Extended Abstract

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Paper Title	Climatic Sensitivity of Agriculture in Eurasia: Identifying Climate Effects Using Weather Observations.

Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.

Abstract	***200 words max***

The paper studies the impact of climate change on agricultural productivity in three important grain producing and exporting nations in Eurasia: Kazakhstan, Ukraine and Russia (KUR). We apply a panel data econometric model that uses both within and between variation and enables consistent identification of climate effects on an economic outcome. Our dataset covers 65 regions in Russia, 22 regions in Ukraine and 12 regions in Kazakhstan, and spans the period 2020-2020. After political and economic transformations in the 1990s and before Russia's war against Ukraine, farm businesses in all three study countries were exposed to market competition and, accordingly, made their production decisions considering market prices for agricultural outputs and inputs. For Russia, this economic regime altered at the latest with the outbreak of the war in February 2022. In this context, our study presents a unique quasi-natural experiment allowing consistent identification of climate effects on agricultural productivity in KUR. Our preliminary results show that climate change affected agricultural productivity mainly in the regions used to be exposed to relatively moderate summer temperatures in the past. Unlike regions with warmer climates, these regions still mainly grow spring cereals. An increase in summer temperatures by 1 degree C in these regions is associated with a decrease in land productivity between 1.3 and 2.2%, on average.

Keywords	Economics of climate change; climate change adaptation; agriculture; Eurasia.
JEL Code	e.g. Energy: Demand and Supply Q41 see: www.aeaweb.org/jel/guide/jel.php?class=Q)

Introduction	***100 – 250 words***

Political and economic reforms of the 1990s induced in the first two decades of the XXI. century a notable agricultural productivity growth in Central and Eastern European countries (CEECs) and 15 post-Soviet states (PSS), including Kazakhstan, Ukraine and Russia (KUR) – three important grain producing and exporting nations in Eurasia (Swinnen et al., 2009; Fugli, 2015; USDA ERS, 2023).

Swinnen et al. (2009) provide a profound discussion of main factors explaining agricultural productivity growth and different trends in its evolution across CEESs and PSS. This topic has been also extensively studied in several empirical investigations in the recent decade. For KUR, the literature refers to weather shocks as an important factor of crop harvest volatility in the region (Lioubimtseva and Henebry, 2012; Bokusheva and Hockmann, 2006, Liefert, 2002). However, the effect of climatic variability and weather shocks on the recent agricultural productivity trends in KUR remains rather unstudied.

This state of the art is not astonishing given that identification of the impacts of climate change on an economic outcome prerequisites long-time observations on both an economic performance indicator and weather. While reliable weather data have been available for KUR also for the periods before 1990s, meaningful indicators of farm economic performance exist for the region only for the periods after the transition to a market economy, as farm decisions in the Soviet era were not driven by market forces but made within the Soviet economic planning system.

Furthermore, the Russia's war against Ukraine seriously affected the Ukrainian economy[1] as well as the Russian economic policy.[2] This development causes structural breaks in agricultural time series for both countries.[3] Therefore, using agricultural statistics for the period 2000-2020 presents the only opportunity to draw consistent inferences about the climate change impact on agricultural productivity in KUR in the presence of farm adaptation actions.

Methodology	***100 – 250 words***

We propose to identify climatic sensitivity of agricultural production in KUR following the identification strategy proposed by Hsiang (2016). In that, producers adapt their production to climate change based on their believes about the climate in respective locations**.** The climate is defined as a vector of selected climatologies, $\mathbf{C}$, mainly long-term averages of corresponding weather variables, $\mathbf{c} \in \mathbf{C}$.

In this setting, the climate affects economic output Y in two ways: First, the climate in a location determines weather variation and, therefore, has a direct effect of on Y; second, farmers' believes over the structure of climate**,** $\mathbf{b}$, may influence their actions and, hence, also their production outcomes, *viz*.:

$$Y(\mathbf{C}) = Y[\mathbf{c}(\mathbf{C}), \mathbf{b}(\mathbf{C})] \qquad (1)$$

Accordingly, the farmer optimization problem can be formulated as follows:

$$Y(\mathbf{C}) = [\mathbf{b}^*(\mathbf{C}), \mathbf{c}(\mathbf{C})] = \max_{b \in R^N} z\,[\mathbf{b}, \mathbf{c}(\mathbf{C})], \text{ where} \qquad (2)$$

$\mathbf{b}^*(\mathbf{C})$ $(b = 1,2,..,N)$ is the vector of actions maximizing producer's value function z under climate $\mathbf{C}$.

Assuming that in each climate farms undertake actions allowing them to maximize their production outcomes under the current climate, the impact of climate is identified by conditioning an economic outcome on both location-specific climate $\mathbf{C}$ and weather outcomes $\mathbf{c}(\mathbf{C})$.

[1] In particular, Ukrainian farmers must permanently adjust their operations and processes due to disruptions in value chains, and direct and indirect impacts of military actions taking place on the territory of the country.
[2] The current agricultural policy regime shaped by producers' support measures aimed at import substitution, export restrictions for a number of agricultural commodities as well as economic sanctions against Russia applied by the EU, the U.S. and a group of other countries, and Russia's countersanctions, distorts Russian farm businesses' decisions. In this context, Russian farms decisions in the current period very likely show substantial suboptimalities.
[3] Though Kazakhstani farmers were comparatively less affected by the war in Ukraine, a low number of regions in the country sets constraints on the application of fixed-effects approaches for Kazakhstan.

