-0.19	-0.05
Barley yield (t/ha)	3.69	3.09	3.59	-0.16	-0.03
Any sales	0.78	0.68	0.77	-0.13	-0.01
Share of output sold	0.82	0.60	0.62	-0.27	-0.24
Revenue/ha 6 main crops (US$)	1,088	714	615	-0.34	-0.44
Inputs/ha 6 main crops (US$)	305	385	197	0.26	-0.36
Inputs/ha 6 main crops (US$)	778	313	418	-0.60	-0.46
Panel B: Other factors					
War damage to land/structures (%)		0.08			
Members working full time on farm	1.53	1.53	1.99	0.00	0.30
Members working part-time on farm	0.68	0.72	0.89	0.06	0.24
Permanent employees	5.31	5.22	5.14	-0.02	-0.02
Rating of personal situation (1-10)	7.37	3.68	4.42	-0.50	0.20
Received public support (%)	0.32	0.40	0.36	0.25	-0.10
if yes, amount received	310.53	308.96	321.06	-0.01	0.04
Lease price paid for land (US$/ha)		115.28	112.88		-0.02
Interested in leasing more land[1]		0.85	0.79		-0.07
Interested in buying land		0.79	0.74		-0.06
Max. price to be paid (US$/ha)		1,540	1,473		-0.04
Received credit last 12 months		0.25	0.22		-0.12
if yes, amount received		84,689	70,755		-0.16
if yes, interest paid		4.57	8.83		0.93
Number of farms	1,206	1,206	1,206		

Source: Own analysis of balanced household survey panel data as described in the text.
Note: Profit is the value of output net of purchased inputs, that is, it includes remuneration for fixed factors and family labor. The six main crops are wheat, barley, rapeseed, soybean, maize, and sunflower. ha = hectare.

Table 3: Comparing PSG and non-PSG participants based on farm survey data

	PSG program beneficiaries					Eligible non-benef.		ΔSig
	Total		Size class			Total		
	2022	2023	<20	20 -50	50 -120	2022	2023	
Panel A: Farm characteristics								
Total area cultivated (ha)	68.7	78.4	14.0	50.6	107.0	55.4	70.0	
Members working full time on farm	1.51	1.76	1.86	1.68	1.74	1.64	2.01	
Members working part-time on farm	0.83	1.04	1.19	1.10	0.98	0.86	1.07	
Permanent employees	0.89	1.08	0.17	1.81	1.20	2.11	2.45	
Have tractor < 40 hp		0.22	0.28	0.20	0.20		0.25	
Have tractor 40-120 hp		0.71	0.38	0.72	0.82		0.66	
Have tractor < 120 hp		0.24	0.04	0.14	0.33		0.25	
Have combine harvester		0.36	0.20	0.38	0.41		0.33	
Rating of personal situation (1-10)	3.65	4.43	4.24	4.18	4.55	3.54	4.24	
Received public support (%)	0.43	0.37	0.43	0.35	0.35	0.40	0.39	
if yes, amount received	904	1000	886	1115	1021	870	859	
Lease price paid for land (US$/ha)	125.8	142.7	110.3	101.3	154.2	107	104.4	
Interested in buying land	0.80	0.75	0.55	0.71	0.83	0.70	0.65	
Max. price to be paid (US$/ha)	1718	1552	1600	1594	1534	1473	1449	
Ever considered applying for credit	0.68	0.67	0.41	0.63	0.76	0.65	0.59	
Received credit last 12 months (	0.16	0.15	0.01	0.09	0.21	0.10	0.11	
if yes, amount received (US$)	40,735	25,953	547	56,741	23,976	37,483	21,902	
if yes, interest paid	6.51	10.41	3.00	12.20	10.39	5.10	9.22	
Interest in working capital loan		0.40	0.68	0.43	0.30		0.42	
If yes, amount desired (US$)		38,078	10,202	30,290	43,724		26,503	
Interest in investment loan (%)		0.40	0.67	0.48	0.30		0.44	
If yes, amount desired (US$)		90,907	31,632	76,122	103,145		75,135	
Interest in 25% match grant (MG)		0.63	0.41	0.64	0.70		0.53	
If yes, target amount (US$)		44,953	16,555	41,910	51,929		38,584	
Panel B: PSG benefits & its use								
Used SAR to apply for support		0.73	0.51	0.76	0.80		0.67	
Amount of PSG received (US$)		4,718	737	3,236	6,426			
used for crop prod./harvest input		0.87	0.85	0.93	0.86			
used for crop investment		0.01	0.04	0.02	0.00			
used for livestock		0.11	0.10	0.04	0.14			
used for consumption/other		0.01	0.00	0.01	0.00			
Area (ha) supported by PSG		55.66	8.70	38.17	75.81			
Obtained support other than PSG		0.62	0.19	0.63	0.76		0.49	
If yes, storage		0.02	0.00	0.00	0.02		0.05	
If yes, credit 5-7-9		0.03	0.00	0.00	0.04		0.01	
If yes, fertilizer		0.87	0.57	0.78	0.91		0.89	
If yes, seed		0.33	0.29	0.34	0.34		0.46	
If yes, other		0.11	0.24	0.08	0.11		0.03	
No. of obs.		514	110	79	325		345	

Source: Own computation based on PSG records.

Note: The types of support other than PSG was a multi response question and hence they do not add up to one, and the other category includes cash grant. Other purposes for which SAR was used include checking information on land parcels or prices. ΔSig is the result of a t test for Δ_{PSG}-$\Delta_{Non\text{-}PSG}$ = 0 where Δ_{PSG} and $\Delta_{Non\text{-}PSG}$ is the difference between values in 2023 and 2022, for PSG participants and eligible non-participants, respectively.

Table 4: Comparison of self-reported area to remotely sensed area for program

	Remotely sensed cultivated area category			Total
	0	0-120 ha	>120 ha	
Number of farms	31	20,368	46	20,445
Registered land plots	1.5	7.0	67.8	7.2
Self-reported area	8.1	19.2	91.2	19.3
Remotely sensed area	0.0	18.8	157.7	19.1

Source: Own computation from SAR records and cadastral data as described in the text
Note: Among the >120 ha category, only one farm has agricultural land in conflict areas. For this farm, remotely sensed cultivated area excluding and including parcels in conflict areas was 121 ha and 124 ha respectively.

