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**EVOLUTIONARY MECHANISMS AND
SPATIO-TEMPORAL EFFECTS OF HOMESTEAD USE
UNDER THE JOINT REFORM OF HUKOU SYSTEM
AND HOMESTEAD SYSTEM**

CUI XIAO

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The Hong Kong Polytechnic University
Department of Building and Real Estate

Tongji University
School of Economics and Management

**Evolutionary Mechanisms and Spatio-Temporal Effects
of Homestead Use under the Joint Reform of
Hukou System and Homestead System**

CUI Xiao

A thesis submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

September 2025

CERTIFICATE OF ORIGINALITY

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_____(Signed)

CUI Xiao (Name of student)

Dedication

To my father in heaven, whose love guides me still;
To my mother, whose strength and presence ground me;
And to my husband, who fights beside me and lifts me up.

Abstract

Guiding the rational evolution of rural homestead is not only a key strategy for rural revitalization but a vital approach to expanding new space for urban–rural development. Since China’s Third Plenary Session of the 18th Central Committee in 2013, comprehensive reforms of hukou and homestead systems have been initiated, inevitably leading to significant changes in the lifestyle and homestead use behaviors of hundreds of millions of rural migrants, and the evolution of homestead use. What impact will reforms have on homestead use behavior? How can the evaluation of homestead use patterns be effectively regulated under institutional reforms? To answer these questions, it’s essential to understand the long-term characteristics of homestead use evolution and potential trends of multiple policy interventions.

Based on this, this study incorporates the macro-level institutional environment, micro-level behavioral responses, and spatial patterns. By comprehensively employing spatial equilibrium models, econometric models, multi-agent systems, and geographic information systems, it reveals the evolutionary mechanisms and spatio-temporal effects of homestead use behavior under the joint reform of hukou system and homestead system. The main conclusions are as follows:

(1) A framework for analyzing the evolutionary mechanisms and spatio-temporal effects of homestead use behavior under the joint reform of hukou system and homestead system is developed. The findings reveal that major homestead system reforms throughout history have been advanced in conjunction with hukou system reforms. Their joint reform changes the nature of homestead property rights, replacing hukou-based rights with market-oriented rights. This transformation affects the equilibrium state among market entities, alters the utility and constraints of rural households, and prompts changes in their homestead use behaviors. The accumulation of numerous micro-level homestead use behaviors results in the differentiation of farmer groups and emerges as spatial-level homestead use evolution, following the logical route of "external shock-behavioral response-effect emergence".

(2) A spatial equilibrium model is developed to theoretically explore the evolutionary mechanisms of homestead use behavior under the joint reform of hukou system and homestead system. Based on the Rosen-Roback model, two institutional variables are introduced to extend the baseline model with Chinese characteristics. Through comparative static analysis, this study analyzes the impacts of institutional reforms on farmers' homestead use behaviors and proposes propositions. The findings indicate that restrictive hukou and homestead systems neither lead to permanent urban settlement nor complete non-agricultural transformation, resulting in a misallocation of human-land resources. The joint reform of two systems plays a complementary role in encouraging farmers to withdraw from homesteads. This complementarity arises because the hukou system reform grants farmers full urban employment rights and welfare benefits, enhancing the income effect of the homestead system reform and reducing farmers' reliance on the homestead. Consequently, rural-to-urban labor migration and homestead withdrawal occur on a larger scale, accompanied by a higher level of utility for rural households, greater total socio-economic output, and a transformation of negative "crowding-out effect" into positive "agglomeration effect."

(3) A difference-in-differences model is constructed to empirically test the hypothesis of homestead use behavior evolution under the joint reform of hukou system and homestead system, with additional focus on the policies, dynamics, and heterogeneity of the effects. The findings based on the national survey data confirm that hukou system reform can improve the effectiveness of homestead system reform in encouraging farmers to withdraw from homesteads, with a 14% increase. Employment and housing policies within the hukou system reform play an effective role. However, as the hukou system reform deepens, the positive effects of the joint reform show an inverted U-shape. At this point, the homestead security function is replaced by urban welfare and is no longer a concern for farmers. Meanwhile, farmers' high expectations for the future value of homesteads, along with their attachment to their hometowns, reduce their willingness to withdraw. Furthermore, heterogeneity analysis reveals that complementarity is stronger between homestead

reform in the central and western regions, non-minority areas, large counties, and distant suburban areas, and hukou system reform in second-tier cities.

(4) A simulation model of homestead use evolution and its spatio-temporal effects under the joint reform of hukou system and homestead system is developed. First, a framework combining a spatially explicit multi-agent system and a geographic information system is established. Then, based on the findings above, methods such as projection, regression, and probability are used to build the model. This model illustrates the social relationships among individuals, households, and village groups, as well as the spatial connections between farmers and their corresponding croplands or homesteads. It captures the interactions, impacts, and feedback among policy interventions, social networks, labor migration, homestead use, and environmental changes. Therefore, a coupled human-land system is established.

(5) Using Yucheng County in China as a case, this study simulates the spatio-temporal effects of homestead use under different institutional reform scenarios. The findings show that reforming hukou system alone can encourage rural-to-urban migration. However, the high cost of urban housing has become a new barrier to farmers' urban integration, thereby reducing the homestead use efficiency. Likewise, reforming the homestead system alone has limited effects. Among related policies, the paid-use policy may help facilitate the withdrawal of illegally or excessively occupied homesteads. However, its pricing mechanism fails to reflect market supply and demand or land value, which harms farmers' interests. Among the compensated withdrawal policies, when cash compensation, combined with farmers' savings, covers a down payment for urban commercial housing, the proportion of farmers withdrawing from homesteads increases significantly. The effect is more pronounced under the apartment exchange policy, especially when exchange units meet farmers' basic housing needs. The joint reform of two systems can promote rural-urban migration, improve homestead use efficiency, and increase farmers' income.

Key Words: Hukou system, Homestead system, Homestead use behavior, Evolutionary mechanisms, Spatio-temporal effects

Publications arising from the thesis

- **Papers arising from the thesis**

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- **Manuscripts under preparation**

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- **Other publication**

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A Journey Through Thorns

As I write this, just after turning thirty, I find myself reflecting on the past few years, which have been filled with both sorrow and gratitude, fear and resilience. The memories are overwhelming, and more than once I have been brought to tears. Since my father was diagnosed with cancer in 2017, I have been at home, caring for him while working on my thesis day by day, moment by moment. Both my master's thesis and PhD application materials were completed on the small tray table beside his hospital bed. Strangely enough, the papers I wrote in the hospital all found their way into journals, while the ones I wrote on campus—neat, structured, and quiet—mainly ended up shelved and rejected. I like to think it was my father's quiet strength that carried me through. In 2020, everything changed again. My father's condition worsened quickly, and my mother was diagnosed with cancer as well. I spent the next few years moving between wards, with my mother in Ward 2 and my father in Ward 6. It was not until 2023 that I returned to campus, after my father passed away and my mother moved in with my grandmother to recover. I returned like a soldier coming back from a long, losing battle: exhausted, broken, and unsure of what was next. Yet even then, I kept telling myself, "It's okay. Just start again."

A Journey Beneath the Sunshine

Even when the road was rough and full of thorns, sunlight still shone above us. Looking back, those days in the hospital with my parents were, in their own quiet way, filled with warmth. On afternoons when no treatment was necessary, the three of us would sit on the lawn, basking in the sun. Sometimes, we took short walks—climbing Qianfo Mountain, visiting Daming Lake, or watching the springs at Baotuquan. When he was feeling well, my father helped plan my wedding. After he passed away, he began appearing in my dreams night after night, telling me he was grateful for my presence and that he was doing just fine in the other world. Throughout it all, my

mother kept looking at me with that steady, fearless gaze and said, “Be strong, stay calm, find a way, everything will get better.” I am endlessly grateful to my parents for giving me so much love, even when they had so little strength left for themselves. They never stopped believing in me. They trusted me, supported me, and stood behind every decision I made.

I am deeply grateful to my supervisor, Chair Professor Eddie Hui Chi Man. When I first expressed my desire to study at The Hong Kong Polytechnic University, he read my resume in just ten minutes and replied with a simple, “Welcome.” After I arrived in Hong Kong, he provided one-on-one guidance every week. I still remember him reviewing my paper on Christmas Day. Every time our meetings ended, he would say, “Judy, keep going.” Last year, he took me to an international conference. I’ll never forget how this globally renowned scholar sat quietly in the audience, cheering me on. After my presentation, he approached me with a warm smile, told me I did a great job, and took photos to capture the moment. During those times, when other students looked at me with admiration, I felt a quiet sense of pride.

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A Journey Amid Blossoms

Spring has arrived in Hong Kong. Flowers bloom along the streets, and when the breeze passes through, petals drift down like confetti, covering the ground in color.

On my walks to campus, I sometimes pick up a few fallen blossoms and place them in a handmade vase—just an empty Yakult bottle, really, but it made my desk feel alive. There’s a small garden on the rooftop of our school, filled with flowers. Every time Menglan returns from a phone call up there, she brings back a few blooms for me. Their fragrance is always refreshing and comforting.

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Chapter 1: Introduction

1.1 Research Background

1.1.1 Given the extensive use of rural homesteads, guiding their rational evolution has become a national-level strategic priority

With the rapid development of industrialization and urbanization, a large number of rural populations are migrating to cities, which inevitably leads to the problem of rural decline and imbalance in urban-rural development faced by most countries worldwide. Due to the urban-rural dual system structure that favors cities, China's imbalanced urban-rural development is particularly severe. The hukou system, which restricts farmers from acquiring urban hukou and accessing corresponding welfare, together with the rural homestead system, which prohibits rural migrants from freely transferring their rural homesteads after moving to cities, has significantly hindered the free flow of land and labor factors between urban and rural areas. As a result, with a large number of surplus rural laborers migrating to cities, issues such as building new houses without demolishing old ones, owning multiple homesteads per household, and excessive land occupation are widespread in rural areas, resulting in a considerable portion of rural homesteads remaining idle for long periods.

Since the reform and opening up, China's urbanization rate has sharply increased from 17.9% in 1978 to 65.22% in 2022, with more than 300 million farmers migrated into urban areas, the urbanization rate of registered population was only 47%, and homestead area even increased by 30.45 million mu, leaving at least 30 million mu of homestead and 70 million farm houses unused or abandoned (Ministry of Agriculture and Rural Affairs, 2020). In sharp contrast, China's 192,000 square kilometers of rural residential areas accommodate approximately 40% of the population, while the 94,000 square kilometers of urban residential land accommodate approximately 60% of the population. As a result, the extensive and inefficient use of rural homesteads, along with the increasing waste of land resources, has become a growing concern,

posing a significant challenge to rural decline in China.

Given the large quantity and wide geographical distribution of rural homesteads in China, guiding their rational evolution and utilization is not only a key component of rural revitalization but also an important means to alleviate the supply-demand imbalance of urban construction land and to expand new spatial resources for integrated urban-rural development. In 2017, the report of the *19th National Congress of the Communist Party of China* clearly proposed the rural revitalization strategy. In the same year, the *No. 1 Central Document* emphasized the need to explore land guarantee mechanisms for agricultural and rural development, improve the spatial planning of urban-rural construction land, and strengthen efforts to activate the existing stock of rural construction land. Subsequently, the *National Land Planning Outline (2016-2030)* issued by the State Council required to adjust and optimize the land layout of rural residential areas, accelerate the remediation of hollow villages and the renovation of dilapidated houses, improve rural infrastructure and public service facilities, and improve the conservation and intensification of land and other resources, and improve the efficiency and effectiveness of land use. In 2019, the Ministry of Agriculture and Rural Affairs issued the *Guidelines on Actively and Prudently Promoting the Revitalization and Utilization of Idle Rural Homesteads and Housing*, calling for localized and adaptive approaches to revitalize underused rural homesteads. The Third Plenary Session of the 20th Central Committee in 2024 explicitly called for the legal protection of homestead use rights and collective income distribution rights of rural migrants, the development of voluntary and compensated mechanisms for homestead withdrawal, and the revitalization of rural housing through rental, equity participation, or cooperative models.

To sum up, achieving the intensive and efficient use of rural homesteads and guiding their orderly and rational evolution has become a strategic priority at the national level.

1.1.2 The new round of hukou and rural homestead system reforms will profoundly influence the homestead use evolution

To promote the intensive use of rural homesteads, reforming the homestead system, granting farmers complete property rights, and encouraging rural migrants to voluntarily withdraw from their idle homesteads have long been shared goals in both academic and policy circles. Obviously, instead of decreasing, the total area of rural homesteads has continued to grow, indicating that homestead reform has not achieved its intended outcomes.

A key reason is that giving up one's homestead often means a permanent loss of the welfare benefits attached to it. In the absence of alternative social security mechanisms, most rural migrants are unable to bear the risks associated with withdrawing from their rural homesteads. The household registration (*hukou*) system, which restricts access to urban welfare for rural migrants, plays a central role in this dilemma. Evidently, the current restrictive *hukou* system weakens both the capacity and willingness of rural migrants to withdraw from their homesteads, thereby significantly undermining the effectiveness of homestead system reform. Therefore, in order to promote more intensive homestead use, attention must be paid not only to reforming the homestead system itself, but also to addressing the institutional constraints imposed by the *hukou* system.

Since the Third Plenary Session of the 18th CPC Central Committee, China has actively pushed forward comprehensive reform efforts, including a new phase of *hukou* and rural homestead system reforms. Regarding the *hukou* system reform, the National New-type Urbanization Plan (2014–2020), released in 2014, proposed accelerating the urban integration of rural migrants by relaxing household registration requirements to varying degrees across cities of different sizes, and by promoting the establishment of a unified urban–rural *hukou* system. This reform has provided rural migrants with fairer access to urban welfare and complete employment rights, thereby promoting citizenization of rural migrants. Regarding the homestead system reform, China launched pilot programs in selected regions in 2015 and again in 2020. In 2018, the "three rights separation" (*San Quan Fen Zhi*) framework was introduced, which separates ownership, qualification rights, and use rights of rural homesteads. The

reform mainly focuses on clarifying collective ownership of homesteads, safeguarding the qualification rights of rural households, liberalizing the use rights, and exploring the market-oriented transfer of homesteads.

The coordinated reform of the hukou and rural homestead systems has eliminated institutional barriers to rural-to-urban migration on the urban side, while opening up channels for realizing the asset value of rural homesteads on the rural side. Driven by both urban pull and rural push factors, this joint reform is expected to accelerate farmers' rural-to-urban migration, as well as promote the paid use, compensated withdrawal, and transfer of homesteads. These changes will profoundly influence the transformation of both the production and living patterns of hundreds of millions of rural households, as well as the ways in which rural homesteads are used, and further drive the evolution of their scale, structure, function, and efficiency.

1.1.3 Insufficient evaluation of the spatio-temporal effects of homestead use evolution under the hukou and homestead system reforms hinders rural development

Under the joint reform of hukou system and rural homestead system, the evolution of homestead use has been increasingly intensified. In this context, rationally regulating the spatial pattern of rural homesteads and guiding their sound development rely on a grasp of the long-term evolution patterns of homesteads and a clear understanding of future policy intervention scenarios. How do farmers understand these systems and their changes? Are there differences in farmers' perceptions and behavioral responses? How do these differences affect the homestead use evolution? Does homestead use evolution generate feedback on relevant policies and systems? These issues are central to promoting the intensive use of rural homesteads, guiding the deepening of institutional reforms, and achieving rural revitalization.

However, national territory spatial planning and village planning in China mostly rely on rigid guidelines for physical space and environmental optimization. In contrast, the evolutionary mechanisms and effects of homesteads driven by the linkage of

multiple factors in the new era are unclear, which weakens the scientific foundation and practical feasibility of rural planning. Moreover, infrastructure construction implemented by local governments, including water, electricity, gas, roads, and environmental management, is mostly carried out according to existing village layouts. This approach lacks sufficient consideration of the evolution of homestead use under institutional reforms and population mobility in the new era. Consequently, the future development direction and trend of homesteads are unclear and lack scientific basis, which can easily lead to low efficiency or even ineffectiveness of future construction investments and seriously hinder the sound development of rural areas.

1.1.4 Studies on the homestead use evolution need to be further deepened

Farmers are the basic unit of homestead use, and their decision-making behavior is affected by the macro-institutional environment. The decision-making behavior of many farmers at the micro level emerges as a result of the evolution of homestead use at the macro level. The evolution of large-scale homestead use will affect subsequent adjustments to policies. In the continuous interaction between humans and land, homestead use evolves, along with the livelihoods and attributes of rural households, which in turn drive further social and economic transformations. This constitutes a complex process of evolution within a coupled human-land system. Therefore, to fully understand the mechanisms underlying the evolution of homestead use and to effectively assess its effects, it is necessary to examine this issue within the framework of the coupled human-land system. However, existing research focuses on descriptive analyses of the current characteristics of homestead use or on exploring the driving forces behind spatial land-use conversion (Su et al., 2019; Zhang et al., 2022; Wang et al., 2024; Zou et al., 2024; Tian et al., 2025), while relatively few studies take “human” as the starting point to investigate farmers’ homestead use behaviors to reveal the general patterns of homestead use evolution.

In addition, the simultaneous implementation of multiple policies is common, and these policies may have certain synergistic or trade-off effects. However, current research primarily focuses on the impacts of individual institutional arrangements on

farmers' willingness to migrate from rural to urban areas or to withdraw from homesteads, with limited attention paid to the comprehensive effects of joint institutional reforms and various future reform scenarios. Even fewer studies explore changes in farmers' homestead use behavior and the resulting spatio-temporal effects under joint institutional reforms, particularly from the perspective of human–land interactions.

1.2 Research questions

From the detailed description of the research background, it is evident that a new round of hukou and homestead system reforms has been fully initiated. Practically, the lack of forward-looking evaluation regarding the spatio-temporal effects of homestead use under institutional reforms has significantly hindered the intensive use of homesteads and rural revitalization. Theoretically, achieving effective forward-looking evaluation relies on a grasp of the long-term evolution patterns of homesteads and a clear understanding of future policy intervention scenarios. Since farmers are the fundamental units of homestead use, the spatial evolution of homestead use results from changes in the behaviors of large-scale micro-farmers. However, existing studies seldom examine the complex process of homestead use evolution from the perspective of human-land interaction, and even fewer explore the systematic impacts of the joint reform of these two systems on this process.

In response to practical needs and theoretical concerns, this dissertation aims to explore the evolutionary mechanisms and spatio-temporal effects of homestead use behavior under the joint reform of hukou system and homestead system. This exploration will be conducted from the perspectives of the macro-institutional environment, micro-subject behavior, and spatial land-use interaction. Specifically, the following scientific questions need to be answered:

(1) What is the underlying logic of the joint reform of hukou system and homestead system? This question aims to clarify the core connotation, reform path, current status, and future direction of these reforms, thereby facilitating a comprehensive understanding of their underlying logic.

(2) How to identify the multiple stakeholders involved in the process of homestead use and their interactive relationships, explore how hukou and homestead system reforms disrupt the balance among these stakeholders, examine how land and labor factors interact and accumulate, and ultimately reach a new equilibrium in homestead use, thereby changing farmers' homestead behavior. Therefore, a theoretical model and an empirical model that incorporate hukou and homestead system variables should be constructed to derive and verify the evolutionary mechanisms of homestead use behavior under the institutional reform.

(3) How to understand the interactive process between micro-farmers' homestead use behavior and spatial homestead use status, explore the varying impacts of different hukou and homestead system reform scenarios on human-land interaction, as well as the spatio-temporal effects that emerge? Therefore, a simulation model of the spatio-temporal effects of homestead use should be constructed, and a series of hukou and homestead system reform scenarios should be designed to explore these effects under different policy combination scenarios, so as to propose a path for deepening institutional reforms.

To sum up, the core theoretical question of this study lies in the field of institutional economics, focusing on the mechanisms through which the extension of land rights bundles and the reduction of migration frictions jointly influence factor mobility. Although China and Western countries share the common goal of promoting factor mobility and improving resource allocation efficiency, their institutional foundations differ significantly. Western theories of land property rights, grounded in private ownership, focus on how ownership affects individual behavior. In contrast, China's collective land ownership grants individuals only use rights, raising the question of whether such theories remain applicable. This study responds to the practical challenge of the lag in the urbanization of "human" and the inefficient utilization of "land" under China's dual urban-rural system, where land is state-owned or communally owned.

1.3 Research objectives

This dissertation mainly explores how homestead use evolves under the hukou and homestead system reforms. The objectives are to clearly understand future policy intervention scenarios, identify the general patterns of long-term homestead use evolution, effectively assess the spatio-temporal effects of homestead use under various institutional reform scenarios, thereby enriching the research perspectives related to homestead use, assisting in the preparation and implementation of village planning, and providing theoretical references for deepening institutional reform. The specific objectives can be outlined as follows:

(1) To reveal the impact mechanisms of hukou and homestead system reforms on homestead use behavior

This dissertation aims to thoroughly analyze the complex interactions among various stakeholders involved in homestead use and to investigate how the joint reform of hukou system and homestead system disrupts the balance among these stakeholders, thereby driving changes in farmers' homestead use behavior. Additionally, it examines the differences in farmers' behavioral responses under different reform intensities, reform policies, regional characteristics, and farmers' attributes, in order to reveal the internal mechanisms driving the evolution of homestead use behavior under institutional reform, and to provide a micro-level perspective on the spatio-temporal effects of homestead use.

(2) To analyze the spatio-temporal effects of homestead use under hukou and homestead system reforms

This dissertation aims to fully understand the interactive relationship between micro-level farmers' homestead use behavior and the macro-level spatial patterns of homestead use, and to establish a coupled human-land system that captures the spatial connections between farmers and their homesteads. This coupled human-land system incorporates the analysis of policy interventions, social networks, labor migration behavior, homestead use decisions, and their interplay with changes in the geographic environment. Additionally, it seeks to assess the complex phenomena, processes, and

outcomes of the spatio-temporal effects of homestead use under different institutional reform scenarios, thereby providing a scientific foundation for the formulation and implementation of village planning and related policy initiatives.

(3) To explore pathways for deepening hukou and homestead system reforms

This dissertation aims to fully understand the fundamental logic and developmental trajectory of the joint reform of hukou system and homestead system, as well as systematically evaluate the interaction mechanisms between the two reforms. It investigates whether these reforms exhibit synergistic effects or trade-off relationships. On this basis, a virtual "policy laboratory" will be constructed to quantitatively compare and analyze the spatio-temporal effects of homestead use under different institutional reform scenarios. By exploring differentiated pathways for deepening institutional reforms, this dissertation seeks to propose targeted policy recommendations, providing theoretical support for the top-level design of hukou and homestead system reforms.

1.4 Research significance

1.4.1 Theoretical contributions

As China's market-oriented reform has entered a critical stage, in which any single policy adjustment may trigger systemic ripple effects, a narrow focus on reforming individual factor markets is increasingly inadequate. There is an urgent need to explore the internal logic of interactions among multiple factors within the context of joint institutional reforms, and to expand the theoretical dimensions of related research. Therefore, this dissertation offers significant theoretical contributions.

(1) Providing a theoretical framework of general equilibrium tailored to China's urban-rural development issues

By combining micro-agent utility analysis in economics with spatial morphology research in geography, this dissertation constructs a spatial equilibrium model that incorporates the urban-rural dual economic structure with Chinese characteristics, which captures key factors such as differences in industrial structures between urban

and rural areas, variations in factor endowments, unequal access to public services, and frictions in labor and land markets. Furthermore, it examines the interactive relationships among stakeholders involved in homestead use under the joint reform of hukou system and homestead system. The findings also extend land property rights theory, which has traditionally been developed under private land ownership frameworks in Western countries, by revealing how the clarification and formalization of land use rights influence homestead use behavior, even in the absence of ownership. Overall, this dissertation presents a theoretical framework for analyzing urban-rural development issues in China within the context of general equilibrium.

(2) Enriching the analytical dimensions of institutional evaluation theory

By building on existing research about the effects of labor and rural land systems, this dissertation creates a predictive simulation of the combined impacts of hukou and homestead system reforms. It constructs a coupled human–land system by integrating a Multi-Agent System (MAS) with a Geographic Information System (GIS), grounded in Complex Adaptive System (CAS) theory. This approach models the intricate evolutionary dynamics of homestead use and enables the pre-implementation evaluation, comparison, and analysis of reform outcomes across different policy options and institutional models. In doing so, it enriches the analytical dimensions of institutional evaluation theory, which has largely focused on single-policy evaluations and the effects of existing institutional arrangements.

1.4.2 Practical contributions

The deepening reform of hukou system and homestead system is expected to transform the lifestyles of hundreds of millions of rural households and change the patterns of homestead use in China, profoundly affecting the evolution of homestead use and restructuring the rural spatial governance. Against this backdrop, understanding the evolutionary mechanisms and spatio-temporal effects of homestead use under the joint reform of multiple systems has become a critical issue of concern for both policymakers and scholars, in response to national strategic needs. Therefore, this dissertation provides significant practical value.

(1) Providing policy tools and decision-making support for deepening rural land system reform

By developing a spatio-temporal simulation model of homestead use grounded in human–land interactions, this dissertation creates a virtual “policy experiment lab” that enables the quantitative evaluation of household behavioral responses under different policy interventions and dynamically simulates the impacts of these interventions on the evolution of homestead use. These findings provide a forward-looking evaluation of policy outcomes, a comparative framework for analyzing alternative reform paths and evidence-based, targeted recommendations for deepening reforms. In doing so, this dissertation contributes to enhancing the scientific basis, predictability, and efficiency of rural land reform policies.

(2) Supporting the scientific formulation and effective implementation of rural development strategies

By revealing the influencing mechanisms of hukou and homestead system reforms on homestead use behavior, and by providing a forward-looking evaluation of potential effects under different institutional reform scenarios, this dissertation constructs detailed spatial simulation maps of homestead use, visually illustrating the possible pathways and future directions of such evolution. These findings offer scientific and intuitive support for the formulation and implementation of territorial spatial planning in the new era, village planning, improvement of rural living environments, and intensive and efficient homestead use.

1.5 Key Concepts and Theoretical Framework

1.5.1 Key Concepts

(1) Homestead use behavior

China’s rural land system is characterized by a distinct separation between land ownership and land use rights. At present, the homestead system implements the “separation of three rights,” meaning that the rural collective holds ownership, while rural households hold both qualification rights and use rights. In some cases of rural industrial development, enterprises may lease homestead for factory construction or

production activities. In other cases, after homestead is expropriated or voluntarily withdrawn, the government may intervene to change its use through policies such as the “linking increase and decrease of urban and rural construction land.” Therefore, the stakeholders involved in homestead use include village collectives, rural households, governments, and enterprises. In this study, given that rural households are the core stakeholders in the use of homestead land, and for the purpose of model simplification, I concentrate specifically on household-level homestead use behavior. Other stakeholders influence homestead use behavior indirectly through the product market, labor market, and land market, which will be elaborated in following sections.

With regard to household behavior, we analyze it mainly based on the rights embedded in homestead use rights. According to Chinese laws, rural households legally enjoy a range of rights including withdrawal, transfer, leasing, shareholding, mortgaging, inheritance, and gifting of homestead use rights. From the perspective of use modes and the final status of the rights, homestead use behavior can be divided into two main types: the first is homestead transfer, where the land is temporarily used by others (e.g., through leasing) without changing the subject of the use right; the second is homestead withdrawal, where the household permanently gives up its use rights.

In this study, we focus on homestead withdrawal, as it represents a fundamental shift in land use behavior. In contrast, homestead transfer only involves temporary delegation of use rights without altering the spatial characteristics or usage nature of the land. Moreover, the efficiency of such transactions depends on the market environment, and prices are typically low, meaning they have limited impact on household livelihoods.

Accordingly, within the scope of this study, we categorize household homestead use behavior into three types: homestead occupation, homestead withdrawal, and homestead idleness:

Homestead occupation refers to rural households that have not left the village for more than six consecutive months and continue to reside on the homestead originally

allocated by the village collective. In this case, households maintain both qualification and use rights, and the homestead continues to fulfill its residential and auxiliary production functions.

Homestead withdrawal refers to situations where households voluntarily accept compensation from the government and give up their homestead use rights. The resulting surplus land is reclaimed by the village collective. Households may choose to retain or fully give up their qualification rights. According to relevant compensation schemes, withdrawing households may receive monetary or housing compensation. It is worth noting that prior to formal institutional reforms, many households engaged in informal homestead transactions in gray markets. Although lacking formal agreements, these customary practices involved the seller voluntarily giving up use rights, and the buyer continuing to use the homestead. In this study, such informal sell-offs are also considered a form of homestead withdrawal. However, unlike legally reclaimed land that is converted into farmland, land withdrawn through informal transactions typically remains residential in nature and does not change in land use.

Homestead idleness refers to situations where the homestead no longer serves its residential function and is left unused or even abandoned. Compared to homesteads in active use, these are considered idle. The main reasons for idleness include long-term migration of household members for work or business, rural elites purchasing homes in cities, and rural residents inheriting ancestral homesteads or building new homes without demolishing the old ones.

Homestead use behavior evolution refers to the process by which a household's use of homestead land shifts from one type to another. For example, when a household migrates permanently to the city, the homestead may become idle, indicating a transition from homestead occupation to homestead idleness.

(2) Spatial-temporal effects of homestead use

The term “effect” essentially refers to a causal phenomenon that occurs under certain conditions and within a limited environment. It typically describes the

direction and magnitude of change in social or natural phenomena . According to Cihai (a comprehensive Chinese dictionary), an effect is understood as a causal relationship between one or more factors and one or more outcomes under specific circumstances. In economics, the term "effect" is often used as a general expression of impact results. For instance, the impact of policy implementation on target groups is commonly referred to as policy effects. The spatial-temporal effect, then, can be understood as the manifestation of such impacts across time and space.

Drawing on these interpretations, the spatial-temporal effects of homestead use under hukou and homestead system reform can be defined as the evolving spatial outcomes of homestead use patterns over time, resulting from institutional reforms that influence farmers' homestead use behavior.

Regarding the concept of homestead use evolution, since homesteads are a specific type of land, it is useful to reference the concept of land-use/land-cover change (LUCC). The United Nations Commission on Sustainable Development (CSD) defines LUCC as changes in land-use types and their spatial distribution over time. Li Some scholars have further expanded this concept by emphasizing that shifts in land-use efficiency should also be taken into account. Others have interpreted land-use change as encompassing transformations in land functions, shaped by a combination of natural conditions and human activities.

However, homesteads in China possess unique characteristics. The current homestead system limits households' rights to qualification rights and use rights, without allowing them to legally alter the type of land use. Nevertheless, with increasing rural-to-urban migration and changes in household livelihood strategies, the functional role of homesteads for rural households has also changed. For instance, some households leave their homesteads idle, resulting in decreased land-use efficiency. Therefore, this study defines the scope of homestead use evolution as including changes in spatial distribution, morphological structure, quantity and scale, utilization efficiency, and functional roles of homesteads.

To summarize, within the context of this study, the spatial-temporal effects of homestead use are defined as the dynamic evolution in the spatial layout, physical form, quantity, efficiency, and function of homestead land, driven by changes in farmers' homestead use behavior resulting from hukou and homestead system reforms.

1.5.2 Theoretical Framework

Based on the analysis of research questions and drawing upon relevant conceptual and theoretical foundations, this dissertation establishes a comprehensive analytical framework. The evolution of homestead use is, essentially, the result of adaptive interactions between multiple agents and a changing external environment. Accordingly, this dissertation adopts the Complex Adaptive Systems (CAS) theory to understand how institutional reforms influence farmers' homestead use behaviors, and how these behaviors, in turn, manifest as the spatio-temporal evolution of homestead use.

The complex adaptive system is composed of adaptive agents that interact, co-evolve, and emerge layer by layer. These agents adjust their behaviors in response to environmental changes to achieve a symbiotic relationship with their surroundings, following the "shock→response" model. Furthermore, changes in agents' behaviors drive transformations in several factors and their relationships, emerging progressively into the overall development of this system, which adheres to the "response→emergence" model. Ultimately, this iterative adaptation process propels the complex evolution of the macro system. As a typical complex coupled human-land system, homesteads serve as the foundation for various activities related to agricultural production and daily life. Based on the fundamental structure of Complex Adaptive System, this dissertation establishes an overarching analytical framework characterized by "external shock→behavioral response→emergent effects" (See Figure 1.1).

