LAND RIGHTS, TIME PREFERENCE AND FARM INVESTMENTS: A COMPARATIVE STUDY FROM KAZAKHSTAN AND UZBEKISTAN

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DEDICATION

To my children, Asad and Shakhina, and my wife, Mukhayyo!

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SUMMARY

Investments in farm technologies are essential for enhancing farm productivity, increasing farm income, and fostering broader economic development in many developing economies. Addressing key constraints to farmers' investments is therefore crucial. This dissertation examines the roles of land rights and time preference as fundamental institutional and behavioral factors shaping farmers' investment decisions in productive assets such as farm machinery and equipment. Productive assets refer to farm machinery and equipment. Three research questions guide the dissertation. First, it examines how different bundles of perceived land rights are associated with farmers' investments in machinery and equipment. The literature often emphasizes land tenure security and transfer rights (two main channels) give farmers highest investment incentives. In addition to these, I empirically examine two possibly additional bundles, use and management rights that may give farmers strong investment incentives. The second research question explores the relationship between time preference and investment, and whether land tenure security conditions (perceived land expropriation risk and government intervention) alter this relationship. While behavioral economics highlights the role of time preference in shaping inter-temporal economic behavior such as investment decisions, there is a need for more empirical evidence in agriculture. Furthermore, it remains unclear whether institutional constraints, such as land tenure insecurity, may alter the extent to which time preference matters for investment decisions. If so, addressing land tenure constraints may be important priority. The third research question examines how farmers' perceptions of protection rights and land expropriation risk (a component of perceived land tenure security), change over time. Land documents do not guarantee stable control over land and tenure security because farmers may experience policy shifts or implementation uncertainty. Therefore, over time, farmers' land tenure perceptions may change. Quantifying temporal changes in perceived protection rights and land expropriation risk, is essential for understanding land tenure security dynamics in developing and transition economies.

The research is grounded in a conceptual framework that views land tenure as a bundle of property rights and emphasizes the separation of key bundles (channels) through which tenure conditions may shape farmers' investment incentives. In this dissertation, these bundles include operational rights (use and management rights), transfer rights, and protection rights, alongside land tenure security (land expropriation risk and government intervention). Recognizing these distinct bundles and separating them enable a more nuanced understanding of how different bundles may differentially relate to investment decisions and how land tenure perceptions evolve across different rights and diverse institutional settings.

The dissertation draws on farm surveys conducted in 2019 and 2022 in Kazakhstan and Uzbekistan. The 2019 cross-sectional dataset is used to address the first two research questions, while a panel dataset of farms observed in both 2019 and 2022 is used for the third research question. The analysis applies a bundles-of-rights perspective based on perceived land rights, complemented by measures of perceived land tenure security (expropriation risk and government intervention), which is particularly relevant where formal legal rights may not fully reflect on-the-ground tenure conditions. The uniqueness of the data stems from the detailed measurement of multiple perceived tenure dimensions and from the contrasting institutional contexts in which the data were collected. The two countries represent different policy approaches and stages of reform toward market economies, providing a comparative lens.

The main findings for Research Question 1 indicate that higher perceived use rights are associated with greater investment in farm machinery and equipment in the Kazakhstan sample, while higher perceived management rights are associated with investment in the Uzbekistan sample. Contrary to expectations, there is limited evidence that protection rights, land tenure security (expropriation risk) and transfer rights are associated with investment incentives. Overall, the rights dimensions linked to investment differ between the two countries, consistent with differences in their economic and institutional environments.

The findings for Research Question 2 show a strong negative association between time preference and investment in farm machinery and equipment in Kazakhstan, consistent with the idea that more impatient farmers are less likely to undertake long-term investments. In Uzbekistan, the association is also negative but weaker, suggesting that time preference is less strongly related to investment behavior. The relationship also depends on land tenure security conditions, particularly perceived government intervention: in Kazakhstan, the previously strong negative association between time preference and investment largely disappears under high government intervention, while in Uzbekistan it becomes more evident under low government intervention. In contrast, separating samples by perceived expropriation risk does not strongly change the baseline results in either setting, suggesting that expropriation-related tenure insecurity does not meaningfully alter the time preference–investment relationship in these samples.

The findings for Research Question 3 show that farmers' perceptions of protection rights and land expropriation risk changed between 2019 and 2022 in both samples. Around a quarter of farmers in each sample experienced large shifts, in both positive and negative directions. Overall, perceived land tenure security improved moderately in Uzbekistan, while changes in Kazakhstan were smaller. Regarding protection rights, trust in courts increased in Kazakhstan for disputes

with the state but declined for disputes with investors; in Uzbekistan, trust in courts improved for disputes with both the state and investors. Overall, the data indicate meaningful tenure dynamics even among farmers holding land documents, underscoring the value of continuous monitoring and cautioning against one-off tenure interventions.

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Abbreviations

CI	Confidence interval
Coef	Coefficient
FAO	Food and Agriculture Organization of the United Nations
Ha, ha	Hectare
Max	Maximum
Min	Minimum
N, n, No	Number of observations
NPV	Net Present Value
SD	Standard deviation
SE	Standard error
SUSADICA	Structured doctoral programme on Sustainable Agricultural Development in Central Asia
USD	United States Dollar

1. INTRODUCTION

1.1 Background information and research needs

Agriculture remains a crucial source of development and income in the developing world (Gollin, 2010; Suri and Udry, 2022; World Bank, 2007). Increasing agricultural productivity depends, among many factors, on farm-level investments such as use and adoption of variable inputs (e.g., yield-increasing seeds, fertilizers), and investments in farm infrastructure such as land, various structures and equipment (Syed and Miyazako, 2013). While the category of investments involving variable inputs often contributes to short-term productivity gains, the latter category of investments involving productive farm assets aims to enhance long-term productivity, generating a stream of benefits over time by supporting production and future income, rather than being fully used up in a single production cycle. Farm productive assets can be further categorized into land-attached assets, such as fences, land improvements, and irrigation infrastructure, and movable (or mobile) assets, including machinery, equipment, and livestock (Carter and Olinto, 2003). Agricultural investments are essential for farm profitability (Deininger and Chamorro, 2004), as they help mitigate production and weather risks (Takeshima and Yamauchi, 2012), contributing to welfare of farm households (Belay and Mengiste, 2023; Gebregziabher et al., 2009). Therefore, gaining a better understanding of the major constraints to farm-level investments holds both practical and policy relevance.

In this dissertation, I focus on land property rights and time preference as two fundamental institutional and behavioral factors shaping farmers' investment decisions. Constraints to land property rights (or broadly land tenure constraints) refer to limitations in property rights to land arising from unclear, restricted, or poorly defined rights. This challenge is particularly evident in developing and transition countries, where farmers typically have limited influence over land tenure rules, which are often regulated by governments. In contrast, farmers may have some control over other institutional constraints, such as access to credit or extension services—for example, by investing jointly or learning from peers. Securing property rights is therefore a precondition for investment, financial development and long-term economic growth, and is critical because individuals cannot protect themselves from such risks (Acemoglu and Johnson, 2005). Therefore, in developing countries, land tenure interventions are considered a key policy to encourage farmers to maintain natural resources, allocate resources efficiently, and engage in high-return economic activities (Deininger, 2003). Addressing land tenure constraints is essential, as it directly affects the costs and benefits associated with using land as an economic resource (Johnson, 1972).

On-farm investments, particularly in productive assets, require intertemporal decision-making, where farmers must bear the upfront costs of acquiring farm assets while the returns—or full recovery of the investment—materialize over time. Time preference, defined as the extent to which an individual prioritizes immediate benefits over future gains (Frederick et al., 2002), influences how farmers perceive and value future benefits from investments. Farmers with a high time preference (greater impatience) are more inclined to favor economic choices that yield immediate benefits, even if it means forgoing economic choices with larger but delayed returns. Time preferences tend to vary both across countries and within populations in the same country (De Lipsis, 2021; Falk et al., 2018; Wang et al., 2016). This variation has been shown to shape several economic outcomes, including national economic growth and income differences at both macro and individual levels (Epper et al., 2020; Hübner and Vannoorenberghe, 2015; Sunde et al., 2022). Time preference is widely recognized in economics as a critical behavioral factor influencing choices and decisions. Recent research has underscored the value of integrating behavioral insights into agricultural policy and practice (Dessart et al., 2019; Palm-Forster and Messer, 2021; Streletskaya et al., 2020; Wuepper et al., 2023), rather than solely relying on prices and income as determinants of choices (Carter, 2016). Focusing on land rights and time preference as two critical factors influencing farmers' agricultural investment behavior, next I describe three research gaps that this dissertation aims to address.

Although it is widely believed that farmers with weaker tenure rights (more constraints) will underinvest compared to those with stronger rights (Ali et al., 2011; Deininger, 2003), empirical evidence on this relationship remains mixed. This inconsistency often stems from differences in how land rights are measured, different investment categories, and contextual factors (Fenske, 2011). There is a call for a well-designed study that offers broader insight into land tenure situation and allows for comparison across contexts. Additionally, much of the existing literature emphasizes a hierarchy in land rights, with land tenure security and transfer rights often viewed as the most critical for long-term, land-attached investments (Deininger and Jin, 2006; Feder and Nishio, 1998). However, this narrow focus may overlook the importance of other categories of land rights such as operational rights. This category for example includes various rights such as the rights over harvest, income, crop choice, and marketing, that directly influence how farmers organize production. Separating these rights from tenure security and transfer rights could reveal insights about other constraints in land tenure that discourage farmers investments. However, the current empirical research uses mainly aggregate measures of land rights, or just focuses on tenure security and transfer rights. This gap highlights the need for further research to understand how different bundles of land tenure rights (i.e., land tenure security, transfer rights and operational rights) are related to farmers' investments especially in farm movable assets

which were investigated to a lesser extent compared to investments in land-attached assets and variable inputs.

Research involving time preference is gaining prominence among scholars (Brañas-Garza et al., 2023). Within the agricultural economics, the literature has examined the empirical relevance of time preferences on various agricultural decisions, including for example compliance and breaches of contractual agreements (Jing et al., 2023), decisions regarding production and marketing contracts (Ihli et al., 2022; Kamoya and Makochekanwa, 2018), and investment in farm productive assets and variable inputs (Di Falco et al., 2019; Duflo et al., 2011). Among studies focusing on technology adoption and investment, most have examined how time preference influences decisions related to technologies and variable inputs that offer short-term productivity gains. In contrast, fewer studies have explored the extent to which high time preference poses a barrier to investments in productive assets that contribute to long-term productivity. Given the general tendency among farmers to prioritize immediate productivity gains, it is crucial to focus on investment decisions related to productive assets that support long-term outcomes. Further, the relationship between time preference and investment may depend on tenure security conditions. For instance, under high tenure insecurity, greater patience (lower time preference) may not necessarily lead to higher investment due to the risk of losing land (e.g., land reallocations). To the best of my knowledge, apart from Olumba et al. (2024), no research has examined how land tenure security may alter the relationship between time preference and agricultural investments. This represents a gap in the current research.

It is often assumed that once property rights to land are formally documented with registration or issuance of land certificate, the rights remain static. However, over time farmers may engage in various arrangements and obligations, such as contract farming or joint production (e.g., agricultural cooperatives), which may lead to a loss of decision-making autonomy or tenure insecurity (Eaton and Shepherd, 2001; Vicol, 2017). Furthermore, in an economy undergoing significant reforms, where institutional conditions may be evolving rapidly, perceptions of property rights security not only would differ between various economic actors (Johnson et al., 2002) but also over time. In agricultural context, this variability may arise, for instance, when some farmers face greater competition for land from other actors, leading to heightened perceptions of tenure insecurity. The extent to which farmers change their assessments of land rights varies not only due to their unique experiences and farm types but also across different bundles of land rights. For instance, perceptions of land tenure security and protection rights may be more susceptible to change over time compared to operational rights. The presence of dynamic and, particularly, declining perceived tenure rights have negative implications for the

sustainability of long-term farming operations, including investments in land improvements, maintenance, and the modernization of farm technologies. Quantifying within-farmer variations in land rights offers valuable insights into temporal aspects of land tenure dynamics and can help policymakers design more targeted tenure interventions. However, conducting such temporal analysis often requires panel data that tracks the same individuals over time (Andreß, 2017). Collecting panel data is resource-intensive and often subject to high attrition rates because of migration, farm exit (Nyariki, 2009). Partly for this reason, limited attention has been given to examining within-farmer variation in land rights. Existing empirical studies using panel data have predominantly focused on farmers before and after tenure interventions, tracking overall changes in land expropriation risks and land disputes (Bezu and Holden, 2014; Deininger et al., 2011). Tracking these perceptions provides valuable insights into the heterogeneity of tenure experiences, revealing patterns that aggregate trends often overlook. However, less is known about how land rights security evolves over time among farmers who already hold formal documentation. Quantifying temporal dynamics in land rights is crucial for addressing this gap and deepening our understanding of tenure security dynamics.

1.2 Dissertation aim and specific research questions

This dissertation aims to examine to what extent perceived land tenure rights and time preference are related to farmers' investment decisions in farm machinery and equipment.

Accordingly, the dissertation examines the following three key research questions:

1. How are different bundles of perceived land tenure rights—specifically operational rights such as use and management rights), transfer rights and protection rights along with land tenure security (land expropriation risk)—associated with farmers' investment decisions in farm machinery and equipment?

2. What is the relationship between time preference and farmers' investments in machinery and equipment, and how is this relationship altered by different perceived land tenure security conditions (land expropriation risk and government intervention)?

3. How do farmers' perceptions of protection rights and land expropriation risk change between 2019 and 2022? To what extent do these changes vary at the group level and within individual farmers?

1.3 Introduction to data and empirical settings

The dissertation utilizes data from two waves of farm surveys conducted in 2019 and 2022 as part of the SUSADICA project funded by the Volkswagen Foundation. The research project was

designed to examine institutional changes in agriculture, with a particular focus on land tenure, farm management, and technology adoption in post-Soviet Central Asia, using samples of farmers from two comparable regions: the Turkistan region in Kazakhstan and the Samarkand region in Uzbekistan. The surveys targeted farmers specializing in cotton, vegetables and horticulture, on both privately owned and leasehold lands. The datasets include an inventory of farm machinery and equipment, owned and present on farms, which can indicate accumulated farm movable assets stemming from past investments. Additionally, the datasets include farmers' perceptions of land rights across four distinct bundles. In developing countries, perceived land rights often provide more accurate insights into which rights farmers can exercise in practice, compared to formal legal rights or tenure classifications. Therefore, in the dissertation perceived land rights are used. The first wave, conducted in 2019, is used to analyze the associations between perceived land rights, time preference, and investments in farm machinery and equipment (Research questions 1 and 2). The second wave, conducted in 2022, aimed partly to re-survey the same farmers to establish a panel dataset. This panel dataset allows for an examination of how perceptions of land tenure security changed among sampled farmers from Kazakhstan and Uzbekistan (Research question 3).

While farm production across post-Soviet Central Asia has been largely individualized, the region has considerable variation in land tenure arrangements (Lerman, 2009; Petrick, 2021; Swinnen, 2001). Kazakhstan and Kyrgyzstan experienced more rapid liberalization reforms, while in Turkmenistan and Uzbekistan, reforms were more modest, and strong government intervention, especially in priority sectors like cotton and wheat, persisted. Central Asia offers a compelling case for studying comparative development due to its unique experience of post-socialist transition, and remains under-researched, primarily because of limited data availability (Brück et al., 2014). The uniqueness of the datasets I use stems not only from documenting several land rights, but also from the institutional context from which the data originates as illustrated in Table 1. The sampled farmers in Kazakhstan generally operate within a relatively liberal, market-oriented agricultural sector with minimal government intervention in farm decisions. In contrast, the sampled farmers in Uzbekistan operate in heavily regulated environment. The Uzbekistan government retained as of 2019 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., 2024). The samples obtained from these contrasting institutional contexts provide a valuable comparative analysis, broadening our understanding of the relationship between land rights and investment across different institutional contexts, as emphasized by many scholars. Throughout the dissertation, the terms "context" and "settings" are used interchangeably, referring to the two study samples. It should be noted that since 2019,

in Uzbekistan the agricultural sector has 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 and investment behavior documented in the 2019 survey should reflect the land tenure and broader organizational situation prior to these reforms.

Table 1. Overview of the study regions (empirical settings) in Kazakhstan and Uzbekistan

Features	Turkistan (Kazakhstan)	Samarkand (Uzbekistan)
Access to land	Multiple tenure options: private ownership, short- and long-term leases. Land reallocations or state-led expropriations are not common; farmers make independent production decisions.	Only long-term leases exist. Tenure is generally insecure due to possible land reallocations under state policies such as "farm optimization" and "cluster policy."
Land distribution	Land was allocated to former members of collective farms.	Land is allocated via auctions, based on applicants' skills, education, and wealth.
Average farm size	~17 ha for cotton; ~11 ha for other crops.	~49 ha for cotton; ~18 ha for other crops.
Agricultural orientation	Market-based agricultural production.	Until 2019/20, cotton and wheat were produced under a state quota system; currently transitioning to private "clusters."
Access to capital and inputs	Private banks, subsidized loans, and input supply (e.g., gins) via contract farming.	State-dominated banking and input supply. Since 2019/20, inputs are provided through contracts with regional "clusters."
Agricultural extension	Provided by public universities, KazAgro Innovation, and processors through contract farming.	Provided by public universities and research institutes; since 2019/20, also by private "clusters."

Source: Kurbanov et al. (2022).
Note: Information reflects the 2019 situation and, where indicated (e.g. Uzbekistan's quota system, farm optimization, cluster policy), the policy framework in the years leading up to 2019.

In both countries, farmers can purchase agricultural equipment and machinery in local markets. Joint ownership of equipment and machinery is not uncommon (Knorr et al., 2021). Companies such as processors or the government offer the necessary credit and lease arrangements to obtain farm machinery. However, farmers complain about short payback periods, high interest rates, and stringent collateral requirements (Petrick and Djanibekov, 2016; Shtaltovna and Hornidge, 2014). In the study areas, farmers can also rely on rental of machinery and equipment

by other farmers or private and government-owned agricultural service providers as an alternative to acquiring own technologies.

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 to 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. 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 and market their output (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 cotton and wheat sub-sectors in Uzbekistan reduces decision-making autonomy and tenure security for producers. 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 among farmers (Hanson, 2017), mass land reallocations or evictions have been rare.

The critical situation of land rights among farmers producing under government control in Uzbekistan have raised concerns about the impact of land tenure constraints on farmers motivation to maintain soil fertility, to increase farm efficiency and productivity, and on overall agricultural sector development (Djanibekov et al., 2024; Rudenko et al., 2009; Zorya et al., 2019). Several studies indicate that unexpected lease contract terminations, short tenure durations, and uncertain ownership rights, are reported by Uzbekistan farmers to be the major deterrent to tree planting and joining land reclamation initiatives (Djalilov et al., 2016; Djanibekov et al., 2018). Limited decision-making rights also restrict farmers' ability to adjust their crop mix and allocate land in response to climate changes, and shifts in markets (Bobojonov et al., 2013).

It is argued that lifting restrictions on decision-making, such as crop choice, may have a little investment-increasing effect on farmers producing cotton or wheat because of agroclimatic conditions and lack of experience in other crop varieties. Moreover, producing government mandated crops comes with its own advantages, such as preferential access to essential resources like facilities and infrastructure, seeds, fertilizer, irrigation water, training, and informational materials, stable output prices (Bobojonov et al., 2013; Djanibekov et al., 2010). As a result, even if farmers were given a complete freedom in crop selection, they might still prefer to cultivate the same crops rather than switching to potentially more profitable alternatives. There is some empirical evidence that supports this argument. For example, in Tajikistan, some individual farmers have been observed to have remained in cotton-specializing collective farms which received more financial and technical support by government. As Nekbakhtshoev (2016) points out, this occurs despite individual ownership offering more decision-making freedom and tenure security. Another critical perspective suggests that institutional support for broader market mechanisms, including well-functioning factor and output markets, is essential for translating stronger land rights into meaningful economic gains (Petrick, 2021). To better understand which bundles of land rights farmers care most in their investment decisions, it is important to empirically separate operational (decision-making) rights from land tenure security. Answering this helps contribute clarity to debates mentioned above.

In these settings, land tenure limitations are not the only investment barriers. Djanibekov et al. (2018) states that farmers operating under a government intervention emphasized long time horizon of slow-growing tree plantations as the main reason for not converting degraded croplands into agroforestry, suggesting the importance of timing of returns from investment. Similarly, Dessalegn et al. (2018) conclude that farmers in South Kazakhstan, specializing in

cotton, wheat, and vegetables, are reluctant to adopt recommendations for sustainable ecosystem management; their hesitancy stems from a preference to maximize immediate benefits while avoiding future risks associated with agricultural technologies. The available evidence suggests that farmers in this context consider intertemporal aspects of economic decisions, such as the timing of payments and costs, indicating a preference for receiving benefits sooner. Even when institutional conditions such as land tenure improve, investment decisions may still be influenced by inter-temporal preferences regarding the timing of payoffs from investments. Therefore, it is important to address the extent to which time preference can be a barrier to investment. Another research conducted in neighboring Tajikistan suggest, tenure risks can significantly shorten farmers' financial planning horizons and make them more inclined to prioritize short-term gains over future benefit (Klümper et al., 2018). The risks of premature termination of lease contracts or land expropriation, often linked to frequent land reallocations, may compel even patient farmers to prioritize economic activities with shorter financial horizons. In addition to land tenure insecurity, limited transfer rights may also reduce long-term planning orientation of farmers (Ali et al., 2011).

Because of strict land-use regulations in the study areas, farmers face legal constraints when investing in land-attached assets, such as fruit trees, storage facilities, and greenhouses. In contrast, investments in movable farm assets, such as machinery and equipment, are less likely to be restricted by policy regulations (Oberkirscher, 2011). 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 farm machinery. With modern portable farm technologies, such as tractor-mounted and aerial sensors, gaining traction in developing country markets, including in Central Asia (Kuhn et al., 2023), it is crucial to examine to what extent land tenure constraints in these two settings can be barrier for investments in farm movable assets and, more broadly, the adoption of emerging nonland innovations.

1.4 Overview of analytical approach and structure of dissertation

The dissertation employs quantitative methods, combining regression analysis and descriptive analysis to examine the relationships between land rights, time preference, and farmers' investment behavior, and to track changes in protection rights and land expropriation risk perceptions over time. The analysis is conducted at the farm level separately for each country. Although no predefined comparative hypotheses are developed, a comparative analysis of data and the main findings is maintained to generate contextual insights.

For Research question 1, which investigates the relationship between different bundles of perceived land rights and investment in farm machinery and equipment, I generated indices for four bundles of perceived land rights. Investment measure is based on total number of and diversity of farm machinery and equipment owned and present in farms. Sections of the analysis corresponding to this research question draw on work published in Kurbanov et al. (2025) and have been revised and extended for inclusion in this dissertation.

For Research question 2, which explores how farmers' time preference relates to investment in machinery and equipment, the key independent variable is a self-assessed measure of time preference, with the same dependent variable used in Research question 1. For examining how perceived land tenure security conditions may be associated with time preference and investment, I used perceived land expropriation risk and perceived government intervention.

For Research question 3, which analyzes temporal changes in farmers' perceptions of protection rights and perceived land expropriation risk, relies on constructed panel datasets using farm surveys collected in 2019 and 2022.

The remainder of the dissertation is structured as follows. Chapter 2 reviews the relevant theoretical and empirical literature related to each research question. Chapter 3 describes the methodology, including data sources, operationalization and description of variables, and quantitative methods. Chapter 4 presents the main findings for each research question and discusses them including elaborating contributions and specific policy implications. Chapter 5 concludes the dissertation by synthesizing the results, highlighting general contributions to the literature, drawing overall policy implications, suggesting directions for future research, and providing concluding remarks.

2. LITERATURE REVIEW: THEORY AND EVIDENCE

This chapter reviews the theoretical and empirical literature on three research questions: The relationship between four bundles of perceived land rights and investments (Section 2.1), the relationship between time preference and investments, and how this relationship is altered by perceived tenure security conditions (Section 2.2), and the temporal dynamics of perceptions of protection rights and land expropriation risk (Section 2.3).

2.1 Land tenure constraints and investment incentives

In this section, I first outline briefly farmers' investment decision from an economic perspective, assuming there is no land tenure issue, I give overview of classic investment models that viewed investment decisions purely from economic perspective. I then draw on theoretical literature to explain step by step how various constraints in land tenure can affect investment incentives (Subsections 2.1.1 and 2.1.2), followed by a review of relevant empirical evidence (Subsection 2.1.3).

Viewing farmers investment decisions from economic perspective means that farmers' investment motivation is driven by purely material rewards such as increasing profits, or reducing costs. Such a narrow perspective suggests that investment is only justified if it generates a return, implying the relevance of economic factors (Brase and LaDue, 1989). The basic logic is that farmers aim to maximize their profits over time, considering both the immediate costs and the future income generated by the investment. In neoclassical economics, the Net Present Value (NPV) is a key criterion for investment decisions. It represents the difference between the present value of expected future returns from an investment and the initial cost of the investment. Farmers and investors in general should invest when the NPV is positive, meaning the discounted future benefits exceed the costs. So, acquiring a particular machinery with positive NPV means over time a farmer gains net benefit from investment, so such investment is economically rational.

The rational economic man is further characterized by possessing (1) clear and sufficiently rich information and knowledge about different aspects of the environment, (2) well-organized and stable preferences, and (3) computational skill, all of which help farmer attain the highest level of utility—whether in the form of profit, consumption, or satisfaction (Savage, 1954; Simon, 1955).

Building on these assumptions, Brase and LaDue (1989) summarized four investment models that empirical studies frequently use to analyze micro-level investment behavior. These models provide several key predictions about investment behavior. Specifically, according to these

models, investment decisions are driven by several key economic factors, including the existing level of capital stock, output prices, the target output level, the quantity of other inputs in production, the cost of capital, tax rates, expected profit, and the availability of funds, among them. It is important to note that this dissertation does not focus on specific investment models or examine investment decision criteria (e.g., Net Present Value, Options Method). For a comprehensive review of early investment models, see Brase and LaDue (1989) and Kataria et al. (2012).

2.1.1 Theory: foundations and predictions

In the following section, I review the literature on how farmers also consider various land tenure constraints when making investment decisions, as these institutional factors can shape incentives beyond purely economic considerations. I start first defining what property right and land tenure are. Property rights are defined as streams of benefits (e.g., Bromley, 1991), and more specifically, they refer to the authority to undertake specific activities related to a resource (Schlager and Ostrom, 1992). Property rights shape how individuals or groups can use and manage resources. Typically land users' property rights are elaborated in land tenure systems, or land contracts. According to the Food and Agriculture Organization (FAO, 2002), "Land tenure is an institution, i.e., rules invented by societies to regulate behavior. Rules of tenure define how property rights to land are to be allocated within societies. In simple terms, land tenure systems determine who can use what resources for how long, and under what conditions." Conditions refer to various obligations and duties, such as making payments for land ownership or use, maintaining soil health, and using the land for designated purposes, such as specific farming activities defined by specialization.

There are different land tenure systems or arrangements. Generally, in many developing countries, three main land tenure systems or forms include statutory (land rights assigned or given by formal bodies, such as government), customary (land rights are assigned by community members or leaders), and informal (land rights or claims of owners formally not recognized) (Payne, 2004). While this broad classification is useful, land tenure arrangements exist along a continuum from formal to informal, as noted by Payne and Durand-Lasserve (2012). For example, land users may have overlapping land tenure due to conflicting interventions in land rights systems by outsiders or may have limited land rights as a result of extensive regulations limiting what farmers can do with their land (Deininger, 2003). Also, various land contracts exist that govern land use relationships between landowners and those who work the land (Otsuka et al., 1992; Lueth, 2019). Reviewing literature on land contracts is beyond the scope of this dissertation.

Early economic theories often related higher investment incentives to private ownership of property, highlighting how constraints typically common in other tenure arrangements (e.g., customary ownership) like ambiguities in property rights, create barriers to investment by increasing transaction costs and limiting the ability to capture returns. Johnson (1972) outlined three criteria for assessing the economic efficiency of land tenure systems (communal, tenant/lease, and private ownership) in facilitating wealth generation, with direct implications for investment incentives. These criteria include clear definition of land rights, costs and rewards internalized and freedom to contract. When property rights are ambiguous, ownership becomes harder to verify, contracts are more difficult to enforce, and legitimate claims to investment returns are less secure—raising transaction costs and discouraging exchange. According to Johnson, this has two implications for investments. First, unclear property rights reduce the value of investments attached to land, which in turn leads to decreased investments. Second, the duration of these investments will be shorter the less certain land rights are.

Furthermore, Johnson (1972) defines the internalization of costs and rewards as "… a cost-reward structure in which the values created by any particular activity are made to accrue to those who bore the cost of undertaking the activity will be defined as a system in which costs and benefits are "internalized." All the costs and benefits from economic activities including investments should accrue to decision maker alone (Barrows and Roth, 1990). The internalization of costs and rewards is a key argument in favor of private property rights, as it allows owners to appropriate the full returns from their labor and financial investments. On contrary, under communal tenure, internalization is low because each user is incentivized to maximize resource use while avoiding contributions to resource management.

Finally, freedom to contract refers to the ability of landowners to fully exercise their property rights without external restrictions. When farmers face constraints, such as limitations on transfer rights, their freedom to contract is curtailed. These restrictions suppress investment incentives by reducing market activity, both on the demand and supply sides, further deterring efficient land use and development. Furthermore, the freedom to contract and negotiate enables landowners to reduce transaction costs and better manage the risks associated with production and investment (Cheung, 1969). This occurs by allowing them to tailor agreements to specific needs, clearly define rights and obligations, and minimize potential disputes over for example long-term investments made in land and assets.

Property rights were often understood as ownership granting exclusive decision-making power over a resource focusing on the assignment of exclusive authority (Alchian, 1965; Alchian and Demsetz, 1973; Johnson, 1972; Merrill, 1998). Exclusivity of use rights is a fundamental feature

of private property rights. Johnson (1972) described private property as the assignment of exclusive authority to an individual to determine the use of goods considered their private property. According to Alchian (2002) private property rights grant individuals the exclusive authority to choose how to utilize their resources, and he described three attributes: (1) exclusivity of rights to the choice of use of a resource, (2) exclusivity of rights to the services of a resource, and (3) rights to exchange the resource at mutually agreeable terms. Exclusive rights to the choice of use of a resource means owner controls how property is used. Exclusive rights to the services of a resource means owner gets to keep the benefits or income property generates. Rights to exchange the resource at mutually agreeable terms means owner has the freedom to transfer property to others. Merrill (1998) argues that property is essentially the authority to exclude others from valuable resources, and that this exclusion right is both necessary and sufficient to establish property. The absence of exclusion rights and the inability to trade at prevailing prices lead to inefficient resource allocation by increasing transaction costs (Alchian and Demsetz, 1973), therefore making investments in property/land unattractive.

Subsequent theoretical developments (by Besley, 1995; Deininger and Jin, 2006; Feder and Onchan, 1999; Place et al., 1994) have focused on refining the mechanisms through which land property rights shape investment incentives, clarifying the channels through which specific land tenure rights, or their absence, affects investment behavior. Besley (1995) developed three arguments to explain the relationship between property rights and investment incentives. 'The Security Argument' states that freedom from land expropriation motivates farmers to invest because they can capture the full benefits of their investments. Land expropriation risk acts as a tax on investment (Besley and Ghatak, 2010), reducing expected returns from investments and forcing farmers to divert their resources elsewhere. For example, such insecurity compels farmers to allocate resources to unproductive defensive measures, such as building fences, hiring guards, or making extralegal payments, further discouraging investment and leaving fewer resources (Besley and Ghatak, 2010). Second, 'The Collateral-Based View' posits that clear property rights, such as defined ownership (there is clear owner and owner can be found easily), well-established farmland boundaries, and improved transferability—enhance the collateralizability of land. Secure and transferable land rights reduce also insecurity of credit lenders stemming from reduced risks of future land disputes and foreclosure issues because of clear ownership, enabling availability of affordable credit to finance investments (Feder et al., 1988). Third, 'A Gains-from-Trade Perspective' states that improved transfer rights (especially the rights to sell and rent out) increase investment incentives because better transfer rights reduce the transaction costs of trading and benefit from this exchange. Better transferable rights ensure that a farmer can realize

the full value of farm investments, either by continuing to use the land productively or by transferring it through sale or rental at a higher price.

It is important to note that tenure security and gains-from-trade arguments primarily address farmers' increased willingness to invest by reducing uncertainty and creating market opportunities whereas the collateral argument addresses farmers' increased ability to invest by enabling access to institutional credit (Brasselle et al., 2002). Differentiating between willingness and ability is crucial because land rights are intended as incentives to motivate farmers to exert labor and financial investments. The implication is that if access to credit incentivizes farmers to invest (as suggested by the collateral-based view), then policies that prioritize lifting financial constraints become essential.

Place et al. (1994) distinguished three dimensions of land tenure security, or what could independently influence farmers' investment behavior. These dimensions include breadths of rights, duration of rights and assurance of rights. Breadth refers to legal quantity of rights (for example, the rights to cultivate any crops, to leave land fallow or uncultivated, to sell) owner holds. Duration refers to length of time during which a given right is legally valid. Assurance implies these rights (breadth and duration) are held with certainty. In other words, assurance means farmers are given guarantees that breadth and duration rights allocated will be enforced and protected by government or formal authorized bodies. When land tenure is short, farmers are unlikely to make investments that extend beyond the duration of their tenure. However, Cheung (1969) argue that land rights with short duration do not necessarily reduce farmers' investment incentives but instead create different incentives, such as encouraging short-lived investments (for example, adopting fertilizers, new seed varieties) that serve short-term productivity gains.