Table 5: Comparing PSG participants and non-participants based on SAR & remote sensing data

	Total	By size in hectares			By type of organization		
		< 20	20-50	> 50	Legal Entity	FOP	Individual
Part A. Land program successful applicants							
Agric. Land (ha)	19.92	6.64	35.76	79.75	49.46	34.29	8.78
Number of parcels	7.16	2.98	11.03	27.37	18.63	12.11	2.95
Cult. in 2019 (ha)	19.47	6.47	34.96	78.04	48.37	33.43	8.59
Cult. in 2020 (ha)	19.66	6.54	35.30	78.86	48.90	33.76	8.67
Cult. in 2021 (ha)	19.52	6.50	35.05	78.24	48.52	33.49	8.62
Cult. in 2022 (ha) elig.	18.62	5.97	33.32	76.07	46.55	32.22	8.09
Cult. in 2023 (ha)	18.99	6.24	34.03	76.68	47.36	32.68	8.33
Self-reported cult. area 2022 (ha)	19.49	6.51	35.19	77.74	49.58	34.09	8.16
Amount received (US$)	1,652	552	2,983	6,590	4,203	2,890	692
Applied for other programs	0.20	0.08	0.47	0.57	0.54	0.49	0.05
Number of farms	19,660	14,313	2,953	2,394	3,801	2,519	13,340
Part B. Land program non-applicants							
Agric. Land (ha)	9.04	4.85	35.08	86.85	42.55	18.18	5.77
Number of parcels	4.07	2.57	11.26	35.58	19.32	7.90	2.61
Cult. in 2019 (ha)	8.71	4.67	33.81	83.43	40.16	17.42	5.62
Cult. in 2020 (ha)	8.80	4.72	34.18	84.44	40.78	17.62	5.67
Cult. in 2021 (ha)	8.75	4.69	33.88	83.88	40.31	17.45	5.65
Cult. in 2022 (ha)	8.23	4.37	32.38	79.65	37.93	16.52	5.32
Cult. in 2023 (ha)	8.45	4.51	32.85	81.42	39.05	16.87	5.45
Applied for other programs							
Number of farms	23,343	21,368	1,236	739	1,464	1,817	20,062

Source: Own computation from SAR records and cadastral data as described in the text

Note: ‘Cultivated area’ is area for which the farm has ownership or lease rights registered and that was, according to crop maps elaborated by KPI and JRC, covered by agricultural crops in the relevant year. Eligible area excludes area located in conflict-affected areas as described in the text.

Table 6: Treatment regressions - estimated program effects on area cultivated with summer crops

	Overall effect	Heterogeneity by Front distance	Heterogeneity by Farm size	Heterogeneity by Formality
PSG	0.1748***			
	(0.0626)			
PSG * < 50 km to front		0.7429***		
		(0.1107)		
PSG * 50 - 100 km to front		0.0905		
		(0.1013)		
PSG * > 100 km to front		-0.1166		
		(0.0846)		
PSG * farm size < 20 ha			0.0809***	
			(0.0261)	
PSG * farm size 20 - 50ha			0.1656	
			(0.1904)	
PSG * farm size > 50ha			0.6773*	
			(0.3982)	
PSG * Individual				0.0924**
				(0.0452)
PSG * FOP				0.3918***
				(0.1357)
PSG * Legal entity				0.3175*
				(0.1876)
Winter crop area	-0.8566***	-0.8566***	-0.8567***	-0.8567***
	(0.0123)	(0.0123)	(0.0123)	(0.0123)
No. of obs (farms)	215,015	215,015	215,015	215,015
R-squared	0.9554	0.9554	0.9554	0.9554
Mean of dep. var.	10.8791	10.8791	10.8791	10.8791
SD of dep. var.	17.5184	17.5184	17.5184	17.5184

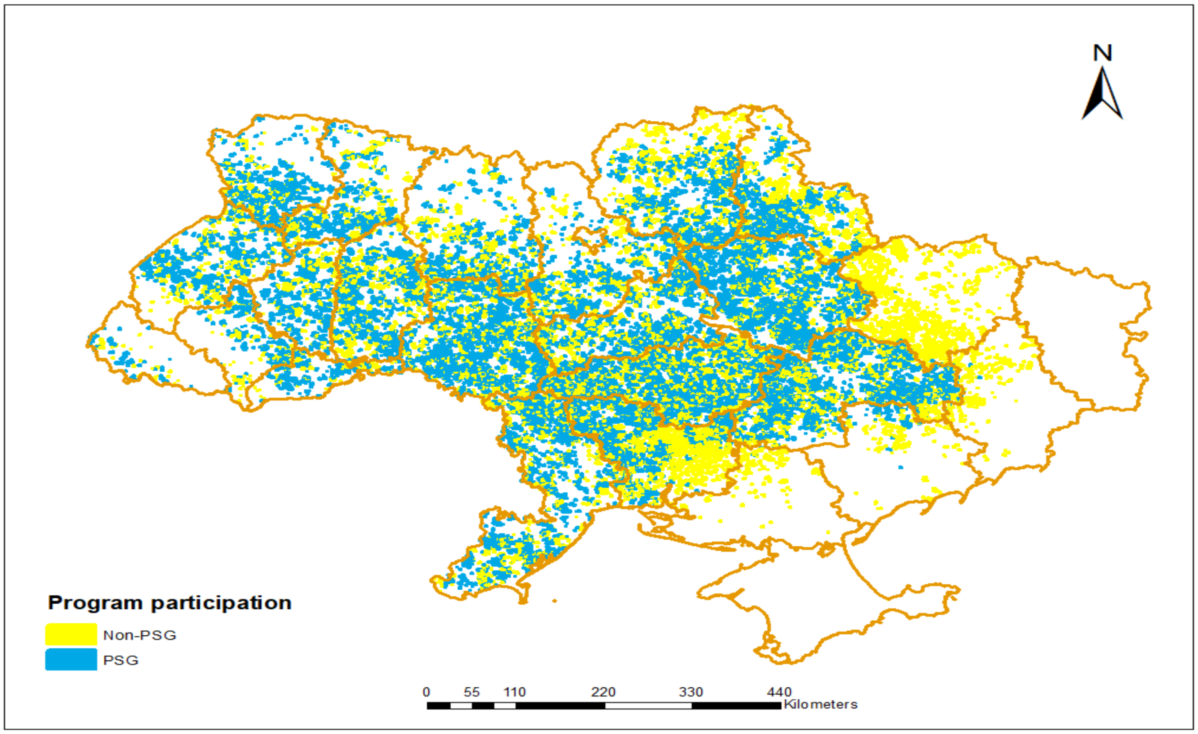
Note: Results are based on weights derived using entropy matching. Dependent area is the area cultivated with summer crops in panel A and the area cultivated with winter crops in panel B. For summer crop regressions in panel A, the level and square of weather variables, in particular GDD (>5°C), total rainfall, and the number of zero precipitation days during the planting and growing seasons, winter crop area, and a constant are included but not reported. In panel B, the cut-off for GDD is >0°C and all weather variables (and their squares) are for planting, dormancy, and growing seasons. Robust standard errors clustered at rayon level in parentheses: * p<0.10, ** p<0.05, *** p<0.010.

