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Land Property Rights and Investment Incentives in Movable Farm Assets: Evidence from Post-Soviet Central Asia

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Abstract
We examined whether perceived land rights—use, management, transfer, and tenure security—are associated with investment in movable farm assets. Using micro-level data from crop-specialized farmers in Kazakhstan and Uzbekistan, we distinguish investment incentives linked to tenure security, transferability, and decision-making autonomy (use and management rights). Comparing market-oriented versus government-controlled contexts provides insights into differential role of land rights on investment behavior. Our findings underscore significant investment incentives linked to use and management rights rather than tenure security or transferability. Moreover, we reveal how country-specific institutional contexts influence the effectiveness of these land rights in stimulating agricultural investments.

Keywords Property rights · Tenure security · Investment · Movable farm assets · Transition economy · Central Asia

JEL Classification P14 · P26 · Q12 · Q15

Introduction

Individual land ownership is widely regarded as offering land users with the strongest production and investment incentives compared to collective or customary arrangements (Deininger 2003; Demsetz 1974; Feder and Nishio 1998; Johnson

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1972). Three main arguments support the positive relationship between individualized land rights and investment decisions. First, as Besley (1995) highlights, farmers are incentivized to invest when the risk of expropriation of production means and output is low. Second, investments are stimulated when stronger transfer rights enable individuals to reap the benefits of their investment by selling or leasing their land. Third, clearly defined rights facilitate the use of land as collateral, alleviating farmers' financial constraints for funding investments. Through these mechanisms, there is a broad agreement in the literature that land tenure security and transfer rights enhance incentives, especially for land-attached investments, such as terracing, land leveling, or other measures preventing soil erosion and improving soil fertility (Deininger and Feder 2001; Deininger and Jin 2006; Fenske 2011; Lawry et al. 2017).

However, the empirical relevance of these mechanisms for non-land agricultural investments, such as the acquisition of farm machinery and equipment (hereafter referred to as movable farm assets), is unclear. Conceptually, investments in movable farm assets differ from land-related investments in several ways. First, investments in movable farm assets are, at least partly, reversible. Even if access to land is lost, a farmer can still derive value from movable assets by renting them out or selling them. Second, unlike land-attached investments such as irrigation systems or orchards, movable assets do not incur dismantling costs when land is lost. For example, dismantling an irrigation facility or uprooting trees involves significant labor and financial expenses, making such investments more vulnerable to tenure risks than easily transferable machinery and equipment. Third, holding transfer rights might not significantly enhance the attractiveness of investing in movable farm assets compared to land-related investments because obtaining farm machinery primarily improves labor productivity rather than land productivity (Brandt et al. 2002). Together, these relations suggest a less straightforward relationship between land tenure (in)security, transferability and investment decisions for movable farm assets.

Scholarly perspectives vary on this issue, ranging from the view that tenure security has potentially minimal or no influence on non-attached investments such as machinery, livestock, tools (Bandiera 2007; Feder and Nishio 1998) to the assertion that access to finance plays a more critical role (Deininger and Feder 2001). Weak farm investment incentives could impede land and labor productivity improvements, thereby limiting broader agricultural growth (Brandt et al. 2002). This issue is becoming increasingly urgent as labor shortages constrain agricultural operations amid expanding off-farm employment opportunities, emphasizing the need for investments in labor-saving technologies. Modern portable farm technologies, such as tractor-mounted and aerial sensors and vehicles, have the potential to enhance farm productivity significantly, but their adoption may hinge on the extent to which land rights incentivize such non-land investments. Therefore, gathering more empirical evidence on this relationship is crucial.

Early studies by Feder and Onchan (1987) and a follow-up analysis by Feder et al. (1988) examined whether investment levels in movable assets, measured by monetary values, significantly differed among farms with varying land tenure arrangements. They found that farms with formal land titles exhibited the highest levels of

investment compared to those with temporary land use certificates or no land documentation. They concluded that the investment incentives for farmers with land titles were primarily driven by improved access to cheaper institutional credit, emphasizing the benefits of collateralizability over the security provided by land titles. Other studies have similarly reported a positive relationship between land tenure security as proxied by land title and investment in movable farm assets (Carter and Olinto 2003; Sitko et al. 2014). On the contrary, a recent study in China found no significant relationship between improved land tenure security from a recent land titling program and the quantity and value of purchased agricultural machinery, such as small tractors and cultivators (Zhou et al. 2022). Likewise, other studies in China found no evidence that land reallocation risks—a measure of tenure insecurity—were associated with past investments in movable assets (Feder et al. 1992; Leight 2016). Additionally, other research suggests that farmers renting in land from multiple households are more likely to shift their investments from high-efficiency to low-efficiency (cheaper) machinery as the likelihood of village-level land reallocation increases (Ma 2023).

A synthesis of this body of literature suggests that when aggregate measures, such as tenure form, are used, there is some evidence supporting the hypothesis that investment incentives arise from land tenure security. However, studies employing more specific measures, such as risks of losing land, do not yield the same empirical support. Overall, the reviewed empirical evidence remains both scarce and inconsistent across different measurement approaches.

Further, a tenure form as an aggregate measure does not allow to disentangle investment incentives that arise from distinct land rights. Among the reviewed literature, Feder and Onchan (1987) stand out for their separate measurement of land rights, emphasizing the relevance of the collateralizability in influencing investments in movable assets. Further disaggregation of land rights, as proposed by Deininger and Jin (2006), could provide deeper insights into the distinct impacts of tenure security and transferability, which are believed to provide strongest investment incentives. Moreover, existing theories tend to overlook operational rights, which may play a critical role in investment decisions, particularly those involving complementary inputs such as machinery and equipment. The literature distinguishes between use and management rights as separate bundles of land rights (FAO 2002; Place et al. 1994). These rights directly influence how farmers organize production, including their choice of primary activities, variable inputs, and marketing strategies, among others. Several empirical studies have examined disaggregated land rights, exploring their distinct roles in shaping investment incentives, particularly in relation to land-related investments (see, for example, Brasselle et al. 2002; Migot-Adholla et al. 1991). However, a similarly detailed disaggregation of land rights has not been observed in the literature focusing on investments in movable farm assets. This gap highlights the need for further research to understand how different components of land tenure influence decisions to make non-land investments. Disaggregating land rights would not only enrich our understanding of how tenure security and transfer rights influence agricultural investments, as the theory predicts, but also may reveal additional channels, such as use and management rights, that incentivize investments.

This study empirically examines the relationship between disaggregated land rights and investment in movable farm assets among farmers in Kazakhstan and Uzbekistan, using farm survey data collected in 2019. Specifically, we analyze four bundles of land rights—use, management, transfer, and protection—following the classification by Akhmadiyeva and Herzfeld (2021). In addition to the protection bundle, we include land expropriation risk as a separate, complementary indicator of land tenure insecurity. The data on land rights are based on farmers' perceptions, which can offer more insights into the real status of land rights which could differ from the legal (written) rights (Van Gelder 2010). We quantify the four bundles using additive indices for the analysis. The data also include an inventory of production-related mostly movable farm assets.

The uniqueness of our data stems not only from its comprehensive assessment of land tenure conditions, capturing an extensive set of 19 distinct land rights, represented by four bundles of land rights, but also from the institutional context from which the data originate. While farm production across post-Soviet Central Asia has been largely individualized, the region exhibits considerable variation in land tenure's legal frameworks (Lerman 2009; Petrick 2021; Swinnen 2001). Farmers in Kazakhstan generally operate within a relatively secure land tenure system and a market-oriented agricultural sector. In contrast, farmers in Uzbekistan face insecure land tenure within a government-controlled sector; the Uzbek government retained pervasive intervention in farm production, particularly in crops such as cotton and wheat, resulting in limited decision-making rights and heightened tenure insecurity (Djanibekov et al. 2012). These contrasting institutional settings offer a valuable comparative perspective, providing a broader lens for understanding the relationship between land rights and investment.[1] It should be noted that since 2019, in Uzbekistan the farmers operating under state intervention, have experienced substantial reforms aimed at fostering a market-oriented agricultural sector. This included the government's withdrawal from assigning production plans and marketing quotas as part of the Agri-Food Development Strategy 2020–2030 (Djanibekov et al. 2024). The perceived land rights documented in our survey reflect the land tenure situation prior to these reforms.