We conduct our empirical analysis using panel data for 65 regions in Russia, 22 regions in Ukraine and 12 regions in Kazakhstan for the period 2000–2020.[4]

Akin Gammans et al., 2022, we employ the following economic output response model formulation enabling identification of climate effects on farm outcome using panel data:

$$\ln y_{it} = \alpha_i + \boldsymbol{\beta} \boldsymbol{e}_{sit}(i,t)\boldsymbol{x}_{it} + f_g(t) + \varphi \boldsymbol{h}_{it} + \varepsilon_{it}$$, where (3)

y_{it} is gross regional product from agriculture per hectare of arable land in region i $(i = 1, 2, .., N = 99)$ and period t $(t = 1, 2, .., T = 21)$, α_i stands for region fixed effects, $\boldsymbol{x}_{it}$ is a M–element vector of weather variables, $f_g(t)$ is time trend for groups of regions with similar trends in economic and technological development, $\boldsymbol{e}_{sit}(i,t)$ is a vector of dummy variables indicating for each season s the climatic interval where region i is located in period t. $\boldsymbol{h}_{it}$ is a vector of control variables and ε_{it} are Conley-HAC standard errors adjusted for spatial and serial correlation (Conley 1999; Hsiang 2010).

This approach is particularly beneficial when identifying the effects of climate change over large territories that cover different climatic zones, as applies to KUR, as it allows inferences to be drawn using both within variation in regional time series and variation between climatic intervals.

We define season-specific climatic intervals by computing for each year-region observation long-term rolling averages in respective season's average daily temperatures and splitting corresponding distributions into 5 equal intervals based on 4 quintiles[5], q_{sp} with $p = 0.2,\ 0.4, 0.6,\ 0.8$. The intervals with highest seasonal climatologies i.e., those beyond $q_{sp=0.8}$, are referred to as climatic intervals (CI) 1, while the intervals with lowest climatologies i.e., $\leq q_{sp=0.2}$, are called CI5. For each season s, the reference climate interval corresponds with CI 1 that is formed by regions with highest temperatures in respective season.

Results	***100 – 250 words***

We estimated model in equation (3) using seasonal temperature and precipitation variables and 30-years rolling averages of seasonal temperatures to define climatic intervals. Our preliminary results show that climate change has a significant negative impact on productivity of regions situated in CIs 3 and 4 (Fig. 1). According to our estimates, an increase in average daily temperature by 1 degree C is associated with a decrease in land productivity of 1.3 and 2.2% in these CIs, respectively, as evaluated at corresponding sample averages. Although these two CIs are associated with relatively moderate summer temperatures (with the long-term summer temperature intervals of 18.6 – 19.7 and 17.6 – 18.6 degrees C, respectively), agricultural productivity in the regions situated in these CIs appears to be affected by an increase in summer temperatures stronger than in regions with hotter climates that is CIs 1 and 2 (above 21.0 and 19.7 – 21.0 degrees C, respectively). An explanation for this outcome is that regions in CIs 1 and 2 reduce their exposure to extreme summer temperatures by producing winter grains. In contrast, regions situated in CIs 3 and 4 still predominantly produce spring grains that are generally more sensitive to extreme temperature events in the summer.

Warmer autumns and winters are expected to favour production of winter grains in higher latitudes of Eurasia. In this context, our results suggest that farmers in CIs 3 and 4 have not yet adapted their production to climate change. According to our model estimates, the effects of autumn and winter temperatures was not found to be significant for any CI. However, our estimates suggest that warmer autumns slightly benefited farming in CI5 – the coldest CI in our sample.

[4] We do not consider regions Luhansk, Donetsk and Crimea in our study as agricultural statistics were missing/incomplete for these regions since 2014.
[5] We determine quintiles based on temperature 30-years averages for the last year in the sample i.e., 2020.

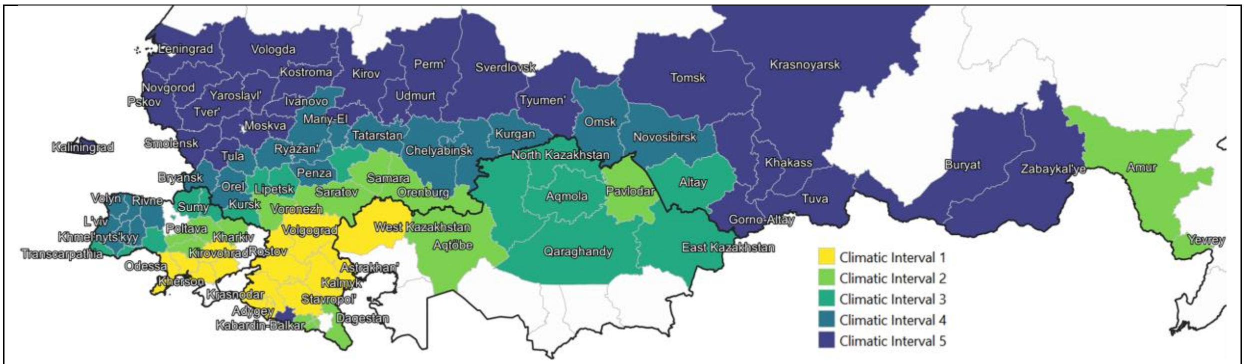

Fig.1: Distribution of climatic intervals for summer.

Note: Black contours correspond with countries' borders, whereas white contours show regional boundaries. Countries and region borders are presented according to FAO (2023).

Discussion and Conclusion	***100 – 250 words***

Our preliminary results show that climate change did not significantly affect agricultural productivity in most productive agricultural regions of Ukraine and the South-European part of Russia over the period 2020-2020. However, high summer temperatures affected productivity of agriculture in all main grain-producing regions of Kazakhstan, 12 Ukrainian regions situated in the Northwest of the country, and a bulk of Russian regions producing spring grains.

We intend to conduct robustness checks of our study results using alternative formulations of climatic intervals, an alternative set of weather variables including degree-days measures as well as other estimators.

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