Table 7: Placebo regressions - estimated program effects on area cultivated with winter crops

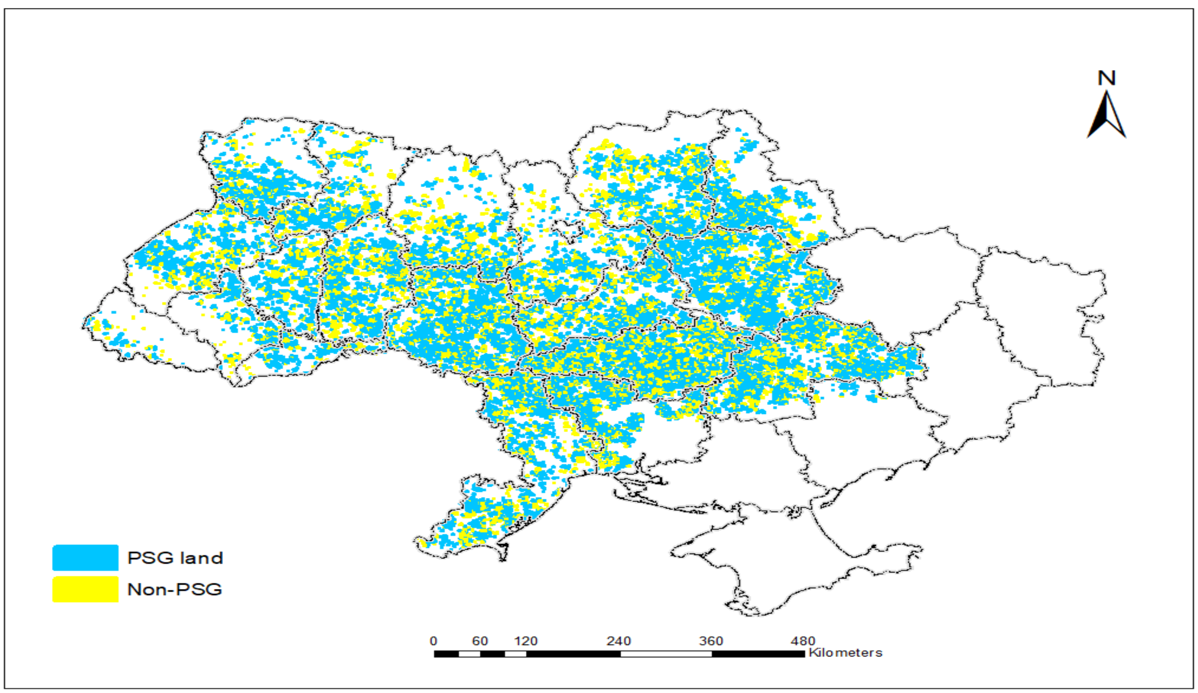
	Overall effect	Heterogeneity by		
		Front distance	Farm size	Formality
PSG	0.0848			
	(0.1118)			
PSG * < 50 km to front		-0.0845		
		(0.1800)		
PSG * 50 - 100 km to front		-0.0364		
		(0.1928)		
PSG * > 100 km to front		0.2243		
		(0.1447)		
PSG * farm size < 20 ha			-0.0028	
			(0.0370)	
PSG * farm size 20 - 50ha			0.2114	
			(0.3382)	
PSG * farm size > 50ha			0.3757	
			(0.6576)	
PSG * Individual				0.0344
				(0.0774)
PSG * FOP				0.0354
				(0.2457)
PSG * Legal entity				0.2859
				(0.2803)
No. of obs (farms)	201,295	201,295	201,295	201,295
R-squared	0.6940	0.6941	0.6941	0.6941
Mean of dep. var.	5.3094	5.3094	5.3094	5.3094
SD of dep. var.	10.2827	10.2827	10.2827	10.2827

Note: Results are based on weights derived using entropy matching. Dependent area is the area cultivated with summer crops in panel A and the area cultivated with winter crops in panel B. For summer crop regressions in panel A, the level and square of weather variables, in particular GDD (>5°C), total rainfall, and the number of zero precipitation days during the planting and growing seasons, winter crop area, and a constant are included but not reported. In panel B, the cut-off for GDD is >0°C and all weather variables (and their squares) are for planting, dormancy, and growing seasons. Robust standard errors clustered at rayon level in parentheses: * p<0.10, ** p<0.05, *** p<0.010.