2.1.2 Bundles of land rights

As stated by Alchian and Demsetz (1973), "More than one party can claim some ownership interest in the same resource. It is not the resource itself which is owned; it is a bundle, or a portion, of rights to use a resource that is owned." A bundle of property rights refers to the collection of (conceptually) distinct bundles of rights, such as the rights to use, control, transfer, and exclude, that can be held, divided, or shared among different individuals or groups over a piece of property (FAO, 2002; Meinzen-Dick, 2014; Schlager and Ostrom 1992). It is a useful conceptual tool for distinguishing among various resource users (Schlager and Ostrom, 1992). Viewing land ownership through the framework of bundled land rights is especially relevant in developing countries, as farmers may have legal ownership but often lack a complete set of rights, with some being missing, restricted, or unclear. Since my dissertation adopts the bundles

of land rights approach, following previous theoretical studies, I will now discuss this framework in more detail and explain how limitations in bundles of land rights may influence investment incentives.

Schlager and Ostrom (1992) identified five bundles of property rights that shape users' incentives to invest in and manage resources effectively. Access rights determine who is allowed to enter a defined area. Withdrawal rights define who may extract the "products" of the resource (e.g., crops, timber, water). Together they constitute (basic) operational rights. Management rights specify how, when, and where the resource may be used or modified. It defines broadly what management decisions are authorized. Exclusion rights specify who else may be excluded from using the resource and under what conditions; and finally transfer rights specify authority to sell, lease, or transfer any of the other rights to others; latter three bundles are named collective-level rights. Schlager and Ostrom (1992) adds that incentives to invest in the resource is highest for users with collective-level rights, especially the rights to transfer and management.

Building on the bundles of property rights framework, Klümper et al. (2018) extended its application to land resources in Tajikistan, Central Asia where formal land rights were not well-defined, by classifying various land rights into three bundles: Use rights, Control and decision-making rights, and Transfer rights. While these bundles encompassed most of the rights from the original framework by Schlager and Ostrom (1992), they also incorporated additional rights. For instance, within the Use rights bundle, they included the right to land-use change, which determines whether a farmer can claim or exercise the right to alter the land's purpose for other uses or economic activities. The Control and decision-making rights bundle was expanded to include rights related to income generation and negotiation. Finally, the Transfer bundle was extended to include the right to bequeath land. Klümper et al. (2018) stressed that having these bundles of land rights gives farmers power and authority to make changes in land, and production and incentivize to invest.

Further, these bundles of land rights were expanded by Akhmadiyeva and Herzfeld (2021), whose framework I applied in this dissertation. Specifically, they introduced an additional bundle consisting of protection rights, which encompasses the protection of tenure rights by courts against various actors, including other farmers, foreign investors, and local authorities, as well as the legal validity of land certificates. The sub-rights included in protection bundle were based on theoretical and empirical literature.

Somewhat not fully recognized in the existing literature, I argue that operational rights such use and management bundles can give farmers strong investment incentives especially in acquiring

own farm technologies. Use and management rights allow farmers to capitalize on new economic opportunities in both input and output markets. Farmers with well-defined, more complete use and management rights can adjust their land use activities in accordance with market and environmental conditions and opportunities. For example, when new yield-enhancing fertilizers become available in the market, a farmer can adopt the new technology given no constraints on technology choice. As Johnson (1972) noted, efficient land tenure allows farmers to internalize costs and benefits of various opportunities, so holding these rights enables farmers to better internalize technological, institutional, and policy innovations, increasing their ability to respond to incentives and make investments, increasing farm productivity and income. In contrast, land tenure security serves to secure the economic and non-economic benefits derived from land. However, it is important to note that the protection bundle, as defined by Akhmadiyeva and Herzfeld (2021), does not include land expropriation risk, which is commonly used as a more direct measure of land tenure security.

2.1.3 From theoretical to empirical evidence

As the following empirical literature will demonstrate, theoretical discussions have largely overlooked the differentiation of agricultural investments based on key characteristics such as payback period (short-, medium-, and long-term investments), the size of upfront and operating costs, and whether the investment is land-based or non-land-based. In this direction, subsequent studies, such as Deininger and Jin (2006), elaborate three channels with a specific focus on land-related long-term investments. Farmers tend to make investments in land, for example applying manure to soil, that align with the duration of their land tenure. Therefore, under land tenure with sufficient long duration, and reduced risks of land expropriation, farmers are more willing to make long-term investments because they are sure to capture the returns on their investment. Moreover, improved transferability of land rights further incentivizes land-related investments. Investments that enhance soil fertility, for example, increase the productive value of farmland, thereby raising its rental and sale price (Feder and Nishio, 1998). So, farmers will confidently make land-improving investments knowing that they can capitalize these investments upon transfer of land.

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. When transaction cost from adjusting capital stock is low,

farmers' may be less concerned about future risks of land (Feder et al., 1992). Second, partly related to previous point, 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 strongly 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). Therefore, improving land tenure security and transfer rights may not give farmers strong investment incentives for the case of farm machinery and equipment.

Indeed, the views on the relationship between land tenure security and investments in movable farm assets vary significantly. Some argue that tenure or ownership security is not strong incentive for mobile investments such as farm equipment (Bandiera, 2007; Place et al., 1994), while others emphasize the role of access to finance as a more crucial determinant (Deininger and Feder, 2001). This divergence in opinions highlights the absence of a clear, unified understanding of how land tenure rights, especially four bundles of land rights, and land expropriation influences non-land investments such as acquiring farm machinery and equipment.

At this point, before reviewing the empirical literature on the role of land rights in investment incentives for movable farm assets, it is important to briefly provide an overview of how land rights are measured. Several definitions and measurements of land rights can be found in the literature (Arnot et al., 2011; Fenske, 2011). Since I have already clarified the bundles of land rights and land expropriation risk examined in this dissertation, as well as their theoretical relevance for investment incentives, I will not review debates on the definition of land tenure security. For such review please see Arnot (2011) and Sjaastad and Bromley (2000). Instead, I will focus on reviewing its measurement approaches. The most common measures of land rights are based on tenure form or ownership status, and perceived or objective expectations regarding the risk of land expropriation, or eviction against farmers will (Huntington and Stevens, 2023; Nizalov et al., 2022). Measures based on tenure form typically involve directly asking farmers whether they own, lease, or rent land. Some studies also collect information on the proportion of land under a particular tenure type or about the period of land reforms under investigation. However, such aggregate measures do not specify which individual land rights a farmer actually possesses. Farmer may have private owned land but may also face several restrictions in transfer rights, for instance. Beyond tenure form and expropriation risk, other measurement approaches include quantity of land rights like transfer rights.

Growing empirical evidence suggests that the strength and direction of the relationship between land rights and investment are highly context-dependent (Brasselle et al., 2002; Fenske, 2011; Lawry et al., 2017). This variability is shaped by a range of factors, from the specific land tenure conditions under which economic decisions are made to the broader institutional environment. A substantial body of evidence from the African context, where customary tenure arrangements have long been in place, highlights the ambiguous relationship between land rights and investment, including instances of a reverse relationship (Bambio and Agha, 2018; Deininger and Jin, 2006; Fenske, 2011; Sjaastad and Bromley, 1997). Sjaastad and Bromley (1997) argue that among African farmers, there are two motives from investments—productivity and rights appropriation. For example, by planting trees, and land clearing farmers demarcate own land plots and signal their claims over land. Although the reverse relationship between land rights and investment tends to be more prevalent in informal, customary tenure settings, evidence suggests that it may also exist in formal tenure settings (Ma et al., 2013). Next, the strength of relationship between land rights and investments also depends on general institutional environment such as access to factor and output market and quality of social, legal settings. For example, credit and land sales markets are essential for unlocking the benefits of individualized land rights (Brasselle et al., 2002). Input constraints can diminish farmers' demand for investment credit, thereby decreasing the likelihood of investments taking place (Feder et al., 1992).

Fenske (2011) sought to understand why the relationship between property rights and investment in Africa appeared confusing and ambiguous. To address this, he conducted a meta-analysis of 54 studies that used regression analysis to test the link between land rights and various forms of investment, including fallowing, land improvements, and tree planting. Additionally, using African data, he re-analysed nine datasets from the same context, examining different investment categories and decisions such as fertilizer and seed use, fallowing, land improvements, drainage investments, manuring, excavation, tree planting, and equipment purchases. The meta-analysis revealed that the evidence on the impact of land rights on investment incentives is ambiguous when sample sizes are small, when land tenure is measured using binary indicators, and when results are highly context-dependent. From his re-analysis of nine datasets, Fenske (2011) found strong evidence supporting the role of land rights in investment decisions such as fallowing and tree planting, but weaker evidence for investments in labor use, manure application, chemical fertilizers, and farm equipment. One key conclusion of the study is that, in the African context, land tenure does not generally affect short-lived investments and inputs such as fertilizer, manure, or insecticides. Another important finding is that the evidence on land rights and investment depends significantly on the methodological approach and local context, emphasizing the role of measurement choices, tenure arrangements,

and the quality of credit markets in shaping investment behavior. Leicht (2016) examines the role of land reallocation risks on various outcomes and decisions including investments in farm structure, fertilizers and in other nonland farm assets that included tools and animals owned by farmers. The study finds that land reallocation risk was strong barrier for investments in farm structure, moderate barrier for fertilizer use but land reallocations risks were not related to investments in tools and animals.

So far it becomes obvious that constraints in land tenure security, transfer rights are less barrier for investments that are short-lived and nonland investments such as farm equipment. Next, I examine in detailed existing body of empirical literature that specifically examined the relationship between land rights and investment in movable farm assets.

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 by Zhou et al. (2022) using panel data found farmers whose tenure security improved as a result of obtaining land titles, did not make investments in movable farm assets as measured by the quantity and value of purchased agricultural machinery such as small tractors and cultivators. 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. But, 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 constraints on bundles of land rights are related to decisions to make investments in movable farm assets.

2.2 Time preference and investment behavior

This section is structured into four subsections. Subsection 2.2.1 outlines the conceptual foundations of time preference and its relevance to investment behavior. Subsection 2.2.2 reviews the main approaches to measuring time preference, focusing on elicited and stated methods. Subsection 2.2.3 examines empirical evidence on how time preference influences agricultural investments and how tenure security conditions may alter this relationship is elaborated in Subsection 2.2.4.

2.2.1 Conceptual foundations: time preference and investment behavior

Many decisions in agriculture involve inter-temporal decision-making, where farmers face immediate costs with benefits that materialize over time (Wuepper et al., 2023). Farm machinery and equipment investments, such as acquiring new assets, replacing old ones, or making repairs, represent inter-temporal decisions, as farmers must bear the costs of investment in the present while the benefits accrue in the future in the form of reduced labor costs and increased yields over time. Additionally, beyond the initial investment, machinery and equipment require ongoing operational and maintenance costs, further extending some costs into the future. Critically, farmers must weigh these present sacrifices (investment costs) against future gains (enhanced productivity and returns). In theory, patient farmers should accumulate more farm assets over time, as their willingness to forgo immediate consumption in favor of future benefits leads to higher past investments. In contrast, impatient farmers, who prioritize short-term gains, tend to undervalue decisions with long-term payoffs. As a result, they are likely to make fewer long-term investments, including in farm assets that contribute to sustained productivity. Moreover, impatient people/farmers are more inclined to sell off productive assets when faced with financial constraints, or save less (Choi and Han, 2018; Epper et al., 2020). Assuming that farm

machinery and equipment can be liquidated relatively quickly, impatient farmers may be more tempted to sell them when cash is needed. Consequently, over time, impatient farmers are likely to possess fewer farm assets than their more patient counterparts.

The standard discounted utility model as the formal framework can capture such inter-temporal decision. Following the formulation of the discounted utility model presented by Frederick et al. (2002), which builds on Samuelson's (1937) framework, the model can be formally expressed as follows (Equation 1):

$$U^T(c_t, \dots, c_T) = \sum_{k=0}^{T-t} D(k)u(c_{t+k}) \qquad \text{(Eq 1)}$$

$$\text{where D(k)} = (\frac{1}{1+p})^k.$$

In this formulation, $U^T(\cdot)$ is total utility assessed at time *T*, and c_t and c_T are consumption at time *t* and some future time *T*, respectively. $u(c_{t+k})$ represents farmer's utility in period *t* + *k*, and D_k is the discount function, indicating the relative weight farmer places at time *t*, on their utility at time *t* + *k*. The parameter *p* denotes farmer's pure rate of time preference (or discount rate). As *p* increases, and time horizon *k* becomes more distant, D_k becomes smaller, thereby reducing the weight assigned to future utility $u(c_{t+k})$ in overall utility evaluations. Thus, farmers with higher time preference assign lower value to future utility, whether in the form of future consumption or future returns from investment, leading to an undervaluation of future gains. Translating this framework into investment behavior, farmers with higher time preference assign a lower present value to the future consumption made possible by today's investments and therefore perceive the returns to capital investments as less attractive. As a result, they invest less over time, which ultimately leads to lower accumulated stocks of farm machinery and equipment.

This formulation refers to exponential discounting, where the farmer discounts future utility (or returns) at a constant rate, leading to a stable time preference over time. However, growing experimental evidence using alternative models suggests that, in addition to exponential discounting, individuals may have hyperbolic discounting, which account for present bias and time-inconsistent preferences (Laibson, 1997; O'Donoghue and Rabin, 1999). Discussions of these alternative discounting models are beyond the scope of this literature review.

2.2.2 Overview of time preference elicitation: Revealed and stated approaches

The approaches to measuring time preference can be broadly categorized into experiment-based revealed elicitation methods and survey-based self-assessments or psychometric scales (De

Marchi et al., 2016). Among economists, one of the most commonly used revealed elicitation methods is the Multiple Price Lists (MPLs) approach (Coller and Williams, 1999). MPLs involve a series of multiple-choice tasks where individuals select between smaller monetary amounts available in the near term or larger amounts available at a later date. Various variants of MPLs have been developed and applied in different contexts (Andersen et al., 2006; Harrison et al., 2002; Liebenehm and Waibel, 2014). An additional experimental method increasingly used to elicit time preferences is the Convex Time Budgets task, developed by Andreoni and Sprenger (2012a). Other experimental tasks include allocation games, where participants allocate funds between present and future use (Angerer et al., 2015; Fischer and Wollni, 2018), and contextualized present and future choice where the wording of choices reflected participants' daily decision-making environments (Pender and Walker, 1990). Economists generally prefer incentivized experiments, as they are believed to better reflect true preferences—participants make decisions with real financial consequences, similar to real-life scenarios.

However, the limitations of such methods are noteworthy. While Andersen et al. (2006) suggest that time preference elicitation is not highly sensitive to experimental design, other studies highlight that factors such as incentivization, stake size, and the order of binary choices can influence results (Meissner et al., 2023). Frederick et al. (2002) expresses concern that there has been much variation in the estimates of time discounting which is partly driven by differences in experiments. Additional complexities arise with domain specificity, as individual discount rates can vary across different types of goods and monetary values (Ubfal, 2016; Wölbert and Riedl, 2013). Moreover, incentivized experiments can be costly and pose challenges in ensuring trust in future payouts, particularly in low-income settings. In such contexts, participants might doubt whether they will receive promised future rewards (Brañas-Garza et al., 2023). Additionally, liquidity constraints can distort results. For instance, participants facing immediate financial needs may prioritize short-term options, thus not accurately reflecting their underlying time preferences (Frederick et al., 2002). Similarly, inflation expectations can influence choices in the experiment (Frederick et al., 2002; Krupka and Stephens, 2013), which tend to be much higher in developing countries.

Within survey-based stated preference approaches, self-assessments and psychometric tests are commonly used methods for measuring time preferences. These assessments typically ask respondents to report their attitudes towards delayed gratification or their general tendencies to prioritize immediate needs over future benefits. A common self-assessment task involves questions about willingness to wait. For example, as reported in Vischer et al. (2013) time preference was elicited using the following question: "Are you generally an impatient person, or

someone who always shows great patience?" Responses were recorded on an 11-point scale, with "0" referring to "very impatient" and "10" to "very patient." Falk et al. (2023) used a similar approach with the following question: "In comparison to others, are you generally willing to give up something today in order to benefit from it in the future, or are you not willing to do so? Please use a scale from 0 to 10, where 0 means 'completely unwilling to give up something today' and 10 means 'very willing to give up something today.'" Such self-assessed measures have been widely adopted in large-scale surveys, including the German Socio-Economic Panel and the Global Preference Survey. Other studies using these measures include Friehe and Pannenberg (2020) and Wang et al. (2023). Self-reported measures have distinct advantages, particularly their simplicity and intuitive nature.

While studies have validated self-assessed time preference measures (Breuer et al., 2022; Falk et al., 2023; Vischer et al., 2013), others have questioned their reliability compared to experimental measures (Bauer et al., 2020). One criticism is that self-reported preferences can be influenced by "cheap talk". These include biases such as social desirability or hypothetical bias, where respondents may provide idealized answers rather than reflecting actual decision-making patterns. However, some research disputes this claim. For instance, Arslan et al. (2020) found that stated risk preferences were more valid than revealed preferences elicited through experiments. They argued that individuals base their self-assessments on lived experiences and memories, which were also affirmed by independent, anonymous evaluations.

By and large, both approaches to measuring time preference have limitations. Studies suggest that in low-income, less educated settings, simpler experiments combined with survey-based self-assessments can offer a more reliable measures of time preferences (Chuang and Schechter, 2015).

2.2.3 Empirical evidence: the role of time preference on agricultural investments

To establish more structured review of the empirical literature, first I examine the role of time preferences on the adoption of agricultural inputs and practices such as fertilizers, seeds, and various land management techniques that primarily enhance short-term productivity. Then, I review literature related to productive assets, including land improvements, acquiring farm machinery, and equipment, which enhance long-term productivity.

Several studies have examined time preference and the use of short-term agricultural inputs such as chemical fertilizers, seeds, and pesticides. Le Cotty et al. (2018) found that an increase in the discount rate (as measured through hypothetical MPL) was associated with a decrease in the total amount of fertilizer purchased. Mostafavi-Dehzooei and Heshmatpour (2024) reported that

patience, measured through hypothetical MPL, was positively associated with the use of pesticides but not with the use of seeds and chemical fertilizers, which were already at high levels of use among the sampled farmers. Similarly, Qian (2021) did not find a strong evidence of relationship between patience (measured as a combination of hypothetical choice MPL and self-assessed willingness to delay) and the use of synthetic fertilizers. Duflo et al. (2011) highlighted the role of present bias in fertilizer investment decisions, showing that farmers who were offered time-limited discounts at harvest and delivery to their homes were more likely to invest in fertilizers. These conditions helped farmers overcome procrastination, promoting timely investment. Overall, evidence on the relationship between time preference and the use of one-year inputs such as chemical fertilizers presents mixed findings. Qian (2021) added that only 8% of the sampled farmers in China used organic manure, compared to around 30% who used synthetic fertilizers.

Other studies have examined the relationship between time preference and the adoption of agricultural inputs and technologies, such as organic fertilizers and soil-enhancing techniques that increase long-term productivity. Qian (2021) found a positive relationship between patience (measured as a combination of hypothetical choice MPL and self-assessed willingness to delay) and the likelihood of using organic fertilizers. Similarly, Mao et al. (2021) observed that time discounting (measured through incentivized choice experiments using MPLs) was negatively associated with the adoption of green agricultural technology, specifically the soil-enhancing straw incorporation technique, among farmers in China. Simutowe et al. (2024) investigated impatience, measured through self-reported willingness to wait, and its association with the extent and intensity of adopting several conservation agricultural practices in Zambia. The study found that higher impatience was associated with a lower likelihood of adopting three out of five conservation practices, suggesting that time preferences significantly influence long-term agricultural investment decisions. However, contrasting findings were reported by Hasibuan et al. (2021), who examined time preference (measured as combinations of incentivized MPLs and self-assessed willingness to give up something today) and the adoption of certified climate-resilient crop seedling varieties among Indonesian tree farmers, finding no significant association. Ding et al. (2021) explored time discounting and the adoption intention of rain covers, measured by willingness to pay, and found no evidence that impatience was associated with a lower willingness to pay for the technology. Oluma et al. (2024) investigated the association between farmers' time preferences—measured through an experiment using hypothetical payoffs—and their decisions to adopt agroforestry, terracing, and land fallowing. The study found that higher time discounting was negatively associated with the adoption of agroforestry and land fallowing practices but not with terracing. While no explicit explanation was provided for this exception,

the authors noted that, unlike agroforestry and land fallowing, terracing involves substantial ongoing maintenance costs in addition to its large upfront cost. Di Falco (2019) examined the relationship between time discounting and investments in livestock and soil conservation structures. Using hypothetical payment options with immediate and future payoffs to elicit discount rates, the study found a negative correlation between time discounting and agricultural investments. However, this relationship was notably stronger for investments in soil conservation structures compared to livestock ownership.

As highlighted by this brief review of empirical literature, existing studies have primarily examined the role of time preference in relation to investments and agricultural inputs and technologies applied to or integrated into land. However, to the best of my knowledge, there is a gap regarding the extent to which time preference may act as a barrier to investments in farm machinery and equipment—a gap that this study seeks to address.

2.2.4 How tenure insecurity conditions alter the relationship between time preference and investment

Many researchers believe that behavioral factors like risk and time preferences systematically influence individual choices and shape various socio-economic outcomes. However, this perspective implicitly overlooks the possibility that the relevance of behavioral factors in economic decisions, such as investments, may depend on the institutional conditions within which individuals live and make decisions. If this is the case, addressing institutional constraints should take precedence over targeting behavioral factors. Accordingly, I examine the existing literature to assess whether tenure insecurity may alter the relationship between high time preference (impatience) and lower investment levels.

Government-led expropriation risks are often considered beyond farmers' control (Acemoglu and Robinson, 2005). Such land tenure risks function like a “random tax”, diminishing the expected returns from investments (Besley and Ghatak, 2010). When farmers perceive a risk of losing land or their investments, they are less likely to risk their resources, resulting in reduced investment activity (Besley, 1995; Feder and Nishio, 1998). Instead, they may divert resources towards protective measures, such as building fences, establishing political connections (Besley and Ghatak, 2010; Markussen and Tarp, 2014), or engaging in safer agricultural activities like cultivating annual crops that yield faster returns, rather than making long-term investments such as planting trees (Orellano et al., 2015). Contrary, under secure tenure conditions it feasible to commit resources to projects with longer payback periods, such as land improvements (Deininger and Jin, 2006), or investments in farm machinery and equipment. Therefore, it is possible that even patient farmers, who are generally more willing to delay immediate utility, under the

conditions of risks of losing investments, may reduce long-term investments, such as acquiring costly farm machinery.

Further, under high land expropriation risks, adopting shorter time horizon for production and investments is rational which may reduce appetite to pursue long-term investment activities in favor of short-term activities. The expectation of land loss shortens the planning horizon, influencing whether long-term investments are deemed desirable at all (Hagos and Holden, 2006). The lack of long-term rights, e.g., bequeath and sale, further limits farmers' ability to make long-term production and investment plans (Deininger et al., 2021). It is crucial to note that under the conditions of high land expropriation risks lower expected returns and shorter time horizon for production and investments are conceptually different and expected to influence farmers' production and investment choices differently. A good analogy to understand these two separate factors is a farmer with shortened personal time horizon, e.g. due to age or health concerns, anticipating at the same time land reallocation risks. Under such scenario, both shorter time horizon and possibility to lose investments to land reallocation tend to dampen incentives to make long-term investments.

Consequently, even patient farmers, who typically value long-term investments, under the risks of land expropriation may avoid making long-term investments in fear of losing these investments and in light of shorter production, investment horizon. Therefore, empirically speaking, when land tenure risks are low, variation in time preference may be systematically related to differences in investment behavior. This would confirm my hypothesis that institutional constraints may precede behavioral constraints in promoting long-term investments.

Unlike land expropriation risks, government intervention may influence the relationship between time preference and investments in a slightly different way. I begin by reviewing various forms of government intervention, primarily focusing on farmer communities, and then draw on the literature to discuss the implications of these interventions for farm productivity, including farmers' long-term investments. At the farm level, government interventions can take multiple forms. These include excessive administrative processes, frequent monitoring, and audits such as on-farm inspections related to land preparation, the purposeful use of land and credits, occupational safety, environmental safety, and more. Frequent and random inspections, requests for reports, and mandatory participation in meetings can create additional burdens for farmers—a phenomenon often referred to in the literature as regulatory or administrative burden (Baekgaard and Tankink, 2022). Since administrative burden is a relatively new area of research (Baekgaard and Tankink, 2022), I draw on empirical examples from developed countries. Several farm surveys conducted in European contexts suggest that farmers' experiences of

administrative burden have increased significantly. For instance, using a farm survey in the German- and French-speaking regions of Switzerland, El Benni et al. (2022) assessed perceptions of workload and the perceived burden from farm work, administrative tasks, and office work. The study found that, on average, farmers reported a higher perceived burden from administrative and office work compared to farm work. Moreover, perceived administrative burden varies among farmers depending on farm type (El Benni et al., 2022), indicating that the level of government oversight and inspections tends to differ based on policies, farm size, and specialization.

For farm businesses, administrative burdens arising from increased government intervention can reduce the time available for productivity-enhancing farm activities. As a result, official inspections are often perceived negatively by farmers (Veissier et al., 2021). Administrative burdens from government interventions impose not only monetary costs (El Benni et al., 2022) but also psychological costs on farmers (Ritzel et al., 2020). Increased administrative burdens have been associated with farmers expressing dissatisfaction with policies (Mack et al., 2021), which can influence the success and adoption of new policies and technologies. For example, Reissig et al. (2022) found that the adoption of e-government services among farmers was low because such services were perceived as either reducing or increasing their administrative burden. Similarly, when applications for obtaining credits or participating in farm support programs for investments (such as co-financing for land improvements or machinery acquisitions) involve complex bureaucratic processes, like lengthy applications or frequent inspections regarding the purposeful use of credits, farmers may find these programs less appealing. This can lead to lower participation, adoption, or investment activity. Increased government intervention can thus reduce the time farmers have for on-farm work and create a sense of urgency to focus on immediate problems, rather than engaging in long-term planning, including investment strategies. One empirical study from a non-agricultural context provides further insight. Using firm-level panel data from Moldova, another transition economy in Eastern Europe, Tan (2023) examined the impact of inspections—measured by the average number of firm inspections by all agencies—on firm productivity, including investments in intangible assets (such as licenses, certificates, and software) and tangible assets (such as infrastructure, equipment, and machinery). The study found that total inspections were negatively associated with investments in tangible assets, although the statistical evidence was weak. This relationship held across different sectors, firm sizes, and ownership forms. In contrast, inspections were positively associated with investments in intangible assets. The study concludes that, in the Moldovan context, firms appeared more concerned with ensuring compliance and facilitating inspection processes, which led them to prioritize investments in intangible assets.

I expect that among farmers with higher perceived government intervention, the relationship between time preference and investments may reduce or disappear because patient farmers, who would otherwise be more willing to invest, will need to focus on short-term concerns made salient by government inspections and forgo investment opportunities involving administrative costs (e.g., especially, government-provided investment programs). Contrary, among farmers with low perceived government intervention, the association between time preference and investments is expected to remain because they can make long-term investment decisions.

Few studies in the farming context have examined the relationship between land tenure insecurity, time preference, and production or investment decisions (Banerjee and Ghatak, 2004; Godoy et al., 1998; Godoy et al., 2001; Olumba et al., 2024; Vertova, 2020). Some studies have conceptually explored the relationship between property rights security and time preference (Howden and Kampe, 2016; Mulligan, 2007). Godoy et al. (1998, 2001) investigated whether higher rates of forest degradation among Bolivians were independently associated with high tenure insecurity and time preference, measured by individuals' self-assessed willingness to delay immediate rewards. However, these studies focused on identifying which factor posed a greater barrier to forestry activities, rather than exploring the interaction between the two. Banerjee and Ghatak (2004) examined how landowners could influence tenants' investment behavior through eviction threats. Their findings suggest that eviction threats could positively influence investment efforts by tenants. However, they also noted that expropriation risk could increase tenants' time preference, potentially reducing investment levels. The study by Olumba et al. (2024), which aligns closely with the focus of this dissertation, explored whether land tenure form and perceived rights moderated the relationship between time preference and investments in land improvements. The study concluded that higher perceived rights, but not legal ownership forms, reduced the negative influence of high time preference on investments. This suggests that even impatient farmers, who would typically avoid long-term investments, were more likely to invest when they felt greater perceived control over exercising multiple land rights. It should be noted that Olumba et al. (2024) only reported this moderation effect for experimentally elicited time preference rather than self-assess measure. Additionally, while evidence of a moderation effect was observed for two investment decisions—agroforestry and terracing—but not for fallowing, the overall statistical strength of this effect was moderate. So, moderation effect from self-assessed time preference remains unknown. Other conceptual studies have highlighted how time preference, as a subjective factor, can be influenced by external conditions, such as changes in property rights security (Howden and Kampe, 2016; Mulligan, 2007). Overall, this literature review highlights an empirical gap in understanding how time preference and investment

decisions, particularly in farm machinery and equipment, is associated with tenure insecurity. This dissertation seeks to address this research gap.

2.3 Temporal changes in the individual perceptions of land tenure security

This section shows the review of existing literature that has tracked temporal changes in perceived land tenure security over time (Subsection 2.3.1) and gives the overview of tenure (in)security dimensions in transition economies (Subsection 2.3.2).

2.3.1 Dynamics in land tenure security: evidence from repeated surveys and panel data

Related studies primarily use either repeated cross-sectional data or panel data to track changes in land tenure security over time. Among those relying on repeated cross-sectional data, Ali et al. (2014) examine how perceived land expropriation risk evolved over a five-year period in response to a pilot land regularization program in Rwanda. The study relies on cross-sectional data, with the treatment group consisting of households that underwent land tenure regularization, while the control group includes farmers just outside these areas. A household survey was conducted in April–May 2010, approximately 2 years after the land tenure regularization program began. Respondents were asked: "What is the likelihood that you will lose this parcel due to expropriation in the coming five years?" The study shows that among treated and control group farmers average perceptions of expropriation was quantitatively similar. The concludes the intervention weakly improved tenure security, with significant effects observed only among married female farmers. The lack of stronger effects may stem from two key factors. First, land tenure regularization did not introduce changes to expropriation policy, meaning that the risk of land loss may have remained institutionally unchanged. Second, households' knowledge of land-related legal procedures may have improved only marginally or not at all, limiting their ability to perceive the program's impact on expropriation risk.

Similarly, Goldstein et al. (2018) evaluate the impact of a land formalization program focused on land demarcation. Their findings indicate that demarcation led to an increase in perceived tenure security, with treatment farmers reporting a significant rise in the number of parcels with clearly defined borders. Like Ali et al. (2014), this study relies on cross-sectional data, comparing tenure security perceptions before and after the intervention between treatment and control groups. The overall program impact, however, masks important heterogeneity. Female-headed households were more responsive to the intervention than male-headed households, suggesting that tenure security improvements are not uniform across all farmers. The study evaluates tenure security improvements based on whether households report clear land borders and their investment behavior following demarcation. Both studies highlight that tenure interventions do

not have uniform effects across all farmers and that the impact of land regularization may depend on gender, policy changes, and farmers' awareness of land rights.

Few studies have used panel data to track changes in land tenure security among farmers (e.g., Bezu and Holden (2014), Deininger et al. (2011), and Li et al. (2022)). Bezu and Holden (2014) analyzed panel data from 2007 and 2012 to examine how households' perceptions of tenure security evolved in response to a land registration and certification program. By 2007, most households had already registered their land. The study assessed tenure security using two indicators. The first was whether households believed that first-stage land certificates protected them from encroachment by non-state actors, such as neighbors. The second indicator measured whether farmers felt secure from further state-led land redistribution. The findings suggest that first-stage land certification improved tenure security over time, reducing encroachment risks and increasing confidence in land tenure. In 2007, only 35% of respondents believed that their certificate protected them from land encroachment, but by 2012, this figure went up to 72%, indicating growing confidence in land certification. Regarding expectations of land redistribution, 35% of men and 32% of women in 2007 believed their land could still be subject to government redistribution. By 2012, these concerns had declined to 21% for men and 20% for women, suggesting a reduction in fears of state-led land reallocation. However, the study does not report how many farmers' perceptions remained unchanged or whether some felt more insecure over time. Additionally, the findings indicate differences in how security perceptions evolved across the two indicators. While a large proportion of farmers reported increased confidence in protection from encroachment, fewer farmers reported a decline in concerns over land redistribution.

Deininger et al. (2011) leveraged a four-wave panel dataset of rural Ethiopian households (1999, 2002, 2004, and 2007) to assess the impact of land certification on tenure security. The first three rounds of the panel captured the period before the land certification program, providing a baseline for comparison. The study measured land tenure security using two indicators, one of which was farmers' expectations of changes in their landholdings—either increases or decreases—due to administrative actions within the next five years. In 1999, 75-78% of respondents anticipated changes in their landholdings due to such interventions. By 2004, even before certification, this expectation declined significantly to 38% in both treatment and control villages. After certification, tenure security further improved in treatment villages, where the percentage dropped to 24%, while it deteriorated in control villages, rising to 39%. The study concludes that land certification significantly reduces tenure insecurity, but it remains a concern,

emphasizing the need for complementary policy measures to fully realize the benefits of the intervention.