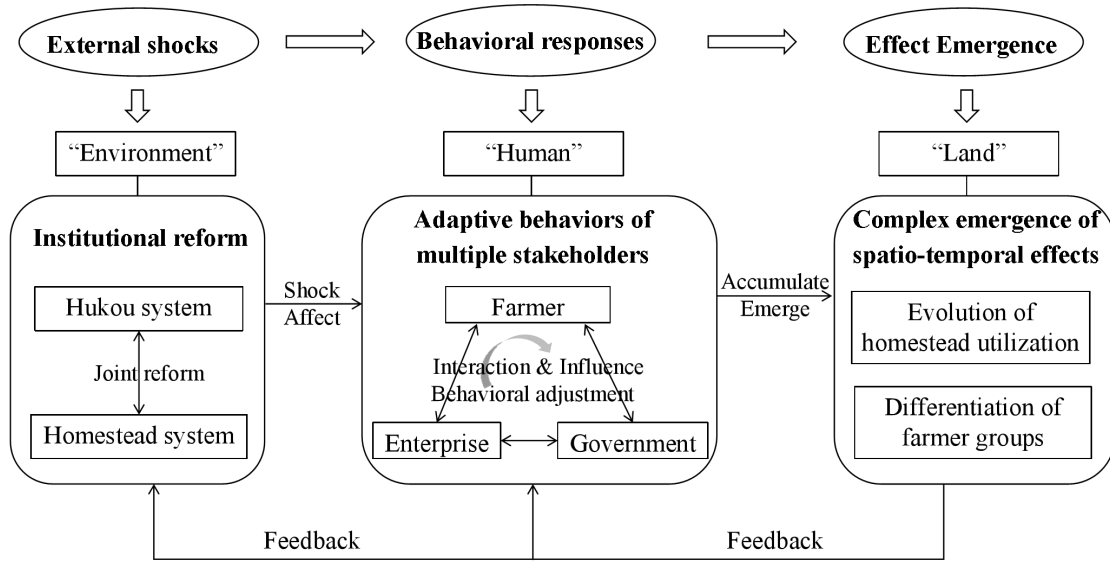


Figure 1.1 The overall logic framework of this dissertation

(1) External institutional reform shocks as the starting point

Any changes in a system are inherently influenced by external environmental factors. When the external environment changes, it first creates an impression in the consciousness of various agents. Subsequently, these agents process and evaluate this impression based on their own values, leading to a preliminary understanding of environmental changes, which serves as the basis for spatial decision-making. In this study, the external environmental shocks we are concerned with are the hukou and homestead system reforms. Their joint reform reduces the institutional barriers to the mobility of labor and land factors between rural and urban areas, disrupting the equilibrium of homestead use system and triggering changes in how farmers use their homesteads.

(2) Farmers' behavioral responses in homestead use to adapt to external shocks

To adapt to environmental changes and meet their own survival and development needs, agents continuously exchange information and learn through interactions with other agents and the external environment. This ongoing process enables them to modify their structures and behaviors, allowing for proactive responses and

adjustments. In this study, hukou and homestead system reforms lead to changes in the external environment, disrupting the equilibrium among the relevant stakeholders in homestead use. As a result of the interactions and combined effects among farmers, other stakeholders, and the external environment, the utility and constraints associated with farmers' choices in homestead use undergo significant changes. To maximize their overall utility, farmers will adapt to external institutional shocks by altering their homestead use patterns.

(3) Large-scale adaptive behavior of farmers emerges as spatio-temporal effects in homestead use

The core idea of complex adaptive system theory is that "adaptation leads to complexity." Through continuous interactions among various agents, different production factors generate new combinations, functional structures, and levels of development, driving the system to gradually evolve into a more complex state. In this dissertation, farmers are the central agents of homestead use. Their behaviors directly affect homesteads, while the ongoing interactions between farmers, other stakeholders, and the external environment also drive the evolution of homestead use. The large-scale adaptive behaviors of farmers in using homesteads accumulate over time and space, ultimately emerging as new patterns of homestead use evolution and the differentiation of farmer groups.

(4) The cyclical adaptive process promotes the dynamic evolution of the human-land system

The interaction between "human" and "land" in this system operates in two ways. On one hand, the spatial behaviors of individuals shape new spatial patterns. On the other hand, these new patterns alter the perception of the environment in individuals' consciousness, further influencing their spatial behaviors. This continuous mutual influence and feedback drives the ongoing evolution of the system. In this dissertation, the evolution of homestead use results in a new use pattern, which will not only directly affect farmers as a new external environment but also lead to institutional adjustments that indirectly influence farmers' behavioral choices. Additionally,

changes in livelihood factors, such as farmers' homestead use behaviors and employment income structures, will serve as crucial bases for farmers' decision-making in subsequent rounds. Over time, the human-land interaction fosters the dynamic evolution of the system.

Based on the above analysis, this study is structured into two main parts. First, it aims to understand how institutional reforms affect farmers' homestead use behaviors, thereby exploring the mechanisms of influence from both theoretical and empirical perspectives. Second, it examines how these behaviors are manifested in the dynamics of homestead use change and conducts simulation from both temporal and spatial dimensions.

1.6 Chapter layout

This thesis consists of seven chapters. The structure of this dissertation is introduced as follows.

Chapter 1: Introduction. This chapter provides an overview of the research background, research questions, objectives, significance, logical framework, dissertation structure, and key innovations.

Chapter 2: Literature review. This chapter discusses farmers' homestead use behavior, the impacts of hukou and homestead system reforms on homestead use behavior, and the effects of homestead use evolution and their simulation. A research framework is also proposed by summarizing and discussing previous studies.

Chapter 3: Evolutionary mechanisms of homestead use behavior under the joint reform of hukou system and homestead system. This chapter addresses Research Questions (1) and (2) by first reviewing the developmental trajectory and practices of hukou and homestead system reforms and analyzing the underlying logic of their joint reform. It then develops a spatial equilibrium model based on China's dual urban-rural economy to examine the mechanisms by which the joint reforms affect homestead use behavior, using simultaneous derivation and comparative statics to propose theoretical hypotheses. Finally, it examines the impacts of the reforms on income, welfare, and total economic output, laying the theoretical foundation for

subsequent empirical analysis.

Chapter 4: Empirical analysis of homestead use behavior under the joint reform of hukou system and homestead system. This chapter addresses Research Questions (1) and (2) by employing a Difference-in-Differences (DID) model with national data to examine the proposed mechanisms and hypotheses of homestead use behavior under the joint hukou and homestead reforms. It also assesses causal robustness, uncovers impact pathways, and examines dynamic and heterogeneous effects, laying the empirical groundwork for the spatio-temporal simulations that follow.

Chapter 5: Design of a simulation model for homestead use under the joint reform of hukou system and homestead system. This chapter addresses Research Question (3) by integrating Multi-Agent System (MAS) and Geographic Information System (GIS) to construct a coupled human-land system. Based on previous findings, it defines agent behavioral rules, environmental influence rules, and human-land interaction rules. It further designs various reform scenarios with different types, intensities, and combinations, and develops a spatio-temporal simulation model of homestead use under hukou and homestead system reforms, providing a modeling foundation for the subsequent simulation analysis.

Chapter 6: Simulation of the spatio-temporal effects of homestead use under the joint reform of hukou system and homestead system. This chapter addresses Research Question (3). Using data from the study area and the NetLogo simulation platform, it models the spatio-temporal effects of homestead use under different institutional reform scenarios. The simulation evaluates reform outcomes in terms of spatial layout, morphological structure, quantity and scale, use efficiency, functional roles, household labor allocation between urban and rural sectors, migration decisions, and income composition. Based on the results, this chapter proposes policy recommendations for deepening hukou and homestead system reforms.

Chapter 7: Conclusion and future work. The main conclusions of this study are summarized, and further the implications of the findings for policymakers and the direction of future research are discussed.

Chapter 2: Literature Review

2.1 Institutional background

2.1.1 China's hukou system and its reform

The hukou system is an institutional mechanism established by the state to identify individuals and regulate population distribution through household registration. In January 1958, China promulgated the “*Regulations on Household Registration*”, which established a system of seven types of population registration: permanent residence, temporary residence, birth, death, out-migration, in-migration, and changes in registration status. This system later became known as the hukou system. Specifically, China's hukou system classifies citizens based on their birthplace and parental identities into urban (non-agricultural) and rural (agricultural) residents.

Between 1958 and 1978, the movement of rural residents to urban areas was strictly restricted. The hukou system discriminatorily favored urban hukou holders in securing employment in state-owned enterprises and in receiving preferential allocations of urban welfare, including housing, healthcare, pensions, and education. In contrast, rural hukou holders were only granted access to rural land but little else (Wu & Zhang, 2018). Therefore, the hukou system has gradually developed social welfare distribution mechanisms and land management systems (Andreas & Zhan, 2016; Zhan, 2017; Zhou & Hui, 2022). Nevertheless, during China's unique planned economy period, the hukou system continued to play a crucial role in addressing social problems and maintaining social stability.

Following China's reform and opening up in 1978, the centrally planned economic system was transformed into a market-based economic system, characterized by rapid economic growth and urban expansion. A large number of rural residents migrated to urban areas for non-agricultural employment. With the reform of urban housing and the employment system, although urban hukou no longer provides

housing and employment guarantees, and the restrictions on rural-urban migration have been relaxed, rural migrants without an urban hukou are still relegated to an outsider status in destination cities. They face higher living costs to access urban public services while being excluded from formal urban employment opportunities (Hui et al., 2014). It is reported that 77.3% of rural migrants were engaged in low-income and temporary jobs in 2019, such as construction, manufacturing, and service industries, and suffered a 38.12% wage gap compared to urban workers (Rural Migrants Monitoring Survey Report, 2019). In this case, rural land from hometowns serves as the primary source of security, creating an inseparable connection for rural migrants to their homesteads and leading to temporary or circular rural-urban migration. This results in a contradiction in the human-land relationship: labor-driven separation versus security-driven attachment (Zhou et al., 2023).

In 2014, hukou system reform at the city level consisted of the following two aspects: (1) a unified hukou system replaced the urban and rural separate hukou system, and (2) a stratified hukou reform approach for different types of cities was established, through which hukou restrictions were abolished in small cities and towns (with an urban population of less than 500,000), relaxed in medium-sized cities (with a population between 500,000 and 3 million), reasonably determined in large cities (with a population between 3 million and 5 million), but tightly maintained in a handful of megacities (with a population exceeding 5 million). Therefore, different cities implemented varying entry criteria based on investment, housing purchases, talent programs, and employment. Specifically, to acquire an urban hukou, rural migrants either invest significant wealth or attain recognized skills through education or certification in cities. Otherwise, they have to wait several years while consistently paying social insurance fees. Moreover, these entry barriers are stricter in larger and more developed cities due to the availability of more extensive facilities and social services. For instance, a Shanghai (China's top city) hukou requires high-level vocational qualifications, relevant work experience, and at least seven years of social insurance contributions.

2.1.2 China's homestead system and its reform

China's current land system can be divided into two categories: urban land owned by the state and rural land owned by rural collectives. Rural collectives consist of all rural residents and are formed at the village level. There are three parts of rural land: contracted agricultural land, homestead land, and other collective lands (rural collective operating construction land, public welfare construction land, and unused land). Moreover, China's land system features a distinct separation between land ownership and land use rights.

Homestead, a type of rural land, is owned by rural collectives but used by rural residents. The homestead system in China consists of three main components: the ownership system, the use rights system, and the management system.

Regarding homestead ownership, the *Land Administration Law* stipulates that rural land is collectively owned by rural collectives. Changes in land ownership can only occur in one direction, when homestead is expropriated by the state and converted into urban construction land, the ownership of the land is transferred from the collective to the state.

Regarding the use rights system, the *Civil Code* defines the scope of homestead use rights as follows: (1) the holder of the homestead use right is legally entitled to possess and use collectively owned land, and has the right to build residential houses and auxiliary facilities on it; (2) if the landowner enjoys or bears servitudes, the homestead use right remains subject to those servitudes after its establishment; (3) the use rights to collectively owned land such as farmland, homesteads, reserved land, and private forest land may not be mortgaged; (4) houses built on homesteads may be inherited, but the law does not explicitly specify whether the homestead use right itself can be inherited.

Regarding the management system, the *Land Administration Law* stipulates that each rural household may possess only one homestead, and its area must not exceed the prescribed standard. Under the “one-household-one-house” policy, rural residents are allocated a homestead free of charge to build their rural houses. This dual

institution of urban and rural land ensures that rural land rights benefit the welfare of rural residents, allowing rural migrants to return to their hometowns and access housing and agricultural incomes if they become unemployed in cities. This is also the main reason why urban slums and large-scale urban unemployment, similar to conditions in Africa, Asia, and Central and South America, did not appear in China during the process of urbanization (Liu & Zhang, 2020). However, farmers also face restrictions on trading, mortgaging, leasing, and subdividing homesteads outside their rural collectives. Once the homestead is sold or leased, farmers will not be allotted another homestead (Zhou et al., 2020). Although there may be informal markets for private homestead transactions in some industrially developed rural areas, they lack legal protection. These transactions often occur between acquaintances and are based on oral agreements. The transaction prices are not high, and disputes frequently arise because farmers lack formal property rights (Zhou et al., 2020; Ma et al., 2022). As a result, with more than 300 million farmers migrating into urban areas since 1978, at least 30 million mu of homesteads and 70 million farmhouses were idle or abandoned by 2020 (Ministry of Agriculture and Rural Affairs, 2020). This imbalance not only harms farmers' interests but also widens the urban-rural gap.

In 2015, China initiated grassroots pilot projects for homestead system reform, selecting 33 pilot counties to explore methods for improving homestead right protection and acquisition, as well as creating a paid use system, paid withdrawal system, and management system. Based on practical outcomes, in 2018, the central government proposed a new reform framework for the rural land system known as the “separation of three rights” (sanquan fen zhi). Under this framework, the reform further emphasized the unwavering adherence to collective ownership of rural land, while simultaneously safeguarding farmers’ qualification rights to homesteads and activating the use rights. Subsequently, in 2020, the state selected 104 counties and 3 cities to pilot and explore concrete implementation models of the “separation of three rights” reform. Although different pilots have different reform plans, their ideas are essentially “right expansion and empowerment”. First, homestead titles are clarified,

confirmed, and certified to secure farmers' rights and interests, thereby reducing land disputes (Song et al., 2020). Second, farmers' rights to homestead are extended on the basis of the original single land use rights, and they are allowed to withdraw from their homesteads voluntarily and freely with compensation options such as direct cash compensation from the government, residential replacement from real estate developers, and land quotas for market trading, thus ensuring farmers' rights to income and disposition (Xu et al., 2022). Third, the long-standing barrier that restricts homestead transfer within rural collectives is broken, and the scope of homestead transfer is moderately expanded, making it possible for the market-oriented circulation of the use right, highlighting the property value of homesteads, and improving farmers' enthusiasm for disposing of their homesteads. Fourth, pilots break through the homestead security function, conform to the trend of multi-functional development of homestead, and actively explore the reuse of idle homestead to develop new rural industries such as tourism and health care, which not only provides land security for rural revitalization, but also allows farmers to obtain property income and share the dividends brought about by the reform (Su et al., 2019). Fifth, the system for examining and approving homesteads is strengthened to control the disorderly expansion of homesteads, and farmers are also required to pay fees for the excess area resulting from population decline.

Changes in rural migrants' land rights resulting from hukou and homestead system reforms are illustrated in Figure 2.1.

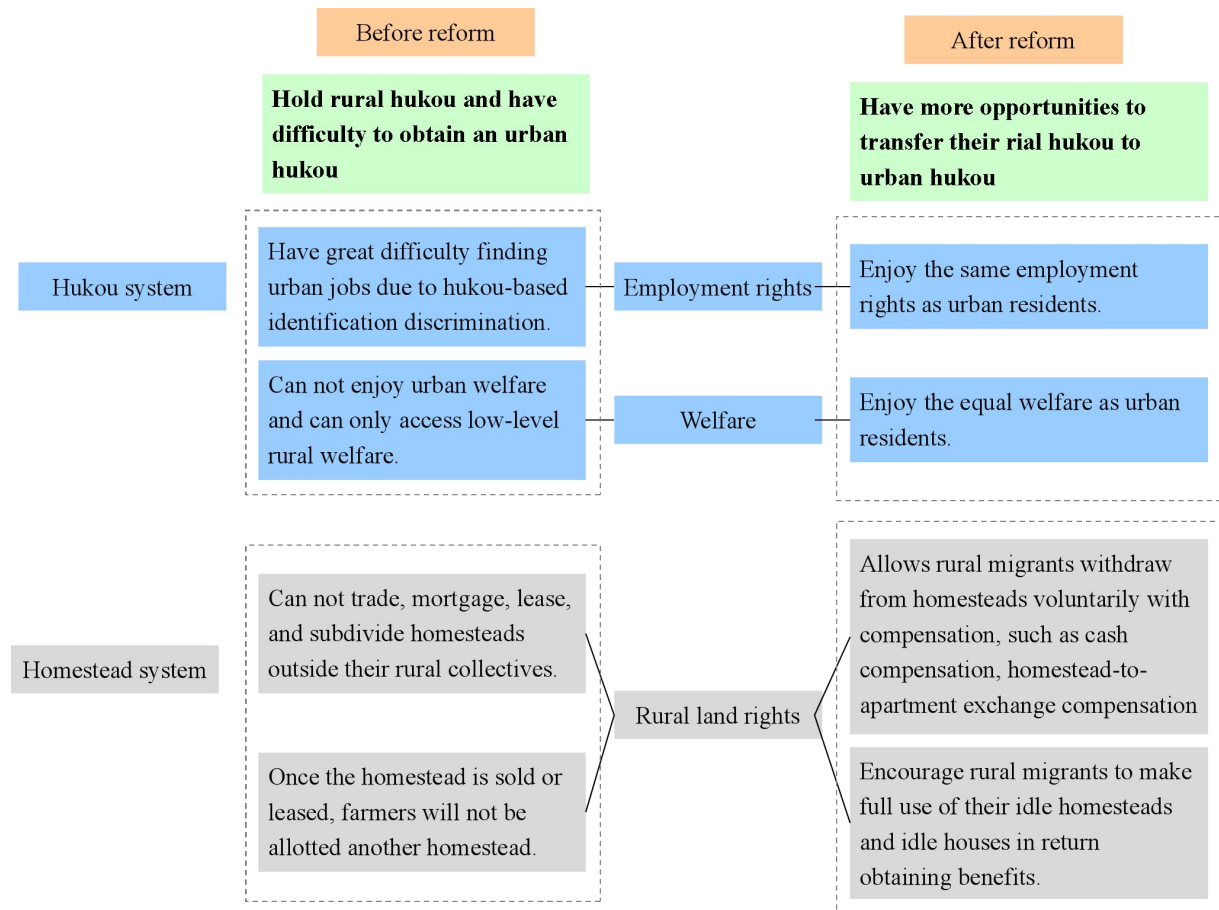


Figure 2.1 Changes in land rights caused by hukou and homestead system reforms

2.2 Farmers' homestead use behavior

Farmers are the core agents in homestead use, and their behaviors primarily include homestead transfer, withdrawal, idling, and occupation. Based on certain principles, farmers decide whether to use a homestead, how to use it, and how much land to use. Accordingly, existing studies have primarily focused on two aspects: the influencing factors of farmers' behavioral choices regarding homestead use and their underlying mechanisms.

2.2.1 The influencing factors of farmers' homestead use behavior

Judging from the existing research, many rural areas in developed regions such as Europe, North America, and Australia have good practical experience in guiding farmers to participate in residential land consolidation (Do et al., 2023; Gorgan & Hartvigsen, 2022; Lisec et al., 2014; Magnan et al., 2023; Orea et al., 2024). In the

process of urbanization and industrialization after World War II, rural areas in these developed countries experienced problems such as a reduction of the rural population and inefficient use of rural residential land, and land consolidation was an effective way to solve these problems (Hendricks & Lisec, 2014; Shizuka Hashimoto & Maiko Nishi, 2016). Farmers were critical stakeholders in this consolidation process, and their willingness to participate was found to be strongly related to their age, occupations, family structures, and primary social contact patterns (Dufty-Jones, 2015; Holtslag-Broekhof et al., 2014; Kupabado & Mensah-Bonsu, 2024).

Compared to developed Western countries, the homestead system reform in China is more special and more complicated (Chen et al., 2017). It is well known that Chinese rural homesteads effectively secure the farmers' housing rights (Wang et al., 2018). As farmers are direct stakeholders in the homestead system reform, their willingness to withdraw from their homesteads is very significant. As a result, current research primarily focuses on the factors that influence farmers' willingness to withdraw from their homesteads. These factors can be categorized into four aspects.

The first category includes factors related to individual and household characteristics, such as age, gender, education level, health status, employment status, marital status, household size, number of permanent rural residents, number of rural migrants, number of elderly and children supported by the family, annual household income, proportion of non-agricultural income, loan demand and so on (Chen et al., 2017; Gu et al., 2020; Zou et al., 2022; Su et al., 2022; Hu et al., 2023; Liu et al., 2022; Xia et al., 2024; Wang et al., 2024). Among these factors, the impact of age and education level on farmers' homestead use behavior shows significant variation in research findings. Some scholars argue that older and less-educated farmers tend to have lower competitiveness in the non-agricultural labor market, making it difficult for them to secure adequate housing and retirement support after giving up their homesteads. As a result, they are more reliant on agricultural production and exhibit a lower willingness to withdraw from their homesteads (Carolan, 2018; Liu & Liu, 2016; Milone & Ventura, 2019). On the contrary, an alternative conclusion has also

been supported: the newer generation, with higher levels of education and better understanding of policies compared to the previous generation, tends to have a clearer grasp of the trends in rural homestead reform. At the same time, affected by the increasing value of urban land, they often hold higher expectations regarding the future value of their rural homesteads, which means they are more inclined to retain their homesteads rather than withdraw from them (Gao et al., 2017; Liu et al., 2020). However, some scholars argue that an individual's education level merely reflects their knowledge literacy and does not necessarily translate into decision-making power within the household, particularly regarding major decisions such as whether to withdraw from homesteads (Fu, 2018).

The second category of influencing factors relates to homestead endowments, including homestead area, location, accessibility to transportation, cultivated land area, transferred farmland area, the structure and age of rural housing, whether the household owns urban housing, and whether the homestead has been officially titled (Cheng et al., 2019; Gao et al., 2022; Song et al., 2020; Su et al., 2022; Tian et al., 2025; Wang et al., 2024; Zhang & Fan, 2020). It is generally believed that the more homestead resources a farmer possesses, the stronger their willingness to withdraw.

The third category of influencing factors encompasses the social and institutional environment, including the level of rural infrastructure development, local public welfare policies, community attitudes toward homestead withdrawal, social networks, cultural sentiments, and related aspects (He & Tang, 2023; Tang et al., 2025; Tian et al., 2025; Wang et al., 2024; Wang et al., 2021; Yao et al., 2023). Some studies suggest that the proportion of households covered by social welfare has a significant positive impact on farmers' willingness to withdraw from their homesteads. However, the rapid development of rural villages and the continuous improvement of the living environment tend to reduce this willingness (Gao et al., 2023; Zhao et al., 2024). Additionally, many farmers have a strong sense of nostalgia, which often leads those with greater ability to settle in cities to instead express a stronger desire to return to

their hometowns and build houses, which further diminishes their enthusiasm for homestead withdrawal (Liu et al., 2021; Yao et al., 2023; Zou et al., 2022).

The fourth category: cognition and psychological status, which includes farmers' cognition of the ownership, disposal, inheritance, mortgage, and other rights related to homesteads (Fan & Zhang, 2019; Guan & Zhao, 2023; Shi et al., 2022; Yao et al., 2024). Existing research indicates that farmers' cognition of homestead inheritance rights has a significant positive impact on their willingness to withdraw from homesteads. In contrast, the greater the perceived importance of mortgage rights, the lower their willingness to withdraw. Additionally, a stronger sense of security associated with homesteads tends to reduce farmers' willingness to withdraw. However, the more positively farmers evaluate local government performance and the better they understand relevant policies, the more likely they are to support and participate in homestead withdrawal (Liu et al., 2021; Wang et al., 2022).

In summary, existing studies on farmers' homestead use primarily focus on their willingness to withdraw, with limited attention to actual withdrawal behaviors. A significant gap thus exists between intention and action. Moreover, most studies examine only a single influencing factor and fail to account for the complex interactions among multiple factors. Several studies have shown that various livelihood choices among farmers are interrelated. For instance, the allocation of labor between agricultural and non-agricultural activities directly affects how both cropland and homestead are used (Xu et al., 2019; Xu et al., 2019). Homestead withdrawal decisions are often linked to the disposition of farmland, and the economic returns from farming, in turn, influence the household's labor allocation between urban and rural sectors. In short, under ongoing institutional reforms, rural households always make livelihood decisions collectively for all family members (Wang & Zhao, 2022). However, most existing studies tend to address either labor allocation or land use decisions independently, overlooking the interactions between them and thereby introducing a degree of endogeneity.

2.2.2 The mechanisms of farmers' behavioral choices in homestead use

Regarding the mechanisms of farmers' behavioral choices in rural land use, existing studies primarily draw on theoretical frameworks such as Farmer Behavioral Theory, Planned Behavior Theory, Rural Household Economics Theory, Push-Pull Theory, and Game Theory.

Farmer Behavior Theory proposes different objectives for farmers' decision-making behavior based on the degree of their rationality. The Organization and Production School, such as (Chayanov, 1966), argues that farmers are typically risk-averse agents who seek to minimize risks in both production and daily life. In contrast, the Rational Peasant school, represented by scholars like (Schultz, 1964), contends that farmers are capable of making rational decisions within resource constraints, seeking to maximize their benefits based on personal preferences. The Historical School, such as (Huang, 1985), emphasizes the concept of bounded rationality, suggesting that farmers must navigate the uncertainties of both internal and external environments by balancing benefit maximization with risk minimization. In reality, farmers' choices regarding homestead use are influenced by external economic conditions, the costs associated with information search, and their subjective cognitive capacities. Consequently, it is widely recognized that farmers' behavior is not solely driven by economic rationality, but also shaped by multiple dimensions of rationality, including cultural, social, and psychological factors (Liu et al., 2021; Wang & Li, 2024; Yao et al., 2023).

Planned Behavior Theory emphasizes agents' evaluations of objective factors, rather than directly incorporating objective indicators into the model. It is believed that subjective norms, behavioral attitudes, and perceived behavioral control collectively influence an individual's behavioral intention (Shi et al., 2022; Zhang et al., 2023; Zhou et al., 2025). Furthermore, to address the limitations of traditional theoretical models, which often fail to fully capture or explain behavioral intentions, some scholars have introduced objective endowment factors and external environmental variables to refine the model. For instance, some have integrated

technology acceptance models (Zhou et al., 2021), and accounted for regional variations in risk-bearing capacity and policy regulation (Shi et al., 2022).

Push-Pull Theory does not explicitly define the objectives behind farmers' behavioral choices. Instead, it explains decision-making by comparing the opposing forces that either promote or hinder farmers. The net effect of these forces determines farmers' final choices (Niu, 2022; Xu et al., 2015). Originally developed to analyze population migration, this theory has more recently been applied to the study of homestead withdrawal. In this context, push factors are typically constructed around issues such as the inefficient use of the homestead, rural underdevelopment, and the significant urban-rural welfare gap. Conversely, pull factors focus on the attractiveness of urban living conditions, employment opportunities, higher income, land asset appreciation, and financing needs. Together, these dimensions help explain the motivations behind farmers' choices regarding homestead use (Fan & Zhang, 2019; Ge et al., 2020).

Rural Household Economics Theory emphasizes the overall balance of labor and resource allocation within rural households, arguing that decisions related to production, consumption, employment, and land use should be made jointly, under the constraints of production possibilities and household budgets, to maximize overall family utility (Wang et al., 2020; Zhao et al., 2021). On this basis, Game Theory has emerged as a powerful tool for modeling collective decision-making. In the context of homestead use behavior, scholars frequently examine the strategic interactions among farmers, village collectives, local governments, and land developers. These models explore the distribution of rights, responsibilities, and interests among the four parties to analyze how farmers' choices are shaped by the interplay of multiple stakeholders (Hu et al., 2024; Song et al., 2020).

The above theories are primarily applied in the context of cropland studies in Western countries. On the one hand, there are notable similarities between cropland and homestead land in terms of their functions, property rights, and benefit structures. These theories can help construct a logical framework for understanding changes in

homestead use behavior. On the other hand, homestead withdrawal represents a transformation in farmers' modes of production and livelihood, which involves a trade-off between the returns brought by withdrawal and the loss of homestead use rights and their associated social security value. Therefore, unlike the Western economic view of rational and self-interested individuals, China's farmers are better characterized as behavioral agents who exhibit clear features of bounded rationality. This calls for further theoretical refinement and innovations.

2.3 The impacts of hukou and homestead system reforms on homestead use behavior

2.3.1 The impacts of hukou system reform

Hukou system reform significantly weakens the restrictions on hukou-based rights by ensuring subsistence rights related to urban security and development rights for equal employment opportunities (Chen et al., 2019; Wang et al., 2023). However, there is little attention paid to its impact on land use. Some studies have provided theoretical evidence suggesting that hukou restrictions can hinder rural migrants' ability to manage risks after withdrawing from the homestead and to maintain high expectations for increased homestead value to support urban settlement, thereby impeding the effectiveness of homestead system reform (Zhang, 2020; Zhang, 2017; Zhang et al., 2020). Yet, whether relaxing hukou restrictions can effectively encourage rural migrants to withdraw from homesteads, only a few studies have provided empirical evidence. Zhu (2017) verified the direct positive effects of hukou system reform on farmers' willingness to withdraw from their homesteads using survey data in Chongqing, China. However, the underlying mechanisms remain unexplored, and it is unclear whether these conclusions apply beyond this study region. Moreover, given that the hukou system is a comprehensive institutional arrangement encompassing policies related to investment, housing purchases, talent programs, and employment, it remains unclear which specific component plays a decisive role in encouraging farmers to withdraw from homesteads, and further studies are needed to clarify this.

Given that the most direct impact of hukou system reform is to promote the rural-to-urban migration of the rural population, many studies have focused on how migration influences farmers' willingness or behavior to withdraw from their homesteads. This body of research provides a foundation for understanding the effects of hukou reform on farmers' homestead use behaviors. Relevant studies have evolved along two flowing lines of inquiry:

On the one hand, most studies examining the unidirectional impact of farmers' migration on their behaviors to transfer or withdraw from homesteads adopt econometric methods such as Probit and Tobit models. These analyses are typically based on national datasets or data from representative regions, aiming to identify causal relationships and explore regional or individual heterogeneity. Findings suggest that rural-to-urban migration significantly promotes farmers' withdrawal from homesteads, primarily through increased household income generated by labor mobility. However, this effect often manifests as a "masking effect," as risks at the market, institutional, and social levels jointly suppress farmers' actual withdrawal behaviors (Xu et al., 2020; Huang et al., 2023; Xu et al., 2017). In addition, some scholars have refined the concept of migration by examining how different stages, patterns, gender, and intergenerational characteristics of migration affect farmers' decisions regarding homestead transfer or withdrawal. For example, Gao, Song, and Sun (2020) used a threshold regression model and found that when the threshold value is less than or equal to 0.125, labor migration significantly promotes rural land transfer. However, when the threshold exceeds 0.125, the effect becomes statistically insignificant. Xu et al. (2018) showed that the ratio of non-agricultural labor to total rural household labor has a significant inverted U-shaped effect on both the probability and scale of land leasing, with turning points at 33.27% and 14.10%, respectively. Huang et al. (2020) found that for every 10% increase in female labor migration, the probability of land transfer decreases by an average of 2.1%, and the area of land transferred drops by approximately 3 mu. In contrast, male migration has a statistically insignificant negative effect on land transfer.

On the other hand, research on the interaction mechanisms between rural-to-urban migration and cropland transfer shows that the scale of labor migration and rural land transfer mutually reinforce each other. Specifically, the impact of land transfer on labor migration outweighs the reverse (Chernina et al., 2014; Hou, 2020). From a spatial viewpoint, there is a distinct segmentation in farmers' willingness to migrate and transfer land, which hampers improvements in resource allocation efficiency. The institutional root of this issue stems from the dual disconnection between the land market and the population management system (Cao et al., 2018; Li et al., 2023).

2.3.2 The impacts of homestead system reform

Under the homestead system reform, previously informal and non-transferable property rights have been clarified, extended, and formalized, which opens a crucial institutional channel to realize the asset value of homesteads under legal protection (Hong et al., 2020; Song et al., 2020). Considerable evidence from Africa, Asia, and South America suggests that formalizing and securing land property rights has a positive impact on land transactions, migration, entrepreneurship, poverty alleviation, and ecological protection (Krishna et al., 2017; Bu & Liao, 2022; Daymard, 2022; Adamopoulos et al., 2024). However, in many developing countries, land ownership is either public or state-owned, and people typically possess only land use rights or partial land property rights. Simply formalizing these rights often fails to provide stable and significant expectations of land value (Li et al., 2021). In China, the impact of the homestead system reform on rural migrants' homestead withdrawal is mixed. Some studies believe that homestead system reform can unlock the asset value of homesteads, providing an economic incentive to encourage farmers to withdraw. However, varying compensation standards and models have different impacts (Su et al., 2019; Z. Xu et al., 2022; Zou et al., 2022). However, some scholars have identified opposite effects. Based on Behavioral Economics Theory, the endowment and ratchet effects accompanying farmers' homestead withdrawal can increase expectations of future homestead value and inhibit withdrawal. Social in-group heterogeneity, such as

age, career, and living conditions, shapes different endowment effects (Gu et al., 2020; Liu et al., 2021; Song et al., 2020). Meanwhile, homestead withdrawal can expose farmers to potential risks, such as unemployment, insecurity of medical and pension benefits, and loss of rural social networks, which are significantly influenced by farmers' professional skills and income levels. Based on Vulnerability Theory, most studies explore farmers' risk perception and its negative impact on homestead withdrawal (Liu et al., 2020; Qian et al., 2022; Xie et al., 2023). The comprehensive impact of the homestead land system reform across the country needs further validation.

