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Is Abandonment of Agricultural Land Increasing with Better Ownership Protection?

Cross-Country Evidence from Transition Economies

Zarema Akhmadiyeva and Thomas Herzfeld

Abstract: Given the high potential of abandoned agricultural land in some transition economies, we investigate the drivers of agricultural land-use change with a specific focus on land titling and transferability. We use time-series cross-sectional data for twenty-nine transition countries in East Asia, Central and Eastern Europe, and the former Soviet Union for the period from 1991 to 2014. We operationalize individual land ownership and transferability using land legislative documents to create variables for our empirical analysis. The results suggest that improving ownership rights only increases land abandonment in transition economies, while countries with full transferability of individual plots experience higher land use.

Keywords: land abandonment, institutional change, transition economies

JEL Classification Codes: P26, Q15, Q18

Transition economies in East Asia (EA), Central and Eastern Europe (CEE), and the former Soviet Union (FSU) produce more than one-third of global agricultural production (see table A1 in the Appendix for country details). Yet many of these countries still have considerable potential to increase the value of their agricultural commodities by putting agricultural land that has been abandoned at the early phase of economic transition back into production (Swinnen et al. 2017). Extensive political and economic reforms intended to establish market-based economies through the privatization of state enterprises, the decollectivization of collective farms, and the liberalization of prices and trade led to crucial institutional changes in the agricultural sectors of transition economies. However, these changes did not always result in the formation of effective land markets and optimal land allocation. Together with market failures, differences in the pre- and post-reform tenure settings are seen by many scholars to distort effective land allocation (Deininger and Jin 2006; Ho and Spoor 2006; Lerman et al. 2004).

Although a large body of literature documents either positive relationships between various aspects of agricultural development and tenure security, or a lack of conclusive evidence (see Besley and Ghatak 2010; Lawry et al. 2017 for an overview), the evidence specific to the formerly centrally planned economies of Europe and Asia is much scarcer. Some land abandonment in these countries can be explained by the extension of cultivation into non-suitable areas under state command (Alcantara et al. 2013). However, regions with similar agroecological conditions have experienced different abandonment rates, which are more likely to be driven by socio-economic and institutional factors. For instance, Jennifer Alix-Garcia et al. (2012) document, by comparing bordering regions in Southeast Poland, Eastern Slovakia, and Western Ukraine, that privately held land in Poland is less likely to be abandoned than plots on former state-owned land. However, broader cross-country analyses that cover the majority of transition economies and explore the role of the institutional framework with respect to land tenure are still lacking.

Ideally, the role of land rights in land-use decisions would be measured at the level of individual farmers. At this level, the perceived land rights could be assessed along different dimensions of rights, as illustrated

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by Frederike Klümper et al. (2018) or Zarema Akhmadiyeva and Thomas Herzfeld (2021). However, such perception-based data are unavailable for a larger panel of transition countries in a comparable format. Consequently, cross-country comparisons require an operationalization of land rights at a macro-level, which can be achieved by assessing indicators such as individual private property rights and the availability of formal land titles (Murken and Gornott 2022).

According to many scholars, the transition to a market-oriented system implied the (re-)establishment of individual ownership of land and the emergence of land markets.¹ However, the governments pursued rather different strategies of privatization and regulating the transferability of land. The functioning of land markets often faced constraints that hindered the transfer of land to more efficient producers (Deininger et al. 2012). Therefore, privatization in transition economies failed to yield the expected improvements in agricultural development. Zvi Lerman et al. (2004) argued that successful agriculture could even evolve without private land ownership. They proposed evaluating land policies against the attributes of market agriculture, particularly private land ownership and transferability.² The reason is that these attributes are related but distinct concepts (Platteau 1996). Following the approach of Lerman et al. (2004), the full establishment of individual land ownership is defined as the legal recognition of private ownership of land in the constitution or a land law. However, the rights individuals could exert differed substantially. Therefore, this legal recognition has to be complemented by the possibility to sell or buy agricultural land (i.e., full transferability of land).

This article aims to analyze the drivers of arable land-use change in transition economies, with a particular focus on the role of national differences in reforming land-use rights and establishing the transferability of land. Controlling for environmental and macroeconomic conditions, we hypothesize that countries with more transferable individual land rights are likely to exhibit higher levels of agricultural land use. However, we expect that the impact of land ownership on land-use change may produce conflicting results. Lessons from this study might assist transition economies in understanding the potential consequences of institutional changes in agriculture and in identifying policies that can cushion strong land abandonment.

To meet the aim of this study, we pursue the following objectives: First, we describe patterns of land-use change and agricultural reforms in transition economies during the period from 1991 to 2014. Then, we present the theoretical model of land-use change and the empirical strategy. Next, we report the results, discussing their implications for agricultural policies, and test the robustness of our results. Finally, we conclude by highlighting the policy implications and proposing suggestions for future research.

Land Abandonment in Transition Economies

Patterns of Land-Use Change

The formerly socialist countries studied in this article have followed different paths in the use of croplands (see figure A1 in the Appendix), though land abandonment occurred in most of them between 1991 and 2014. For instance, in Russia, Ukraine, and Kazakhstan alone, approximately 31 percent of croplands were abandoned from 1991 to 2000 (Meyfroidt et al. 2016). By 2004, Albania, Azerbaijan, Moldova, Romania, and Uzbekistan had abandoned between 9 and 11 percent of cropland compared to 1990. Armenia, Bulgaria, Croatia, Poland, and Slovakia removed more than 20 percent of their cropland from use in the 1990s. Some of the abandoned land is still potentially available for crop production in terms of agro-climatic conditions and could be recultivated, contributing to global food security (Schierhorn et al. 2014; Swinnen et al. 2017).

Studies summarizing the literature on different forms of land-use change, such as land abandonment (Li and Li 2017; Pointereau et al. 2008; Rey Benayas et al. 2007; Terres et al. 2015; van Vliet et al. 2015), agricultural intensification (Keys and McConnell 2005), and wetland conversion (van Asselen et al. 2013), distinguish three main categories of drivers: environmental, socio-economic, and institutional. Most recent changes in land use are largely attributed to environmental and socio-economic factors (Briassoulis 2003; Rey Benayas et al. 2007). For example, land abandonment in some former socialist countries emerged in locations

¹ In most European transition countries, private ownership of land never ceased formally. However, once integrated into collective farms, the owners were denied their use rights.

² To ensure consistency in the use of terms throughout the article and avoid confusion, the terms “land ownership” and “land transferability” here refer to individual land ownership and transferability. Collective or community ownership is not encompassed within this definition.

with low land productivity or in remote regions with adverse market access and poor job opportunities (Alcantara et al. 2013; Lerman 2009). However, regions with similar agroecological conditions, where land market mechanisms coexist with more favorable political and institutional settings, experience lower land abandonment (Alix-Garcia et al. 2012; Prishchepov et al. 2012). This implies that land abandonment could be driven by variations in agricultural policy and institutional arrangements. Indeed, the political interest in agriculture varied substantially across the transition economies. While countries like Tajikistan, Turkmenistan, and Uzbekistan maintained government control over agricultural production, at least for key strategic crops such as cotton and wheat, agriculture was largely neglected during the 1990s in Moldova, Russia, and Ukraine (Hartvigsen 2014; Lerman et al. 2004). This situation changed with the period of increasing global food prices starting in 2007/2008, which revived political interest.

Land Reforms and Tenure Rights

Farm restructuring, aimed at individualization and land reallocation from collective agricultural enterprises to family farms or other market-oriented organizational forms, emerged as one of the key reforms in the transition to a market economy. China, one of the first reformers, began its transition in 1978 by introducing the household responsibility system, which replaced the production team system and allowed households to manage their own agricultural production on contracted land. This reform led to a dramatic transformation of rural areas and significant growth in agricultural productivity (Lin 1988). Nearly a decade later, other Asian countries—such as Vietnam, Laos, and Myanmar—implemented similar land reforms during the second half of the 1980s, following China's example (Rozelle and Swinnen 2004; Rungsuriyawiboon and Wang 2012). These countries could achieve an outstanding increase in income and a reduction in rural poverty.

When the CEE and FSU countries started the transition to a market economy in the early 1990s, observers and governments expected similar success. Yet, the outcomes were disappointing, as these countries experienced a huge drop in agricultural outputs. The reasons for the drop lay in the fact that the FSU and CEE countries had differences not only in initial institutional conditions but also in the implementation of market and institutional reforms. Strategies for farm restructuring in CEE and FSU countries were characterized by the restitution of farmland to former owners and distribution to workers, which caused high heterogeneity in farm structures. While some countries preserved large-scale enterprises (for example, Slovakia, the Czech Republic, the northern part of Kazakhstan, Russia, and Ukraine), others allocated land to small family farms that became the dominant organizational form (for example, Tajikistan, Azerbaijan, Armenia, Kyrgyzstan, Poland, and Lithuania) (Swinnen et al. 2017).

The varying speeds at which land privatization occurred led to discrepancies in the scale of agricultural production and land-use change (Prishchepov et al. 2012). In several CEE nations, such as Poland, Romania, and the Czech Republic, private land ownership existed during the socialist period, which allowed the (re-) establishment of institutions to occur more swiftly. A large share of land previously operated by collective farms in these countries was returned to former owners. In contrast, all land in the Commonwealth of Independent States (CIS) countries was state-owned during the socialist era. After the dissolution of the USSR, many CIS nations simply distributed land certificates that, in practice, were not connected with a specific physical plot. As a result, land distribution remained only on paper, while the tenure rights of certificate holders were uncertain (Kvartiuk and Herzfeld 2019). Later on, however, some countries, such as Moldova and Ukraine, succeeded in converting land certificates into physical plots. The governments of Belarus, Laos, Tajikistan, Uzbekistan, and Vietnam provided only leasehold tenancy to farmers, retaining the main landowner. Moreover, state and collective farms were retained in some countries, complicating the transition to private ownership. For instance, Belarus has maintained a strong role for state-owned and collective farms in its agricultural sector (Giovarelli and Bledsoe 2001). Similarly, in Tajikistan, the government still holds control over some state and collective farms, particularly in sectors like cotton production (Akramov and Shreedhar 2012).

Although a perfect land market assumes private ownership of agricultural land inseparable from transferability of these rights, land reforms related to privatization and transferability of property and use rights were introduced in some transition economies at different times. In Albania, Armenia, and Azerbaijan, for instance, land ownership was introduced in the first years of transition without the possibility of selling the land. The reason behind this was a two-stage land allocation that initially implies the distribution of land shares and, later, the allocation of physical plots. Another example is Turkmenistan, where the government

completely prohibits selling land despite granting land ownership rights (Lerman and Brooks 2005). Therefore, the rights to own and transfer land are frequently considered separately in the evaluation of land markets and land policies (Lerman et al. 2004).

Land may be non-transferable even when there are no legal restrictions on land transactions. Kazakhstan and Russia legalized land ownership for all agricultural producers, but due to the lack of administrative infrastructure and high transaction costs, the share of private agricultural land is still negligible, and land markets are inefficient (Kvartiuk and Herzfeld 2019). In addition, the Kazakh and Russian governments applied land policies facilitating land transfers to large agricultural enterprises. The owners of large agricultural enterprises that often combine agricultural production with other types of entrepreneurship may speculate on future increases in land values, concentrating land that may actually remain unused or used for other purposes (Visser et al. 2012). Land speculation by elites leads to growing insecurity among small land users regarding their land rights and inevitably creates a negative impact on agricultural productivity at the country level. To prevent land speculation, some governments can inhibit land market development deliberately. Kyrgyzstan, for instance, imposed a five-year moratorium on all land transactions in 1998 to protect new landowners from land speculation and improvident sales (Lerman et al. 2004). Hence, introducing land ownership in countries that were in a collectivistic system for decades may result in unexpected consequences regarding land use and agricultural production.

In addition to land reforms, the liberalization of markets also contributed to declines in agricultural output in the CEE and CIS regions. The removal of agricultural subsidies and disruptions in supply chains caused by market liberalization had a significant impact on agricultural land use and production. During the Soviet era, both input and output prices were heavily subsidized. However, when prices were liberalized and subsidies were cut, the input-output price ratios changed dramatically in most countries, making agriculture less attractive and leading to significant rural-urban migration. These policies had varying effects on agricultural output in different countries. For instance, while Belarus, Uzbekistan, and Turkmenistan continued to implement price controls, Russia liberalized prices but retained subsidies for inputs (Rozelle and Swinnen 2004).

Theoretical Model of Land Use

Using a model of land expansion proposed by Edward B. Barbier (2001) as a starting point, we develop an economic model of agricultural land-use change. Each farmer is assumed to be a rational individual who considers land as one of the production factors that can be allocated among various uses (Barbier 2001; Chomitz and Gray 1996). From an economic perspective, land-use decisions can be related to a land user's expected or realized gains from production, conditional upon natural/environmental and institutional constraints. In market-based economies, the main economic incentive in individual land-use choices is to maximize the net present value of return to the land. The vector of net returns includes all potential cash returns, which are not only returns from using the land for production, but also from land transfers, such as reallocating, renting out, and selling. The total return to land can be defined as the difference between the revenue from yield and the cost of production (Equation 1):

$$\max R_a(\mathbf{p}, \mathbf{c}, A) = \mathbf{p}\mathbf{q} - \mathbf{w}\mathbf{c} \quad (1)$$

where R_a is a total return to the land, $\mathbf{q}$ is a vector of all outputs produced from this land, $\mathbf{c}$ is a vector of inputs, and A is the area of land which is considered a fixed allocatable input. Prices for inputs and outputs are indicated by vectors $\mathbf{w}$ and $\mathbf{p}$, respectively.