The rest of the paper is structured as follows. The next section describes both countries' land tenure and investment conditions, and the conceptual framework. Section "Data" and "Methods" present the data and methods. Section "Results" presents the results, and Section "Discussion, implications for theory and policy, and conclusion" discusses the main findings, draws research and policy implications and concludes the paper.

[1] This paper is based on farm survey dataset of the AGRICHANGE project. The project investigated institutional changes in irrigated agriculture across Central Asia, with a specific focus on Kazakhstan and Uzbekistan, focusing on land tenure, governance, and rural livelihoods. The project specifically looked at two provinces (regions), South Kazakhstan and Samarkand in Uzbekistan, which represent distinct institutional settings.

Institutional Settings and Conceptual Framework

Institutional Settings

In Kazakhstan, the Land Code permits agricultural land to be privately owned or leased. Private landowners have the right to sell, rent out, and bequeath their land (Parliament of Kazakhstan 2003). Land can be leased from the state, granting lessors land-use rights for a duration from less than five years to 49 years, with options to extend the lease or exercise a priority right to purchase the leased land (Akhmadiyeva and Herzfeld 2021; Kvartiuk and Petrick 2021). However, transfer rights to leased land are limited to inheritance rights. Both privately owned land and land-use rights on leased land can be used as collateral (Gaisina 2011). In Uzbekistan, individual tenure is governed by the law "On Individual Farm" adopted in 1998 and revised in 2004 (Parliament of Uzbekistan 2004). Individuals are granted land-use rights for a duration of 30–50 years. Similar to Kazakhstan, transfer rights are restricted to inheritance, and land-use rights can also serve as collateral. In both countries, agricultural land is prohibited from being converted to other uses, such as constructing residential houses or transforming it into grazing areas.

Despite individualized land tenure and the officially declared freedom to make production decisions, Uzbekistan's cotton and wheat sectors remained under government control until 2019.[2] Through a so-called procurement policy, the government mandated farmers to allocate significant portions of their land to these crops, achieve specific production targets, and sell their harvest to state organizations (Djanibekov et al. 2012). On the contrary, individual farmers in Kazakhstan have the freedom to grow any crops at their discretion (Shtaltovna and Hornidge 2014). To further encourage diversification of crop production, regional governments in Kazakhstan design subsidy schemes for inputs and outputs, incentivizing farmers' cropping portfolios (Baubekova et al. 2021).

Government intervention in Uzbekistan reduces decision-making autonomy and tenure security for producers of strategic crops. Failure to meet production targets can result in reducing farm size or terminating the lease contract. Moreover, these producers operate within a highly dynamic policy environment. Since the establishment of individual farms in 2004, the Uzbek government has implemented a series of agricultural policy reforms, including the 'optimization' of farm size through consolidation (2008–2015), adjustment of cropping structure (2016–2019), and ongoing farm restructuring (since 2019) (Zorya et al. 2019). These reforms have often led to the premature termination of lease contracts for some farmers (Babadjanov and Petrick 2023; Djanibekov et al. 2012), increasing uncertainty and ambiguity around land property rights for those who remain. In contrast, farmers in Kazakhstan operate within a more secure environment. Although land expropriation by the Kazakh government remains a concern (Hanson 2017), mass land reallocations or evictions have been rare.

[2] Cotton and wheat are considered strategic crops in Uzbekistan. Cotton has been a significant source of foreign currency. Despite the gradual decline in sown area, as of 2016 cotton occupied over one-third of total sown area and 40% of sown area in individual farms; and planting of wheat has proportionately increased to achieve self-sufficiency in view of increasing population (Zorya et al. 2019).

In both countries, farmers can purchase agricultural equipment and machinery in local markets. Joint ownership of equipment and machinery is not uncommon, especially among relatives and farmers with smaller landholdings (Knorr et al. 2022). Companies such as processors or the government offer the necessary credit and lease arrangements. However, farmers complain about short payback periods, high interest rates, and stringent collateral requirements (Petrick and Djanibekov 2016; Shtaltovna and Hornidge 2014). Farmers can rely on mechanization services offered by other farmers or private and government-owned agricultural service providers as an alternative to owning farm machinery.

Conceptual Framework

Schlager and Ostrom (1992) identified five bundles of property rights that influence users' incentives to invest in a common resource: access, withdrawal, management, exclusion, and transfer rights. Access and withdrawal rights determine who is permitted to enter a defined area and extract the "products" of the resource. Management rights define "how, when, and where harvesting from a resource may occur, and whether and how the structure of a resource may be changed" (Schlager and Ostrom 1992, p. 251). Exclusion rights determine who else may benefit from the resource and under what conditions. Finally, transfer rights allow individuals to sell, lease, or give the rights of management, exclusion, or any other bundle or specific right to other users. Klümper et al. (2018) adapted this framework to apply to private resources, such as farmland. Access and withdrawal rights, summarized as *use rights,* encompass all rights governing a farmer's access to and use of the plot of land and its products. The combination of management and exclusion rights, referred to as *management rights* in the following, describe all rights regulating the use of land. Transfer rights govern the ability to transfer these rights and are accordingly termed *transfer rights*. Akhmadiyeva and Herzfeld (2021) introduced an additional category of land rights, referred to as a "government protection", which encompasses protection by courts and power of land certificates; in our study, we refer to this bundle as *protection rights*. Alongside protection rights, we use *land expropriation risk* as an additional indicator of land tenure security, following the relevant literature.

As shown earlier, the existing literature rarely differentiates between different specific rights. Therefore, we hypothesize that a farmer with at least one bundle of rights will have a higher incentive to invest in movable assets. However, we cannot identify a definitive theoretical ranking across different bundles of rights based on the available literature.

Data

Sampling Strategy

Farm survey data were collected in 2019 from the Turkistan (former South Kazakhstan) region in Kazakhstan and the Samarkand region in Uzbekistan. Turkistan is

Fig. 1 Research districts in Turkistan region (Kazakhstan) and Samarkand region (Uzbekistan). *Source:* Global Administrative Areas. 2012. GADM database of Global Administrative Areas, version 2.0. [online] URL: www.gadm.org.

the southernmost region of Kazakhstan, bordering Uzbekistan. Both regions are dominated by irrigated agriculture. In Kazakhstan, a regional specialization pattern defined that farmers in southern regions specialize in vegetables and horticulture (Kvartiuk and Petrick 2021). These irrigated areas are close in their farming system to Uzbekistan, where post-Soviet crop specialization has been retained, with cotton staying as a dominant cash crop.

Three districts were selected from these regions based on logistical convenience and their similar cultural, biophysical, and farming system contexts (Fig. 1). In Turkistan, the selected districts were Maktaaral and Shardara, which specialize in cotton cultivation, and Sariagash, which focuses on vegetables, melons, and fruits. In Uzbekistan, the chosen districts were Pastdargom and Payarik, which were oriented toward cotton production, and Jomboy, which focused on vegetables and gardens. A list of eligible farmers, defined as main decision-makers and cultivating at least 80% of the total arable area under irrigation, was obtained from local government administration in each district. In Kazakhstan, a stratified two-step sampling procedure was employed. First, sub-districts were selected from the three districts, followed by the random selection of 50 farms from each sub-district. In Uzbekistan, farmers were randomly sampled directly from the selected three districts. Survey interviews were conducted by trained local enumerators and completed in early spring 2019. The final sample consists of 903 farmers, with 503 from the Turkistan region and 460 from the Samarkand region. In the survey, farmers were asked about personal and farm-specific characteristics, such as age, education, previous occupation, farm

Table 1 Typology of movable farm assets owned by farmers in Kazakhstan and Uzbekistan

Type of assets, share of farmers owning	Kazakhstan (%)	Uzbekistan (%)
Machinery		
Harvester (cotton and grain)	4	0
Lorry	3	8
Sower machine	2	36
Storage facility (hay)[a]	2	1
Tractor	26	85
Trailer	4	61
Equipment		
Electricity generator	0	2
Mechanized irrigation pump	0	17
Milling machine	2	0
Sprayer (motorized and manual)[a]	1	14

This table provides the percentage of farmers owning farm machinery and equipment.