Given that the homestead system is a comprehensive institutional arrangement that integrates multiple policies, including homestead rights titling, paid use, paid withdrawal, and multifunctional reuse, scholars in fields such as public administration, economics, and management have conducted extensive research on the impact of homestead system reform on homestead use behavior. These studies mainly focus on the following aspects:

Regarding the impact of the homestead titling system on homestead use behavior, most studies have been conducted by scholars in the field of public administration. Drawing on land property rights theory, these studies commonly argue that homestead titling enhances the security, stability, and completeness of farmers' rights to possess, use, benefit from, and transfer both the homestead and the house built on it. It is believed that titling safeguards farmers' usufructuary rights, reduces transaction costs, and incentivizes voluntary and compensated withdrawal from homesteads (Holden et al., 2011). However, some scholars argue that although homestead titling generally facilitates the homestead transfer, its positive effects are mostly limited to suburban areas, revealing that the economic impact of titling is closely related to local market demand (Qian et al., 2020). Others argue that homestead titling reinforces farmers' perception of private ownership, thereby making them more inclined to permanently retain their homesteads rather than opt for low-cost transfers or passive withdrawal. The stronger the perceived exclusivity of property rights, the less willing farmers are

to withdraw from their homesteads, which suggests that psychological ownership may inhibit voluntary withdrawal (Liu et al., 2021; Shi et al., 2022).

Regarding the impact of the paid use system on homestead use behavior, research has largely been undertaken by scholars in management studies. The findings suggest that the implementation of a paid-use system can incentivize the withdrawal of excess homestead occupation while simultaneously activating the asset value of homesteads (Chen, 2019; S. Liu & Xiong, 2018). Changing farmers' perception of free homestead use and establishing appropriate pricing standards are considered key to ensuring effective implementation (Hu et al., 2018; Zhang et al., 2021). Several studies have further estimated the effective threshold for chargeable areas and corresponding pricing standards. Some rely on a comprehensive analysis of national village planning standards, existing provincial and municipal benchmarks, and local data (Yue & Zhang, 2010). Still others apply utility functions under household budget constraints to estimate the chargeable area range (Hu et al., 2019).

Regarding the impact of compensation methods within the paid withdrawal system on homestead use behavior, existing studies are primarily conducted by economists. Common forms of compensation include cash compensation, apartment compensation, as well as non-financial welfare benefits, such as employment assistance, pension security, and housing subsidies. Existing studies mainly examine the applicability and feasibility of these compensation methods from the perspectives of farmers' preference structures, potential risks, and welfare outcomes. Findings suggest that different types of rural households respond differently to compensation methods, depending on their development capacity. Specifically, growth-oriented households tend to favor housing subsidy policies, stability-oriented households are more inclined to accept apartment compensation, and subsistence-oriented households are better suited to land-for-pension arrangements (Wu & Wu, 2020). Further studies emphasize that cash compensation should be accompanied by a robust housing security system for migrants, while an apartment compensation policy must ensure the

protection of farmers' welfare, and quota-based compensation models should focus on enhancing farmers' resilience to unemployment risks (Shangguan et al., 2017).

Regarding the impact of compensation standards within the paid withdrawal system on homestead use behavior, research in this area has been primarily carried out by economists. These studies mainly focus on the composition of homestead value and its pricing mechanisms. Based on property rights theory, some scholars divide the value of a homestead into ownership value, use value, and development value (Zhou et al., 2024). Others determine land value through market-based evaluations of supply and demand (Zhu & Zhang, 2016). Another line of research adopts a functional perspective, categorizing land value into production value, security value, asset value, ecological value, and psychological value (Cui et al., 2024; Su et al., 2022). Various methods and theoretical frameworks have been employed to propose compensation standards, including the value-added analysis based on land withdrawal (Song et al., 2017), cost-benefit analysis (Hu et al., 2018), and marginal opportunity cost theory (Zhou et al., 2021).

2.3.3 The impacts of the joint reform of hukou and homestead systems

Given that the implementation of the homestead system is based on the collective economic organization membership granted to farmers by the hukou system, their inherent coupling means that limitations in one will inevitably hinder the thorough reform of the other. Further, we analyze the internal logic of the joint reform between the two systems. From the perspective of land ownership, it fundamentally changes the nature of rural property rights, eroding hukou-based rights and introducing market-oriented rights. In terms of land interests, it essentially dismantles the hukou-based land closure protection mechanism and replaces it with urban security systems. This change facilitates the free flow of labor and land factors, optimizing resource allocation by reorganizing inefficient combinations. From the perspective of resource allocation, the introduction of market-oriented mechanisms has enabled various production factors to flow freely, thereby reorganizing the inefficient

combination of rural production factors and maximizing the efficiency of resource allocation.

In brief, the hukou system and the homestead system may exhibit functional overlaps or differences, resulting in a substitutive or complementary relationship. This suggests that their joint reform could involve complex interactions affecting rural migrants' homestead withdrawal behavior. However, the literature typically discusses hukou system reform and homestead system reform as distinct processes, frequently overlooking their connection. Only a few studies on the impacts of their joint reform mainly engage in general logical reasoning or case studies from a macro perspective. One type of study identifies the close connection between the two systems in terms of reform evolution, system formation logic, and functional linkages, emphasizing the necessity of joint reform (Tao et al., 2011; Zhu, 2014; Han et al., 2019). These studies find that every major rural land system reform in China has historically been accompanied by a concurrent reform of the hukou system. Without fundamental rural land system reform, comprehensive hukou system reform cannot be achieved, highlighting the necessity for coordinated reform of both systems. The second type of research focuses on case studies, summarizing specific models of joint reform in terms of implementation background, participant interaction, and operational mechanisms (Chen et al., 2020; Zhao & Zhang, 2014). On this basis, reform pathways such as the “linking people with land” model and the rural land shareholding system reform have been proposed to facilitate joint reform of the rural land and hukou systems. However, these studies rarely empirically examine the impact of the joint reform on farmers' behavior from a micro perspective, nor do they reveal the internal logic and complete influence channels. Thus, there are two main shortcomings in the current results. First, an effective connection path for the joint reform of rural land, labor, capital, and other production factors has not been proposed. Second, further investigation is needed into how reform intensity and socio-economic conditions influence the effectiveness of joint reform to ensure more effective operation. Answering these questions can guide developing countries with communal land

ownership and incomplete property rights to better encourage rural migrants to withdraw from rural land, promoting both rural revitalization and sustainable urbanization.

2.3.4 Theories and methods for studying the impacts of institutional reform

Theoretical and methodological research on the impact of the joint reform of hukou and homestead systems can be broadly categorized into two aspects. First, a small number of studies adopt a micro-level perspective to examine the effects of the joint reform, mostly employing econometric methods to evaluate specific cases. However, these studies often fail to clarify the combined effects of the two systems on farmers' behavior from the perspective of individual utility trade-offs. Although some scholars have conducted relatively rich case studies based on local practices, there is still a lack of large-scale, nationwide quantitative analyses that provide general conclusions. Moreover, these studies rarely identify which specific policy combinations are most effective, limiting their ability to inform top-level institutional design and improve policy implementation efficiency. Second, from a macro-level perspective, some research explores the necessity of joint reform through theoretical analysis and proposes reform pathways in a qualitative manner. These studies typically rely on international comparison, stylized facts, and general logical reasoning, but seldom incorporate formal theoretical modeling or mathematical derivation.

Among the few studies that use mathematical deduction to explore the urban-rural flow of labor and land factors, Spatial Equilibrium Theory and its models are more typical. For example, Harris & Todaro (1970) constructed a dynamic framework of urban and rural sectors, exploring how wage differences, urban unemployment, and other factors contribute to the continuous flow of labor between rural and urban areas. Krugman (1991) introduced the theory of increasing returns to scale and imperfect competition into spatial economic analysis, establishing a "center-periphery" spatial equilibrium model and explaining the spatial distribution structure of economic activities. However, most of these studies focus primarily on

the transfer of labor and capital, with little attention given to the allocation of land resources between urban and rural areas. Even the few studies that involve land factor often overlook the coordinated allocation of labor and land. For instance, the Rosen-Roback (1982) model analyzed the factor allocation between urban and rural areas from the dual perspectives of wages and land prices, positing that rural-urban differences in wages, living costs, and environmental quality could lead to factor flow. Similarly, equilibrium models of urban systems, including those by Henderson (1985), incorporated urban spatial structures and real estate markets, but typically focused only on single urban sectors or urban systems with specialized divisions of labor, without considering the role of the rural sector and issues related to land allocation.

Regarding the modes of spatial equilibrium models, current dynamic models are usually used to study the evolution and cyclical problems of institutional reforms, as well as to explore the inter-period decisions of micro-individuals and their impact effects (Garriga et al., 2021, 2023; Lennox, 2023). In contrast, static models can more carefully describe the flow of various production factors, the interaction among various market entities, and the impact of various policy systems (Redding, 2016; Le et al., 2023; Adamopoulos et al., 2024). Therefore, static equilibrium models are more suitable for describing the rural-urban flow of various factors under different labor, public service, and land policies, along with their effects on income and welfare.

2.4 The effects of homestead use evolution and their simulation

2.4.1 The spatio-temporal effects of homestead use evolution

A large number of micro-level changes in homestead use behavior will inevitably lead to the evolution of homestead use at the spatial level. Meanwhile, given that the homestead system is a unique welfare arrangement in China, changes in farmers' homestead use behaviors will necessarily involve shifts in their production and living welfare levels, thereby affecting the overall economic and social development. Consequently, existing research is mainly carried out from two perspectives: natural scientists (geographers, ecologists) tend to examine the spatial effects of homestead use at the spatial level, while social economists are more inclined to examine farmers'

welfare effects at the micro level, as well as the economic effects at the macro level.

(1) Spatial level: spatial effects of homestead use

At the spatial level, studies on the spatial effects of homestead use are mainly conducted from the perspectives of scale, efficiency, morphological structure, spatial layout, functional roles, ecological transformation, and other related dimensions. Specifically, due to differences in land classification systems and related factors, research in different countries focuses on varying spatial units such as rural settlements and rural residential areas. Given that homesteads constitute a core component of both rural settlements and residential areas, this study conducts a literature review primarily with reference to research on these spatial units.

Regarding the evolution of the homestead use scale, existing studies have primarily focused on changes in indicators such as the total area of rural residential land or homesteads, per capita homestead area, and the proportion of idle land. Their findings vary significantly across different spatial and temporal scales, but in most regions in China, the per capita homestead area has continued to increase (Wen et al., 2020; Zhang et al., 2022; Tian et al., 2025). Meanwhile, from the perspective of the human-land relationship, a sharp decline in the rural population has been accompanied by an expansion, rather than a contraction, of rural residential land, leading to a mismatch between the scale of urban-rural construction land and the population it is intended to support (Dong et al., 2021; Liu et al., 2024).

Regarding the evolution of homestead use efficiency, existing literature has focused on issues such as resource redundancy and the effectiveness of land security. Some studies further emphasize the importance of striking a balance between social and economic efficiency. Accordingly, many scholars have employed multi-factor evaluation methods, including models such as DEA-Tobit models (Wang & Zhao, 2021), and stochastic frontier production functions (Michler & Shively, 2015), to evaluate the efficiency of homestead use. Other studies have used indicators such as rural residential consolidation potential (Li et al., 2014; Fang et al., 2016), the degree of rural hollowing (Shi et al., 2025; Wen et al., 2023; Zhang et al., 2025), and the

potential for homestead withdrawal (Yu et al., 2023) to reflect the inefficiency degree of homestead use. Findings suggest that, with a large number of rural laborers migrating to urban areas, the efficiency of homestead use has been continuously declining. In contrast, homesteads in urban villages and suburban villages tend to exhibit higher use efficiency (Shen, 2017).

Regarding the evolution of spatial layout, existing studies have paid more attention to the spatial distribution differences of homesteads across various regions. These studies typically employ software tools such as ArcGIS and ENVI, draw on the theoretical framework of landscape ecology, and analyze spatial layout from two main perspectives: patch aggregation and patch complexity. In general, areas with flat terrain feature larger individual patches and more compact spatial layouts; hilly regions tend to have a higher number of patches with lower degrees of aggregation; while mountainous areas, characterized by greater topographic variation, exhibit smaller patch sizes, fewer total patches, but higher levels of spatial clustering (Yang et al., 2016; Yanbo et al., 2018; Yan et al., 2022). Over time, the spatial distribution of rural residential areas in China has gradually evolved from being highly uneven to becoming more balanced.

Regarding the evolution of morphological structure, numerous studies have explored the internal morphological characteristics of homesteads within specific regions. The main technical approaches include GIS spatial analysis, remote sensing mapping and interpretation, landscape pattern analysis, quadrat analysis, and spatial data mining techniques. Research has shown that the morphological structure of rural settlements has undergone a developmental trajectory from “uniformity” to “diversification” and eventually to “differentiation” (Su et al., 2019). With the rapid development of China’s economy, local governments have relocated previously fragmented rural settlements into nearby central villages or towns. As a result, the spatial morphology of rural settlements has evolved from irregular strip-like forms to more regular circular patterns, with the distances between patches continuously decreasing (Li et al., 2021).

Regarding the evolution of functional roles, residential security and production support have traditionally constituted the core functions of homesteads. Driven by rural revitalization policies, the development of local industries has led to the expansion and diversification of homestead functions in both degree and direction, as they shift toward multifunctional roles integrating production, processing, commerce, tourism, leisure, healthcare, and vacation services (Su et al., 2019; Wang et al., 2024). In terms of spatial differentiation, homesteads in urban villages and suburban areas have increasingly acquired asset functions, while those in remote rural villages largely lack such functions. Due to large-scale labor migration, many of these remote homesteads remain idle and fail to perform essential functions (Su et al., 2019; Zhao et al., 2021).

Regarding the evolution of the ecological environment, changes in homestead use often lead to alterations in land cover, which in turn affect the overall ecological balance. Currently, most studies primarily analyze regional land use change patterns using land use change data. On this basis, they apply ecological impact evaluation methods such as the ecosystem service value model and the ecological footprint method to evaluate the effects of different land use types on the ecological environment. Existing research indicates that when rural households withdraw from their homesteads, the overall ecological environment can be positively affected. This occurs through mechanisms such as a reduction in the number of households using firewood as fuel and a diminished marginal effect of rural wastewater treatment facilities on the local ecosystem (Narimani et al., 2017; Gong & Liu, 2023; Zou et al., 2024).

(2) Micro level: welfare effects on rural households

At the micro level, existing studies focus on the optimization of livelihoods, non-agricultural employment, poverty reduction and income increase, and other welfare effects brought about by changes in farmers' homestead use behavior. These types of studies are mainly conducted from three perspectives. First, analyzing farmers' satisfaction with the benefits they can enjoy after withdrawing from

homesteads. Second, examining the changes in production and living conditions before and after farmers' homestead withdrawal. Third, quantifying the welfare changes pre- and post-withdrawal to evaluate the impact of institutional reforms. The main findings indicate that farmers will receive compensation for transferring or withdrawing from their homesteads, thereby increasing their livelihood capital stock to a certain extent. However, the loss of their homesteads will increase the radius of agricultural cultivation and agricultural costs, promoting a shift in farmers' livelihood strategies toward non-agricultural activities and raising their family income levels. Consequently, the withdrawal from homesteads will improve the livelihood capital structure of farmers (He & Wang, 2017; Qi et al., 2022; Hu et al., 2023), improve farmers' non-agricultural employment decisions and non-agricultural employment intensity (Sun et al., 2024; Zhang & Lerman, 2025), and reduce the poverty vulnerability of rural households (Zhang et al., 2023; Xue et al., 2025), thereby significantly improving farmers' subjective sense of well-being (Cheng et al., 2018).

Furthermore, with the development of society, scholars have shifted their focus from merely assessing material wealth to adopting a comprehensive evaluation model that measures farmers' living quality after the disposal of homesteads across multiple dimensions, including economic status, health, social relationships, and environmental quality, and put forward several new concepts such as psychological welfare, environmental welfare, and opportunity welfare. Due to the different selection of measurement indicators, there are inconsistent conclusions on whether the homestead withdrawal can improve farmers' welfare levels, but all believe that it could increase the welfare differences among farmers from different regions and backgrounds (Guo et al., 2023; Wang et al., 2024; Wu & Wu, 2021).

(3) Macro level: overall economic effects

At the macro level, there are few studies examining the effects of homestead use evolution on total economic output. Due to the limited availability of empirical data, only a small number of related studies have employed case analyses or theoretical frameworks to explore the causal and interactive relationships between the two. The

mainstream view in existing research is that farmers' widespread homestead withdrawal can generate marginal equalization effects and resource allocation effects, primarily in the following two aspects.

On the one hand, withdrawing from an idle homestead can achieve marginal benefits, which, under the influence of the law of diminishing marginal returns, will eventually tend to equalize (Chen et al., 2017). The underlying assumption of this "equalization effect" of marginal benefits is the existence of a profit-averaging mechanism between industries or sectors, meaning that the homestead withdrawal can provide investors and users with sufficiently high returns (Yao, 1999; Liu et al., 2022).

On the other hand, only when economic entities operate on an equal footing can they optimize resource allocation through competition. China's current property rights system has increased the friction in resource allocation. Reforming the rural homestead system and establishing a rational homestead withdrawal mechanism for farmers is essential to clarify and expand the bundle of rural land property rights, thereby creating an orderly land transfer process, reducing transaction costs, optimizing land resource allocation, and promoting integrated urban-rural development (Fang et al., 2016; Lyu et al., 2020; Lu et al., 2023; Zhao et al., 2024).

2.4.2 The simulation of the effects of homestead use evolution and its methods

Given that current research on the effects of homestead use evolution is mainly carried out from the perspectives of spatial homestead use, micro-farmer welfare, and macro-economic output, the relevant simulation methods can be summarized into the following two categories.

Regarding the simulation methods for micro-farmer welfare and macro-economic output effects, existing studies primarily use qualitative approaches for case studies or regression analyses employing models such as OLS, DID, and Logit (Li et al., 2022; Wang et al., 2024; Zhang & Lerman, 2025; Cui et al., 2024). However, existing studies have primarily focused on the actual changes in farmers' welfare levels before and after changes in homestead use behavior. In contrast, there

is a lack of research on counterfactual situations, such as how the welfare of farmers who withdrew from homesteads would have changed if they had chosen not to, and how the welfare of those who did not withdraw would have changed if they had chosen to do so. Additionally, existing studies tend to focus on static income, consumption, or multidimensional welfare states, overlooking the dynamic effects of homestead use evolution. This oversight overlooks the human-land interactive process and lacks a comprehensive evaluation of the long-term effects of institutional reforms.

Regarding the simulation methods for the spatial evolution of homestead use, there are few related studies due to the relatively scattered layout of rural land, which limits the accuracy of simulation models. Therefore, we must broaden the scope of our review to include simulation methods for land-use evolution. The earliest models for simulating land use evolution employed mathematical equations; however, these static models struggle to capture the dynamic processes of land use change. In contrast, System Dynamics (SD) can effectively illustrate the interactions between complex system structures, functions, and dynamic behaviors, but it is also based on the expression of experience and equations, and is difficult to integrate with spatial information (Song et al., 2021; Hou et al., 2024; Zhang et al., 2024). Cellular Automata (CA) models have the capability to simulate complex spatio-temporal changes. However, the cells in this model are immobile and often fail to account for the social and environmental effects resulting from land use changes, which makes it challenging to explore the interactions between these factors, leading to lower simulation accuracy (Gao et al., 2024; Tian et al., 2022; Zhao et al., 2023). The Conversion of Land Use and its Effects at Small Region Extent (CLUE-S) model quantifies the spatial relationships between land use types based on empirical models, enabling dynamic simulations of predetermined land demand. Essentially, this involves iterative spatial allocation based on the competition between driving factors and various land use types. However, the CLUE-S model struggles to incorporate analyses of the impacts of complex, difficult-to-quantify policy interventions (Li & Song, 2020; Sheng & Lian, 2023).

Multi-Agent System (MAS) has developed from Complex Adaptive System Theory and distributed artificial intelligence technology, and they have been widely applied in fields such as natural resource management, urban spatial expansion, policy analysis, and planning (Ralha et al., 2013; Yang et al., 2016; He & Wang, 2017). The evolution of homestead use occurs through the interactions of various stakeholders, including farmers, village collectives, and governments, making it difficult for traditional spatial evolution models to account for the complex factors influencing human behavior.

The calculation of multi-agent models takes into account the subjectivity, adaptability, and sociality of artificial intelligence, and can be applied to the computational simulation of complex systems, effectively coupling the spatial and social pathways of evolution, providing new insights for the study of complex coupled natural-human systems (Liu et al., 2006; Zhang et al., 2016; Ito, 2024). Moreover, multi-agent models are highly extensible and can be flexibly integrated with various theories, systems, and methods. For instance, they can be combined with behavioral decision theories like BDI to characterize agent decision-making and behaviors (Coelho et al., 2016; Lu et al., 2022); integrated with Geographic Information Systems (GIS) to endow the models with both intelligence and spatial attributes (Walsh et al., 2013; Liu et al., 2020); and integrated with policy scenario analysis to quantify the effects of policy reforms, facilitating the comparison of policy options (Lu et al., 2022; Yin et al., 2024).

2.5 Research gaps and research design

2.5.1 Research gaps

(1) Unclear mechanisms of multi-factor interactions in the evolution of homestead use behavior

Regarding homestead use, existing studies have primarily drawn on behavioral economics and social psychology frameworks to analyze farmers' homestead use behavior, typically through econometric modeling. These efforts have shed light on the roles of individual and household characteristics, land endowments, institutional

and social environments, as well as cognitive and psychological factors. However, most of these studies tend to focus on individual variables, examining their impacts in a linear or static manner. As a result, they fall short in capturing the dynamic, interdependent nature of multiple influencing factors and the extent to which controllable variables shape behavioral evolution. This limits our ability to fully explain the complex and adaptive process through which homestead use behavior evolves over time.

(2) Insufficient theoretical and empirical analysis of the combined effects of dual system reforms

Regarding the impacts of hukou and homestead system reforms on homestead use behavior, existing research, based on land property rights theory and related theories, has examined how various homestead reform policies influence farmers' decisions, and affirmed the positive role of hukou system reform in encouraging farmers to withdraw from homesteads. However, current research remains largely limited to the effects of individual institutional reforms, typically examining either hukou system or homestead system in isolation and their respective impacts on rural-urban migration or farmers' willingness to withdraw from homesteads under existing institutional settings. Few studies adopt a global perspective of spatial equilibrium to systematically reveal the combined effects of joint institutional reforms on the evolution of homestead use behavior. Even fewer attempt to simulate and predict the spatio-temporal effects under different reform scenarios, providing insights into potential pathways for advancing institutional reforms. Although some studies have demonstrated the necessity of the joint reform of hukou system and homestead system from a theoretical perspective, their research methods are primarily limited to international comparisons, case-based summaries, and general logical reasoning, with little emphasis on mathematical-level theoretical derivation. Existing literature employing spatial equilibrium theory and methods tends to focus on the urban-rural flows of labor and capital, while largely overlooking the issue of urban-rural land allocation under the joint reform of multiple systems. Moreover, empirical studies

rarely use national-level data for universal verification and lack in-depth quantitative analysis of impact pathways, dynamics, heterogeneities, and other critical dimensions.

(3) Disconnection between macro-level spatial evolution and micro-level behavioral changes

Regarding the effects of homestead use behavior evolution, natural scientists (geographers, ecologists) focus more on the spatial impacts (i.e., scale, efficiency, structure, layout, functions, and surface ecology) in a spatially explicit way using remote sensing and geographic information systems. Although this type of research provides abundant spatial information, it fails to capture the heterogeneity and dynamics of individual household behaviors. In contrast, social economists often employ statistical analysis methods such as econometric models, focusing on the optimization of livelihoods, non-agricultural employment, poverty reduction, and income increase, and policy guarantee effects brought about by changes in farmers' homestead use behavior from a micro level, or focusing on the marginal equalization effect and resource allocation effect from the macroeconomic level. While this research provides valuable insights into the characteristics of farmers' behavioral choices, it overlooks the spatial connections between farmers, homesteads, and other geographical and environmental factors. This chasm between natural and social sciences has hindered a better understanding of the complex interactions between the natural system and the human system. Currently, few studies comprehensively understand the human-land interaction process by establishing a coupled human-land system, and even fewer explore the dynamic changes and comprehensive effects of the human-land system under exogenous institutional shocks from multiple perspectives, including macroeconomics, micro-level individual behavior, and spatial geography.

(4) Incomplete modeling approaches for human-land interactions and their spatio-temporal effects

Regarding the simulation methods for spatio-temporal effects, traditional methods include regression analysis methods such as OLS, DID, and Logit, as well as

spatial analysis methods like SD, CA, and CLUE-S. However, these two types of methods are distinct from each other, with limitations including poor visualization, low simulation accuracy, difficulty in quantification, and limited scalability, rendering them inadequate for effectively characterizing the human-land interaction process. In contrast, the multi-agent system (MAS), developed based on distributed artificial intelligence technology, integrates a geographic information system (GIS) and models interactions among multiple agents, as well as between agents and the geographical environment, flexibly. This offers significant reference value for this study.

2.5.2 Research design

In response to the identified research gaps, the dissertation is structured around four major research components, as depicted in Figure 2.2.

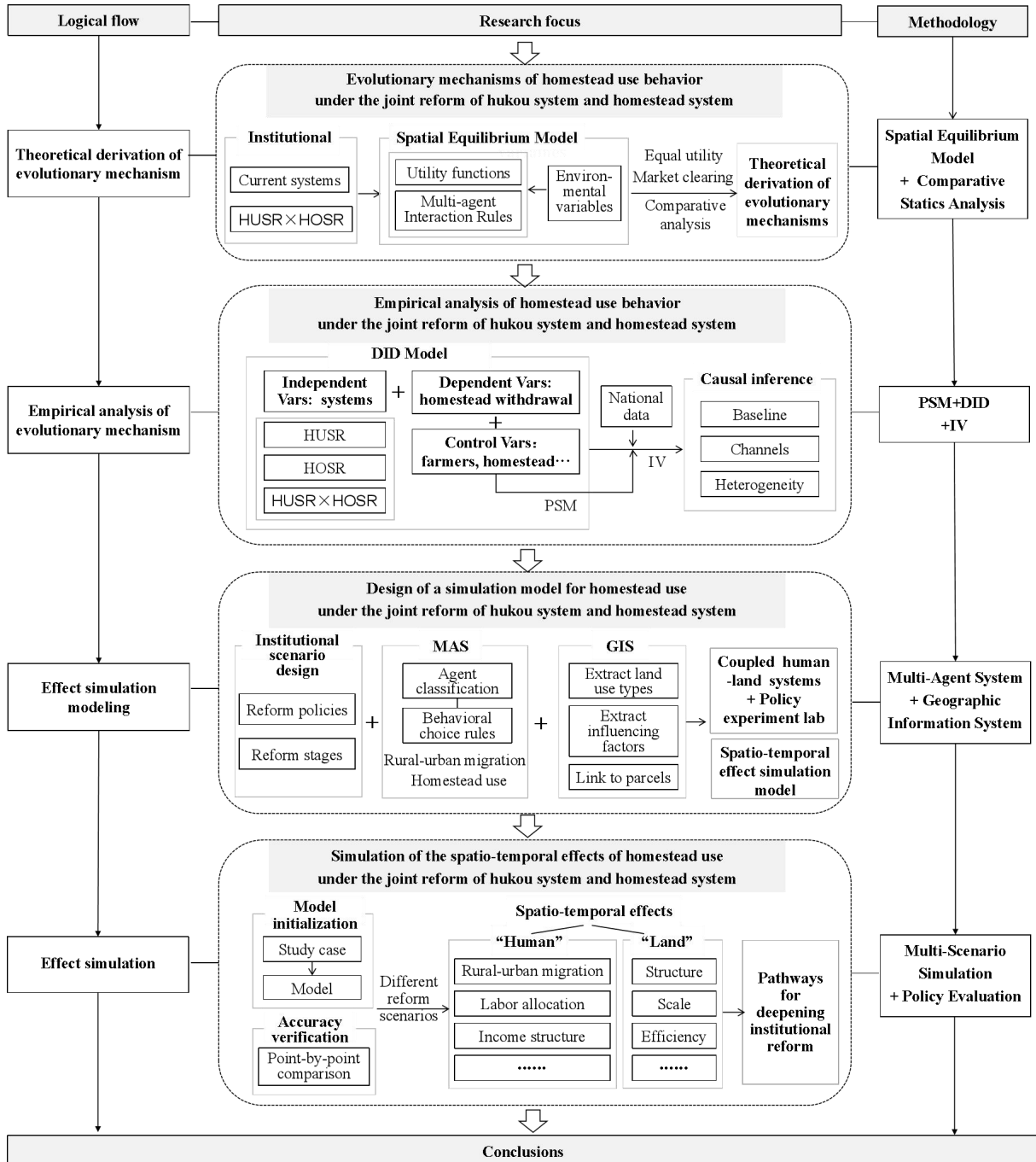
Firstly, this dissertation constructs a spatial equilibrium model (SEM) that incorporates the urban-rural allocation of labor and land. Using mathematical analysis methods such as comparative static analysis, it theoretically explores the impact of the joint reform of hukou system and homestead system on farmers' homestead use behavior, thereby addressing the lack of theoretical research on the combined effects of multiple institutional reforms.

Subsequently, a difference-in-differences (DID) model is employed to empirically investigate this impact mechanism using national-level data, and its dynamics and heterogeneity are further analyzed, thereby addressing the lack of comprehensive, nationwide empirical validation in existing studies on the joint institutional reform.

Additionally, this study integrates a multi-agent system (MAS) with a geographic information system (GIS) to develop a coupled human-land system and establish a policy simulation laboratory. This approach helps overcome current methodological limitations such as poor visualization and low simulation accuracy.

Furthermore, based on this integrated system, the effects of homestead use behavior evolution under various institutional reform scenarios will be examined from both temporal and spatial perspectives, integrating macro-economic factors,

micro-individual behaviors, and spatial geography. Based on the findings from this exploration, pathways for deepening institutional reforms will be identified. Therefore, this dissertation helps bridge the current disconnect between research on spatial land-use evolution and micro-level land-use behavior.



Note: HUSR is hukou system reform; HOSR is homestead system reform

Figure 2.2 The research design of this dissertation

Chapter 3: Evolutionary Mechanisms of Homestead Use Behavior under the Joint Reform of Hukou System and Homestead System

3.1 Introduction

The first two chapters have established the overall analytical framework of the dissertation. This chapter focuses on the "external shocks → behavioral responses" component of the framework by examining the evolutionary mechanisms of homestead use behavior under hukou and homestead system reforms.

Different from the influence of an individual institutional reform, the joint reform of these two systems may cause the labor market and the land market to interact with each other, resulting in complicated mutual influences and compound effects on the rural migrants' decision-making regarding labor and land allocation (Adamopoulos et al., 2024; Li et al., 2023). Whether and how the joint reform of urban migration policies and rural land system can complement each other to play a synergistic role in rural migrants' land withdrawal behavior and further advance the dual goals of sustainable urbanization and rural revitalization is still understudied. Many existing studies primarily analyze one system in isolation, with less attention given to the interactions between different systems, either in policy design or evaluation (Guo et al., 2020; Song et al., 2020; Zhu, 2017). A few studies highlight the necessity of joint reform of multiple systems from a macro-theoretical perspective through various qualitative methods such as international experience comparison, case analysis, and general logical reasoning (Tao et al., 2011; Zhu, 2017; Han et al., 2019). However, there is less emphasis on the micro-individual level, particularly in exploring how the interactive role of perfecting land rights and reducing migration restrictions affects farmers' utility and subsequently changes their decision-making/behavior regarding land withdrawal. This gap makes it challenging to understand the comprehensive impact of these reforms on urbanization and rural

development scientifically, let alone the dynamics and heterogeneity of this impact, which is of great significance for implementing more precise reform policies.

To this end, based on the Rosen-Roback spatial equilibrium model from urban economics, this chapter first modifies the model to reflect China's dual urban-rural economic structure and develops a baseline framework to analyze the mechanisms of homestead use behavior under the current institutional setting. It then incorporates institutional variables based on a theoretical understanding of hukou and homestead system reforms to extend the model. Through model solving and comparative static analysis, it examines changes in interactions among key actors and their impact on rural migrants' homestead use decisions, and proposes theoretical hypotheses. Furthermore, it examines the impacts of institutional reforms on income, welfare, and aggregate economic output, providing a theoretical foundation for the subsequent empirical analysis.

My work contributes to existing literature in three ways. First, from an equilibrium perspective, this chapter examines the income and welfare effects of joint reforms in the urban-rural labor and land markets, addressing the limitation of existing literature that tends to focus on individual markets in isolation. Second, grounded in China's institutional context, this dissertation theoretically characterizes key features of the dual urban-rural structure, including differences in industrial composition and factor endowments, unequal public services, and market frictions in labor and land allocation. It investigates the interactions among stakeholders under hukou and homestead system reforms, reveals the mechanisms underlying the evolution of homestead use behavior, and provides a general equilibrium framework for analyzing China's urban-rural development issues. Third, by evaluating policy combinations under multiple objectives from the perspectives of aggregate output, income distribution, and welfare disparities, this dissertation proposes directions for optimizing the policies and offers insights for advancing rural revitalization and improving household income and welfare.

This chapter is organized as follows. Section 3.2 explores the developmental

trajectory, policy practices and underlying logic of the joint reform of hukou system and homestead system. Section 3.3 constructs and solves the baseline model to simulate the evolutionary mechanisms of homestead use behavior under the existing institutional settings. Section 3.4 extends the model to incorporate the institutional reform scenarios, analyzing the corresponding evolutionary mechanisms. Section 3.5 provides a further discussion of the economic and welfare effects of homestead use behavior evolution under joint institutional reform. Finally, Section 3.6 concludes the chapter.