We assume that the individual has only two options for land use: maintaining crop cultivation and discontinuation of cultivation. Selecting between these options, a producer replaces profit maximization with loss minimization. If the private net return of land cultivation is zero or negative, the land will be abandoned; otherwise, the cultivation will be continued or expanded. The specification of net returns changes in accordance with the specific land-use context that determines the value of land. The pattern of land use at the country-level is determined by an accumulation of individual decisions. Aggregated responses to R_a over all land users in a given country can be expressed as a change in agricultural area between two periods:

$$\Delta A_t = A_t - A_{t-1} = \begin{cases} 0 \text{ or } \Delta A (\text{land cultivation}) & \text{if } R_a > 0 \\ -\Delta A (\text{land abandonment}) & \text{if } R_a \leq 0 \end{cases} \quad (2)$$

where A_{t-1} is the area of land used for cultivation in the previous period; A_t is the land used for cultivation in the current period. ΔA stands for the difference between the two periods, which is negative if abandonment occurs. The value of a hectare used for cultivation is given by:

$$V_a = V(p, w, s, \delta) \quad (3)$$

where p is the value of yield harvested from that hectare, w is the cultivation cost, s is the productivity factor, encompassing agroclimatic and soil characteristics, and δ is the discount rate of a future asset's returns. Following Robert T. Deacon and Henning Bohn (2000), we assume that secure ownership decreases the expropriation probability of future profits. On the contrary, the loss of ownership postpones receipts into the future and, hence, decreases the expected present value of future returns to land. Thus, the total return to cultivated land can be rewritten as:

$$R_a = \delta * V(p, w, s, \delta) = R_a(p, w, s, \delta) \quad (4)$$

which is increasing in p and s and decreasing in δ and w . Considering that optimum use of agricultural land is determined by the first-order conditions for Equation 1 (Alig et al. 1988) and combining with Equation 4, the change in aggregated agricultural land between two periods is decreasing in δ and w , and increasing in p and s :

$$\Delta A_t = A(p, w, s, \delta) \quad (5)$$

Any analysis of land-use change at the farm level within one country will not be able to control for variables that are constant across observations. Cross-country analysis provides an opportunity to include factors such as macroeconomic policy and institutional drivers that influence decision parameters through agricultural markets and land tenure conditions. The main differences between country-level and household-level models are that prices at the country-level become endogenous and must be replaced by underlying drivers such as macroeconomic variables and policy instruments. Particularly, considering that output and input prices are functions of aggregate supply and demand, we can use exogenous factors that lead to changes in aggregate supply and demand (for example changes in exchange rates, household wealth, subsidies).

Replacing p and w in Equation 5 by the vector of structural economic and demographic variables, z , we may present the rate of aggregated land-use change (Δr_{Ait}) as

$$\Delta r_{Ait} = r_{Ait}(\delta_{it}, s_{it}, z_{it}) \quad (6)$$

where δ_{it} is a vector of institutional variables that influences agricultural land use not only through land markets but also by affecting future assets' returns through land tenure security, and s_{it} is a vector of environmental variables that influences land productivity and cultivation costs.

We use two indicators of institutional arrangements that approximate the degree of ownership and transferability rights. Based on the literature presented above, we expect that improved land rights (for example, the implementation of full private ownership) will increase aggregated land use. Similarly, increased freedom to transfer agricultural land to other users will cause the economic value of land to rise and, thus, provide incentives to exercise land use.

However, macroeconomic models have several limitations. For instance, they fail to provide insights on the impact of individual farmer characteristics and the effects of non-economic attitudes and perceptions, which cause differences in behavioral patterns and play an important role in investigating drivers of land-use change (Lambin et al. 2000). In addition, individual country-specific analysis gives an opportunity to take unobservable country heterogeneity into account, which might come from differences in the implementation of agricultural reforms at the local level. Such heterogeneity is a source of inaccuracy and bias in the interpretations of the estimates in macroeconomic studies, particularly estimates of the institutional effects (Fischer 2010).

Data and Methodology

Empirical Specification

We use Equation 6 to derive the empirical model of land abandonment to test institutional drivers of agricultural land use

$$\Delta r_{Ait} = \alpha + \beta_{Gt} G_{it} + \beta_{Xt} X_{it} + v_i + \varepsilon_{it} \quad (7)$$

where Δr_{Ait} is the rate of arable land use in country i , α is a constant term, G_{it} is a vector of institutional variables, and X_{it} is a vector of additional variables, β_{Gt} and β_{Xt} are vectors of coefficients to be estimated, v_i is unobserved country-specific effects, and ε_{it} is the random error term.

Measuring Land-Use Rates

There is no commonly accepted measure for land-use change that would provide the most accurate estimation of increases or decreases in agricultural area. In this study, we refer to the two most relevant Food and Agriculture Organization (FAO) definitions, which are relevant to the area of cultivated land (Food and Agriculture Organization 2017). One of them is agricultural land that comprises arable land together with permanent croplands, pastures, and hayfields. Another definition is arable land that consists of land under temporary crops, pastures, and temporarily fallow land. In both indicators, double-cropped areas are counted only once. Permanent pastures and hayfields may be likely to contain abandoned land, which points to arable land as the more appropriate measure. However, several remote-sensing and environmental studies raise concerns related to the miscalculation of arable lands in official statistics. For example, land sown with perennial grasses is often reported as part of official arable land in Russia (Ioffe et al. 2012). Moreover, after more than five years, unutilized fallow land may often be recorded as arable land, when, in fact, it is abandoned. Grigory Ioffe et al. (2012) and Florian Schierhorn et al. (2013) claim that the sown area recorded in official agricultural inventory statistics demonstrates the closest match with independent remote-sensing estimates for land abandonment because it is reported annually by farmers to local agricultural administrations. Yet, such discrepancies have only been studied in certain countries, particularly European Russia, Ukraine, and Belarus, and the existence of similar problems in the other selected focus countries is unknown. In addition, studies on mapping abandoned land might face challenges that result in inaccuracies (Lesiv et al. 2018). Official statistics on sown area in tropical countries, such as Vietnam, Laos, and China, include double-cropped acreage, which creates difficulties for calculating the physical sown area. For these reasons, we employ the data on arable area despite the limitations mentioned above.

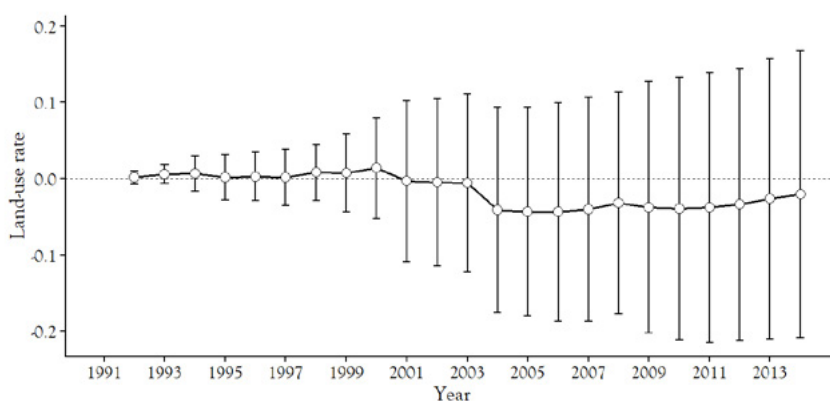
Following previous studies, we use land-use rate as a dependent variable that simultaneously reflects not only abandonment, but also recultivation or agricultural expansion. Thomas Sikor et al. (2009) identify land abandonment in each period as “the percentage change in cropland from the amount of cropland at the start period.” Patrick Meyfroidt et al. (2016) estimate the ratio of abandoned land to the total cropland area using the annual sown area statistics at the provincial level. A similar measure was introduced by Zhonglei Yu et al. (2017), estimating an index of seasonal farmland abandonment by measuring the difference between total farmland area and crop planting area as a share of total farmland area. Since our focus is on changes in arable land use, we apply the opposite of previous studies to calculate the land abandonment rate and estimate the rate of land use by

$$\Delta r_{Ait} = \frac{A_t - A_0}{A_0} \quad (8)$$

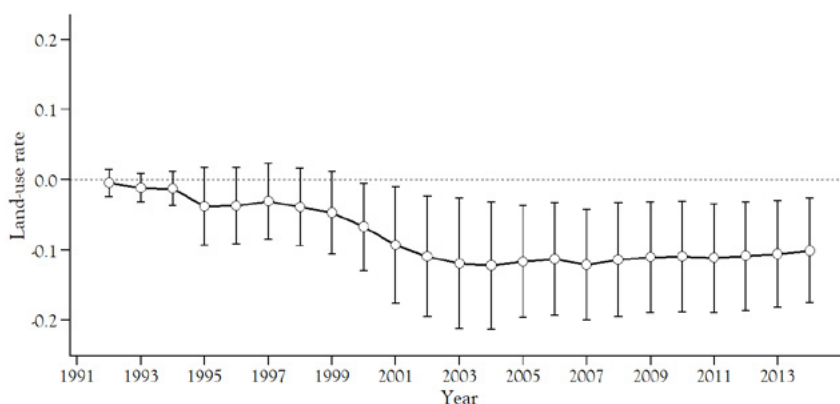
where A_0 is the initial arable area at the beginning of the 1990s (that is, the first year with available data) and A_t is the arable area for every following transition period year. Negative values of the rate imply abandonment of arable area; positive values indicate cultivation or recultivation of abandoned land (see figure A2 in the Appendix for the trends of land-use rates in each country).

Figure 1 displays the mean values of land-use rates from 1991 to 2014 for two groups of transition economies. First, countries that recognized private ownership of land partially or fully after 1991 belong to Group A. Second, Group B consists of countries that recognized potential ownership for all farmland before 1991 or never suppressed private ownership. Standard deviations represent the dispersion of land-use rates for each group. Average land-use rates in the first group (figure 1a), which comprises not only CIS but also East Asia, decrease relatively slightly until 2007 and then partly recover. The widening standard deviation in Group A marks the substantial variability of land-use rates among these economies.

The second group (figure 1b), consisting mainly of CEE countries, is characterized by a decrease in land use on average until 2004. After that, the rate slightly recovers, indicating the recultivation of abandoned land. Considering that these countries had established land rights rather quickly, the decreasing trend of land-use change appears to be an unexpected result and contradicts the hypothesis that improved land rights result in greater land use. The decrease in average land-use rates for Group B is absolutely greater than for Group A. However, standard deviations are smaller across Group B, indicating less heterogeneity between countries compared to Group A. The greatest loss of arable land was observed in Mongolia, Estonia, and Georgia, where farmers abandoned more than half of the stock of arable land in the early 1990s (figure A2 in the Appendix). Although such big countries as China, Kazakhstan, Russia, and Ukraine exhibit low declines in land-use rates, the absolute amount of abandoned area is many times greater than in other countries.

Figure 1. Dynamics of Land-Use Rate Between Two Groups of Transition Economies (1991–2014)**a) Land-Use Rate in Countries* that Recognized Land Ownership Partially or Fully After 1991**

* Group A: Belarus, China, Georgia, Kazakhstan, Kyrgyzstan, Laos, Mongolia, Russia, Tajikistan, Turkmenistan, Uzbekistan, Vietnam

b) Land-Use Rate in Countries* that Recognized Full Land Ownership Before 1992

* Group B: Albania, Armenia, Azerbaijan, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, North Macedonia, Moldova, Poland, Romania, Slovakia, Slovenia, Ukraine

Notes: Vertical bars show one-half standard deviation above and below the mean land-use rate for each year.

Source: Calculations based on FAOSTAT.

Measuring Institutional Change

When considering the role of land rights in transition economies, it is crucial to acknowledge that private ownership does not align with the traditional Western approach to property rights, particularly in terms of the ability to transfer land rights (Lerman et al. 2004). While one country may have successful market agriculture on state-owned land, another country may impose restrictions on land transactions for individual landowners. Considering these variations, the primary aim of this study is to identify whether individual land rights are associated with land abandonment in transition economies.

Table 1. Operationalization of Land Ownership and Land Transferability

Level	Private land ownership	Land transferability of commercial farms
0	None	No rights to transfer or moratorium
1	Households	Right to lease and inherit
2	Commercial farms and households	Right to buy, sell and lease

Source: Adopted from Lerman et al. (2004)

The separation of land ownership from land transferability allows for a more precise analysis of their individual impacts on land use. We adopt the operationalization method suggested first by Lerman et al. (2004, 96) to turn land ownership and land transferability into distinct ordinal variables. For each year within the 1991–2014 period, these two indicators are assessed based on land codes and relevant legislation (table A2 in the Appendix). Resulting indicators can take on three levels of ownership and transferability rights for farmers and households on agricultural land (table 1). For land ownership, we assign a score of 0 to countries that do not recognize private ownership for both farms and households in a particular year. A score of 1 is assigned to those countries that partially recognize ownership and grant this right to households, whereas commercial farmers remain deprived of private land ownership. Countries where households and farmers are allowed to own agricultural land have a score of 2.