[a]Storage facility is included in the analysis because in the study settings, these structures are built as low-cost and easily removable in case officials find them to interfere with land use regulations or if farmers anticipate risks of land reallocation.

area, land ownership form, specific land rights and production-related farm assets owned in farms.

Machinery and Equipment

Table 1 presents the list of farm machinery and equipment owned by farmers at the time of the survey. In Kazakhstan, 26% of farmers owned tractors, followed by trailers and harvesters, each owned by 4% of farmers. Less than 2% of farmers owned other types of assets. In Uzbekistan, 85% of farmers owned tractors, 61% owned trailers, and 36% owned sowing machines. Additionally, 17% owned mechanized irrigation pumps, 14% owned sprayers, and 8% owned lorries. Ownership of cotton and grain harvesters, storage facilities, electricity generators, and milling machines was rare, with less than 2% of respondents reporting possessing these assets. This highlights a clear disparity in the inventory of movable farm assets between the two settings.

Based on the inventory details described above, we employed the standard quantity-based approach to measure investment (Doss et al. 2020). We counted the types and total units of each asset a farmer owns. For instance, if a farmer owns both a tractor and a lorry, regardless of the number of units for each asset, the farmer was assigned a diversity score of 2. We refer to this first measure of investment as *Asset diversity*. While asset diversity provides valuable insights into investment, it does not fully capture past investments. For instance, a farmer may have a low asset diversity score but own a larger inventory of the same type of assets due to specialization needs or familiarity with this technology (Takeshima and Salau 2011). To account

for this, we also counted the total units of assets owned, referred to as *Total assets*. Table 3 presents the descriptive statistics for both investment measures.

Perceived Land Rights

In the survey, farmers responded to approximately 20 questions addressing a range of land property rights, as outlined by Akhmadiyeva and Herzfeld (2021). For example, one question asked: '*How free are you in deciding where/how, whom and for how much to sell main harvested crops?*'. Respondents could select one of the five options: 'I cannot decide myself', 'I can rarely decide on myself', 'I can decide sometimes', 'I can decide most of the time', or 'It is fully my decision'. The wording of questions and responses was slightly adjusted for protection rights to align them with the legal context familiar to farmers. To avoid confounding farmers' perceptions of actual land rights, they were instructed to respond without considering physical, health, climate, and technological constraints in exercising these rights. Responses were coded on a scale from 1 to 5, where higher values indicated stronger perceptions of land rights, except for the expectation of land expropriation risk, where 1 represented no expropriation risk and 5 represented high expropriation risk. Table 2 presents the mean values of perceived land rights reported by the farmers.

The main takeaway from Table 2 is twofold. First, the mean values of perceptions of nearly all land rights in Kazakhstan exceed those in Uzbekistan, indicating that Kazakhstan farmers, on average, perceive a higher degree of rights. Second, for only a few land rights—the rights to enter the land, exclude others from entering the land, and seek protection in land disputes against other farmers—the calculated mean differences are statistically not different from zero. This suggests that Uzbek farmers share an understanding of the limited rights available to them.

We constructed a property rights index for four bundles of land rights following the method outlined by Holden et al. (2009). For each specific land right, farmers received a score of 0, 0.5, or 1 based on their responses. A score of 0 was assigned for the perception of having no rights, while a score of 0.5 was assigned for the perception falling between 2 and 4, and a score of 1 was given when the perception was 5. These scores were then summed across all rights within the corresponding bundle to generate an overall score for that specific bundle of rights. For example, if a farmer rated all three use rights as 5, each right was assigned a value of 1, resulting in a total score of 3 for the use bundle. This process was repeated for the other three bundles, namely *Management rights*, *Transfer rights*, and *Protection rights*. The composition of the protection bundle does not include land expropriation risk. To account for the potential correlation between these two measures of tenure security, protection rights, and land expropriation risk were included as separate variables in the estimated models. Descriptive statistics of these four land rights categories are presented in Table 3.

Table 2 Mean difference of perceived land rights between farmers in Kazakhstan and Uzbekistan

	Kazakhstan	Uzbekistan	Mean difference
Use rights			
Enter land	4.890	4.915	−0.024
Collect harvest	4.711	2.502	2.210***
Change land use purpose from cropping to grazing	4.588	1.469	3.119***
Management rights			
Decide on crop choice	4.763	1.576	3.187***
Decide on cultivation method, inputs	4.725	4.258	0.467***
Invest in land	4.674	4.291	0.383***
Exclude others from entering land	4.534	4.530	0.004
Market own product (price, outlet)	4.731	1.571	3.160***
Transfer rights			
Permit others use own land	3.508	1.339	2.170***
Sell land	3.695	1.004	2.691***
Rent out land	3.874	1.265	2.610***
Rent in leased land	3.852	1.178	2.675***
Bequeath land	4.222	1.608	2.614***
Protection rights			
Trust in courts in tenancy disputes against other farmers	3.904	3.943	−0.038
Trust in courts in tenancy disputes against other investors	3.423	3.023	0.400***
Trust in courts in tenancy disputes against government	3.409	2.245	1.164***
Importance of tenancy documents in proving property rights	4.618	4.180	0.438***
Expropriation risk	1.624	2.752	−1.128***

This table presents the mean-level of perceptions for each specific right, and mean differences across two settings. For expropriation risk higher values indicate higher risks of land expropriation. Four bundles of rights and expropriation risk are separately used in further analysis.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$, (two-sided t-test)

Source: Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

Variables Used in the Analysis

We controlled for important variables that could potentially drive investment decisions. These variables can be grouped into (1) *Farm characteristics*, (2) *Resource availability,* (3) *Farmer characteristics,* and (4) *Districts*. The breakdown of these sets of variables, along with descriptive statistics, can be found in Table 3.

The mean values of the two investment measures presented in Table 3 indicate that farmers in Uzbekistan have more diverse and numerous movable farm assets than those in Kazakhstan. Particularly, the mean value of asset diversity was 0.45 for Kazakhstan and 2.27 for Uzbekistan. Similarly, the mean total assets were 0.60 for Kazakhstan and 3.99 for Uzbekistan. In Uzbekistan, the means for both investment measures exceed their standard deviations, whereas the opposite is observed

Table 3 Descriptive statistics

Key variables	Measurement	Kazakhstan		Uzbekistan	
		Mean	SD	Mean	SD
Dependent variables					
Asset diversity	Count of types of assets owned (units)	0.449	0.893	2.269	1.186
Total assets	Count of number of assets owned (units)	0.598	1.488	3.991	3.038
Variables of interest					
Use rights	Perceived freedom to exercise use rights (scale 0–3)	2.680	0.443	1.496	0.492
Management rights	Perceived freedom to exercise control and decision-making rights (scale 0–5)	4.418	0.743	2.753	0.758
Transfer rights	Perceived freedom to exercise transfer rights (scale 0–5)	3.515	1.562	0.489	0.608
Protection rights	Perceived protection rights (scale 0–4)	2.666	0.676	2.206	0.482
Expropriation risk	Perceived expectation of losing ownership or land-use rights in the next three years (scale 1–5)	1.624	0.929	2.752	0.956
Farm characteristics					
Tenure form	Farmer operates privately owned land not leased land (0/1)	0.669	0.470	–	–
Specialization	Farmer specializes in cotton and /or wheat (0/1)	0.612	0.487	0.673	0.469
Contract farming	Farmer participated in contract farming in 2018 (0/1)	0.149	0.356	0.058	0.235
Farm area	Total farmland area (ha)	14.186	36.930	38.944	26.535
Hired labor	Number of permanent workers	1.648	2.482	3.904	3.582
Hires agronomist	Farmer hires an agronomist on permanent basis (0/1)	0.149	0.356	0.102	0.303
Farm age	Number of years since farm was established	18.256	5.518	9.210	6.717
Irrigation infrastructure	Condition of on-farm irrigation and drainage network from good to bad (1–3)	1.904	0.790	1.915	0.652
Resource availability					
Access to land	Farmer can lease additional land if needed (0/1)	0.606	0.489	0.334	0.472
Price-related input constraints	Number of variable inputs a farmer perceives as financially inaccessible (0–4)	0.948	0.863	0.730	0.686
Availability-related input constraints	Number of variable inputs a farmer perceives as physically inaccessible (0–4)	0.159	0.426	0.789	0.856
Credit	Farmer obtained credit in 2018 (0/1)	0.274	0.446	0.280	0.449