Figure 1: Location of eligible treated and untreated parcels
Panel A: Entire sample

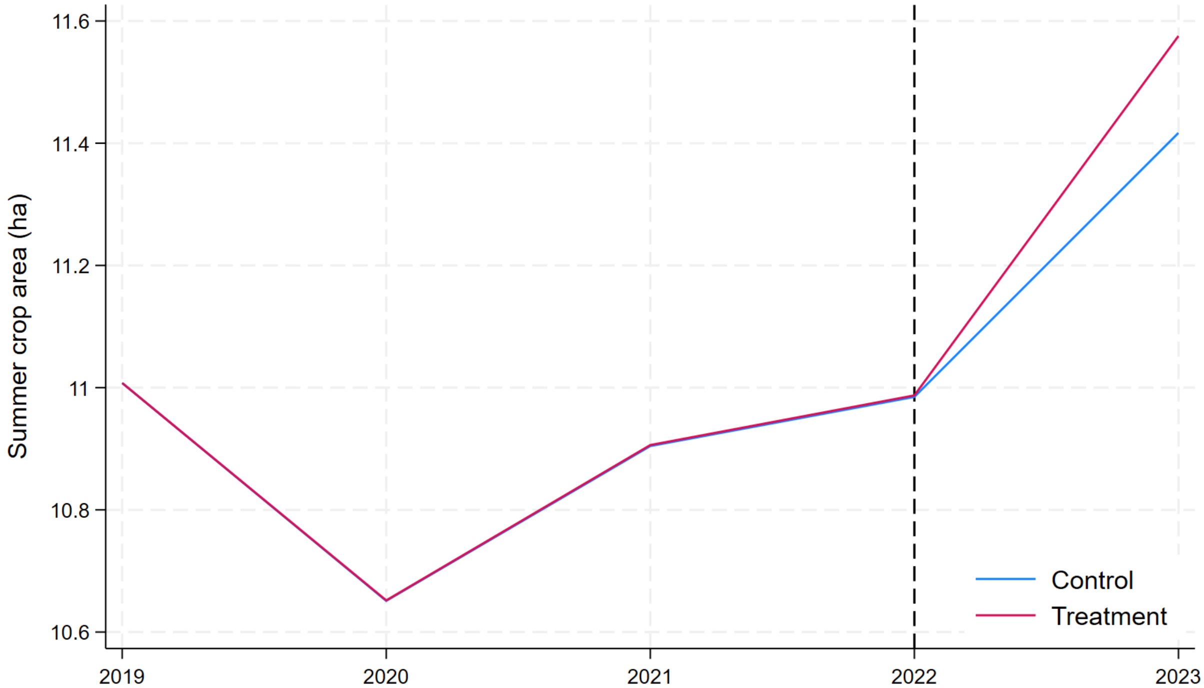


Panel B: Analysis sample



Note: Oblast boundaries indicated for ease of reference.

Figure 2: Pre--and post-program means for summer crop area per farm for treatment and control



Appendix table A1: Volume of approved PSG applications under the land program by region and farm size, full sample

	Number of successful applicants				Amount	Area per farm			
	Total	**<20 ha**	**20- 50 ha**	**> 50 ha**	**($ mn.)**	**Total**	**<20 ha**	**20- 50 ha**	**> 50 ha**
Total	21,050	15,269	3,168	2,613	35.131	19.5	6.5	35.2	77.7
Panel A: By region									
Center	9,619	6,250	1,774	1,595	19.506	23.92	6.97	35.03	77.97
East	12	11	0	1	0.013	13.18	5.84		93.90
North	1,629	1,027	328	274	3.402	24.64	6.65	36.21	78.21
South	5,297	4,371	580	346	6.863	15.28	7.41	35.88	80.23
West	4,493	3,610	486	397	5.347	14.04	4.44	34.56	76.17
Panel B: By organizational form									
Individual	14,218	13,076	895	247	9.819	8.15	5.50	30.93	65.68
FOP	2,647	1,254	720	673	7.669	34.18	9.79	35.17	78.56
Legal entity	4,185	939	1,553	1,693	17.643	49.73	15.65	37.75	79.62

Source: Own computation based on PSG records.

Appendix table A2: Likelihood of completing the follow-up survey

PSG beneficiary	0.097***	0.102***	0.107***
	(0.025)	(0.026)	(0.027)
Applied to other programs	0.178***	0.176***	0.178***
	(0.027)	(0.027)	(0.028)
Owner respondent	-0.021	-0.020	-0.013
	(0.063)	(0.064)	(0.066)
Manager respondent	-0.012	-0.008	0.003
	(0.068)	(0.068)	(0.071)
Log holding size (ha)	-0.021**	-0.023**	-0.020*
	(0.010)	(0.010)	(0.010)
FOP	0.128***	0.123***	0.127***
	(0.032)	(0.032)	(0.032)
Individual	0.063	0.058	0.080*
	(0.041)	(0.042)	(0.044)
Managing multiple farms	-0.070**	-0.071**	-0.077**
	(0.031)	(0.031)	(0.032)
Considered applying for credit	0.071***	0.070**	0.066**
	(0.027)	(0.027)	(0.028)
Personal situation on a scale of 1 to 10	0.007	0.008	0.008
	(0.006)	(0.006)	(0.007)
Not directly affect by conflict	0.046	0.048	0.041
	(0.039)	(0.041)	(0.041)
Close to frontline (within 50 km from frontline)			-0.013
			(0.027)
East		0.022	0.037
		(0.053)	(0.055)
North		-0.019	-0.011
		(0.035)	(0.037)
South		-0.027	-0.012
		(0.030)	(0.033)
West		-0.065*	-0.055
		(0.035)	(0.036)
No. of obs (farms)	2,101	2,101	1,987

Note: Reported coefficients are marginal effects from a probit model: * p<0.10, ** p<0.05, *** p<0.010

Appendix table A3: Changes in prices & use of outputs and total area cultivated 2021-2023

	2021	**2022**	**2023**	**Δ21-22**	**Δ21-23**
Panel A: Output prices (US$/t)					
Winter wheat	240	137	129	-0.43	-0.46
Winter rapeseed	675	360	302	-0.47	-0.55
Spring barley	214	120	100	-0.44	-0.53
Corn	224	132	123	-0.41	-0.45
Sunflower	657	348	303	-0.47	-0.54
Soybean	602	336	381	-0.44	-0.37
Panel B: Input prices					
Seed (EU variety)	403	480	432	0.19	0.07
Fertilizer (Ammonium nitrate)	383	615	410	0.61	0.07
Fertilizer (Urea)	490	734	524	0.50	0.07
Pesticide	8.7	10.2	9.4	0.18	0.09
Plowing (1ha)	19.7	21.1	19.7	0.07	0.00
Harvesting (1ha)	38.7	41.0	38.3	0.06	-0.01
Grain transport (t/30 km)	4.0	5.9	4.5	0.48	0.13
Panel C: Area cultivated (mn. ha)					
Total	26.69	25.43	24.88	-0.05	-0.07
Winter	9.45	8.38	6.76	-0.11	-0.28
Summer	17.23	17.06	18.12	-0.01	0.05

Source: Own computation based on UCAB data (panels A & B) and satellite crop monitoring (www.cropmaps-ua.com).