Similarly, the indicator of land transferability takes on a score of 2 if a country grants farmers the right to lease, sell, and buy agricultural land without any restrictions (restrictions for foreigners are not considered). A score of 1 is given to countries that allow leasing and inheritance but prohibit the buying and selling of land. Countries that only allow rights to use land without rights to transfer or have a moratorium on land transactions are assigned a value of zero. This indicator relies on the right to land transferability for commercial farmers, excluding households mainly involved in subsistence farming. We only make an exception for China, Laos, and Vietnam, as the laws of these countries do not differentiate between farming households and commercial farmers.

The values of both indicators for twenty-four years are presented in table A3 and A4 in the Appendix. Analysis of the dataset showed that ten out of twenty-nine countries that introduced land ownership rights for commercial farms failed to provide the right to sell and buy land in some years due to a moratorium on farmland transactions (Kyrgyzstan and Ukraine), delayed land reforms (Albania, Armenia, Azerbaijan, Bulgaria, Georgia, Macedonia, and Romania), or complete prohibition of land transactions (Turkmenistan). In contrast, in Belarus, individual farmers were granted permanent use rights, and the land was given in lifetime inheritable possession. In Laos, Tajikistan, and Vietnam, land is transferable despite fully belonging to the state.

To integrate the evaluation of the quality of governance, we use the Rule of Law indicator that is a part of the World Bank's Worldwide Governance Indicators (WGI) dataset. According to the definitions of WGI, the rule of law reflects the extent to which a country adheres to legal rules and enforces them. This indicator ranges from -2.5 to 2.5 , with higher values indicating better governance performance. We rescaled this indicator to a range of 0 to 10.

Although a possible correlation between land ownership, land transferability, and the rule of law might exist, they still measure different aspects of governance. In transition economies, land ownership does not necessarily entail the right to sublease or sell. Some countries that allow land ownership may restrict land transferability, creating impediments to effective land allocation (for example, Ukraine before July 2021 and Turkmenistan). On the contrary, some countries grant partial or full rights to transfer land without ownership rights (for example, Vietnam and Tajikistan). Lerman et al. (2004, 78) assert that land transferability plays a greater role in establishing land markets and effective resource allocation than land ownership. From the methodology of the rule of law, which is based on perceptions of the level to which governments enforce contracts and maintain the security of property rights, it is obvious that this indicator measures the informal side of legal rights, particularly to what extent these rights can be enjoyed (Kaufmann et al. 2010).

Control Variables

Following the existing studies on land use and abandonment, in addition to institutional drivers, we control for environmental and socio-economic drivers. First, to determine the environmental potential of agricultural land, we use two climatic datasets: annual mean *temperature* and *precipitation*. We retrieved the data from the World Bank database and calculated annual temperature and precipitation averages in crucial months for crop growth from March to June. We converted the temperatures from Celsius to Fahrenheit to eliminate negative values in order to estimate the natural logarithm of annual average temperatures.

To control the impact of potential rural labor availability, our study includes the occupational *migration rate* and *population density* as part of a set of socio-economic variables. Previous research has shown that substantial structural changes in transition economies have resulted in an outflow of agricultural labor (Herzfeld and Akhmadiyeva 2021). This trend is supported by studies that have found that land abandonment often occurs

in regions with declining and poorer populations (Ioffe et al. 2012; Meyfroidt et al. 2016). Other studies have shown that the probability of using land for agricultural purposes is higher in regions with increasing population pressure (Wolfersberger et al. 2015). As population density increases, the demand for food also increases, resulting in mounting pressure on cultivated land. We use data from World Development Indicators (WDI) on population density and from the International Labor Organization (ILO) on agricultural and non-agricultural employment. We follow the study of Thomas Herzfeld and Zarema Akhmediyeva (2021) to calculate the occupational migration rate, which is the difference between the growth rates of total labor and agricultural labor. Positive values of the *migration rate* indicate a move out of the agricultural sector, which we expect to have a negative impact on the land-use rate. *Population density* is assumed to have a positive impact on land-use rate (Meyfroidt et al. 2016).

To identify the relative importance of economic development for land-use change, we include structural agricultural and economic variables in the model, such as the per capita gross domestic product (*GDP per capita*), real exchange rate (*RER*), and the terms of trade of agriculture (*TOT*). *GDP per capita* is indirectly associated with farming opportunity costs related to urbanization and industrialization (Li and Li 2017; Rey Benayas et al. 2007; Xie et al. 2014; Yu et al. 2017). Thus, we expect a negative sign for the coefficient related to *GDP per capita*. Fluctuations of the *RER* influence the value of agricultural incomes and land through changes in agricultural commodity prices (Hooper and Kohlhausen 1978). However, the effect will differ depending on the country's trade status and integration into international markets for agricultural inputs. For instance, a currency depreciation motivates farmers to increase production of export goods (Houck 1986). Increases in *RER* were found to be responsible for deforestation and expansion of cropland for soybean production in South America from 1995 to 2005 (Richards et al. 2012). Here, we control for the counterbalancing effects of *RER* by using the interaction terms of *RER* and net trade status for agricultural products, *NI* for net import, and *NX* for net export. We expect that a decline in *RER* will increase land cultivation in net-importing economies but decrease land use in net-exporting economies. A decline in agricultural prices relative to non-agricultural prices, measured by the sectoral *TOT*, is expected to foster rural-urban migration and a reduction in agricultural land use. Following Rita Butzer et al. (2002), we measure *TOT* by the ratio of agricultural GDP deflator to non-agricultural GDP deflator.

An increase in agricultural production can be related to more intensive production on a constant area and/or to the recultivation of earlier abandoned land. In the process of liberalization, areas with low productivity tend to be abandoned or converted to forests (Sali 2012). Thomas Rudel et al (2009) found evidence that rising yields were not associated with cropland declines in countries that export grain and do not apply conservation programs. We include the variable *cereal yield* per hectare to capture the cross-country differences in average productivity.

In addition, we add the variable of *military conflicts* as a control variable to observe their impact on land use. Causing forced displacement from combat zones and the destruction of settlements, armed conflicts indirectly influence land use and land abandonment (Witmer and O'Loughlin 2009). Even after an armed conflict ends, the existence of disputed territories may make it difficult to invest in agriculture and to recultivate abandoned lands (Johnson 2012). The number of deaths in state and non-state conflicts provided by the Uppsala Conflict Data Program Georeferenced Event Dataset (Sundberg and Melander 2013) allows us to investigate not only the impact of conflict on land use but also the impact of the severity of a conflict.

Finally, we include the *road network density* measured as the total length of motorways per 100 km² and collected from statistical yearbooks as a proxy for infrastructural development. Land abandonment mostly occurs in areas with poor market access and high transportation costs (Van Eetvelde and Antrop 2004). Yet, developed infrastructure may have a negative impact on land use since improved road networks may provide an opportunity to access off-farm jobs. Thus, the direction of the effect of improved infrastructure on land use is unknown a priori.

Descriptive Statistics and Estimation Strategy

Due to missing observations, the sample is reduced to twenty-six countries and nineteen years. Summary statistics are presented in table A5 (full sample) and table A6 (by country). To address inefficiency in coefficient and standard error estimation and to select a proper estimator for the land-use model, we inspect the nature of

the time-series cross-sectional data (TSCS) and then check for the presence of heteroscedasticity, autocorrelation, and cross-sectional dependency.

Following Jeffrey Wooldridge (2008, 328), we transformed such variables as *GDP per capita*, number of deaths in *military conflicts*, *temperature*, *precipitation*, *population density*, *RER*, *TOT*, *cereal yields* per hectare, and *road density* into logarithmic form. To deal with zero observations in the number of military conflict deaths, we added 1 to the original variable before transforming it to a logarithm. The log transformation yields distributions that are closer to normal and makes the non-linear relations as linear as possible by narrowing the range of the data. The analysis of correlation coefficients in table A7 in the Appendix demonstrates the absence of collinearity among most of the variables. To remove any doubts about multicollinearity among variables, we found the mean of the Variance Inflation Factor (VIF) using regression with all independent variables. VIF is 3.97, and the highest individual VIF value is 7.11. Both are below the critical threshold of 10, assuming the absence of multicollinearity among explanatory variables.

The strategy for estimating Equation 7 involves two sets of regressions: a set of regressions with a focus on land ownership and transferability rights (Model I) and a set of regressions with the rule of law (Model II). Tests for joint significance were performed to justify the legitimacy of three institutional variables: land ownership, transferability, and rule of law. The null hypothesis that three coefficients are equal to zero was rejected ($\chi^2=28.04$). We also estimate two baseline regressions of Model I and Model II only with institutional variables to figure out how the model reacts to the addition of control variables.

Results of Wooldridge, Modified Wald, Pesaran, Frees, and Friedman tests are summarized in table 2. As can be seen from the results, the existence of serial correlation, heteroscedasticity, and cross-sectional dependence is confirmed for both models.

Table 2. Specification Tests

Model I	Test	Pooled	Random Effects	Fixed Effects
Serial correlation	Wooldridge	62.295***		
Heteroscedasticity	Modified Wald			20485.58***
Cross sectional dependency	Pesaran		0.470	-0.130
	Frees		4.387***	6.547***
	Friedman		24.287	13.334
Model II				
Serial correlation	Wooldridge	63.672***		
Heteroscedasticity	Modified Wald			19414.71***
Cross sectional dependency	Pesaran		0.917	-0.017
	Frees		4.393***	5.904***
	Friedman		26.293	14.371

Note: ***, **, * denote significance level of 1%, 5%, and 10%, respectively.
Source: Authors' calculations.

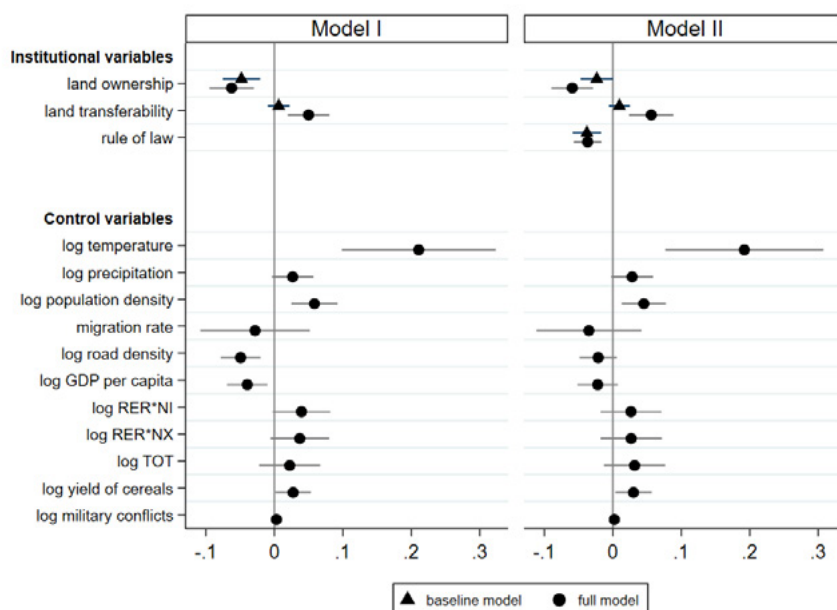
For models with these characteristics, Nathaniel Beck and Jonathan Katz (1995) suggest employing the Prais-Winston regression with Panel-Corrected Standard Errors (PCSE), which is very accurate for TSCS data with $T>15$. The Monte Carlo simulations confirmed that the PCSE estimator with group-wise first-order autocorrelation (AR(1)) produces accurate coefficients for any level of serial correlation (Moundigbaye et al. 2017). This technique helps to modify the entire dataset by considering the common average autocorrelation across panels. Beck and Katz's (1995, 640) claim that in comparative politics studies, the assumption of common autocorrelation for all panels gives consistent results.

We run our models using pairwise selection because PCSE requires balanced data (Moundigbaye et al. 2017). Considering that the regression coefficients are subject to sampling uncertainty, we present the regression results with 95 percent confidence intervals (CIs) to avoid misinterpretation (Hirschauer et al. 2018; Wasserstein et al. 2019). Coefficients are derived from Stata 15 with the function `xtpcse` and viewed as coefficient plots with the Stata command `coefplot` written by Ben Jann (2014).

Results and Discussion

Figure 2 presents the results of Model I and II with and without control variables. Despite adding control variables, the effects of the focus variables—land ownership and land transferability—remain consistent with the baseline models. The negative coefficient of land ownership suggests that countries with improved ownership rights experienced a reduction in arable land use relative to the early 1990s. In the full Model I, the coefficient of land ownership is -0.0625, indicating that a one-standard-deviation increase in the land ownership index would lead to a 4.31 percent decrease in the land-use rate ($-0.0625 \times 0.69 \times 100$), relative to its initial value. In contrast, countries with more transferable land rights show an increase in land-use rate. A one-standard-deviation increase in land transferability is associated with a 3.19 percent increase in the land-use rate ($0.0499 \times 0.64 \times 100$). While the estimated effect of land ownership remains stable after controlling for additional variables, the effect of land transferability becomes even stronger, indicating the importance of transferable rights in influencing land-use patterns. The difference in the effects of land transferability between the two models shows that the influence of control variables in full models cannot be neglected. These findings confirm previous studies that claim that land abandonment is mainly driven by aggregated socio-economic and political changes (Müller et al. 2012; Prishchepov et al. 2013).