Table 3 (continued)

Key variables	Measurement	Kazakhstan		Uzbekistan	
		Mean	SD	Mean	SD
Livestock	Farmer owned livestock three years ago (0/1)	0.157	0.364	0.028	0.165
Nonfarm income	Farmer engages in non-farm activity (0/1)	0.405	0.491	0.280	0.449
Farmer characteristics					
Age	Age of farmer (years)	46.198	13.226	42.750	10.043
Education	Farmer has higher education (0/1)	0.296	0.457	0.334	0.47
Risk attitude	Willingness to take risks (1–5)	4.188	0.922	3.495	0.88
Districts					
District dummies		Included		Included	

Source: Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

in Kazakhstan. This suggests that there is a greater variability in movable farm asset ownership in the Kazakhstan sample compared to that in the Uzbekistan sample.

The generated property rights indices align with the descriptions of specific land rights presented in Table 2. Among the sampled farmers in the two countries, the largest differences in perceived rights are observed in the bundles of use, management, and transfer rights. Farmers in Kazakhstan report significantly greater decision-making freedom regarding land and production than their Uzbekistan peers. Interestingly, while the expectation of land expropriation risk is higher in Uzbekistan, the mean and standard deviations for the perceived protection rights are not so different between the two groups of farmers.

Last but not least, in both settings, a similar share of farmers specialized in cotton production (61% and 67%, respectively) and obtained credit (27% and 28%, respectively). However, farms in Kazakhstan are, on average, twice as old as those in Uzbekistan, with a mean age of 18 years since establishment compared to 9 years. This disparity may be attributed to frequent land reallocations and a higher likelihood of lease contract termination in Uzbekistan, which appear to have shortened the average life of farms. In Kazakhstan, there is a higher prevalence of livestock ownership and greater risk attitudes compared to Uzbekistan. A more liberal agricultural environment in Kazakhstan may encourage additional agriculture-related income-generating activities and correspondingly foster a willingness to take risks. Regarding access to production inputs, although farms in Uzbekistan are, on average, larger than those in Kazakhstan, a smaller proportion of farmers in Uzbekistan can obtain additional land when needed (approximately 60% in Kazakhstan compared to 30% in Uzbekistan). Lastly, farmers in Kazakhstan primarily expressed price-related concerns related to variable inputs, while those in Uzbekistan expressed concerns with the physical availability of variable inputs.

Methods

To examine the relationship between perceived land rights and investment in movable farm assets, we specify the following regression equation:

$$\begin{aligned} Y_i^m = {} & \alpha_i + \beta_1 Use_i + \beta_2 Management_i + \beta_3 Transfer_i \\ & + \beta_4 Tenure\ security_i + \phi' F_i + \mathfrak{O}' R_i + \theta' P_i + \varphi' D_i + e_i \end{aligned} \tag{1}$$

where Y_i^m represents the diversity (Asset diversity) and total units of movable farm assets (Total assets) owned by farms as of the survey period. β_1–β_4 are the parameters to be estimated for the four (categories of) disaggregated land rights. As previously mentioned, tenure security is further divided into protection rights and the land expropriation risk. F_i is a vector of the farm characteristics and includes control variables such as agricultural specialization and contract farming (whether the farm specializes in cotton, engages in contract farming, respectively), farm area, hired labor both number of permanent workers and whether farm employs agronomist, numbers of years since farm establishment, quality of irrigation and drainage systems. R_i corresponds to a vector of resource availability regarding farm access

to arable land and variable inputs, credit use, livestock ownership, and nonfarm income. P_i is a vector of personal characteristics, including farmers' age, education and risk attitude. D_i includes three districts in each country, and e_i is the error term.

Given the nature of our data, we employ count data models. Specifically, we use two model variants to address distributional properties, e.g., overdispersion and excess zeros. When overdispersion occurs, meaning the variance of investment exceeds its mean and indicates greater variability in the data, the traditional Poisson model becomes inappropriate, requiring the use of alternative models such as the Negative Binomial or zero-inflated variants (Green 2021; Hilbe 2011). A visual inspection of data from Figure 2 indicates a heavily skewed distribution of both investment measures in Kazakhstan, indicating a high concentration of zeros on the left-hand side. Conversely, in Uzbekistan, the distributions for both investment measures exhibit a more Gaussian or normal pattern, especially for Asset diversity. We conducted a formal test developed by Fávero et al. (2020) to detect overdispersion (Table 7). The test results indicated the presence of overdispersion in both investment outcomes in Kazakhstan, while overdispersion was detected only for Total assets in Uzbekistan. Based on this, we selected the Negative binomial model for the Kazakhstan sample and for the Total assets in the Uzbekistan sample. For Asset diversity in the Uzbek sample, the overdispersion test indicates a negative parameter, revealing the presence of under-dispersion (variance smaller than the mean). Therefore, we compared the AIC and BIC values of the Poisson model and a Generalized linear model relevant to count data (McCall and Villafranca 2024). Based on these criteria, we selected the generalized linear model for predicting asset diversity in Uzbekistan.

One key assumption of count data models is that time exposure influences the accumulation of farm assets, meaning that farms operating for longer periods are likely to possess more machinery and equipment. Research suggests to properly control for time exposure (Long and Freese 2006). Therefore, in Eq. (1), we include the 'Farm age' variable under 'Farm characteristics' to control for time.

We report incidence rate ratios (IRR) for the negative binomial model because they are much more intuitive to interpret (Zhang et al. 2020). An IRR greater than 1 indicates that if the independent variable increases by one unit, the expected count of the dependent variable also increases by a factor equal to the IRR. Conversely, an IRR less than 1 indicates a decrease in the expected count of the dependent variable as the independent variable increases by one unit. We can also convert IRR into percentages by this formula: (IRR*100) − 100%. The resulting positive (negative) value is interpreted as a percent increase (decrease) in the dependent variable in response to a unit change in the independent variable, holding other variables constant. The coefficient from generalized linear model is interpreted as follows: for each one-unit increase in the independent variable, the expected value of the dependent variable increases (decreases) by coefficient value, holding other variables constant.

Lastly, we performed two separate tests for the two subsamples as a robustness check. When data include zeros, researchers suggest to transform count data by creating dichotomous variable or log transformation, and use models such as logit or generalized linear models (Green 2021; Hilbe 2011; Myers and Montgomery 1997; Warton et al. 2016). For Kazakhstan, we tested the logit model

using a dichotomous variable (*Presence of Farm assets*), which takes the value of 1 if both asset diversity and total assets are positive (indicating the presence of assets in a farm) and 0 otherwise (indicating no assets in a farm). For Uzbekistan, we ran a linear regression model (Ordinary Least Squares) by transforming the investment variable following Ives (2015). The coefficient from the logit model is interpreted as follows: a one-unit increase in the independent variable is associated with an increase of coefficient value in the log odds of the outcome occurring, holding other variables constant.