Appendix table A4: Comparing PSG and non-PSG participants based on farm survey data

	Beneficiaries of PSG program				Non-beneficiaries	
	Total	<20 ha	20 -50 ha	50 -120 ha	< 120 ha	> 120 ha
Panel A: Farm characteristics						
Total area cultivated (ha)	82.0	14.0	74.5	107.0	94.4	596.4
Members working full time on farm	1.76	1.86	1.68	1.74	2.01	2.33
Members working part-time on farm	1.04	1.19	1.10	0.98	1.07	0.47
Permanent employees	1.08	0.17	1.81	1.20	2.45	13.88
Have tractor < 40 hp	0.22	0.28	0.20	0.20	0.25	0.29
Have tractor 40-120 hp	0.71	0.38	0.72	0.82	0.66	0.82
Have tractor < 120 hp	0.24	0.04	0.14	0.33	0.25	0.61
Have combine harvester	0.36	0.20	0.38	0.41	0.33	0.62
Rating of personal situation (1-10)	4.43	4.24	4.18	4.55	4.24	4.59
Received public support (%)	0.37	0.43	0.35	0.35	0.39	0.32
if yes, amount received	1,000.1	885.7	1,114.8	1,021.0	859.4	969.3
Lease price paid for land (US$/ha)	142.7	110.3	101.3	154.2	104.4	118.8
Interested in buying land	0.75	0.55	0.71	0.83	0.65	0.81
Max. price to be paid (US$/ha)	1,551.7	1,600.0	1,594.4	1,534.1	1,448.5	1,449.7
Ever considered applying for credit	0.67	0.41	0.63	0.76	0.59	0.88
Received credit last 12 months (	0.15	0.01	0.09	0.21	0.11	0.42
if yes, amount received (US$)	25,952.9	546.9	56,740.5	23,975.5	21,902.0	76,401.6
if yes, interest paid	10.41	3.00	12.20	10.39	9.22	7.94
Interest in working capital loan	0.40	0.68	0.43	0.30	0.42	0.22
If yes, amount desired (US$)	38,078.4	10,202.4	30,289.6	43,723.9	26,503.2	89,187.3
Interest in investment loan (%)	0.40	0.67	0.48	0.30	0.44	0.24
If yes, amount desired (US$)	90,906.9	31,631.6	76,122.1	103,145.4	75,135.4	193,357.4
Interest in 25% match grant (MG)	0.63	0.41	0.64	0.70	0.53	0.69
If yes, target amount (US$)	44,952.7	16,555.0	41,909.7	51,928.5	38,584.0	92,795.6
Panel B: Use of SAR & support						
Did not use SAR in 2023	0.11	0.26	0.11	0.05	0.14	0.06
Used SAR to apply for support	0.73	0.51	0.76	0.80	0.67	0.62
Used SAR to check on support	0.28	0.28	0.22	0.30	0.28	0.37
Used SAR for other purposes	0.38	0.25	0.34	0.44	0.40	0.48
Obtained support other than PSG	0.62	0.19	0.63	0.76	0.49	0.59
If yes, value of support obtained	1,982.9	665.3	1,717.1	2,137.5	1,904.9	2,051.4
If yes, storage	0.02	0.00	0.00	0.02	0.05	0.16
If yes, credit 5-7-9	0.03	0.00	0.00	0.04	0.01	0.11
If yes, fertilizer	0.87	0.57	0.78	0.91	0.89	0.85
If yes, seed	0.33	0.29	0.34	0.34	0.46	0.49
If yes, other	0.11	0.24	0.08	0.11	0.03	0.04
Panel C: PSG benefits & its use						
Received PSG benefit	1.00	1.00	1.00	1.00	0.00	0.00
if yes, amount received (US$)	4,718.2	737.2	3,235.5	6,426.0		
crop prod. input incl harvest	0.87	0.85	0.93	0.86		
crop prod. investment	0.01	0.04	0.02	0.00		
livestock	0.11	0.10	0.04	0.14		
consumption/other	0.01	0.00	0.01	0.00		
Area (ha) supported by PSG	55.66	8.70	38.17	75.81		
No. of obs.	514	110	79	325	345	347

Source: Own computation based on PSG records.

Note: The types of support other than PSG was a multi response question and hence they do not add up to one, and the other category includes cash grant. Other purposes for which SAR was used include checking information on land parcels or prices.

Appendix table A5: PSG and non-PSG participants 50 km from the frontline based on farm survey data