Figure 2. Regression Coefficients of a Linear Model Explaining Land-Use Change with a 95% Confidence Interval



Note: Detailed estimation results are presented in tables A8 and A9 (Appendix).

The negative impact of land ownership appears to contradict our initial statement that land use is higher in countries with better tenure conditions. However, the result aligns with previous findings that the introduction of individual land ownership can sometimes lead to land abandonment (Deininger et al. 2012). This suggests that simply introducing ownership rights, without addressing market and institutional weaknesses, may not lead to better land-use outcomes. The ongoing process of land individualization in transition economies is followed by inconsistencies in the economic, institutional, legal, and political aspects of land tenure systems. If land markets are constrained and land cannot be transferred to more efficient producers, farmers may find cultivation financially unfeasible and may be forced to abandon their plots.

It is important to note that the estimated coefficients should be interpreted as correlations rather than evidence of causality. Establishing a causal relationship between land ownership and land use is challenging due to the presence of potential omitted variables, such as the timing and implementation of land reforms, broader economic conditions, and institutional factors that influence land-use decisions. While land rights

reforms may correlate with land-use changes, the complexities of these reforms, such as their distribution and enforcement, can lead to different outcomes depending on context.

Furthermore, the inconclusive outcomes regarding the impact of land ownership could also be explained by the speculative behaviors of landowners (Deininger et al. 2012). During the emergence of land markets, wealthy and powerful landowners may buy and keep agricultural land, anticipating its future appreciation, without using it for agricultural production (Barbier 1997). However, if market conditions become uncertain or the expected increase in land value never happens, speculators may choose to abandon their land. A more comprehensive approach is needed to properly understand the relationship between land ownership and economic outcomes.

In addition, in transition economies, particularly former Soviet Union countries, the introduction of land ownership occurred during a period of broader resource reallocation. As a result, much of the unproductive land, previously used under planned economic systems, was abandoned during the transition to more market-based economies (Nguyen et al. 2018). The introduction of land ownership during the transition period created market conditions under which effective resource allocation occurred, and unproductive lands were abandoned at the forefront.

The positive relationship between land transferability and land-use rate aligns with our theoretical expectations and previous research (Deininger and Jin 2006; Lerman et al. 2004), suggesting that improved land markets can promote more efficient land use. However, it is crucial to consider the initial conditions of land distribution in transition economies. The distribution mechanism of land shares or land-use rights often followed principles of equality, rather than maximizing potential productivity. As a result, post-reform land distribution was typically inefficient in terms of allocative efficiency. However, the results show that, despite this, land transferability allows land to move from less efficient to more efficient producers over time, contributing to increased land-use efficiency. The economic significance of land transferability underscores the need for functioning land markets, clear legal frameworks, and policies that reduce transaction costs to promote more efficient and productive land use.

The negative effect of the rule of law that reflects the effectiveness of property rights and contract enforcement does not seem surprising and demonstrates that countries with more effective governments experience a decline in land use during the transition from a planned to a market economy. Its negative impacts in both the baseline and full models suggest that a one-standard-deviation increase in the rule of law is associated with a 5.45 percent decrease in the land-use rate ($-0.0368 \times 1.48 \times 100$). Evidence from developing countries has pointed to a negative correlation between the effectiveness of regulatory structures and deforestation rates, which is the same as agricultural land expansion (Barbier and Tesfaw 2015; Deacon and Bohn 2000).

The estimated effects of population density on land use are positive, with coefficients of 0.06 and 0.05 in Models I and II, respectively. This means that a one-standard-deviation increase in population density (1.06) is associated with a 6.2 percent increase (Model I) and a 4.8 percent increase (Model II) in the land-use rate. The positive coefficients of cereal yields in both models suggest that intensification involves an increase in agricultural land. As a proxy for agricultural land productivity, it indicates that countries with more favorable environmental conditions for agricultural production and greater economic opportunities to intensify land use have experienced less land abandonment. Both average annual temperature and precipitation impose a positive effect on the arable land-use rate, demonstrating that pressure on agricultural land is higher in warmer and more humid regions. However, these effects cannot clearly explain the heterogeneity of land use across transition countries. The reason might be attributed to the high heterogeneity of environmental characteristics within countries. Reliable environmental drivers that may be powerful predictors of land abandonment generally exist at district levels (Baumann et al. 2011). Representing new economic opportunities and a higher level of industrialization, an increase in road density and GDP per capita are associated with land abandonment (although the associations are not consistently reliable in Model II).

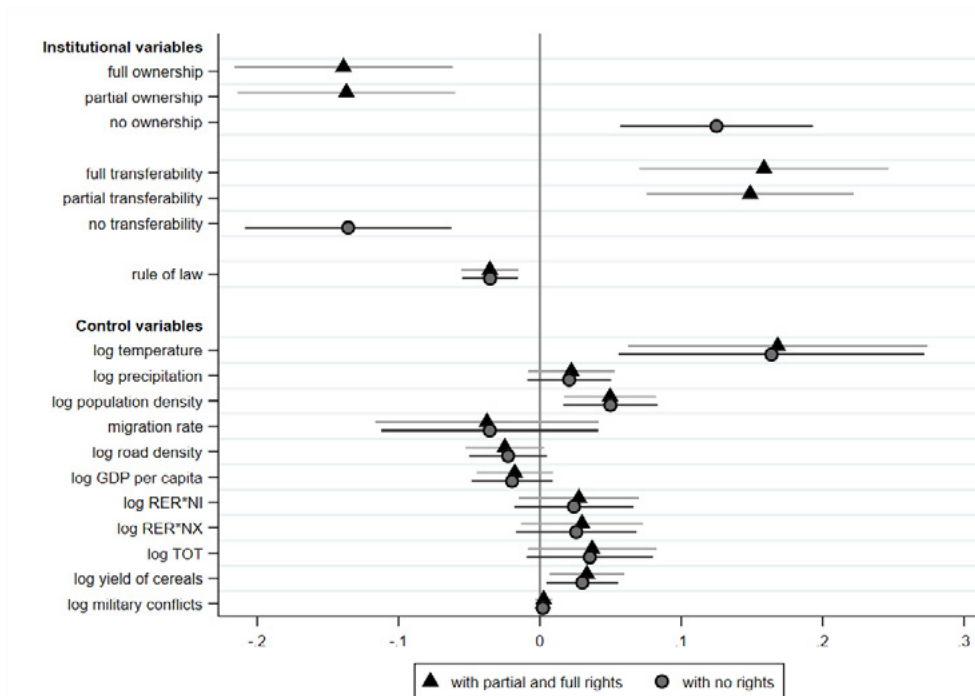
Robustness Assessment

To assess the robustness of the results, we perform several additional tests. The first analysis is related to the robustness of model specification, questioning the linearity of the relationship between land-use rate and land rights. The second one addresses the data issues that could occur due to methodological changes in measuring

the area of arable land. Moreover, an additional model with fixed time effects is estimated to eliminate omitted variable bias caused by excluding unobserved time-variant drivers.

We repeated Model II using the same estimator (PCSE) with decomposed land rights to control whether the relationship between land rights and land use is not linear. The rationale of this method was to capture the influence of land rights on different levels of limitation. We modified the measurements of land ownership and land transferability, which have three-point estimation, into dummy variables for each point. Thus, we introduced three dummy variables for land ownership (no ownership, partial ownership, and full ownership) and three for land transferability (no transferability, partial transferability, and full transferability). To avoid the so-called “dummy variable trap,” we ran two regressions: the first included two dummies of land ownership and two dummies of land transferability, and the second estimated the effects of the remaining dummies. An interpretation of the dummy variables has to be done in relation to the omitted category. It means that the land-use rate is equal to the constant term at the reference category (dummy variable that was left out of the model).

Figure 3. Coefficients of Regressions with Dummy Variables for Land Rights with a 95% Confidence Interval

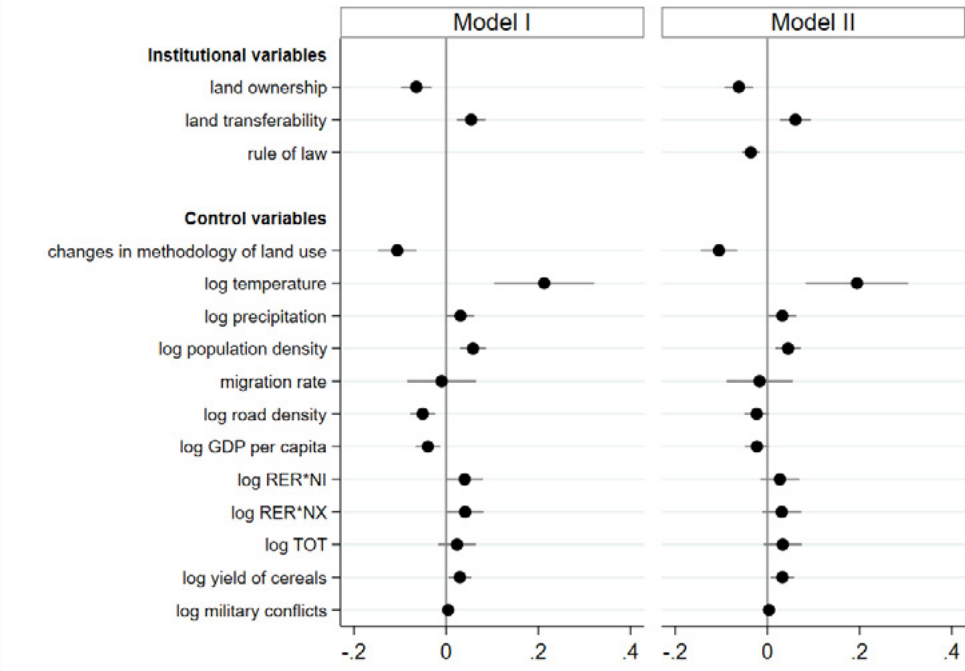


Note: Detailed estimation results are presented in table A10 in the Appendix.

Figure 3 presents the results, which are similar to the results in figure 2. The model with dummy variables of partial and full land rights shows that countries with limited and full land ownership have higher levels of land abandonment, while partial and full land transferability is associated with increasing agricultural land use. Inversely, the absence of land ownership creates the opposite effect by increasing land use, and the absence of the right to transfer the land causes higher land abandonment. The effects of the control variables are very similar to those presented in figure 2, apart from the fact that the effects of the dummies are more prominent than the three-point measurements of land rights.

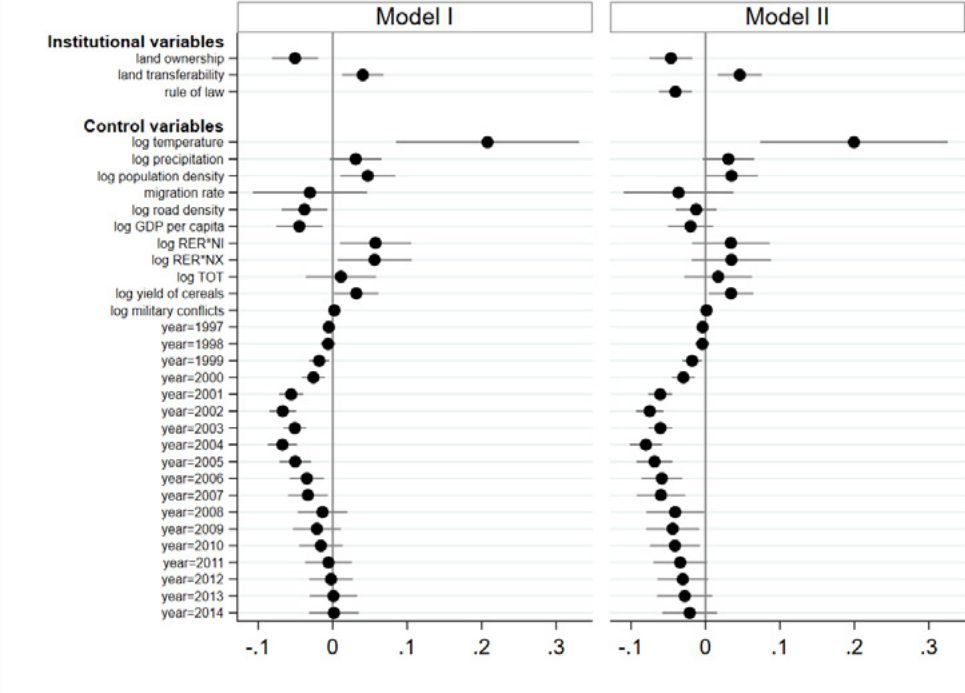
Recognizing that FAO data on arable land contains bias originating from methodological changes for some countries in particular years, we examine additional specifications for Models I and II. We introduce a dummy variable that controls for sharp drops in arable land caused by changes in statistical methodologies. Table A11 in the Appendix demonstrates countries and years when methodological changes occurred. Figure 4 shows the results of these additional estimations. Changes in the methodology of land use have a significant negative influence on the land-use rate. Simultaneously, it has a minor effect on other coefficients, highlighting the robustness of our results.