An impact evaluation study by Huntington et al. (2018) tracks changes in Zambian households' tenure security, along with other key outcomes, in response to the certification of customary land rights. The study utilizes panel data collected in 2014 and 2017 to assess these changes over time. A unique feature of this research is its measurement of multiple indicators of land tenure insecurity, including perceived expropriation risk from internal actors, perceived expropriation risk from external actors, and the experience of at least one land dispute. The first two measures have two time-based variants: perceived threats within the next three years, which indicate short-term tenure security, and land expropriation risk beyond four years, which reflects long-term tenure security. The study finds that households receiving land certification perceive their fields as more secure from reallocation or unauthorized appropriation by both internal and external actors in both the short term (next three years) and the long term (beyond four years). However, the evaluation finds no evidence that the intervention affected the actual prevalence of land disputes, noting that the incidence of disputes was generally low at both baseline and follow-up. The study also identifies heterogeneous effects across subgroups. Female-headed households and elderly farmers experienced strong positive impacts, whereas youth-headed households and land-constrained farmers did not show similar improvements in tenure security perceptions. This suggests that not all participants felt more secure over time, indicating variation in how individual farmers' perceptions changed in response to the intervention. Building on this dataset, Huntington and Shenoy (2021) further analyze the impacts of tenure interventions and find that they had stronger effects on threats related to local authorities (such as chiefs and headmen) than on private threats (such as encroachment by neighbors or family members).

Li et al. (2022) use panel data from 2014 and 2019 on Chinese farmers, most of whom hold land certificates, to track changes in their perceptions of land tenure security in response to village democratization, measured through both subjective and objective indicators of village democracy. The study assesses perceived tenure security using three key measures. The first is the perception of land reallocation, which is evaluated based on farmers' expectations regarding whether their land will be reallocated within the next five years. The second measure is the perception of land certificate effectiveness, assessed through farmers' belief that land certificates effectively protect their land rights. The third indicator is the perception of land rights integrity, reflecting farmers' belief that they have full access to a "bundle of rights," including transfer, mortgage, and inheritance rights. The findings indicate that higher levels of democratization in village governance enhance farmers' perceptions of land certificate effectiveness and land rights

integrity. However, democratization did not significantly influence perceptions of land reallocation. These results suggest that while land tenure security may evolve over time among documented farmers, its different dimensions do not necessarily change in a uniform manner.

Some general conclusions emerge from these studies. While tenure security improved over time, the changes were not uniform across different dimensions of tenure security or subgroups of farmers. A key overarching theme is that most of the evidence comes from contexts where farmers experienced tenure interventions, rather than from settings where no major reforms occurred. Furthermore, only Li et al. (2022) specifically examined farmers with formal land documentation, whereas other studies included both documented and undocumented farmers. Also, most studies report average changes in tenure security, which can mask individual variations in how farmers respond to land tenure interventions. Some farmers may be more sensitive to these interventions, experiencing and reporting a greater increase in their perceived tenure security, while others may exhibit minimal or no change in their perceptions. This highlights the importance of considering heterogeneous effects rather than relying solely on aggregate trends.

2.3.2 Persistence of land tenure insecurity in transition economies

According to Svejnar (2002) no transition economy managed to create rapidly legal system and institutions that support functioning of market economy and preservation of private property. In many transition economies, land titling led to "empty institutions" rather than "credible institutions.", meaning that while formal systems were established on paper, they often had little real-world impact due to lack of societal trust, enforcement, or local adaptation (Ho and Spoor, 2006). Land rights formalization with land titles and certificates are not sufficient to give and maintain secure tenure because of the abuse by local power holders (Sikor, 2006). Courts have an important role in enhancing property rights security not only by resolving disputes between private parties but also by imposing limits on the actions of state officials (Frye, 2004). Land tenure security increases as farmers realize the existence of conflict resolution pathways (Edeh et al., 2022), which courts can provide. Ultimately, economic actors should believe that property rights are credible and unlikely to be subject to arbitrary change over time (Frye, 2004). So, the quality of courts is essential to manage land tenure insecurity dynamics.

Zhllima et al. (2010) distinguish between direct and indirect (perceived) land tenure insecurity in Albania, an Eastern European country where post-Soviet land reforms focused on redistributing land previously confiscated during Soviet collectivization. Indirect insecurity arises from low government effectiveness and weak credibility of property rights institutions, such as courts and cadasters. In contrast, direct land tenure insecurity occurs when former landowners obstruct land

sales or demand a share of the sale price from current owners. This type of insecurity imposes greater transaction costs on present landowners compared to indirect insecurity, as it arises during land use and transfer decisions. Importantly, this highlights that land tenure insecurity can be multidimensional and may evolve independently over time.

This review of the available literature highlights the need to track within-farmer variations in perceptions of tenure security over time, in addition to overall or group-level changes. Doing so provides deeper insights into tenure dynamics within a given context. In transition context, the literature suggests that certain dimensions of tenure security (e.g., court effectiveness in dispute resolution) may remain persistently low, even as economic and institutional conditions improve.

3. METHODOLOGY

To examine the empirical relationship between land rights, time preference, and farmers' investments in machinery and equipment, as well as the temporal patterns in perceived tenure security, this chapter details the data sources, operationalization of key variables, and quantitative methods applied to analyze changes in tenure security perceptions and investment behavior over time. Since the research questions are interrelated and share common data sources and key variables, this chapter first outlines the methodological aspects (Sections 3.1 and 3.2). It then presents the specific methodological approaches tailored to each research question (Section 3.4).

3.1 Data sources: farm surveys and sampling strategy

3.1.1 Farm surveys

This study utilized survey data from two waves of farm surveys conducted in 2019 and 2022 as part of the SUSADICA project. This project was designed to examine institutional changes in agriculture, with separate modules on land tenure, farm management, and technology adoption in Turkistan province (Kazakhstan) and Samarkand province (Uzbekistan). Figure 1 provides a geographical overview of the study regions, illustrating the districts surveyed in Kazakhstan and Uzbekistan. The surveys provide comprehensive data on farm characteristics, land rights, production decisions, financial access, and investment patterns, making them highly relevant to this dissertation's research objectives. Specifically, the 2019 survey wave was used to investigate how land rights and time preference relate to investment in farm machinery and equipment (Research questions 1 and 2). Meanwhile, the panel version of the dataset that combines both survey waves from 2019 and 2022 was used for the analysis of changes in farmers' perceptions of land tenure security over time (Research question 3).

The questionnaires in each survey wave consisted primarily of close-ended questions, including multiple-choice formats, Likert scales, and numerical responses to ensure consistency in responses. To accommodate different languages spoken among farmers in two countries, the questionnaire was translated into Uzbek, Kazakh, and Russian languages. Before implementation, the questionnaire underwent pretesting and piloting with a sample of farmers in the surveyed regions. This process ensured that the questions were clear, comprehensible, and relevant to the target population. Based on feedback, minor modifications were made to improve clarity and ease of response.

The first wave of the farm survey was conducted in early 2019, covering a total of 963 farmers, 503 from Turkistan province (Kazakhstan) and 460 from Samarkand province (Uzbekistan). The

second wave, conducted in 2022, aimed partly to re-survey the same farmers to construct a panel dataset for longitudinal analysis. The final 2022 sample included 950 farmers, with 500 from Turkistan and 450 from Samarkand. A significant portion of the original 2019 respondents participated in the 2022 wave, allowing for creating panel data structure. However, some farmers were lost to attrition, primarily due to farm closures, changes in land tenure especially in Uzbekistan context where some farmer managers gave up land use rights to newly established clusters. A subset of new respondents, 239 farmers from Kazakhstan and 159 farmers from Uzbekistan participating in both survey waves, was included in 2022 to maintain a consistent sample size. It should be noted that, to identify farmers who participated in both survey waves, I used date of birth, a stable identifier over time, rather than for example farm names, which can change during farm transfers. The panel dataset is used to analyze changes in tenure security perceptions over time (Research question 3), while the 2019 cross-sectional dataset is utilized for investment-related analyses (Research questions 1 and 2).

Figure 1. Map of the study areas

Source: Global Administrative Areas (2012). GADM database of Global Administrative Areas, version 2.0. [online] URL: www.gadm.org.

3.1.2 Sampling strategy

The study focuses on Turkistan province (Kazakhstan) and Samarkand province (Uzbekistan), two regions where agriculture is dominated by irrigated farming systems and shaped by distinct land tenure institutions. These regions were selected due to their comparability in agroecological

conditions and their contrasting reform paths, including institutional and land governance systems. Within each province, three districts were selected based on logistical feasibility and their alignment with the project's goals. In Turkistan, the selected districts, Maktaaral, Shardara, and Sariagash, represent diverse cropping patterns, with Maktaaral and Shardara specializing in cotton cultivation, while Sariagash focuses on vegetables, melons, and fruits. In Samarkand, the selected districts, Pastdargom, Payarik, and Jomboy, reflect similar agricultural specializations, with Pastdargom and Payarik being cotton-dominated and Jomboy concentrating on vegetable and orchard production.

In Kazakhstan a two-stage random sampling approach was applied. In the first stage, sub-districts (rayons) were selected within the three target districts. In the second stage, 50 farms per sub-district were randomly chosen from official farmer lists obtained from local government organizations. In Uzbekistan, in contrast, a direct random selection approach was applied. Farmers were randomly selected from district-level farmer lists. The sampling strategy remained consistent between survey waves to maintain comparability. New respondents were added to maintain sample size, but the panel dataset only includes farmer managers/owners who participated in both waves.

To ensure the sample aligned with the study's objectives, only farms meeting the following inclusion criteria were surveyed: 1. Legally registered and actively operating within the designated project districts; 2. Primary production must be crop-based (cotton, wheat, vegetables, or fruits); 3. At least 80% of total arable land must be irrigated; 4. The farm must have been operational in 2018 and remained active in 2019, ensuring that farms affected by the land (reform) optimization process in Uzbekistan were not included; 5. Respondents must be the primary decision-maker (owner or manager) in farm operations; 6. Respondents must be at least 22 years old.

The implications of the sampling strategy for generalizability and statistical inference must be acknowledged. First, the samples are not nationally representative. In both Kazakhstan and Uzbekistan, farms vary considerably in terms of tenure arrangements, specialization, and agroecological conditions, limiting the extent to which findings can be extrapolated to the national level. Furthermore, as is common in panel data studies, attrition was relatively high in the Uzbekistan sample. Many farms ceased operations due to land reforms and structural changes, and these farms may systematically differ from those that remained active. This could introduce attrition bias, particularly when analyzing changes in tenure security perceptions, as farmers who exited the sector might have had different tenure experiences than those who remained. Despite these limitations, random selection within villages enhances internal validity,

reducing potential selection bias within the surveyed areas. Therefore, the findings pertain mainly to the samples investigated and to some extent to farmers producing similar crops or with similar specialization.

3.2 Key variables: survey questions and measurement

3.2.1 Investment in farm machinery and equipment

Regarding investments in productive farm assets the surveys included two questions. One is about the inventory of farm assets, such as machinery and equipment owned in farms and another is about recent investments made by farmers in the last 12 months in various categories farm assets (for example, land, livestock and machinery), including their monetary values and source of financing. Farmers provided information on the types and quantities of assets they owned by responding to the following survey questions:

- "Did you own any of the following types of machinery and equipment as of the year 2018?"
- "How many units of the following types of machinery and equipment did you own as of the year 2018?"

Farmers also reported their investments in various farm asset categories over the past 12 months, including the amount invested and sources of financing, by responding to the following survey question:

- "Did your farm invest over the last 12 months, in which assets, what amount, and how did the farm finance this investment?”

Existing farm assets, including machinery, equipment, or land-attached assets (e.g., irrigation infrastructure), often reflects past investment decisions aimed at enhancing farm productivity and performance. Since these assets are typically acquired through investment, their presence and accumulation serve as a reasonable proxy for past long-term investment behavior. For the analysis, I used farm asset inventory question to construct investment measures, as it captures more comprehensive list of assets owned by farms, potentially indicating accumulated capital stock over time. In contrast, investments over the past 12 months tend to reflect recent investments rather than sustained investment patterns. An additional advantage of using asset inventory data is that farmers can more accurately recall the types and quantities of machinery they own, whereas monetary-based measures, such as market value or original purchase price, are often subject to recall bias and valuation inconsistencies. Therefore, in the main analysis, I use farm asset ownership as an indication of past long-term investment behavior.

To construct the investment variable, I applied a standard quantity-based approach, following Doss et al. (2020), counting the total number of asset units owned and the types of assets. The count of total number of assets, referred to as Total assets, captures the overall scale of past and recent investments. For example, if a farmer reported about owning two units of tractor and one unit of lorry, the total assets owned by farmers would be 3. Some farmers may diversify their agricultural production, and as a result invest in various types of equipment and machinery to support different on-farm activities (Bokusheva et al., 2007). Counting only the total units of assets owned by farmers may underestimate some investment strategies like on-farm income diversification. Therefore, I also calculated the diversity of assets. For instance, a farmer owning both a tractor and a lorry, regardless of the number of units owned, was assigned an asset diversity score of 2. This second measure of investment is referred in this study as Asset diversity. As already noted total assets and asset diversity, though may be correlated, should capture distinct investment, production strategies. Total assets reflect the scale of investment, while asset diversity indicates breadth, signaling diversification, risk management. Separating investments by intensity and diversity can lend more insights on the investment behaviors and their differential response to tenure constraints and behavioral factors such as time preference. Both total assets and asset diversity were used in Research question 1 and 2. The descriptive statistics for two investment variables along with raw investment data are presented in Section 3.3.

3.2.2 Perceived land rights bundles

The survey included several questions designed to measure a comprehensive range of land rights, using a bundles of land rights approach initially developed by Klümper et al. (2018) and later expanded by Akhmadiyeva and Herzfeld (2021). This classification captures four distinct bundles of land rights: Use rights, Management rights, Transfer rights, and Protection rights, with each bundle encompassing several specific sub-rights. We measure farmers' perceived land rights using several Likert-type items. For illustration, respondents were asked questions such as:

- "To what extent are you free in changing the purpose of land use within agriculture (e.g., changing from cropping to grazing)?"
- "How free are you in deciding where, how, whom, and for how much to sell your main harvested crops?"
- "To what extent are you free to rent out your land?"
- "How important are land registration documents for protecting land ownership and tenure rights when you need to prove them?"

These questions correspond to perceived use rights, management rights, transfer rights, and protection rights, respectively. For each question, respondents selected one of five response categories ranging from “cannot exercise/It is impossible” (coded 1) to “can fully exercise/fully my decision” (coded 5). The 5-point scale may be better than alternative binary measures (secure/insecure), as the latter can overlook existence of moderate perceptions of land rights. The 5-point scale can also capture more variability which would allow some freedom in quantitative analysis. Additionally, as pointed out by Nizalov et al. (2022), the 5-point scale may be better able to capture small shifts in security over time, which is particularly relevant for Research question 3. During survey respondents were reminded to disregard physical, health, climate, and technological constraints when assessing their land rights. This, to some extent helps reduce measurement error (noise) in perceived land rights. The complete questions for land rights can be found in Table A1 in Appendix.

Having data on perceived land rights disaggregated into four bundles offer at least two key advantages over conventional tenure measures. First, these four bundles provide a more comprehensive assessment of tenure conditions by capturing multiple land rights dimensions. Specifically, they allow for a clear distinction between the breadth of rights (e.g., use, transfer, and management) and the assurance/security of tenure (Place et al., 1994). In contrast, relying on aggregate measures, such as tenure form or a few selected rights (e.g., the right to sell or rent out land), overlooks the possibility that certain land rights may be more critical for investment incentives than initially assumed. Second, in the study area—as well as in many developing countries—common measures of land tenure rights, such as the presence of land documents or the duration of tenure for a given plot, often fail to capture the actual rights exercised by farmers. For example, farmers may possess formal land documents, yet their actual control over land, decision-making authority, and enforcement of property rights may not fully align with what is legally recognized. Using perceived land rights data provides more accurate picture of actual land tenure situations as perceived by farmers.

Using all sub-rights in the regression analysis could be tedious, so instead I used bundles of land rights as measures of land tenure rights. To measure each bundle, I followed the approach of Holden et al. (2009). For each specific sub-right, farmers were assigned a score based on their survey responses. A score of 0 was given when a farmer reported being unable to exercise a given sub-right, while a score of 1 was assigned when a farmer indicated full ability to exercise a specific sub-right. For responses that fall between these two extremes (indicating moderate perceptions of the right) a score of 0.5 was assigned. These scores were then summed up over all sub-rights to create an overall score for the specific bundle. For example, if a farmer evaluated all three sub-

rights within use bundle as 5, i.e., each right was assigned a value of 1, resulting in a total score of 3 for the *Use rights* bundle. This process was repeated for three other bundles, namely *Management rights*, *Transfer rights*, and *Protection rights*. The generated additive index for each bundle of land rights reflects the extent to which farmers perceive their land rights as more complete or secure. Similar additive approaches are commonly used in the empirical literature. For instance, some researchers have quantified land rights by summing the number of rights farmers possess (for example, Besley, 1995), while others categorized farmer/plots based on the number of rights they hold (for example, Brasselle et al., 2002; Hayes et al., 1997).

In addition to capturing farmers' perceptions of land rights bundles, the survey also asked them to report their subjective expectation of land expropriation risk in the near future—one of the most commonly used measures of land tenure security in the literature (Arnot et al., 2011; Nizalov et al., 2022). The survey question was worded as follows:

- "How likely is it that you may lose your ownership or land use right in the next 3 years?"

The responses included categories ranging from "extremely unlikely" (coded 1) to "extremely likely" (coded 5), higher values indicating greater tenure insecurity. I refer to this variable as Expropriation risk. Both land expropriation risk and the bundle of protection rights are conceptually related to land tenure security. However, they are not identical. Farmers may assign different levels of importance to various tenure risks (Linkow, 2016). For example, the bundle of protection rights may capture more general situation regarding rule of law, courts while land expropriation can capture more direct threats or worries of farmers about losing their land or other assets. Considering potential correlation of land expropriation risk and protection rights, they were used separately in the analysis.

As a measure of land tenure security, I also employed a concept of government intervention. It is assumed that farmers who are tenure insecure, or have weak protection can be more subject to excessive, illegal interventions by government or local governors in the form of frequent inspections, extra-legal demands. Specifically, government intervention refers to regulatory oversight of farms, aimed in part at ensuring compliance with land use and input regulations. This may include frequent inspections by local authorities, monitoring activities, mandatory attendance at government-organized meetings, and requests for new reports on farm indicators. In the study areas, such interventions—especially when they occur during peak farming periods—can disrupt farm operations, reduce the time available for critical agricultural activities, and add to farmers' stress levels. To assess the extent of these interventions, the survey included the following question:

- “How strongly would the following factors PREVENT you from increasing crop yield on your farm in the next years? – Intervention of state administration during crop cultivation and harvesting”

Responses were recorded using a five-point scale, ranging from "Very weak" (coded 1) to "Very strong" (coded 5), with higher values indicating more ‘harming’ government intervention. I refer to this as the Government intervention variable. Since this variable is not part of the original bundle framework, it was not combined to the bundles’ measurement.

To summarize, four bundles of land rights, along with land expropriation risk, were used in Research question 1 to examine the relationship between land rights and investment incentives. Land expropriation risk and government intervention were used for Research question 2 to examine whether tenure insecurity alters the relationship between time preference and investment behavior. In Research question 3, protection rights and land expropriation risk were used to analyze the temporal dynamics of perceived tenure security using panel data.

3.2.3 Time preference

I used a self-reported measure of time preference, validated in Falk et al. (2023). This approach is particularly recommended for large samples and populations with lower levels of education, as it reduces cognitive complexity and response burden, making it a practical alternative to more complex experimental approaches. In the survey, the respondents were asked the following question:

- “How well do the following statements describe you as a person? How willing are you to give up something that is beneficial for you today in order to benefit more from that in the future?”

Responses were recorded on a five-point scale, ranging from "Completely unwilling" (coded 1) to "Very willing" (coded 5). For the analysis, the scale was reversed so that higher values correspond to greater impatience, meaning a stronger preference for immediate benefits over delayed benefits. Lower values indicate greater patience and a higher willingness to delay gratification. This measure is referred to as the Time preference variable in the analysis.

There are several reasons why the self-assessed measure of time preference by Falk et al. (2023) is more appropriate for use in the study area compared to other self-assessed or psychometric methods. For instance, Vischer et al. (2013) also validated a survey-based, self-assessed time preference measure that asks respondents to describe themselves as either impatient or patient, using a scale from 0 to 10, where 0 indicates "very impatient" and 10 indicates "very patient."

However, using terms like "patience" or "impatience" could introduce bias in responses, particularly in the Central Asian context. In Uzbekistan, for example, cultural and political norms often emphasize patience and resilience in the face of difficulties. As a result, such question wording may encourage farmers to align their answers with these prevailing social expectations, potentially skewing results towards greater expressions of patience.

3.2.4 Background variables

The control variables were selected based on the review of theoretical and empirical literature. I group them into three. Their definitions and measurement units are provided in Table 2.

- *Farmer-specific variables:* Characteristics related to farmer, such as age, education.
- *Farm-specific variables*: Characteristics related to farm, including land size, specialization.
- *Economic and institutional environment variables:* Contextual factors such as access to inputs, credit.

Table 2. Definitions and measurement of background variables

Name of variables	Definitions	Measurement unit
Farmer-specific variables		
Farmer age	Calculated as the difference between the survey year and the farmer's birth year	In years
Education	Whether farmer has attained a higher education level	Yes or No (1/0)
Risk attitude	Assessed by the question, "How strongly are you willing to take risks?	On a 1–5 scale, Response categories range from completely unwilling (1) to very willing (5)
Business horizon	For how many more years will farmer continue farm business	Four categories from 1 (up to 3 years), 2 (up to 5 years), 3 (up to 10 years), and 4 (more than 10 years)
Farm-specific variables		
Farm age	Calculated as the difference between the survey year and the year farm was established	In years
Farm area	How much land was available for the farm in 2018	In hectares (ha)
Specialization	Whether the farmer primarily cultivates cotton and/or wheat	Binary (1 = Cotton/ Wheat, 0 = Other)
Tenure form	Whether the farmer operates on privately owned land rather than leased land	Binary (1 = Private, 0 = Leased)
Contract farming	Farmer participated in contract farming in 2018	Binary (1 = Yes, 0 = No)
Sufficient inputs	Farmer has enough input resources (for example, machinery, financial	Scale (1 = Strongly Disagree, 5 = Strongly Agree)

	resources, and land) to increase crop yield in the next 3 years.	
Total tax	Total amount spent on electricity and irrigation services per farm in 2018	In USD[a]
Hired agronomist	Farmer employs an agronomist on a permanent basis	Binary (1 = Yes, 0 = No)
Workers	Number of permanent workers employed on the farm	Count (number of workers)
Livestock	Farmer owned livestock three years ago	Binary (1 = Yes, 0 = No)
Irrigation system condition	Farmer's evaluation of on-farm irrigation and drainage network condition	Scale (1 = Bad, 2 = Satisfying, 3 = Good)
Soil fertility	Percentage of farmland with a bonitet ratio between 50 and 70, indicating good fertile	Percentage (%)
Economic and institutional environment		
Access to land	Farmer can lease additional land if needed	Binary (1 = Yes, 0 = No)
Credit obtained	Farmer received credit in 2018	Binary (1 = Yes, 0 = No)
Nonfarm income	Farmer engages in non-farm activities	Binary (1 = Yes, 0 = No)
Economic access to variable inputs	Number of variable inputs a farmer perceives as financially inaccessible	On a 0-4 scale
Physical access to variable inputs	Number of variable inputs a farmer perceives as physically inaccessible	On a 0-4 scale
Maktaaral	Farm is located in Maktaaral district, South Kazakhstan	Binary (1 = Yes, 0 = No)
Sariagash	Farm is located in Sariagash district, South Kazakhstan	Binary (1 = Yes, 0 = No)
Shardara	Farm is located in Shardara district, South Kazakhstan	Binary (1 = Yes, 0 = No)
Jomboy	Farm is located in Jomboy district, Samarkand, Uzbekistan	Binary (1 = Yes, 0 = No)
Pastdargom	Farm is located in Pastdargom district, Samarkand, Uzbekistan	Binary (1 = Yes, 0 = No)
Payarik	Farm is located in Payarik district, Samarkand, Uzbekistan	Binary (1 = Yes, 0 = No)

Note: Variable definitions and coding follow the SUSADICA Farm Survey 2019 questionnaire and the author's coding.

a. Exchange rates used for currency conversion are based on approximate values for year 2018. The exchange rate of the Kazakh tenge to US dollars was around 1 USD = 370 KZT, and the exchange rate of the Uzbek soum to US dollars was around 1 USD = 8,200 UZS.

3.3 Descriptive statistics

This section presents the descriptive statistics for the variables included in the dissertation. First, it provides an overview of investment behavior, perceived land rights, and time preferences. Then, it summarizes the background variables.

3.3.1 Key variables

Table 3 presents the share of sampled farmers owning different types of farm machinery and equipment; assets with no reported ownership in both samples are not included. In Kazakhstan, 26% of farmers own tractors, followed by trailers and harvesters, each owned by 4% of farmers. Less than 2% of farmers own other types of assets. In Uzbekistan, 85% of farmers own tractors, 61% own trailers, and 36% own sowing machines. Additionally, 17% own mechanized irrigation pumps, 14% own sprayers, and 8% own lorries. Less than 2% of the respondents in Uzbekistan own cotton and grain harvesters, storage facilities, electricity generators, or milling machines. As it is evident, farmers in Uzbekistan report significantly higher ownership rates of machinery and equipment compared to their counterparts in Kazakhstan. It is important to point out that in both study areas, it is possible to produce without owning machinery. Farmers can use machinery services or rent in necessary technologies from other farmers.

Table 3. Ownership patterns of movable productive farm assets

Type of assets, share of farmers owning	Kazakhstan (N= 503)	Uzbekistan (N= 460)
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)	1%	14%

Source: SUSADICA Farm Survey 2019. Own calculations.
a. Storage facility is included because in the study areas storage facilities and resting sheds are built such that they are easy to remove (and low cost) in case officials find them to interfere with land use regulations or if farmers anticipate risks of land reallocation.

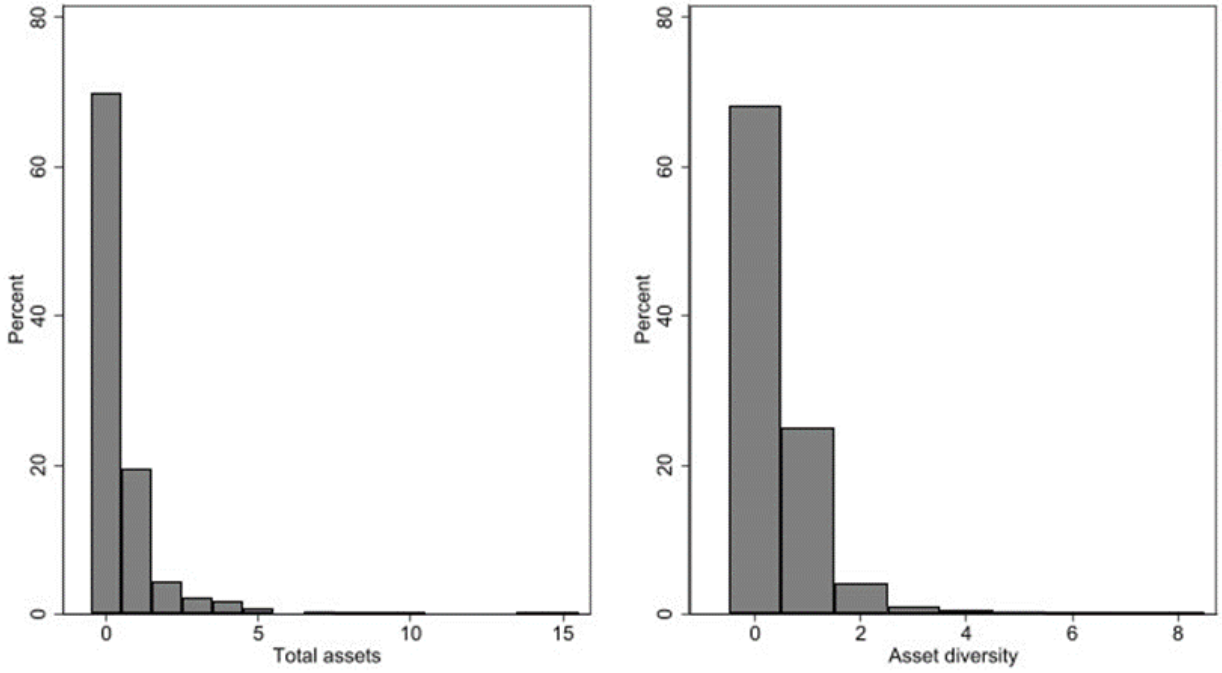
Figure 2 shows the distribution of movable farm asset ownership among sampled farmers in Kazakhstan and Uzbekistan. The left and right panels describe total assets and asset diversity,

respectively. For Kazakhstan sample, the distributions for both investment measures are highly skewed, with over 60% of farmers owning no machinery and around 20% owning only one or two units of movable farm assets. Ownership beyond five units and four asset types are rare. These patterns suggest that most sampled Kazakhstan farmers may rely on renting or shared access to machinery rather than acquiring own farm assets.

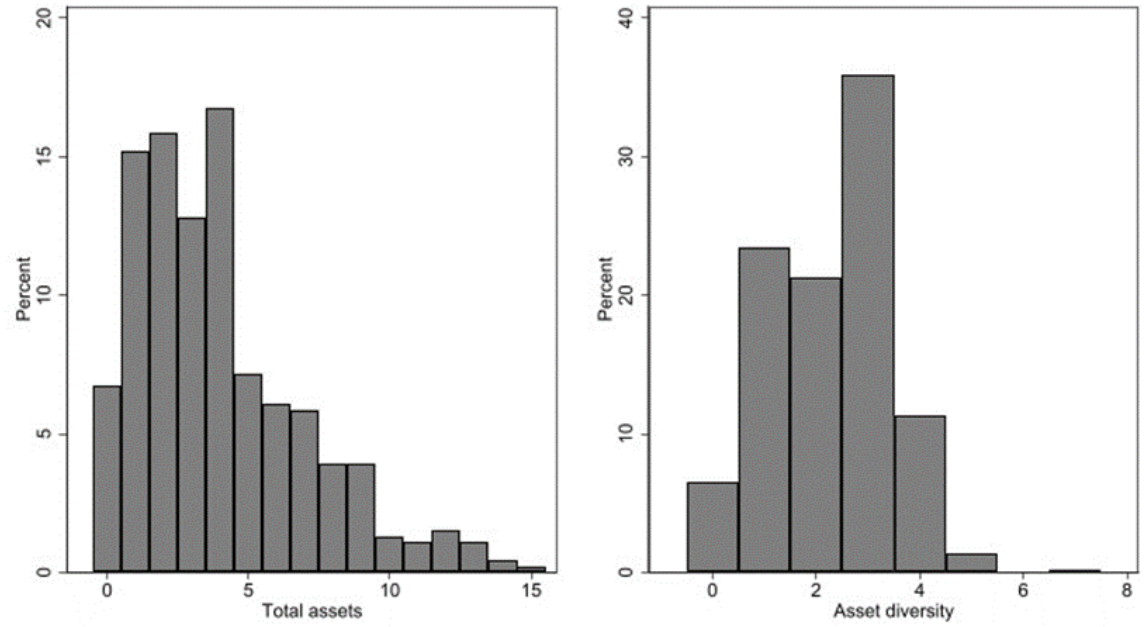
Figure 2 illustrates the distribution of movable farm asset ownership in Uzbekistan. Unlike Kazakhstan, the distribution is less skewed, with most farmers owning multiple assets. The majority have on average between three and six units of total assets, and asset diversity peaks at 3. The average number of total assets and asset diversity among sampled farmers in Kazakhstan is 0.60 (s.d. = 1.49) and 0.45 (s.d.= 0.89) units, respectively, while in Uzbekistan, the averages are approximately 4.00 (s.d. = 3.04) and 2.27 (s.d. = 1.18), respectively. Across both investment measures, means are higher in Uzbekistan sample with smaller standard deviations, compared to numbers in Kazakhstan. This confirms previous observation that farmers in Uzbekistan generally own more machinery and equipment than those in Kazakhstan. These higher ownership levels suggest that Uzbek farmers place strong emphasis on investing in their own technologies—reflecting the critical role of mechanization in the country's agricultural system.