Results

Panels A and B of Tables 4, 5 and 6 present the regression results for Kazakhstan and Uzbekistan, respectively. Notably, the coefficients for the association between land rights and asset diversity in Uzbekistan were estimated using a generalized linear model, while all other coefficients in both panels were estimated using a negative binomial model. We see that for Kazakhstan farmers, the relationship between perceived use rights and investment in movable farm assets is positive and statistically significant across both investment measures (Panel A, columns 1–4). An increase in perceived use rights is associated with an expected increase in asset diversity and total assets by factors of 1.527 and 1.669, respectively, holding all other independent variables constant (columns 1 and 3). The coefficients for management and transfer rights have the expected sign but are relatively small and statistically not significant (columns 1–4 of Panel A). Additionally, among Kazakh farmers, a higher perceived risk of land expropriation risk is associated with lower asset diversity, albeit the coefficient is statistically significant at the 0.10 level (Panel A, column 2). A one-unit increase in the expectation of losing land is associated with the reduction in the rate of asset diversity by a factor of 0.854, or 14.6% (i.e., 0.854 – 1.0*100%), holding all other independent variables constant (column 2). On the contrary, the coefficient for the relationship between protection rights and investment in movable farm assets is not in the expected direction (IRR < 1) and is statistically not significant. The results indicate that land expropriation risks have a stronger statistical relationship with investment in movable farm assets than protection rights. Overall, the results for the Kazakhstan sample support the hypothesis that farmers' investment in movable farm assets tends to increase with stronger perceived use rights and, to a lesser extent, with greater tenure security as indicated by a lower expectation of land expropriation risk.

Panel B of Table 4 presents the estimated outcomes for Uzbekistan using a generalized linear model for asset diversity and a negative binomial model for total assets. The results reveal a negative relationship between perceived use rights and investment in movable farm assets across both asset diversity and total assets (Panel B, columns 1–4). Among Uzbekistan farmers, an increase in perceived use rights is associated with a decrease in the indicator of asset diversity by 0.251, while total assets are predicted to decrease by a factor of 0.840 or by 16%, holding all other independent variables constant (columns 1 and 3).

Table 4 Land rights and investment in movable assets in Kazakhstan and Uzbekistan with control variables for farm characteristics, resource availability, farmer characteristics, and districts

	Asset diversity (1)	Asset diversity (2)	Total assets (3)	Total assets (4)
Panel A: Kazakhstan				
Use rights	1.527** (0.331)	1.494** (0.323)	1.669** (0.418)	1.646** (0.413)
Management rights	1.084 (0.141)	1.036 (0.136)	1.158 (0.167)	1.129 (0.166)
Transfer rights	1.056 (0.066)	1.054 (0.064)	1.026 (0.070)	1.009 (0.068)
Protection rights	0.974 (0.120)	Excluded	0.835 (0.117)	Excluded
Expropriation risk[a]	Excluded	0.854* (0.079)	Excluded	0.962 (0.092)
Sets of control variables	Included	Included	Included	Included
No. of observations	503	503	503	503
Panel B: Uzbekistan				
Use rights	−0.251** (0.110)	−0.271** (0.110)	0.840** (0.058)	0.835*** (0.058)
Management rights	−0.041 (0.067)	−0.027 (0.069)	1.126*** (0.047)	1.120*** (0.048)
Transfer rights	−0.080 (0.088)	−0.099 (0.089)	0.900* (0.049)	0.903* (0.051)
Protection rights	−0.126 (0.107)	Excluded	0.899 (0.060)	Excluded
Expropriation risk	Excluded	−0.024 (0.056)	Excluded	1.041 (0.036)
Sets of control variables	Included	Included	Included	Included
No. of observations	460	460	460	460

Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (two-tailed test)

Source: Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

Management and transfer rights show a statistically significant relationship with total assets, although the direction of this relationship differs between these two bundles. Specifically, stronger perceptions of management rights are associated with an increase in total assets, whereas greater perceptions of transfer rights are linked to a decrease in total assets (Panel B, columns 3–4). Neither protection rights nor land expropriation risk exhibit a statistically significant relationship with investment in movable farm assets for Uzbekistan farmers. These findings indicate that Uzbekistan farmers are more likely to invest in movable farm assets if they perceive stronger management rights but are less inclined to invest when they perceive greater freedom in use and transfer rights.

Lastly, Table 4 (columns 2 and 4) shows that for both samples when land expropriation risk is used in regressions, the estimated coefficients for other bundles change slightly in magnitude. Specifically, for Kazakhstan, there is a systematic reduction in the coefficient for use rights, whereas in Uzbekistan, the changes are less pronounced. This suggests that land expropriation risk, at least in Kazakhstan's case, not only has a direct relationship with investments but also seems to have a moderating role.

We undertook further analysis to check the robustness of the main results. First, we modified the composition of use, management, and transfer bundles and observed whether the previously detected relationships would alter (Tables 5, 6). Second, we used binary and log-transformation of count data as alternative investment measures

Table 5 Modified use and management rights in Kazakhstan and Uzbekistan with control variables for farm characteristics, resource availability, farmer characteristics, and districts

	Asset diversity (1)	Asset diversity (2)	Total assets (3)	Total assets (4)
Panel A: Kazakhstan				
Modified Use rights	2.023*** (0.517)	1.989*** (0.509)	2.125*** (0.606)	2.087*** (0.596)
Modified Management rights	0.967 (0.151)	0.909 (0.144)	1.058 (0.185)	1.030 (0.182)
Transfer rights	1.056 (0.065)	1.054 (0.063)	1.029 (0.070)	1.012 (0.068)
Protection rights	0.975 (0.119)	Excluded	0.837 (0.116)	Excluded
Expropriation risk	Excluded	0.849* (0.079)	Excluded	0.965 (0.092)
Sets of control variables	Included	Included	Included	Included
No. of observations	503	503	503	503
Panel B: Uzbekistan				
Modified use rights	−0.279*** (0.107)	−0.292*** (0.107)	0.886* (0.059)	0.876* (0.059)
Modified management rights	−0.050 (0.072)	−0.039 (0.074)	1.137*** (0.051)	1.129*** (0.052)
Transfer rights	−0.076 (0.087)	−0.091 (0.089)	0.902* (0.050)	0.907* (0.051)
Protection rights	−0.131 (0.106)	Excluded	0.894* (0.059)	Excluded
Expropriation risk	Excluded	−0.010 (0.055)	Excluded	1.047 (0.036)
Sets of control variables	Included	Included	Included	Included
No. of observations	460	460	460	460

A right to choose crop type was replaced with a right to change land purpose within Modified Use rights, and correspondingly, the former right was omitted from Modified Management rights. Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, (two-tailed test)

Source: Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

and ran logit and linear regression models in Kazakhstan and Uzbekistan settings, respectively. The results of this analysis are presented in Tables 8, 9 in the Appendix.

Panels A and B of Table 5 present the regression results incorporating *Modified Use and Management rights* in the two settings. Within the bundle of use rights, the right to convert agricultural land purpose was replaced with the right to choose crop type, while the right to choose crop type was omitted from the bundle of management rights to avoid double-counting. The composition of the other bundles remained unchanged. The results in Table 5 are qualitatively consistent with those reported in Table 4. In Kazakhstan, use rights remain positively and significantly associated with both dependent variables, as indicated by asset diversity and total assets. Similarly, the expectation of land expropriation risk continues to show a negative relationship with asset diversity. The coefficient for land expropriation risk and total assets narrowly missed statistical significance at the 10% level (p-value slightly above 0.10). The coefficients for management and transfer rights remain positive but small and statistically not significant. Notably, quantitative changes are observed in the estimation results for Kazakhstan farmers when comparing the results between Tables 4 and 5. For example, the coefficients of association between use rights and

Table 6 Modified management and transfer rights in Kazakhstan and Uzbekistan with control variables for farm characteristics, resource availability, farmer characteristics, and districts