Figure 4. Coefficients of Regressions with a 95% Confidence Interval and a Dummy Variable that Indicates Methodological Changes in Agricultural Land Use



Note: Detailed estimation results are presented in table A12 in the Appendix.

Figure 5. Coefficients of Regressions with a 95% Confidence Interval and Year Fixed Effects



Note: Detailed estimation results are presented in table A13 in the Appendix.

Controlling for time-specific confounders with year-fixed effects also does not cause substantial changes in the coefficients of land rights indicators (figure 5). However, confidence intervals for dummy variables of years show that some unobserved variables that could better explain a reduction in arable land in the period from 1999 to 2007 are omitted. Overall, all three additional models confirm the robustness of the estimates in figure 2.

As a final robustness check, we ran the regression using an alternative proxy for the returns in the agricultural sector. The terms of trade of agriculture may not fully reflect the structural transformation in a transition context, wherein returns from other sectors generally increase over time. We replaced the sectoral *TOT* with the ratio of gross agricultural output to agricultural labor force and non-agricultural gross output to the non-agricultural labor force, which is also known as relative labor productivity in the literature (Blanco and Raurich 2022). However, the results reported in table A14 in the Appendix show that substituting the sectoral *TOT* for relative labor productivity does not make much difference to the coefficients. Although the estimated coefficients of land ownership and transferability are slightly undervalued, they remain strongly associated with agricultural land use.

The goodness-of-fit measures for the PCSE regression models are presented in the Appendix. The Wald test, which assesses whether the joint effect of the variables is statistically significant, confirmed that the models met this condition, suggesting a good model fit. Additionally, the performance of the models was evaluated using root mean squared errors (RMSE), which represent the standard deviation of the residuals. The RMSE values, approximately 0.14, are lower than the standard deviation of the land-use rate, which is 0.19. This indicates that models outperform the benchmark criterion. Although the R-squared value is not particularly informative for panel data models in the presence of issues such as heteroscedasticity or serial correlation (Wooldridge 2010), it can still be useful for evaluating the relative performance of models. The R-squared values presented in the Appendix demonstrated that the model accounting for methodological changes in the agricultural land calculations performed better than others.

Conclusions

The transition from a planned to a market economy involves substantial shifts in the institutional environment, with significant implications across all sectors, including agriculture. This transformation offers a unique opportunity to explore the relationship between institutional change and agricultural land use. In this study, we aimed to improve understanding of the association between arable land use and changes in institutional arrangements in the context of transition economies. This is the first study to apply the operationalization of land ownership and land transferability indicators proposed by Lerman et al. (2004) to create variables for TSCS data in order to conduct empirical analysis across transition economies. We employ a PCSE estimator to identify the various factors that drive changes in land use.

This article demonstrates that institutional drivers are as important as socio-economic factors in driving land-use change, even though the empirical results may not fully align with the theoretical expectations. Specifically, the findings indicate that the introduction of private land ownership in transition economies can lead to land abandonment, particularly during the initial years of transitioning to individualized land tenure systems. Because of enormous structural changes—such as land restitution and distribution to individual users, the reallocation of production factors to more fertile locations, the sharp removal of agricultural subsidies, and disruptions in supply chains—the various aspects of the land tenure system were not able to support consistency with each other. In other words, the social, technical, economic, legal, and political elements of the land tenure system in these countries could not provide the necessary framework for the realization of land rights. Therefore, analyzing land ownership rights without taking into account the broader context of the tenure system can produce confusing results.

This study reveals that the distinction between land ownership and transferability is crucial, as merely introducing land ownership does not ensure efficient land use if the rights to buy, sell, or lease the land are not accessible. The empirical results demonstrate that the ability to transfer land is more critical for reducing land abandonment than land ownership alone. Enhancing land transferability increases the value of land by facilitating access to credit and enabling more efficient producers to acquire and utilize the land, thereby fostering more effective land use.

This study has implications for policymakers in transition economies. First, the results suggest that introducing individual land ownership rights without addressing broader market, institutional, and legal weaknesses may not lead to the desired outcomes of increased agricultural land use and productivity. Policymakers should consider a sequenced and coordinated approach to land reforms, focusing on establishing well-functioning land markets and institutions to support efficient land transactions and allocations. In particular, land reform policy should consider reducing transaction costs, simplifying legal procedures for land transfers, and ensuring that land can be easily bought, sold, and leased. Additionally, adequate social, economic, and trade policies, as well as the creation of new economic opportunities in rural areas, are crucial to provide incentives for residents to stay in rural areas. This, in turn, will indirectly support agriculture through rural development.

While reducing land abandonment and enhancing agricultural productivity are critical for addressing global food security, the ecological impacts of unsustainable farming practices must also be considered. The environmental consequences of such practices can offset the short-term gains in productivity and worsen ecological conditions in the future. Therefore, policymakers should promote institutional frameworks that encourage efficient land use through enhanced transferability and support sustainable farming practices.

The main limitation of this study is that it only assesses land rights in a formal context, ignoring actual tenure conditions. These findings could be improved by integrating additional measurements of actual realization of land rights at the country level, which would provide a more comprehensive picture of the relationship between land tenure and arable land cultivation. Furthermore, the assessment of land transferability in this study focuses primarily on commercial farmers. Yet, improved land transferability can sometimes result in the transfer of land from small-scale household producers to large companies or wealthier farmers. In such cases, if land is acquired for speculative purposes rather than productive use, the land-use rate may decrease rather than increase. To better understand these dynamics, future research should focus on countries with dominant small-scale agriculture, paying particular attention to the land rights of households and the potential for different outcomes when land is transferred between smallholders and larger commercial entities.

It is also crucial to acknowledge that macroeconomic analyses provide only broad guidance. Results derived from statistical analyses of aggregate national data are unlikely to lead to strong conclusions about the land abandonment issue at the local level. To develop more targeted and effective policy recommendations, it is essential to conduct case-specific research that explores the finer institutional, cultural, and regional factors influencing land use.

Disclosure Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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Appendix

Table A1. Agrarian Characteristics of Countries in Transition in 2015

Country	Income Per Capita ¹ (const. 2011)	% of Rural Population ³	% of Agriculture in GDP ³	% of Sown Area in Agricultural Land ²	% in Global Agricultural Production ³
Transcaucasia					
1 Armenia	8,196	36.92	17.2	19	0.06
2 Azerbaijan	16,699	45.29	6.2	34	0.11
3 Georgia	9,025	42.55	7.9	11	0.03
Balkans					
4 Albania	10,970	42.56	19.8	35	0.06
5 Bulgaria	16,999	26.01	4.1	66	0.14
6 Romania	20,666	46.11	4.2	60	0.38
7 Slovenia	29,038	46.22	2	28	0.03
8 Croatia	21,026	43.85	3.5	54	0.07
9 North Macedonia	12,761	42.59	9.7	15	0.04
Baltics					
10 Estonia	27,550	31.28	2.7	62	0.03
11 Latvia	23,019	32.02	3.6	61	0.05
12 Lithuania	27,046	32.77	3.4	77	0.10
Central Asia					
13 Kazakhstan	23,524	42.81	4.7	10	0.37
14 Kyrgyzstan	3,238	64.22	14.1	11	0.08
15 Tajikistan	2,641	73.26	21.9	17	0.08
16 Turkmenistan	14,992	49.68	9.3	5	0.11
17 Uzbekistan	5,700	49.25	16.6	14	0.58
Central Europe					
18 Czech Republic	30,605	26.52	2.2	70	0.16
19 Hungary	25,034	29.5	3.7	82	0.24
20 Poland	25,307	39.72	2.2	72	0.82
21 Slovakia	28,309	46.11	3.4	65	0.06
East Asia					
22 Mongolia	11,412	31.77	13.4	0.4	0.04
23 China	13,569	44.5	8.83	32	23.7
24 Viet Nam	5,554	66.19	17	96	1.3
25 Lao PDR	5,755	66.89	17.6	64	0.11
European CIS					
26 Belarus	17,219	22.82	6.3	68	0.30
27 Republic of Moldova	4,747	57.51	12.2	61	0.06
28 Russian Federation	24,517	25.95	4.1	36	2.32
29 Ukraine	7,465	30.94	12.1	66	1.16

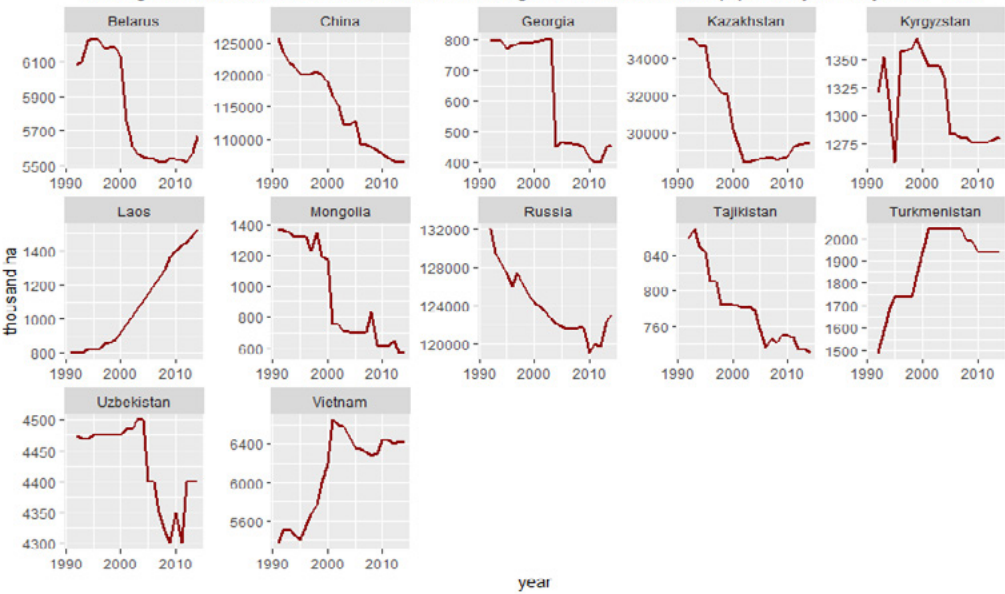
¹ World Development Indicators

² Statistical Yearbooks of countries, 2014

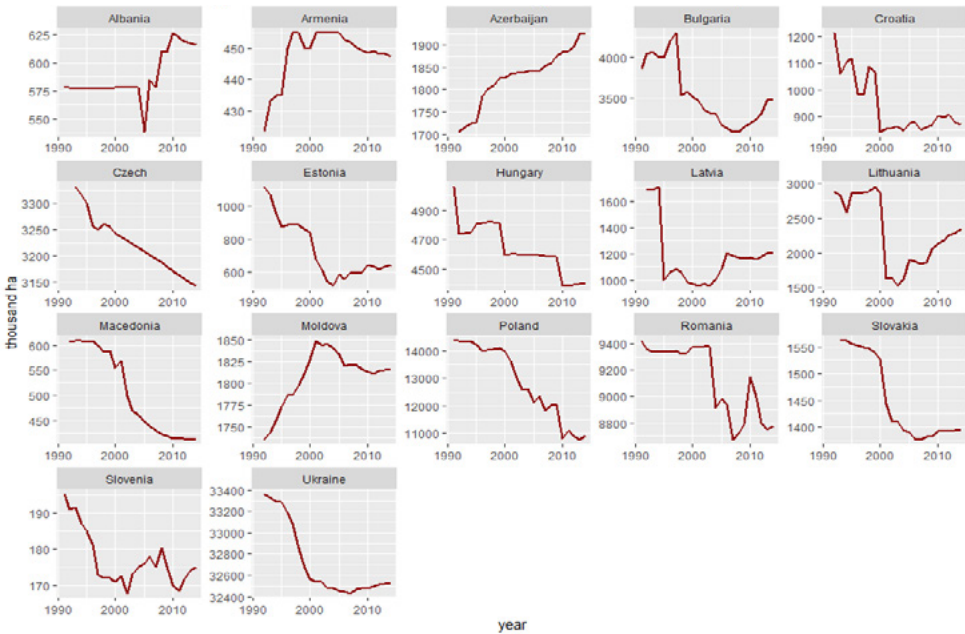
³ FAOSTAT 2015, Gross Agricultural Production Value (constant 2004–2006 1000 I\$)

Figure A1. Area of Arable Land in Transition Countries during the Period of 1991–2014 (Base Year = 1990).

a)



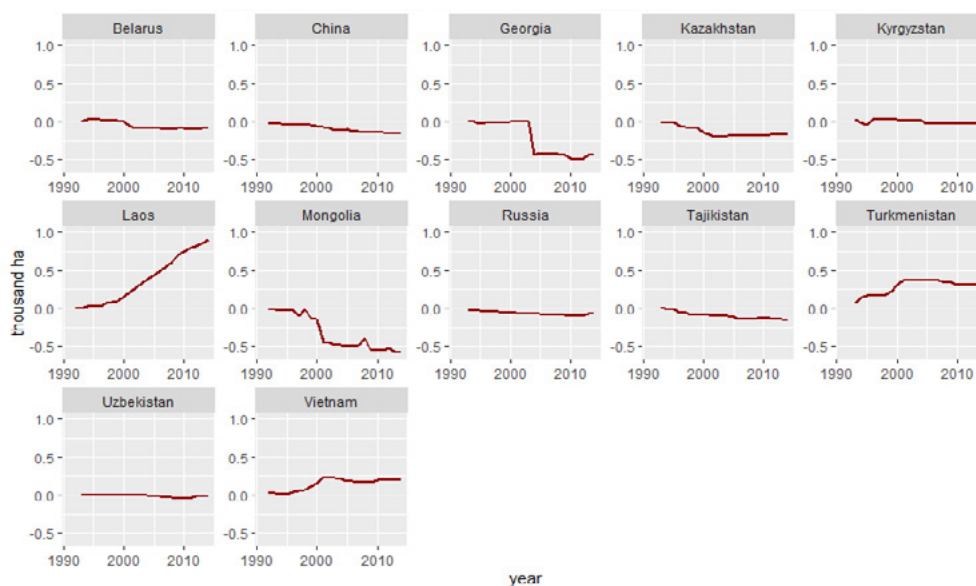
b)