	PSG program beneficiaries					Eligible non-benef.		ΔSig
	Total		Size class			Total		
	2022	2023	<20	20 -50	50 -120	2022	2023	
Panel A: Farm characteristics								
Total area cultivated (ha)	65.9	76.2	16.3	47.5	106.5	59.6	80.2	*
Members working full time on farm	1.44	1.69	1.59	1.62	1.75	1.66	1.70	*
Members working part-time on farm	0.84	1.02	1.16	1.05	0.96	0.78	0.87	
Permanent employees	0.39	0.74	0.00	2.14	0.67	0.69	1.64	
Have tractor < 40 hp		0.19	0.19	0.29	0.16		0.22	
Have tractor 40-120 hp		0.70	0.38	0.67	0.83		0.68	
Have tractor < 120 hp		0.19	0.03	0.10	0.27		0.30	
Have combine harvester		0.32	0.09	0.38	0.39		0.39	
Rating of personal situation (1-10)	3.43	4.27	3.78	3.62	4.62	3.49	4.17	
Received public support	0.54	0.46	0.50	0.43	0.46	0.44	0.42	
if yes, amount received	839	991	803	1124	1041	807	815	
Lease price paid for land (US$/ha)	97.8	123.1	147.3	81.6	129.2	102.0	101.8	
Interested in buying land	0.79	0.68	0.47	0.62	0.78	0.67	0.60	
Max. price to be paid (US$/ha)	1,875	1,543	2,031	1,700	1,410	1,506	1,345	
Ever considered applying for credit	0.63	0.59	0.34	0.48	0.71	0.63	0.56	
Received credit last 12 months	0.10	0.13	0.00	0.14	0.17	0.10	0.10	
if yes, amount received (US$)	20,123	26,579		75,540	19,047	50,081	18,354	
if yes, interest paid	6.75	9.00		6.00	9.46	3.58	8.75	
Interest in working capital loan		0.46	0.75	0.42	0.38		0.44	
If yes, amount desired (US$)		29,793	6,836	14,045	36,703		25,749	
Interest in investment loan		0.45	0.74	0.40	0.36		0.46	
If yes, amount desired (US$)		76,021	12,761	44,891	93,535		70,040	
Interest in 25% match grant (MG)		0.61	0.43	0.60	0.69		0.55	
If yes, target amount (US$)		29,841	9,981	44,268	31,403		31,833	
Panel B: PSG benefits & its use								
Used SAR to apply for support		0.72	0.47	0.71	0.82		0.73	
Amount of PSG received (US$)		4,463	737	2,865	6,304			
used for crop prod./harvest input		0.94	0.93	1.00	0.93			
used for crop investment		0.00	0.00	0.00	0.00			
used for livestock		0.06	0.06	0.00	0.07			
used for consumption/other		0.00	0.01	0.00	0.00			
Area (ha) supported by PSG		52.65	8.70	33.80	74.37			
Obtained support other than PSG		0.63	0.19	0.57	0.81		0.55	
If yes, storage		0.02	0.00	0.00	0.03		0.08	
If yes, credit 5-7-9		0.02	0.00	0.00	0.03		0.00	
If yes, fertilizer		0.75	0.17	0.58	0.84		0.85	
If yes, seed		0.59	0.67	0.58	0.58		0.63	
If yes, other		0.16	0.17	0.17	0.16		0.06	
No. of obs.		136	32	21	83		128	

Source: Own computation based on PSG records.

Note: The types of support other than PSG was a multi response question and hence they do not add up to one, and the other category includes cash grant. Other purposes for which SAR was used include checking information on land parcels or prices. ΔSig is the result of a t test for Δ_{PSG}-$\Delta_{Non\text{-}PSG}$ = 0 where Δ_{PSG} and $\Delta_{Non\text{-}PSG}$ is the difference between values in 2023 and 2022, for PSG participants and eligible non-participants, respectively.

Appendix table A6: Balance test between PSG and of pre-treatment indicators

	PSG beneficiaries	Non PSG beneficiaries		Standardized difference	
		Pre matching	Post matching	Pre matching	Post matching
Agricultural land (ha)	19.92	9.05	19.91	0.414	0.00009
Winter crop 2019 (ha)	6.18	2.92	6.18	0.285	0.00005
Winter crop 2020 (ha)	4.45	2.04	4.45	0.266	0.00005
Winter crop 2021 (ha)	5.04	2.27	5.04	0.276	0.00006
Winter crop 2022 (ha)	4.58	2.05	4.58	0.268	0.00005
Summer crop 2019 (ha)	10.37	4.23	10.37	0.360	0.00010
Summer crop 2019 (ha)	10.44	4.32	10.44	0.356	0.00009
Summer crop 2019 (ha)	10.85	4.46	10.84	0.365	0.00009
Summer crop 2019 (ha)	11.03	4.60	11.03	0.369	0.00009
Rain 2019 sowing (mm)	118.0	124.9	118.0	-0.172	-0.00027
Rain 2019 growing (mm)	257.7	276.4	257.7	-0.231	-0.00032
Rain 2020 sowing (mm)	91.0	90.1	91.0	0.041	0.00001
Rain 2020 growing (mm)	295.3	310.7	295.3	-0.174	-0.00020
Rain 2021 sowing (mm)	103.0	104.1	103.0	-0.055	-0.00009
Rain 2021 growing (mm)	274.0	274.5	274.0	-0.014	-0.00013
Rain 2022 sowing (mm)	87.0	88.3	87.0	-0.045	-0.00005
Rain 2022 growing (mm)	122.8	127.0	122.8	-0.084	-0.00006
Summer crop GDD 2019	1493	1461	1493	0.202	0.00026
Summer crop GDD 2010	1290	1261	1290	0.197	0.00025
Summer crop GDD 2021	1317	1290	1317	0.219	0.00029
Summer crop GDD 2022	1343	1313	1343	0.185	0.00023
No. of obs.	19,660	23,343			

Source: Own computation from SAR records and cadastral data as described in the text

Note: Pre refers to before entropy balancing and post refers to after entropy balancing that adjusts for differences in the first and second moment of all the covariates and reweighting.

References:

Abate, G. T., T. Bernard, S. Makhija and D. J. Spielman. 2023. "Accelerating Technical Change through ICT: Evidence from a Video-Mediated Extension Experiment in Ethiopia." *World Development* 161.
Adema, J., C. G. Aksoy, Y. Giesing and P. Poutvaara. 2023. "The Effect of Conflict on Ukrainian Refugees' Return and Integration." CESifo, CESifo Working Paper Series: 10877.
Agwu, G. A. 2023. "The Boko Haram Conflict and Food Insecurity: Does Resilience Capacity Matter?" *Journal of African Economies* 32 (4): 352-382.
Aiken, E., et al. 2021. "Machine Learning and Mobile Phone Data Can Improve the Targeting of Humanitarian Assistance." National Bureau of Economic Research, Inc, NBER Working Papers: 29070.
Aiken, E., et al. 2023. "Estimating Impact with Surveys Versus Digital Traces: Evidence from Randomized Cash Transfers in Togo." *National Bureau of Economic Research Working Paper Series* No. 31751.
Akresh, R., S. Bhalotra, M. Leone and U. Osili. 2023. "First- and Second-Generation Impacts of the Biafran War." *Journal of Human Resources* 58 (2): 1-45.
Arias, M. A., A. M. Ibáñez and A. Zambrano. 2019. "Agricultural Production Amid Conflict: Separating the Effects of Conflict into Shocks and Uncertainty." *World Development* 119: 165-184.
Assuncao, J., R. McMillan, J. Murphy and E. Souza-Rodrigues. 2019. "Optimal Environmental Targeting in the Amazon Rainforest." National Bureau of Economic Research, Inc, NBER Working Papers: 25636.
Assunção, J., C. Gandour, R. Rocha and R. Rocha. 2020. "The Effect of Rural Credit on Deforestation: Evidence from the Brazilian Amazon." *The Economic Journal* 130 (626): 290-330.
Ba, A., et al. 2019. "Digitizing Agriculture: Evidence from E-Voucher Programs in Mali, Chad, Niger, and Guinea ", *AFCW3 Economic Update*, World Bank, Washington DC.
Banerjee, A., et al. 2020. "E-Governance, Accountability, and Leakage in Public Programs: Experimental Evidence from a Financial Management Reform in India." *American Economic Journal: Applied Economics* 12 (4): 39-72.
Ben Yishay, A., R. Sayers and K. Sing. 2024. "Landmine Clearance and Economic Development: Evidence from Nighttime Lights, Multispectral Satellite Imagery, and Conflict Events in Afghanistan." College of William & Mary, Blacksburg.
Birner, R., T. Daum and C. Pray. 2021. "Who Drives the Digital Revolution in Agriculture? A Review of Supply-Side Trends, Players and Challenges." *Applied Economic Perspectives & Policy* 43 (4): 1260-1285.
Büttner, N., M. Grimm and S. Soubeiga. 2022. "Political Instability and Households' Investment Behavior: Evidence from Burkina Faso." *Journal of Comparative Economics* 50 (2): 350-368.
Carlson, K. M., et al. 2018. "Effect of Oil Palm Sustainability Certification on Deforestation and Fire in Indonesia." *Proceedings of the National Academy of Sciences* 115 (1): 121.
Chancellor, W. 2023. "Exploring the Relationship between Information and Communication Technology (Ict) and Productivity: Evidence from Australian Farms." *Australian Journal of Agricultural & Resource Economics* 67 (2): 285-302.
Chiovelli, G., S. Michalopoulos and E. Papaioannou. 2018. "Landmines and Spatial Development." National Bureau of Economic Research, Inc, NBER Working Papers: 24758.
Chiovelli, G., S. Michalopoulos, E. Papaioannou and S. Sequeira. 2021. "Forced Displacement and Human Capital: Evidence from Separated Siblings." National Bureau of Economic Research, Inc, NBER Working Papers: 29589.
Couttenier, M., N. Monnet and L. Piemontese. 2022. "The Economic Costs of Conflict: A Production Network Approach." Centre for Economic Policy Research, Discussion Paper DP16984, London.
Deines, J. M., et al. 2021. "A Million Kernels of Truth: Insights into Scalable Satellite Maize Yield Mapping and Yield Gap Analysis from an Extensive Ground Dataset in the Us Corn Belt." *Remote Sensing of Environment* 253: 112174.
Deininger, K., et al. 2023a. "Quantifying War-Induced Crop Losses in Ukraine in near Real Time to Strengthen Local and Global Food Security." *Food Policy* 115: 102418.
Deininger, K., et al. 2024. "Micro Level Impacts of the War on Ukraine's Agricultural Sector: Distinguishing Local and National Effects over Time." *World Bank Policy Research Working Paper*, Washington, DC.
Deininger, K. W., D. A. Ali and R. Neyter. 2023b. "Impacts of a Mandatory Shift to Decentralized Online Auctions on Revenue from Public Land Leases in Ukraine." *Journal of Economic Behavior & Organization* 213: 432-450.
Devadoss, S. and W. Ridley. 2024. "Impacts of the Russian Invasion of Ukraine on the Global Wheat Market." *World Development* 173: 106396.
Duncan, E. C., S. Skakun, A. Kariryaa and A. V. Prishchepov. 2023. "Detection and Mapping of Artillery Craters with Very High Spatial Resolution Satellite Imagery and Deep Learning." *Science of Remote Sensing* 7: 100092.
Ecker, O., A. Al-Malk and J.-F. Maystadt. 2023. "Civil Conflict, Cash Transfers, and Child Nutrition in Yemen." *Economic Development and Cultural Change*: 000-000.
Egert, B., C. d. la Maisonneuve and B. Egert. 2023. "The Impact of the War on Human Capital and Productivity in Ukraine." CESifo, CESifo Working Paper Series: 10513.
Federle, J., A. Meier, G. Muller and V. Sehn. 2022. "Proximity to War: The Stock Market Response to the Russian Invasion of Ukraine." CEPR Discussion Paper 17185.
Fergusson, L., A. M. Ibanez and J. F. Riano. 2020. "Conflict, Educational Attainment, and Structural Transformation: La Violencia in Colombia." *Economic Development and Cultural Change* 69 (1): 335-371.
Fetzer, T. 2020. "Can Workfare Programs Moderate Conflict? Evidence from India." *Journal of the European Economic Association* 18 (6): 3337-3375.