	Asset diversity (1)	Asset diversity (2)	Total assets (3)	Total assets (4)
Panel A: Kazakhstan				
Use rights	1.524* (0.335)	1.474* (0.323)	1.698** (0.434)	1.659** (0.424)
Modified Management rights	1.136 (0.179)	1.106 (0.173)	1.170 (0.206)	1.154 (0.205)
Modified Transfer rights	1.030 (0.075)	1.027 (0.073)	1.002 (0.082)	0.985 (0.079)
Protection rights	0.995 (0.120)	Excluded	0.853 (0.118)	Excluded
Expropriation risk	Excluded	0.853* (0.078)	Excluded	0.953 (0.090)
Sets of control variables	Included	Included	Included	Included
No. of observations	503	503	503	503
Panel B: Uzbekistan				
Use rights	− 0.250** (0.109)	− 0.268* (0.109)	0.845** (0.058)	0.842** (0.058)
Modified Management rights	− 0.035 (0.071)	− 0.019 (0.072)	1.109** (0.050)	1.104** (0.050)
Modified Transfer rights	− 0.129 (0.109)	− 0.159 (0.111)	0.858** (0.058)	0.863** (0.060)
Protection rights	− 0.123 (0.107)	Excluded	0.899 (0.060)	Excluded
Expropriation risk	Excluded	− 0.031 (0.056)	Excluded	1.044 (0.036)
Sets of control variables	Included	Included	Included	Included
No. of observations	460	460	460	460

A right to exclude others from using land was omitted from Modified Management rights, and a right to rent in additional land was omitted from Modified Transfer rights. Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (two-tailed test)

Source: Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

investment increased from 1.52 to 2.02 for asset diversity and from 1.66 to 2.12 for total assets, respectively (Tables 4 and 5, columns 1 and 3). For Kazakhstan sample these findings indicate that the greater investment incentives associated with holding use rights are primarily driven by a stronger perception of the right to choose crop type rather than the right to change land purposes.

Similarly, for the Uzbekistan sample, the estimated coefficients for modified land rights and investment relationship remain largely consistent with the results from the previous analysis. Particularly, use and transfer rights remain negatively associated with both asset diversity and total assets, while only management rights remain positively and significantly associated with total assets. However, the regression analysis using the modified bundles yielded a notable change in the results for the protection rights in Uzbekistan. The previous negative and statistically insignificant association between protection rights and total assets has become statistically significant at $p < 0.10$ (Panel B, column 3), indicating a negative relationship between perception of protection rights and investment in movable farm assets. The magnitude and statistical significance of coefficients, especially those pertaining to modified use rights, also shifted, although the changes are less pronounced compared to

the results observed for Kazakhstan. Lastly, omitting the right to choose crop type from the management rights bundle did not result in substantial changes to the main findings for Uzbekistan.

In the original framework proposed by Schlager and Ostrom (1992), the right to exclude was treated as a separate bundle, and the right to rent in or acquire additional resources, such as farmland in our case, was not considered. The ability to exclude others from unauthorized entry to one's land may be conceptually comparable to tenure security, making it critical to reassess how modifications to the bundle of management rights might influence investment incentives. This is particularly important given that management rights have been shown to impact investment in the Uzbek context positively. Similarly, the right to rent in additional land—part of the transfer bundle—may be more important for motivating farmers to acquire their own farm machinery than traditional transfer rights, which focus on transferring land to others.

In the following, we reassess the same regression models omitting the rights to exclude others from entering own land and to rent in additional land from management and transfer rights, respectively (Table 6, Panel A, B). We keep the composition of other bundles unchanged. For the Kazakhstan sample, excluding these two rights from the management and transfer bundles does not lead to significant changes in the results. Investment in movable farm assets among Kazakh farmers remains positively associated with perceived use rights and negatively associated with land expropriation risk. The relationships between management rights, transfer rights, protection rights, and investment remain unchanged from previous estimations, both in terms of sign and statistical significance. Similarly, in Uzbekistan, the results align closely with those reported in Table 4, showing similar qualitative trends. Perceived use rights exhibit a significant negative association with asset diversity and total assets, while management and transfer rights show contrasting relationships with total assets. Neither protection rights nor land expropriation risk are statistically significantly associated with investment in movable assets.

Notably, in the Uzbekistan sample, omitting the exclusion right results in a slight reduction in the coefficient for modified management rights and total assets compared to unmodified management rights. This indicates that farmers in Uzbekistan experience stronger investment incentives when they hold management bundle including the right to exclude others from entering their land. More subtle changes are observed regarding modified transfer rights. Comparing the results from Table 6 with those from Table 4, we notice that the size of the transfer rights coefficient decreased from 0.90 to 0.85 (Panel B, columns 3 and 4); also omitting the right to rent in additional land increases the statistical significance of this coefficient. This indicates that granting the right to rent in additional land, appears to mitigate the disincentives for investment among sampled Uzbekistan farmers.

Last but not least, we conducted additional analyses to determine whether alternative regression models would alter the main results. Tables 8 and 9 in the Appendix present the results of the logit and linear models. The findings confirm that the main results remain robust to changes in regression model specifications.

Discussion, Implications for Theory and Policy, and Conclusion

This paper explores the relationship between land rights and farmers' investment incentives, focusing on non-land investments such as machinery and equipment. Recognizing the complexity of land rights, we investigate how different bundles of rights—land tenure security, transferability, use and management rights—incentivize investment decisions. Theory provides clearer predictions regarding the strength of land rights in influencing land-related investments, a focus also reflected in the empirical literature. However, the evidence remains mixed and primarily drawn from studies on land-related investments with less attention to non-land investments such as machinery and equipment. To address this gap, we use a unique farm survey dataset collected from individual farmers in two regions of Kazakhstan and Uzbekistan. These regions share similar farming systems and biophysical conditions but differ significantly in their institutional environments.

For the sample of farmers from Turkistan region (Kazakhstan) included in this study, our analysis reveals the following main findings: Higher perceptions of use rights are strongly and consistently associated with increased investment in movable farm assets, both in terms of asset diversity and total assets. In contrast, tenure insecurity, as expressed by higher land expropriation risk, is associated with a decreased investment only measured as asset diversity, although the relationship is statistically weak. On the other hand, data do not support the existence of positive relationship between perceptions of transfer, management, protection rights, and investments in movable farm assets. Furthermore, robustness checks reveal that Kazakh farmers tend to derive greater investment incentives from holding the right to choose crop type compared to the rights to exclude others from using land and to rent in additional land.

Although the evidence linking land tenure security to investments in movable farm assets is weak, it remains consistent with theoretical predictions (Besley 1995; Deininger and Jin 2006; Feder and Nishio 1998) and aligns with findings from other empirical studies (Carter and Olinto 2003; Sitko et al. 2014). This alignment supports the notion that tenure security can provide incentives for investment by reducing uncertainty and ensuring returns. However, the weak and inconsistent nature of the evidence for land tenure insecurity in our study suggests that the strength of this relationship may depend on the type of investment and the specific measure of land tenure insecurity employed (Fenske 2011).[3] It is possible that, compared to land-related investments, the incentive effects of tenure security on movable assets are less pronounced due to the relatively mobile nature of these assets, which allows for high reversibility of such investments. These findings suggest that in the studied context of Kazakhstan tenure security, while important, may not be the primary factor farmers consider when it comes to non-land agricultural investments such as machineries and equipment.

The results from Kazakhstan revealed two key findings regarding use rights and investment incentives. First, use rights, in general, are strongly associated with

[3] Besides, particular investment strategies farmers employ may also influence to what extent farmers consider land tenure security (Smith 2004).

investment in movable assets. This finding aligns with our expectations that stronger perceptions of the ability to allocate land, choose economic activities, and retain harvests and associated income incentivize farmers to invest in their own machinery and equipment. In contrast to Deininger et al. (2021), who emphasizes the role of long-term rights such as the ability to sell or bequeath in shaping investment behavior, our findings suggest that short-term operational rights can also play a significant role in driving investments in certain contexts.

Second, among the specific components of use rights, the right to select crop types emerged as a particularly strong investment incentive. Brasselle et al. (2002) highlight that basic use rights, even without strong managerial or transfer rights, can be sufficient to incentivize simple land-related investments among smallholders, as they directly support livelihoods. In Kazakhstan sample, this is evident in the stronger investment incentives tied to the freedom to select crop types, which directly impact short-term productivity and profitability by helping farmers manage risks and optimize income (Takeshima and Yamauchi 2012).