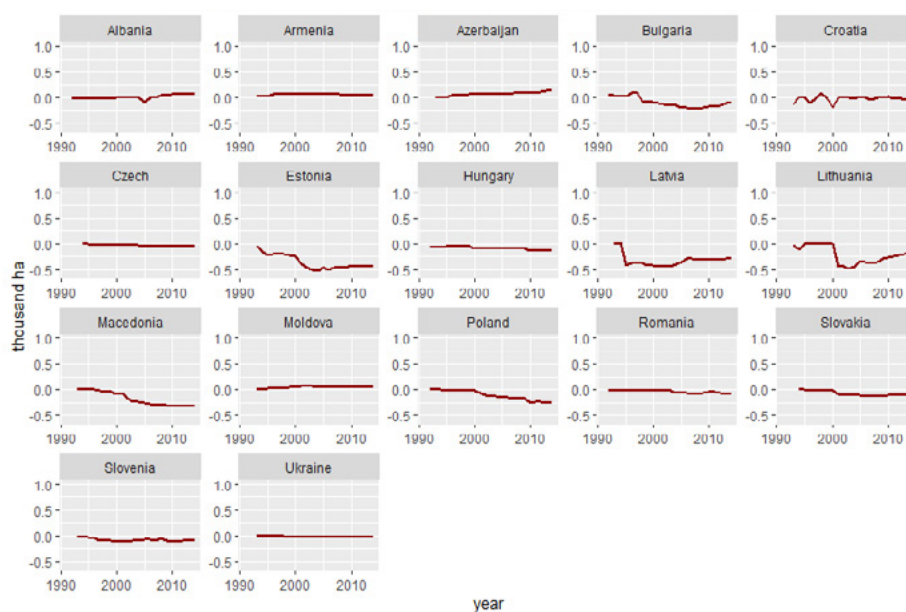
Source: FAOSTAT.

Figure A2. Land Use Rate in Transition Countries during the Period of 1991–2014 (Base Year = 1990).

a)



b)



Source: FAOSTAT.

Table A2. List of Land Codes and Documents Related to the Land Ownership and Transferability

Country	Legal Base of Agricultural Land Ownership and Transfer Rights
Albania	Land Law No. 7501 (19/07/1991): land ownership, land only for use; Law no. 7983 (1995) for buying and selling agricultural land, meadows and pastures.
Armenia	Law "On peasant and peasant collective economies" (1991): land ownership; Moratorium on land sales expired in February 1994.
Azerbaijan	Land Code (1991): land ownership; Law on Land Reforms (1996): land transferability.
Belarus	Law "About peasant farm" (1991): land use rights to all with lifetime inheritable possession; Land Code (1999): ownership only for households.
Bulgaria	Land ownership existed before 1990; 1993, land restitution completed. Guideline on Technical Land Prices was issued.
Croatia	Land ownership and transferability existed before 1990.
Czech Republic	Land ownership and transferability existed before 1990.
Estonia	Law on Land Reform (1991): land ownership and transferability.
Georgia	Land Privatization Decree (1992): land ownership for households; Law of Agricultural Land Ownership (1996): land transferability.
Hungary	Land ownership and transferability existed before 1990; Act LV of 1994 on Arable Land: land transferability.
Kazakhstan	Presidential Decree on Land Reform (1994): land use for farmers; ownership for households; Land code (2003): land ownership and transferability for all land.
Kyrgyzstan	Law on peasant farms (1991): land redistribution; Land of land reform (1991); Presidential Decree "Measures on Promoting Land and Agrarian Reforms (1994) Land Code (1999): full land ownership and transferability; Moratorium on land sales (1999–2001); Moratorium was lifted (2002).
Latvia	Land Reform in Rural Areas Act (1990): full land ownership and transferability.
Lithuania	Law on Land Reform (1991) full land ownership and transferability.
North Macedonia	1986 Law on Protection and Use of Agricultural Land of 1986
Moldova	Law on Property (1991); Land Code (1991): full land ownership and transferability.
Mongolia	Law on Land (1994): land ownership only for households; land possession right may be transferred by inheritance.
Poland	Land ownership and transferability existed before 1990.
Romania	Land ownership and transferability existed before 1990; Law No 54 "On the Legal Circulation of Land" (1998).
Russian Federation	Law on Land Reform (1990).
Slovakia	Land ownership and transferability existed before 1990.
Slovenia	Land ownership and transferability existed before 1990.
Tajikistan	Law on Land Reform, 1992: the right to sublease land for dehkans; Land Code (1996).
Turkmenistan	Constitution (1992): land ownership; all land transactions are prohibited
Ukraine	Law "On Land Reform" (1990): land ownership; Law on Forms of Land Ownership (1992); Decree "On Privatization of Land Allotments" (1992): land transferability only for households. Land code (2002) Moratorium on land sales (2002)
Uzbekistan	Constitution (1992): state ownership of land; all land transactions are prohibited.
China	Household Responsibility System reform (1979): all rural land is owned by rural collectives: farmers are allowed to sublease their land.
Laos	Decree by the Prime Minister on land (1992): state ownership of land; farmers are allowed to transfer land use right; Program "Land and Forest Allocation" for rural areas.
Vietnam	Land Law of (1987); Land Law (1993): land transferability.

Table A3. Indicator of Land Ownership (1991–2014)

Country Code	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ALB	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
ARM	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
AZE	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
BLR	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BGR	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CHN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HRV	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CZE	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EST	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
GEO	0	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
HUN	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
KAZ	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
KGZ	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LAO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LVA	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LTU	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
MKD	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
MDA	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
MNG	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
POL	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
ROM	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
RUS	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
SVK	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SVN	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
TJK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TKM	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
UKR	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
UZB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Authors' assessment. Country codes are taken from the World Development Indicators: ALB – Albania, ARM – Armenia, AZE – Azerbaijan, BLR – Belarus, BGR – Bulgaria, CHN – China, HRV – Croatia, CZE – Czech Republic, EST – Estonia, GEO – Georgia, HUN – Hungary, KAZ – Kazakhstan, KGZ – Kyrgyzstan, LAO – Laos, LVA – Latvia, LTU – Lithuania, MKD – North Macedonia, MDA – Moldova, MNG – Mongolia, POL – Poland, ROM – Romania, RUS – Russian Federation, SVK – Slovakia, SVN – Slovenia, TJK – Tajikistan, TKM – Turkmenistan, UKR – Ukraine, UZB – Uzbekistan, VNM – Vietnam.

Table A4. Indicator of Land Transferability (1991–2014)

Country Code	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ALB	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
ARM	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
AZE	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
BLR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BGR	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CHN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HRV	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CZE	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EST	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
GEO	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
HUN	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
KAZ	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
KGZ	0	0	1	1	1	1	1	1	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
LAO	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LVA	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LTU	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
MKD	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MDA	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
MNG	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
POL	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
ROM	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
RUS	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
SVK	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SVN	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
TJK	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TKM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UKR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
UZB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VNM	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Note: Authors' assessment. Country codes are taken from the World Development Indicators: ALB – Albania, ARM – Armenia, AZE – Azerbaijan, BLR – Belarus, BGR – Bulgaria, CHN – China, HRV – Croatia, CZE – Czech Republic, EST – Estonia, GEO – Georgia, HUN – Hungary, KAZ – Kazakhstan, KGZ – Kyrgyzstan, LAO – Laos, LVA – Latvia, LTU – Lithuania, MKD – North Macedonia, MDA – Moldova, MNG – Mongolia, POL – Poland, ROM – Romania, RUS – Russian Federation, SVK – Slovakia, SVN – Slovenia, TJK – Tajikistan, TKM – Turkmenistan, UKR – Ukraine, UZB – Uzbekistan, VNM – Vietnam.

Table A5. Descriptive Statistics of Key Variables and their Sources

Variable	Description	Source		Mean	SD	Min	Max	Observations
Land use rate	Rate 0–1	FAOSTAT	overall	–0.08	0.19	–0.58	0.91	N = 494
			between		0.17	–0.39	0.45	n = 26
			within		0.09	–0.50	0.37	
Land ownership	No ownership=0; full ownership=2	Land codes	overall	1.65	0.69	0.00	2.00	N = 494
			between		0.68	0.00	2.00	n = 26
			within		0.17	0.81	2.02	
Land transferability	Non-transferable=0; transferable=2	Land codes	overall	1.60	0.64	0.00	2.00	N = 494
			between		0.61	0.00	2.00	n = 26
			within		0.21	0.08	2.08	
Rule of law	Governance performance: 0–10	WGI	overall	4.60	1.48	2.05	7.75	N = 494
			between		1.46	2.39	7.05	n = 26
			within		0.37	3.30	6.20	
Temperature	log of Fahrenheit	CCKP	overall	3.84	0.20	3.01	4.34	N = 494
			between		0.21	3.12	4.32	n = 26
			within		0.03	3.73	3.95	
Precipitation	log of mm	CCKP	overall	3.92	0.51	2.48	5.24	N = 494
			between		0.49	2.81	5.05	n = 26
			within		0.14	3.46	4.33	
Population density	log of persons per km ²	WDI	overall	3.99	1.06	0.39	4.98	N = 494
			between		1.07	0.49	4.93	n = 26
			within		0.05	3.84	4.14	
Migration rate	rate	ILO	overall	0.026	0.06	–0.30	0.28	N = 494
			between		0.01	–0.001	0.05	n = 26
			within		0.06	–0.31	0.27	
Road density	log of km per 100 km ²	Statistical yearbooks	overall	3.55	1.16	1.09	5.42	N = 494
			between		1.15	1.15	5.13	n = 26
			within		0.25	2.28	4.25	
GDP per capita	log of \$ (2011)	PWT	overall	9.12	0.77	7.42	10.37	N = 494
			between		0.69	7.82	10.15	n = 26
			within		0.36	8.12	10.21	
RER *NI	log of RER*net import (dummy)	PWT	overall	0.65	0.60	–0.37	2.10	N = 494
			between		0.45	–0.03	1.56	n = 26
			within		0.41	–0.39	1.90	
RER *NX	log of RER*net export (dummy)	PWT	overall	0.37	0.62	–0.28	2.31	N = 494
			between		0.49	–0.04	1.40	n = 26
			within		0.39	–1.01	1.57	
Military conflicts	log of number of deaths	PRIO, UCDP & HSR	overall	0.53	1.53	0.00	8.73	N = 494
			between		1.27	0.00	6.15	n = 26
			within		0.89	–3.54	8.48	
TOT	log of Rate 0–1	UN MAD	overall	0.15	0.24	–0.39	1.17	N = 494
			between		0.13	–0.09	0.48	n = 26
			within		0.20	–0.40	0.98	
Yield of cereals	log of kg per ha	WDI	overall	7.96	0.47	6.16	8.80	N = 494
			between		0.43	6.84	8.59	n = 26
			within		0.20	7.28	8.53	

Note: WDI, World Bank – World Development Indicators; WGI, Worldwide Governance Indicators; CCKP, Climate Change Knowledge Portal; UN MAD, United Nations Main Aggregates Database; PWT, Penn World Table (9.0); PRIO, UCDP & HSR, Peace Research Institute Oslo, Uppsala Conflict Data Program and Human Security Reports; FAOSTAT, Food and Agriculture Organization of the United Nations; ILO, International Labor Organization.