Figure 2. Distribution of total assets and asset diversity

Panel A: Kazakhstan



Panel B: Uzbekistan

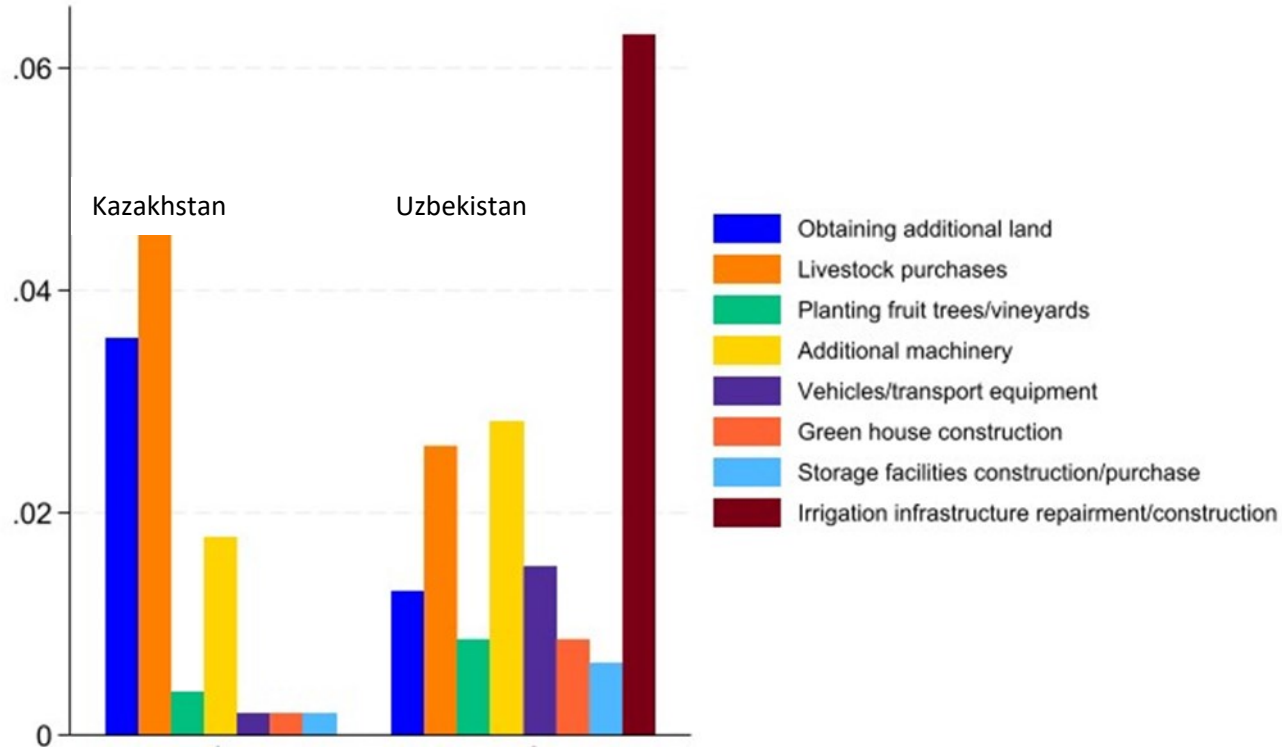


Source: SUSADICA Farm Survey 2019. Own calculations.

Table 4 present recent investments in productive assets made by sampled farmers in the last 12 months prior to the survey, as well as the sources of financing. In Kazakhstan sample, the most common investment was in livestock, with slightly over 4% of 503 farmers making purchases, followed by land acquisitions at just under 4%. Investment in machinery was reported by less than 2% of farmers, while investments in trees, transport, greenhouses, and storage facilities remained minimal, each accounting for less than 1%. Notably, no farmers in the Kazakhstan

sample reported investments in irrigation systems during the surveyed period. In Uzbekistan sample, the most common investment was in irrigation infrastructure, with just over 6% of 460 farmers making such improvements. Less than 2% of farmers invested in machinery, livestock (2%), land, or transport, while fewer than 1% invested in trees, greenhouses, or storage facilities. Despite the overall low investment rates, irrigation infrastructure stood out as the most frequently reported investment, likely reflecting the critical role of water management in Uzbek agriculture. By and large investment in farm assets over the past 12 months seems relatively low in both samples. Further, among both groups of sampled farmers using own savings to finance investments seems a dominant approach (Table 4). In Kazakhstan loans were more common for machinery, transport, and storage, suggesting that loans may be more available for financing investments/technologies related to crop production. Similarly, in Uzbekistan own savings were the primary source of financing for most investments in Uzbekistan, particularly for land, livestock, trees, and irrigation infrastructure. Machinery and transport investments were more loan-dependent. Overall, in both countries, self-financing was the preferred method across most asset categories, though loans played a notable role in transport investments. In Kazakhstan, three out of ten farmers used loans, compared to just one out of ten in Uzbekistan, suggesting that Kazakh farmers may have better access to credit or more favourable lending conditions.

Figure 3. Patterns of recent investments in productive assets



Source: SUSADICA Farm Survey 2019. Own illustration.

Table 4. Sources of investment financing (Number of farmers)

	Kazakhstan			Uzbekistan		
	Loan	Own savings	TOTAL	Loans	Own savings	TOTAL
Obtaining additional land	5	13	18	1	6	7
Livestock purchases	3	20	23	1	12	13
Planting fruit trees/vineyards	1	1	2	0	4	4
Additional machinery	6	3	9	2	12	14
Vehicles/ transport equipment	1	0	1	4	3	7
Green house construction	0	1	1	1	3	4
Storage house construction	1	0	1	0	3	3
Irrigation infrastructure repairment/	0	0	0	0	29	29
TOTAL	17	38	55	9	72	81

Source: SUSADICA Farm Survey 2019. Own calculations.

Table 5 presents a cross-tabulation of farmers' perceived land rights in Kazakhstan and Uzbekistan, categorized into three levels: very low, moderate, and very high. In Kazakhstan, farmers generally report strong perceptions of land rights, with a large majority indicating very high levels across most bundles. Within the use rights bundle, most farmers report strong perceptions of their right to enter land. In contrast, about three-quarters of Kazakhstan farmers report having full freedom to harvest and change land use. Next, most Kazakhstan farmers report having very high perceptions of management rights. This shared view is especially pronounced for the right to crop choice. While data show most farmers have strong perceptions of use and management rights, the pattern visibly changes for transfer and protection bundles among Kazakhstan farmers. Particularly, less than two-third of farmers report having complete freedom in transfer decisions while quite a bit of farmers report having very low and moderate perceptions of transfer rights. Among transfer rights, the right to rent in leased land is perceived high only among around half of the sample, confirming restrictions around transfer rights on leased land.

When it comes to the protection bundle, the proportion of farmers with very high perceptions declines significantly compared to the previous three bundles. Instead, most Kazakhstan farmers appear to hold moderate perceptions of their protection rights. Nevertheless, most farmers in Kazakhstan report high tenure security about low land expropriation risks and moderate perceptions of regarding government intervention. Between these two institutional threats, fewer Kazakhstan farmers share the view that they do not face government intervention. By and large, data on perceived land rights from Kazakhstan sample align with contextual information—farmers have on average more freedom in use, management and transfer rights, and higher

tenure security in terms of low risks of land expropriation risk. At the same time, we observe that there is quite a bit of variability in perceptions of all land rights.

In Uzbekistan sample, within use bundle, the right to enter land is widely perceived as strong, with 433 farmers reporting very high perceptions, and only 4 reporting very low perceptions. However, the perceptions of the right to collect harvest shows greater variation, as only 87 Uzbekistan farmers report very high perceptions, while 191 report moderate perceptions, and a large group of 182 farmers report very low perceptions, indicating greater restrictions or uncertainties regarding ownership of own harvest. A substantial majority of Uzbekistan farmers report very low perceptions of having freedom to change land use purpose, which aligns with restrictions around using land for other purposes. Next, regarding management rights, there is quite a lot of variability in perceptions and across management rights. Specifically, a little more than half of Uzbekistan farmers seem to express complete freedom in terms of cultivation methods and investing in land while majority of these farmers express complete freedom in excluding others from entering land. Contrary, majority of Uzbekistan farmers report having very low freedom in crop choice and marketing. Among many transfer rights in Uzbekistan, most farmers reported having no freedom. This group of farmers with low perceptions is slightly lower for bequeath right, indicating only this right within transfer rights is more or less perceived to exist to some level in Uzbekistan context.

In Uzbekistan, sampled farmers' perceptions of protection rights generally are similar to perceptions reported in Kazakhstan—majority of farmers have moderate perceptions or trust in courts. Around a quarter of Uzbekistan farmers tend to report very higher perceptions of courts in disputes with other farmers and half of farmers report very high perceptions of land documents importance in proving land rights. Nearly all Uzbekistan farmers report moderate perceptions of land expropriation risks in the future while around two-thirds report moderate perceptions regarding government intervention. Little less than a quarter of Uzbekistan farmers complain about very high government intervention compared to those complaining about high land expropriation risks, suggesting possibly more sensitivity among sampled Uzbekistan farmers to government intervention.

Overall, the data reveal that in both Kazakhstan and Uzbekistan, there is much variability in perceptions of land rights and in Kazakhstan, most sampled farmers enjoy more freedom in use, management and transfer decisions regarding land and production. The description of perceived land rights aligns well with the actual land tenure situation in both regions. Additional information regarding the mean differences in perceived land rights can be found in Appendix in Table A2.

Table 6 presents the mean, standard deviation, minimum, and maximum values for the quantified measures of the four bundles of land rights. In Kazakhstan, the mean values for use and management rights are relatively close to their maximum, indicating that most farmers perceive strong rights in these areas. In contrast, transfer and protection rights have much lower mean values compared to their maximum, reinforcing earlier observations from the raw data that these rights are more restricted. Meanwhile, in Uzbekistan, none of the four bundles have mean values approaching their maximum, suggesting that farmers generally perceive their land rights as more constrained. Additionally, in both countries, some farmers report incomplete or nearly absent land rights, particularly in the case of transfer rights.

Table 5. Cross-tabulation of perceived land rights

	Kazakhstan (N = 503)			Uzbekistan (N = 460)		
Use rights	Very low	Moderate	Very high	Very low	Moderate	Very high
Enter land	1	48	454	4	23	433
Collect harvest	2	125	376	182	191	87
Change land use purpose	14	114	375	343	111	6
Management rights						
Decide on crop choice	4	86	413	314	132	14
Decide on cultivation methods	4	108	391	37	150	273
Invest in land	4	118	381	28	169	263
Exclude others from entering land	20	99	384	31	46	383
Market own harvest	2	106	395	302	146	12
Transfer rights						
Permit others use own land	116	142	245	352	106	2
Sell land	131	70	302	458	2	0
Rent out land	81	119	303	360	100	0
Rent in leased land	63	169	271	398	61	1
Bequeath land	52	107	344	288	169	3
Protection rights						
Trust in courts in disputes with other farmers	26	301	176	0	353	107
Trust in courts in disputes with investors	34	387	82	14	434	12
Trust in courts in disputes with state	35	352	116	128	319	13
Importance of land documents in proving land rights	9	93	401	2	256	202
Land tenure security[a]						
Land expropriation risk	296	199	8	14	439	7
Government intervention	179	306	18	5	364	91

Source: SUSADICA Farm Survey 2019. Own calculations.

Note: Very low = lowest perception value, Moderate = values between 2 and 4, Very High = highest perception value

a. For both land expropriation risk and government intervention high perceptions mean high insecurity, while for all bundles of land rights high perceptions mean high security.

Table 6. Summary statistics of perceived bundles of land rights (Index)

	Kazakhstan (N = 503)				Uzbekistan (N = 460)			
	Mean	**S.D.**	**Min.**	**Max.**	**Mean**	**S.D.**	**Min.**	**Max.**
Use rights	2.681	0.443	1	3	1.497	0.492	0	3
Management rights	4.418	0.743	1	5	2.753	0.759	0.5	5
Transfer rights	3.516	1.563	0	5	0.489	0.608	0	2
Protection rights	2.667	0.677	0.5	4	2.207	0.483	0.5	4

Source: SUSADICA Farm Survey 2019. Own calculations.

Table 7 shows descriptive statistics for time preference. In the Kazakhstan sample, the average self-reported time preference score is 3.572, with a median of 4, indicating that most respondents are moderately willing to delay immediate benefits. The scores range from 1 (completely unwilling to delay) to 5 (very willing to delay). In the Uzbekistan sample, the mean time preference score is 3.289, slightly lower than that in Kazakhstan, with the median also at 4. The standard deviation is 0.893, indicating slightly less variability in responses compared to Kazakhstan.

Table 7. Descriptive statistics of self-reported time preference

	Mean	**Median**	**S.D.**	**Min.**	**Max.**
Kazakhstan	3.572	4	1.024	1	5
Uzbekistan	3.289	4	0.893	1	5

Source: SUSADICA Farm Survey 2019. Own calculations.

3.3.2 Background (control) variables

In the following Table 8 I provide a description of key background variables for sampled farmers in Kazakhstan and Uzbekistan. Starting from Kazakhstan sample, one can see that for farmer-specific characteristics, the average age of farmers in Kazakhstan is 46.2 years, with the youngest farmer aged 19 and the oldest 78. There is also variation in education levels, with approximately 30% of farmers having completed higher education. Further, sampled farmers in Kazakhstan exhibit a relatively higher willingness to take risks, with an average risk attitude score of 4.19 (on a 1–5 scale), suggesting a greater openness to engaging in activities with risky, uncertain outcomes.

Moving to farm-specific variables, in Kazakhstan the average farm age since establishment is 18.3 years, more than double the average in Uzbekistan. However, the farm area varies widely, with an average of 14.2 hectares, a minimum of 1.5 hectares, and a maximum of 651 hectares. Farmers in Kazakhstan report moderate access to inputs (finance, inputs, land), with an average rating of 3.58 (on a 1–5 scale). On average, farms employ 1.65 workers, and about 16% of farmers own

livestock. Additionally, the condition of irrigation systems is reported at an average of 1.91 (on a scale of 1–3), indicating moderate conditions across sampled farms.

In terms of economic and institutional variables, 60.6% of Kazakhstan farmers report being able to obtain land when needed, indicating relatively better access to land markets. Access to credit is relatively low, with only 27.4% of farmers successfully securing loans. Farmers in Kazakhstan on average report quite good access to variable inputs, though access to inputs in terms financial availability seem to be slightly worse than physical availability.

In Uzbekistan sample, it can be seen that the average age of farmers in Uzbekistan is 42.8 years, slightly younger than in Kazakhstan, with the youngest farmer at 20 years and the oldest at 68 years. A slightly higher proportion of farmers (33.5%) report having higher education. In contrast to Kazakhstan, farmers in Uzbekistan exhibit lower risk-taking behavior, with an average risk attitude score of 3.50, suggesting a more cautious approach to decision-making.

Regarding farm-specific variables, farms in Uzbekistan are much younger, with an average age of 9.2 years, possibly shorter tenure durations reflecting frequent land reallocations. Uzbekistan farms tend to be larger, with an average area of 38.9 hectares and a range from 4 to 203 hectares. Farmers in Uzbekistan report similar input sufficiency (3.77 on a 1–5 scale) as their Kazakhstan peers. On average, Uzbekistan farms employ 3.90 workers, more than double the number in Kazakhstan. The prevalence of livestock ownership is much lower, with only 2.8% of farmers owning livestock, compared to 15.7% in Kazakhstan. The reported irrigation system condition is similar to Kazakhstan, with a mean value of 1.92 on a 1–3 scale.

In terms of the economic and institutional environment, only 33.5% of farmers in Uzbekistan report being able to obtain land if needed, which is much lower than in Kazakhstan, indicating more restricted land access. Access to credit is also low (28%), similar to Kazakhstan. Regarding access to variable inputs, Uzbekistan farmers on average find variables inputs quite accessible both in terms of physical and financial availability. Additional information about the mean comparisons in control variables between samples can be found in Table A3 and Table A5 in Appendix.

Table 8. Summary statistics of background variables

	Kazakhstan (N = 503)				Uzbekistan (N = 460)			
Farmer-specific variables	**Mean**	**S.D.**	**Min.**	**Max.**	**Mean**	**S.D.**	**Min.**	**Max.**
Farmer age	46.199	13.227	19	78	42.75	10.043	20	68
Education	0.296	0.457	0	1	0.335	0.472	0	1
Risk attitude	4.189	0.922	1	5	3.496	0.884	1	5
Business horizon	3.652	0.768	1	4	3.674	0.655	1	4
Farm-specific variables								
Farm age	18.256	5.519	0	28	9.211	6.718	0	28
Farm area	14.187	36.93	1.5	651	38.944	26.535	4	203
Specialization	0.612	0.488	0	1	0.674	0.469	0	1
Tenure form	0.670	0.471	0	1	0	0	0	0
Contract farming	0.149	0.357	0	1	0.059	0.235	0	1
Sufficient inputs	3.579	0.915	1	5	3.765	0.762	2	5
Total tax	72.401	105.895	0	1027.027	1259.944	1214.1	0	12195.122
Hired agronomist	0.149	0.357	0	1	0.102	0.303	0	1
Workers	1.648	2.482	0	15	3.904	2.583	0	26
Livestock	0.157	0.364	0	1	0.028	0.166	0	1
Irrigation system condition	1.905	0.790	1	3	1.915	0.653	1	3
Soil fertility	35.052	41.750	0	100	56.593	40.530	0	100
Economic and institutional environment								
Access to land	0.606	0.489	0	1	0.335	0.472	0	1
Credit obtained	0.274	0.447	0	1	0.280	0.450	0	1
Nonfarm income	0.406	0.491	0	1	0.280	0.450	0	1
Economic access to variable inputs	0.948	0.864	0	4	0.730	0.687	0	3
Physical access to variable inputs	0.159	0.426	0	3	0.789	0.856	0	4

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: Statistics for district dummies are not reported; they are represented nearly equally in both settings.

3.4 Quantitative methods

This section outlines the quantitative methods applied in the dissertation. To estimate the relationship of land rights and time preference with investment decisions, regression analysis was applied (Research questions 1 and 2). To examine the temporal changes in farmers' tenure security perceptions descriptive methods were mainly applied (Research question 3).

3.4.1 Selection of econometric model

The investment variables in this dissertation were measured as the count of farm assets, specifically the total number of machinery and equipment owned by farms and their diversity. Given the nature of these variables, a family of count data models is most appropriate (Cameron and Trivedi, 2013). Count data consist of non-negative integers (e.g., 0, 1, 2, …) and have been widely used in agricultural research to model various decisions. For example, count models have been applied to analyze agricultural technology adoption (Mariano et al., 2012; Paxton et al., 2011; Sharma et al., 2011; Zhang et al., 2020), where the dependent variable often reflects the number of technologies adopted by a farmer. Similarly, count models have been employed to study demand for extension services (Gido et al., 2015), the prevalence of livestock diseases (Hüls et al., 2017), and rural migration decisions (Mullan et al., 2011), among others.

Hüls et al. (2017) provide a simple flowchart for selecting the most appropriate count data model. The study recommends starting with the Poisson model and then assessing whether the dependent variable exhibits over-dispersion (where the variance of the dependent variable exceeds its mean) or under-dispersion (where the variance is smaller than its mean). If neither over-dispersion nor under-dispersion is present, the Poisson model is appropriate. However, when the variance exceeds the mean, the Poisson model becomes inappropriate due to greater variability in the data, requiring alternative models such as the negative binomial or quasi-Poisson (Green, 2021; Hilbe, 2011). The next step is to evaluate whether the data exhibit zero inflation, which occurs when the dataset contains more zeros than expected under standard count models. While there is no formal threshold for what constitutes an "excessive" number of zeros, zero inflation may arise, for example, if a survey includes farmers who never invest in productive assets or if, at the time of data collection, most farmers happened not to invest. If zero inflation is present, a Zero-inflated negative binomial (ZINB) model or a Hurdle model should be used. Conversely, if zero inflation is not a concern, a negative binomial or quasi-Poisson model remains suitable for handling over-dispersion. The choice between these models is determined through inspection of data (e.g., how common are zeros) and formal tests (e.g., overdispersion test). When two models are equally appropriate, studies suggest comparing the Akaike Information

Criterion (AIC) and Bayesian Information Criterion (BIC). A smaller AIC or BIC value indicates a better-fitting model (Hüls et al., 2017).

A visual inspection of the distribution of total assets and asset diversity in two samples in Figure 2 indicates a heavily skewed distribution of both investment measures in Kazakhstan, indicating a high concentration of zeros on the left-hand side. In Uzbekistan, the distributions for both investment measures exhibit a more normal pattern, especially for Asset diversity. I conducted a formal test developed by Fávero et al. (2020) to detect overdispersion (Table A4). The test results indicated the presence of overdispersion in both investment outcomes in Kazakhstan, while overdispersion was detected only for Total assets in Uzbekistan, indicating relevance of negative binomial model for Kazakhstan sample and for total assets in Uzbekistan. Since excessive zeros could be an issue in the Kazakhstan sample, potentially requiring the use of zero-inflated count models, I compared the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values for negative binomial model and zero-inflated model variants. The results indicated that the negative binomial model provided a slightly better fit than the zero-inflated alternatives. Consequently, the negative binomial model was selected to model investment decisions for the Kazakhstan sample and for total assets in the Uzbekistan sample. The overdispersion test for asset diversity in Uzbekistan sample (Table A4) indicated a negative parameter, suggesting the presence of under-dispersion (the variance of asset diversity is smaller than its mean). Researchers suggest to transform count data by creating dichotomous variable or log transformation, and use models such as generalized linear models (Green, 2021; Hilbe, 2011; Myers and Montgomery, 1997; Warton et al., 2016; McCall and Villafranca, 2024). Count data models such as Poisson model is a special case of Generalized linear models (Williams, 2016). Therefore, the generalized linear model was used to model asset diversity in Uzbekistan.

The interpretation of count data model coefficients is as follows: for a one-unit change in a predictor variable, the difference in the log of expected counts is expected to change by the corresponding regression coefficient, assuming all other predictor variables remain constant. A positive coefficient indicates a positive relationship between the variable of interest and the dependent variable, meaning that as the predictor increases, the expected count also increases. Conversely, a negative coefficient suggests a negative relationship, where an increase in the predictor is associated with a decrease in the expected count. Since coefficients in count models are typically log-linear, they must be exponentiated to be interpreted as incidence rate ratios (IRRs). For example, a coefficient of 0.20 corresponds to an IRR of e^0.20≈ 1.22, meaning a 22% increase in the expected count of assets. In other words, a one-unit increase in an independent variable is associated with a 22% increase in the expected count of total assets owned, holding

all other predictor 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 all other predictor variables constant.

3.4.2 Model specifications

Research questions 1 is whether different categories of perceived land rights are associated with investment incentives for the case farm machinery and equipment. Research question 2 is whether time preference is associated with investment levels for the case farm machinery and equipment. In this order, I specify the econometric models. Specifically, the first model examines the relationship between disaggregated land rights, captured through use, management, transfer, and tenure security rights, and investment in movable farm assets. Since over-dispersion was observed in the Kazakhstan datasets and in total assets for the Uzbekistan data set, the negative binomial model was applied. In cases of under-dispersion, a generalized linear model was used.

Based on theoretical and empirical literature, several key control variables related to investment decisions are included. More details about them are given below. One of the key assumptions in count models relevant for model specification is that time exposure influences asset accumulation. Farms that have been in operation for longer periods are more likely to have made more investments in productive assets. Ignoring time exposure could lead to biased estimates, as observed differences in asset ownership may be due to farm longevity rather than differences in land tenure security. Therefore, following Long and Freese (2006), I include 'Farm Age' as a control variable under 'Farm Characteristics' in Equation (1) to account for differences in the time available for investment accumulation.

The empirical specification for Research question 1 is written as follows (Equation 2):

$$I_i^m = \alpha_i + \beta_1 Use_i + \beta_2 Management_i + \beta_3 Transfer_i + \beta_{4,5} Tenure\ security_i + \theta' P_i + \Phi' F_i + \upsilon' R_i + \varphi' D_i + e_i$$

where I_i^m represents past investments in farm machinery and equipment as indicated by the total assets and asset diversity. β_1 to β_5 are the parameters to be estimated for the four bundles of perceived land rights. As previously mentioned, I separated a bundle of perceived protection rights from perceived land expropriation risk because they may be correlated. So I entered them in regressions separately; therefore, β_4 is the parameter to be estimated for the bundle of perceived protection rights and β_5 is the parameter to be estimated for perceived land expropriation risk. Further, the model includes sets of control variables. P_i is a vector of personal characteristics, representing farmers' age, education and risk attitude. F_i is a vector of the farm

characteristics and includes 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, livestock ownership and quality of irrigation and drainage systems. R_i corresponds to a vector of economic and institutional environment and captures farm access to arable land and variable inputs, credit use, and nonfarm income. D_i is includes three districts in each country, and e_i is the error term. θ', ϕ', σ', and φ' are vector parameters to be estimated for P_i, F_i, R_i and D_i, respectively. Some of the key economic factors, such as investment returns, farm profitability are unavailable and were not included as control variables. To partially address this limitation, I include farm size in the model. Farm size not only can reflect farm profits but also can indicate how profitable investments can be due to economies of scale. Because of the indivisibility of farm assets, meaning unlike variable inputs, machinery and equipment cannot be purchased in parts (Feder et al., 1992), larger farms may be more willing and financially capable to acquire own farm machinery compared to smaller farms (Qiu and Luo, 2021).

Before presenting model specification for research question 2, it is important to define analytical steps which I later use to present model results. Frederick et al. (2002) emphasize that time preference is made from two components—pure time preference and other reasons (uncertain future, immediate need for cash, poor cognitive ability, etc.) that influence their discounting behavior. Farmers can reveal more short-term preferences or behavior partly because they are experiencing financial constraints at that moment. Literature consistently shows that higher income and wealth levels are associated with lower discount rates (Pender and Walker, 1990; Tanaka et al., 2010; Meissner et al., 2023). So, it is important to control financial correlates such as access to credit in regressions.

Similarly, expressions of time preference are confounded with some personal factors. Among them, cognitive deficits have been linked to higher impatience (Dohmen et al., 2010; Huffman et al., 2019; Meissner et al., 2023). Cognitive skills help to plan better for the future, fostering control mechanisms to resist temptations, and reducing health and mortality risks (Bauer et al., 2020). Controlling for education can be one way to capture cognitive skills. Further, it is easy to conflate time preference with time horizon. While, they can be related, they are distinct concepts. Mortality, health risks, can shorten time horizon, and can be associated with greater discounting of the future. So, it is important to control time horizon. Moreover, risk preferences are inherently intertwined with time preferences, as uncertainty about future outcomes can shape discounting behavior (Andreoni and Sprenger, 2012b). For example, farmers feeling more

uncertain about the future, may be tempted to choose immediate opportunities. This requires controlling for risk preference.

Environmental conditions can influence how individuals perceive and value future outcomes. Research has shown that variations in rainfall are associated with differences in discounting behavior, with higher environmental unpredictability potentially leading to more present-focused decision-making (Di Falco et al., 2019). These findings suggest that environmental variability and resource endowments can shape perceptions of future returns, thereby influencing time preference. Therefore, it is important to control for soil fertility and access to irrigation water in the context of arid, irrigated agriculture.

Given these broader associations, it is important to control for financial, personal, and environmental factors when examining the relationship between time preference and investment decisions. I select proxy variables, from the list of control variables from Subsection 3.2.4, that could proxy for such confounders.

Accordingly, for Research question 2 I specify the following regression model (Equation 3):

$$Y_i^m = \alpha_i + \beta_1 Time\ preference_i + \delta' L_i + \mu' S_i + \omega' E_i + \pi' C_i + e_i$$

where as in Equation 2, Y_i^m represents past investments in farm machinery and equipment as indicated by total assets and asset diversity. It should be noted that the dependent variable is same in both equations. β_1 is the parameter of interest to be estimated for time preference variable. L_i is a vector of "Financial correlates" such as whether the farmer has sufficient inputs to increase farm productivity, has credit and livestock. These variables should be relevant proxies to capture financial needs of farmers. S_i corresponds to a vector of "Personal correlates" that include education, risk attitude and business horizon. E_i is is a vector of "Environmental correlates" such as irrigation system condition and soil fertility. Because study area is irrigation based, instead of rainfall variation, quality of irrigation systems can capture bio-physical constraints. C_i is a vector of other control variables such as farmer age, farm age, farm area, specialization, tenure form, contract farming, total tax, workers hired and nonfarm income; and e_i is the error term. δ', μ', ω' and π' are vector parameters to be estimated for these sets of control variables.

Since I also examine whether land tenure insecurity conditions may alter the relationship between time preference and investments, it is important to clarify how this is reflected in the model specification. Researchers commonly use interaction terms between a moderating variable—such as land tenure insecurity in this case—and the key independent variable, time preference. However, the use of interaction terms is less preferred here for two main reasons.

First, count data models are non-linear, meaning that the interpretation of interaction terms differs from that in linear models, where interactions are simply the product of two variables (McCabe et al., 2022). As a result, interpreting interaction effects in count data models is less intuitive (Erdogdu, 2013). Second, my analytical goal is not to estimate interaction effects, but rather to assess the direct relationship between time preference and investment within different tenure security conditions.

These conditions are captured either by comparing country contexts—such as the Kazakhstan and Uzbekistan samples—or by splitting the sample based on other indicators of tenure security (Amin and Ulku, 2019), such as perceived land expropriation risk and perceived government intervention. For this purpose, I further split each country sample into sub-samples using these two variables. Originally, both were measured on a 5-point Likert scale. I recoded them into binary variables to capture contrasting levels of perceived risk or state involvement, based on lower (high tenure security) and upper (low tenure security) values on the scale. Because the distribution of responses differed across countries, I applied different cut-off points.

For Kazakhstan, the response "Extremely unlikely" for perceived land expropriation risk, and "Very weak" and "Weak" for perceived government intervention were coded as 1 to indicate a high tenure security condition. All other responses were coded as 0 to indicate a low tenure security condition. For Uzbekistan, "Extremely unlikely" and "Unlikely" for land expropriation risk, and "Very weak," "Weak," and "Average" for government intervention were coded as 1 to indicate high tenure security. All other responses were coded as 0 to indicate low tenure security.

The model in Equation 3 is first estimated for the full Kazakhstan and Uzbekistan samples, which serves as the baseline analysis. To examine whether the relationship between time preference and investment holds under different tenure security conditions, the same specification is then estimated separately for sub-groups defined by high and low tenure security. The set of confounding and control variables remains consistent across all models. Note that depending on the samples and analysis some control variables are omitted.

All regression models were estimated with robust standard errors to account for potential heteroskedasticity and were implemented using Stata 18.0.

3.4.3 Methods for temporal analysis of land tenure security dynamics

Since Research question 3 examines how farmers' perceptions of tenure security have changed over time, a longitudinal approach is required. Common methods for constructing longitudinal evidence include repeated cross-sectional data, panel data, and oral histories, among others (Ruspini, 1999). In quantitative research, methods for assessing temporal changes can generally

be categorized into regression-based approaches—such as difference-in-differences and time series analysis—and descriptive approaches, including transition probabilities, test-retest reliability, and correlational analysis.

Given that the objective is to describe patterns of change rather than establish causal relationships, I employed the Wilcoxon signed-rank test and transition matrices. The Wilcoxon signed-rank test is a non-parametric method well-suited for analyzing paired (repeated measures) data over time, particularly when dealing with ordinal variables (e.g., Likert scales) that may not follow a normal distribution. This test assesses median changes in perceptions, making it an appropriate tool for evaluating shifts in tenure security assessments. While it effectively captures overall trends, one limitation is that it does not fully account for individual-level variation.

Transition matrices are widely used to examine changes or probabilities of moving between different states, status, or conditions over time, for example in mobility research (Nichols, 2014), in agricultural research involving changes in credit risk assessments (Mashange et al., 2022). However, this approach has limitations when applied to tenure security perceptions. Unlike objective states (e.g., employment status or credit ratings), perceptions can be dynamic. Particularly, tenure security perceptions tend to be subjective and context-dependent, influenced by policy changes, economic conditions, and personal experiences (Linkow, 2016; Ma et al., 2013). As a result, using transitions probabilities may not offer additional analytical value beyond generating probability estimates.

Therefore, instead of transition probability matrices, frequency-based transition matrices are used in this study. This approach directly tracks how perceptions shifted over time. This method allows for a detailed examination of the direction of change (e.g., positive or negative) and the magnitude of shifts (e.g., mild vs. large transitions).

4. Main Findings and Discussion

4.1 Land rights and investment in farm machinery and equipment in Kazakhstan and Uzbekistan

The Results section for Research Question 1 is organized as follows. Subsection 4.1.1 presents findings on the relationship between perceived land rights and total farm assets and asset diversity, using count data models. Econometric models used in each regression analysis are indicated in relevant tables. Each table presents the estimation results from two models. Model 1 includes protection rights, while Model 2 includes land expropriation risk. The same sets of control variables are retained in the analyses. Following the debates around p-value (Head et al., 2015; Hirschauer et al., 2019), I report coefficients, standard errors, and confidence intervals obtained from regression estimations. The focus is on the sign and relative magnitude of the coefficients, rather than on a precise interpretation of individual coefficient values. Subsection 4.1.2 discusses the main findings and summarizes the contributions, policy implications and limitations.

4.1.1 Perceived land rights bundles and machinery/equipment asset counts and diversity

Table 9 reports negative binomial estimates for Kazakhstan on the relationship between perceived land-rights bundles and farmers' total machinery and equipment assets. Model 1 includes the four bundles of perceived land rights—use, management, transfer, and protection rights—together with the full set of control variables. Model 2 follows the same specification but replaces protection rights with land expropriation risk. Comparing the four bundles, the coefficient for perceived use rights is the largest relative to its standard error (0.512 vs. SE 0.278), indicating the strongest association among the rights bundles. However, its confidence interval narrowly includes zero (95% CI: −0.032 to 1.057), so the evidence is not fully robust. Overall, the pattern is suggestive that, in Kazakhstan, farmers who report greater freedom to use their land tend to hold more machinery and equipment. By contrast, the coefficients for management rights, transfer rights, and protection rights are small relative to their standard errors and their confidence intervals include zero, providing limited evidence of an association with total assets. Land expropriation risk is also close to zero with a confidence interval that includes zero, indicating little evidence of a relationship with total assets.