Finger, R. 2023. "Digital Innovations For sustainable And resilient Agricultural Systems." *European Review of Agricultural Economics* 50 (4): 1277-1309.
Ghorpade, Y. 2020. "Calamity, Conflict, and Cash Transfers: How Violence Affects Access to Aid in Pakistan." *Economic Development and Cultural Change* 68 (4): 1131-1184.
Guo, J., S. Jin, J. Zhao and Y. Li. 2023. "E-Commerce and Supply Chain Resilience During Covid-19: Evidence from Agricultural Input E-Stores in China." *Journal of Agricultural Economics* 74 (2): 369-393.
Harari, M. and E. La Ferrara. 2018. "Conflict, Climate, and Cells: A Disaggregated Analysis." *Review of Economics and Statistics* 100 (4): 594-608.
Heilmayr, R., L. L. Rausch, J. Munger and H. K. Gibbs. 2020. "Brazil's Amazon Soy Moratorium Reduced Deforestation." *Nature Food* 1 (12): 801-810.
Hidrobo, M., V. Mueller and S. Roy. 2022a. "Cash Transfers, Migration, and Gender Norms." *American Journal of Agricultural Economics* 104 (2): 550-568.
Hidrobo, M., et al. 2022b. "Paying for Digital Information: Assessing Farmers' Willingness to Pay for a Digital Agriculture and Nutrition Service in Ghana." *Economic Development & Cultural Change* 70 (4): 1367-1402.
Huang, J., L. Su, Q. Huang and X. Liu. 2022. "Facilitating Inclusive Ict Application and E-Commerce Development in Rural China." *Agricultural Economics* 53 (6): 938-952.
Ibanez, A. M., A. Moya and A. Velasquez. 2022. "Promoting Recovery and Resilience for Internally Displaced Persons: Lessons from Colombia." *Oxford Review of Economic Policy* 38 (3): 595-624.
Jouanjean, M.-A. 2019. "Digital Opportunities for Trade in the Agriculture and Food Sectors." OECD Publishing, OECD Food, Agriculture and Fisheries Papers: 122.
Khanna, M. 2021. "Digital Transformation of the Agricultural Sector: Pathways, Drivers and Policy Implications." *Applied Economic Perspectives & Policy* 43 (4): 1221-1242.
Korovkin, V. and A. Makarin. 2023. "Conflict and Intergroup Trade: Evidence from the 2014 Russia-Ukraine Crisis." *American Economic Review* 113 (1): 34-70.
Kussul, N., et al. 2022. "Biophysical Impact of Sunflower Crop Rotation on Agricultural Fields." *Sustainability* 14 (7): 3965.
Kussul, N., et al. 2023. "Assessing Damage to Agricultural Fields from Military Actions in Ukraine: An Integrated Approach Using Statistical Indicators and Machine Learning." *International Journal of Applied Earth Observation and Geoinformation* 125: 103562.
Leasure, D. R., et al. 2023. "Nowcasting Daily Population Displacement in Ukraine through Social Media Advertising Data." *Population and Development Review* 49 (2): 231-254.
Lee, J. S. H., et al. 2020. "Does Oil Palm Certification Create Trade-Offs between Environment and Development in Indonesia?" *Environmental Research Letters* 15 (12): 124064.
Merkus, E. 2024. "The Economic Consequences of Environmental Enforcement: Evidence from an Anti-Deforestation Policy in Brazil." *World Development* 181: 106646.
Moffette, F. and H. K. Gibbs. 2021. "Agricultural Displacement and Deforestation Leakage in the Brazilian Legal Amazon." *Land Economics* 97 (1): 1-26.
Moffette, F., M. Skidmore and H. K. Gibbs. 2021. "Environmental Policies That Shape Productivity: Evidence from Cattle Ranching in the Amazon." *Journal of Environmental Economics & Management* 109: 102490.
Mohammed, S. and A. Abdulai. 2022. "Do Ict Based Extension Services Improve Technology Adoption and Welfare? Empirical Evidence from Ghana." *Applied Economics* 54 (23): 2707-2726.
Muralidharan, K., P. Niehaus and S. Sukhtankar. 2016. "Building State Capacity: Evidence from Biometric Smartcards in India." *American Economic Review* 106 (10): 2895-2929.
Muralidharan, K., P. Niehaus, S. Sukhtankar and J. Weaver. 2021. "Improving Last-Mile Service Delivery Using Phone-Based Monitoring." *American Economic Journal: Applied Economics* 13 (2): 52-82.
Muralidharan, K., P. Niehaus and S. Sukhtankar. 2023. "Identity Verification Standards in Welfare Programs: Experimental Evidence from India." *The Review of Economics and Statistics*: 1-46.
Neyter, R., S. Zorya and O. Muliar. 2024. "Agricultural War Damages, Losses, and Needs Review ", Kyiv School of Economics, Kyiv.
Nivievskyi, O. 2020. "Where Is the State Agricultural Land Disappearing?", Economic Pravda, Kyiv.
Pacheco, P., et al. 2020. "Governing Sustainable Palm Oil Supply: Disconnects, Complementarities, and Antagonisms between State Regulations and Private Standards." *Regulation & Governance* 14 (3): 568-598.
Premand, P. and D. Rohner. 2024. "Cash and Conflict: Large-Scale Experimental Evidence from Niger." *American Economic Review: Insights* 6 (1): 137-153.
Reinhardt, T. 2023. "The Farm to Fork Strategy and the Digital Transformation of the Agrifood Sector--an Assessment from the Perspective of Innovation Systems." *Applied Economic Perspectives & Policy* 45 (2): 819-838.
Reyes, C. M. and C. D. Mina. 2017. "Assessment of the Targeting and Financing Aspects of the Rsbsa-Aip." *Policy Note 2017-11*, Philippine Institute for Development Studies, Manila.
Rose, A., Z. Chen and D. Wei. 2023. "The Economic Impacts of Russia–Ukraine War Export Disruptions of Grain Commodities." *Applied Economic Perspectives and Policy* 45 (2): 645-665.
Schwab, B. 2019. "Comparing the Productive Effects of Cash and Food Transfers in a Crisis Setting: Evidence from a Randomised Experiment in Yemen." *Journal of Development Studies* 55: 29-54.

Sessou, F. E. and C. H. C. A. Henning. 2024. "Conflict and Farm Inputs Investment : Can Social Safety Nets Have Any Mitigation Effect?" *Applied Economics* 56 (17): 1991-2007.
van Campenhout, B. 2022. "Icts to Address Information Inefficiencies in Food Supply Chains." *Agricultural Economics* 53 (6): 968-975.
Wilson, W. W., P. Lakkakula and D. W. Bullock. 2024. "Implications of the Russian Invasion on the Logistical Competition for Corn Shipments from the United States and Ukraine." *Journal of Agricultural & Resource Economics* 49 (1): 162-184.
Yacoubou Djima, I. and T. Kilic. 2024. "Attenuating Measurement Errors in Agricultural Productivity Analysis by Combining Objective and Self-Reported Survey Data." *Journal of Development Economics* 168: 103249.
Zant, W. 2024. "Mobile Phones and Mozambique Farmers: Less Asymmetric Information and More Trader Competition?" *World Development* 180: 106574.