Table A6. Individual Means and Standard Deviations of Variables

	Albania		Armenia		Azerbaijan		Belarus		Bulgaria		China		Croatia		Czech		Estonia		Georgia	
Variable	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd
land use rate	0.02	0.04	0.07	0.01	0.09	0.02	-0.06	0.05	-0.12	0.09	-0.10	0.04	-0.01	0.06	-0.04	0.01	-0.39	0.11	-0.26	0.22
land ownership	2.00	0.00	2.00	0.00	2.00	0.00	0.84	0.37	2.00	0.00	0.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00
land transferability	2.00	0.00	2.00	0.00	2.00	0.00	1.00	0.00	2.00	0.00	0.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00
rule of law	3.65	0.38	4.15	0.12	3.13	0.32	2.84	0.33	4.76	0.16	4.00	0.12	5.00	0.52	6.81	0.24	6.91	0.50	3.79	0.96
log of temperature	3.99	0.02	3.84	0.02	3.98	0.01	3.81	0.03	3.96	0.02	3.80	0.01	3.96	0.02	3.87	0.03	3.77	0.03	3.81	0.02
log of precipitation	4.39	0.17	3.79	0.17	3.61	0.12	3.98	0.12	3.98	0.20	3.87	0.06	4.50	0.18	4.05	0.12	4.04	0.14	4.36	0.11
log of population density	4.70	0.03	4.65	0.03	4.63	0.07	3.87	0.03	4.26	0.04	4.93	0.03	4.37	0.02	4.90	0.01	3.47	0.02	4.29	0.07
migration rate	0.01	0.03	0.01	0.02	0.01	0.01	0.02	0.01	0.04	0.08	0.03	0.02	0.04	0.08	0.04	0.04	0.05	0.08	0.00	0.03
log of road density	4.17	0.02	3.54	0.11	3.20	0.15	3.67	0.19	3.07	0.32	3.26	0.51	3.89	0.03	5.11	0.01	4.85	0.09	3.35	0.04
log of GDP pc	8.79	0.32	8.48	0.44	8.64	0.83	9.34	0.36	9.36	0.28	8.76	0.43	9.74	0.21	10.12	0.15	9.75	0.36	8.47	0.45
log of RER*NI	1.09	0.37	1.24	0.38	1.11	0.32	1.04	0.79	0.00	0.00	0.57	0.53	0.58	0.27	0.66	0.39	0.58	0.34	1.24	0.26
log of RER*NX	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.47	1.16	0.41	0.54	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
log of military conflicts	0.10	0.45	0.25	0.59	2.47	1.06	0.00	0.00	0.00	0.00	0.73	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.95	1.85
log of TOT	0.17	0.27	0.05	0.13	0.13	0.32	-0.09	0.14	0.27	0.26	-0.08	0.10	0.09	0.07	0.28	0.20	0.23	0.20	0.27	0.23
log of yield of cereals	8.20	0.22	7.63	0.27	7.76	0.18	7.87	0.25	8.09	0.25	8.56	0.07	8.53	0.15	8.44	0.13	7.77	0.26	7.57	0.17

	Hungary		Kazakhstan		Kyrgyzstan		Laos		Latvia		Lithuania		N. Macedonia		Moldova		Mongolia		Poland	
Variable	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd
land use rate	-0.09	0.03	-0.15	0.04	-0.00	0.03	0.45	0.30	-0.35	0.06	-0.24	0.17	-0.20	0.12	0.05	0.01	-0.39	0.20	-0.13	0.08
land ownership	2.00	0.00	1.63	0.50	1.84	0.37	0.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00	1.00	0.00	2.00	0.00
land transferability	2.00	0.00	1.63	0.50	1.53	0.77	1.00	0.00	2.00	0.00	2.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00	2.00	0.00
rule of law	6.69	0.28	3.17	0.43	2.99	0.49	3.00	0.26	6.11	0.52	6.26	0.35	4.29	0.29	4.28	0.32	4.79	0.49	6.34	0.30
log of temperature	3.94	0.03	3.79	0.03	3.63	0.03	4.32	0.01	3.79	0.03	3.81	0.03	3.93	0.02	3.93	0.03	3.50	0.04	3.86	0.03
log of precipitation	3.95	0.19	3.06	0.10	3.50	0.17	5.05	0.12	4.03	0.11	4.01	0.10	3.98	0.19	3.77	0.14	2.88	0.13	3.94	0.11
log of population density	4.72	0.02	1.76	0.05	3.29	0.07	3.22	0.09	3.58	0.07	3.96	0.07	4.39	0.02	4.83	0.01	0.50	0.07	4.83	0.01
migration rate	0.03	0.05	0.03	0.03	0.02	0.05	0.01	0.00	0.04	0.10	0.04	0.09	0.02	0.04	0.01	0.08	0.02	0.07	0.04	0.03
log of road density	4.75	0.89	1.21	0.09	2.25	0.01	2.63	0.29	4.55	0.02	4.82	0.07	3.93	0.10	3.72	0.09	1.15	0.00	4.84	0.04
log of GDP pc	9.86	0.19	9.29	0.55	7.82	0.19	7.88	0.40	9.60	0.34	9.69	0.35	9.13	0.20	7.94	0.32	8.47	0.55	9.71	0.25
log of RER*NI	0.00	0.00	0.34	0.38	0.72	0.71	1.56	0.29	-0.03	0.19	0.53	0.58	1.08	0.23	0.00	0.00	0.76	0.63	0.38	0.51
log of RER*NX	0.67	0.32	0.69	0.69	0.89	0.96	0.00	0.00	-0.04	0.10	0.23	0.24	0.00	0.00	1.40	0.36	0.52	0.71	0.35	0.30
log of military conflicts	0.00	0.00	0.00	0.00	0.71	1.53	0.72	1.15	0.00	0.00	0.00	0.00	0.40	1.08	0.00	0.00	0.00	0.00	0.00	0.00
log of TOT	0.22	0.24	0.16	0.12	0.48	0.36	-0.02	0.10	0.02	0.14	0.23	0.19	-0.02	0.09	0.16	0.29	0.19	0.17	0.01	0.13
log of yield of cereals	8.43	0.18	6.94	0.25	7.86	0.09	8.15	0.17	7.85	0.20	7.97	0.20	8.01	0.15	7.87	0.14	6.84	0.40	8.08	0.13

	Romania		Russia		Slovakia		Slovenia		Tajikistan		Turkmenistan		Ukraine		Uzbekistan		Vietnam		
Variable	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	m	sd	
land use rate	-0.04	0.03	-0.07	0.02	-0.08	0.04	-0.09	0.02	-0.09	0.05	0.28	0.09	-0.02	0.01	-0.01	0.02	0.14	0.08	
land ownership	2.00	0.00	1.63	0.50	2.00	0.00	2.00	0.00	0.00	0.00	1.92	0.41	2.00	0.00	0.00	0.00	0.00	0.00	
land transferability	1.89	0.32	1.63	0.50	2.00	0.00	2.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.83	0.56	
rule of law	4.86	0.25	3.25	0.20	5.85	0.29	7.05	0.18	2.43	0.35	2.08	0.19	3.32	0.23	2.39	0.21	4.01	0.17	
log of temperature	3.90	0.03	3.12	0.06	3.85	0.03	3.90	0.02	3.67	0.03	4.11	0.02	3.88	0.03	4.02	0.02	4.33	0.01	
log of precipitation	4.02	0.17	3.61	0.03	4.16	0.15	4.69	0.15	3.76	0.15	2.51	0.22	3.86	0.09	2.81	0.19	5.04	0.11	
log of population density	4.53	0.05	2.18	0.01	4.72	0.00	4.61	0.01	3.85	0.13	2.28	0.1	4.41	0.04	4.13	0.09	5.55	0.10	
migration rate	0.02	0.06	0.04	0.10	0.05	0.06	0.00	0.09	0.00	0.01	0.01	0.02	0.03	0.06	0.02	0.02	0.02	0.02	0.02
log of road density	3.51	0.08	1.48	0.33	4.30	0.37	5.13	0.30					3.37	0.01	2.65	0.25			
log of GDP pc	9.34	0.40	9.57	0.38	9.87	0.26	10.15	0.13	7.72	0.31	9.16	0.41	8.84	0.34	8.55	0.26	7.85	0.44	
log of RER*NI	0.92	0.49	0.98	0.40	0.72	0.44	0.34	0.27	1.22	0.88	0.40	0.65	0.00	0.00	0.40	0.69	0.08	0.28	
log of RER*NX	0.07	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.6	0.96	1.16	0.96	1.36	0.32	1.38	0.88	1.52	0.58	
log of military conflicts	0.00	0.00	6.15	1.66	0.00	0.00	0.00	0.00	2.77	2.89	0.00	0.00	0.44	1.92	0.85	1.76	0.00	0.00	
log of TOT	0.25	0.24	0.08	0.12	0.24	0.22	0.12	0.11	0.30	0.29	0.00	0.00	0.20	0.22	0.34	0.28	-0.07	0.1	
log of yield of cereals	7.99	0.25	7.54	0.18	8.32	0.18	8.59	0.12	7.47	0.45	7.51	0.40	7.91	0.24	8.19	0.28	8.37	0.18	

Table A7. Correlation Matrix

	Land Use Rate	Log Temperature	Log Precipitation	Log Population Density	Log Road Density	Log Gdp Pc	Logrer* Ni	Logrer* Nx
land use rate	1							
log temperature	0.47	1						
log precipitation	0.11	0.37	1					
log population density	0.16	0.48	0.56	1				
log road density	-0.11	0.38	0.51	0.72	1			
log GDP pc	-0.32	-0.16	0.04	0.06	0.50	1		
log RER*Ni	0.12	-0.14	0.05	-0.04	-0.15	-0.20	1	
log RER*Nx	0.18	0.20	-0.22	-0.01	-0.24	-0.38	-0.67	1
migration rate	-0.13	-0.01	0.03	0.01	0.09	0.18	-0.12	-0.04
log TOT	-0.01	-0.13	-0.10	0.01	0.01	-0.14	0.20	0.09
log yield of cereals	0.16	0.43	0.55	0.70	0.57	0.34	-0.19	-0.07
log military conflicts	0.05	-0.40	-0.08	-0.14	-0.29	-0.12	0.25	-0.10
land ownership	-0.23	-0.12	-0.02	0.13	0.48	0.51	-0.11	-0.24
land transferability	-0.21	-0.01	0.47	0.32	0.46	0.34	-0.10	-0.30
rule of law	-0.44	-0.04	0.36	0.26	0.70	0.65	-0.29	-0.27
	migration rate	log TOT	log yield cereals	log military conflicts	land ownership	land transferability	rule of law	
migration rate	1							
log TOT	-0.11	1						
log yield of cereals	0.09	-0.19	1					
log military conflicts	-0.07	0.08	-0.21	1				
land ownership	0.06	0.10	0.03	-0.10	1			
land transferability	0.13	-0.01	0.18	-0.10	0.60	1		
rule of law	0.10	0.00	0.36	-0.30	0.44	0.56	1	

Table A8. Results of PCSE (AR1) without Control Variables

Dependent Variable: land use rate	Model I			Model II		
	Coeff	p-value	95 % CI	Coeff	p-value	95 % CI
land ownership	-0.0482	0.001	-0.076 – -0.021	-0.0234	0.054	-0.047 – 0.0004
land transferability	0.0063	0.436	-0.003 – 0.022	0.0096	0.222	-0.006 – 0.025
rule of law				-0.0379	< 0.001	-0.058 – -0.017
constant	-0.0037	0.830	-0.038 – 0.030	0.1143	0.001	0.033 – 0.195
Observations	494			494		

Table A9. Results of PCSE (AR1) with Control Variables (con'd)

Dependent Variable:	Model I			Model II		
	Coeff	p-value	95 %CI	Coeff	p-value	95 %CI
land use rate						
land ownership	-0.0625	< 0.001	-0.095 – -0.030	-0.0592	< 0.001	-0.089 – -0.028
land transferability	0.0499	0.001	0.019 – 0.080	0.0562	0.001	0.024 – 0.089
rule of law				-0.0368	< 0.001	-0.057 – -0.016
log of temperature	0.2109	< 0.001	0.098 – 0.323	0.1922	0.001	0.077 – 0.308
log of precipitation	0.0267	0.082	-0.003 – 0.057	0.0282	0.071	-0.002 – 0.059
log of population density	0.0585	0.001	0.025 – 0.092	0.0453	0.006	0.013 – 0.078
migration rate	-0.0282	0.489	-0.108 – 0.052	-0.0349	0.373	-0.112 – 0.419
log of road density	-0.0493	0.001	-0.078 – -0.020	-0.0214	0.124	-0.049 – 0.006
log of GDP pc	-0.0396	0.009	-0.069 – -0.009	-0.022	0.143	-0.052 – 0.007
log of RER*Ni	0.0396	0.065	-0.003 – 0.082	0.0265	0.242	-0.018 – 0.071
log of RER*Nx	0.0371	0.090	-0.006 – 0.079	0.0268	0.242	-0.018 – 0.072
log of TOT	0.0224	0.325	-0.022 – 0.067	0.0318	0.165	-0.013 – 0.077
log of yield of cereals	0.0274	0.038	0.001 – 0.053	0.0301	0.026	0.004 – 0.057
log of military conflicts	0.0031	0.339	-0.003 – 0.009	0.0023	0.451	-0.004 – 0.008
constant	-0.9295	0.001	-1.498 – -0.361	-0.925	0.002	-1.502 – -0.348

Table A9. Results of PCSE (AR1) with Control Variables (con'd)

Dependent Variable: <i>land use rate</i>	Model I			Model II		
	<i>Coeff</i>	<i>p-value</i>	<i>95 %CI</i>	<i>Coeff</i>	<i>p-value</i>	<i>95 %CI</i>
Observations	494			494		
R ²	0.2387			0.2582		
Wald (Chi2)	117.80***			119.64***		
RMSE	0.145			0.142		

Note: In Wald test, *** denotes significance level of 1%.