3.2 The developmental trajectory, policy practices and underlying logic of the joint reform of hukou system and homestead system

3.2.1 The developmental trajectory of joint institutional reform

Drawing on the developmental trajectory of China's hukou and rural land system reforms (see Figure 3.1), this section examines the contextual conditions, core objectives, and implementation strategies of these reforms, aiming to understand their internal logic, practical impacts, and future trajectories.

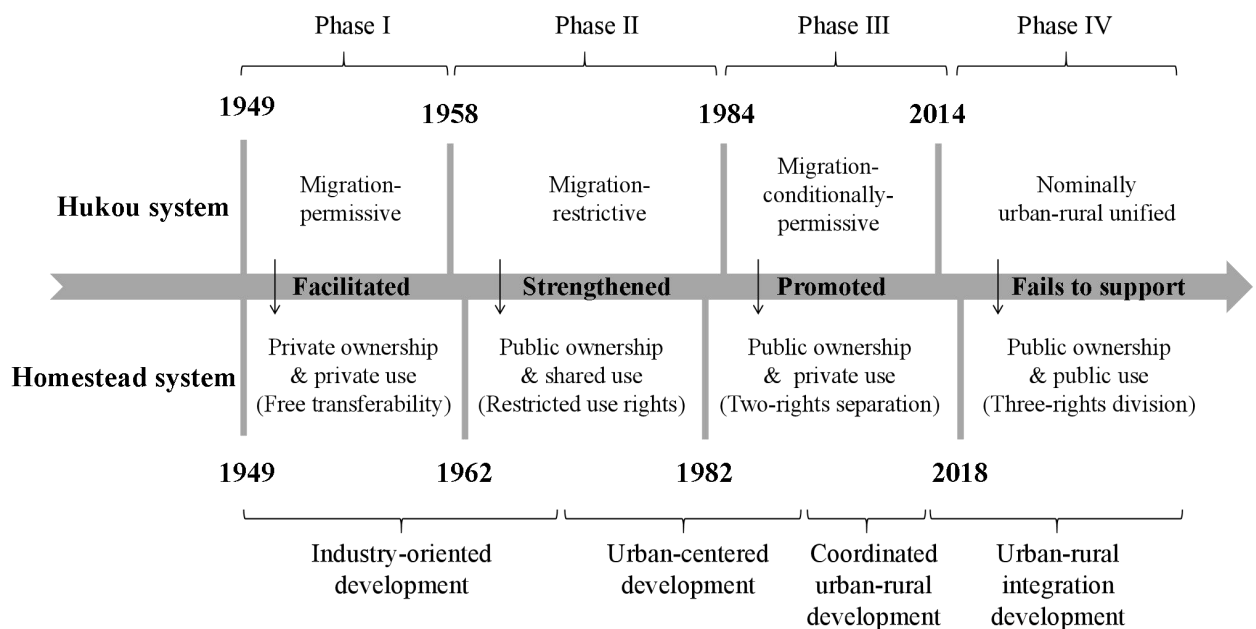


Figure 3.1 The developmental trajectory of hukou and homestead system reforms

Phase I: The “migration-permissive” hukou system facilitated the homestead system reform toward “private ownership and private use”

In 1949, as China was newly established, the nation was emerging from decades of turmoil, with all sectors in disarray and an urgent need for national reconstruction. At that time, China made great efforts in both land allocation and population management.

On the one hand, China restructured land ownership by expropriating land from the landlord class and redistributing it free of charge to farmers for production and subsistence. Land ownership was transferred to rural collectives, and the *1950 Land Reform Law* explicitly allowed rural collectives to manage the land autonomously. These measures significantly boosted farmers' enthusiasm for agricultural production.

On the other hand, the government issued the *Provisional Regulations on Urban Hukou Registration* and launched a nationwide population census. At that time, the hukou system served primarily as a tool for demographic registration, and citizens were permitted to migrate freely between urban and rural areas. In 1954, "Citizens have freedom of residence and migration" was written into the *Constitution*. Under the joint reform of these two systems, the national economy of New China recovered rapidly. It was the free flow of production factors, achieved through the reforms, that improved the efficiency of resource allocation.

Phase II: The “migration-restrictive” hukou system strengthened the homestead system reform toward “public ownership and shared use”

To rapidly develop its economy, China has implemented a policy of agricultural support for industry.

In terms of the hukou system, in 1958, China promulgated the ‘*Regulations on Household Registration*’, which divided all citizens into urban and rural hukou, strictly restricting the migration of rural residents to urban areas. Although the 1975 *Constitution Amendment* removed these restrictions on free migration, the urban-rural dual structure had already taken shape.

In terms of the homestead system, in 1962, the *Draft Amendment to the Rural*

People's Commune Work Regulations stipulated that rural land was to be uniformly allocated by production teams and explicitly prohibited private leasing or sale of land. At this point, the era in which rural homestead ownership was held by individual farmers came to an end. The hukou system, which strictly restricted free migration, effectively locked farmers to rural land, depriving them of both the right and the capacity to claim land ownership. However, this unified distribution system, with unclear property rights and inconsistent with market laws, has had a significant negative impact on the inequality between urban and rural residents, leading China down a distorted path of economic development.

Phase III: The “migration-conditionally-permissive” hukou system promoted the homestead system reform toward the exploration of “two-rights separation”

With the development of the market economy, the hukou system has undergone a series of reforms. In 1984, the *State Council's Notice on the Issue of Rural Residents Settling in Market Towns* allowed farmers who met certain conditions to obtain urban hukou. In 1992, the distinction between rural and urban hukou was further relaxed. From 1997 to 2001, rural residents and their family members were permitted to obtain urban hukou under various conditions. In 2001, the State Council issued a *Notice on Approving the Ministry of Public Security's Opinions on Promoting the Hukou System Reform in Small Towns*, which fully relaxed the hukou restrictions in small towns and marked the beginning of a new phase in hukou system reform. The relaxation of the hukou system enabled capable rural residents to migrate to urban areas for non-agricultural employment, thereby increasing household income and facilitating the implementation of the “two-rights separation” system for rural homesteads.

From 1982 to 1998, the Chinese government formalized the “separation of two rights” in rural land ownership: rural collectives retained land ownership rights, while individual farmers were granted land use rights. This system provided farmers, whose cropland and homesteads became idle due to migration to urban areas, with the opportunity to freely transfer their land use rights. However, most people who could

afford rural land were urban citizens. As a result, when rural migrants lost their jobs and returned to their hometowns, they often lost their rural land and faced the challenges of unemployment and landlessness. Therefore, in 1999, the *Notice on Strengthening the Management of Land Transfers and Strictly Prohibiting Speculative Trading of Land* explicitly prohibited urban residents from purchasing rural housing, marking the beginning of a strictly closed era for the homestead system. However, the gradual relaxation of the hukou system led to a large number of rural households migrating to urban areas, while the rigid homestead system resulted in widespread idleness of the homestead. In 2015, the *Opinions on the Pilot Program for Reforming the Rural Land Expropriation System, the Market Entry of Collectively-Owned Commercial Construction Land, and the Rural Homestead System* were issued, signaling China's intention to explore whether and how the homestead system should be liberalized. In this context, the hukou system reform has promoted the homestead system to explore the institutional model of "public ownership with private use."

Phase IV: The "nominally urban-rural unified" hukou system fails to support efficiency-oriented homestead system reform from "two-rights separation" to "three-rights division"

In this phase, China has entered a new phase of comprehensive reform. In 2014, the *Opinions on Further Advancing Hukou System Reform* abolished hukou restrictions in county-level cities and small towns, thereby facilitating rural-to-urban migration. At the same time, the existing "two rights separation" land system was increasingly incompatible with the evolving productive forces. In response, China began to explore the functional separation of rights within the homestead system: collective ownership of the homestead, farmers' qualification rights (eligibility to hold a homestead), and farmers' rights to use the homestead. This "three rights separation" model aimed to maintain the stability of collective land ownership, safeguard farmers' housing needs, and unlock the asset value of rural homesteads. Meanwhile, the *2018 Rural Revitalization Strategic Plan* officially proposed the "three rights separation"

system for homestead, which seeks to promote the free transfer of homestead, improve land use efficiency, and generate secondary value from rural land resources.

However, the current hukou and homestead systems still impede the free flow of production factors between urban and rural areas. On the one hand, the hukou system reform has failed to dismantle the social welfare distribution mechanisms attached to hukou. In particular, the differentiated settlement policies across cities of various administrative levels have become new institutional barriers that stratify social classes and hinder the urban integration of rural migrants. On the other hand, holding a rural hukou remains the sole condition for farmers to access land rights, which restricts the flow of urban capital into rural areas and results in a one-way flow of land resources from rural to urban areas.

As a result, although the hukou system is nominally unified across urban and rural areas, the dual constraints of labor migration control and the welfare-based allocation of rural land make it difficult in practice to achieve the anticipated Pareto improvement expected from the transition from the “separation of two rights” to the “separation of three rights” in rural land reform.

Through the developmental trajectory of hukou and homestead system reforms, this dissertation finds that all major homestead system reforms have been linked to hukou system reforms. Furthermore, when these two systems relax restrictions on labor and land factors, Pareto improvements in rural development are often more likely to be achieved; conversely, these relaxations have varying negative impacts on rural development. Therefore, these two system reforms should unwaveringly aim to remove obstacles to the flow of labor and land factors in rural areas, while also protecting the interests of farmers.

3.2.2 The policy practices of joint institutional reform

Drawing on the policy practices of China’s hukou and rural land system reforms, this section analyzes the reform directions, aiming to lay the groundwork for designing system reform variables and scenarios in the subsequent sections.

This dissertation selects typical reform pilot cases in the central and western

regions and summarizes the practices of joint reform of hukou and homestead systems across different regions, focusing on the institutional environment, patterns of reform, and the provision of policy instruments (as shown in Table 3.1).

Based on the main reform practices of pilot regions listed in Table 3.1, and taking into account the differences in resource endowments, development foundations, and land use demands across regions, the homestead use patterns under the joint reform of hukou system and homestead system can be summarized into three types (as shown in Figure 3.2).

Table 3.1 The policy practices of the joint reform of hukou system and homestead system

Regions		Eastern Region			Western Region		Central Region		
Pilot cases		Jizhou District, Tianjin Province	Wujin District, Jiangsu Province	Yiwu City, Zhejiang Province	Chongqing Province	Pingluo County, Ningxia Province	Dali County, Yunnan Province	Jinzhai County, Anhui Province	Yujiang District, Jiangxi Province
Background	Resource endowment	Mountain metro area, good transport	Plains, developed water-land transport	Urban fringe area	Mountainous, mostly poor counties	High mountains, deep valleys, no access	Rich tourism, favorable location	Hilly, uneven, fragmented land	Rural hinterland
	Economic level	Developed economy, advanced industries	Thriving private and emerging sectors	Developed non-farm and wholesale sectors	Underdevelop ed industries, low income	Traditional agriculture, underdeveloped	Agriculture and tourism-based	Traditional agriculture, underdeveloped	Traditional agriculture
	Labor structure	Stable population structure	Population inflow	Population inflow	Large migrant population	Population outflow	Large migrant population	Population outflow	Population outflow
	Human-land relationship	High demand with idle land	High demand with idle land	High demand for industrial land	High demand with idle land	Large-scale land idle	Illegal expansion and misuse	Mountainous, limited usable land	Temporarily idle land
Homestead system reform	Reform model	Voluntary paid withdrawal + homestead equity	Voluntary paid withdrawal + urban-rural land quota linkage	New community clustering + “land pooling vouchers”	Land ticket system + interprovincial land quota linkage	Land reserve + “land for pension”	Multi-purpose land transfer and operation	Relocation for poverty relief and reservoir resettlement	Unpaid / paid land withdrawal
	Paid use standards	5~15 Yuan/m ²	20 Yuan/m ² * 20 years	0.15% of benchmark land price + 20% per 36m ² added	3~15 Yuan/m ²	2~6Yuan/m ²	Regulatory payment on operational land: 5~20Yuan/m ²	3 Yuan/m ² + 3 Yuan/m ² per 50 m ² added	10Yuan/m ² + 5Yuan/m ² per 50 m ² added
	Compensated withdrawal standards	cash compensation 900 Yuan/m ²	cash compensation: Market entry	cash compensation: ≥ 60000	Based on the land quota transaction	cash compensation: 8000~10000	cash compensation: ≈150 Yuan/m ²	cash compensation: 40-80 Yuan/m ²	cash compensation: 20-150Yuan/m ²

		price of collectively operated land + Apartment exchange	Yuan/person + Apartment exchange: 20% off + Social insurance: 50 months	price +housing subsidy: 10000 Yuan/household	Yuan/ Mu		+Poor HH: 20,000 Yuan/person; Relocated HH: 15,000 Yuan/person	+housing subsidy: 600~800 Yuan/m ²
Leading stakeholder	Government + financing institutions	Village collective + local government + enterprises	Local government + market + enterprises	Local government + market	Local government + village collective	Local government + enterprises	Local government	Villager self-governance + returned elites
Hukou system reform	Urban–rural integration, point-based hukou	Lower hukou threshold, improve public services	Lower hukou threshold, improve public services	Hukou and social security reform aligned with land system	Full removal of hukou restrictions	Full removal of hukou restrictions	Use land quota and poverty funds to improve public services	"Hukou+" multi-channel housing support

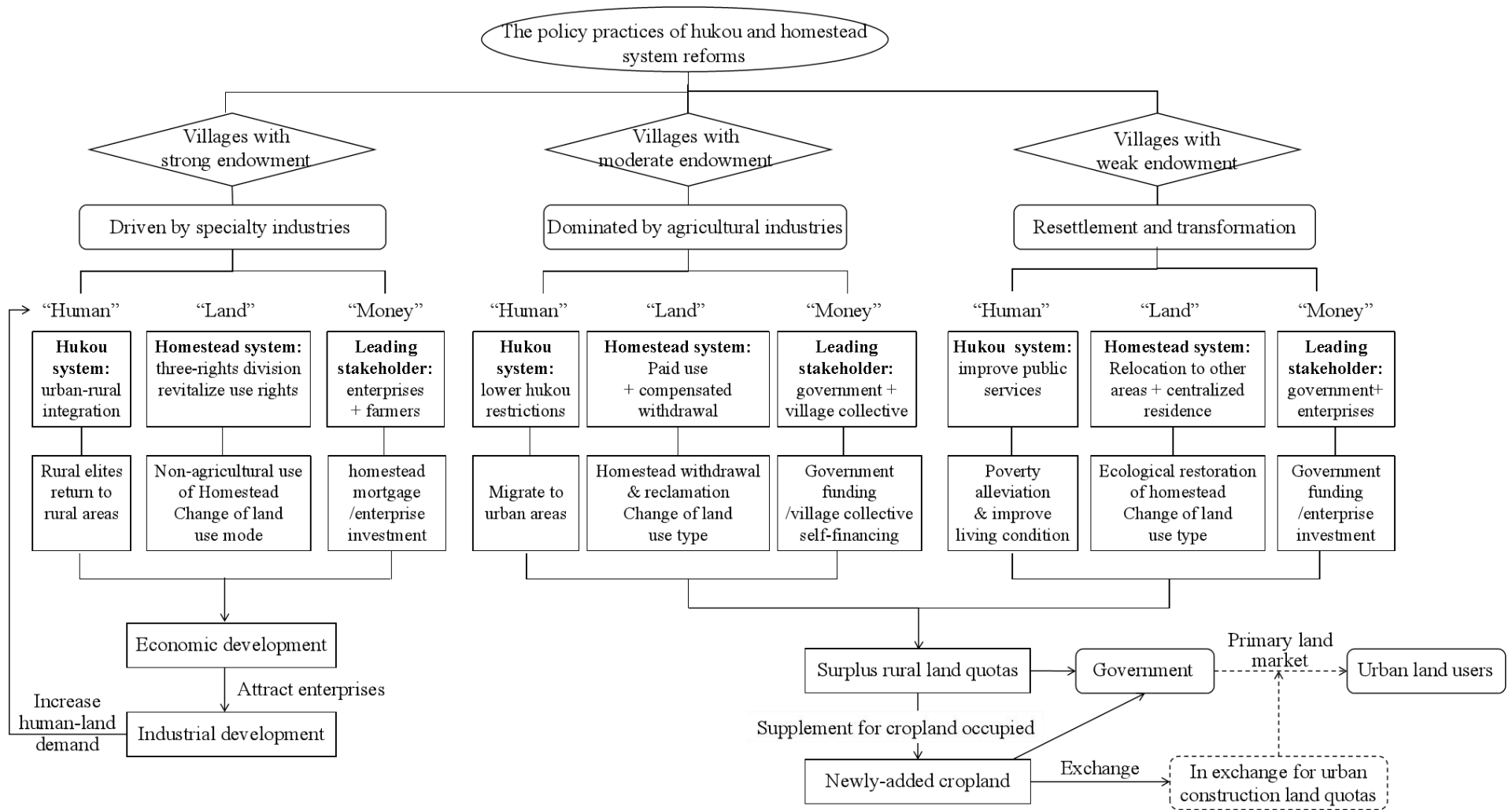


Figure 3.2 The homestead use patterns under the joint reform of hukou system and homestead system

According to Figure 3.2, under the joint reform of hukou system and homestead system, homestead use patterns can be classified into three types.

Type I: Villages with strong endowments attract rural elites to rural areas and explore non-agricultural use of homesteads

This type of village always has unique geographical locations, natural landscapes, or resource structures, and have innate advantages in developing rich new business formats. The key to their development lies in enabling the free flow of human, land, and money between urban and rural areas, injecting sufficient human resources and capital into their development. On the one hand, hukou system reform can eliminate institutional barriers to urban residents moving to rural areas and local elites returning to their hometowns. On the other hand, the liberalization of homestead land use rights under the homestead system reform can provide land support for large-scale business operations. Driven by the joint reform of these two systems, farmers are consciously turning to more profitable uses of their homesteads, such as opening agritourism and handicraft processing factories. This transformation in homestead use can shift its functional value from solely providing residential security to supporting auxiliary business activities. It not only improves homestead use efficiency but also significantly increases household income and promotes rural industrial development.

Type II: Villages with moderate endowments encourage farmers to leave their land and explore the withdrawal and reclamation of homesteads

This type of villages always lacks advantageous characteristics, has a large proportion of traditional agriculture, and is mostly located in the remote suburbs of cities, making it difficult for them to enjoy the benefits of urban development. Driven by the urban-rural income gap, surplus labor in these villages often chooses to work outside the village, inevitably leaving a large amount of homesteads idle. The development of these villages often focuses on further improving agricultural efficiency. On the one hand, hukou system reform can lower the barriers for rural migrants to settle in cities and facilitate citizenization. On the other hand, the homestead system reform can provide an institutional channel for paid use and compensated withdrawal of the homestead, encouraging farmers who have migrated

to urban areas to withdraw from their idle homesteads. Driven by the joint reform of these two systems, a large number of idle homesteads can be converted into cropland, enabling concentrated and continuous land management and thereby improving agricultural production efficiency. Alternatively, barren land can also be consolidated into public service construction land, thereby contributing to the improvement of rural living conditions and human settlement environments.

Type III: Villages with weak endowments promote centralized residential settlements and explore the ecological restoration of homesteads

This type of village is almost located in remote areas with fragile ecological environments, scarce resources, and high poverty rates. Most farmers in these villages are pure agricultural laborers who lack the ability to settle in cities, but are eager to escape poverty. On the one hand, hukou system reform can provide farmers with effective public services for production, daily life, and elderly care in urban areas. On the other hand, the homestead system reform is often implemented in conjunction with local poverty alleviation policies, guiding scattered households in the mountains to relocate to central towns for centralized settlement. The idle homestead is often reclaimed as ecological land for vegetation restoration. Driven by the joint reform of these two systems, government management costs can be reduced, farmers' incomes can be increased, their living environment can be improved, and the area of ecological land can be expanded, achieving the dual goals of restoring the ecology and alleviating poverty.

Relinquished homestead enters the urban land market through the policy of linking the increase and decrease of urban and rural construction land.

This policy provides compensation and resettlement for rural households that have withdrawn from their homesteads, while the vacated homesteads are consolidated and reclaimed. Through land quota exchange, urban construction land quotas are acquired, which are subsequently transferred to land users via primary land market mechanisms, such as bidding, auction, and listing. This approach not only ensures that the total amount of cropland remains constant, but also enhances the efficiency of homestead use and increases the area of urban construction land.

More importantly, the reallocation of land development rights in urban and rural areas can be realized. The land quota generated from relinquished homesteads originally represents the land development rights of both rural households and collectives. After land reclamation by local governments, these quotas are converted into urban construction land quotas and sold in the primary land market. The ownership of the reclaimed cropland remains with the rural collective economic organization, while the use rights can either be retained by the original homestead users or contracted to other members of the collective. This process illustrates the transfer of land development rights from rural to urban areas as homestead land is withdrawn, consolidated, reclaimed, and quota exchanged.

3.2.3 The underlying logic of joint institutional reform

Based on the Land Property Rights theory, this study analyzes the internal logic of the hukou system reform, the homestead system reform, and their joint reform (as shown in Figure 3.3).

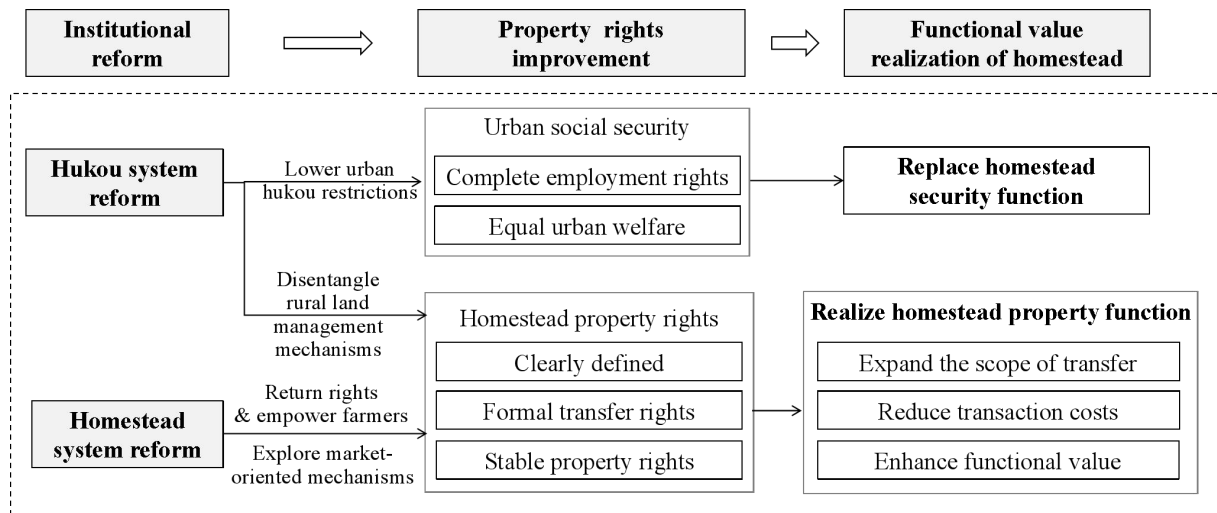


Figure 3.3 The underlying logic of joint reform of hukou system and homestead system

China's current hukou system is deeply attached to the public welfare allocation system and the rural land management mechanism, in addition to serving its primary function of population registration. The hukou system reform seeks to gradually disentangle these rights distribution mechanisms from hukou, while establishing a

unified urban-rural resident registration system to lower the barriers for rural migrants to obtain urban hukou. As a result, this reform creates more opportunities for rural migrants to access comprehensive urban public welfare and equitable employment rights, thereby reducing the friction of rural-to-urban migration and dismantling institutional barriers that hinder the free movement of population.

China's current homestead system faces several challenges, including unclear property rights, incomplete and unstable ownership structures, which hinder the full realization of the functional value of homesteads. The primary focus of the homestead system reform is to clarify ownership by certification, restore rights, and empower stakeholders, which has brought significant changes in three key areas. First, enforce the collective ownership of homesteads to safeguard the foundational principle of public land ownership in the reform process. Second, expand the qualification rights for homesteads by granting farmers, as members of collective economic organizations, the original (direct) right to acquire homesteads. Third, revitalize the use rights of homesteads by providing farmers with channels to realize the property value of their homesteads, and allowing farmers to voluntarily and fairly withdraw from homesteads for compensation. The scope of homestead transfer is no longer restricted to rural collectives, paving the way for market-oriented transfer mechanisms. Additionally, the functions of homesteads are diversified, encouraging the use of idle homesteads for new rural industries, such as tourism and handicrafts, to unlock their full potential. In summary, the homestead system reform establishes clear and stable property rights while granting formal, market-oriented transfer rights, breaking down institutional barriers that previously restricted the free transfer of land.

Further, this study analyzes the internal logic of the joint reform between the two systems. From the perspective of land ownership, it fundamentally changes the nature of rural property rights, eroding hukou-based rights and introducing market-oriented rights. In terms of land interests, it essentially dismantles the hukou-based land closure protection mechanism and replaces it with urban security systems. This change facilitates the free flow of labor and land factors, optimizing resource allocation by reorganizing inefficient combinations. From the perspective of resource

allocation, the introduction of market-oriented mechanisms has enabled various production factors to flow freely, thereby reorganizing the inefficient combination of rural production factors and maximizing the efficiency of resource allocation.

The joint reform of hukou system and homestead system can achieve Pareto improvement, which can be discussed by comparing the benefits of farmers and the government before and after the reform. Before the system reform, for rural farmers, although their idle homesteads incurred certain opportunity costs, the simultaneous enjoyment of the security value of their homesteads created a balance between costs and benefits, making it efficient for the farmers.

In financial terms, governments do not spend money on farmers' unused land, but they have little motivation to maintain the status quo because it does not increase their marginal benefits. In fact, any extra investment in farmers' land or social security might decrease the government's marginal returns. Meanwhile, the conflict between the limited urban construction land and the many idle homesteads in rural areas becomes increasingly evident during urban and rural development, which can motivate the government to seek change. After the reform, with the welfare function of the hukou system diminishing and the property function of rural land becoming more evident, the allocation mechanism of rural homesteads gradually became market-oriented. Land resources are reallocated across different production units, regions, and industries, participating in fair bidding in a competitive market environment. For rural migrants, the cost of withdrawing from their homesteads is reduced, allowing them to achieve higher returns. For farmers who remain in rural areas, withdrawing from homesteads and reclaiming the land increases the area of cultivated land, supporting large-scale farming operations and boosting output. For the government, it benefits from sharing the added value generated through the homestead transfer.

3.3 Baseline model construction and solution: evolutionary mechanisms of homestead use behavior under the existing institutional setting

3.3.1 Framework of baseline model

Based on spatial equilibrium theory and the classic urban economics Rosen-Roback model (Roback, 1982), this dissertation takes into account the urban-rural dual economic structure with Chinese characteristics, incorporates urban-rural industrial structure, differences in factor endowments, and public service provision, analyzes the interactions among multiple agents involved in homestead use under the current institutional framework (i.e., without reforms to the hukou and homestead systems), and constructs a baseline model accordingly. The model's structure is illustrated in Figure 3.4.

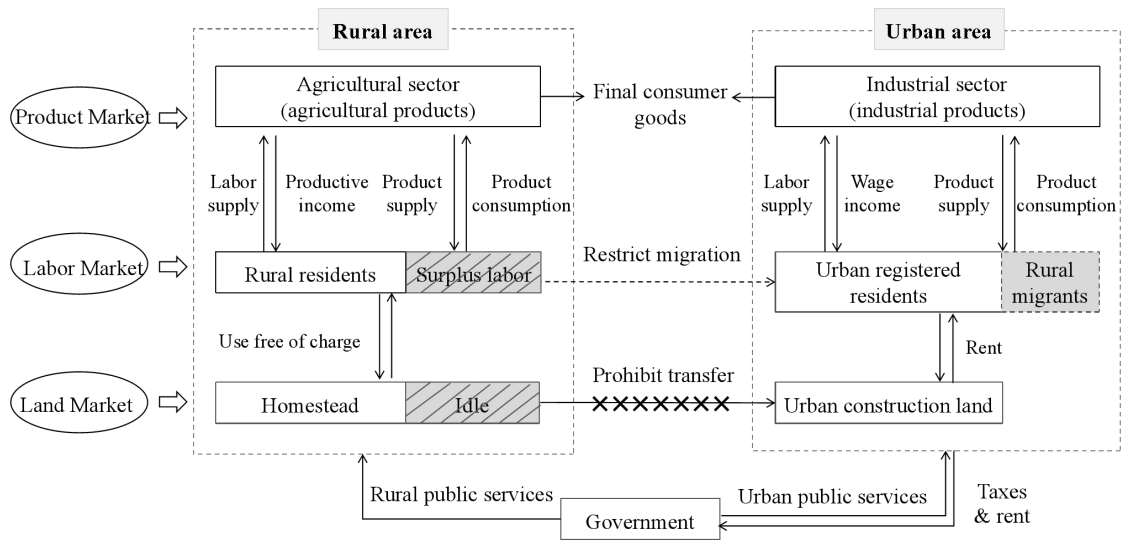


Figure 3.4 The structure of baseline model under the existing institutional setting

It is assumed that the entire economy consists of two regions with varying levels of public services: rural area and urban area, and accommodates three types of entities: urban residents (including both the urban registered residents and rural migrants), as well as rural residents, and encompasses two sectors: rural agricultural production and urban industrial production. In rural areas, land primarily consists of cropland and homesteads, both of which are owned by the village collective and allocated free of charge to rural registered residents for agricultural production and residential construction. Farmers use cropland for agricultural activities and sell their products in the market to generate productive income. In urban areas, land is primarily designated as construction land, which is owned by the government and leased to urban industrial

sectors for production and to urban residents for housing. Urban industrial sectors utilize construction land and employ urban laborers to conduct industrial production, selling manufactured goods in the market to generate profits, while urban laborers receive wage income as a result. The final products, comprising both agricultural and industrial goods, are consumed by urban and rural residents alike. During the production process, the government can obtain various taxes, which are used to provide transfer payments to urban registered residents and to deliver public services in both urban and rural areas.

Assume that the total population, comprising both urban and rural residents, is N , with an initial distribution of N_u urban residents and N_r rural residents. The total land endowment is T , with rural land area denoted as T_r (of which cropland area is T_{Ar} and homestead area is T_{Rr}), and urban land area denoted as T_u (of which residential land area is T_{Ru} and industrial land area is T_{Mu}). Driven by the urban-rural income gap, farmers make decisions about whether to stay in rural areas and engage in agricultural production or migrate to urban areas for non-agricultural activities, based on their utility maximization. Let N_{ru} denote the number of farmers who choose to migrate to urban areas.

When hukou and homestead systems remain unreformed, farmers who migrate to cities provide labor for urban areas but are unable to obtain an urban hukou due to restrictions on the hukou system, which means they are denied equal access to urban public services. Meanwhile, their rural-to-urban migration inevitably leads to some cropland and homesteads becoming idle, which can be transferred to other rural residents for cultivation in exchange for rental income. However, under the current homestead system, the transfer of idle homesteads is strictly prohibited. This restriction is intended to ensure that farmers who move to cities retain a base in their hometowns, allowing them to return to rural life and production in the event of unemployment. In practice, however, a widespread gray market for homesteads exists,

and farmers often sell part of their homesteads and the houses built on them privately to others at lower prices.

When the utility gained by rural labor from staying in rural areas equals that from migrating to urban areas, farmers will stop migrating to urban areas. Similarly, when the utility derived from selling homesteads equals that of retaining them, the sale of homesteads will come to a halt. Once the labor market, land market, and product market are all cleared, the economic system reaches equilibrium. Based on this, we can further analyze the specific changes in key variables such as the equilibrium urban and rural population sizes, the scale of homestead withdrawal, and the incomes of urban and rural residents.

3.3.2 Utility functions of urban and rural residents

The utility of urban and rural residents is derived from the consumption of final products and residential housing. Their decision-making objective is to maximize utility by choosing the quantity of final products consumed and the amount of residential land used, given a fixed level of public service facilities and subject to their respective budget constraints. The three groups considered in this study —urban registered residents, rural migrants, and rural residents —differ in their sources of housing and their cost-income structures. Accordingly, their utility functions and budget constraints are different.

(1) The utility function of urban registered residents

For urban registered residents, let c_{uu} denotes the quantity of final products consumed, and t_{Ru} represents the amount of urban residential land rented for housing. Their income primarily consists of after-tax non-agricultural wage income $(1-\tau)w_u$, transfer payments from the government, such as pensions and medical insurance a_u , and dividends d_u from urban land development. Accordingly, their utility function and budget constraint can be expressed as follows:

$$\begin{aligned} \max \quad & U_{uu} = s_{uu} c_{uu}^{\alpha} t_{Ru}^{1-\alpha} \\ \text{s.t.} \quad & p c_{uu} + r_{Ru} t_{Ru} = (1-\tau)w_u + a_u + d_u \end{aligned} \quad (3.1)$$

Where u represents urban areas; uu represents the initial urban registered residents; s_{uu} represents the amount of urban public services enjoyed by urban registered residents, which reflects the levels of economic development; $0 < \alpha < 1$ represents the proportion of final product consumption in total residents' consumption expenditure; p represents the prices of the final products; r_{Ru} represents the rent of urban construction land; τ represents the income tax rate.