Next, I summarize the main results for control variables used in the analysis (Model 1 and 2 of Table 9). Among farmer characteristics, on education is strongly associated with total assets in the Kazakhstan sample. Specifically, the coefficient for education is 0.355 with SE 0.173 and a 95% confidence interval ranging from 0.017 to 0.694, indicating strong positive association

between higher education and holding more machinery and equipment. Contrary, farmer age (with negative sign) and risk attitude (with positive sign) do not appear strongly associated with total assets although the signs of coefficients are meaningful. Among farm-specific variables, farm age has a positive relationship with total assets, with a coefficient of 0.043 (SE 0.019) [0.006, 0.080], suggesting that older farms tend to have more assets. Additionally, having a hired agronomist is associated with higher asset levels, with a coefficient of 0.595 (0.214) [0.175, 1.015]. Among the variables capturing the economic and institutional environment, nonfarm income is positively associated with total assets, with a coefficient of 0.410 (0.173) [0.070, 0.749] in Model 1, as is physical access to variable inputs (0.567 (0.207) [0.161, 0.974]). Regarding the latter variable, the coefficients indicate that among sampled Kazakhstan farmers more variable inputs are inaccessible physically, more total assets farmers tend to have. Finally, farms located in Maktaaral and Shardara, two cotton-specializing districts, farmers tend to have more total assets compared to the reference district Sariagash. The coefficients on the control variables in Model 2 are broadly similar to those in Model 1.

Table 9. Relationship between perceived land rights and total assets in Kazakhstan

Negative binomial model	Coef (SE) (1)	95% [CI]	Coef (SE) (2)	95% [CI]
Use rights	0.512 (0.278)	[-0.032,1.057]	0.498 (0.278)	[-0.047,1.044]
Management rights	0.146 (0.160)	[-0.167,0.460]	0.121 (0.165)	[-0.201,0.444]
Transfer rights	0.025 (0.068)	[-0.108,0.159]	0.009 (0.067)	[-0.121,0.140]
Protection rights	-0.180 (0.137)	[-0.448, 0.088]	Excluded	Excluded
Expropriation risk	Excluded	Excluded	-0.039 (0.113)	[-0.260, 0.182]
Farmer-specific variables				
Farmer age	-0.012 (0.006)	[-0.024,0.001]	-0.010 (0.007)	[-0.023,0.002]
Education	0.355 (0.173)	[0.017, 0.694]	0.362 (0.172)	[0.025, 0.700]
Risk attitude	0.114 (0.102)	[-0.087,0.315]	0.109 (0.101)	[-0.089,0.306]
Farm-specific variables				
Farm age	0.043 (0.019)	[0.006, 0.080]	0.041 (0.018)	[0.005, 0.077]
Farm area	0.010 (0.008)	[-0.006,0.026]	0.010 (0.008)	[-0.006,0.027]
Specialization	-0.027 (0.305)	[-0.624,0.571]	-0.004 (0.302)	[-0.595,0.588]
Contract farming	-0.121 (0.207)	[-0.526,0.283]	-0.086 (0.198)	[-0.473,0.302]
Hired agronomist	0.595 (0.214)	[0.175, 1.015]	0.670 (0.216)	[0.248, 1.093]
Workers	0.061 (0.035)	[-0.008,0.130]	0.060 (0.036)	[-0.011,0.130]
Livestock	0.477 (0.202)	[0.082, 0.873]	0.461 (0.200)	[0.070, 0.853]
Irrigation system condition	0.059 (0.107)	[-0.152,0.269]	0.101 (0.111)	[-0.117,0.320]
Economic and institutional environment				
Access to land	0.154 (0.180)	[-0.199,0.507]	0.117 (0.175)	[-0.225,0.460]
Credit obtained	0.127 (0.190)	[-0.245,0.498]	0.111 (0.190)	[-0.262,0.484]
Nonfarm income	0.410 (0.173)	[0.070, 0.749]	0.407 (0.174)	[0.065, 0.748]
Economic access to variable inputs	0.225 (0.120)	[-0.011,0.461]	0.248 (0.12)	[0.013, 0.483]
Physical access to variable inputs	0.567 (0.207)	[0.161, 0.974]	0.576 (0.209)	[0.167, 0.985]
Maktaaral	1.590 (0.387)	[0.832, 2.348]	1.575 (0.388)	[0.815, 2.335]
Shardara	1.684 (0.375)	[0.950, 2.418]	1.725 (0.377)	[0.985, 2.465]
N	503		503	
Pseudo R2	0.1433		0.1419	

Source: SUSADICA Farm Survey 2019. Own calculations.

Table 10 presents the estimation results of the relationship between perceived land rights and asset diversity in Kazakhstan sample, using a negative binomial regression model. The results show that perceived use rights have a positive coefficient of 0.424 (SE 0.233), with a 95%

confidence interval ranging from −0.033 to 0.880. Although the confidence interval includes zero, the coefficient size relative to the standard error is larger than other three bundles (Model 1 and 2). Specifically, the coefficients for management rights and transfer rights are 0.081 (SE 0.156) [−0.226, 0.387] and 0.054 (0.063) [−0.069, 0.177], respectively, with confidence intervals including zero, indicating limited evidence of a relationship with asset diversity. The coefficient for protection rights is −0.026 (0.113) [−0.247, 0.195], similar to previous finding reported in Table 9. In Model 2, perceived land expropriation risk has gained a negative coefficient of −0.158 (0.076) with a 95% confidence interval of −0.307 to −0.009, suggesting that a higher perceived risk of land expropriation may be associated with lower diversity of farm machinery and equipment. In sum, while perceived use rights remain the most prominent rights-related correlate of asset diversification, perceived expropriation risk appears more strongly related to whether farmers diversify their machinery and equipment portfolio.

Next, the results for the selected control variables are presented. Among farmer characteristics, Education remains positively associated with asset diversity as reported earlier, but now the confidence interval includes zero. The coefficients did not change for farmer age and risk attitude. Among the farm-specific variables, the presence of a hired agronomist shows a positive coefficient of 0.360 (0.168) [0.030, 0.689], and the number of workers has a coefficient of 0.057 (0.029) [0.001, 0.114], indicating a positive association with asset diversity. Livestock ownership also shows a positive coefficient of 0.459 (0.189) [0.088, 0.830], indicating a possibility that livestock ownership can facilitate investment in livestock-supporting activities and technologies. Regarding the broader economic and institutional environment, nonfarm income is associated with greater asset diversity, with a coefficient of 0.395 (0.156) [0.090, 0.700], while physical access to variable inputs also exhibits a positive coefficient of 0.464 (0.157) [0.156, 0.771]. Farms in Maktaaral and Shardara show higher asset diversity compared to the reference district. The estimated coefficients for the control variables are broadly consistent with the earlier results for total assets, except that permanent worker size becomes more relevant and the association with farm age is no longer evident. In addition, the control-variable estimates in Model 2 are similar to those in Model 1 for asset diversity.

Overall, in the Kazakhstan sample, the estimated relationships between bundles of perceived land rights and machinery and equipment holdings are predominantly positive, with perceived use rights showing the strongest (though not fully robust) association with both total assets and asset diversity. In addition, perceived expropriation risk is negatively associated with asset diversity, suggesting that higher perceived insecurity is linked to lower diversification of machinery and equipment.

Table 10. Relationship between perceived land rights and asset diversity in Kazakhstan

Negative binomial model	Coef (SE) (1)	95% [CI]	Coef (SE) (2)	95% [CI]
Use rights	0.424 (0.233)	[-0.033, 0.880]	0.401 (0.234)	[-0.057, 0.86]
Management rights	0.081 (0.156)	[-0.226, 0.387]	0.035 (0.155)	[-0.268, 0.339]
Transfer rights	0.054 (0.063)	[-0.069, 0.177]	0.052 (0.06)	[-0.065, 0.17]
Protection rights	-0.026 (0.113)	[-0.247, 0.195]	Excluded	Excluded
Expropriation risk	Excluded	Excluded	-0.158(0.076)	[-0.307, -0.009]
Farmer-specific variables				
Farmer age	-0.005 (0.006)	[-0.016, 0.007]	-0.006(0.006)	[-0.017, 0.006]
Education	0.303 (0.165)	[-0.021, 0.626]	0.307 (0.163)	[-0.012, 0.627]
Risk attitude	0.109 (0.092)	[-0.070, 0.289]	0.106 (0.089)	[-0.069, 0.281]
Farm-specific variables				
Farm age	0.031 (0.017)	[-0.003, 0.065]	0.030 (0.017)	[-0.004, 0.063]
Farm area	0.003 (0.002)	[-0.001, 0.006]	0.003 (0.002)	[-0.001, 0.006]
Specialization	-0.021 (0.258)	[-0.526, 0.485]	- 0.012(0.25)	[-0.517, 0.492]
Contract farming	0.053 (0.180)	[-0.300, 0.406]	0.072 (0.17)	[-0.26, 0.405]
Hired agronomist	0.360 (0.168)	[0.030, 0.689]	0.398 (0.165)	[0.075, 0.721]
Workers	0.057 (0.029)	[0.001, 0.114]	0.061 (0.029)	[0.005, 0.117]
Livestock	0.459 (0.189)	[0.088, 0.830]	0.447 (0.187)	[0.08, 0.814]
Irrigation system condition	0.058 (0.104)	[-0.145, 0.261]	0.069 (0.103)	[-0.134, 0.271]
Economic and institutional environment				
Access to land	0.133 (0.172)	[-0.203, 0.469]	0.119 (0.168)	[-0.211, 0.448]
Credit obtained	0.104 (0.171)	[-0.231, 0.439]	0.088 (0.171)	[-0.247, 0.423]
Nonfarm income	0.395 (0.156)	[0.090, 0.700]	0.374 (0.154)	[0.073, 0.676]
Economic access to variable inputs	0.158 (0.100)	[-0.038, 0.354]	0.149 (0.098)	[-0.043, 0.341]
Physical access to variable inputs	0.464 (0.157)	[0.156, 0.771]	0.469 (0.155)	[0.166, 0.772]
Maktaaral	1.503 (0.373)	[0.773, 2.233]	1.474 (0.372)	[0.745, 2.204]
Shardara	1.721 (0.345)	[1.045, 2.397]	1.696 (0.344)	[1.022, 2.371]
N	503		503	
Pseudo R2	0.1549		0.1583	

Source: SUSADICA Farm Survey 2019. Own calculations.

Next, I present the results for the relationship between bundles of perceived land rights and total assets and asset diversity among Uzbekistan sampled farmers, using negative binomial model (Table 11 and Table 12). As before, Model 1 includes perceived protection rights while Model 2

includes perceived land expropriation risk. To begin with, in Model 1 of Table 11, three of the four land rights bundles have negative coefficients, with use rights standing out as both sizable relative to its standard error and statistically robust: the coefficient is −0.174 (SE 0.066) and the 95% CI excludes zero (−0.303 to −0.040). This pattern indicates a clear negative association between perceived use rights and total assets in the Uzbekistan sample. In contrast, management rights show a positive and robust association with total assets (0.119 vs. SE 0.044; 95% CI: 0.031 to 0.206), making it the strongest positive correlate among the bundles. Transfer rights are negative (−0.106 vs. SE 0.054), but the confidence interval narrowly includes zero (−0.212 to 0.001), suggesting the evidence is weak, while protection rights are also negative but imprecisely estimated (CI includes zero). In Model 2, replacing protection rights with expropriation risk yields a small positive coefficient (0.040 vs. SE 0.033) with a confidence interval that includes zero (−0.024 to 0.104), providing limited evidence of an association. Overall, in the Uzbekistan sample, the estimated relationships between most bundles of perceived land rights and total machinery and equipment assets are in opposite direction, which contrasts with the patterns reported for the Kazakhstan sample.

Next, the results for the control variables for Uzbekistan sample are presented. Among farmer characteristics, farmer age, education, and risk attitude have the expected signs, similar to the Kazakhstan sample, but the coefficients are not robust in either model. Among farm characteristics, farm age shows a positive coefficient of 0.019 (SE 0.004) [0.011, 0.028], suggesting that older Uzbekistan farms tend to have more total assets. Farm size also exhibits a positive coefficient of 0.004 (0.002) [0.001, 0.007], indicating a positive relationship with total assets. By contrast, having a hired agronomist is associated with lower total assets, with a negative coefficient of −0.518 (0.135) [−0.783, −0.254]. The number of workers shows a positive coefficient of 0.053 (0.012) [0.029, 0.077], suggesting more workers are associated with higher asset levels. The relationship between irrigation system condition and total assets is also negative and robust. Next, physical access to variable inputs has a positive coefficient of 0.108 (0.038) [0.034, 0.182], suggesting that, as in Kazakhstan, farmers invest more in machinery and equipment when facing input access constraints. In contrast, access to land exhibits a negative coefficient of −0.200 (0.070) [−0.337, −0.062], suggesting that as expanding farm size becomes possible, Uzbekistan farmers may find invest in farm machinery and equipment less attractive. District effects appear less pronounced than in Kazakhstan, with the coefficients for Pastdargom and Payarik being −0.087 (0.435) [−0.938, 0.765] and −0.245 (0.438) [−1.103, 0.613], respectively, with confidence intervals including zero.

Table 11. Relationship between perceived land rights and total assets in Uzbekistan

Negative binomial model	Coef (SE) (1)	95% [CI]	Coef (SE) (2)	95% [CI]
Use rights	-0.174 (0.066)	[-0.303, -0.04]	-0.180 (0.066)	[-0.309, -0.050]
Management rights	0.119 (0.044)	[0.031, 0.206]	0.113 (0.045)	[0.026, 0.201]
Transfer rights	-0.106 (0.054)	[-0.212, 0.001]	-0.102 (0.055)	[-0.21, 0.007]
Protection rights	-0.107 (0.062)	[-0.229, 0.015]	Excluded	Excluded
Expropriation risk	Excluded	Excluded	0.040 (0.033)	[-0.024, 0.104]
Farmer-specific variables				
Farmer age	-0.003 (0.003)	[-0.009, 0.003]	-0.003 (0.003)	[-0.009, 0.003]
Education	0.068 (0.067)	[-0.064, 0.200]	0.060 (0.067)	[-0.071, 0.192]
Risk attitude	0.060 (0.034)	[-0.007, 0.126]	0.053 (0.034)	[-0.014, 0.120]
Farm-specific variables				
Farm age	0.019 (0.004)	[0.011, 0.028]	0.018 (0.004)	[0.010, 0.027]
Farm area	0.004 (0.002)	[0.001, 0.007]	0.004 (0.002)	[0.001, 0.007]
Specialization	0.077 (0.431)	[-0.768, 0.922]	0.087 (0.433)	[-0.761, 0.935]
Contract farming	-0.228 (0.182)	[-0.585, 0.130]	-0.211 (0.185)	[-0.573, 0.151]
Hired agronomist	-0.518 (0.135)	[-0.783, -0.25]	-0.535 (0.135)	[-0.801, -0.27]
Workers	0.053 (0.012)	[0.029, 0.077]	0.055 (0.012)	[0.03, 0.079]
Livestock	0.003 (0.192)	[-0.373, 0.380]	0.02 (0.194)	[-0.361, 0.401]
Irrigation system condition	-0.144 (0.044)	[-0.23, -0.058]	-0.145 (0.044)	[-0.231, -0.058]
Economic and institutional environment				
Access to land	-0.200 (0.070)	[-0.337, -0.06]	-0.206 (0.071)	[-0.344, -0.068]
Credit obtained	0.060 (0.066)	[-0.069, 0.188]	0.067 (0.066)	[-0.062, 0.195]
Nonfarm income	-0.038 (0.071)	[-0.178, 0.102]	-0.032 (0.072)	[-0.174, 0.109]
Economic access to variable inputs	-0.052 (0.049)	[-0.148, 0.045]	-0.057 (0.049)	[-0.153, 0.039]
Physical access to variable inputs	0.108 (0.038)	[0.034, 0.182]	0.105 (0.038)	[0.031, 0.18]
Pastdargom	-0.087 (0.435)	[-0.938, 0.765]	-0.096 (0.436)	[-0.95, 0.758]
Payarik	-0.245 (0.438)	[-1.103, 0.613]	-0.244 (0.439)	[-1.105, 0.617]
N	460		460	
Pseudo R2	0.0827		0.0821	

Source: SUSADICA Farm Survey 2019. Own calculations.

Table 12 shows the results of the relationship between perceived land rights and asset diversity in Uzbekistan. Generalized linear model (GLM) was used to obtain the estimates. It can be observed that the estimated coefficients for all examined land rights are negative similar to

findings for total assets in Uzbekistan sample. The coefficients for perceived management rights and perceived transfer rights are −0.041 (0.070) [−0.179, 0.096] and −0.080 (0.094) [−0.265, 0.104], respectively, with confidence intervals including zero, indicating limited evidence of a relationship with asset diversity. Even management rights, which were previously positive and moderately associated with total assets, now lost robustness. Additionally, the results for use rights qualitatively did not change much for asset diversity, indicating the presence of strong negative association between use rights and diversifying farm machinery and equipment. Perceived protection rights have a coefficient of −0.126 (0.106) [−0.333, 0.082], with a wide confidence interval that also includes zero. In Model 2, the coefficient on perceived land expropriation risk for asset diversity in the Uzbekistan sample is not robust, but its sign differs from the positive association observed for total assets. This pattern is suggestive that higher perceived expropriation risk may be linked to lower diversity in machinery and equipment holdings, similar to the result observed for asset diversity in the Kazakhstan sample.

Next, the results for the control variables are presented. Overall, the findings for the control variables are largely consistent with the previous results for total assets, with a few exceptions. The relevance of land area diminishes, while economic access to variable inputs gains importance. Specifically, as farmers find more variable inputs economically inaccessible, they tend to have fewer asset diversity. Beyond these differences, asset diversity shows a positive relationship with farm age, number of workers, and physical access to variable inputs. In contrast, it is negatively associated with hiring an agronomist, irrigation system quality, access to land, and economic access to variable inputs.

Several cross-setting patterns emerge from the control variables. Most notably, farm age and access to variable inputs are consistently and positively associated with higher levels of farm machinery and equipment in both settings, indicating that earlier-established farms tend to accumulate more machinery assets over time. In the Kazakhstan setting, farmers operating in cotton-specialized districts report significantly higher levels of farm machinery and equipment, a pattern that is not observed in the Uzbekistan setting. By contrast, farm size is positively associated with machinery and equipment levels in Uzbekistan, but no such relationship is evident in Kazakhstan.

Table 12. Relationship between perceived land rights and asset diversity in Uzbekistan

Generalized linear model	Coef (SE) (1)	95% [CI]	Coef (SE) (2)	95% [CI]
Use rights	-0.251 (0.105)	[-0.457, -0.04]	-0.271 (0.107)	[-0.480, -0.062]
Management rights	-0.041 (0.070)	[-0.179, 0.096]	-0.027 (0.073)	[-0.170, 0.116]
Transfer rights	-0.080 (0.094)	[-0.265, 0.104]	-0.099 (0.096)	[-0.288, 0.089]
Protection rights	-0.126 (0.106)	[-0.333, 0.082]	Excluded	Excluded
Expropriation risk	Excluded	Excluded	-0.024 (0.056)	[-0.134, 0.085]
Farmer-specific variables				
Farmer age	-0.003 (0.005)	[-0.012, 0.007]	-0.003 (0.005)	[-0.012, 0.007]
Education	0.177 (0.103)	[-0.024, 0.378]	0.161 (0.102)	[-0.039, 0.361]
Risk attitude	0.056 (0.054)	[-0.051, 0.163]	0.058 (0.055)	[-0.050, 0.167]
Farm-specific variables				
Farm age	0.031 (0.007)	[0.017, 0.045]	0.031 (0.007)	[0.017, 0.045]
Farm area	0.001 (0.003)	[-0.004, 0.006]	0.001 (0.003)	[-0.005, 0.006]
Specialization	0.185 (0.234)	[-0.274, 0.644]	0.236 (0.206)	[-0.168, 0.640]
Contract farming	-0.255 (0.256)	[-0.757, 0.246]	-0.238 (0.257)	[-0.741, 0.266]
Hired agronomist	-0.740 (0.150)	[-1.035, -0.44]	-0.757 (0.152)	[-1.054, -0.460]
Workers	0.060 (0.022)	[0.016, 0.103]	0.058 (0.022)	[0.014, 0.102]
Livestock	0.071 (0.338)	[-0.591, 0.733]	0.046 (0.339)	[-0.618, 0.711]
Irrigation system condition	-0.149 (0.072)	[-0.29, -0.007]	-0.150 (0.073)	[-0.293, -0.008]
Economic and institutional environment				
Access to land	-0.286 (0.106)	[-0.49, -0.078]	-0.298 (0.107)	[-0.508, -0.089]
Credit obtained	0.098 (0.113)	[-0.124, 0.319]	0.097 (0.113)	[-0.124, 0.317]
Nonfarm income	-0.075 (0.112)	[-0.295, 0.145]	-0.079 (0.112)	[-0.298, 0.141]
Economic access to variable inputs	-0.197 (0.074)	[-0.342, -0.05]	-0.215 (0.073)	[-0.358, -0.071]
Physical access to variable inputs	0.196 (0.058)	[0.082, 0.310]	0.184 (0.058)	[0.07, 0.299]
Pastdargom	0.010 (0.250)	[-0.48, 0.501]	-0.049 (0.223)	[-0.486, 0.387]
Payarik	-0.353 (0.266)	[-0.874, 0.169]	-0.406 (0.242)	[-0.881, 0.069]
N	460		460	
Log pseudolikelihood	-653.510		-654.139	

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: Log pseudolikelihood smaller negative value indicates better fitting model.

Table 13 and Table 14 present the regression results incorporating Modified Use and Management rights. Specifically, I changed the composition of previous bundle of use rights by replacing the right to convert land for other uses (e.g., animal grazing) with the right to choose crop type, and omitting the latter right from Management bundle to avoid using this right in both bundles. The composition of transfer and protection bundles along with control variables remain same. If the results reported earlier change when perceived crop-choice rights are included or omitted, this suggests that crop-choice autonomy is relatively important among the bundles examined in these settings. For ease of readability and to avoid repetition, the estimation results for the control variables are omitted. The results for the control variables in the modified bundles analysis remain unchanged from the baseline specifications; therefore, the discussion here focuses on the perceived land rights bundles.

Panel A and B of Table 13 demonstrate the results of estimations for Kazakhstan for total assets and asset diversity, respectively. After adding the right to choose crop type to the use-rights bundle, two changes are noteworthy. First, the previously observed relationship between perceived use rights and investments increased quite substantially. For example, the coefficient of use rights and total assets increased, by around 50%, from 0.512 (in Table 9, model 1) to 0.754 (Table 13, Panel A, model 1). Similarly, the coefficient of use rights and asset diversity increased from 0.424 (in Table 10, model 1) to 0.705 (Table 13, Panel B, model 1). Clearly, among sampled farmers in Kazakhstan, the data tell that autonomy in selecting crop types appears more important than autonomy in converting land for other uses (e.g., livestock). Second, omitting the right to choose crop type from the bundle of management rights led to a reduction in the coefficient for total assets compared to initial estimations in Table 9 and Table 10, and for the case of asset diversity the sign of coefficient for management bundle turned negative, suggesting the relevance of crop choice freedom in investment incentives among sampled farmers in Kazakhstan. Using modified bundles of use and management rights, did not alter the previous findings for other land rights. Particularly, the negative relationship, although not strongly robust, remains between land expropriation risk and lower asset diversity among Kazakhstan farmers.

Similarly, for the Uzbekistan sample, as indicated in Table 14, the estimated coefficients for the relationship between land rights and farm machinery and equipment ownership remain largely consistent with the previous analysis. Specifically, use rights continue to show a strong negative association with both asset diversity and total assets, while only management rights remain positively and strongly associated with total assets. The relationship between perceived transfer rights and investments remains negative and weak. As in Kazakhstan, the coefficient for the modified bundle of use rights and investments in Uzbekistan also changed slightly. However, the

magnitude was smaller, and the coefficient actually decreased. This suggests that the investment disincentive linked to stronger use rights may diminish when farmers have greater autonomy in crop choice, as opposed to autonomy in changing land purpose. In other words, for Uzbek farmers, the ability to choose crops may help offset constraints imposed by land use regulations, such as specialization requirements. However, the changes in the composition of management rights in Uzbekistan did not alter the results that there is positive relationship between perceived management rights and total assets.

In summary, the results suggest that operational land rights play a key role in shaping investment incentives for farmers in both Kazakhstan and Uzbekistan. In Kazakhstan, use rights, and to some extent, expropriation risk, appear particularly influential, while in Uzbekistan, management and use rights are more relevant. Notably, only in Uzbekistan is there strong evidence that certain rights, such as use rights, may actually discourage investment. Land tenure security and transfer rights appear to be weak indicators of investment motivation in both samples, though there is some evidence that expropriation risk may be more relevant than protection rights for investments such as diversification of farm machinery and equipment. Last but not least, as discussed in the theoretical literature, the two investment outcomes examined here capture distinct farm strategies: higher total machinery and equipment holdings reflect production intensification, whereas greater asset diversity reflects production diversification into additional activities. The results suggest that these strategies relate differently to perceived tenure constraints across the two settings. In both countries, diversification appears more sensitive to tenure risks, while operational freedom, captured by perceived use and management rights, seems more relevant for intensification, and also for diversification particularly in Kazakhstan.

Table 13. Relationship between modified perceived land rights and total assets/asset diversity in Kazakhstan

Panel A: Total assets (Negative binomial model)	Coef (SE) (1)	95% [CI]	Coef (SE) (2)	95% [CI]
Modified Use rights	0.754 (0.324)	[0.118, 1.390]	0.736 (0.325)	[0.099, 1.372]
Modified Management rights	0.056 (0.189)	[-0.315, 0.427]	0.030 (0.196)	[-0.35, 0.414]
Transfer rights	0.028 (0.068)	[-0.104, 0.161]	0.012 (0.066)	[-0.118,0.143]
Protection rights	-0.178 (0.13)	[-0.447, 0.091]	Excluded	
Expropriation risk	Excluded		-0.036 (0.114)	[-0.260,0.188]
Control variables	Included		Included	
N	503		503	
Pseudo R2	0.1452		0.1437	
Panel B: Asset diversity (Negative binomial model)				
Modified Use rights	0.705 (0.276)	[0.163, 1.246]	0.688 (0.279)	[0.141, 1.234]
Modified Management rights	-0.033(0.186)	[-0.397, 0.331]	-0.095 (0.188)	[-0.463,0.273]
Transfer rights	0.054 (0.062)	[-0.067, 0.176]	0.053 (0.06)	[-0.064, 0.17]
Protection rights	-0.025(0.113)	[-0.247, 0.196]	Excluded	
Expropriation risk	Excluded		-0.164 (0.078)	[-0.317, -0.01]
Control variables	Included		Included	
N	503		503	
Log pseudolikelihood	0.1585		0.1621	

Source: SUSADICA Farm Survey 2019. Own calculations.

Note: Sets of control variables include farmer and farm characteristics, economic and institutional environment and districts (following Equation 2). Standard errors in parentheses.

Table 14. Relationship between modified perceived land rights and total assets/asset diversity in Uzbekistan

Panel A: Total assets (Negative binomial model)	Coef (SE) (1)	95% [CI]	Coef (SE) (2)	95% [CI]
Modified Use rights	-0.121 (0.065)	[-0.249, 0.006]	-0.13 (0.066)	[-0.26,-0.004]
Modified Management rights	0.128 (0.048)	[0.034, 0.222]	0.121 (0.049)	[0.026, 0.217]
Transfer rights	-0.104 (0.054)	[-0.209, 0.002]	-0.097(0.055)	[-0.204,0.010]
Protection rights	-0.112 (0.062)	[-0.235, 0.010]	Excluded	
Expropriation risk	Excluded		0.046 (0.033)	[-0.018, 0.11]
Control variables	Included		Included	
N	460		460	
Pseudo R2	0.0818		0.0813	
Panel B: Asset diversity (Generalized linear model)				
Modified Use rights	-0.280 (0.107)	[-0.489,-0.07]	-0.292(0.107)	[-0.50, -0.08]
Modified Management rights	-0.049 (0.076)	[-0.198, 0.100]	-0.039(0.079)	[-0.195,0.116]
Transfer rights	-0.076 (0.093)	[-0.258, 0.106]	-0.091(0.095)	[-0.276,0.094]
Protection rights	-0.128 (0.105)	[-0.335, 0.078]	Excluded	
Expropriation risk	Excluded		-0.010(0.055)	[-0.118,0.097]
Control variables	Included		Included	
N	460		460	
Log pseudolikelihood	-652.702		-653.452	

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: Sets of control variables include farmer and farm characteristics, economic and institutional environment and districts (following Equation 2). Standard errors in parentheses.

4.1.2 Discussion of the main findings

Decision-making freedom from having stronger operational rights give farmers confidence that they can generate profits from pursuing profitable investment activities and be confident that they can appropriate returns from these investments. This has been noted by Brasselle et al. (2002) highlighting 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. Research suggests that farmers acquire diverse farm assets in response to market and weather fluctuations (Takeshima and Yamauchi, 2012). Therefore, a stronger and more complete bundle of operational rights may enable farmers to diversify their on-farm activities, allowing them to expand their asset base as a strategy to mitigate agricultural income losses from various shocks.

Greater land expropriation risk, contrary to general beliefs (Feder and Nishio, 1998), appeared to provide weaker incentives for Kazakhstan and Uzbekistan farmers to invest in farm machinery and equipment. As expected, unlike land-related investments, investments in movable farm assets are less sensitive to the risk of land loss, as farmers can recoup these investments through sale or rental. As noted by Feder et al. (1992, p. 20), tenure risks may not hinder productive investments when "… the transaction costs of capital stock adjustment in response to land reallocation might have been perceived to be minor." This suggests that not all farmers perceive high transaction costs when investing in movable farm assets, even in the presence of future tenure risks. There was some evidence suggesting that land expropriation risk is associated with reduced asset diversity than with lower total assets especially in Kazakhstan. This indicates that, diversifying farm assets may be more vulnerable to tenure risks. A possible explanation is that asset diversification is often linked to engaging in a variety of on-farm activities. When the risk of land expropriation is high, farmers may scale back diversification efforts, possibly because uncertainty over land tenure discourages them from maintaining multiple agricultural activities. As a result, they may acquire fewer assets that support different activities, leading to a more cautious investment strategy. One such on-farm activity mentioned by Smith (2004) is livestock ownership, where farmers may make fixed investments, such as fencing, to support their livestock operations. In fact, in the Kazakhstan sample, more than 15% of farmers owned livestock. Given this, higher land expropriation risk may lead this group of farmers to scale back investments in livestock-supporting technologies such as feed processing technologies, threshers, and milling equipment. The potential loss of land could discourage farmers from acquiring complementary income-earning assets.

The prevailing view among economists is that transfer rights—particularly 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, findings from the Kazakhstan sample revealed no strong association between transfer rights and investment in movable farm assets. These results align with Brasselle et al. (2002) and Omura (2008), who also found limited evidence for the role of certain transfer rights in promoting investment in land. Brasselle et al. (2002) argue that in settings where land markets are underdeveloped, possessing transfer rights may have no noticeable effect on investment incentives. Similarly, though from a different perspective, Omura (2008) suggests that transfer rights are more relevant for high-cost, immobile land infrastructure investments.

The context matters. The land sales market in Kazakhstan remains underdeveloped (Kvartiuk and Petrick, 2021). Instead, farmers in Kazakhstan tend to adjust their farm size through both formal

and informal rental markets (Kvartiuk and Petrick, 2021; Mukhamedova and Pomfret, 2019). Therefore, it is less likely that lack of access to additional land is the reason behind limited role of transfer rights on investment incentives. In fact, background variables from the sample indicate that more than 60% of respondents in Kazakhstan reported that they could obtain land if needed. While access to more land would typically increase demand for farm machinery, farmers may not acquire their own equipment solely in response to improved transfer rights—especially when rental options are available. Instead, as discussed earlier, it is the ability to engage in more profitable on-farm activities, such as crop diversification or livestock production, that likely drives the motivation to invest in machinery ownership, rather than the mere freedom to expand farm size.

Lastly, the evidence from Kazakhstan sample does not support the notion that stronger management and protection rights strongly increase investment incentives. This finding contradicts my expectations that enhanced managerial decision-making and greater protection rights (presence of strong, independent courts and having credible land documents) should empower farmers and provide the security needed to invest in their farms (Zorya et al., 2019). One possible explanation for the weak association between management rights and investment is that the benefits of participating in input markets and accessing marketing channels may be relatively uniform among the sampled farmers in Kazakhstan. Despite a more liberal market environment, some scholars note that Kazakhstan farmers continue to face input constraints, particularly in accessing modern yield-enhancing seeds and fertilizers, as well as the high costs of variable inputs (Shtaltovna and Hornidge, 2014). As a result, higher perceptions of management rights may not necessarily translate into increased investment in farm machinery and equipment. Another possible explanation is that farmers in the Kazakhstan sample may hold relatively similar perceptions of management rights, which could lead to a lack of visible relationships in the regression results.