Table A10. Results of PCSE (AR1) with Disaggregated Land Rights

Dependent Variable: <i>land use rate</i>	Model with Partial and Full Rights			Model with No Rights		
	<i>Coeff</i>	<i>p-value</i>	<i>95 %CI</i>	<i>Coeff</i>	<i>p-value</i>	<i>95 %CI</i>
<i>partial ownership</i>	-0.1369	<0.001	-0.214 – -0.059			
<i>full ownership</i>	-0.1389	<0.001	-0.216 – -0.062			
<i>no ownership</i>				0.1249	< 0.001	0.057 – 0.193
<i>partial transferability</i>	0.1487	<0.001	0.076 – 0.222			
<i>full transferability</i>	0.1585	<0.001	0.070 – 0.247			
<i>no transferability</i>				-0.1356	< 0.001	- 0.209 – - 0.062
<i>rule of law</i>	-0.0354	0.001	-0.056 – -0.015	-0.0352	< 0.001	-0.055 – -0.015
<i>log of temperature</i>	0.1681	0.002	0.062 – 0.274	0.1638	0.003	0.057 – 0.272
<i>log of precipitation</i>	0.0222	0.154	-0.008 – 0.529	0.0207	0.170	-0.009 – 0.050
<i>log of population density</i>	0.0496	0.003	0.017 – 0.082	0.0499	0.003	0.016 – 0.083
<i>migration rate</i>	-0.0374	0.353	-0.116 – 0.042	-0.0354	0.365	-0.112 – 0.041
<i>log of road density</i>	-0.0248	0.081	-0.053 – 0.003	-0.0225	0.109	-0.050 – 0.005
<i>log of GDP pc</i>	-0.0178	0.200	-0.045 – 0.009	-0.0197	0.178	-0.048 – 0.009
<i>log of RER*NI</i>	0.0276	0.204	-0.015 – 0.070	0.0241	0.263	-0.018 – 0.066
<i>log of RER*NX</i>	0.0298	0.177	-0.013 – 0.073	0.0257	0.238	-0.017 – 0.068
<i>log of TOT</i>	0.0369	0.111	-0.008 – 0.082	0.0353	0.122	-0.009 – 0.079
<i>log of yield of cereals</i>	0.0332	0.014	0.007 – 0.059	0.0300	0.020	0.004 – 0.055
<i>log of military conflicts</i>	0.0027	0.390	-0.003 – 0.009	0.0021	0.477	-0.004 – 0.008
<i>constant</i>	-0.9183	0.001	-1.454 – -0.382	-0.8400	0.002	-1.383 – -0.297
Observations	494			494		
R ²	0.2928			0.2661		
Wald (Chi2)	139.05**			116.61***		
RMSE	0.139			0.140		

Note: In Wald test, *** denotes significance level of 1%.

Table A11. Reasons for Abnormal Drop in the Area of Arable Land

Country	Year	Reason
Albania	2004	Principles of the European Statistics Code of Practice were incorporated into the National Statistics System. ^a
Bulgaria	1998	Implementation of Special Accessions Programme for Agriculture and Rural Development. New methodologies in agricultural census. ^b
Croatia	2000	Non-cultivated arable land was separated from the arable land and gardens. ^c
Georgia	2004	Territories of Abkhazia and the former South Ossetia were excluded from assessment of agricultural statistics. ^d
Latvia	1995	Land use statistics have been re-calculated in 1995 excluding the unutilized agricultural area. ^e
Lithuania	2001	Kitchen gardens were excluded from calculations. ^f
Mongolia	2001	Updating survey methodologies initiated by UNDP. ^g
Romania	2004	Incorporation of the methodology of the Economic Accounts for Agriculture for the EU Member States. ^h

Note: The sharp decreases in Kyrgyzstan in 1994 and Uzbekistan in 2005 were not included into the table because of the evidences that two countries experienced a physical decrease in agricultural land use; no changes in the methodology of national statistics were applied.ⁱ

^a INSTAT. 2015. "The European Union's IPA 2012 Programme: Project 1: National Accounts Methodology. Description of Sources and Methods. Part A, GNI Compilation. Albania."

^b European Stability Initiative (ESI). 2017. "SAPARD and Rural Development - Background Information - Bulgaria."

^c Eurostat. 2017. "Eurostat Handbook for Annual Crop Statistics"; Food and Agriculture Organization (FAO). 2019. "Country Notes—FAOSTAT Release Sep 2019."

^d Food and Agriculture Organization (FAO). 2015. "Report of In-Depth Country Assessment: Georgia. Global Strategy to Improve Agricultural and Rural Statistics."

^e Food and Agriculture Organization (FAO). 2019. "Country Notes—FAOSTAT Release Sep 2019."

^f Eurostat. 2017. "Eurostat Handbook for Annual Crop Statistics."

^g United Nations Development Programme (UNDP). 2011. "Assessment of Development Results: Evaluation of UNDP Contribution- Mongolia."

^h European Union. 2003. "Council Regulation (EC) No 1782/2003." Official Journal of the European Union.

ⁱ Muradov, Bakhodyr, and Alisher Ilkhamov. 2014. "Uzbekistan's Cotton Sector: Financial Flows and Distribution of Resources," Working Paper; Spoor, Max. 1999. "Agrarian Transition in Former Soviet Central Asia: A Comparative Study of Kazakhstan, Kyrgyzstan and Uzbekistan," Institute of Social Studies, The Working Paper Series. Hague; USAID. 2011. "USAID Country Profile - Property Rights and Resource Governance - Kyrgyzstan."

Table A12. Results of PCSE (AR1) with Dummy Variable that Indicates Methodological Changes in Agricultural Land Use

Dependent Variable:	Model I			Model II		
	Coeff	p-value	95 %CI	Coeff	p-value	95 %CI
land use rate						
land ownership	-0.0646	< 0.001	-0.097 - -0.031	-0.0617	< 0.001	-0.093 - -0.031
land transferability	0.0544	0.001	0.023 - 0.086	0.0609	< 0.001	0.027 - 0.094
rule of law				-0.0359	< 0.001	-0.055 - -0.017
change in methodology	-0.1061	< 0.001	-0.147 - -0.064	-0.1049	< 0.001	-0.144 - -0.065
log of temperature	0.2127	< 0.001	0.104 - 0.321	0.1944	0.001	0.083 - 0.306
log of precipitation	0.0311	0.040	-0.001 - 0.062	0.0326	0.035	0.002 - 0.063
log of population density	0.0582	< 0.001	0.029 - 0.086	0.0449	0.001	0.017 - 0.072
migration rate	-0.0098	0.797	-0.085 - 0.064	-0.0168	0.647	-0.089 - 0.055
log of road density	-0.0508	< 0.001	-0.078 - -0.024	-0.0231	0.088	-0.049 - 0.003
log of GDP pc	-0.0396	0.004	-0.066 - -0.013	-0.0226	0.090	-0.049 - 0.003
log of RER*NI	0.0402	0.048	0.000 - 0.079	0.0272	0.209	-0.015 - 0.069
log of RER*NX	0.0412	0.044	0.001 - 0.081	0.0311	0.150	-0.011 - 0.074
log of TOT	0.0236	0.259	-0.017 - 0.065	0.0334	0.114	-0.008 - 0.075
log of yield of cereals	0.0298	0.018	0.005 - 0.055	0.0326	0.012	0.007 - 0.058
log of military conflicts	0.0044	0.149	-0.002 - 0.010	0.0036	0.212	-0.002 - 0.009
constant	-0.9719	< 0.001	-1.511 - -0.433	-0.9684	0.001	-1.515 - -0.422
Observations	494			494		
R ²	0.3079			0.3276		
Wald (Chi2)	188.35***			189.32***		
RMSE	0.143			0.140		

Note: In Wald test, *** denotes significance level of 1%.

Table A13. Results of PCSE (AR1) with Year Fixed Effects (con'd)

Dependent Variable:	Model I			Model II		
	Coeff	p-value	95 %CI	Coeff	p-value	95 %CI
<i>land use rate</i>						
<i>land ownership</i>	-0.0506	0.001	-0.082 – -0.020	-0.0464	0.002	-0.075 – -0.018
<i>land transferability</i>	0.0404	0.004	0.013 – 0.068	0.0460	0.002	0.016 – 0.076
<i>rule of law</i>				-0.0404	< 0.001	-0.063 – -0.018
<i>log of temperature</i>	0.2078	0.001	0.085 – 0.331	0.1994	0.002	0.073 – 0.325
<i>log of precipitation</i>	0.0309	0.081	-0.004 – 0.066	0.0307	0.082	-0.004 – 0.065
<i>log of population density</i>	0.0471	0.012	0.010 – 0.084	0.0350	0.053	0.000 – 0.070
<i>migration rate</i>	-0.0307	0.434	-0.107 – 0.046	-0.0361	0.337	-0.110 – 0.038
<i>log of road density</i>	-0.0379	0.015	-0.069 – -0.007	-0.0125	0.370	-0.040 – 0.015
<i>log of GDP pc</i>	-0.0448	0.005	-0.076 – -0.014	-0.0200	0.195	-0.050 – 0.010
<i>log of RER*NI</i>	0.0574	0.018	0.010 – 0.105	0.0341	0.200	-0.018 – 0.086
<i>log of RER*NX</i>	0.0562	0.026	0.007 – 0.106	0.0348	0.201	-0.019 – 0.088
<i>log of TOT</i>	0.0110	0.648	-0.036 – 0.058	0.0170	0.465	-0.029 – 0.063
<i>log of yield of cereals</i>	0.0317	0.037	0.002 – 0.061	0.0343	0.025	0.004 – 0.064
<i>log of military conflicts</i>	0.0022	0.477	-0.004 – 0.008	0.0014	0.624	-0.004 – 0.007
<i>Years</i>						
1997	-0.0052	0.162	-0.013 – 0.002	-0.0038	0.292	-0.011 – 0.003
1998	-0.0062	0.219	-0.016 – 0.004	-0.0042	0.391	-0.014 – 0.005
1999	-0.0181	0.008	-0.032 – -0.005	-0.0179	0.008	-0.031 – -0.005
2000	-0.0260	0.001	-0.042 – -0.010	-0.0297	< 0.001	-0.045 – -0.014
2001	-0.0558	< 0.001	-0.072 – -0.040	-0.0608	< 0.001	-0.077 – -0.045
2002	-0.0671	< 0.001	-0.085 – -0.049	-0.0748	< 0.001	-0.093 – -0.057
2003	-0.0509	< 0.001	-0.066 – -0.035	-0.0605	< 0.001	-0.076 – -0.045
2004	-0.0676	< 0.001	-0.087 – -0.048	-0.0800	< 0.001	-0.102 – -0.058
2005	-0.0504	< 0.001	-0.072 – -0.029	-0.0684	< 0.001	-0.093 – -0.044
2006	-0.0348	0.003	-0.058 – -0.012	-0.0586	< 0.001	-0.086 – -0.031
2007	-0.0333	0.014	-0.060 – -0.007	-0.0599	< 0.001	-0.092 – -0.027
2008	-0.0137	0.422	-0.047 – 0.020	-0.0407	0.019	-0.080 – -0.002
2009	-0.0213	0.197	-0.054 – 0.011	-0.0441	0.008	-0.080 – -0.008
2010	-0.0159	0.286	-0.045 – 0.013	-0.0410	0.008	-0.075 – -0.007
2011	-0.0057	0.720	-0.037 – 0.026	-0.0339	0.028	-0.070 – 0.002
2012	-0.0022	0.881	-0.032 – 0.027	-0.0304	0.033	-0.065 – 0.004
2013	0.0010	0.953	-0.031 – 0.033	-0.0279	0.068	-0.065 – 0.009
2014	0.0016	0.924	-0.032 – 0.035	-0.0212	0.127	-0.058 – 0.016
constant	-0.9170	0.002	-1.510 – -0.324	-0.9657	0.001	-1.561 – -0.370
Observations	494			494		
R ²	0.2385			0.2614		
Wald (Chi2)	108.87***			107.73***		
RMSE	0.144			0.141		

Note: In Wald test, *** denotes significance level of 1%.

Table A14. Results of PCSE (AR1) with the Ratio Between Agricultural Labor Productivity and Non-Agricultural Labor Productivity

Model II			
Dependent Variable:	Coeff	p-value	95 %CI
<i>land use rate</i>			
<i>land ownership</i>	-0.0649	< 0.001	-0.097 – -0.033
<i>land transferability</i>	0.0647	< 0.001	0.031 – 0.099
<i>rule of law</i>	-0.0362	0.001	-0.057 – -0.015
<i>log of temperature</i>	0.2125	0.001	0.09 – 0.335
<i>log of precipitation</i>	0.0322	0.061	-0.001 – 0.066
<i>log of population density</i>	0.0405	0.023	0.006 – 0.075
<i>migration rate</i>	-0.0287	0.499	-0.112 – 0.055
<i>log of road density</i>	-0.0208	0.148	-0.049 – 0.007
<i>log of GDP pc</i>	-0.0260	0.132	-0.06 – 0.008
<i>log of RER*NI</i>	0.0381	0.087	-0.006 – 0.082
<i>log of RER*NX</i>	0.0387	0.088	-0.006 – 0.083
<i>relative labor productivity</i>	-0.0522	0.199	-0.132 – 0.027
<i>log of yield of cereals</i>	0.0364	0.023	0.005 – 0.068
<i>log of military conflicts</i>	0.0029	0.406	-0.004 – 0.01
<i>constant</i>	-1.0168	0.001	-1.613 – -0.42
Observations	483		
R ²	0.2851		
Wald (Chi2)	150.82***		
RMSE	0.139		

Note: In Wald test, *** denotes significance level of 1%.