Furthermore, the indirect utility function of urban registered residents can be derived as follows:

$$V_{uu} = \frac{\alpha^\alpha (1-\alpha)^{1-\alpha} [(1-\tau)w_u + a_u + d_u] s_{uu}}{p^\alpha r_{Ru}^{1-\alpha}} \quad (3.2)$$

(2) The utility function of rural residents

For rural residents, the quantity of final products they consumed is denoted by c_{rr} . Their housing is provided by homesteads $t_{Rr,ave}$ allocated free of charge according to national uniform standards, and they further invest in construction products c_h into building houses on these homesteads. In particular, China's homestead also undertakes various functions, such as mitigating market risks through its social security function and providing emotional support for coping with attachment to the hometown. Although they cannot directly receive transfer payments like urban registered residents, the homestead provided by the government serves a comparable social security function, which is abstracted as a_r in this study. Additionally, rural residents are either allocated cropland $t_{Ar,ave}$ for free or may rent additional cropland from other villagers at a rent r_{Ar} to expand their cropland area. The sole source of income for them is agricultural income w_r . Based on these conditions, their utility function and budget constraint can be expressed as follows:

$$\begin{aligned} \max \quad & U_{rr} = s_{rr} c_{rr}^\alpha t_{Rrr}^{1-\alpha} \\ \text{s.t.} \quad & t_{Rrr} = t_{Rr,ave} c_h \\ & p(c_h + c_{rr}) + r_{Ar} t_{Ar,redis} = w_r + a_r \end{aligned} \quad (3.3)$$

Where r represents rural areas; rr represents rural residents; s_{rr} represents the amount of rural public services enjoyed by rural residents. The first constraint specifies the number of final products c_h consumed by rural residents to build houses on the premise of owning homestead $t_{Rr,ave}$. The second constraint represents the trade-off rural residents face, given their income level, between allocating final products to housing construction c_h and to direct consumption c .

Furthermore, the indirect utility function of rural residents can be derived as follows:

$$V_{rr} = \frac{\alpha^\alpha (1-\alpha)^{1-\alpha} (w_r + a_r - r_{Ar} t_{Ar,redis}) t_{Rr,ave}^{1-\alpha} s_{rr}}{p} \quad (3.4)$$

(3) The utility function of rural migrants

For rural migrants, the final products c_{ru} they consume is derived from two sources: urban residential land t_{Rru} and rural homestead $t_{Rr,ave}$. Under the restrictions of the homestead system, rural migrants have no rights to transfer or withdraw from their homesteads, leading to their inevitable idleness. Under the restrictions of the hukou system, they are unable to obtain urban hukou and thus are ineligible for urban welfare benefits. However, they can still benefit from certain non-excludable public goods, such as urban transportation and green spaces, that are not tied to hukou, thereby enhancing their utility to some extent. As a result, the quantity of public services s_{ru} accessible to rural migrants falls between that available to urban residents s_{rr} and that available to rural residents s_{uu} (see Section 3.2.4 for specific definitions). Meanwhile, due to identity-based discrimination stemming from their lack of urban hukou, farmers are deprived of certain employment rights. As a result, their income for the same job is often lower than that of individuals with urban hukou. Before the hukou system reform, farmers had virtually no opportunity to obtain urban hukou and could only earn the minimum wage. In this

dissertation, let o_{low} denote the proportion of wage income that farmers retain after wage deductions, and $0 < o_{low} < 1$.

It is worth noting that, in reality, some rural areas with locational advantages, such as the suburbs of large cities or regions with natural scenic attractions, offer farmers the opportunity to privately trade homesteads. However, this gray market for homesteads typically occurs among acquaintances and friends. The transaction prices are generally low, with no legal protection, and the associated risks of disputes are often high. This study assumes that the transaction price in such cases is at the lowest end of the land market price, denoted exogenously as r_{Rr_low} . Furthermore, the sale of homesteads signifies the transfer of farmers' homestead use rights, resulting in the loss of both the social security value a_r and the emotional attachment value a_e associated with the homesteads. In this context, farmers lack both homestead security and urban social security, which means they must pay higher costs c to access public services such as healthcare and education in cities. The higher the city's level, the better the social security provisions, but also the greater the cost required to obtain these benefits. In this study, k_1 is used to represent the level of the city to which farmers migrate. Furthermore, regarding the emotional value of homesteads, existing research has confirmed that farmers of different ages experience varying degrees of homesickness, resulting in differing perceptions of the emotional value associated with their homesteads. This study uses k_2 to represent the degree of farmers' emotional attachment to their homesteads. In addition, the gray market enables farmers to retain their homesteads as risk allocation assets, with an expected value of v . Assuming the risk-return rate is δ , the present discounted value is $v\delta$. Meanwhile, the most critical factor influencing the value of homesteads is their locational endowment, which fundamentally shapes farmers' expectations regarding the future appreciation of their homesteads. In this study, k_3 is used to represent the degree of locational advantage of the homestead area.

In summary, the income of rural migrants consists of after-tax non-agricultural wage income $(1-\tau)o_{low}w_u$, rental income $r_{Ar}t_{Ar,ave}$ from leasing idle cropland to other farmers in the same village, and rental income $r_{Rr_low}t_{Rr,ave}$ from privately selling idle homesteads. Under these circumstances, the utility function and budget constraint for rural migrants are as follows:

$$\begin{aligned} \max \quad & U_{ru} = s_{ru} c_{ru}^\alpha \left[t_{Rru}^\rho t_{Rr}^{1-\rho} \right]^{1-\alpha} \\ \text{s.t.} \quad & pc_{ru} + r_{Ru}t_{Rru} + k_3v\delta(t_{Rr,ave} - t_{Rr}) + k_1c(t_{Rr,ave} - t_{Rr}) + k_2a_e(t_{Rr,ave} - t_{Rr}) \\ & = (1-\tau)o_{low}w_u + a_r t_{Rr}/t_{Rr,ave} + r_{Ar}t_{Ar,ave} + r_{Rr_low}(t_{Rr,ave} - t_{Rr}) \end{aligned} \quad (3.5)$$

Where ru represents the rural migrants; s_{ru} represents the amount of urban public services enjoyed by rural migrants; ρ represents the relative strength of demand for urban housing.

Furthermore, the indirect utility function of rural migrants can be derived as follows:

$$\begin{aligned} V_{ru} = & \frac{\alpha^\alpha [\rho(1-\alpha)]^{\rho(1-\alpha)} [(1-\rho)(1-\alpha)]^{(1-\rho)(1-\alpha)} \left[(1-\tau)o_{low}w_u + r_{Ar}t_{Ar,ave} + (r_{Rr_low} - k_3v\delta - k_1c - k_2a_e)t_{Rr,ave} \right] s_{uu}}{p^\alpha r_{Ru}^{\rho(1-\alpha)} \left[r_{Rr_low} - k_3v\delta - k_1c - k_2a_e - a_r/t_{Rr,ave} \right]^{(1-\rho)(1-\alpha)}} \end{aligned} \quad (3.6)$$

So far, it is assumed that there are N_{ru} members of rural migrants in urban areas. As a result, in the labor market, the total urban population becomes $N_{uu} = N_u + N_{ru}$, while the total rural population becomes $N_{rr} = N_r - N_{ru}$.

3.3.3 Production functions of urban and rural sectors

Assuming that the final products consumed are produced using both agricultural and industrial products, the relationship among the three can be expressed as follows:

$$y_c = y_{c_A}^\psi y_{c_M}^{1-\psi} \quad (3.7)$$

Where y_c, y_{c_A}, y_{c_M} represents the output of final products, agricultural products and industrial products respectively; ψ represents the share of agricultural inputs in the final products.

(1) The production function of the urban industrial sector

Assume that all industrial products originate from the urban industrial production sector. Production in this sector follows a Cobb-Douglas production function, and firms maximize profits by choosing the number of laborers to hire l_M and the amount of urban industrial land to rent t_{Mu} . Accordingly, the production function and profit function of the urban industrial production sector are defined as follows:

$$y_{c_M} = \phi_M l_M^\beta t_{Mu}^{1-\beta} \quad (3.8)$$

$$\max P_M = p_M y_{c_M} - w_u l_M - r_{Mu} t_{Mu} \quad (3.9)$$

Where p_M represents the market price of industrial products; r_{Mu} represents the rent of urban industrial land; ϕ_M represents the productivity of the urban industrial production sector; β represents the share of labor in industrial production.

Regarding the productivity ϕ_M of the urban industrial production sector, as noted by Ciccone & Hall (1996), industrial production within cities exhibits agglomeration effects, meaning that industrial productivity increases with industrial output. The relationship between the two is as follows:

$$\phi_M = \overline{\phi_M} y_{c_M}^{\eta-1} \quad (3.10)$$

Where $\overline{\phi_M}$ represents the exogenous component of industrial productivity that is not affected by the number of laborers; $\eta-1$ is the elasticity of industrial productivity with respect to the relative total industry output.

With respect to urban construction land, its available supply is denoted by T_u . The proportion of productive land within urban construction land is determined by local government development plans. Under China's fiscal system, such development plans must be approved by higher-level authorities before they can be implemented. Therefore, the proportion of urban land allocated to production use and residential use is treated as an exogenous variable, expressed as follows:

$$T_{Mu} = \xi T_u \quad (3.11)$$

Where ξ denotes the proportion of urban construction land allocated to productive use, while $1-\xi$ represents the proportion allocated to residential use. Both proportions are determined exogenously by higher-level government authorities. Meanwhile, the government leases residential land to urban residents at a rental rate of r_{Ru} , and leases industrial land to the industrial sector at a rental rate of r_{Mu} . For the purposes of this study, it is assumed that the rental prices for residential and industrial land are equal, that is, $r_u = r_{Ru} = r_{Mu}$.

(2) The production function of the rural agricultural sector

Assume that all agricultural products originate from the rural agricultural production sector, whose production also follows a Cobb-Douglas production function. The production function for an individual farmer can be expressed as:

$$y'_{c_A} = \phi_A l_A^\gamma (t_{Ar,ave} + t_{Ar,redis})^{1-\gamma} \quad (3.12)$$

Where this study assumes that productivity ϕ_A in rural areas is exogenously fixed, primarily influenced by local resource endowments and the level of mechanized farming, and is unaffected by changes in the labor or land markets. In the production function, $l_A=1$ denotes the labor input in individual agricultural operations, and γ represents the share of labor in agricultural production. After rural-to-urban migration, the remaining rural laborers are N_{rr} , so the total agricultural output is $y_{c_A} = y'_{c_A} N_{rr}$. The profit of the rural agricultural sector is then $P_A = p_A y_{c_A} - r_{Ar} t_{Ar,redis} N_{ru}$, which is equal to the total agricultural income of the rural population, that is, $P_A = w_r N_{rr}$.

Regarding the allocation of cropland for agricultural production, when some farmers migrate to cities, part of the cropland will inevitably become idle. The government encourages farmers to transfer idle land to local villagers or rural cooperatives for continued cultivation, thereby obtaining a certain amount of rental

income. To simplify the model and reflect the government's efforts to prevent cropland from lying idle, this study assumes that the cropland left by the migrating rural population is evenly redistributed among the remaining rural residents for continued cultivation, thereby ensuring food security. In this case, the per capita cropland available $t_{Ar,redis}$ to rural residents is:

$$t_{Ar,redis} = \frac{t_{Ar,ave} N_{ru}}{N_{rr}} \quad (3.13)$$

3.3.4 Urban-rural allocation functions of governments for public services

Government fiscal revenue consists of two main components: first, taxes on non-agricultural income paid by urban workers ($\tau w_u N_u + \tau O_{low} w_u N_{ru}$); second, land rental income generated from urban construction land ($r_u (T_{Ru} + T_{Mu})$). These revenues are allocated to three expenditure categories: first, transfer payments for social security to urban residents ($a_u N_u$), land dividend distribution shared with urban registered residents (d_u), and investment in urban and rural public service infrastructure (G). It is assumed that the proportion of government expenditure allocated to urban public services is θ_u , while the proportion allocated to rural public service infrastructure is θ_r , and $\theta_u + \theta_r = 1$.

Regarding the distribution of revenue from urban construction land, only residents with urban hukou are eligible to receive land dividends. It is assumed that the government allocates a proportion ς of land transfer income to the urban registered residents. The per capita land income for urban registered residents is:

$$d_u = (1 - \varsigma) r_u T_u / N_u \quad (3.14)$$

In summary, the government's budget constraint can be expressed as:

$$\tau w_u N_u + \tau O_w w_u N_{ru} + \varsigma r_u T_u / N_u = a_u N_u + G \quad (3.15)$$

The government provides public services that can be categorized into two types: welfare benefits A_{hi} such as education and healthcare, which are accessible only to individuals with urban hukou, and non-hukou-related benefits A_{ni} such as green spaces and roads, which are available to all residents. All public services received by urban registered residents are provided by urban areas, while public services for rural registered residents are entirely supplied by rural areas. However, for urban migrants who live in urban areas but retain their rural hukou, their access to public welfare is determined by a combination of non-hukou-related benefits provided in urban areas and hukou-related benefits available in rural areas, due to the restrictions imposed by the hukou system. The total amount of public services A_i provided by the government in i -th region can be expressed as: $A_{hi} + A_{ni} = A_i = \theta_i G / p$. Under the dual urban-rural public service system, the total public services received by urban registered residents, rural residents, and urban migrants can be expressed respectively as:

$$s_{uu} = \left(\frac{A_{nu}}{1-\chi}\right)^{1-\chi} \left(\frac{A_{hu}}{\chi N_u}\right)^{\chi} \quad s_{rr} = \left(\frac{A_{nr}}{1-\chi}\right)^{1-\chi} \left(\frac{A_{hr}}{\chi N_r}\right)^{\chi} \quad s_{ru} = \left(\frac{A_{nu}}{1-\chi}\right)^{1-\chi} \left(\frac{\delta A_{hr}}{\chi N_r}\right)^{\chi} \quad (3.16)$$

Where $\chi \in (0,1)$ represents the crowding effect of hukou-related public services; δ represents the loss incurred when accessing public services outside one's place of hukou registration.

The government needs to allocate welfare between urban and rural areas in a rational manner, taking into account both hukou-based and non-hukou-based welfare, to maximize the welfare of all residents. Following Zhao Fuyang and Chen Binkai (2021), the optimal level of public services for the three types of residents can be derived as follows:

$$s_{uu} = \frac{\theta_u G}{p N_u^{\chi}} \quad s_{rr} = \frac{\theta_r G}{p N_r^{\chi}} \quad s_{ru} = \frac{\theta_u^{1-\chi} (\delta \theta_r)^{\chi} G}{p N_r^{\chi}} \quad (3.17)$$

3.3.5 Specification of spatial equilibrium

To achieve equilibrium in the model, the following conditions must be satisfied.

(1) No further labor migration: when the utility of rural migrants is indifferent between staying in rural areas and migrating to urban areas, labor migration reaches equilibrium:

$$V_{ru} = V_{rr} \quad (3.18)$$

(2) Land market clearing: when the total demand for urban construction land, comprising both residential use by urban residents and production use by urban industrial sectors, equals the supply of urban construction land. Formally:

$$t_{Ruu}N_u + t_{Rru}N_{ru} + t_{Mu} = T_u \quad (3.19)$$

(3) Agricultural market clearing: when the agricultural output from rural areas satisfies the consumption demands of both rural and urban laborers. That is:

$$y_{c_A} = c_A \quad (3.20)$$

(4) Industrial market clearing: when the industrial products produced in urban areas satisfy the consumption demands of both rural and urban laborers. That is:

$$y_{c_M} = c_M \quad (3.21)$$

In summary, the total amount of final products made from agricultural and industrial sources meets the consumption needs of both rural and urban populations. That is:

$$N_u c_{uu} + N_{ru} c_{ru} + N_r c_{rr} = c_A^\psi c_M^{1-\psi} \quad (3.22)$$

3.3.6 Analysis of the impacts of the current system on homestead use behavior

Building on the foundation of the previous section, a baseline spatial equilibrium model has been constructed under the scenario where the current institutional framework (specifically, the hukou system and homestead system remains unchanged). Under this scenario, farmers face migration frictions when moving to cities due to hukou restrictions and are unable to freely transfer their homesteads because of the constraints of the homestead system. Even if they engage in informal or grey market transactions by privately selling their homesteads, the buyers typically use the

property for self-occupation rather than altering its designated use or function. As a result, the total area of homesteads remains constant. However, the homestead use behavior of rural migrants shifts from occupation to idleness, meaning that the extent of homestead idleness varies with the number of farmers who migrate to cities under equilibrium conditions. Hence, this section first calculates the number of rural migrants under equilibrium, then analyzes the influencing factors, and ultimately derives the degree of homestead idleness.

The total urban population N_u^* under equilibrium can be expressed as follows:

$$N_u^* \propto \frac{\beta^{\alpha\beta} (1-\beta)^{\alpha(1-\beta)} (1-\alpha+\alpha\beta)^{\frac{\alpha}{\alpha+\beta}} \left(\frac{\theta_u G}{pN_u^\chi}\right)^{\frac{\alpha}{1+\alpha\beta}} \varphi_M^{\frac{\alpha}{1+\alpha\beta}} T_{Mu}^{\frac{(1-\beta)\alpha}{1+\alpha\beta}} T_{Ru}^{\frac{1-\alpha}{1+\alpha\beta}}}{V_{ru}^{\frac{1}{1+\alpha\beta}}} \quad (3.23)$$

Where T_{Mu} and T_{Ru} represent the total area of industrial land and residential land in urban areas, respectively. Their allocation ratio is primarily determined exogenously by government planning and budgeting, which in turn influences both firms' production decisions and the residential space available to the urban population.

By solving the above equation, we obtain the total area of idle homesteads T_{Rru} under the scenario in which both hukou system and homestead system remain unreformed:

$$T_{Rru} \propto \frac{\beta^{\alpha\beta} (1-\beta)^{\alpha(1-\beta)} (1-\alpha+\alpha\beta)^{\frac{\alpha}{\alpha+\beta}} \left(\frac{\theta_u G}{pN_u^\chi}\right)^{\frac{\alpha}{1+\alpha\beta}} \varphi_M^{\frac{\alpha}{1+\alpha\beta}} T_{Mu}^{\frac{(1-\beta)\alpha}{1+\alpha\beta}} T_{Ru}^{\frac{1-\alpha}{1+\alpha\beta}}}{V_{ru}^{\frac{1}{1+\alpha\beta}}} - V_{ru}^{\frac{1}{1+\alpha\beta}} N_u \quad (3.24)$$

By taking the total differential of the above equation, we obtain the following result:

$$\frac{\partial T_{Rru}}{\partial \varphi_M} > 0, \frac{\partial T_{Rru}}{\partial \theta_u} > 0, \frac{\partial T_{Rru}}{\partial o_{low}} > 0, \frac{\partial T_{Rru}}{\partial T_{Mu}} > 0 \quad (3.25)$$

From the above results, it can be seen that when neither the hukou system nor the homestead system is reformed, the area of idle homesteads is an increasing function of $\varphi_M, \theta_u, o_{low}, T_{Mu}$. In other words, the higher the urban industrial productivity, the

greater the proportion of government investment in urban public services, and the larger the planned area for urban construction land, the more rural households migrate to urban areas at equilibrium, leading to a larger area of idle homesteads. Additionally, the rural-to-urban flow of land and labor factors exhibits the following characteristics. First, it is profit-driven, meaning that production factors tend to move from regions with lower returns to those with higher returns. Second, it is complementary, as production factors combine in certain proportions to contribute to regional output. Without institutional reforms, the existence of labor market frictions and restrictions on land transfer prevents land and labor from achieving optimal allocation, thereby hindering both residents' utility and the overall economic output to some extent.

Furthermore, to investigate the impacts on farmers' utility and overall socioeconomic output, this study first examines changes in key indicators, such as product prices, urban construction land rent, and labor income, under equilibrium conditions.

$$p^* \propto \left[\frac{\beta^{\alpha\beta} (1-\beta)^{\alpha(1-\beta)} (1-\alpha+\alpha\beta)^{\frac{\alpha}{\alpha+\beta}} \left(\frac{\theta_u G}{p N_u^\chi}\right)^{\frac{\alpha}{1+\alpha\beta}} \phi_M^{\frac{\alpha}{1+\alpha\beta}} T_{Mu}^{\frac{(1-\beta)\alpha}{1+\alpha\beta}} T_{Ru}^{\frac{1-\alpha}{1+\alpha\beta}}}{V_{ru}^{\frac{1}{1+\alpha\beta}}} \right]^{-\beta\eta(1-\psi)} \quad (3.26)$$

$$\times \left(\frac{T_{Mu} + T_{Ru}}{T_{u0}} \right)^{-(1-\beta)\eta(1-\psi)} (N_u + N_r - N_u^*)^{-\gamma\psi}$$

$$r_{Ru}^* \propto K \left(\frac{N_u^*}{N_u} \right)^{\beta(1-\psi)\frac{\eta}{1-\eta\beta}(1+\frac{\gamma\psi}{1-\psi})} p^* \quad (3.27)$$

Where $K = \left(\frac{N_r^*}{N_r} \right)^{\beta\psi} \left(\frac{T_u + \phi(N_u^* - N_u)(t_{Rr,ave} - t_{Rr})}{T_u} \right)^{(1-\beta)(1-\psi)\frac{\eta}{1-\eta\beta}(1+\frac{\gamma\psi}{1-\psi})-1}$.

$$w_u = M \frac{p_A \phi_A l_A^\gamma (t_{Ar,ave} + t_{Ar,redis})^{1-\gamma} - r_{Ar} t_{Ar,redis} (N_u^* - N_u)}{y_{c_A} p_A / y_{c_M} p_M} \quad (3.28)$$

Where $M = \left[\frac{(1-\tau)\beta}{N_u^*} + \frac{\delta\theta_t G_{all} / y_{c_M} p_M}{N_u + \delta N_u^* - \delta N_u} + \frac{(1-\varsigma)\phi(1-\beta)}{T_u / (t_{Rr,ave} - t_{Rr}) + \phi(N_u^* - N_u)} \right]$

Based on the preliminary analysis of product price p^* , urban construction land rent r_{Ru}^* , and urban income w_u , it can be observed that, with the process of

urbanization, there are two mechanisms for the lack of institutional reform to hinder the full flow of labor and land factors: the land price mechanism and the wage income mechanism. Figure 3.5 illustrates how the restrictive hukou system and the homestead system affect farmers' rural-to-urban migration and homestead use behavior.

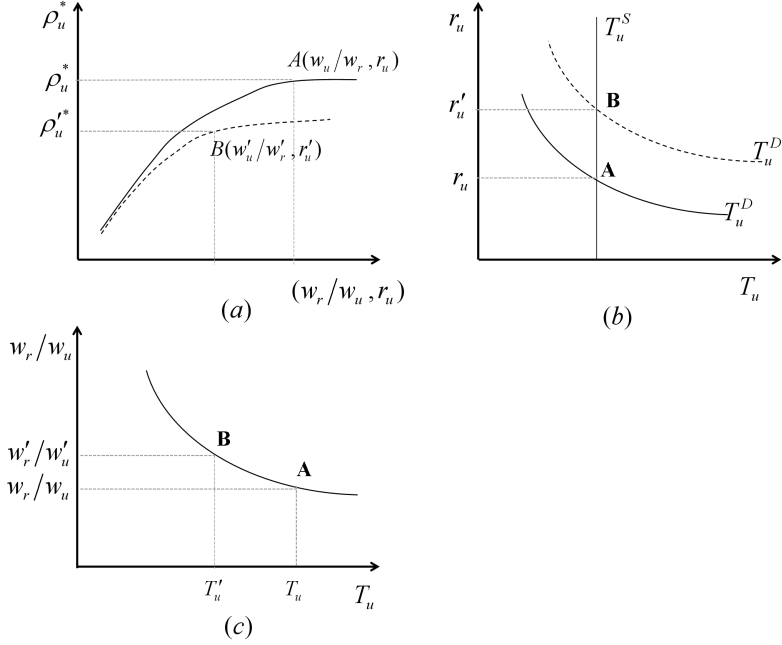


Figure 3.5 Farmers' rural-to-urban migration and homestead use under the existing institutional setting

In Figure 3.5, panel (b) illustrates that under the scenario where homestead system remains unreformed and the supply of urban construction land T_u^S remains unchanged, a large influx of rural migrants into urban areas increases the demand for urban construction land from T_u^D to $T_u^{D'}$, resulting in a rise in urban land rent r_u to r'_u . Housing prices thus become the primary cost directly faced by rural migrants in the process of gaining urban citizenship. According to the 2017 National Migrant Population Dynamic Monitoring Survey, 62.89% of rural migrants reported that they could not afford to buy a house in their destination cities, and only 37.84% expressed a willingness to settle there permanently. The continuous rise in urban housing prices further reinforces the restrictive effect of the hukou system on rural-to-urban

migration. Furthermore, panel (c) demonstrates that as more farmers migrate to urban areas, the per capita area of urban construction land T_u gradually decreases, and wage income in urban areas becomes relatively lower compared to productive income in rural areas, as indicated by a decrease in the ratio w_r/w_u .

Based on panels (b) and (c), the conclusion shown in panel (a) can be drawn: as the urban-rural income gap narrows and urban construction land rents increase, the overall utility of rural households inevitably decreases. This significantly impedes the pace at which rural labor migrates to urban areas, leading to a further decrease in the urbanization rate (defined as the proportion of the urban population in the total urban and rural population, that is ρ_u^*). For rural migrants, this manifests as a negative “crowding-out effect,” forcing them to rely on rural land as a form of security to hedge against urban risks. At this stage, the human–land relationship is characterized by a coexistence of separation (in terms of labor) and attachment (in terms of security). Rural migrants have neither achieved permanent settlement in urban areas nor equal access to urban public services, nor have they fully transitioned out of agriculture, receiving compensation for relinquishing their rural land rights. This situation not only hinders China’s urbanization and rural revitalization but also undermines rural migrants’ interests.

3.4 Model extension and solution: evolutionary mechanisms of homestead use behavior under joint institutional reform

3.4.1 Framework of the extended model

Building on the baseline model, variables representing hukou and homestead system reforms are introduced to extend the framework. The structure of the extended model is illustrated in Figure 3.6. Hukou system reform lowers the threshold for rural households to obtain urban hukou, granting them access to urban public services and reducing wage losses caused by hukou-based discrimination. Homestead system reform allows rural households to withdraw from idle homesteads in exchange for compensation. The idle homesteads are then collectively reclaimed by the village and

converted into cropland, creating surplus rural land quotas. Through the **policy of linking the increase and decrease of urban and rural construction land**, these quotas are transferred to urban areas, thereby increasing the supply of urban construction land. Let T_{ru} denote the area of newly-added urban construction land.

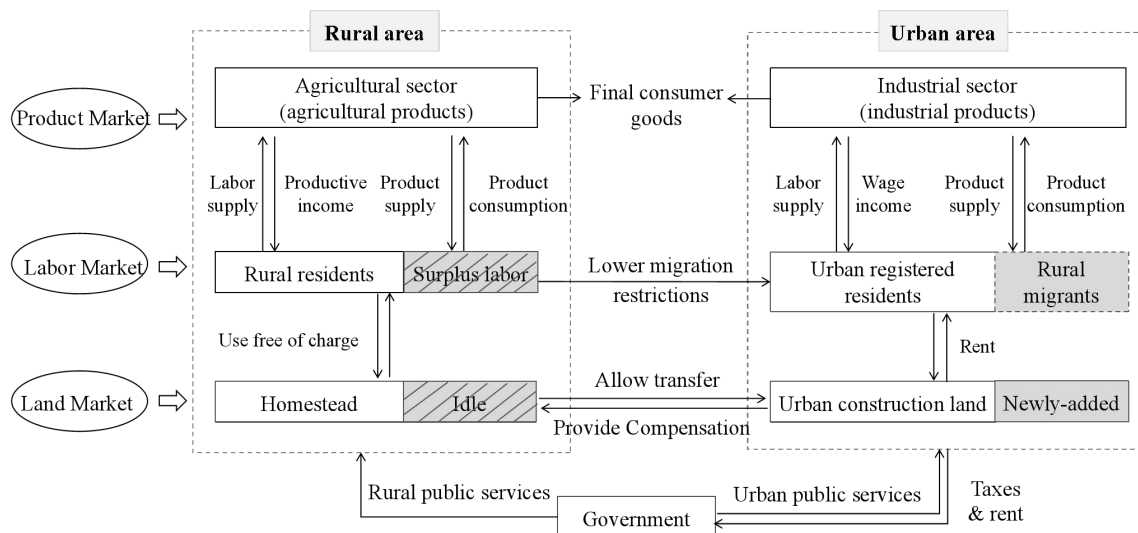


Figure 3.6 The structure of the extended model under joint institutional reform

3.4.2 Introduction of hukou and homestead system reform variables

(1) Introduction of the homestead system reform variable

Based on the review of the homestead system reform in Section 2.1.2, as well as the interpretations and analysis in Section 3.2, the reform allows farmers to voluntarily withdraw from their homesteads for compensation. The scope of homestead transfer is no longer limited to the local village collective, and there is ongoing exploration of market-oriented mechanisms for homestead transactions, thereby enriching the functions of the homestead. As a result, farmers no longer need to rely on illegal grey markets for homestead transfers as they did before the reform. The withdrawn homesteads can be utilized, through the mechanism of *Linking the Increase and Decrease of Urban and Rural Construction Land*, to supplement the supply of urban construction land. Through this process, the homestead system reform transforms the land factor from being absolutely restricted to enabling a one-way flow from rural to urban areas.

Essentially, the core of the homestead system reform lies in clarifying and stabilizing property rights, thereby strengthening and expanding the bundle of rights associated with the homestead. This provides farmers with an institutional channel to withdraw from their homesteads and realize the value of their land as an asset. As a result, the transaction rules of the homestead market are changed, and the price of homestead withdrawal (r_{Rr}) will henceforth be determined by the market.

In summary, under the scenario of the homestead system reform, the utility function of rural migrants can be rewritten as:

$$\begin{aligned} \max \quad & U_{ru} = s_{ru} c_{ru}^\alpha \left[t_{Rru}^\rho t_{Rr}^{1-\rho} \right]^{1-\alpha} \\ \text{s.t.} \quad & p c_{ru} + r_{Ru} t_{Rru} + k_3 v \delta (t_{Rr,ave} - t_{Rr}) + k_1 c (t_{Rr,ave} - t_{Rr}) + k_2 a_e (t_{Rr,ave} - t_{Rr}) \\ & = (1-\tau) o_{low} w_u + a_r t_{Rr} / t_{Rr,ave} + r_{Ar} t_{Ar,ave} + r_{Rr} (t_{Rr,ave} - t_{Rr}) \end{aligned} \quad (3.29)$$

Furthermore, under the scenario of homestead system reform, the indirect utility function for rural migrants can be derived as follows:

$$\begin{aligned} V_{ru} = & \frac{\alpha^\alpha [\rho(1-\alpha)]^{\rho(1-\alpha)} [(1-\rho)(1-\alpha)]^{(1-\rho)(1-\alpha)} [(1-\tau) o_{low} w_u + r_{Ar} t_{Ar,ave} + (r_{Rr} - k_3 v \delta - k_1 c - k_2 a_e) t_{Rr,ave}] s_{uu}}{p^\alpha r_{Ru}^{\rho(1-\alpha)} [r_{Rr} - k_3 v \delta - k_1 c - k_2 a_e - a_r / t_{Rr,ave}]^{(1-\rho)(1-\alpha)}} \end{aligned} \quad (3.30)$$

At this stage, the total area of withdrawn homestead by farmers is denoted by $N_{ru}(t_{Rr,ave} - t_{Rr})$. Drawing on (Guo et al., 2023; Zhou et al., 2017), this study assumes that each unit of withdrawn homestead can be converted into an equivalent φ units of urban construction land quota, which is exogenously determined. Consequently, the supply of urban construction land increases from T_u to $T_u + \varphi N_{ru}(t_{Rr,ave} - t_{Rr})$, while the area of cropland increases from T_{Ar} to $T_{Ar} + (1-\varphi) N_{ru}(t_{Rr,ave} - t_{Rr})$. It is important to note that this newly-added cropland will be allocated free of charge by the village collective, so farmers are not required to pay rent for this land. Correspondingly, the government's land transfer revenue increases from $\mathcal{G}_u T_u$ to

$\mathcal{G}_u [T_u + \varphi N_{ru} (t_{Rr,ave} - t_{Rr})]$, and the government's revenue-cost function can thus be rewritten as:

$$\tau w_u N_u + \tau O_w w_u N_{ru} + \mathcal{G}_u [T_u + \varphi N_{ru} (t_{Rr,ave} - t_{Rr})] = a_u N_u + G \quad (3.31)$$

Therefore, the increase in urban construction land and cropland will inevitably affect production in both the industrial and agricultural sectors, leading to changes in product prices and land rent. These shifts, in turn, influence farmers' decisions regarding migration to urban areas and their willingness to withdraw from homesteads.

(2) Introduction of the hukou system reform variable

Based on the review of hukou system reform in Section 2.1.2, as well as the interpretation and analysis in Sections 3.2, the reform implements differentiated hukou registration policies for cities of various sizes: restrictions on hukou registration are removed for small towns, relaxed for medium-sized cities, and strictly maintained for a limited number of mega-cities. At the same time, a unified hukou registration system is established for both urban and rural residents.