Further, observing no strong association between better protection rights and investments in farm machinery and equipment in both samples is surprising. As I measured protection bundle in this study, the protection rights (courts, present of land documents) may be a less direct indicator of land tenure risks. When farmers make investment decisions, they may not consider all sources of insecurity to the same extent (Linkow, 2016) and rather focus on tenure risks that impose direct costs on them (Zhllima et al., 2010). So, for sampled farmers land expropriation risks may pose a greater threat to their economic activities than general protection rights.

Next, I continue describing findings focusing on Uzbekistan sample. Contrary to theoretical predictions (Besley, 1995; Feder and Nishio, 1998), the findings from Uzbekistan do not support

the presence of a strong association between land tenure security—measured through protection rights and land expropriation risk—and investments in movable farm assets. The relationships were not strong and showed ambiguous signs. This aligns with other studies documenting weak or no 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 machinery and equipment, may be perceived by farmers as relatively risk-free and reversible, posing minimal conflict with government land policies (Oberkircher, 2011). So, Uzbekistan farmers when investing in farm machinery and equipment may not consider tenure risks as the biggest barrier because they can recoup these investments in case they lose access to land. 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 (I interpret 'normalization' as the state in which farmers no longer perceive land tenure insecurity as a concern.); 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. The data they report seem to contradict their arguments about Uzbek farmers becoming insensitive to tenure risks. The weak relationship between land expropriation risk and investments in movable farm assets among Uzbekistan farmers is most likely due to the mobility of such investments. Additionally, unlike in the Kazakhstan sample, where land expropriation risk was somewhat associated with lower asset diversity, in Uzbekistan sample there may be a positive association between increased land expropriation risk and total assets. Uzbekistan farmers may respond to tenure insecurity by acquiring additional farm assets of the same type. This pattern aligns with Oberkirscher's (2011) argument that Uzbekistan farmers tend to make investments (e.g., irrigation pumps installed outside farmlands near irrigation water source) that do not interfere with prevailing land policies.

Next, the observed positive relationship between management rights and investment in movable assets aligns with my expectations that greater managerial freedom fosters investment decisions (Zorya et al. 2019). Even while farming under Uzbekistan's heavily regulated agricultural sector, Uzbekistan 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 I conducted, which revealed that the relationship between management rights and total assets did not change much when the right to choose crop types was excluded from the management bundle. Under strict land tenure arrangements limiting crop choice freedom, some Uzbekistan farmers may instead

rely more on exercising managerial freedom to enhance farm productivity and income, and therefore find investments in farm machinery and equipment profitable.

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 my 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, where economic incentives from farming are suboptimal and land use is heavily controlled, farmers may lack sufficient motivation to prioritize agricultural investments. Within an economically unprofitable system, farmers with stronger perceptions of use and transfer rights may find it rational to allocate land to alternative income-generating activities rather than investing in productivity-enhancing measures within their own specialization. Potential informal strategies could involve renting out land to other producers in exchange for rental payments or farm managers themselves cultivating informally high-value crops that stay outside government oversight. Therefore, farmers with greater freedom in land use may be more inclined to reduce agricultural investments in in low-return production like cotton.

The findings obtained in the dissertation contributes to relevant literature in several ways. In the literature related to land rights-investment relationship, the prevailing belief is that the most significant land tenure constraints are land tenure insecurity and limited transfer rights. However, evidence from Kazakhstan and Uzbekistan challenges these assumptions—at least for the case of investments in farm machinery and equipment (movable farm assets). The findings suggest that investment incentives among sampled farmers primarily related to operational rights, such as use rights and management rights. Although operational rights are said to be increasing short-term productivity, as noted by Deininger (2021, p. 2), and are believed less critical than transfer and land tenure security rights, the results indicate otherwise. In both settings, stronger use and management rights, appear to provide long-term investment incentives, as reflected by higher accumulation farm machinery and equipment. These findings broaden our understanding of the mechanisms through which investment incentives emerge. By using bundles of land rights approach, I was able to disaggregate conceptually distinct bundles of land rights which made it possible to isolate investment incentives stemming from different channels. Farmers' willingness to invest should not be explained only by how secure or transferable their land rights are, but also by how much operational autonomy and flexibility those tenure arrangements allow in

practice. This evidence adds to emerging findings from other studies like Brasselle et al. (2002) who highlight the importance of basic use rights.

Additionally, this study contributes to the literature by responding to calls to better account for methodological and contextual differences that make synthesis of existing evidence difficult (e.g., Besley, 1995; Fenske, 2011; Lawry et al., 2017). To do so, I compare Kazakhstan and Uzbekistan—two neighboring settings where farmers produce similar crops under comparable cultural and biophysical conditions but operate under distinct institutional environments—using identical survey questions and measurement approaches. Results indicate that, during the study period, Uzbekistan's unfavorable business climate, particularly for strategic-crop farmers, was associated with weaker investment incentives. This is reflected in the opposite directions of the associations between perceived land rights and investments in farm machinery and equipment in Uzbekistan compared to Kazakhstan. Together, these patterns suggest that weak economic incentives and heavy regulation of farmers' property rights can dampen investment even when land tenure is formally individualized.

Based on the obtained results, I draw the following policy implications for Kazakhstan:

Prioritize operational autonomy, especially crop-choice flexibility. The results are most consistent with the interpretation that use rights—particularly crop-choice autonomy—are the tenure dimension most closely associated with higher machinery and equipment asset holdings among sampled farmers in Kazakhstan. This suggests that policies aimed at stimulating investment in movable farm assets may benefit from prioritizing greater operational freedom within farms' production decisions, including flexibility over crop portfolios and related management choices.

Strengthen perceived land tenure security to support diversification of machinery and equipment. While most land-rights bundles show limited evidence of association with investment outcomes, the asset-diversity results indicate that higher perceived expropriation risk is linked to lower diversification of machinery and equipment. This pattern is consistent with the view that experimentation and gradual diversification of farm technologies may require credible expectations of continued land access and predictable tenure conditions. Policy efforts that strengthen perceived land tenure security and reduce uncertainty around land retention may therefore support diversification-oriented investment.

Complement legal reforms with communication, transparency, and awareness-building. Tenure-related policy changes can only shape behavior if farmers are aware of them and view them as credible. In Central Asian rural contexts, awareness of land users' rights and obligations may be incomplete, and farmers' interpretations of existing tenure arrangements may lag behind formal

reforms. Alongside legal measures (e.g., greater operational autonomy and stronger tenure security), Kazakhstan policymakers should therefore prioritize clear communication and transparency: disseminate information on tenure rules and reforms—especially improvements in farmers' autonomy and security—through public channels (TV, radio, newsletters) and reinforce messages through farmer unions and local government-led meetings. These efforts can help farmers update their understanding of the tenure environment and align perceptions with the intended direction of reforms.

Complement tenure measures with capability-building and predictable investment environments. Investment in modern machinery typically requires learning, planning, and adjustment. Even if land-rights improvements enhance incentives, farmers may still face barriers related to information and skills. Extension and training that improve farmers' education and familiarity with machinery options, operation requirements, and investment planning may help translate incentives into effective adoption and use.

Pair tenure measures with investment finance that matches long planning horizons. The results also point to the importance of household financial capacity (e.g., livestock holdings and nonfarm income) as correlates of asset accumulation, suggesting that some farmers rely on internal resources to finance equipment. Because this channel is unlikely to be sufficient for more expensive technologies, policies that expand access to affordable, longer-horizon financing (e.g., cheaper credit, leasing, or subsidy schemes) may be necessary complements to tenure-related measures.

A forward-looking note on transfer rights. Transfer rights show limited evidence of association in the current Kazakhstan setting, but their relevance may increase if formal land markets develop and become a meaningful channel for investment incentives. In that case, strengthening transparent and predictable transfer mechanisms (e.g., easy and less costly participation in land lease tenders and sale) could become more important over time.

Next, I draw policy actions for Uzbekistan:

Prioritize management autonomy as the most relevant rights bundle for investment. The results for Uzbekistan indicate that management rights are the land-rights dimension most closely associated with higher machinery and equipment asset holdings. This suggests that policies aiming to stimulate investment in movable farm assets should prioritize greater managerial autonomy, including farmers' ability to organize production decisions and operate their farm businesses with fewer administrative constraints.

Strengthen perceived land tenure security to support experimentation and diversification. Although land tenure security does not emerge as a consistently strong correlate of total asset holdings, investment in new machinery and equipment often requires learning, experimentation, and longer planning horizons. Policies that improve perceived land tenure security—by reducing farmers' concerns about losing land—may therefore be particularly important for encouraging gradual modernization and, over time, more diversified technology portfolios.

If crop-choice liberalization is constrained, expand management freedom within crop specialization. If further relaxing crop-choice restrictions is politically difficult, a practical second-best approach is to expand farmers' discretion within existing crop specialization (e.g., cotton and wheat). This includes giving farmers more freedom to plan production activities, choose technologies, organize labor, and make operational adjustments, even if the crop portfolio remains regulated.

Align rights reforms with economic incentives in regulated crop systems. The Uzbekistan results also underscore that expanding rights on paper may not translate into higher investment if farming remains insufficiently profitable. In regulated crop systems, improving incentives requires strengthening farmers' economic returns and decision-making power. A starting point is to expand autonomy in marketing, pricing, and buyer choice, and to strengthen farmers' effective ownership over output revenues. Support for direct marketing channels, including access to export markets where feasible, can further increase the payoff to productivity-enhancing investments.

Remember the cost side: reduce production costs. Raising investment incentives also requires addressing production costs. If cotton production remains input-intensive and costly, farmers may have limited capacity to invest even when rights improve. Measures that support a shift away from highly input-intensive practices, where agronomic evidence supports it, can reduce costs and may also improve environmental performance.

Communication and long planning horizons. Similar to Kazakhstan, legal reforms in Uzbekistan are more likely to translate into higher investment if farmers perceive them as credible and have time to adjust their plans. Given ongoing reforms in Uzbekistan, policymakers should strengthen communication, transparency, and awareness by clearly explaining tenure rules and improvements in autonomy and security through TV, radio, newsletters, and channels such as farmer organizations and local government-led meetings. At the same time, policy design should recognize that machinery modernization is gradual and requires learning and long planning

horizons, which reinforces the need for stable tenure conditions and complementary support that facilitates long-term investment planning.

Several limitations should be acknowledged. First, it should be noted that the results mostly pertain to investment in machinery and equipment holdings; investments in land-attached assets and variable inputs have different financial horizon in returns for example, and different adjustment costs. I address broader generalizability to other investment types in the Conclusion. Second, the bundling approach used in this study represents just one possible way to categorize land rights. Future research could explore alternative bundling frameworks, such as disaggregating income rights, duration as described by Slangen and Polman (2008). This would enhance our understanding of how different constraints in land tenure shape investment behavior. Second, this study did not address the potential endogeneity of perceived land rights, particularly the possibility of a reverse relationship. It is possible that farmers with higher levels of technology, could feel more tenure secure for example. While in many post-socialist contexts, property rights allocation is largely determined by top-down government policies (Ho and Spoor, 2006; Kapeliushnikov et al., 2013) rather than by farmers' land claims, as is common under customary tenure, there remains a possibility that acquiring farm machinery and equipment itself strengthens farmers' perceptions of land rights. By acquiring farm machinery and equipment farmers may signal government their 'commitment' to farm business, potentially reinforcing farmers' confidence in their land tenure security and potentially higher decision-making autonomy in various production decisions. This concern may be particularly relevant in Uzbekistan, where state involvement in agriculture remains strong. Additionally, perceptions of certain land rights may increase alongside access to farm support programs such as subsidies. If farmers' decisions to acquire machinery and equipment are influenced by their ability to secure investment subsidies, this could simultaneously enhance their perceptions of land use freedoms, particularly in relation to cultivating government-recommended priority crops. Exploring this further could provide valuable insights into the interplay between land rights, policies, and investment behavior, making them promising avenues for future research on the land rights–investment relationship.

4.2 Time preference and investment in farm machinery and equipment

The results section for Research question 2 is organized as follows. First, in Subsection 4.2.1, I present the findings for the relationship between farmers' time preferences and their investments in farm machinery and equipment, using total assets and asset diversity as dependent variables for Kazakhstan and Uzbekistan samples, respectively. Next, in Subsection 4.2.2, I present the findings of whether the relationship between time preference and total assets/asset diversity differs under high and low perceived tenure security conditions as measured by perceived land expropriation risk and perceived government intervention. Econometric models used in each regression analysis are indicated in relevant tables. The Subsection 4.2.3 discusses findings, and summarizes the contributions to literature, and policy implications and limitations. Because most control variables used in Research Question 1 are also included in Research Question 2, coefficients for controls are omitted. Full regression outputs are available upon request.

4.2.1 Time preference and machinery/equipment asset counts and diversity

The estimation results on the relationship between time preference and total assets/asset diversity are presented in Tables 15-18. Following the analytical steps outlined in Subsection 3.4.2, I included one by one sets of relevant correlates of time preference, namely financial, personal and environmental correlates. Control variables are listed below the tables.

Table 15 presents the estimation results for the relationship between time preference and total assets among Kazakhstan farmers. Model 1, which includes only time preference as an explanatory variable, the coefficient is negative (-0.216 with standard error 0.109 and 95% CI of [-0.43, -0.002]). The standard error is approximately half the size of the coefficient, indicating a moderate relationship between time preference and total assets. As control variables are added, the time preference coefficient decreases in magnitude, and the confidence interval widens to include zero (Model 5). In Model 5, which includes all control variables, the coefficient on time preference increases in magnitude (-0.262) while the standard error sharply decreases (0.009), reinforcing a stronger negative relationship, providing evidence that time preference is negatively related to total assets. These results indicate that high time preference (or unwillingness to wait for larger but delayed rewards) may discourage investment in farm machinery and equipment reducing accumulation of productive assets among sampled farmers in Kazakhstan.

Table 16 presents the estimation results for the relationship between time preference and asset diversity among Kazakhstan farmers. The results closely mirror those found earlier for total assets. Across all models, the coefficient remains negative, and its magnitude generally decreases

until broader control variables are introduced in Model 5. This confirms that farmers who have a strong preference for immediate but smaller rewards over larger delayed rewards are less reluctant to invest and, as a result, tend to have fewer farm movable assets accumulated over time. Additionally, a notable observation is that the coefficients for asset diversity remain quantitatively similar to those for total assets.

Table 15. Relationship between time preference and total assets in Kazakhstan

Negative binomial model	Coef (SE), [95% CI]				
	(1)	(2)	(3)	(4)	(5)
Time preference	-0.216 (0.109) [-0.43, -0.002]	-0.171 (0.106) [-0.38, 0.04]	-0.136 (0.115) [-0.36, 0.09]	-0.145 (0.112) [-0.36, 0.07]	-0.262 (0.009) [-0.43, -0.09]
Sets of control variables Included	Not included				
Financial correlates		Included	Included	Included	Included
Personal correlates			Included	Included	Included
Environmental correlates				Included	Included
Other control variables					Included
N	503	503	503	503	503
Pseudo R2	0.0055	0.0230	0.0316	0.0337	0.1107

Source: SUSADICA Farm Survey 2019. Own calculations.

Note: Financial correlates include sufficient inputs, credit obtained, livestock in the past. Personal correlates include education, risk attitude and business horizon. Environmental correlates include irrigation system condition and soil fertility. Other control variables include farmer age, farm age, farm area, specialization, contract farming, total tax, workers hired and nonfarm income. Districts are not included in the regression analysis.

Table 16. Relationship between time preference and asset diversity in Kazakhstan

Negative binomial model	Coef (SE), [95% CI]				
	(1)	(2)	(3)	(4)	(5)
Time preference	-0.207 (0.101) [-0.40, -0.01]	-0.172 (0.094) [-0.35, 0.01]	-0.158 (0.0950 [-0.34, 0.03]	-0.162 (0.093) [-0.34, 0.02]	-0.23 (0.075) [-0.37, -0.08]
Sets of control variables Included	Not included				
Financial correlates		Included	Included	Included	Included
Personal correlates			Included	Included	Included
Environmental correlates				Included	Included
Other control variables					Included
N	503	503	503	503	503
Pseudo R2	0.0075	0.0368	0.0459	0.0474	0.1297

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: Financial correlates include sufficient inputs, credit obtained, livestock in the past. Personal correlates include education, risk attitude and business horizon. Environmental correlates include irrigation system condition and soil fertility. Other control variables include farmer age, farm age, farm area, specialization, contract farming, total tax, workers hired and nonfarm income. Districts are not included in the regression analysis.

Next, I report the estimation results for Uzbekistan. Table 17 presents the negative binomial model relating time preference to total assets, and Table 18 reports the generalized linear model relating time preference to asset diversity. Sets of relevant control variables are included across different models. In Table 17 Model 1, which includes only time preference as an explanatory variable for total assets, the coefficient is negative (-0.06, SE: 0.04, 95% CI: [-0.139, 0.019]). However, the confidence interval includes zero, indicating weak evidence of a relationship between time preference and total assets. As groups of correlates are added, the coefficient further decreases in magnitude (-0.06 in Model 1 to -0.006 in Model 4), and the confidence interval continues to include zero, suggesting no or very weak evidence. In model 5, which includes all broader farm and economic control variables (e.g., farm size, specialization, contract farming), the coefficient remains small (-0.025, SE: 0.045), with the confidence interval still covering zero ([-0.113, 0.063]). The standard errors remain large in relation to the coefficients across all models for the case of total assets, suggesting little or no evidence for the relationship between time preference and investment among sampled farmers in Uzbekistan.

Yet, there are some similarities between the results observed in the Uzbekistan and Kazakhstan samples. First, across all model specifications, the coefficients remain negative, suggesting that, although to a lesser extent (as indicated by the smaller coefficient sizes), farmers in Uzbekistan may still consider their subjective time preferences when making investment decisions. Additionally, similar to the Kazakhstan sample, the inclusion of control variables follows a comparable pattern in both samples. Specifically, in models 2–4, the coefficient size declines notably before increasing again in Model 5, where broader farm and economic variables are introduced. This pattern suggests that while time preference plays a (quantitatively different) role in both contexts, its relevance in investment decisions is sensitive to the inclusion of especially farm and broader economic factors.

Table 18 reports results from a generalized linear model examining the relationship between time preference and asset diversity among Uzbekistan farmers. The results are broadly consistent with those observed for total assets. Across all models, the coefficient remains negative, though small in magnitude. The baseline model (Model 1) shows a coefficient of -0.058 (SE: 0.062, 95% CI: [-0.18, 0.064]), and as additional correlates are included, the coefficient fluctuates between -0.016 and -0.086, but confidence intervals consistently include zero. In Model 5, the coefficient remains negative (-0.086, SE: 0.081), though it grew slightly in magnitude. As with total assets, there is little evidence that time preference is strongly associated with asset diversity among the sampled Uzbekistan farmers.

Across both settings, coefficient signs are negative, which is consistent with the conceptual link between greater impatience and lower investment in farm machinery and equipment. However, the evidence is stronger in Kazakhstan than in Uzbekistan. The stepwise specifications further suggest that farm-specific characteristics contribute more to explaining these investment outcomes than personal, financial, or biophysical factors—again, more clearly in Kazakhstan—indicating that the time preference–investment relationship is partly intertwined with farm business features such as specialization and land area. Lastly, across the settings examined here, total machinery and equipment assets and their diversity appear to involve a similar degree of inter-temporal decision-making: whether farmers pursue production intensification (investing in the same or upgraded technologies) or diversification (investing in different technologies that enable additional economic activities), both strategies seem to entail comparable inter-temporal trade-offs in the data.

Table 17. Relationship between time preference and total assets in Uzbekistan

Negative binomial model	Coef (SE), [95% CI]				
	(1)	(2)	(3)	(4)	(5)
Time preference	-0.06 (0.04) [-0.139, 0.019]	-0.03 (0.04) [-0.107, 0.048]	-0.01 (0.052) [-0.112, 0.092]	-0.006 (0.051) [-0.107, 0.095]	-0.025 (0.045) [-0.113, 0.063]
Sets of control variables Included	Not included				
Financial correlates		Included	Included	Included	Included
Personal correlates			Included	Included	Included
Environmental correlates				Included	Included
Other control variables					Included
N	460	460	460	460	460
Pseudo R2	0.0010	0.0207	0.0288	0.0350	0.0756

Source: SUSADICA Farm Survey 2019. Own calculations.

Note: Financial correlates include sufficient inputs, credit obtained, livestock in the past. Personal correlates include education, risk attitude and business horizon. Environmental correlates include irrigation system condition and soil fertility. Other control variables include farmer age, farm age, farm area, specialization, contract farming, total tax, workers hired and nonfarm income. Districts are not included in the regression analysis.

Table 18. Relationship between time preference and asset diversity in Uzbekistan

Generalized linear model	Coef (SE), [95% CI]				
	(1)	(2)	(3)	(4)	(5)
Time preference	-0.058 (0.062) [-0.18, 0.064]	-0.016 (0.063) [-0.14, 0.108]	-0.039 (0.083) [-0.203, 0.124]	-0.037 (0.084) [-0.202, 0.128]	-0.086 (0.081) [-0.245, 0.072]
Control variables	Not included				
Financial correlates		Included	Included	Included	Included
Personal correlates			Included	Included	Included
Environmental correlates				Included	Included
Other control variables					Included
N	460	460	460	460	460
Log pseudolikelihood	-730.583	-715.051	-702.900	-696.444	-669.4669

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: Financial correlates include sufficient inputs, credit obtained, livestock in the past. Personal correlates include education, risk attitude and business horizon. Environmental correlates include irrigation system condition and soil fertility. Other control variables include farmer age, farm age, farm area, specialization, contract farming, total tax, workers hired and nonfarm income. Districts are not included in the regression analysis.

4.2.2 Role of tenure security on the relationship between time preference and machinery/equipment asset counts and diversity

Tables 19–22 report estimates of whether tenure security conditions, captured by perceived land expropriation risk and perceived government intervention, alter the relationship between time preference and investments in farm machinery and equipment examined in the preceding section. I begin by presenting results for Kazakhstan. Table 19 reports estimates for total assets (Panel A) and asset diversity (Panel B), comparing subsamples characterized by low and high perceived land expropriation risk. It can be seen that the sign of coefficient of time preference for both subsamples is negative and confidence intervals include zero. Specifically, among farmers reporting low land expropriation risk (tenure security), the coefficient is -0.310 (SE: 0.116, 95% CI: [-0.538, -0.082]), while for those with high expropriation risk (tenure insecurity), the coefficient is -0.276 (SE: 0.116, 95% CI: [-0.503, -0.048]). The estimated coefficient for the Low expropriation group is slightly larger in magnitude. These results indicate that regardless of land expropriation risks, more impatient farmers tend to report lower levels of total assets in farm machinery and equipment, and vice versa. For asset diversity, time preference remains

negatively associated with asset diversity (Panel B of Table 19). The coefficient is -0.240 (SE: 0.103, 95% CI: [-0.441, -0.038]) for farmers with low expropriation risk and -0.257 (SE: 0.105, 95% CI: [-0.462, -0.052]) for those with high expropriation risk. It can be observed that time preference coefficients are larger for total assets than for asset diversity under both conditions, though this difference in coefficients is slightly smaller among High expropriation group.

Table 20 presents the results for the second measure of tenure insecurity, perceived government intervention in Kazakhstan. For total assets (Panel A), time preference shows a negative relationship with investment among Kazakhstan farmers under low government intervention, with a coefficient of -0.314 (SE: 0.093, 95% CI: [-0.496, -0.131]), reinforcing the trend observed in the overall Kazakhstan sample. Contrary, among farmers experiencing high government intervention, the coefficient is -0.008 (SE: 0.167, 95% CI: [-0.335, 0.319]), indicating lack of evidence for the relevance of time preference in farm machinery and equipment accumulation. This suggests that when government intervention is high, the extent farmers consider (im)patience on investment decisions diminishes. Note that the coefficient size is quite similar in magnitude to what was observed in the main analysis for Uzbekistan sample.

For asset diversity (Panel B), the results point at similar pattern. Specifically, time preference has a negative relationship with diversity of farm machinery and equipment among farmers with low government intervention, with a coefficient of 0.278 (SE: 0.086, 95% CI: [-0.446, -0.11]), meaning that less patient farmers tend to have lower diversity of farm machinery and equipment when government intervention is not perceived. However, under high government intervention, the coefficient for time preference becomes -0.102 (SE: 0.114, 95% CI: [-0.326, 0.122]), including zero. So, this pattern aligns with my proposition that under high government intervention, that can reduce farm productivity, patience matters less for investment decisions, which we may be observing in Kazakhstan sample.

Cross-examining these two land tenure security conditions, the absolute values of the coefficients for time preference and total assets are very similar among Kazakhstan farmers reporting low expropriation risk and low government intervention: -0.310 (SE: 0.116) for land expropriation risk and -0.314 (SE: 0.093) for government intervention. This pattern also holds for asset diversity, where the coefficients remain close in magnitude. This may indicate that farmers experience these two forms of tenure insecurity in comparable ways when making long-term investment choices. Overall, these findings from Kazakhstan suggest that greater administrative burden from government intervention, but not greater risks of land expropriation risk, may limit farmers' ability to leverage patience for long-term investments.

Table 19. Time preference and total assets/asset diversity under different levels of perceived land expropriation risk in Kazakhstan

	Low expropriation		High expropriation	
Panel A: Total assets (Negative binomial model)	Coef (SE)	95% CI	Coef (SE)	95% CI
Time preference	-0.310 (0.116)	[-0.538, -0.08]	-0.276 (0.116)	[-0.503, -0.048]
Control variables	Included		Included	
N	296		207	
Pseudo R2	0.1054		0.1764	
Panel B: Asset diversity (Negative binomial model)				
Time preference	-0.240 (0.103)	[-0.44, -0.038]	-0.257 (0.105)[a]	[-0.462, -0.052]
Control variables	Included		Included	
N	296		207	
Pseudo R2	0.1168		0.2085	

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: Financial correlates include sufficient inputs, credit obtained, livestock in the past. Personal correlates include education, risk attitude and business horizon. Environmental correlates include irrigation system condition and soil fertility. Other control variables include farmer age, farm age, farm area, specialization, contract farming, total tax, workers hired and nonfarm income. Districts are not included in the regression analysis. Standard errors are presented in parenthesis.
a. Estimated coefficients come from Poisson model.

It is important to recall that the earlier analysis for the Uzbekistan sample did not find strong evidence that time preference is relevant for farmers' investment decisions, even though the estimated association with investment was negative (in the expected direction). Tables 21 and 22 therefore examine whether this conclusion changes when the analysis is considered under two perceived land tenure security conditions. Panel A of Table 21 shows that the coefficient for time preference and total assets is negative under both low and high land expropriation risk conditions. Specifically, among farmers reporting low land expropriation risks, the coefficient is -0.011 (SE: 0.053, 95% CI: [-0.116, 0.093]) whereas for those reporting high land expropriation risk the coefficient is -0.088 (SE: 0.081, 95% CI: [-0.246, 0.07]). A similar pattern is observed for asset diversity, with coefficients being negative and confidence intervals including zero under both conditions. The subsample analysis shows that these results are consistent with those for the full Uzbekistan sample, providing no strong evidence that time preference is relevant for sampled Uzbek farmers' investment decisions, but they contrast with the Kazakhstan findings, where time preference was negatively related to both total assets and asset diversity under both low and high perceived land expropriation risk.

Table 20. Time preference and farm investment under different levels of perceived government intervention in Kazakhstan

	Low intervention		High intervention	
Panel A: Total assets (Negative binomial model)	Coef (SE)	95% CI	Coef (SE)	95% CI
Time preference	-0.314 (0.093)	[-0.496, -0.131]	-0.008 (0.167)	[-0.335, 0.319]
Control variables	Included		Included	
N	295		208	
Pseudo R2	0.1376		0.1139	
Panel B: Asset diversity (Negative binomial model)				
Time preference	-0.278 (0.086)	[-0.446, -0.11]	-0.102 (0.114)[a]	[-0.326, 0.122]
Control variables	Included		Included	
N				
Pseudo R2	0.1489		0.1600	

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: Financial correlates include sufficient inputs, credit obtained, livestock in the past. Personal correlates include education, risk attitude and business horizon. Environmental correlates include irrigation system condition and soil fertility. Other control variables include farmer age, farm age, farm area, specialization, contract farming, total tax, workers hired and nonfarm income. Districts are not included in the regression analysis. Standard errors are presented in parenthesis.
a. Estimated coefficients come from Poisson model.

Next, Table 22 reports the results for the Uzbekistan sample when splitting by perceived government intervention. Panel A shows that the coefficient on time preference is negative for total assets under both conditions, but the strength of evidence differs. Under low government intervention, the coefficient is -0.190 (SE: 0.065; 95% CI: [-0.317, -0.064]), with the confidence interval excluding zero. Under high government intervention, the estimate is much smaller (-0.057, SE: 0.063) and the confidence interval includes zero. A similar pattern emerges for asset diversity (Panel B). Under low government intervention, the coefficient is relatively large and negative (-0.225, SE: 0.111; 95% CI: [-0.442, -0.008]), whereas under high intervention it is essentially zero (0.003, SE: 0.108; 95% CI: [-0.210, 0.215]). Taken together, these results suggest that time preference becomes relevant for investment outcomes—such as acquiring farm machinery and equipment—when perceived government intervention is low, an association that is not apparent in the full Uzbekistan sample. In contrast, among farmers reporting high government intervention, the relevance of time preference remains muted, consistent with the full-sample findings. This lends support to the proposition that government intervention can inhibit more patient farmers' ability to translate long-term orientation into long-term investment decisions. This pattern mirrors the Kazakhstan results, where the relevance of time preference for investment likewise vanishes under high perceived government intervention.

Overall, the findings indicate that time preference is more consistently associated with farm machinery and equipment—both total assets and asset diversity—in Kazakhstan than in Uzbekistan. However, the relevance of time preference varies across tenure security conditions within each setting. In Kazakhstan, perceived land expropriation risk does not appear to materially alter the relationship between time preference and investment, whereas in Uzbekistan the relationship remains largely absent under both expropriation-risk conditions. By contrast, perceived government intervention substantially changes the results in both settings: the association between time preference and investment is evident under low intervention but disappears under high intervention. I discuss these findings in the following section.

Table 21. Time preference and farm investment under different levels of perceived land expropriation risk in Uzbekistan

	Low expropriation		High expropriation	
Panel A: Total assets (Negative binomial model)	Coef (SE)	95% CI	Coef (SE)	95% CI
Time preference	-0.011 (0.053)	[-0.116, 0.093]	-0.088 (0.081)	[-0.246, 0.07]
Control variables	Included		Included	
N	246		214	
Pseudo R2	0.0987		0.0844	
Panel B: Asset diversity (Generalized linear model)				
Time preference	-0.086 (0.100)	[-0.282, 0.110]	-0.152 (0.136)	[-0.418, 0.114]
Control variables	Included		Included	
N	246		214	
Log pseudolikelihood	-347.155		-306.169	

Source: SUSADICA Farm Survey 2019. Own calculations.

Note: Financial correlates include sufficient inputs, credit obtained, livestock in the past. Personal correlates include education, risk attitude and business horizon. Environmental correlates include irrigation system condition and soil fertility. Other control variables include farmer age, farm age, farm area, specialization, contract farming, total tax, workers hired and nonfarm income. Districts are not included in the regression analysis. Standard errors are presented in parenthesis.

Table 22. Time preference and farm investment under different levels of perceived government intervention in Uzbekistan

	Low intervention		High intervention	
Panel A: Total assets (Negative binomial model)	Coef (SE)	95% CI	Coef (SE)	95% CI
Time preference	-0.190 (0.065)	[-0.317, -0.064]	0.057 (0.063)	[-0.066, 0.179]
Control variables	Included		Included	
N	156		304	
Pseudo R2	0.1159		0.0832	
Panel B: Asset diversity (Generalized linear model)				
Time preference	-0.225 (0.111)	[-0.442, -0.008]	0.003 (0.108)	[-0.21, 0.215]
Control variables	Included		Included	
N	156		304	
Log pseudolikelihood	-191.901		-451.540	

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: Financial correlates include sufficient inputs, credit obtained, livestock in the past. Personal correlates include education, risk attitude and business horizon. Environmental correlates include irrigation system condition and soil fertility. Other control variables include farmer age, farm age, farm area, specialization, contract farming, total tax, workers hired and nonfarm income. Districts are not included in the regression analysis. Standard errors are presented in parenthesis.

4.2.3 Discussion of main findings and implications for policy

Evidence from the Kazakhstan's (full) sample shows that time preference (impatience) is negatively associated with both farm machinery and equipment total assets and asset diversity. The results obtained align with previous empirical studies (Di Falco et al., 2019; Mao et al., 2021; Olumba et al., 2024) and confirm the theoretical prediction that impatient individuals tend to accumulate less capital over time (Sunde et al., 2022). In particular, Di Falco et al. (2019) found a strong negative relationship between time discounting and agricultural investments, measured through livestock ownership and land improvements. The finding that time preference is also associated with asset diversity in the Kazakhstan sample contrasts with Sarwosri and Mußhoff (2020), who found no evidence that time preference plays a significant role in tree crop diversification decisions. Asset diversification is commonly viewed as a strategy for farmers to mitigate risks from market and weather fluctuations (Takeshima and Yamauchi, 2012), thus emphasizing the role of risk preferences rather than time preferences. However, the Kazakhstan results suggest that patience may also be relevant for diversification, particularly for building a more varied machinery and equipment portfolio, which may reflect a forward-looking strategy to enhance resilience to multiple risks over time.