The current consensus among economists is that transfer rights—especially the rights to rent out and sell land –enhance investment incentives (Besley 1995; Deininger and Jin 2006; Schlager and Ostrom 1992). However, contrary to theoretical expectations, our findings from Kazakhstan sample reveals no significant relationship between transfer rights and investment in movable farm assets. These results align with Brasselle et al. (2002) and Omura (2008), who found no significant association between certain transfer rights and land-related investments. Brasselle et al. (2002) adds that in settings with no functioning land markets, having transfer rights will have no visible effects on investment incentives. Similarly, but from a different perspective, Omura (2008) highlights that transfer rights can be more important for high-cost, nonreversible land infrastructure investments. In fact, the land sales market in Kazakhstan is not well-developed (Kvartiuk and Petrick 2021). Farmers adjust their farm size through land rental, including informal rental arrangements, which are common in the region (Mukhamedova and Pomfret 2019). Since land sales are limited and land rental is accessible to potentially all land users, a lower importance of the transferability may also be attributed to weak land markets, similar to the findings of Brasselle et al. (2002).

Lastly, the evidence from Kazakhstan sample does not support the notion that stronger management and protection rights significantly increase investment incentives. This finding contradicts our expectations that enhanced managerial decision-making and greater tenure security (bolstered by stronger courts and the importance of land documentation) would empower farmers and provide the security needed to invest in their farms (Akhmadiyeva and Herzfeld 2021; Zorya et al. 2019). One possible explanation for the lack of observed incentives from stronger management rights is that the benefits from participating in input markets and accessing marketing options may be relatively uniform among the sampled farmers in Kazakhstan. Some scholars report, despite a more liberal market environment in Kazakhstan, farmers complain about input constraints, particularly accessing modern yield-enhancing seeds and fertilizers, and about the high cost of variable inputs (Shtaltovna and Hornidge 2014). Through this channel, higher perceptions of management rights may not necessarily translate into

higher returns from investing in farm machinery and equipment. Further, observing no significant association between protection rights and investment measures is surprising. As we measure them in this study, the protection rights may be a less direct indicator of land tenure security. When farmers make investment decisions, they may not consider the general quality of institutions like courts (Linkow 2016) and rather focus on tenure risks that impose direct costs on them (Zhllima et al. 2010). The data suggest that farmers in Kazakhstan may view land expropriation risks as a greater threat to their tenure and economic activities than protection rights when making investment decisions.

In Uzbekistan, our analysis highlights only management rights are significantly and positively associated with investments in movable farm assets in terms of total assets only. Conversely, higher perceptions of use rights are strongly and consistently associated with lower investments in movable farm assets in terms of both asset diversity and total assets. Similarly, a negative relationship emerged between perceived transfer rights and total assets, although the relationship is statistically weak. The analysis from Uzbekistan suggests that land tenure security, as indicated by protection rights and the risk of land expropriation, is not a significant factor in farmers' decisions to invest in machinery and equipment. Moreover, robustness checks indicated that the rights to choose crop type, to exclude others from using land, and to rent in additional land tend to weakly incentivize investment among farmers in Uzbekistan.

Contrary to theoretical predictions (Besley 1995; Feder and Nishio 1998), our findings from Uzbekistan do not support a significant relationship between land tenure security—measured through protection rights and land expropriation risk—and investments in movable farm assets. The relationships were statistically insignificant and showed ambiguous signs. This aligns with other studies documenting no strong link between land tenure security and movable asset investments (Feder and Onchan 1987; Feder et al. 1992; Leight 2016; Zhou et al. 2022). It appears that investments in movable assets, such as machinery and equipment, may be perceived by Uzbekistan farmers as relatively risk-free and reversible, posing minimal conflict with government land policies (Oberkircher 2011). Another explanation for the lack of evidence linking land tenure security and investments has been proposed by Niyazmetov et al. (2021), who suggest that under Uzbekistan's persistently insecure tenure environment, farmers may have become insensitive to tenure risks or normalized them; the same study and a follow-up by Niyazmetov (2023) reported that policy experts in Uzbekistan ranked secure land rights as a high priority, and farmers expressed a willingness to pay for secure land contracts if given greater freedom to choose their tenure arrangements. Taken together, these findings suggest that in the context of Uzbekistan, land tenure security may be a less critical incentive for motivating farmers to make non-land agricultural investments.

Next, the observed positive relationship between management rights and investment in movable assets aligns with our expectations that greater managerial freedom fosters investment decisions (Zorya et al. 2019). Even while operating under Uzbekistan's heavily monitored agricultural sector, Uzbek farmers with higher perceptions of management rights appear to make more productivity-enhancing decisions and better organize production within their agreed specialization. This mechanism is

further supported by robustness checks, which revealed that the relationship between management rights and total assets strengthened slightly when the right to choose crop types was excluded from the management bundle. This suggests that the ability to choose crop types gives farmers the authority to cultivate more profitable crops, and in its absence, farmers may instead rely more on the benefits of broader managerial freedom to enhance productivity.

Surprisingly, among Uzbekistan's farmers, the relationships between use, transfer rights and investment were found to be negative. This indicates that farmers with stronger perceptions of use and transfer rights made lower investments in movable farm assets. This result contrasts with our expectations and theoretical predictions. A possible explanation for this counterintuitive finding is provided by Yi et al. (2014), who suggest that low farm returns may increase the perceived value of land for alternative uses. In Uzbekistan's highly regulated agricultural sector, farmers may lack adequate economic incentives to prioritize agricultural investments.[4] Under an economically unprofitable system, farmers with higher perceptions of use and transfer rights may find it rational to use land for alternative income-earning activities at the expense of agricultural investments.

Comparative analysis of Kazakhstan and Uzbekistan has provided valuable insights into the similarities and differences in how land rights influence investment incentives. The findings reveal that, in both settings, farmers place importance similarly on operational rights, such as use and management rights, when deciding to invest in farm machinery and equipment. As discussed, the empirical evidence for a link between land rights and investment is highly contextual. Output and factor markets, as well as the economic incentives derived from farming are likely to shape how farmers respond to land rights. By adopting a comparative approach that examines farmers operating under distinct institutional contexts, this study addressed the growing call from influential research (e.g., Besley 1995; Fenske 2011; Lawry et al. 2017) to account for contextual factors and to adopt systematic and comparable land tenure measures. This paper contributes to a deeper understanding of how institutional and market environments may moderate the role of land rights on investment behavior.

In the following, we draw implications for theory and policy. Economists should broaden their perspective beyond mere tenure security and transferability rights to include use and management rights, which provide farmers with a wider range of economic opportunities and act as distinct sources of investment incentives. As previously noted, our findings reinforce the argument that context plays a pivotal role in realizing the benefits of land rights, particularly those associated with individualized rights (Lawry et al. 2017). Specifically, individualized land tenure may be less

[4] Shtaltovna and Hornidge (2014), using data from the same study regions, calculated the total cost of cotton production in Kazakhstan to be at approximately 800 USD/ha, compared to 1,200 USD/ha in Uzbekistan. Thus, Uzbekistan farmers incurred 50% higher expenses for the same effort and land compared to their peers in Kazakhstan. Tadjiev et al. (2023), also using data from the same study regions, calculated the costs of labor, fertilizer and cotton seeds to be at around 280 USD/ha in Kazakhstan and approximately 550 USD/ha in Uzbekistan. This tells despite nearly a decade between these studies, tight economic environment in Uzbekistan's interventionist agricultural sector persisted.

useful in contexts where market environment and structure of economic opportunities are absent (Barrows and Roth 1990).