Basically, hukou system reform mainly weakens the hukou-based public resource distribution by reducing barriers to urban hukou registration, making it easier for migrant farmers to access equal urban social benefits and secure employment rights. This study uses σ to represent the probability that rural households obtain urban hukou under hukou system reform. On the one hand, according to relevant regulations, farmers are not allowed to retain rural land rights after acquiring an urban hukou; only by formally withdrawing from their homestead through official procedures can they become eligible for an urban hukou and the associated welfare benefits a_u . Therefore, if a rural household chooses to give up its homestead, under the hukou system reform, the expected return from urban social welfare is denoted as σa_u . At this point, farmers are more likely to avoid paying additional costs typically required to access urban public services such as healthcare and education, these costs are thereby reduced to σc . On the other hand, wage income for farmers will also change under

the hukou reform: as the probability of obtaining an urban hukou increases, household wage income rises accordingly, i.e., $(1-\tau)\sigma w_u$.

In summary, under the scenario of hukou system reform, the utility function of rural migrants can be rewritten as:

$$\begin{aligned} \max \quad & U_{ru} = s_{ru} c_{ru}^\alpha \left[t_{Rru}^\rho t_{Rr}^{1-\rho} \right]^{1-\alpha} \\ \text{s.t.} \quad & p c_{ru} + r_{Ru} t_{Rru} + k_3 v \delta (t_{Rr,ave} - t_{Rr}) + k_1 c (1-\sigma) (t_{Rr,ave} - t_{Rr}) + k_2 a_e (t_{Rr,ave} - t_{Rr}) \quad (3.32) \\ & = (1-\tau)\sigma w_u + r_{Ar} t_{Ar,ave} + r_{Rr} (t_{Rr,ave} - t_{Rr}) + \sigma a_u \end{aligned}$$

Furthermore, under the scenario of hukou system reform, the indirect utility function of rural migrants can be derived as:

$$\begin{aligned} V_{ru} = & \frac{\alpha^\alpha [\rho(1-\alpha)]^{\rho(1-\alpha)} [(1-\rho)(1-\alpha)]^{(1-\rho)(1-\alpha)} [(1-\tau)\sigma w_u + r_{Ar} t_{Ar,ave} + \sigma a_u + (r_{Rr} - k_3 v \delta - k_1 c (1-\sigma) - k_2 a_e) t_{Rr,ave}] s_{uu}}{p^\alpha r_{Ru}^{\rho(1-\alpha)} [r_{Rr} - k_3 v \delta - k_1 c (1-\sigma) - k_2 a_e]^{(1-\rho)(1-\alpha)}} \quad (3.33) \end{aligned}$$

3.4.3 Analysis of the impacts of joint institutional reform on homestead use behavior

The above section has constructed an extended model that introduces variables of hukou system and homestead system. This section proceeds to solve and derive the extended model and further understand the impact mechanisms of the joint reform of hukou system and homestead system on homestead use behavior through comparative statics analysis.

For rural migrants, although rural homesteads no longer serve their original functions as housing and production auxiliaries, they still play a series of other important roles. First, homesteads possess the welfare and security attributes of quasi-public goods, serving as virtually the only solid backstop for farmers to cope with market risks. Second, as a natural resource, homesteads possess asset value, an attribute that is increasingly realized under ongoing institutional reforms. Third, as the birthplace of farmers, homesteads carry a strong sense of family belonging and a psychological connection to the rural land, which in turn fosters a strong emotional attachment to the homesteads (Liu et al., 2021; Su et al., 2019.; Zou et al., 2022).

Under the influence of hukou and homestead system reforms, the realization or erosion of these homestead functions will affect farmers' utility, consequently, their decisions regarding homestead withdrawal.

To reveal the impact pathway of the joint reform of the hukou system and the homestead system on farmers' homestead use behavior, this dissertation employs a two-step analytical strategy. First, by focusing solely on the homestead system reform, it identifies the key factors that affect the reform's effectiveness. Second, it examines how these factors can be mitigated or enhanced through hukou system reform.

(1) The impacts of the homestead system reform alone on farmers' homestead use behavior

To simplify the model, this dissertation selects two boundary states: one in which farmers fully withdraw from all homesteads ($t_{Rr} = 0$), and another in which farmers retain all their homestead land ($t_{Rr} = t_{Rr,ave}$). The utility difference between these two states represents the maximum effort required by the institutional reform to encourage farmers to withdraw from idle homesteads. Ideally, if this difference is greater than 0, farmers will withdraw from their homesteads.

Under homestead system reform alone, the utility difference Z' between the states of withdrawing from and not withdrawing from the homestead can be expressed as:

$$Z' = \frac{\alpha^\alpha [\rho(1-\alpha)]^{\rho(1-\alpha)} s_{ru} [r_{Rr} t_{Rr,ave} - k_1 c - k_2 a_e - k_3 \delta r_{Rr} t_{Rr,ave} - a_r]}{p^\alpha r_{Ru}^{\rho(1-\alpha)}} \quad (3.34)$$

Homestead system reform provides farmers with more secure land use rights and more formal land transfer rights, creating an institutional channel for realizing the asset value of the homestead (Song et al., 2020). According to the property rights theory of new institutional economics, secure and formal property rights can reduce transaction costs, alleviate information flow barriers, and facilitate smoother negotiations (Zhang et al., 2022; Gao et al., 2020; Su et al., 2023). These effects are expected to increase market transaction prices for homestead land to some extent. The

resulting impacts on farmers' homestead use behavior can be summarized in the following three aspects:

First, from $\frac{\partial Z'}{\partial(r_{Rr}t_{Rr,ave})} \cdot \frac{\partial(r_{Rr}t_{Rr,ave})}{\partial r_{Rr}} > 0$, it follows that the increase in the

transaction price of homesteads increases the property income $r_{Rr}t_{Rr,ave}$ of farmers who withdraw from homesteads, which can help farmers increase capital investment in non-agricultural activities to improve marginal output. This has a positive income effect, encouraging farmers to withdraw from their homesteads.

Second, from $\frac{\partial Z'}{\partial(k_3\delta_{Rr}t_{Rr,ave})} \cdot \frac{\partial(k_3\delta_{Rr}t_{Rr,ave})}{\partial r_{Rr}} < 0$, it follows that the strengthening of

property rights and the diversification of rights-related values have raised farmers' expectations for future homestead prices, thereby increasing the opportunity cost $k_3\delta_{Rr}t_{Rr,ave}$ of withdrawing from homesteads. According to behavioral economics, land transaction decisions are influenced not only by current market prices but also significantly by expectations of future prices. When farmers anticipate that the homestead will appreciate in value, they tend to be more cautious about short-term transactions and prefer to hold the asset for the long term, thus forming a negative opportunity cost effect that discourages homestead withdrawal (Fu et al., 2022; Liu et al., 2021; Qi et al., 2023).

Third, from $\frac{\partial Z'}{\partial a_r} < 0$ and $\frac{\partial Z'}{\partial(k_2a_e)} < 0$, it follows that, given that the homestead

also serves a social security function a_r in coping with market risks and an emotional function k_2a_e in reinforcing attachment to hometown, this attachment effect on homestead can also reduce farmers' enthusiasm for withdrawing from their homesteads to a certain extent.

In summary, the homestead system reform alone primarily generates three types of effects: positive income effects, negative opportunity cost effects, and negative attachment effects. Under the overlapping influences of these multiple positive and

negative utility effects, the sign of Z' is ambiguous, suggesting that the impacts of homestead system reform on farmers' homestead withdrawal behavior may be limited. Furthermore, this dissertation analyzes the negative factors inhibiting farmers' homestead withdrawal and identifies the factors that limit the effectiveness of homestead system reform. Among them, two factors are found to be closely related to the hukou system:

First, from $\frac{\partial Z'}{\partial(k_1c)} < 0$, we can see that under the constraints of the hukou system,

farmers have to pay additional living costs k_1c to access public welfare. The higher the administrative level k_1 of migration destination cities, the greater these costs become. Faced with such high living expenses, the utility gained from the property income generated by withdrawing from homesteads appears minimal and fails to provide sufficient financial support for rural-to-urban migration, significantly limiting the positive income effect of homestead system reform.

Second, from $\frac{\partial Z'}{\partial a_r} < 0$, we can see that the restrictions imposed by the hukou

system on farmers' access to urban welfare imply that, once they withdraw from their homesteads, they are left without alternative sources of security. This further reinforces their reliance on homestead-based security and weakens their enthusiasm for withdrawing from homesteads.

Proposition 1: The strict hukou system constitutes a major external institutional barrier that constrains the expected effectiveness of homestead system reform.

(2) The impacts of the joint reform of hukou system and homestead system on farmers' homestead use behavior

Under the joint reform of hukou system and homestead system, the utility difference Z'' between the states of withdrawing from and not withdrawing from homestead can be expressed as:

$$Z'' = \frac{\alpha^\alpha [\rho(1-\alpha)]^{\rho(1-\alpha)} s_{ru} [(\sigma - \sigma_{low})(1-\tau)w_u + r_{Rr} t_{Rr,ave} + \sigma a_u - k_1(1-\sigma)c - k_2 a_e - k_3 \delta r_{Rr} t_{Rr,ave} - a_r]}{p^\alpha r_{Ru}^{\rho(1-\alpha)}} \quad (3.35)$$

Hukou system reform can lower the requirements for obtaining urban hukou and weaken the hukou-based mechanism of resource allocation. From $\frac{\partial Z''}{\partial \sigma} > 0$ we can see that the hukou system reform can improve the effect of the homestead system reform. The main channels are as follows:

First, from $\frac{\partial Z''}{\partial((\sigma - \sigma_{low})(1-\tau)w_u)} \cdot \frac{\partial((\sigma - \sigma_{low})(1-\tau)w_u)}{\partial \sigma} > 0$, it follows that

hukou system reform reduces human capital frictions, which provides farmers with more opportunities to obtain urban hukou, helps them get rid of identity discrimination, and increases their likelihood of finding formal jobs with labor contracts and higher wages. Meanwhile, from $\frac{\partial Z''}{\partial(k_1(1-\sigma))} \cdot \frac{\partial(k_1(1-\sigma))}{\partial \sigma} > 0$, it follows that hukou system reform enables farmers to access equal social welfare as urban residents, which not only reduces living costs but also reinforces the income effect generated by homestead system reform, thereby jointly contributing to higher total household income and increasing the likelihood of farmers voluntarily withdrawing from their homesteads.

Second, from $\frac{\partial Z''}{\partial(\sigma a_u - a_r)} \cdot \frac{\partial(\sigma a_u - a_r)}{\partial \sigma} > 0$, it follows that under the hukou

system reform, farmers gain access to urban social welfare, which means that the homestead is no longer their sole source of security. This diversification of security sources reduces farmers' reliance on the homestead and encourages them to withdraw from their homesteads.

Proposition 2: Hukou system reform enhances the effects of homestead system reform by strengthening the positive income effect and weakening the negative attachment effect, making the two reforms complementary in promoting farmers' homestead withdrawal.

(3) Impact dynamics of joint institutional reform on farmers' homestead use behavior

Given the complementary role played by the joint reform of hukou system and homestead system, we are particularly interested in how to better and sustainably leverage this role. In the above analysis, homestead reform, by increasing the asset value of the homestead, has generated two opposing effects: the income effect and the opportunity cost effect. Related studies have found that the trade-off between these two effects is primarily influenced by factors such as household income levels and the substitution degree of land for livelihood security (Khalil & Wu, 2017; Liu et al., 2021). Hukou reform provides farmers with more livelihood and housing options, which not only increases their income levels but also provides them with more comprehensive urban social welfare, thereby partially replacing the land security function. Therefore, the intensity of hukou system reform can influence the trade-off between the income effect and the opportunity cost effect to a certain extent. As the hukou system reform continues to deepen, its complementary role with the homestead system will also exhibit dynamic characteristics.

To this end, this dissertation examines whether the complementary role of joint reform of the hukou system and the homestead system can evolve as the hukou system reform progresses. Assuming that the hukou system is nearly completely relaxed, that is, the probability σ of farmers obtaining urban hukou approaches 1 infinitely, farmers are likely to gain access to higher wage income and better urban social welfare, which can fully substitute the security function previously provided by rural homesteads. In this study, F is used to represent the level of social welfare that farmers can obtain, and $B = r_{Rr} t_{Rr,ave}$ is used to represent the compensation for farmers' withdrawal from the homestead. At this time, the indirect utility function of farmers choosing to retain their homesteads is:

$$V_{ru1}''' = \frac{\alpha^\alpha [\rho(1-\alpha)]^{\rho(1-\alpha)} [(1-\tau)w_u + r_{Ar} t_{Ar,ave} + a_u + k_3 \delta r_{Rr} t_{Rr,ave}] s_{ru}}{p^\alpha r_u^{\rho(1-\alpha)}} = V(F + \delta B) \quad (3.36)$$

Assuming that farmers are exactly at the boundary states between withdrawing and not withdrawing from their homesteads, in other words, compared to obtaining a certain compensation B for homestead withdrawal, farmers are more inclined to retain the homestead use rights, even though doing so implies a certain risk in future income. In this case, the optimal condition for allocating a certain value B to risky assets can be determined by $\partial V'''/\partial B = 0$, namely:

$$\delta V'(F + \delta B) = 0 \quad (3.37)$$

Differentiating the above formula with respect to F yields:

$$\frac{\partial G}{\partial F} = \frac{-\delta V''(F + \delta B)}{\delta^2 V''(F + \delta B)} \quad (3.38)$$

Under the general assumptions of diminishing absolute risk aversion and that the expected return on risky assets is greater than 0, the above equation can be shown to be greater than 0 (Jehle & Reny, 2002). This implies that for farmers, the optimal allocation to assets with uncertain returns is proportional to their level of living welfare. Specifically, when economic conditions are favorable and social welfare is guaranteed, reaching F , farmers are more likely to view their homesteads as risky investment assets and retain them, thus reaching the boundary state for retaining their homesteads. However, farmers with poor economic conditions and no access to urban social security will allocate less to risky assets than B , as their living welfare is less than F . In other words, when the hukou system reform is weak, farmers who cannot secure a stable urban life will tend to withdraw from their homesteads to obtain certain compensation B .

Therefore, there is an inflection point in the improvement of the effect of the homestead system reform brought about by the hukou system reform. After this point, further hukou system reform will no longer generate significant marginal improvements. Specifically speaking, as hukou restrictions are gradually relaxed, farmers become more optimistic about obtaining urban benefits and rights, less dependent on homestead security, and more willing to give up their homesteads in order to seek financial support and move to urban areas. At this time, the homestead

system reform exhibits an income effect. When hukou restrictions are almost completely relaxed, farmers can obtain full urban rights, and the security from homestead is no longer their primary concern. More stable urban jobs and higher incomes may make farmers less interested in the asset value of their homesteads and more concerned with the future returns. At this time, the homestead system reform may exhibit an opportunity cost effect. Meanwhile, negative emotional attachment effects may also become more prominent, making farmers more inclined to remain on their homesteads.

Proposition 3: The complementary relationship between hukou and homestead system reforms is nonlinear. As hukou system reform intensifies, the probability of farmers withdrawing from their homesteads may first rise and then fall, forming an “inverted U-shaped” trend.

(4) Impact heterogeneity of joint institutional reform on farmers' homestead

In Eq. (3.35), the impacts of the joint reform of hukou system and homestead system on farmers' homestead use behavior is also moderated by other factors.

First, the economic development level, welfare level, infrastructure level, and employment conditions of farmers' migration destinations determine farmers' living costs and employment opportunities k_1 , which in turn influences the cost of farmers leaving their hometowns (Wang et al., 2023).

Second, differences in farmers' individual characteristics, such as skill level, years of education, and age, lead to variations in how they perceive the relative importance of different functional values of homesteads, including residential, security, asset, and emotional attachment functions. These perceptual differences k_2 influence their subjective attitudes toward withdrawing from their homesteads (Zhao et al., 2018).

Third, the geographic characteristics of a homestead, including the economic region, its distance from the city center, and whether it is situated within a scenic area, determine its inherent endowment and asset value k_3 . These factors influence farmers' judgments regarding both the current value of homestead and its future

market prospects (Chen et al., 2017; Xu et al., 2019).

Fourth, the hukou system and homestead system are both comprehensive systems that integrate multiple policies. Different hukou restriction policies, various compensation models and standards for homestead withdrawal, and other related policies have significant influence on farmers with diverse socio-economic characteristics, through different impact mechanisms and to varying degrees. These factors affect the costs and benefits of farmers' different homestead use behaviors (Zhang et al., 2019).

Proposition 4: The heterogeneity across individual characteristics, homestead endowments, regional contexts, and policy implementation may moderate the effects of the joint reform of hukou and homestead systems on farmers' land use behavior.

3.5 Further discussion: economic and welfare effects of homestead use behavior evolution under joint institutional reform

3.5.1 Analysis of changes in the socioeconomic output under joint institutional reform

Equilibrium in economics requires that, given the supply of labor and land in both urban and rural areas, the labor and land markets clear through the adjustment of factor prices. The number of homestead withdrawals and rural-urban land transfers is affected by the number of farmers migrating to cities N_{ru} and the proportion of urban land that can be replaced by the withdrawn homestead φ . The number of farmers migrating to the cities depends on the individual utility indifference condition, which requires that $V_{ru} = V_{rr}$.

Therefore, to ensure the existence of a general equilibrium in this model, it is required that $V_{ru}(0; \varphi) > V_{rr}(0; \varphi)$ and $V_{ru}(0; \varphi) < V_{rr}(0; \varphi)$. Under this condition, there exists a corresponding solution $0 < N_{ru} < N_r$. Accordingly, we obtain the utility indifference condition:

$$\delta \left(\frac{S_{ru}}{S_{rr}} \right) \left(\frac{IN_{ru}}{IN_{rr}} \right) = \left[\left(\frac{r_{Ru}}{\rho} \right)^\rho \left(\frac{r_{Rr} - a/t_{Rr,ave}}{1 - \rho} \right)^{1-\rho} \right]^{1-\alpha} \left(\frac{t_{Rr,ave}}{p} \right)^{1-\alpha} \quad (3.39)$$

Where $\frac{S_{ru}}{S_{rr}}$ is the urban-rural public service gap of rural migrants under general equilibrium; $\frac{IN_{ru}}{IN_{rr}}$ is the urban-rural income gap of rural migrants;

$\left[\left(\frac{r_{Ru}}{\rho} \right)^\rho \left(\frac{r_{Rr} - a/t_{Rr,ave}}{1 - \rho} \right)^{1-\rho} \right]^{1-\alpha} p^{\alpha-1}$ is the relative land price, that is, the ratio of land price to the price of final consumer goods, which reflects the difference in living costs between urban and rural areas among rural migrants. The above equation expresses the relationship between the urban-rural income gap, the public service gap, and the relative land price under general equilibrium. Next, we analyze the three parts of the above equation separately.

First, the urban-rural public service gap for rural migrants under the general equilibrium can be expressed as:

$$\frac{S_{ru}}{S_{rr}} = \left(\frac{\theta_u}{\theta_r} \right)^{1-\chi} \delta^\chi \quad (3.40)$$

As indicated by the above equation, the urban-rural public service gap for rural migrants is primarily related to the loss of non-local public services, rather than the scale of the migrant population. The smaller the loss in accessing public services tied to urban hukou in migration destination cities, the smaller the urban-rural public service gap experienced by rural migrants.

Second, the urban-rural income gap for rural migrants under general equilibrium can be expressed as:

$$\frac{IN_{ru}}{IN_{rr}} = \frac{N_r - N_{ru}}{p_A y_{c_A}} \left[\frac{(1-\tau)\beta}{N_u + N_{ru}} + \frac{\theta_t \delta G_{all}}{N_u + \delta N_{ru}} + \frac{(1-\varsigma)\varphi(1-\beta)}{T_u / (t_{Rr,ave} - t_{Rr}) + \varphi N_{ru}} \right] \quad (3.41)$$

Where θ_t is the proportion of government fiscal revenue used for transfer payments to urban residents. By analyzing the above equations, we obtain:

$$\frac{IN_{ru}}{IN_{rr}} = \frac{N_r - N_{ru}}{p_A y_{c_A} / p_M y_{c_M}} \left[\frac{(1-\tau)\beta}{N_u + N_{ru}} + \frac{\theta_t G_{all} / y_{c_M} p_M}{N_u / \delta + N_{ru}} + \frac{(1-\varsigma)\phi(1-\beta)}{T_u / (t_{Rr,ave} - t_{Rr}) + \phi N_{ru}} \right] \quad (3.42)$$

Under general equilibrium, final product supply equals demand, so

$$\frac{y_{c_A} p_A}{y_{c_M} p_M} = \frac{\rho}{1-\rho}. \text{ The total revenue of government mainly comes from labor taxes and}$$

land transfer income, that is $G_{all} = \tau w_u (N_u + N_{ru}) + r_u (T_{ru} + T_u)$. Where

$$\tau w_u (N_u + N_{ru}) = \beta y_{c_M} p_M + \gamma y_{c_A} p_A, \quad \mathcal{G}_u (T_{ru} + T_u) = (1-\gamma) y_{c_A} p_A + (1-\alpha)(IN_{ru} + IN_u),$$

$$IN_{ru} + IN_u = IN_{all} - y_{c_A} p_A. \text{ Therefore, } \frac{G_{all}}{y_{c_M} p_M} = \frac{(1-\rho)\beta + \alpha\rho + (1-\alpha)(1-\rho)^2}{1-\rho}, \text{ and}$$

both $\frac{y_{c_A} p_A}{y_{c_M} p_M}$ and $\frac{G_{all}}{y_{c_M} p_M}$ are constant terms.

It can be seen that the urban-rural income gap $\frac{IN_{ru}}{IN_{rr}}$ for rural migrants tends to

decrease as the scale of migrants N_{ru} increases. This positive effect can be amplified by the increasing scale of homestead withdrawal $t_{Rr,ave} - t_{Rr}$. Furthermore, the lower the friction in accessing non-local public services, the smaller the urban-rural income gap for rural migrants.

Third, the relative land price under general equilibrium can be expressed as:

$$\left[\left(\frac{r_{Ru}}{\rho} \right)^\rho \left(\frac{r_{Rr} - a/t_{Rr,ave}}{1-\rho} \right)^{1-\rho} \right]^{1-\alpha} p^{\alpha-1} = \frac{(\alpha-\gamma)\rho + 1 - \alpha}{T_u + \phi(t_{Rr,ave} - t_{Rr})N_{ru}} y_{c_A}^\rho y_{c_M}^{1-\rho} \quad (3.43)$$

In equilibrium, the number of rural migrants, together with the amount of land transfers between urban and rural areas, jointly determines the relative land price, namely:

$$\frac{r_{Ru}}{p} \propto \left(\frac{N_u + N_{ru}}{N_u} \right)^{\frac{\beta(1-\psi)\eta}{1-\eta\beta}(1+\frac{\gamma\psi}{1-\psi})} \left(\frac{N_r - N_{ru}}{N_r} \right)^{-\beta\psi} \left(\frac{T_u + \phi N_{ru} (t_{Rr,ave} - t_{Rr})}{T_u} \right)^{(1-\beta)(\psi-1)\frac{\eta}{1-\eta\beta}(1+\frac{\gamma\psi}{1-\psi})-1} \quad (3.44)$$

Where $\frac{\eta}{1-\eta\beta}(1+\frac{\gamma\psi}{1-\psi}) > 1$. When the hukou system and the homestead system

are reformed jointly, the human capital friction of rural migrants decreases, the

probability of obtaining an urban hukou increases, compensation for withdrawing from the homestead increases, and the proportion of construction land transferred increases, all of which can increase rural migrants' utility or income in urban areas. As a result, under the original equilibrium level of factor flows, the utility of rural households migrating to urban areas exceeds that of those remaining in rural areas, i.e., $V_{ru} > V_{rr}$. This utility gap induces more rural households to move to urban areas, along with the corresponding surplus rural land quotas, which are transferred into urban areas and converted into urban construction land through urban-rural land increase and decrease linkage system. This process continues until the utilities are equalized again and a new equilibrium is reached. In this process, if economic output is defined as the total production of final products, the inflow of migrant farmers and construction land into urban areas generates more industrial products, which in turn increases the output of final products and the total socioeconomic output.

In summary, the joint reform of hukou system and homestead system produces a twofold impact on factor allocation and overall productivity. On the one hand, hukou system reform can reduce institutional barriers to rural-urban labor migration, lower the human capital friction faced by rural households in seeking urban employment, and improve the welfare benefits available to them in urban areas, which can attract more rural labor to move to urban areas, generate agglomeration effects, and significantly boost urban industrial productivity. On the other hand, the homestead system reform opens a channel for the rural-to-urban flow of land, allowing some idle homestead quotas to flow into urban areas. As a result, on the urban side, the supply of urban land increases, and as the proportion of construction land transferred increases, the relative land price decreases; on the rural side, as rural households migrate to cities, more cropland becomes available for concentrated cultivation by those who remain in rural areas, thereby improving the returns to rural land. Consequently, the joint reform of these two systems leads to the flow of both surplus rural labor and land toward more efficient locations, undoubtedly optimizing the allocation of labor and land factors and increasing aggregate socioeconomic output.

Proposition 5: The joint reform of hukou system and homestead system is expected to promote aggregate socioeconomic output.

3.5.2 Analysis of changes in the urban-rural income gap under joint institutional reform

This section examines the changes in actual income levels and income gaps among urban and rural residents resulting from the flow of labor and land factors under the joint institutional reform. In order to comprehensively characterize the changes in quality of life resulting from income variations between urban and rural residents, this dissertation divides farmers' income into two categories: nominal income and real income for analysis, and uses $w_u, w_r, w_u/p, w_r/p, w_u/w_r$ to represent the nominal income of farmers in rural areas, the nominal income of farmers who have migrated to urban areas, the real income of farmers in rural areas, and the real income of farmers who have migrated to urban areas, respectively. The expression of each variable under the general equilibrium is:

$$w_r \propto \frac{1}{N_r - N_{ru}} \quad (3.45)$$

$$w_u \propto \frac{(1-\tau)\beta}{N_u + N_{ru}} + \frac{a_u N_u}{N_u + N_{ru}} + \frac{(1-\varsigma)T_u(1-\beta)y_{c_M}p_M}{N_u[T_u + \phi N_{ru}(t_{Rr,ave} - t_{Rr})]} \quad (3.46)$$

$$p \propto \left(\frac{N_u + N_{ru}}{N_u}\right)^{\frac{\beta(\psi-1)\eta}{1-\eta\beta}(1+\frac{\gamma\psi}{1-\psi})} \left(\frac{N_r - N_{ru}}{N_r}\right)^{-\beta\psi} \left(\frac{T_u + \phi N_{ru}(t_{Rr,ave} - t_{Rr})}{T_u}\right)^{(1-\beta)(\psi-1)\frac{\eta}{1-\eta\beta}(1+\frac{\gamma\psi}{1-\psi})} \quad (3.47)$$

For rural residents, the outflow of a large surplus labor increases the amount of cropland per capita, thereby raising their nominal income w_r . At the same time, under institutional reforms, the inflow of both labor and land into urban areas generates agglomeration effects, which improve industrial productivity. This leads to a surge in product supply, creating a buyer's market and driving down the prices of final consumer goods p . Consequently, farmers' real incomes w_r/p can have a considerable increase.

For rural migrants, firstly, wage income from non-agricultural work in urban areas is generally higher than the income from agricultural work in rural areas. Secondly, with the hukou system reform, farmers are expected to overcome identification discrimination and be granted equal urban welfare and employment rights, thereby reducing human capital frictions and enabling them to obtain higher wage incomes. Furthermore, with the homestead system reform, homestead withdrawal compensation can also provide additional property income for farmers, thereby increasing their nominal income w_u . Combined with the decline in final consumer goods prices p , farmers' real income w_u/p will also increase.

For urban registered residents, it's unclear whether the increased tax revenue and land revenue from the inflow of rural migrants can cover transfer payments for pensions, medical insurance, and other related expenses. Per capita government transfer income is likely to decrease, offsetting the benefits of lower final product prices. Therefore, the real income of those with urban household registration will only increase if the agglomeration effect of a city is sufficiently strong. As a result, the per capita amount of government transfer income may decline, potentially offsetting the benefits brought by lower prices of final goods. Therefore, only when the agglomeration effects in urban areas are sufficiently strong will the real income of urban registered residents increase.

Furthermore, the urban-rural income gap can be expressed as:

$$\frac{w_u}{w_r} \propto (N_r - N_{ru}) \frac{(1-\tau)\beta}{N_u + N_{ru}} + \frac{a_u N_u}{N_u + N_{ru}} + \frac{(1-\varsigma)T_u(1-\beta)y_{cm}p_M}{N_u[T_u + \phi N_{ru}(t_{Rr,ave} - t_{Rr})]} \quad (3.48)$$

It can be seen from the above formula that with the increase in the migration population N_{ru} , the urban-rural income ratio w_u/w_r will decrease accordingly. Combined with the analysis of actual income levels of urban and rural residents, it can be concluded that rural-to-urban migration of the rural population can reduce the urban-rural income gap to some extent.

Proposition 6: The joint reform of hukou system and homestead system is expected to reduce the urban-rural income gap.

3.5.3 Analysis of changes in the urban-rural welfare gap under joint institutional reform

This section examines the changes in the welfare level V_{uu}, V_{rr} and welfare gap V_{uu}/V_{rr} of urban and rural residents caused by the flow of labor and land factors under the joint institutional reform. The expression is:

$$V_{uu} \propto \frac{\theta_u G}{p N_r^\chi} \left(\frac{r_{Ru}}{p} \right)^{\alpha-1} \frac{w_u}{p} \quad (3.49)$$

$$V_{rr} \propto \frac{\theta_r G}{p N_r^\chi} \frac{w_r}{p} \quad (3.50)$$

$$\frac{V_{uu}}{V_{rr}} \propto \frac{\theta_u N_r^\chi}{\theta_r N_u^\chi} \left(\frac{r_{Ru}}{p} \right)^{\alpha-1} \frac{w_u}{w_r} \quad (3.51)$$

It can be seen from the above formula that the impacts of joint institutional reform on the welfare level of urban and rural residents mainly occur through three channels: residents' actual income, the amount of public services they can obtain, and the relative prices of land and products.

Regarding the impacts of residents' real income on their welfare levels, the previous analysis showed that institutional reforms will increase the real incomes of both rural residents and migrants, improving the welfare of rural population. However, the impact of institutional reforms on the real incomes of urban registered residents is uncertain, and so are the changes in urban registered residents' welfare levels.

Regarding the impacts of public services they can obtain on their welfare levels, the previous analysis showed that with the increase in the number of rural migrants and land transfers, the real incomes of rural residents can increase significantly. Furthermore, the decline in final product prices can improve the level of rural public services, thus improving the welfare of rural residents. For urban registered residents, the decline in final product prices will also lead to an improvement in the level of urban public services, thereby also improving their welfare levels.

Regarding the impacts of the relative prices of land and products on welfare, the relative land price decreases as the flow of labor and land factors increases. Factor

flow also helps narrow the urban–rural income gap, thereby reducing the welfare disparity between urban and rural residents.

Proposition 7: The joint reform of hukou system and homestead system is expected to reduce the urban-rural welfare gap.

To sum up, the segmentation of urban and rural labor and land markets is a key factor contributing to the income and welfare disparities between urban and rural areas. Under the joint reform of hukou system and homestead system, the barriers to the flow of production factors between urban and rural areas have been broken down, impacting the income and welfare of urban and rural residents primarily through three dimensions: income, public services, and land prices. First, the frictional costs of rural-urban migration decrease, resulting in a larger influx of farmers into urban areas. This not only provides higher wage incomes for rural migrants but also increases the cropland area of farmers who remain in rural areas, boosting per capita agricultural income. Meanwhile, labor allocation is optimized, industrial productivity in urban areas is enhanced, and prices for final consumer goods are lowered. As a result, the overall cost of living declines, and both urban and rural residents experience an increase in income. Second, the relaxation of hukou constraints enables rural migrants to access urban public services equally, thereby reducing the costs of citizenization, improving their welfare levels, and narrowing the urban-rural welfare gap. Third, through the homestead system reform, the mechanisms for land price formation and benefit distribution are improved, which increases farmers' property income, increases the supply of urban construction land, and enhances the welfare levels of both urban and rural residents. Based on the above analysis, the joint reform of hukou system and homestead system can turn the negative "crowding-out effect" on rural migrants in the absence of system reform into a positive "agglomeration effect".

3.6 Conclusions

Based on spatial equilibrium theory, this chapter clarifies the developmental trajectory, policy practices, and underlying logic of hukou and homestead system reforms, constructs a spatial equilibrium model that conforms to China's urban-rural

dual economic environment, analyzes the evolutionary mechanism of homestead use behavior under institutional reform, and proposes propositions.

The major results are as follows:

First, historically, almost all major homestead system reforms have been jointly advanced with hukou system reforms. In this round of reform, several pilot areas have explored different models of homestead non-agricultural operations, land reclamation and consolidation, and land reclamation and return to agriculture based on their own resource endowments. Combining land property rights theory, the essential logic of the two system reforms is analyzed as follows: changing the nature of rural land property rights, weakening hukou-based rights, and introducing market-oriented rights, thereby achieving Pareto improvements.