Analysis of (full) sample from Uzbekistan did not support the claim that time preference is strongly associated with investments in farm machinery and equipment, including both total assets and asset diversity. Other empirical studies found limited evidence for the role of time discounting in long-term agricultural technology adoption (Ding et al., 2021; Hasibuan et al., 2021). The lack of evidence in the Uzbekistan sample may stem from specific economic and institutional conditions experienced by sampled farmers. Policy uncertainty, production targets, limitations in land rights, particularly regarding land tenure security, can discourage even patient farmers from making long-term investments, such as acquiring farm machinery and equipment. These farmers, who might otherwise be inclined to invest, may avoid such decisions due to the risk of losing their investments or land (Besley and Ghatak, 2010; Feder and Nishio, 1998). As a result, variation in time preference may not translate into significant differences in investment behavior among Uzbekistan farmers. Additionally, the relatively low economic returns from farming among sampled Uzbekistan farmers, compared to their counterparts in Kazakhstan (Shtaltovna and Hornidge, 2014; Tadjiev et al., 2023), could further discourage investment. Patient farmers may perceive limited returns from investing in farm assets, diminishing their motivation to commit resources. In such cases, unfavorable economic prospects may pose bigger constraint than behavioral factors like time preference in shaping investment decisions.

These patterns point to the possibility that institutional conditions may alter whether and how time preferences shape investment behavior. It could be of course other factors which could impede the relevance of time preference on farmers investment decisions, quality of trainings and information, social norms. For this reason, in the previous analysis I examined if two land tenure security variables—perceived land expropriation risk and perceived government intervention—can be such factors.

The subsample analysis showed indeed perceived land tenure security conditions may alter how time preferences are related to investments in farm machinery and equipment. In Kazakhstan, the negative association between time preference and investment remained consistent across both low and high land expropriation risk groups, with similar coefficient magnitudes. Notably, under low expropriation risk—where tenure is more secure—the strong negative relationship aligns with expectations that secure tenure allows patient farmers to act on their long-term outlook, as the expected returns to investment are higher when land rights are stable (Besley and Ghatak, 2010). However, it is puzzling that even under high perceived land expropriation risk among Kazakhstan farmers, time preference remains strongly associated with investment in farm machinery and equipment. One possible explanation is that investment in farm machinery and equipment, being movable and potentially resalable, may be less sensitive to land-tenure-related

risks than land-attached investments. Even if farmers anticipate a higher probability of future land loss, they may still invest in machinery because it can be sold or rented out, allowing them to recover part of the investment value, meaning there is small adjustment cost from changing farm machinery portfolio (Feder et al., 1992). This could help explain why the association between time preference and investment remains evident in Kazakhstan setting even under high perceived expropriation risk.

In the Uzbekistan subsample analysis, there is still no strong evidence of a relationship between time preference and investment in farm machinery and equipment under either low or high perceived land expropriation risk. Given the institutional and economic conditions that Uzbekistan farmers face, this is not particularly surprising. Farmers producing cotton, wheat, and other crops are often preoccupied with meeting annual production targets and navigating complex policy requirements and implementation challenges on the ground. Under such immediate pressures, adopting a strongly future-oriented approach may not be a feasible, or even an effective, strategy for managing production decisions. Further, given economic returns to production (of cotton) are low, as indicated in prior studies (Shtaltovna and Hornidge, 2014; Tadjiev et al., 2023), even patient farmers will be reluctant to invest or modernize technologies.

Next, in both Kazakhstan and Uzbekistan settings, the association between time preference and investment in farm machinery and equipment was strongest under conditions of low government intervention, while under high government intervention, previously robust relationship disappeared. These findings align with my proposition that patience (time preference) is more likely to be relevant when farmers face fewer operational slowdowns and administrative burdens arising from government intervention. Contrary, high government intervention may push farmers into managing their present problems such as meeting policy reequipments and targets instead of taking long-term proactive decisions. Relevance of government intervention even showed up in Uzbekistan setting, where previously time preference was not strongly associated with investment. These findings suggest that in both contexts, administrative burdens—such as frequent inspections, mandatory meetings, and field monitoring—may constitute stronger barriers to investment than land expropriation risk. High levels of government regulation, control and oversight may generate a sense of immediacy, forcing farmers to concentrate on meeting short-term compliance requirements rather than planning for long-term improvements such as soil fertility improvements or adopting innovations.

There may be also another explanation. Sampled farmers may engage in informal economic activities—such as adjusting their crop portfolio or relying on informal land-transfer arrangements—that may not fully align with their formal rights and obligations and may diverge

from official policy priorities (Akhmadiyeva and Herzfeld, 2021). Under high government intervention, for example through regular inspections during planting and harvesting seasons, these side activities may become more visible and therefore riskier. If income from such activities helps finance investments, heightened intervention could prompt farmers to scale them back, thereby reducing the funds available for acquiring farm machinery and equipment.

These analyses offer several contributions to existing empirical and theoretical literature on time preference. Empirically, this study extends the evidence on time preference and farm investment by focusing on machinery and equipment—a movable category of productive assets that has received less attention in the literature, which has more often examined land-related investments such as variable inputs or land improvements. In addition, the analysis provides new evidence on how perceived land tenure security conditions, captured through land expropriation risk and government intervention, relate to the relevance of time preference for investment outcomes. The results suggest that, in both settings, government intervention may constitute a more binding constraint, such that under high intervention the association between time preference and long-term investment outcomes becomes muted, whereas expropriation risk conditions do not substantially change the pattern. To my knowledge, this specific institutional channel, government intervention limiting the extent to which patience is reflected in intertemporal investment decisions, has not been shown in prior work.

While earlier studies have emphasized that land expropriation risks discourage investment by reducing the incentive to commit resources (Besley, 1995; Besley and Ghatak, 2010; Feder and Nishio, 1998), and that such risks are beyond individual control (Acemoglu and Robinson, 2005), the results suggest that these risks may be less binding for nonland investments. Patient farmers may continue to invest in movable capital such as machinery, even in the face of perceived land expropriation risk.

Conceptually, these findings motivate a refinement in how the role of time preference is interpreted in intertemporal decision-making: the extent to which patience translates into higher accumulation of productive assets (including physical capital, and potentially other forms such as human capital) may depend on prevailing institutional and economic conditions. If so, this implies that policies aimed at leveraging behavioral traits may be less effective unless key institutional and economic constraints are addressed first. More broadly, the study demonstrates the value of a comparative approach, showing that examining structurally different settings can reveal heterogeneity that would remain hidden in a single-sample analysis.

Several policy implications can be derived: For Kazakhstan, it is important *to align farm modernization support with farmers' investment horizons and the timing of costs and returns*. The Kazakhstan results indicate that time preference is strongly associated with investment in farm machinery and equipment, implying that more present-oriented farmers are less likely to undertake costly investments with delayed payoffs. This is particularly relevant for high-efficiency but expensive machinery and technologies that enhance long-term productivity, where benefits accrue over extended periods. Policy interventions that aim to stimulate such investments, such as subsidies, co-financing, or credit support, should therefore account explicitly for the timing of both costs and expected returns. Designing payment schedules to better match farmers' income streams and reduce short-term liquidity pressure can make long-horizon investments more feasible; for example, adoption can increase when payments are deferred to periods of higher liquidity (e.g., after harvest rather than upfront), as shown in related settings (Casaburi and Willis, 2018).

Reduce policy uncertainty and administrative pressures that divert attention toward short-term problem-solving. Even when farmers are relatively patient, high perceived government intervention and broader policy uncertainty can limit the extent to which patience translates into investment by increasing operational slowdowns and administrative burdens. Maintaining stable rules and reducing unpredictable intervention can support farmers' ability to plan and invest in technology modernization rather than focusing primarily on immediate compliance demands.

For Uzbekistan, it is important to *address binding institutional and economic constraints before expecting patience to translate into higher investment.* In Uzbekistan, the full-sample evidence does not show a robust relationship between time preference and investments in farm machinery and equipment, suggesting that intertemporal preferences may not be the main limiting factor under prevailing conditions. Policies should therefore prioritize improving the broader economic and institutional environment that shapes investment feasibility and incentives—such as strengthening managerial freedom, improving profitability, and expanding operational autonomy (including crop-choice flexibility).

Reduce high government intervention that appears to mute long-horizon investment behavior. The subsample results indicate that time preference becomes more relevant when perceived government intervention is low, while its relevance disappears under high intervention. This highlights the importance of reducing regulatory and administrative burdens—particularly those that absorb time and resources during key production periods—so farmers can redirect attention and capacity toward long-term productivity strategies and sustainable investment decisions.

Several limitations warrant attention and offer directions for future research. First, the findings are correlational rather than causal, leaving open the possibility of a reverse relationship—farmers who make long-term decisions like acquiring farm machinery may, in turn, assess themselves as more patient. Establishing causality would require experimental or longitudinal designs. Second, while this study examined whether perceived tenure security conditions alter the relationship between time preference and investment, it does not pinpoint the exact mechanisms driving these patterns. Apart from economic returns (which I did not analyze in this dissertation), for example, variation in farmers' time horizons could explain differences in investment behavior. Future research could explore these mechanisms in greater detail. Third, the study lacks detailed financial data on the analyzed assets, particularly regarding the timing and distribution of costs and returns. This is a critical gap because even within the same asset category, different investment types may have varying payback periods and initial return timelines.

4.3 Tracking land tenure security perceptions in Kazakhstan and Uzbekistan

The results section for Research Question 3 is organized as follows. First, Subsection 4.3.1 presents the findings on group-level changes in perceptions of protection rights and land expropriation risk. Next, Subsection 4.3.2 examines within-farmer changes in these land tenure dimensions. Subsection 4.3.3 discusses the findings and summarizes contributions to the literature, policy implications, and limitations.

4.3.1 Group-level shifts

Table 23 and Table 24 present the results of the Wilcoxon signed-rank test for samples from Kazakhstan and Uzbekistan, assessing the extent to which the sample median perceptions of tenure security changed between 2019 and 2022. Table 23 shows that, for the Kazakhstan sample, the median did not change between 2019 and 2022 for four of the five land tenure security dimensions, with the exception of trust in courts in disputes against the state. Across both years, farmers reported the highest perceived security for land documents being able to prove land rights (median = 5; p = 0.0060), followed by trust in courts in disputes against farmers (median = 4; p = 0.6995) and trust in courts in disputes against investors (median = 3; p = 0.0397). Perceived land expropriation risk remained very low and unchanged (median = 1, indicating that farmers generally viewed land loss as unlikely; p = 0.8437). By contrast, trust in courts in disputes against the state increased, with the sample median rising from 3 to 4 between the two periods. Despite these limited median changes, the positive and negative ranks indicate meaningful within-farmer variation: farmers reported both increases and decreases in perceived protection

rights and expropriation risk over time. Only for trust in courts in disputes against the state and land documents can prove land rights does the share of farmers reporting positive changes exceed those reporting negative changes, whereas for trust in courts in disputes against investors the share reporting negative changes exceeds those reporting positive changes. Overall, the limited change in sample medians suggests broadly stable perceived land tenure security between 2019 and 2022, but this stability masks offsetting individual-level shifts, pointing to substantial heterogeneity in how farmers' perceptions evolved over time.

Table 24 shows that, in the Uzbekistan sample, perceived land tenure security changed more visibly between 2019 and 2022 than in Kazakhstan. The most pronounced shifts are in trust in courts, where perceptions improved substantially: trust in courts in disputes against the state increased from median 2 to 4 ($p = 0.0000$) and trust in courts in disputes against investors increased from median 3 to 4 ($p = 0.0000$). These changes are also reflected in the rank patterns, with a clear majority of farmers reporting positive shifts (78% for disputes against the state and 57% for disputes against investors). By contrast, other dimensions show greater stability in medians, while still exhibiting offsetting individual-level movements. Notably, perceived land expropriation risk increased from median 2 to 3, which would indicate higher tenure insecurity (since higher values reflect a greater likelihood of losing land), but positive and negative changes are nearly balanced and the statistical evidence for change is weak ($p = 0.4412$). Overall, the Uzbekistan results suggest improving institutional trust alongside heterogeneous and partly offsetting changes in other aspects of perceived tenure security.

Across 2019 and 2022, both samples show that perceived tenure security does not move uniformly across all dimensions, and that stable sample medians can mask offsetting individual-level changes, indicating heterogeneity in perception dynamics. The key difference is the magnitude of aggregate change: Kazakhstan exhibits broad stability over time, with only a modest improvement in trust in courts in disputes against the state, whereas Uzbekistan shows more pronounced improvements in court-related trust—especially in disputes against the state and investors. Another contrast is expropriation risk, which remains very low and unchanged in Kazakhstan but shifts upward in Uzbekistan, suggesting higher perceived insecurity, albeit with mixed movements across farmers.

Table 23. Changes in median perceptions of land tenure security and Wilcoxon signed-rank test results in Kazakhstan by year (N = 239)

	Median (2019)	Median (2022)	Positive ranks (n)	Negative ranks (n)	Zeros (n)	p-value
Trust in courts in disputes against farmers	4	4	84 (35%)	85 (35%)	70 (30%)	0.6995
Trust in courts in disputes against investors	3	3	82 (34%)	105 (44%)	52 (22%)	0.0397
Trust in courts in disputes against state	3	4	108 (45%)	70 (30%)	61 (25%)	0.0006
Land documents can prove land rights	5	5	47 (20%)	25 (10%)	167 (70%)	0.0060
Land Expropriation risk	1	1	64 (27%)	68 (28%)	107 (45%)	0.8437

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.
Note: Reported median values represent the 50th percentile. The percentages reported for each right are rounded and add up to 100. For land expropriation variable higher values indicates higher likelihood of losing land in the future (i.e., tenure insecurity).

Table 24. Changes in median perceptions of land tenure security and Wilcoxon signed-rank test results in Uzbekistan by year (N = 159)

	Median (2019)	Median (2022)	Positive ranks (n)	Negative ranks (n)	Zeros (n)	p-value
Trust in courts in disputes against farmers	4	4	44 (28%)	56 (35%)	59 (37%)	0.2416
Trust in courts in disputes against investors	3	4	91 (57%)	23 (15%)	45 (28%)	0.0000
Trust in courts in disputes against state	2	4	124 (78%)	14 (9%)	21 (13%)	0.0000
Land documents can prove land rights	4	4	45 (28%)	66 (42%)	48 (30%)	0.0059
Land Expropriation risk	2	3	58 (37%)	64 (40%)	37 (23%)	0.4412

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.
Note: Reported median values represent the 50th percentile. The percentages reported for each right are rounded and add up to 100. For land expropriation variable higher values indicates higher likelihood of losing land in the future (i.e., tenure insecurity).

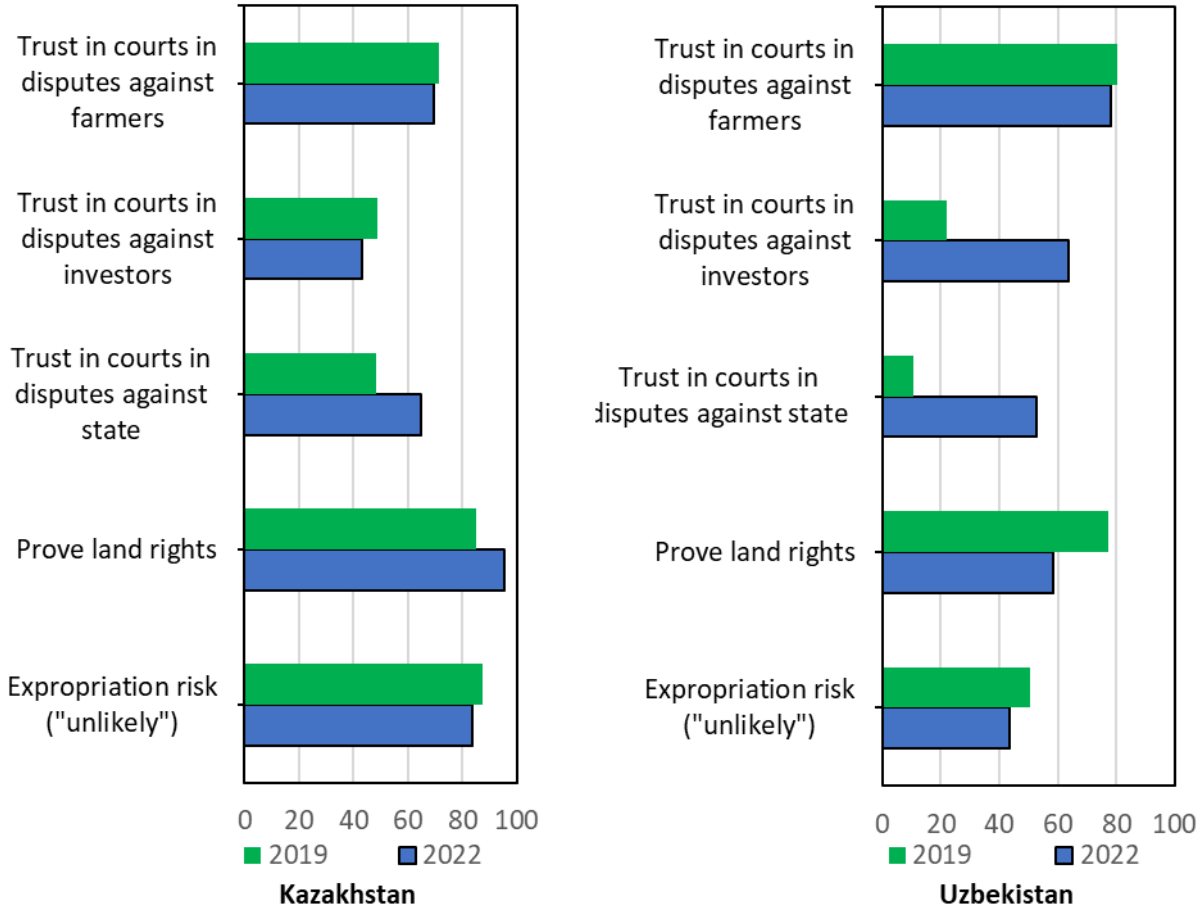
Figure 4 illustrates the share of farmers reporting high or very high perceptions across four protection rights and land expropriation risk between 2019 and 2022 in Kazakhstan and Uzbekistan. In Kazakhstan, the share of farmers expressing high or very high trust in courts for

land disputes against the state increased from around 50% in 2019 to over 60% in 2022. Similarly, confidence in land documents as proof of land rights rose, with the share of farmers strongly believing in their effectiveness increasing from just under 85% in 2019 to over 95% in 2022, though to a lesser extent. In contrast, trust in courts for disputes with investors declined slightly, with the share of farmers perceiving strong tenure security in this dimension decreasing from around 50% in 2019 to slightly over 40% in 2022. Meanwhile, trust in courts for disputes with other farmers and perceptions of low land expropriation risk remained largely unchanged over time. Building on previous observations, farmers' perceptions of security in Kazakhstan moderately changed in three key dimensions: trust in courts for disputes with the state improved, confidence in land documents increased, and trust in courts for disputes with investors declined.

Figure 4 also illustrates changes over time in the share of Uzbek farmers reporting high perceived tenure security across different dimensions. Notably, the share of farmers expressing strong trust in courts for disputes with investors rose substantially from around 20% in 2019 to just over 60% in 2022. Similarly, trust in courts for disputes with the state increased from around 10% in 2019 to over 50% in 2022. In contrast, perceptions of strong tenure security declined slightly in terms of the importance of land documents in proving land rights and perceptions of low expropriation risk. In 2019, just under 80% of farmers reported high confidence in land documents proving land rights, but this figure dropped to around 60% in 2022. Likewise, the share of farmers perceiving low expropriation risk declined from around 50% in 2019 to approximately 40% in 2022, though to a lesser extent.

So far, the analysis has captured the extent and intensity of group-level changes in perceived tenure security among sampled farmers from Kazakhstan and Uzbekistan, revealing general trends while also hinting at individual-level variations. Next, I examine individual shifts in greater detail.

Figure 4. Share of respondents reporting high or very high perceived security in 2019 and 2022



Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

4.3.2 Within farmer shifts

Next, I examine within-farmer shifts in tenure security perceptions over time to better understand the heterogeneity underlying average sample-level patterns (Table 25 Panels A and B). The goal here is not to provide detailed findings but rather to identify general patterns in how farmers' assessments of protection rights and land expropriation risk changed over time in both samples. A value of zero indicates no change in perception, positive values to the right indicate improvements in perceptions, and negative values to the left indicate a decline. For perceived land expropriation risk, the interpretation is reversed: positive values indicate a higher expectation of losing land, while negative values indicate a lower expectation of losing land.

Consistent with earlier observations, Panel A of Table 25 shows that among Kazakhstan farmers, shifts in tenure security perceptions occurred in both directions across all five dimensions. Notably, across all dimensions, the share of farmers reporting no change or only mild shifts (+/-1) is larger than those experiencing more significant shifts (+/-2). Comparing these shifts across dimensions, 69.8% of Kazakhstan farmers maintained their perceptions of the importance of land

documents in proving land rights, followed by 44.7% who maintained their perceptions of expropriation risk. For the other three dimensions, the share of farmers whose perceptions remained unchanged ranged between 21.7% and 29.3%. When combining these figures with the share of farmers making minor shifts, the total proportion exceeded 70% for most dimensions. This pattern, observed across multiple dimensions, indicates that even in a relatively stable setting like Kazakhstan, there are small groups of farmers who make more drastic changes in their assessments of tenure security.

Panel B of Table 25 illustrates the shifts in perceptions of tenure security among Uzbek farmers. Overall, the pattern is similar to that observed in the Kazakhstan sample, with a larger share of farmers experiencing no or only mild shifts in perceptions of security compared to those making larger shifts. However, two key distinctions should be noted. First, the share of farmers with no or mild shifts is smaller than in Kazakhstan, suggesting a more dynamic tenure environment in Uzbekistan during the survey periods. Second, extreme shifts (+/-4) are rarer in Uzbekistan than in Kazakhstan.

Overall, the analysis of transition magnitude reveals considerable variation in how farmers in both Kazakhstan and Uzbekistan adjusted their perceptions of land tenure security across all five dimensions. While perceptions shifted in both directions with varying intensity, larger shifts remained less common.

In summary, between 2019 and 2022, perceptions of land tenure security among farmers in Kazakhstan and Uzbekistan followed distinct patterns. In Kazakhstan, changes were modest, with trust in courts for disputes with the state improving, while other dimensions remained largely stable except for a decline in trust in courts for disputes with investors. In contrast, Uzbekistan saw more positive changes, particularly in trust in courts for disputes with the state and investors, though perceptions of land documents proving land rights declined slightly. Examining within-farmer changes revealed that perceptions shifted in both directions, indicating that despite similar legal environments in each context, farmers interpreted the security of their land tenure differently. While some farmers made strong shifts in their perceptions, extreme changes were less common than smaller, incremental adjustments. The complete tabulations can be found in Tables A6-A15.

Table 25. Magnitude of shifts in within-farmer perceptions of land tenure insecurity between 2019 and 2022

Panel A: Kazakhstan (N= 239)	Change in perceptions of land rights over three years, N (%)									
	-4	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**Total**
Trust in courts against disputes with farmers	3 (1.2)	8 (3.3)	24 (10.0)	50 (20.9)	70 (29.3)	60 (25.1)	10 (4.2)	8 (3.3)	6 (2.5)	239 (100.0)
Trust in courts against disputes with investors	6 (2.5)	13 (5.4)	29 (12.1)	57 (23.8)	52 (21.7)	53 (22.1)	18 (7.5)	10 (4.2)	1 (0.4)	239 (100.0)
Trust in courts against disputes with state	2 (0.8)	5 (2.1)	20 (8.3)	43 (18.0)	61 (25.5)	48 (20.1)	37 (15.5)	17 (7.1)	6 (2.5)	239 (100.0)
Land documents can prove land rights	2 (0.8)	1 (0.4)	6 (2.5)	16 (6.7)	167 (69.8)	16 (6.7)	28 (11.7)	0 (0.0)	3 (1.2)	239 (100.0)
Expropriation risk[a]	0 (0.0)	10 (4.2)	8 (3.3)	50 (20.9)	107 (44.7)	34 (14.2)	8 (3.3)	11 (4.6)	11 (4.6)	239 (100.0)
Panel B: Uzbekistan (N=159)										
Trust in courts against disputes with farmers	0 (0.0)	7 (4.4)	11 (6.9)	38 (23.9)	59 (37.1)	30 (18.8)	8 (5.0)	6 (3.7)	0 (0.0)	159 (100.0)
Trust in courts against disputes with investors	0 (0.0)	1 (0.6)	2 (1.2)	20 (12.5)	45 (28.3)	54 (34.0)	27 (17.0)	9 (5.6)	1 (0.6)	159 (100.0)
Trust in courts against disputes with state	0 (0.0)	0 (0.0)	3 (1.8)	11 (6.9)	21 (13.2)	43 (27.0)	45 (28.3)	32 (20.1)	4 (2.5)	159 (100.0)
Land documents can prove land rights	0 (0.0)	9 (5.6)	29 (18.2)	28 (17.6)	48 (30.2)	33 (20.7)	10 (6.3)	1 (0.6)	1 (0.6)	159 (100.0)
Expropriation risk[a]	0 (0.0)	13 (8.1)	15 (9.4)	36 (22.6)	37 (23.2)	34 (21.4)	20 (12.5)	4 (2.5)	0 (0.0)	159 (100.0)

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.
Note: a. For land expropriation risk variable positive values imply increase in perceptions of expropriation risk (tenure insecurity).

4.3.3 Discussion of main findings and policy implications

The two most noticeable changes in land tenure security in Kazakhstan context relate to farmers' perceptions of the courts in dispute resolution. First, there has been an improvement in farmers' trust in the courts in disputes with the state. Conversely, some farmers have experienced a decline in confidence regarding the courts' handling of disputes with investors. I begin with the latter observation. Unlike its Central Asian neighbors, Kazakhstan boasts vast arable land, which attracts both local and foreign investors (Lew, 2021; Petrick et al., 2013). Often developing countries rely on these large-scale investments for their potential to drive economic growth (Fernández, 2017). But they have also led to concerns over land grabbing and state-led land expropriation in favor of investors (De Schutter, 2011). Such investments are relatively common in Kazakhstan (Lew, 2021; Petrick et al., 2013), intensifying competition for land. Not surprisingly, in recent years, Kazakhstan has witnessed several farmer protests against government decision to change land code allowing investors, especially foreign ones, to purchase land (Lew, 2021). These protests resulted in significant policy changes, including a moratorium on land sales to foreign investors. Although these incidents were generally resolved in favor of the local community, a possibility of future conflicts with private sector actors has not completely disappeared. Hanson (2017) asserts that land disputes in southern Kazakhstan often arise between farmers and the government or private firms, with courts ultimately serving the interests of the latter group. The decline in trust in courts for disputes with investors in Kazakhstan may reflect these events and underlying concerns.

Interestingly, during the same period in Kazakhstan, farmers' trust in courts for disputes with the state increased. At first glance, this may seem contradictory given the earlier discussion. However, it is important to note that perceptions have shifted in both directions, suggesting that views on land tenure are not fixed. On the one hand, the reported incidents, particularly those resolved in favor of local communities, may have led some farmers to develop a more positive perception of the government or increased public voice including courts' independence.

In Uzbekistan, trust in courts in disputes with both state and investors improved sharply, indicating a broad increase in confidence in legal institutions. This may be linked to ongoing judicial reforms and government policies aimed at strengthening land tenure governance (Djanibekov et al., 2024). Zorya (2020) noted that the elimination of state-mandated production targets in Uzbekistan in 2020 would remove the responsibility of local governors to enforce these quotas, thereby helping to strengthen farmers' land tenure security. Under the previous system, farmers who failed to meet state-imposed cotton production targets risked losing their land lease agreements. With the removal of these quotas, farmers were no longer subject to yield-based

lease terminations, granting them greater stability in land tenure. This policy change appears to be having the intended effect, as reflected in the improved perceptions of tenure security among some farmers in Uzbekistan in terms of improved trust in courts with government and investors.

Beyond the general trends observed, the transition analysis revealed significant within-farmer variations in how perceptions of tenure security evolved over time. A key insight is that these perception shifts were not uniform; rather, the direction and magnitude of changes differed among farmers in both study areas. In Uzbekistan, these variations suggest that recent legal and institutional reforms may have affected different groups of farmers in distinct ways. Several factors could explain these differing interpretations. First, the implementation of policy reforms may have played a role. Some farmers lost their land or were not properly compensated, as indicated by Babadjanov and Petrick (2023). Among the sampled farmers, some may have personally experienced this, while others may have been influenced by the experiences of fellow farmers. As Cheng et al. (2022) highlight, perceptions of tenure security are shaped not only by personal experiences but also by the experiences of others within the community. Additionally, while the abolition of the state procurement policy was intended to enhance tenure security, it is possible that some Uzbekistan farmers, particularly those skeptical of government policies, perceived the change differently, perhaps even viewing it as yet another potentially tenure insecurity enhancing policy.

These findings contribute to the literature in several ways. First, on the empirical side, the study constructs a panel dataset that follows the same farmers over time and tracks changes in perceived land tenure security across multiple dimensions. This extends prior panel-based evidence, which has often focused on a single legal dimension of tenure or only a limited set of perceived security indicators. In addition, the Uzbekistan panel results offer rare empirical evidence that helps assess how recent post-2019 tenure interventions may be reflected in farmers' perceptions, while recognizing that these perceptions are formed in a changing environment where implementation remains incomplete.

Second, the findings speak to theory on land tenure interventions and perception dynamics. A common implicit assumption is that once interventions strengthen and formalize rights, perceptions of tenure security should improve and then remain relatively stable over time. The results challenge this view: even in the comparatively stable Kazakhstan setting, aggregate stability masks offsetting within-farmer changes, while in Uzbekistan perceptions shift more visibly across dimensions, including improvements in some areas alongside declines in others. This suggests that tenure security perceptions can remain dynamic after interventions and may

continue to evolve in response to how reforms are implemented, as well as to broader institutional, market, and household circumstances.

These results also have implications for researchers. When examining links between land tenure and outcomes such as investment or productivity, careful attention should be paid to the choice of tenure variables. If the objective is to capture relatively stable tenure conditions, it can be preferable to use more objective indicators, such as legal tenure measures or experience-based measures, because they are often more temporally stable than perceptions. When perception-based measures are necessary (for example, because legal indicators do not reflect de facto conditions or experience measures are unavailable), two practical strategies can help. First, select perception-based tenure measures that are not directly tied to changing policies in the given setting. Second, and more broadly if the study design allows researchers to choose the sample or context, prioritize settings that are not undergoing major tenure-related transitions during the study period.

Based on the analysis, I draw the following policy actions for Kazakhstan: *Strengthen perceived fairness and reliability of dispute resolution with private actors (investors).* The decline in trust in courts for disputes involving investors suggests that farmers may perceive weaker protection when conflicts involve private actors. Policy priorities should therefore focus on improving the transparency, objectivity, and accessibility of dispute resolution in cases involving private actors. Practical steps could include clearer procedures for handling investor–farmer disputes, strengthening the availability of legal support, and expanding alternative dispute resolution to reduce reliance on courts and lower farmers' transaction costs.

Strengthen document-based security through simpler and more accessible land administration. Although confidence in land documents is generally high and has improved for some farmers, sustaining this requires continued attention to land administration. Simplifying and standardizing registration and verification—especially for farmers in remote areas—can strengthen the practical value of land documents and reduce uncertainty about proving land rights.

For Uzbekistan, the policy actions should include *sustaining credible legal and administrative signals to farmers to show actual improvements in courts.* The large increase in trust in courts, particularly for disputes against the state and investors, suggests meaningful improvements in perceived institutional protection. To maintain these improvements, policymakers should focus on consistent implementation, clear and transparent procedures, and easily accessible complaint and appeal channels, so that farmers' trust can build over time.

Rebuild confidence in land documentation systems and address remaining insecurity signals. At the same time, declining confidence in land documents and continued concern around land loss (potential future risks of land expropriation by government) highlight areas requiring attention. Strengthening the accessibility and reliability of land registration and verification, through measures such as electronic land cadaster records, reducing bureaucratic hurdles, and ensuring consistent enforcement, could help restore the perceived value of documentation. Complementary outreach and support (e.g., farmer-facing guidance and better-trained local administrators) can also reduce uncertainty about how documents protect rights in practice.

Clarify expropriation rules and strengthen safeguards to reduce perceived land-loss risk. Even if legal reforms such as elimination of production quotas can reduce formal risk, the observation from the data indicates that Uzbekistan farmers may remain wary of land expropriation. Clear communication of expropriation rules, transparent procedures, and fair compensation can help reduce uncertainty and improve perceived protection against arbitrary land loss.

In post-Soviet Central Asia, where land governance is still evolving, it is important to monitor tenure-security perceptions and their dynamics over time rather than assuming that land documentation or policy interventions will automatically produce stable or rising perceived security. Across both settings, the coexistence of stable sample medians and sizable within-farmer shifts indicates that perceived tenure security is dynamic and heterogeneous. Regular monitoring of tenure-security perceptions, using for example annual farm-survey based barometers, can help identify emerging issues early and guide targeted interventions (e.g., where trust is eroding or where documentation systems are losing credibility).