For Kazakhstan, our findings suggest that enhancing use rights and strengthening land tenure security could significantly boost farm productivity and should be a key priority for policymakers. These efforts might begin with improving farmers' awareness of their rights as land users and decision-makers, regardless of the specific land ownership structure. Compared to neighboring Uzbekistan, Kazakhstan is already in a stronger position by avoiding large-scale land reallocations and unexpected agricultural policy shifts. However, it is important to recognize that farmers' perceptions of land tenure insecurity can increase even without direct experiences of land conflicts (Cheng et al. 2022). To address this, policymakers should ensure clear and transparent communication regarding the reasons for land expropriation or premature lease terminations. Leveraging social media channels to disseminate this information can be particularly effective. Additionally, timely updates on changes in land policies, rights, and obligations should be provided to maintain trust and reduce uncertainty among farmers. For Uzbekistan, our findings suggest that simply granting additional land rights without properly aligning economic incentives is unlikely to address the issue of low investment incentives. Policymakers should prioritize improving economic incentives from farming and investment in parallel with strengthening management rights. The starting point is to follow Kazakhstan's approach of allowing farmers to market their own products. The findings from Kazakhstan and Uzbekistan offer valuable insights for other transition and developing economies undergoing similar reforms, especially regarding establishing necessary economic and institutional conditions for the functioning of individualized land tenure.

In the study, some limitations must be acknowledged. First, our study is based on a cross-sectional analysis, providing a snapshot of the relationship between land rights and investment incentives at a specific point in time. Panel data or other causal methods would be valuable to confirm and strengthen these findings. Second, we did not address the potential endogeneity of perceived land rights, especially the possibility of a reverse relationship. Although in many post-socialist settings, the allocation of property rights typically originates from top-down government policies (Ho and Spoor 2006; Kapeliushnikov et al. 2013) rather than from farmers' claims to land, it is plausible that perceptions of rights may evolve in response to changes for example in enforcement or the availability of farm support programs, such as subsidies. Given the strong link between crop choice flexibility and investments in movable farm assets observed in Kazakhstan, it would be particularly insightful to explore whether the relationship between perceived use rights and investment is influenced by government subsidy programs. This could provide a deeper understanding of the mechanisms driving investment behavior in different policy and institutional contexts.

Appendix

See Fig. 2 and Tables 7, 8, 9.

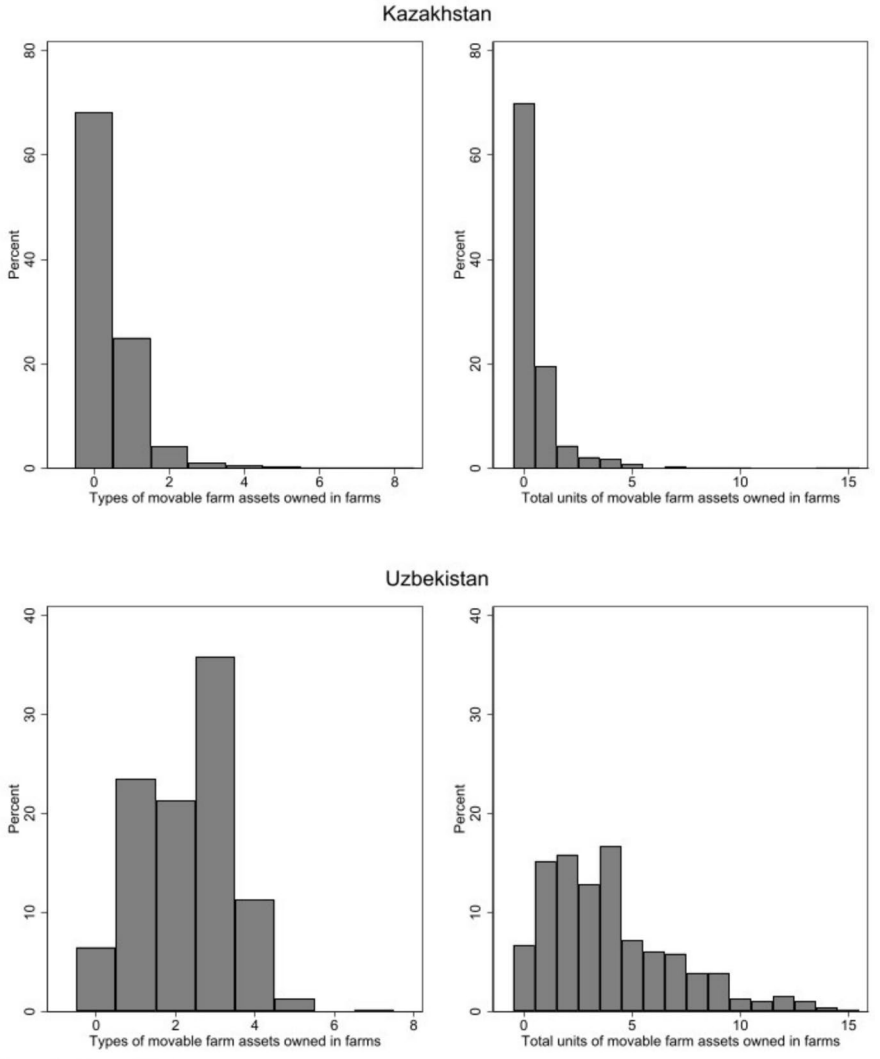

Fig. 2 Histogram of movable asset diversity and total movable assets in Kazakhstan and Uzbekistan. *Source:* Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

Table 7 Overdispersion test

Variable	Kazakhstan			Uzbekistan		
	Mean	Standard error	Overdispersion parameter	Mean	Standard error	Overdispersion parameter
Asset diversity	0.449	0.124	0.402***	2.269	0.015	−0.223***
Total assets	0.598	2.208	0.906***	3.991	0.024	0.125***

Negative dispersion parameter (the case of Asset diversity in Uzbekistan) suggests there is under-dispersion.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$, (two-sided t-test)

Source: Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

Table 8 Logit model estimation of relationship between land rights and presence of farm assets in Kazakhstan with control variables for farm characteristics, resource availability, farmer characteristics, and districts

Dependent Variable: *Presence of Farm assets* (1 = asset diversity and total assets > 0; 0 = otherwise)	Asset diversity (1)	Asset diversity (2)	Total assets (3)	Total assets (4)
Use rights	0.767** (0.317)	0.742** (0.316)	0.781** (0.322)	0.761** (0.321)
Management rights	0.148 (0.194)	0.096 (0.195)	0.071 (0.194)	0.032 (0.195)
Transfer rights	0.057 (0.090)	0.031 (0.087)	0.025 (0.090)	0.000 (0.088)
Protection rights	−0.228 (0.191)	Excluded	−0.216 (0.192)	Excluded
Expropriation risk[a]	Excluded	−0.096 (0.130)	Excluded	−0.055 (0.130)
Sets of control variables	Included	Included	Included	Included
No. of observations	503	503	503	503

Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (two-tailed test)

Source: Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

Table 9 Linear model estimation of land rights and investment in movable farm assets in Uzbekistan (investment variables are log-transformed) with control variables for farm characteristics, resource availability, farmer characteristics, and districts

	Asset diversity (1)	Asset diversity (2)	Total assets (3)	Total assets (4)
Use rights	−0.108*** (0.041)	−0.116*** (0.040)	−0.173*** (0.059)	−0.181*** (0.059)
Management rights	−0.019 (0.025)	−0.013 (0.025)	0.069* (0.036)	0.068* (0.037)
Transfer rights	−0.033 (0.032)	−0.041 (0.033)	−0.082* (0.047)	−0.082* (0.048)
Protection rights	−0.051 (0.039)	Excluded	−0.084 (0.057)	Excluded
Expropriation risk[a]	No	−0.010 (0.021)	No	0.019 (0.030)
Sets of control variables	Included	Included	Included	Included
No. of observations	460	460	460	460

Standard errors in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (two-tailed test)

Source: Authors' calculations based on the AGRICHANGE farm survey dataset (2019).

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Declarations

Conflict of interest The authors declare no conflict of interest regarding the submitted manuscript titled: "Land property rights and investment incentives in movable farm assets: Evidence from post-Soviet Central Asia."

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