Second, when neither the hukou system nor the homestead system is reformed, idle rural homesteads will coexist with a shortage of urban construction land, creating a mismatch between urban and rural land that does not meet the needs of both sides. This will lead to rising rents for urban construction land, declining wage incomes for farmers, and reduced overall household utility. These effects exert a negative "crowding-out effect" on rural labor in urban areas, consequently slowing down urbanization.

Third, the joint reform of the two systems plays a complementary role in encouraging farmers to withdraw from their homesteads. This complementarity stems from the fact that reforming the hukou system can give farmers equal rights to urban employment and welfare guarantees, strengthen the income effect of homestead reform, and reduce farmers' dependence on the security provided by their homesteads.

Fourth, the joint reform of the two systems can significantly reduce friction in the flow of labor and land factors, promote more efficient matching of human and land resources, and thus increase the scale of rural-to-urban labor migration and homestead withdrawals. This also raises farmers' household utility and overall social and economic output, transforming the negative "crowding-out effect" into a positive "agglomeration effect."

Chapter 4: Empirical Analysis of Homestead Use Behavior under the Joint Reform of Hukou System and Homestead System

4.1 Introduction

The previous chapter has revealed the mechanisms through which the joint reform of hukou system and homestead system influences homestead use behavior and proposed a set of theoretical hypotheses. This chapter aims to empirically test the validity and applicability of these hypotheses.

Although scholars have conducted a considerable number of case studies on specific local practices, a lack of nationwide, quantitative research of general significance remains. Moreover, existing studies have not clearly identified which combinations of policies can generate better outcomes, nor have they addressed issues of heterogeneity and dynamics. As a result, the literature provides limited theoretical guidance from the perspective of top-level institutional design for improving policy implementation efficiency.

To bridge the research gap, this chapter employs propensity score matching and difference-in-differences (PSM-DID) models on national individual-level data extracted from the China Rural Household Panel Survey (CRHPS) in 2015, 2017, and 2019. It then analyzes the interactive relationship between these two systems and rural migrants' homestead withdrawal behavior, proposes and verifies the mechanisms by which their joint reform affects rural migrants' behavior, and conducts a heterogeneity analysis to discuss the conditions under which the two reforms can operate more effectively.

My work contributes to the existing literature in three ways. First, unlike the general research on urbanization efficiency that focuses on rural-urban migration, this study emphasizes urbanization sustainability from a new perspective, matching population migration with rural land withdrawal, and explores how to promote rural

migrants' land withdrawal, thereby enriching the discussion on urbanization pathways. Second, beyond the general qualitative studies that focus solely on land property arrangements and overlook migration friction, this chapter is the first to utilize national, individual-level data to provide quantitative evidence for the complementary relationship between land withdrawal and migration, and further discusses the underlying mechanisms, thereby bridging the knowledge gaps in the land use decision literature. Third, this study identifies the nonlinear interaction characteristics of these two systems and reveals the factors that cause sudden changes. Combined with heterogeneity analysis, it proposes effective pathways and an implementation environment to ensure that the joint reforms of these two systems continuously generate positive synergistic effects, thereby guiding more cost-effective policy design.

The rest of this chapter is organized as follows. Section 4.2 presents the hypotheses. Based on the data, variables, and methodology presented in Sections 4.3 and 4.4, the estimated effect of joint reform of hukou and homestead systems on rural migrants' homestead withdrawal behavior, along with its heterogeneity and dynamics analysis, is discussed in Sections 4.5 and 4.6, respectively. Finally, Section 4.7 concludes this chapter.

4.2 Hypotheses

Based on the theoretical analysis of the mechanisms through which the hukou and homestead system reforms affect homestead use behavior in Chapter 3, this section further draws on relevant theories to sort out the hypotheses.

The push-pull theory and cost-benefit theory have been widely used to explain the internal mechanisms for land transfer or withdrawal globally. The push-pull theory suggests that factors conducive to improving living conditions in the destination are pulling forces, while unfavorable living conditions in the places of origin are pushing forces (Fan & Zhang, 2019; Woods, 2018). The cost-benefit theory suggests that rural migrants prioritize maximizing expected returns and minimizing the cost to their families in the land transfer or withdrawal decision (Li et al., 2023). Moreover,

various factors have been verified as closely linked with farmers' homestead withdrawal behavior, such as the characteristics of individuals, households, homestead, rural origins, and urban destinations (Liu & Liu, 2016; Zhang et al., 2020; Fu et al., 2022).

Based on the above theoretical research, when choosing whether to withdraw from homesteads, China's rural migrants might maximize the expected total utility by considering the costs and benefits of homestead use decisions. For rural migrants, although rural homestead no longer functions as a residence and production auxiliary, it still undertakes a series of important functions. First, it has welfare and security attributes of quasi-public goods and serves as a critical safety net against market risks for decades, and it is almost the only backup to cope with market risks. Further, as a kind of natural resource, homestead has the asset value, although it's nearly impossible to realize under the current homestead system restrictions. Last but not least, as the place of birth, homesteads bear a sense of family belonging and psychological connection to land, which contributes to farmers' strong emotional attachments (Liu et al., 2021; Su et al., 2019; Zou et al., 2022). Under the influence of hukou and homestead system reforms, the realization or loss of above homestead functions can affect rural migrants' utility, thereby determining their homestead withdrawal behavior.

Regarding the interactive relationship between the hukou and homestead system in prompting rural migrants' homestead withdrawal behavior, whether they are complementary or substitutive requires further analysis. Propositions 1~2 in Chapter 3 provides a theoretical answer to this question. Specifically, when the homestead system reforms, farmers are granted more secure homestead use rights and more formal homestead transfer rights (Song et al., 2020), enabling them to withdraw from homesteads with compensation and realize the homestead asset function. According to the property rights theory in New Institutional Economics, secure and formal property rights can give people positive expectations for market transactions by reduced transaction costs, free flow of information, and smooth negotiations (Zhang et al., 2019; Cao et al., 2020; Hong et al., 2020; Su et al., 2023). Therefore, compared with

the previous gray homestead transaction market, homestead system reform significantly increases farmers' homestead withdrawal opportunities and potential land property income, supporting higher labor returns from non-agricultural work (Chernina et al., 2014). This is a positive income effect that can encourage farmers to withdraw from homesteads.

However, Behavioral Economics suggests that land transaction decisions are influenced by future price expectations, not just current market prices (Liu et al., 2021; Fu et al., 2022; Qi et al., 2023). Strengthened property rights and diversified right value realization lead to higher future price expectations, reducing farmers' willingness to withdraw from homesteads at current prices, making them view homesteads as long-term investments. This is a negative opportunity cost effect reducing farmers' incentive. Meanwhile, despite the property income, homestead withdrawal means losing the security and emotional ties, leaving rural migrants subject to various uncertainties, survival crises, and homesickness. This is a negative attachment effect. Under the trade-off between above effects, the overall effect of homestead system reform on rural migrants' homestead withdrawal might be limited.

Proposition 1 in Chapter 3 suggest that the hukou system reform could weaken the hukou-based resource allocation mechanism by lowering the requirements for urban hukou, allowing rural migrants easier access to urban social welfare and equal employment (Zhang, 2017). On the one hand, rural migrants are more likely to overcome identification discrimination and find a formal job, increasing wages and reducing the additional living costs of urban security. This undoubtedly strengthens the income effect caused by homestead system reform, and the two work together to promote total household income increase. On the other hand, the homestead security function is no longer the only security source for rural migrants, which can significantly reduce their reliance on the homestead, weaken the security attachment effect caused by homestead system reform, and encourage rural migrants to withdraw from homesteads. The theoretical framework is shown in Figure 4.1.

Building on the above analysis, and drawing from the theoretical deductions of Propositions 1 to 2 in Chapter 3 regarding impact mechanisms of the joint reform of

hukou system and homestead system, we can infer that, in terms of influencing rural migrants' homestead withdrawal behavior, the interaction between these two institutional reforms tends to be complementary. Based on this, the first research hypothesis is as follows:

Hypothesis 1 (complementary role of hukou and homestead system reforms):

Hukou system reform can improve the effect of homestead system reform on rural migrants' homestead withdrawal.

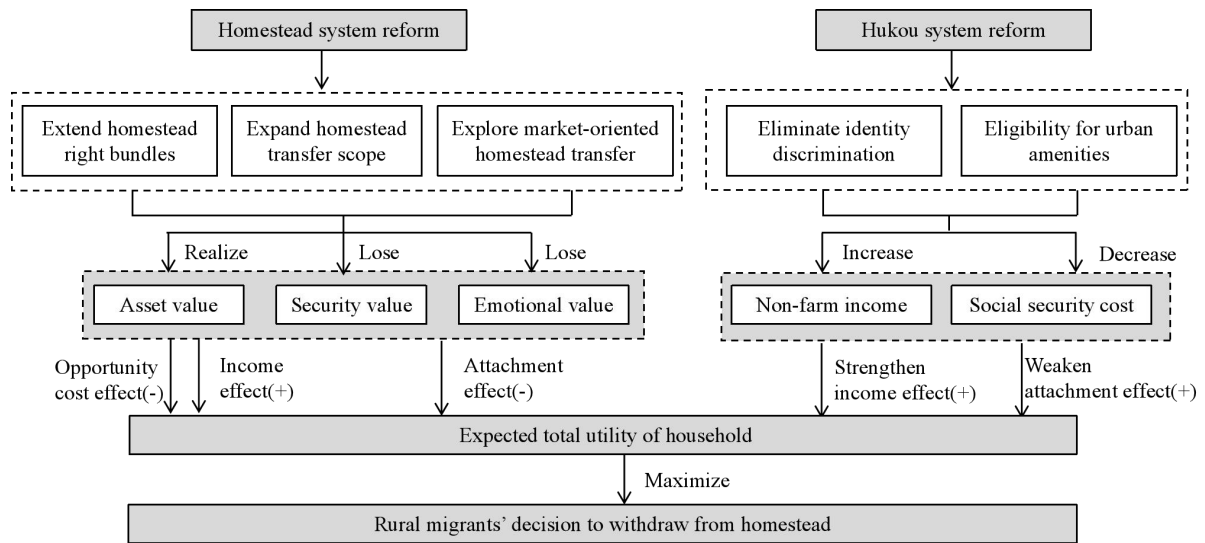


Figure 4.1 The mechanisms of hukou and homestead system reforms affecting homestead withdrawal

In the above analysis, the effects of homestead system reform, through realizing the asset value of the homestead, include opposing income and opportunity cost effects. The presence of one effect inherently precludes the other. The literature has identified that the trade-off between these two effects is mainly affected by factors such as farmers' income levels and the substitutability degree of land-based livelihood security (Khalil & Wu, 2017; Liu et al., 2021). Hukou system reform changes the opportunities for farmers to obtain better urban welfare and higher wage incomes by lowering the barriers to accessing urban status, providing them with more livelihood and residential alternatives. Thus, this determines the substitutive relationship between the income effect and the opportunity cost effect and, ultimately, the

dynamics of complementarity between hukou and homestead system reforms in promoting rural migrants' homestead withdrawal.

Drawing specifically on Proposition 3 in Chapter 3, as hukou restrictions are gradually relaxed, rural migrants are more optimistic about obtaining urban welfare and rights and less dependent on homestead security. Consequently, they are more willing to withdraw from their homesteads in pursuit of financial support to settle in cities. Therefore, homestead system reform shows an income effect. When the hukou restriction is almost completely relaxed, rural migrants can be granted complete urban rights. At this time, homestead security is no longer their primary concern. More stable urban jobs and higher income might make rural migrants less interested in the asset value of homestead while caring more about its future benefits (Wang & Gu, 2016). Therefore, homestead system reform might show an opportunity cost effect. Furthermore, the negative emotional attachment effect will also be highlighted, farmers are more inclined to hold homestead. Thus, the complementary relationship between hukou and homestead system reforms is non-linear. As the hukou system reform intensity increases, the probability of rural migrants' homestead withdrawal may follow an inverted U-shape, initially increasing and then decreasing. Based on this, the second research hypothesis is proposed:

Hypothesis 2 (non-linear complementary relationship): As hukou system reform intensifies, changes in rural migrants' homestead withdrawal behavior under the joint reform of hukou and homestead system may exhibit an "inverted U-shaped" pattern.

4.3 Data and variables

4.3.1 Data source and sample processing

The main data are derived from the “China Rural Household Panel Survey (CRHPS)”, which is part of the Chinese Family Database (CFD) maintained by Zhejiang University. The CRHPS is a follow-up survey of rural households in 29 provinces across China conducted every two years from 2011 to 2019. This database has three levels: an individual-level questionnaire focusing on education, employment,

migration and other demographic characteristics; a household-level survey investigating assets, income, consumption, rural land use and land transfer decisions; and a community-level survey tracing the geographical features, as well as political and economic development indicators. In addition, the database also includes a comparable number of urban household samples, which can serve as a reference group for comparative analysis between rural and urban areas.

This study selected three rounds of survey data in 2015, 2017, and 2019 for further variable processing and sample screening and finally obtained three periods of balanced panel data consisting of 9024 individuals from 3008 rural households. The selected samples are nationally representative in terms of geographical distribution (See Figure 4.2). The data processing process is as follows. (1) 2015 is regarded as the year of policy intervention, since homestead system reform took place in 2015, and almost all provincial hukou system reform plans were launched in 2015, although related requirements were proposed in 2014. (2) The information that farmers were asked was from surveys in the previous year (e.g., in the 2015 survey, the information is about farmers' situations in 2014), so we selected samples from one period before and two periods after policy intervention. (3) Since our research subjects are rural migrants, we drop the samples who are not rural residents since birth at all, who are rural residents but have not left their hometowns, who are rural residents but have not been allocated homesteads for some reasons in 2014. A special situation is that some farmers have more than one homestead due to inheritance and other reasons, which is not our concern. (4) We exclude these farmers affected by land expropriation. (5) The samples that are unsuccessfully tracked or rotated out are deleted.

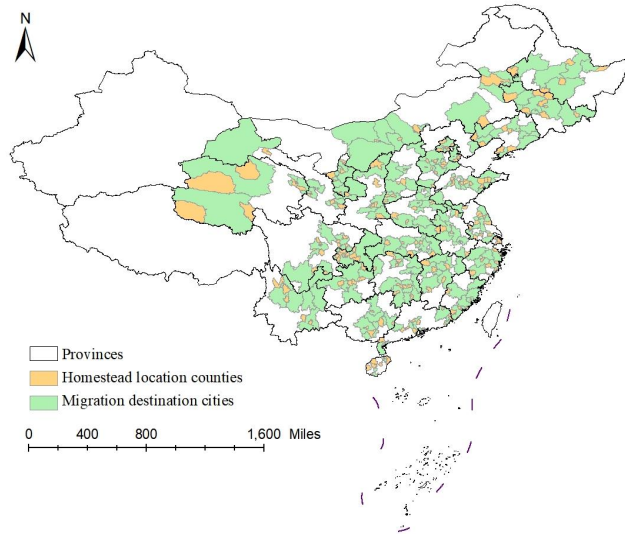


Figure 4.2 Geographical distribution of samples

In addition, to obtain the specific policies of the hukou system, we searched the websites of local hukou management departments. Furthermore, the county-level and city-level economic, industrial, and demographic variables are all derived from the China Urban Statistical Yearbook.

4.3.2 Variables selection and specification

(1) Dependent variable. The dependent variable is the homestead withdrawal behavior of rural migrants, which is measured by the survey question, “Did you withdraw from homesteads last year?” A binary variable is coded “1” for those who withdrew from homestead and “0” for those who didn't.

(2) Independent variables. There are two independent variables: whether the homestead system is reformed and the intensity of the hukou system reform.

The former can be obtained by observing whether the homestead is located in reform counties. This treatment is primarily based on the institutional nature of the reform: the government designates official pilot areas with clear policy milestones, and regions not selected as pilots typically do not implement the reform in any comparable form. In this context, the binary variable captures the exogenous shock associated with policy adoption, which is appropriate for a DID framework. In the subsequent heterogeneity analysis, this study further examines specific, quantifiable

components of the homestead system reform, namely, the one-time cash and apartment replacement compensation under the homestead withdrawal policy, and the monetary charges for excess land occupation under the paid use policy. These variables are used in regression analysis to both test the robustness of the baseline results and to identify which concrete policy measures are driving the observed effects.

For the latter, we consider reform intensity rather than a simple binary indicator of whether reform occurred, as nearly all cities had implemented hukou system reforms by 2015, making a 0–1 dummy variable inappropriate. Although the reform intensity varied significantly across cities, most policies covered four common dimensions: investment, home purchase, talent introduction, and employment. More importantly, the overall policy design and direction were broadly similar across cities, which provides a useful foundation for constructing a reform intensity index. Following (Zhang et al., 2019), we use the projection tracing method to calculate the difficulty index of obtaining local hukou in each city in the corresponding year. The reform intensity is then defined as the difference between 1 and this difficulty index, yielding a continuous measure ranging from 0 to 1. A value of 1 denotes fully relaxed hukou registration restrictions, while a value of 0 indicates that restrictions remain fully in place.

The operational steps of the Projection Pursuit Model are as follows:

Step 1: Normalization of evaluation indicators.

Let x_{ij} denote the value of the j -th hukou evaluation indicator for the i -th city, where n is the number of cities and p is the number of indicators. The dataset can be represented as: $X = (x_{ij} | i = 1, 2, \dots, n; j = 1, 2, \dots, p)$. To eliminate the effects of differing units and scales across indicators, all variables are normalized. In this context, a higher indicator value signifies a higher threshold or more difficulty in obtaining local hukou. Therefore, all indicators are treated as positively correlated with hukou acquisition difficulty. The normalization is conducted using the following formula:

$$x_{ij}^* = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (4.1)$$

Step 2: Construction of the projection index function $Q(a)$.

The normalized data matrix X is projected onto a one-dimensional subspace using an n -dimensional unit vector $a = (a_1, a_2, \dots, a_p)$ as the projection direction.

The resulting one-dimensional projection values Z_i are obtained as follows:

$$Z_i = \sum_{j=1}^p a_j x_{ij}^*, i = 1, 2, 3, \dots, n \quad (4.2)$$

The objective of the projection pursuit method is to ensure that the projected values Z_i form compact clusters (high local density) while keeping those clusters as well-separated as possible. This helps to reveal underlying structures in the data. Accordingly, we adopt the Friedman–Tukey projection index function, defined as: $Q(a) = S(a)D(a)$. where $S(a)$ denotes the between-class scatter, which is approximated by the standard deviation of the projected values Z_i , and $D(a)$ represents the within-class density, which measures the local concentration of the projected values Z_i :

$$S(a) = \left[\frac{\sum_{i=1}^n (Z_i - E)^2}{n-1} \right]^{1/2} = \left[\frac{\sum_{i=1}^n (\sum_{j=1}^n (a_j x_{ij}^* - E))^2}{n-1} \right]^{1/2} \quad (4.3)$$

$$D(a) = \sum_{i=1}^n \sum_{j=1}^n (R - r_{ij}) \times u(R - r_{ij}) \quad (4.4)$$

Where E denotes the mean of the projected sequence Z_i , and R represents the window radius used for calculating local density. The choice of R depends on the properties of the data and is typically determined based on empirical testing. The distance between samples is defined as $r_{ij} = |Z_i - Z_j|$. The function $u(R - r_{ij})$ is a step function such that: $u(R - r_{ij}) = 1$ when $(R - r_{ij}) \geq 0$, otherwise $u(R - r_{ij}) = 0$.

Step 3: Optimization of the Projection Index Function.

The projection function varies only with the projection direction. Different directions reflect different structural characteristics of the data. The optimal projection direction should reflect the structural characteristics of high-dimensional data as much as possible. In light of this, the optimal projection direction is estimated by solving the maximization problem of the projection index function, specifically:

$$\text{Objective function: } \text{Max} Q(a) = S(a) \times D(a) \quad (4.5)$$

$$\text{Constraints: } s.t. \sum_{j=1}^p a_j^2 = 1 \text{ and } a_j (j = 1, 2, \dots, p) \geq 0 \quad (4.6)$$

The objective function is a complex nonlinear optimization problem with the projection direction a as the variable. In this study, we use a real-coded genetic algorithm to solve it.

Step 4: Ranking of Hukou Threshold Values.

The optimal projection direction a is substituted into the original dataset to compute the projected values Z_i for each sample.

The cities are then ranked based on the magnitude of their corresponding Z_i values, which represent the hukou threshold index for each city.

(3) Control variables. To guard against potential endogeneity, some variables that affect the farmers' homestead withdrawal should be controlled, including individual attributes, household demographics, household capital assets, homestead geographic access, characteristics of counties where the homestead is located and characteristics of migration destination cities. All of the variables are described in Table 4.1.

Table 4.1. Variable descriptions

Variables	Description	Mean	S.D.
Dependent variable:			
Homestead withdrawal behavior	Whether to withdraw from homesteads (Dummy: Yes = 1; No = 0)	0.015	0.123
Independent variables:			
Homestead system reform	Whether the homestead system is reformed (Dummy: Yes = 1; No = 0)	0.047	0.108
Hukou system reform	The intensity of hukou system reform (Continuous: percentage)	0.587	0.284
Individual attributes:			
Age	Age of household head (Continuous: years)	51.636	13.943
Gender	Gender of household head (Dummy: Male = 1; female = 0)	0.826	0.379
Physical health	The self-assessed physical health status of household head (Dummy: healthy=1, unhealthy=0)	0.836	0.370
Educational level	Education years of household head (continuous: years)	8.706	3.791
Household demographics:			
Household size	Number of family members (Continuous)	3.549	1.613
Dependency ratio	Dependents divided by workers (Continuous: percentage)	0.959	1.666
Household capital assets:			
Household income	Total annual household income (Continuous: yuan/year)	55134	271384
Cropland area	Total area of cropland (Continuous: mu)	6.919	42.037
Homestead area	Total area of homestead (Continuous: metre square)	440	608
Geographic access of homestead:			
Location relative to city center	Dummy: city district=1; city suburb=2; big town=3; small town=4; village and town=5; village=6	5.704	0.953
Distances to public services	Distance to the township center (Continuous: kilometre)	2.671	10.978
County characteristics			

GDP	Gross Domestic Product of county where the homestead is located (Continuous: billion yuan)	423	639
Proportion of tertiary industry	Continuous: percentage	0.406	0.160
Population	Number of permanent residents (Continuous: ten thousand people)	73	47
Urbanization	(Number of permanent urban residents)/ (total population) (Continuous: percentage)	0.580	0.237
Number of immigrant population	(Continuous: ten thousand people)	5.572	9.347
Number of emigrant population	(Continuous: ten thousand people)	3.335	5.854
City characteristics			
GDP	Gross Domestic Product of urban destination (Continuous: billion yuan)	5390	5650
Proportion of tertiary industry	Continuous: percentage	0.445	0.114
Population	Number of permanent residents (Continuous: ten thousand people)	741	640
Unemployment rate	Registered urban unemployment rate (Continuous: percentage)	0.024	0.014
Salary level	City average salary (Continuous: yuan)	54009	14078
House price	City average house price (Continuous: yuan/metre square)	8398	7921
Basic education level	Number of students/Number of teachers in compulsory education stage (Continuous)	14.804	2.399
Medical service level	Number of medical beds (Continuous)	39093	34429

Figure 4.3 displays our preliminary findings statistically. We divide samples into four groups according to the intensity of hukou system reform and plot the homestead withdrawal rate for each group under both reform and non-reform of the homestead system. Additionally, we show the distribution of the population within homestead system reform areas using a bar graph in the background. We find a higher proportion of rural migrants withdrawing from homesteads in reform areas, and this proportion increases with the deepening of hukou system reform. However, this positive promotion effect declines when hukou restrictions are close to being completely relaxed. Furthermore, without homestead system reform, hukou system reform struggles to have an impact. Therefore, their relationship is complex and requires robust empirical verification.

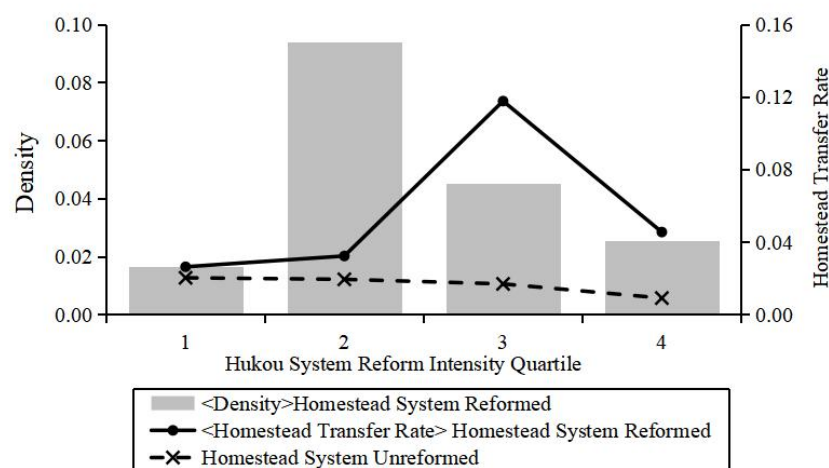


Figure 4.3 The distribution of homestead withdrawal behavior of rural migrants under system reform

4.4 Methodologies

The binary dependent variable generally suggests using a Logistic model. However, unobserved heterogeneity between the counties where the homestead system is reformed, the cities where the hukou system is reformed, and years can significantly increase the estimation bias, while fixed effects in the Logistic model can cause a large number of observations to be removed. Therefore, we adopt the

Difference-in-Differences model with county, city, and year fixed effects. Meanwhile, there is a concern that government might not randomly select pilot areas and possibly prioritize those with more significant homestead withdrawal potential, which may cause selection bias. Besides, when estimating hukou system reform effects, the omitted variables at city or individual levels can cause endogeneity. To address these issues, in addition to controlling covariates, we match reform and non-reform areas through propensity score matching, and conduct instrumental variable estimations and robustness tests to improve the credibility of results.

4.4.1 Propensity score matching (PSM)

Using county characteristic data before homestead system reform and based on propensity scores, this study matches reform counties with non-reform counties that have similar characteristics, so as to construct a counterfactual framework to reduce the selection bias. The following equation is used to estimate propensity scores.

$$\ln\left(\frac{P_g}{1-P_g}\right) = a + bCovariate + c_g \quad (4.7)$$

Where P_g represents the propensity score of county g ; $Covariate$ refers to the covariates used for matching. In terms of matching method, the caliper matching with a radius of 0.05 is used. Finally, only samples that are successfully matched are suitable for subsequent causal inference.

4.4.2 Difference-in-Differences model (DID)

DID model can be used to test the effect of individual homestead system reform. To explore the effect of the joint reform of the hukou system and homestead system, we multiply the variable of hukou system reform intensity with the basic DID model, which is shown as follows:

$$\begin{aligned} Transfer_{ight} = & \alpha_0 + \alpha_1 HomesteadSR_{igt} + \alpha_2 HukouSR_{iht} + \alpha_3 HomesteadSR_{igt} * HukouSR_{iht} \\ & + \sum \alpha_m X_{m,ight} + \sum \alpha_n D_{n,ight} \cdot t + \mu_g + \nu_h + \eta_t + \varepsilon_{ight} \end{aligned} \quad (4.8)$$

Where i, g, h, t represent rural migrant, county, city and year respectively.

$Transfer_{ight}$ is rural migrant's behavior on whether to withdraw from homesteads. We have three regressors of interest. The first is $HomesteadSR_{igt}$, the indicator of whether homestead system is reformed. $HomesteadSR_{igt} = Treat_{ig} * Post_{gt}$, if homestead system is reformed, $Treat_{ig} = 1$, and zero otherwise; if the year is after homestead system reform, $Post_{gt} = 1$, and zero otherwise. The second is $HukouSR_{iht}$, the hukou system reform intensity, a continuous variable ranging from 0 to 1. The last one is the interaction term of above two, and its coefficient α_3 indicates the impacts of joint reform of these two systems on homestead withdrawal, which is our concern.

The control variables, $X_{m,ight}$, include a range of individual, household, homestead, county and city characteristics that influence homestead withdrawal. Meanwhile, according to (P. Li et al., 2016), the interaction term between regional characteristic variables $D_{n,ight}$ and time trend t is added to eliminate the differences caused by time trend of these variables. Since homestead system reform was implemented at county level and hukou system reform was implemented at city level, we also controlled the fixed effects of rural homestead location county μ_g and the urban migration destination city ν_h . η_t is the year fixed effect. ε_{ight} is error term.

4.5 Empirical analysis

4.5.1 Substitutive or complementary: relationship between hukou and homestead system reforms

(1) Baseline estimates

Table 4.2 shows the sample balance test results after PSM, which attests that there is no statistical difference between the treatment group and the control group, so the balance assumption of the DID model is satisfied. Further, we use “whether the homestead system is reformed” to conduct a Logit regression on county characteristics, and the results in Column (4) indicate that these characteristics do not

determine whether to reform the homestead system. All the above illustrates that self-selection of homestead system reform pilots is not serious.

Table 4.2 Balance test results after PSM

	(1)		(2)		(3)	(4)
Variables	Reform areas (treatment group)		Non-reform areas (control group)		Difference (t value)	Pr(reform=1)
	Mean	S.D.	Mean	S.D.		
ln_GDP	15.473	0.648	15.437	0.751	0.320	0.389(0.312)
Proportion of tertiary industry	0.371	0.071	0.366	0.084	0.440	-0.583(2.157)
ln_population	4.507	0.136	4.474	0.489	0.620	0.248(0.239)
Urbanization	0.593	0.104	0.592	0.547	0.000	-0.356(1.062)
ln_immigrant	0.774	0.896	0.811	1.2703	-0.240	0.219(0.184)
ln_emigrant	1.607	1.459	1.538	1.144	0.330	0.302(0.361)
Wald Chi2						4.480(0.612)
Observations	143		2865			3008

Note: (1) Column (4) reports the coefficients and robust standard errors, and the data in parentheses of Wald chi2 is P-value.

Table 4.3 reports the estimated effects of homestead system reform. As indicated in Column (1), it significantly promotes the rural migrants to withdraw from their homestead. In order to guarantee robustness of the results, some control variables including individual attributes, household demographics and household capital assets are added to the original model. As shown in Column (2), the coefficient of homestead system reform is statistically significant at 0.015, which indicates that homestead system reform still has a significant effect when controlling for individual characteristics and family variables. In terms of control variables, male farmers had a lower probability of transferring homesteads, which may have been because men had a higher risk awareness and did not easily make these types of decisions. Moreover, older, healthier and highly-educated rural migrants generally have stronger intention to transfer homestead because of higher human resources. However, the square coefficients for age indicates that when farmers reach a certain age threshold, their willingness to settle in cities decreases, which was possibly because farmers'

emotional dependence for homestead and desire for stable life are stronger as the age grows. Regarding household characteristics, larger family size and the dependency ratio, and lower proportion of family members access to social security mean farmers' heavier survival burden and poorer ability to fight potential risks, so farmers are less likely to transfer homestead that provides a solid living security. On the contrary, good economic conditions, that is, the higher the per capita income, the less farmers care about the security value of homestead but the asset value, so it has a significant positive impact on the homestead withdrawal. Finally, farmers with larger homestead areas are found to be more likely to withdraw from homesteads, which is directly proportional to compensation from transferring homestead, while more cropland does not mean a higher willingness to transfer homestead, because the more agricultural production there are, the more costs of farming and warehousing will increase for farmers without homestead to play an important production auxiliary function.

For more reliable results, considering that the homestead system reform pilots are more likely to be selected in these counties with strong demand for homestead withdrawal, and these places are also key areas for the implementation of the national new-type urbanization policy, which may closely relate to the motivation of rural migrants' land urbanization. Therefore, we control the interaction term between county-level characteristic variables and time trend to control for possible non-equilibrium trends. Further, the geographical characteristics of homestead itself are contextual factor that determines the function and value of the homestead, which greatly affect the farmers' decision to withdraw from homestead, which are also controlled in Column (3). The results reveal that the probability of rural migrants' homestead withdrawal within homestead system reform pilots increases by 2.1% over that of farmers outside the pilots. Meanwhile, the closer to big cities, and the more convenient the homestead location, the higher the farmer's expectation of homestead' property value, the higher the opportunity cost of farmer's homestead withdrawal.

Furthermore, in Column (4), I examine the effects of county and city level variables and find that both urban housing prices and unemployment rates have

negative and statistically significant impacts on homestead withdrawal. Specifically, higher housing prices increase the cost of settling in cities, making rural migrants less willing to give up their homesteads, which serve as a form of residential security. Similarly, higher unemployment rates signal greater economic uncertainty, reducing rural migrants' confidence in stable urban employment and further discouraging them from their homestead withdrawal behavior. These findings suggest that unfavorable urban conditions increase the perceived risks of migration, lowering the likelihood of homestead withdrawal even under reform policies.