Analysis includes some limitations which future research can consider. First, the present analysis focused solely on perceived protection rights and land expropriation risks. It would be useful to investigate whether similar patterns emerge in other categories of land rights for example operational rights and transfer rights. Second, the analysis did not address which factors are driving temporal changes (no changes) in examined perceived land tenure rights. Finally, another important direction could be examining empirically the implications of such variations in perceived rights on farmers' production and investment planning.

5. CONCLUSION

This chapter is organized into four sections. Section 5.1 provides a synthesis of the key research findings obtained from two samples in Kazakhstan and Uzbekistan. Section 5.2 makes the policy recommendations. Section 5.3 discusses the contributions of the dissertation to the existing literature. Section 5.4 outlines the limitations, suggests directions for future research, and presents concluding remarks.

5.1 Synthesis of key findings

This dissertation empirically examines how bundles of perceived land rights and time preference are associated with farmers' investment in machinery and equipment—movable productive assets—measured by total asset holdings and asset diversity, using farm survey datasets from the Turkistan region in Kazakhstan and Samarkand region in Uzbekistan. A key novelty of these datasets is that they enable comparative insights across two institutionally and structurally different settings: a more market-oriented setting in Kazakhstan and a less market-oriented setting in Uzbekistan. The first research question examines the relationship between four bundles of perceived land rights such as use, management, transfer and tenure security (distinguishing between protection rights and land expropriation risk) and total machinery and equipment assets and asset diversity. In Kazakhstan, except for protection rights, the estimated associations between perceived land rights bundles and investment generally follow the expected directions: stronger perceived use, management, and transfer rights are positively associated with investment, whereas higher perceived land expropriation risk is negatively associated with investment. Specifically, the most consistent evidence relates to perceived use rights, especially freedom of crop choice, which is positively associated with both machinery and equipment total assets and asset diversity, while perceived land expropriation risk is negatively associated mainly with asset diversity. Overall, stronger perceived use rights—especially crop-choice freedom—are associated with higher machinery and equipment investment in both scale and diversity, whereas higher perceived land expropriation risk is associated with lower diversification of these movable assets.

In Uzbekistan, the results reveal a markedly different pattern. Except for management rights, and to some extent land expropriation risk, the estimated associations for the other tenure dimensions largely run in the opposite direction, with stronger perceived use and transfer rights, as well as higher perceived protection-rights-related insecurity, being negatively associated with investment in farm machinery and equipment. In addition, crop-choice freedom, unlike in Kazakhstan, may somewhat discourage machinery and equipment investment among the sampled Uzbekistan farmers. Specifically, perceived management rights show the clearest

positive association, but only for total assets. By contrast, perceived use rights are negatively associated with both total assets and asset diversity, and perceived transfer rights are negatively associated mainly with total assets. For perceived land expropriation risk, the evidence is weaker overall, but it points to a negative association with asset diversity, consistent with reduced incentives to diversify when perceived land-loss risk is higher. Overall, these findings indicate that in the Uzbekistan context, farmers' machinery and equipment investment is most closely aligned with perceived managerial autonomy in production decisions, whereas broader perceived freedoms captured by use and transfer rights are associated with lower investment.

The second research question using the same datasets explores the extent there is relationship between time preference and farmers' investments using the same investment measures, as well as whether two perceived tenure security conditions such as land expropriation risk and government intervention alter this relationship. Findings from Kazakhstan setting indicates a strong negative association between time preference and both total assets and asset diversity, suggesting that more impatient farmers tend to make fewer investments in farm machinery and equipment. In contrast, data from Uzbekistan provided only weak evidence of this negative association for investments in farm machinery and equipment, implying that the prevailing institutional and economic conditions experienced by sampled farmers in Uzbekistan may discourage investment. Subsample analyses indicate that the relevance of time preference for investment decisions varies across farmers reporting different levels of land tenure security. Particularly, in both settings, contrary to my expectations, the relationship between time preference and investment remained unchanged under conditions of both low and high land expropriation risk. However, as expected, under varying levels of government intervention. In both settings, when government intervention was low, strong association between time preference and investment remained in Kazakhstan, while strong relationship emerged in Uzbekistan setting. This suggests administrative burden from government intervention and inspections may discourage long-term investment planning and push farmers be "busy" with immediate issues.

The third research question, using panel data, examined the temporal dynamics of perceived land tenure security across five dimensions—trust in courts in disputes with three actors, the importance of land documents, and land expropriation risk—between 2019 and 2022, using the same samples. The analysis of both samples revealed that even among farmers holding legal ownership documents, perceptions of land tenure security may not be static. In both samples, around a quarter of farmers, although to a lower extent in Kazakhstan, exhibited significant shifts in their perceptions of security across all dimensions, in both directions and with considerable

magnitude. Such dynamics are often masked in group-level analysis which is commonly used in empirical studies reporting changes in average values of tenure security variables. At the group level, tenure security improvements in Kazakhstan over the observed period were relatively modest. Farmers exhibited greater trust in courts when dealing with disputes against the state, while trust in courts for disputes with investors saw a slight decline. Other dimensions of tenure security at group level remained largely unchanged. In contrast, over the same period, farmers in Uzbekistan, possibly due to recent reforms, appeared to experience greater gains in land tenure security compared to their counterparts in Kazakhstan. Farmers in Uzbekistan demonstrated increased trust in courts for disputes with both the state and investors, while other dimensions of tenure security at group level, particularly land expropriation risk, remained largely persistent.

5.2 Policy implications

The findings suggest that instead of overhauling entire tenure system, policymakers in Kazakhstan and Uzbekistan should prioritize strengthening specific land rights that directly influence investment behavior. Particularly, in Kazakhstan, policies should focus on reinforcing use rights, autonomy in crop choice, while addressing risks related to land expropriation. This could involve ensuring transparent land governance, clearer processes for lease renewals, and strengthening protection against arbitrary land reallocations. Additionally, continued improvements to the legal system and courts are important, especially as competition for land intensifies, which may increase the potential for disputes among actors.

In Uzbekistan, policy priorities should focus on strengthening farmers' management rights and enhancing the economic incentives for agricultural investment. Production must be sufficiently profitable to sustain interest in farming and long-term investment. While Uzbekistan has been progressively shifting toward more liberal land relations and reducing government control over production (Djanibekov et al., 2024), continuous monitoring of policy implementation is essential to ensure reforms are effective without imposing additional administrative burdens. Additionally, land tenure interventions should be coupled with policies addressing specific land expropriation conditions (Ali et al., 2014), and terminations should only be permitted in clearly specified circumstances, such as environmental damage, pollution, or bankruptcy (World Bank 2022).

The results showed that sampled farmers take subjective time preference into account when making investment decisions—an important insight for policymakers in Kazakhstan and Uzbekistan, where traditional policy instruments often overlook the systematic influence of behavioral factors on economic decision-making. A crucial starting point is recognizing that high time preference can be a barrier to long-term investments. Policymakers should prioritize the

temporal dimensions of investment decisions, such as the timeframe for farmers to recoup their investments and the expected timing of initial returns. These factors play a critical role in shaping farmers' willingness to invest. It is important to emphasize that addressing institutional constraints, such as high administrative burden from government intervention, should be a top priority in the short term.

Further in these settings, the evidence showed that trust in courts and land expropriation risk as perceived by farmers are highly dynamic. Farmers may lose autonomy when entering new contracts, negotiating arrangements, or facing disputes with local authorities, all of which contribute to tenure insecurity dynamics. Rising perceptions of tenure insecurity can have significant consequences for long-term planning and investment decisions. Therefore, policymakers should implement regular short surveys to monitor farmers' perceptions and concerns regarding tenure security to enable timely policy adjustments.

5.3 Contributions to the literature

This study contributes to the literature by emphasizing the importance of distinguishing between bundles of land rights other than land tenure security and transfer rights, an area often overlooked in empirical studies. The findings highlight that while land expropriation risk presents a significant constraint, limiting farmers' ability to protect their assets (Acemoglu and Robinson, 2005), investments in farm machinery and equipment, being not tied to land, can be less vulnerable to tenure risks as several studies mentioned (Bandiera, 2007; Place et al., 1994). Tenure risks may not pose big threat on such investments because farmers can adjust their assets/capital stock (e.g., selling, renting out) with lower transaction cost (Feder et al., 1992). By differentiating between several bundles of land rights, this research offers new insights into how operational rights can also give farmers long-term investment incentives.

This study contributes to the literature by addressing a gap in comparative empirical evidence on land tenure and investment in Central Asia. The region's distinct institutional trajectories make it a valuable case for comparative analysis of development (Brück et al., 2014). By leveraging micro-level data that captures multiple bundles of land rights, along with panel data, this study broadens the analytical framework for assessing tenure-investment relationships. The findings reinforce concerns raised in previous studies that the effectiveness of land rights in promoting investment is highly context-dependent (Besley, 1995; Fenske, 2011; Lawry et al., 2017) and relies on supportive economic and institutional conditions (Barrows and Roth, 1990; Bromley, 2009).

Behavioral factors, such as time preference, are often seen as systematically influencing economic decisions such as investments in physical capital, human capital both at individual and

national levels (Dohmen et al., 2015; Sunde et al., 2022). However, this study provides evidence that behavioral and institutional constraints interact, shaping investment behavior in complex ways. Findings showed high government interventions can be barrier for long-term operational planning, and tend to limit farmers' forward-looking decisions like investments. This suggests that patience can lead to higher capital accumulation and income over time when institutional environment is conducive.

5.4 Limitations and future research directions, and concluding remarks

While this dissertation provides valuable insights, it is important to acknowledge its limitations. One limitation of this study is that, due to the specific empirical setting used to sample farmers, the findings may not be directly generalizable to other farm types in these countries. Relatedly, future research on perceived land rights should aim to sample farms with more diverse specialization/tenure arrangements to capture greater variability in land rights. Relatedly, the results mainly speak to movable farm assets such as machinery and equipment. Investments in land-attached assets, and variable inputs involve different characteristics. Additionally, mixed-methods research could offer deeper insights into how farmers adapt to tenure constraints, particularly regarding land expropriation risks and government intervention. Qualitative approaches, in particular, could help uncover farmers' adaptive strategies to both short- and long-term risks. Future research could also explore the regulatory and administrative burdens that farmers in post-socialist environments experience and perceive. While land tenure security is a critical constraint, government-imposed compliance and regulatory requirements can create significant transaction costs. This is particularly relevant in transition economies undergoing reforms, making it an important and promising direction for further study.

As concluding remarks, this dissertation demonstrates that land tenure constraints and time preference critically shape investment decisions in agriculture. The findings align with Barrows and Roth (1990), and other literature that the success of individualized tenure rights depends on supportive market environments such as economic opportunities available to farmers and broader institutional environment. Without these, secure tenure alone may not encourage investment. Overall, this research emphasizes the need for integrated policy approaches that account for the full decision-making environment. Policies that combine sufficient economic incentives, enabling institutional conditions, and farmers' behavioral factors may be more effective in increasing farmers willingness to invest in their farms and land, and in fostering conditions for sustainable development in transition and developing economies.

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APPENDIX

Table A1. Survey questions on bundles of perceived land rights

Bundle of use rights	
Enter land	How free are you to enter agricultural land of your farm?
Collect harvest	How free are you in collecting harvest from your land?
Decide on land use (purpose) change	To what extent are you free in changing the purpose of land use within agriculture? (change from one agricultural activity to another: from cropping to grazing, for example)
Bundle of management rights	
Decide on crop choice	To what extent are you free in deciding which crop to cultivate, crop rotation to use?
Decide on cultivation method, inputs	To what extent are you free in deciding which cultivation methods to use, such as amount of pesticides and fertilizers, crop rotation and others?
Invest in land	To what extent are you free in deciding how much to invest in land (for example in melioration, maintaining the irrigation canals and others)?
Exclude others from entering land	How free are you in prohibiting other farmers and households from producing crops on your land?
Market own product (price, outlet)	How free are you in deciding where/how, whom and for how much to sell main harvested crops?
Bundle of transfer rights	
Permit others use own land	How free are you in granting another person permission to use your land?
Sell land	How free are you in selling land to others?
Rent out land	To what extent are you free to rent out your land?
Rent in leased land	To what extent are you free to use the land of other farmers who lease land from government?
Bequeath land	To what extent are you free to give your land as a heritage?
Bundle of protection rights	
Trust in courts in disputes with farmers	How much do you trust courts to assist you in the disputes on tenancy or ownership with other farmers?
Trust in courts in disputes with investors	How much do you trust courts to assist you in the disputes on tenancy or ownership with investors outside of your district?
Trust in courts in disputes with state	How much do you trust courts to assist you in the disputes on tenancy or ownership with state authorities?
Importance of land document in proving land rights	How important are land registration documents for protecting land ownership and tenure rights when you need to prove them?

Source: SUSADICA Farm Survey 2019.

Table A2. Mean differences in perceived land rights

	Kazakhstan (N=503)	Uzbekistan (N=460)	Mean difference
Use rights			
Enter land	4.89	4.92	-0.02
Collect harvest	4.71	2.50	2.21***
Change land use purpose	4.59	1.47	3.12***
Management rights			
Decide on crop choice	4.76	1.58	3.18***
Decide on cultivation methods	4.73	4.26	0.46***
Invest in land	4.67	4.29	0.38***
Exclude others from entering land	4.53	4.53	0.00
Market own product	4.73	1.57	3.16***
Transfer rights			
Permit others use own land	3.51	1.34	2.17***
Sell land	3.70	1.00	2.69***
Rent out land	3.87	1.27	2.61***
Rent in leased land	3.85	1.18	2.67***
Bequeath land	4.22	1.61	2.61***
Protection rights			
Trust in courts in disputes with other farmers	3.90	3.94	-0.04
Trust in courts in disputes with investors	3.42	3.02	0.40***
Trust in courts in disputes with government	3.41	2.25	1.16***
Importance of land documents in proving land rights	4.62	4.18	0.44***
Land tenure security			
Land expropriation risk	1.62	2.75	-1.13***
Government intervention	2.229	3.785	-1.55***

Source: SUSADICA Farm Survey 2019. Own calculations.

Note: Table 2 presents the mean-level of perceptions for each specific right, and mean differences across 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)

Table A3. Mean differences in control variables

Farmer-specific variables	Kazakhstan (N=503) Mean	Uzbekistan (N=460) Mean	Mean diff.	t-statistics
Farmer age	46.199	42.750	3.449***	4.53
Education	0.296	0.335	-0.0386	-1.29
Risk attitude	4.189	3.496	0.693***	11.88
Business horizon	3.652	3.674	-0.0218	-0.47
Farm-specific variables				
Farm age	18.256	9.211	9.046***	22.91
Farm area	14.187	38.944	-24.76***	-11.85
Specialization	0.612	0.674	-0.0616**	-1.99
Tenure form	0.670	0.000	n/a	n/a
Contract farming	0.149	0.059	0.0904***	4.6
Sufficient inputs	3.579	3.765	-0.187***	-3.42
Total tax	72.401	1259.944	-1187.5***	-21.85
Hired agronomist	0.149	0.102	0.0469**	2.19
Workers	1.648	3.904	-2.256***	-13.82
Livestock	0.157	0.028	0.129***	6.95
Irrigation system condition	1.905	1.915	-0.0106	-0.23
Soil fertility	35.052	56.593	-21.540***	-8.11
Economic and institutional environment				
Access to land	0.606	0.335	0.272***	8.75
Credit obtained	0.274	0.280	-0.006	-0.21
Nonfarm income	0.406	0.280	0.125***	4.11
Economic access to variable inputs	0.948	0.730	0.218***	4.31
Physical access to variable inputs	0.159	0.789	-0.630***	-14.64
Government intervention	2.229	3.785	-1.556***	-23.74

Source: SUSADICA Farm Survey 2019. Own calculations.

Table A4. Overdispersion test

	Kazakhstan (N=503)			Uzbekistan (N=460)		
Variable	**Mean**	**Variance**	**Overdispersion parameter**	**Mean**	**Variance**	**Overdispersion parameter**
Asset diversity	0.45	0.79	0.40***	2.27	1.41	-0.22***
Total assets	0.60	2.21	0.90***	4.00	9.23	0.12***

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: 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).

Table A5. Mean differences in control variables between private owners and leaseholds in Kazakhstan

Farmer-specific variables	Leasehold (n= 166) Mean	Private (n= 377) Mean	Mean diff.	t-statistics
Farmer age	47.157	45.727	1.43	1.14
Education	0.289	0.300	-0.0105	-0.24
Risk attitude	4.114	4.226	-0.111	-1.27
Business horizon	3.675	3.641	0.0337	0.46
Farm-specific variables				
Farm age	17.825	18.469	-0.644	-1.23
Farm area	16.189	13.201	2.988	0.85
Specialization	0.566	0.635	-0.0687	-1.49
Contract farming	0.120	0.163	-0.0427	-1.26
Sufficient inputs	3.452	3.641	-0.189**	-2.19
Total tax	72.087	72.555	-0.468	-0.05
Hired agronomist	0.157	0.145	0.0112	0.33
Workers	1.572	1.685	-0.113	-0.48
Livestock	0.102	0.184	-0.0816**	-2.37
Irrigation system condition	1.892	1.911	-0.0194	-0.26
Soil fertility	39.024	33.095	5.929	1.5
Economic and institutional environment				
Access to land	0.675	0.573	0.102**	2.21
Credit obtained	0.313	0.255	0.0581	1.37
Nonfarm income	0.361	0.427	-0.0659	-1.41
Economic access to variable inputs	0.958	0.944	0.0142	0.17
Physical access to variable inputs	0.229	0.125	0.104***	2.59
Government intervention	2.277	2.205	0.0724	0.67

Source: SUSADICA Farm Survey 2019. Own calculations.
Note: * p <0.10, ** p<0.05, *** p<0.01, (two-sided t-test).

Table A6. Trust in courts to assist you in the disputes on tenancy or ownership with farmers in Kazakhstan (N = 239)

Years 2019 (row)/ 2022 (column)	*Not trust*	*Rarely*	*Sometimes*	*Often*	*Fully trust*	**Row total**
Not trust	2 (0.8)	0	0	5 (2.1)	6 (2.5)	**13 (5.4)**
Rarely	1 (0.4)	1 (0.4)	4 (1.6)	2 (0.8)	3 (1.25)	**11 (4.6)**
Sometimes	1 (0.4)	0	10 (4.2)	25 (10.4)	8 (3.3)	**44 (18.4)**
Often	6 (2.5)	1 (0.4)	20 (8.3)	32 (13.4)	31 (13.0)	**90 (37.6)**
Fully trust	3 (1.25)	2 (0.8)	22 (9.2)	29 (12.1)	25 (10.4)	**81 (33.9)**
Column total	**13 (5.4)**	**4 (1.6)**	**56 (23.4)**	**93 (39.0)**	**73 (30.5)**	**239 (100.0)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A7. Trust in courts to assist you in the disputes on tenancy or ownership with investors in Kazakhstan (N = 239)

Years 2019 (row)/ 2022 (column)	*Not trust*	*Rarely*	*Sometimes*	*Often*	*Fully trust*	**Row total**
Not trust	1 (0.4)	1 (0.4)	3 (1.25)	8 (3.3)	1 (0.4)	**14 (5.8)**
Rarely	2 (0.8)	1 (0.4)	9 (3.7)	8 (3.3)	2 (0.8)	**22 (9.2)**
Sometimes	10 (4.2)	10 (4.2)	26 (10.8)	34 (14.2)	7 (2.9)	**87 (36.4)**
Often	8 (3.3)	5 (2.1)	35 (14.6)	21 (8.8))	9 (3.7)	**78 (32.6)**
Fully trust	6 (2.5)	5 (2.1)	14 (5.8)	10 (4.2)	3 (1.25)	**38 (15.9)**
Column total	**27 (11.3)**	**22 (9.2)**	**87 (36.4)**	**81 (33.9)**	**22 (9.2)**	**239 (100.0)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A8. Trust in courts to assist you in the disputes on tenancy or ownership with state in Kazakhstan (N = 239)

Years 2019 (row)/ 2022 (column)	*Not trust*	*Rarely*	*Sometimes*	*Often*	*Fully trust*	**Row total**
Not trust	0	0	4 (1.6)	7 (2.9)	6 (2.5)	**17 (7.1)**
Rarely	2 (0.8)	0	8 (3.3)	14 (5.8)	10 (4.2)	**34 (14.2)**
Sometimes	3 (1.25)	3 (1.25)	23 (9.6)	25 (10.4)	19 (7.9)	**73 (35.5)**
Often	3 (1.25)	3 (1.25)	17 (7.1)	18 (7.5)	15 (51.7)	**56 (23.4)**
Fully trust	2 (0.8)	2 (0.8)	14 (5.8)	21 (8.8)	20 (8.3)	**59 (24.7)**
Column total	**10 (4.2)**	**8 (3.3)**	**66 (27.6)**	**85 (35.5)**	**70 (29.3)**	**239 (100.0)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A9. Land documents can prove my rights on land in Kazakhstan (N = 239)

Years 2019 (row)/ 2022 (column)	*Never*	*Rarely*	*Sometimes*	*Frequently*	*Always*	**Row total**
Never	0	0	0	0	3 (1.25)	**3 (1.25)**
Sometimes	0	1 (0.4)	1 (0.4)	3 (1.25)	28 (11.7)	**33 (13.8)**
Frequently	0	1 (0.4)	0	0	13 (5.4)	**14 (5.8)**
Always	2 (0.8)	1 (0.4)	5 (2.1)	15 (6.2)	166 (69.4)	**189 (79.1)**
Column total	**2 (0.8)**	**3 (1.25)**	**6 (2.5)**	**18 (7.5)**	**210 (87.8)**	**239 (100.0)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A10. Likelihood of losing land ownership or land use right in the next 3 years in Kazakhstan (N = 239)

Years 2019 (row)/ 2022 (column)	*Extremely unlikely*	*Unlikely*	*Neutral*	*Likely*	*Extremely likely*	**Row total**
Extremely unlikely	89 (37.2)	30 (12.5)	8 (3.3)	10 (4.2)	11 (4.6)	**148 (61.9)**
Unlikely	43 (18.0)	15 (6.2)	2 (0.8)	0 (0.0)	1 (0.4)	**61 (5.4)**
Neutral	6 (2.5)	5 (2.1)	0 (0.0)	2 (0.8)	0 (0.0)	**13 (5.4)**
Likely	9 (3.7)	2 (0.8)	2 (0.8)	2 (0.8)	0 (0.0)	**15 (6.2)**
Extremely likely	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.4)	**2 (0.8)**
Column total	**147 (61.5)**	**53 (22.2)**	**12 (5.0)**	**14 (5.8)**	**13 (5.4)**	**239 (100.00)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A11. Trust in courts to assist you in the disputes on tenancy or ownership with farmers in Uzbekistan (N = 159)

Years 2019 (row)/ 2022 (column)	*Not trust*	*Rarely*	*Sometimes*	*Often*	*Fully trust*	**Row total**
Rarely	0	1 (0.6)	0	3 (1.9)	6 (3.7)	**10 (6.3)**
Sometimes	0	1 (0.6)	1 (0.6)	14 (8.8)	5 (3.1)	**21 (13.2)**
Often	5 (3.1)	3 (1.9)	14 (8.8)	47 (29.5)	16 (10.0)	**85 (53.4)**
Fully trust	0	2 (1.2)	8 (5.0)	23 (14.4)	10 (6.3)	**43 (27.0)**
Column total	**5 (3.1)**	**7 (4.4)**	**23 (14.4)**	**87 (54.7)**	**37 (23.2)**	**159 (100.0)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A12. Trust in courts to assist you in the disputes on tenancy or ownership with investors in Uzbekistan (N = 159)

Years 2019 (row)/ 2022 (column)	*Not trust*	*Rarely*	*Sometimes*	*Often*	*Fully trust*	**Row total**
Not trust	0	0	1 (0.6)	3 (1.9)	1 (0.6)	**5 (3.1)**
Rarely	0	2 (1.2)	7 (4.4)	16 (10.0)	6 (3.7)	**31 (19.5)**
Sometimes	2 (1.2)	5 (3.1)	27 (17.0)	44 (27.6)	10 (6.3)	**88 (55.3)**
Often	1 (0.6)	0	13 (8.1)	16 (10.0)	3 (1.9)	**33 (20.7)**
Fully trust	0	0	0	2 (1.2)	0	**2 (1.2)**
Column total	**3 (1.9)**	**7 (4.4)**	**48 (30.2)**	**81 (51.0)**	**20 (12.5)**	**159 (100.0)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A13. Trust in courts to assist you in the disputes on tenancy or ownership with state in Uzbekistan (N = 159)

Years 2019 (row)/ 2022 (column)	*Not trust*	*Rarely*	*Sometimes*	*Often*	*Fully trust*	**Row total**
Not trust	0	4 (2.5)	21 (13.2)	21 (13.2)	4 (2.5)	**50 (31.4)**
Rarely	2 (1.2)	8 (5.0)	21 (13.2)	20 (12.5)	11 (7.0)	**62 (39.0)**
Sometimes	1 (0.6)	2 (1.2)	7 (4.4)	16 (10.0)	4 (2.5)	**30 (18.8)**
Often	0	1 (0.6)	7 (4.4)	6 (3.7)	2 (1.2)	**16 (10.0)**
Fully	0	0	1 (0.6)	0	0	**1 (0.6)**
Column total	**3 (1.9)**	**15 (9.4)**	**57 (35.8)**	**63 (39.6)**	**21 (13.2)**	**159 (100.0)**

Source: Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A14. Land documents can prove my rights on land in Uzbekistan (N = 159)

Years 2019 (row)/ 2022 (column)	*Never*	*Rarely*	*Sometimes*	*Frequently*	*Always*	**Row total**
Never prove	0	0	0	0	1 (0.6)	**1 (0.6)**
Rarely	0	0	2 (1.2)	1 (0.6)	1 (0.6)	**4 (2.5)**
Sometimes	1 (0.6)	1 (0.6)	9 (5.6)	11 (7.0)	9 (5.6)	**31 (19.5)**
Frequently	0	5 (3.1)	16 (10.0)	14 (8.8)	20 (12.5)	**55 (34.6)**
Always	0	9 (5.6)	23 (14.4)	11 (7.0)	25 (15.7)	**68 (42.7)**
Column total	**1 (0.6)**	**15 (9.4)**	**50 (31.4)**	**37 (23.2)**	**56 (35.2)**	**159 (100.0)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

Table A15. Likelihood of losing land ownership or land use right in the next 3 years in Uzbekistan (N = 159)

Years 2019 (row)/ 2022 (column)	*Extremely unlikely*	*Unlikely*	*Neutral*	*Likely*	*Extremely likely*	**Row total**
Extremely unlikely	0 (0.0)	3 (1.9)	2 (1.2)	2 (1.2)	0 (0.0)	**7 (4.4)**
Unlikely	14 (8.8)	20 (12.5)	22 (13.8)	15 (9.4)	2 (1.2)	**73 (46.0)**
Neutral	3 (1.9)	4 (2.5)	5 (3.1)	7 (4.4)	3 (1.9)	**22 (13.8)**
Likely	11 (7.0)	12 (7.5)	17 (10.7)	12 (7.5)	2 (1.2)	**54 (33.9)**
Extremely likely	0 (0.0)	2 (1.2)	0 (0.0)	1 (0.6)	0 (0.0)	**3 (1.9)**
Column total	**28 (17.6)**	**41 (25.8)**	**46 (29.0)**	**37 (23.2)**	**7 (4.4)**	**159 (100.0)**

Source: SUSADICA Farm Surveys 2019 and 2022 (panel data; farms linked across years). Own calculations.

CURRICULUM VITAE

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FIELDS OF RESEARCH INTEREST

Sustainable agricultural development; Institutional/organizational innovations; Applied behavioral science and behavioral economics.

(1) Improving, introducing institutional innovations that support farmers, including land tenure, contract farming, and partnership models. (2) Applying insights from behavioral science and economics to design agricultural initiatives and programs that enhance adoption and participation among farmers. (3) Promoting and advocating for sustainable agricultural practices that integrate agri-entrepreneurship with a focus on social and environmental impact.

EMPLOYMENT

2019-present: Researcher at the Department of Agricultural Policy, Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale), Germany.

Doctoral program: Structured doctoral programme on Sustainable Agricultural Development in Central Asia (SUSADICA), funded by the Volkswagen Foundation

Activities:

2025-present: post-doctoral research (stipend-based). Activities include supporting ongoing and future research projects related to Central Asia.

2019-2025: Development of own doctoral research. Activities include formulating research questions and hypotheses, methodology, data collection, data analysis, writing.

September 2016 – December 2018: Associate lecturer at the Westminster International University in Tashkent (WIUT), (https://wiut.uz). Responsibilities included teaching bachelor students on subjects like introductory and intermediate microeconomics, public finance, module leadership preparing annual syllabus and student assessments.

August 2013 – July 2014: Junior Finance officer in KDB Bank Uzbekistan, (https://kdb.uz/en), Responsibilities include preparation of daily/weekly reports for board of directors, Assistance in reconciliation and bookkeeping, Improvement of the depth and comprehensiveness of operational reports.

ACADEMIC QUALIFICATIONS

July 2016: MSc. in Environmental and Natural Resource Economics, The University of Rhode Island, Rhode Island, USA

July 2013: BA. in Banking, Tashkent Financial Institute, Tashkent, Uzbekistan

SELECTED RESEARCH PROJECTS, CONSULTANCIES AND OTHER ACTIVITIES

2016-2018—National Innovation Contest in Uzbekistan, led a project "Competition and Knowledge hiding: Lab experiment" in the framework of National Innovation Contest in Uzbekistan (one of the three winners out of around 150 applications for research grant.

2016-2018—International Labor organization (ILO) funded project on “Qualitative survey on recruitment processes and practices in temporary seasonal agriculture in Uzbekistan, with a focus on cotton”. Activities included preparation of questionnaire, field surveys, contributing to writing final report.

2017—US Embassy research grant. Conducted training of school children on the "The Role of Raising Environmental Awareness among School Children in Secondary Educational Institutions in Tashkent, Uzbekistan"

Mentorship activities (2018): Help Muskie interns with identifying and preparing for internship opportunities in USA.

PUBLICATIONS

Published

Kurbanov, Z., Djanibekov, N., Herzfeld, T. (2025) Land property rights and investment incentives in movable farm assets: Evidence from post-Soviet Central Asia. Comparative Economic Studies.

Kurbanov, Z., Tadjiev, A., Djanibekov, N., Akramkhanov, A., Govind, A. (2024) Farmers' participation in messenger-based social groups and its effects on performance in irrigated areas of Kazakhstan and Uzbekistan. Agribusiness.

Kurbanov, Z., Tadjiev, A., Djanibekov, N. (2022) Adoption of sustainable agricultural practices and investments in productive assets in irrigated areas of Central Asia: Farm-survey evidence from Kazakhstan and Uzbekistan. IAMO Annual 24: 69-79.

Ongoing/Submitted works

Determinants and impacts of sustainable agricultural practices in Uzbekistan

Risk preferences and perceptions of land tenure risks: application of prospect theory

Applications of behavioural insights in agricultural policy design in Central Asia

Presentations in academic conferences/workshops

Kurbanov, Zafar; Tadjiev, Abdusame; Djanibekov, Nodir (2022) Different but same? Enhancing farm resilience through sustainable agricultural practices and investments in productive assets among farmers in Kazakhstan and Uzbekistan. IAMO Forum 2022 "Enhancing resilience in a post-pandemic era: challenges and opportunities for rural development", Halle (Saale), Deutschland.

Kurbanov, Zafar (2022) Give us more decision-making autonomy! Strategic commodities, property rights and investment incentives: Case studies from Kazakhstan and Uzbekistan. Sustainable Management of Natural Resources in Uzbekistan, Berlin, Deutschland.

Kurbanov, Zafar (2021) Does time preference affect farmers' agricultural investments? Evidence from Central Asia. 31st Virtual ICAE 2021, Neu Delhi / Online, Indien.

Kurbanov, Zafar (2020) Time preference and farmer's investment behaviour. Research Workshop "SUSADICA - Structured doctoral programme on Sustainable Agricultural Development in Central Asia", Halle (Saale), Deutschland.

Kurbanov, Zafar (2020) Farmers investments in productive assets: Preliminary insights from Kazakhstan and Uzbekistan. Sustainable agricultural development and regional cooperation for inclusive growth in Central Asia, online, Usbekistan.

Kurbanov, Zafar (2020) Farmers investments in productive assets: Insights from Kazakhstan and Uzbekistan. SUSADICA Online Workshop, Online, Deutschland.

Kurbanov, Zafar (2019) Application of Experimental Economics Methods in Agriculture. Sustainable Agricultural Development in Central Asia, Tashkent, Usbekistan.

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Eidesstattliche Erklärung / Declaration under Oath

Ich erkläre an Eides statt, dass ich die Arbeit selbstständig und ohne fremde Hilfe verfasst, keine anderen als die von mir angegebenen Quellen und Hilfsmittel benutzt und die den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht habe.

I declare under penalty of perjury that this thesis is my own work entirely and has been written without any help from other people. I used only the sources mentioned and included all the citations correctly both in word or content.

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Datum / Date Unterschrift des Antragstellers / Signature of the applicant