Table 4.3 The effects of homestead system reform on rural migrants' homestead withdrawal

Variables	(1)	(2)	(3)	(4)
	Withdrawal	Withdrawal	Withdrawal	Withdrawal
Reform	0.022* (0.012)	0.015** (0.012)	0.021** (0.012)	0.035** (0.016)
Age		0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)
Age-squared		-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)
Gender		-0.015*** (0.004)	-0.014*** (0.004)	-0.012*** (0.004)
Physical health		0.011*** (0.004)	0.009*** (0.004)	0.008*** (0.004)
Education level		0.001** (0.000)	0.001* (0.000)	0.001 (0.000)
Household size		-0.009*** (0.003)	-0.008*** (0.003)	-0.007*** (0.003)
Dependency ratio		-0.003 (0.003)	-0.004 (0.003)	-0.007* (0.003)
Cropland area		-0.006*** (0.001)	-0.005*** (0.001)	-0.004*** (0.001)
Homestead area		0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)
Household income		0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
Proportion of social security		0.003 (0.005)	0.002 (0.005)	0.002 (0.005)
3. Location of homestead			-0.010 (0.007)	-0.007 (0.008)
5. Location of homestead			-0.011* (0.007)	-0.010 (0.008)

			(0.006)	(0.007)
6. Location of homestead			-0.014*	-0.009
			(0.007)	(0.009)
Distance to pubic facilities			-0.005**	-0.006***
			(0.002)	(0.002)
GDP_county				0.097
				(0.084)
Proportion of tertiary industry_county				-1.116*
				(0.666)
Population_county				-0.001
				(0.117)
Urbanization_county				0.248
				(0.333)
Number of immigrant population_county				-0.113**
				(0.054)
Number of emigrant population_county				0.111
				(0.070)
GDP_city				-0.188
				(0.137)
Proportion of tertiary industry_city				0.483
				(0.325)
Population_city				-0.093
				(0.197)
Unemployment rate_city				-0.059**
				(0.025)
Salary level_city				0.018
				(0.140)
House price_city				-0.558***
				(0.206)
Basic education level_city				0.011
				(0.022)
Medical service level_city				0.259
				(0.241)
County fixed effect	No	No	No	Yes
Year fixed effect	No	No	No	Yes
Observations	9024	9024	9024	9024

Note: (1) The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01

Table 4.4 shows the baseline results from estimating the DID model. As indicated in Column (1), homestead system reform significantly promotes rural migrants to withdraw from the homestead by 3.5%, which is in line with evidence by (Guo et al., 2020). This finding can enrich the traditional Land Property Rights

Theory, suggesting that even without land ownership, clear and secure land use rights can also foster positive market expectations and encourage individuals to engage in land transactions. In Column (2), we find that one unit increase in the intensity of hukou system reform can significantly push up the probability of homestead withdrawal by 2.4%, which is quite different from Zhu (2017) conclusion that hukou system reform can increase farmers' willingness to withdraw from the homestead by 37%. There are two possible reasons. Firstly, Zhu's study area is a province in western China, where the market demand for homestead is relatively low under slow rural industrial development, rural migrants can only rely on the channels provided by institutional reform, which can overestimate its effect. Secondly, a large discrepancy between behavior and intention is verified empirically through the comparison between Zhu's results with ours. Although hukou system reform can promote farmers' subjective willingness, there is a process of rethinking and accepting to turn willingness into behavior, which is easily affected by internal and external factors. This finding indicates that simply reforming the hukou system to relax rural-urban migration restrictions without strengthening land rights proves largely ineffective in facilitating land transfer. In other words, although restrictive migration policies can limit land liquidity (Zhang, 2020; Zhang, 2017; Zhang et al., 2020), easing these restrictions doesn't necessarily lead to positive outcomes. Combining the results from Column (1) and Column (2), the more important revelation is that formal land property rights are a prerequisite for promoting land withdrawal. Without secure rights and a well-functioning land market, high transaction costs, and low transaction prices can hinder land liquidity, even when other external conditions are favourable.

Column (3) includes both two system indicators as regressors. The coefficients are similar to those in previous columns, but the significance of hukou system reform greatly decreases, suggesting that hukou reform plays an indirect and relatively weak role in promoting homestead withdrawal, compared with homestead system reform.

In Column (4), the interaction term between two systems is introduced, and its positive and significant coefficient reveals the complementary relationship between

homestead system reform and hukou system reform, which confirms the theoretical conjecture of (Tao et al., 2011; Zhu, 2017; Han et al., 2019). Hypothesis 1 is supported. As is shown, homestead system reform raises homestead withdrawal probability by 14.3% more as the intensity of hukou system reform increases by one unit. China is a microcosm of many developing countries, like Vietnam, Mexico, and various African regions, where state or collective land ownership, imperfect land systems, and undeveloped markets lead to conflicts between poor land liquidity and low land use rate. Our research goes beyond single-system studies, incorporates migration restrictions and land property rights into a unified theoretical framework, verifies that the joint reform of these two systems can achieve the complementary effect that produces more with less effort, and offers new insights for these developing countries to improve land liquidity and achieve efficient matching of human and land resources.

Table 4.4 Estimation of relationship between hukou and homestead system reforms

Variables	(1)	(2)	(3)	(4)
	Withdrawal	Withdrawal	Withdrawal	Withdrawal
Homestead system reform	0.035** (0.016)		0.037** (0.016)	-0.031 (0.035)
Hukou system reform		0.024* (0.013)	0.023 (0.014)	0.022 (0.014)
Homestead system reform × Hukou system reform				0.143** (0.066)
Constant	-0.131*** (0.049)	-0.099 (0.119)	-0.275** (0.136)	-0.282** (0.136)
Control variables	Yes	Yes	Yes	Yes
Homestead location County fixed effect	Yes	---	Yes	Yes
Migration destination City fixed effect	---	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	9024	9024	9024	9024
Adjusted R ²	0.021	0.006	0.022	0.022

Note: (1) The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01; (2) All controls are included in Column (3) and Column (4), while city characteristics are excluded in Column (1) and county characteristics are excluded in Column (2).

(3) Underlying mechanisms

Baseline results confirm the complementary relationship between two system reforms in promoting rural migrants' homestead withdrawal. To verify the underlying mechanisms behind this complementarity, we proceed in two steps. First, we examine how the effects of homestead system reform might be restricted if implemented alone. Second, we analyze how the hukou system reform can enhance the effectiveness of homestead system reform when both are reformed jointly.

① What restricts the effect of homestead system reform?

Given that the income effect and opportunity cost effect are opposite, the income effect exists if homestead system reform can promote homestead withdrawal, otherwise, opportunity cost effect may exist. The results in Columns (1)~(2) of Table 4.5 confirm that homestead system reform can significantly increase village-level average homestead transaction price, which is the motivation for rural migrants to withdraw from the homestead. Combined with the baseline results that homestead system reform has a significant promotion effect on homestead withdrawal, the existence of income effect rather than opportunity cost effect can be confirmed.

However, under the restrictions of the hukou system, this positive income effect is limited. Without urban hukou, rural migrants will face fewer employment opportunities, lower labor returns, and additional costs of lacking urban social security, making the income from homestead withdrawal seem insignificant and cannot provide vital financial support for farmers' migration. We measure the hukou restriction degree by city size. Generally speaking, the bigger the city size, the more difficult it is to obtain a local hukou and the higher the living costs because it provides access to a wide range of facilities and social services. As shown in Column (3), when we interact the term of city size by the terms of homestead system reform and homestead price, both the significance and value of the coefficient become smaller. This result attests that the restrictions of the hukou system can weaken the positive income effect of homestead system reform, and even turn it into a negative effect.

Homestead carries crucial security functions for farmers. If rural migrants cannot

obtain security supplements tied to urban hukou or even have no ability to take root in cities under restrictions of hukou system, they will rely on homesteads as a backup, which can hinder the effect of homestead system reform. We describe rural migrants' reliance degree on homesteads from two aspects: objectively, rural migrants' non-agricultural capability, and subjectively, rural migrants' estimation of future unemployment risks. The former is a comprehensive index of education, age, and physical condition, and the latter is tested based on answers to “How likely are you to become unemployed?”. As Columns (4) ~ (5) demonstrated, the coefficients of interaction items between homestead system reform and whether farmers' non-agricultural capability or expected unemployment risk reflect the negative impact of attachment effect caused by hukou restrictions on homestead system reform effects.

In summary, under hukou restrictions, the effects of homestead system reform manifest as limited positive income effect and strong negative attachment effect.

Table 4.5 The influence of restrictive hukou system on homestead system reform effects

Variables	(1) Homestead Price	(2) Withdrawal	(3) Withdrawal	(4) Withdrawal	(5) Withdrawal
Homestead system reform	0.080* (0.048)	-1.138*** (0.139)	0.186** (0.089)	0.168** (0.068)	0.053*** (0.018)
Homestead price		0.003 (0.004)	0.002 (0.004)		
Homestead system reform × Homestead price		0.183*** (0.021)			
City size			0.001 (0.011)		
Homestead system reform × Homestead price × City size			-0.004* (0.002)		
non-agricultural capability				-0.005 (0.012)	
Homestead system reform × non-agricultural capability				-0.164** (0.082)	
Unemployment risk					-0.010*** (0.003)
Homestead system reform					-0.046*

× Unemployment risk					(0.025)
Constant	7.237*** (0.153)	-0.169*** (0.055)	-0.146 (0.095)	-0.126** (0.050)	-0.128*** (0.049)
Control variables	Yes	Yes	Yes	Yes	Yes
Homestead location County fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	9024	9024	9024	9024	9024
Adjusted R ²	0.888	0.030	0.021	0.022	0.023

Note: (1) The standard errors are presented in parentheses; * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$; (2) City characteristics are excluded in control variables here.

② Why does hukou system reform matters?

Hukou system reform lowers hukou registration requirements. Rural migrants with urban hukou can get rid of identity discrimination and are more likely to find formal jobs with labor contracts, which promotes homestead withdrawal because of employment security and a higher labor return. Columns (1)~(2) in Table 4.6 report that hukou system reform can improve household formal contract coverage. Besides, the significant and positive coefficient of interaction term of labor contract coverage and homestead system reform reflects that the complementarity of these two systems is indeed stronger for pairs where more labors have formal jobs.

Besides, under the hukou system reform, more family members could have the opportunity to obtain urban hukou, thereby enjoying better urban security and public services, which can replace the security function of the homestead and weaken farmers' attachment to it, thereby promoting homestead withdrawal. Columns (3) and (4) of Table 4.6 demonstrate that hukou system reform can increase household urban social security coverage, and this increase enhances the effects of homestead system reform, as evidenced by the larger and more significant coefficient of the interaction term between urban security coverage and homestead system reform.

Therefore, the above results are consistent with the hypothesis, suggesting that the complementary relationship between hukou and the homestead system arises because hukou system reform can strengthen the income effect while weakening the attachment effect brought by the homestead system reform.

Table 4.6 The influence of hukou system reform on homestead system reform effects

Variables	(1)	(2)	(3)	(4)
	Formal contract coverage	Withdrawal	Urban security coverage	Withdrawal
Hukou system reform	0.108** (0.046)		0.059* (0.035)	
Formal contract coverage		0.002 (0.003)		
Homestead system reform		-0.007 (0.023)		0.021 (0.017)
Homestead system reform × Formal contract coverage		0.124*** (0.047)		
Urban security coverage				0.012*** (0.004)
Homestead system reform × Urban security coverage				0.126*** (0.046)
Constant	0.967** (0.409)	-0.231* (0.134)	0.609* (0.314)	-0.184 (0.133)
Control variables	Yes	Yes	Yes	Yes
Homestead location County fixed effect	---	Yes	---	Yes
Migration destination City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	9024	9024	9024	9024
Adjusted R ²	0.104	0.065	0.242	0.024

Note: The standard errors are presented in parentheses; * $p < 0.1$, * * $p < 0.05$, and * * * $p < 0.01$

4.5.2 Linear or non-linear: relationship changes between hukou and homestead system reforms

To examine changes in the complementary relationship between hukou and homestead system reforms, the sample is divided into four groups based on hukou reform intensity, and regressions are performed on each group. The results in Table 4.7 show that the promotion effect of homestead system reform on homestead withdrawal is insignificant when the hukou restrictions are high. As the hukou system continues to be relaxed, the complementarity between the two systems in promoting

homestead withdrawal is increasingly stronger. However, there is an inflection point at the fourth quartile, namely, an almost completely relaxed hukou system. After that, the joint reform no longer has a significant promoting effect. In summary, as the hukou system reform deepens, the impact of joint reform on promoting homestead withdrawal presents an “inverted U-shaped” trend. Hypothesis 2 is supported.

Table 4.7 Estimation of relationship changes between hukou and homestead system reforms

Groups by hukou system reform intensity	(1) [0,0.25)	(2) [0.25,0.50)	(3) [0.50,0.75)	(4) [0.75,1]
Variable	Withdrawal	Withdrawal	Withdrawal	Withdrawal
Homestead system reform	-0.037 (0.226)	-0.436** (0.193)	-1.042 (0.667)	-0.187 (0.417)
Hukou system reform	-0.189 (0.231)	0.042 (0.149)	0.355 (0.287)	0.034 (0.067)
Homestead system reform × Hukou system reform	0.231 (1.213)	1.332** (0.549)	1.858* (1.110)	0.302 (0.483)
Constant	0.590 (1.235)	-0.481 (0.597)	-0.826 (0.661)	-0.266 (0.213)
Control variables	Yes	Yes	Yes	Yes
Homestead location County fixed effect	Yes	Yes	Yes	Yes
Migration destination City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	1440	2640	1500	3444
Adjusted R ²	0.125	0.085	0.101	0.091

Note: The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01

Why does completely relaxing restrictions on the hukou system even weaken farmers' enthusiasm for withdrawing from their homesteads? Only fourth-quartile samples are selected to explore underlying mechanisms. On the one hand, Column (1) of Table 4.8 reveals that without hukou restrictions, the increase in homestead transaction price cannot promote homestead withdrawal but becomes an upward signal for the homestead market, raising expectations for future homestead price, which is a negative opportunity cost. In other words, imperfect or insecure homestead property rights are often bolstered through informal transactions, leading to farmers'

inflated and unrealistic expectations about future homestead values, which essentially amounts to land speculation by rural migrants (Kan & Chen, 2021). On the other hand, homestead carries migrants' emotional attachment to their hometowns. To represent farmers' homesickness, we introduce a dummy variable for the old generation, as both cohort and age effect theory suggest that the older a farmer is, the deeper his feelings for his hometown will be (Rhodes, 1983). The negative and significant coefficient of the interaction term between homestead system reform and the old generation in Column (2) shows that farmers' emotional attachment to their hometowns becomes more prominent without hukou restrictions, thereby inhibiting homestead withdrawal.

In conclusion, when hukou restrictions are completely relaxed and homestead security is replaced by urban welfare, the negative opportunity cost and emotional attachment effects become more pronounced, discouraging rural migrants from withdrawing from their homesteads.

Table 4.8 Relationship changes between hukou and homestead system reforms

Variables	(1)	(2)
	Withdrawal	Withdrawal
Homestead system reform	1.215* (0.633)	0.120*** (0.027)
Homestead price	0.001 (0.004)	
Homestead system reform × Homestead price	-0.191* (0.106)	
Old generation		-0.004 (0.003)
Homestead system reform × Old generation		-0.114*** (0.031)
Constant	-0.036 (0.059)	-0.010 (0.037)
Control variables	Yes	Yes
Homestead location county fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	3444	3444
Adjusted R ²	0.018	0.015

Note: The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01

4.5.3 Robustness check

(1) Placebo test for homestead system reform

One concern is that without homestead system reform, homestead withdrawal also shows an increasing trend, influenced by unknown or unobservable factors. Therefore, a placebo test is designed using data from 2013 and 2015, with 2014 set as the year of virtual policy intervention. Table 4.9 shows that neither the coefficients of the two systems nor the interaction term are significant, indicating that virtual policy cannot significantly change farmers' decision-making on homestead withdrawal, which further convinces us of the estimation results in the baseline.

Table 4.9 The results of placebo test

Variables	(1)	(2)	(3)	(4)
	Withdrawal	Withdrawal	Withdrawal	Withdrawal
Homestead system reform	-0.012 (0.021)		-0.013 (0.021)	0.061 (0.073)
Hukou system reform		-0.044 (0.060)	-0.044 (0.060)	-0.020*** (0.007)
Homestead system reform *Hukou system reform				-0.159 (0.181)
Constant	0.031*** (0.011)	0.037*** (0.014)	0.037*** (0.014)	0.026*** (0.004)
Control variables	Yes	Yes	Yes	Yes
Homestead location County fixed effect	Yes	---	Yes	Yes
Migration destination City fixed effect	---	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	3574	3574	3574	3574
Adjusted R ²	0.011	0.011	0.011	0.014

Note: (1) The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01; (2) All controls are included in Column (3) and Column (4), while city characteristics are excluded in Column (1) and county characteristics are excluded in Column (2).

(2) Instrumental variable estimation for hukou system reform

Two instrumental variables are selected: the average hukou system reform intensity of other cities in the same province and city level, and a one-period lag index of hukou system reform, following Zhang et al. (2020). A city's hukou system reform

decision may be influenced by peer cities in the same province, while the hukou registration policies in other cities cannot affect farmers' decisions on the use of their homesteads in hometowns, which satisfies IV's exogeneity. The one-period lag index of hukou system reform is related to that in the current period, but after controlling for current hukou requirements, it no longer affects individual land withdrawal.

Both instrumental variables pass the over-identification test (P-value of Chi2 is 0.472) and the weak instrument test (the Cragg-Donald Wald F statistic is 237, which is greater than the threshold of 16.38 under a 10% maximal IV size), indicating that the IV estimation is valid. The Hausman test results ($P = 0.405 > 0.1$) indicate that the endogenous problem in the baseline DID is not severe, confirming the robustness of the results. Furthermore, the results of the second-stage estimation indicate that the hukou system reform has a positive and significant effect on homestead withdrawal. Compared with the baseline result in Table 4.10, after using IV estimation to overcome potential endogeneity, this promoting effect becomes greater.

Table 4.10 The results of instrumental variable estimations

	(1)	(2)
	First stage	Second stage
Variables	Hukou system reform	Withdrawal
Hukou system reform		0.033* (0.017)
IV (Average hukou system reform intensity of other cities)	0.966*** (0.006)	
IV (One-period lag index of hukou system reform)	0.077*** (0.013)	
Constant	0.569*** (0.055)	-0.088 (0.146)
Control variables	Yes	Yes
Migration destination city fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	9024	9024
Adjusted R ²	0.973	0.007

Note: (1) The standard errors are presented in parentheses; * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$; (2) County characteristics are excluded in control variables here.

(3) Other policy interference

There are two policies that deserve attention for their impacts: Comprehensive Pilots of New-type Urbanization and Rural Reform Pilots. In these pilots, a series of measures to support rural development, including strengthening infrastructure construction and introducing rural enterprises, can affect farmers' judgment of homestead values. We separately test their impacts on homestead withdrawal, and Columns (1)~(2) show that neither policy has a significant effect. Furthermore, after controlling for these two policies, we do another DID estimation. As shown in Columns (3)~(6), the coefficients are similar to those in the baseline, which can verify the robustness of the results.

Table 4.11 The reform effects after excluding other policy interference

Variables	(1) Withdrawal	(2) Withdrawal	(3) Withdrawal	(4) Withdrawal	(5) Withdrawal	(6) Withdrawal
Comprehensive Pilot of New-type Urbanization	-0.006 (0.008)		-0.006 (0.008)	-0.003 (0.008)	-0.008 (0.008)	-0.007 (0.008)
Rural Reform Pilot Area		0.010 (0.014)	0.009 (0.014)	0.015 (0.014)	0.005 (0.014)	0.006 (0.014)
Homestead system reform			0.035** (0.016)		0.038** (0.016)	-0.030 (0.036)
Hukou system reform				0.025* (0.014)	0.023 (0.014)	0.022 (0.014)
Homestead system reform *Hukou system reform						0.143** (0.067)
Constant	-0.241* (0.133)	-0.250* (0.134)	-0.129*** (0.049)	-0.139 (0.130)	-0.275** (0.137)	-0.282** (0.137)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Homestead location	Yes	Yes	Yes	---	Yes	Yes
County fixed effect						
Migration destination City fixed effect	Yes	Yes	---	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9024	9024	9024	9024	9024	9024
Adjusted R ²	0.021	0.021	0.021	0.021	0.022	0.022

Note: (1) The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01;

(2) All controls are included in Column (1), (2), (5) and (6), while city characteristics are excluded in Column (3) and county characteristics are excluded in Column (4).

4.6 Heterogeneity analysis

The above evidence suggests that hukou system reform can enhance the impact of homestead system reform. To enhance the role of their joint reform, this section proposes and tests two additional arguments. First, since the hukou system reform is a comprehensive reform involving various policies, it is necessary to identify which ones have a positive and crucial impact. Second, natural factors such as resource endowment and geographical conditions, as well as socioeconomic factors such as institutional and cultural background, have been proven to affect farmers' perception of homestead value (Chen et al., 2017; Zhang et al., 2018), causing regional differences and spatial dependencies in reform outcomes. Therefore, exploring regional heterogeneity is essential.

4.6.1 Policy heterogeneity analysis

(1) Policy heterogeneity of hukou system reform

Hukou registration requirements consist of four key aspects: investment, housing purchase, talent introduction, and employment. We regress the reform index of each part separately on homestead withdrawal. Table 4.12 reveals that only employment and housing purchase policy reforms have a significant promoting effect on homestead withdrawal. Rural migrants with stable urban housing or jobs tend to live there permanently. Consequently, as homesteads no longer serve as a primary source of security, they are more motivated to withdraw from them. This finding sheds light on the practical and feasible paths to realize more cost-effective joint reform. Meanwhile, due to the slow progress of reform and the low intensity of investment and talent introduction policies, it is challenging to directly impact farmers with low incomes and limited educational levels.

It is worth noting that the unified urban-rural hukou policy does not play a positive role as expected, which confirms that merely blurring the concepts of urban-rural hukou, rather than fundamentally breaking the urban-rural gap cannot effectively promote rural-urban migration and homestead withdrawal. Coupled with

rural development under China's rural revitalization strategy, farmers are less enthusiastic about the unified urban-rural hukou.

Table 4.12 Estimations of the effects of various sub-policies in hukou system reform

Variables	(1)	(2)	(3)	(4)	(5)
	Withdrawal	Withdrawal	Withdrawal	Withdrawal	Withdrawal
Homestead system reform	-0.044 (0.054)	-0.136** (0.061)	-0.114 (0.072)	0.012 (0.053)	0.080 (0.053)
Unified urban-rural hukou policy	0.040 (0.033)				
Homestead system reform × Unified urban-rural hukou policy	0.086 (0.054)				
Employment policy		0.016 (0.019)			
Homestead system reform × Employment policy		0.248*** (0.084)			
Home purchase policy			0.015 (0.025)		
Homestead system reform × Housing purchase policy			0.183** (0.085)		
Investment and tax policy				-0.005 (0.009)	
Homestead system reform × Investment and tax policy				0.024 (0.052)	
Talent introduction policy					0.001 (0.013)
Homestead system reform × Talent introduction policy					-0.106 (0.121)
Constant	-0.227* (0.134)	-0.272* (0.143)	-0.219 (0.134)	-0.246* (0.136)	-0.241* (0.136)
Control variables	Yes	Yes	Yes	Yes	Yes
Homestead location County fixed effect	Yes	Yes	Yes	Yes	Yes
Migration destination City fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	9024	9024	9024	9024	9024
Adjusted R ²	0.022	0.023	0.021	0.021	0.021

Note: The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01

(2) Policy heterogeneity of homestead system reform

Homestead system reform primarily involves two key policy instruments: the paid use policy and the compensated withdrawal policy. Among them, the paid use policy targets those portions of the homestead that exceed the legally allocated quota due to inheritance or illegal occupation. Rural households are required to pay fees for the excess area beyond the national standard of free allocation. The compensated withdrawal policy allows rural residents to voluntarily relinquish their homestead rights in exchange for certain forms of compensation. The specific forms and standards of compensation vary across regions. The most common approaches include one-time cash compensation and apartment replacement schemes. In some pilot areas, combinations of multiple compensation methods have also been introduced. Given the variety of policy instruments, a key empirical question is: Which policies of homestead system reform can play a decisive role in influencing farmers' withdrawal decisions? To answer this, this dissertation estimates separate regressions of farmers' withdrawal decisions on several policy variables, including the amount of fees charged or compensation offered (in thousand RMB) and the floor area of housing provided via replacement (in square meters). The results are shown in Table 4.13.

Table 4.13 Estimations of the effects of various sub-policies
in homestead system reform

Variables	(1)	(2)	(3)	(4)
	Withdrawal	Withdrawal	Withdrawal	Withdrawal
Hukou system reform	0.022 (0.014)	0.022 (0.014)	0.022 (0.014)	0.021 (0.014)
Paid use of homestead	0.000 (0.002)			
Hukou system reform × Paid use of homestead	0.007* (0.004)			
Cash compensation for homestead withdrawal		0.010 (0.010)		0.027** (0.011)
Hukou system reform × Cash compensation		0.040** (0.017)		0.058*** (0.018)
Apartment compensation for homestead withdrawal			0.073 (0.096)	0.156 (0.100)

Variables	(1)	(2)	(3)	(4)
	Withdrawal	Withdrawal	Withdrawal	Withdrawal
Hukou system reform			0.408**	0.472***
× Apartment compensation			(0.169)	(0.165)
Constant	-0.277*	-0.298**	-0.298**	-0.293**
	(0.136)	(0.136)	(0.136)	(0.136)
Control variables	Yes	Yes	Yes	Yes
Homestead location County fixed effect	Yes	Yes	Yes	Yes
Migration destination City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	9024	9024	9024	9024
Adjusted R ²	0.023	0.022	0.022	0.029

Note: The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01

From Column (1), the paid use policy for homesteads exerts a certain degree of influence in promoting farmers' withdrawal from homesteads. However, this effect is relatively limited. The primary reason is that the policy mainly targets households with excessive occupation of homestead, whereas the more widespread phenomenon of idle homesteads is largely driven by rural–urban migration. Therefore, it is understandable that the overall effect is not statistically significant. Columns (2) and (3) indicate that the paid withdrawal policies for homesteads have a more pronounced effect on encouraging farmers to withdraw from homesteads, especially under the apartment compensation approach, which is more favored by farmers. Field investigations reveal that many rural households currently lack the capacity to fully integrate into urban life, and the amount of cash compensation provided is often insufficient to support housing purchases in urban areas. In comparison, apartment compensation offers a more direct solution, ensuring that farmers still have a stable place to live after giving up their homestead. Column (4) shows that when a combined policy involving both cash and apartment compensation is implemented, farmers have more choices. This approach can meet their housing needs while also providing financial support for rural-to-urban migration or self-employment. As a result, the combined compensation model is more effective in promoting homestead withdrawal.

4.6.2 Regional heterogeneity analysis

(1) Size heterogeneity of migration destination cities

To investigate in which urban hierarchy reform can be more effective, we divide the entire sample into four city groups. Table 4.14 shows that farmers who migrate to second-tier cities are most motivated to withdraw from their homesteads. Not only can they enjoy the better infrastructure of larger cities, but they can also avoid the risks and pressures of first-tier cities. In addition, the promotional effect can be observed in third-tier and fourth-tier cities, although its significance and coefficients are not as high as in second-tier cities, which can well explain China's unique labor return phenomenon. Farmers are neither willing to stay in the migration destination cities, nor return to their hometowns in villages. They are inclined to return to the counties where their hometowns are located (mostly third-tier and fourth-tier cities). If hukou system is reformed here, it will significantly promote farmers' enthusiasm to withdraw from homesteads, which is in line with findings of Wu & Lu (2020).

Table 4.14 Heterogeneity analysis of the joint reform-Grouped by destination city tiers

Groups	(1)	(2)	(3)	(4)
	First-tier	Second-tier	Third-tier	Fourth-tier
Homestead system reform	0.022 (0.159)	-0.097* (0.059)	-0.010 (0.098)	-0.165 (0.112)
Hukou system reform	-0.003 (0.041)	0.046* (0.028)	-0.017 (0.028)	0.025 (0.024)
Homestead system reform × Hukou system reform	-0.169 (0.548)	0.299*** (0.102)	0.272** (0.120)	0.237* (0.127)
Constant	0.003 (0.047)	0.001 (0.019)	0.013 (0.033)	-0.028 (0.041)
Control variables	Yes	Yes	Yes	Yes
Homestead location	Yes	Yes	Yes	Yes
County fixed effect	Yes	Yes	Yes	Yes
Migration destination	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Observations	2634	1542	2190	2658
Adjusted R ²	0.022	0.027	0.003	0.001

Note: The standard errors are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01

(2) Geographical heterogeneity of homestead in rural origins

The economic region and geographical location of a homestead can affect farmers' judgment of the current value and future market prospects of the homestead (Chen et al., 2017; Xu et al., 2019). It is a trade-off for farmers between the income effect and the opportunity cost effect. In addition, areas where clan values are prevalent and minority nationalities live together have a greater sense of “Falling Leaf Returns To Root”, which also determines homestead value (Yao et al., 2023). Therefore, we group the entire sample by eastern-central-western region, big-small county, suburb-outer suburb, and whether it is a minority area, respectively.

Table 4.15 The heterogeneity analysis results of homestead location

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Groups	Region		Suburb		County size		Minority Nationality Areas	
	Eastern Region	Central-Western Region	Suburb	Outer suburb	Small county	Big county	Minority Nationality	Non-Minority Nationality
Homestead system reform	0.025 (0.056)	-0.055 (0.047)	0.031 (0.567)	-0.031 (0.037)	0.081 (0.057)	-0.153*** (0.051)	0.048 (0.084)	-0.070* (0.040)
Hukou system reform	0.036** (0.017)	0.007 (0.018)	0.030 (0.050)	0.024* (0.013)	0.022 (0.014)	0.018 (0.027)	-0.034 (0.032)	0.036** (0.014)
Homestead system reform *Hukou system reform	0.017 (0.120)	0.203** (0.083)	-0.148 (1.593)	0.139** (0.066)	-0.089 (0.095)	0.465*** (0.103)	0.057 (0.206)	0.206*** (0.071)
Constant	-0.029 (0.032)	0.001 (0.039)	-0.004 (0.156)	-0.001 (0.036)	-0.005 (0.041)	0.060 (0.084)	-0.001 (0.041)	-0.004 (0.028)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4515	4509	1434	7590	7215	1809	2880	6144
Adjusted R ²	0.011	0.016	0.003	0.017	0.008	0.069	0.042	0.019

Note: The t-statistics are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01

From the results presented in Columns (1)~(6) of Table 4.15, the joint reform of homestead system and hukou system has a significant promotion effect on homestead transfer in central and western regions, big counties, and outer suburbs in China. Those places are generally population-exporting areas with low demand for homesteads in the local market. The legal path to withdraw from homesteads with compensation provided by institutional reform is regarded as a good opportunity to realize unused assets. Especially in large counties with comprehensive policies and a high cognitive level among farmers, the incentive effect of institutional reform is more pronounced. On the contrary, in the eastern suburbs, homesteads have taken on diverse functions with the development of industries; their higher value can limit the incentive effect of institutional reform. In particular, farmers from minority areas tend to build farmhouses or apply for additional homesteads for their offspring out of hometown-loving sentiments, even though they have moved to cities and are covered by urban social security due to the hukou system reform.

4.6.3 Farmer heterogeneity analysis

With the increasing frequency of labor mobility between rural and urban areas, the occupational and residential structure of rural households has become increasingly diversified (Long et al., 2016; Chang & Liu, 2018). Currently, more than 80% of rural households are full-time farmers, and part-time farming households with agriculture as the primary source of income account for 50% to 80%. Those with non-agricultural activities as their main source represent 20% to 50%, and non-agricultural households make up approximately 20%. In addition, differences in living environments during upbringing, education levels, and historical backgrounds have led to significant generational disparities between older and younger farmers in terms of village attachment and urban identity. These factors strongly influence farmers' perception of the value of their homestead (Zhao et al., 2018).

Therefore, this study analyzes farmer heterogeneity from four perspectives. First,

the highest level of education within a household is used to indicate the skill level and employment stability of its members. Based on this, the sample is divided into three groups to reflect differences in human capital: households with 0 to 9 years of schooling (within compulsory education), those with 9 to 16 years of schooling (encompassing university education), and those with more than 16 years of schooling (encompassing higher education). Second, whether a household owns urban housing is used to represent the degree of residential stability. Third, household income level is used to assess the impact of living standards on homestead land use. High-income households are defined as those in the top 20%, middle-income households as those between the 20% and 80%, and low-income households as those in the bottom 20%. Fourth, the age of the household head is used to reflect intergenerational differences, with samples divided into three groups: those under 45 years old, those aged 45 to 65 years old, and those over 65 years old. Regression analyses are conducted separately for each subgroup to examine how the joint reform of hukou system and homestead systems performs across different types of households. The results are presented in Table 4.16.

Table 4.16 Farmer heterogeneity analysis results

Groups	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Years of schooling			Urban housing		Income level			Age		
	[0,9]	(9~16]	Above 16	Yes	No	Low income	Middle income	High income	[0,45)	[45,65)	Above 65
Homestead system reform	0.008 (0.044)	-0.077 (0.079)	-0.111 (0.148)	0.033 (0.054)	-0.043 (0.044)	-0.001 (0.116)	-0.034 (0.041)	-0.065 (0.092)	0.067 (0.062)	-0.179*** (0.054)	0.007 (0.087)
Hukou system reform	0.007 (0.013)	0.030 (0.038)	0.040 (0.060)	0.035 (0.023)	0.004 (0.015)	-0.009 (0.029)	0.020 (0.014)	0.011 (0.040)	-0.008 (0.024)	0.024 (0.016)	0.052 (0.034)
Homestead system reform	0.073 (0.087)	0.253* (0.133)	0.178 (0.268)	-0.066 (0.106)	0.290*** (0.075)	-0.011 (0.185)	0.240*** (0.078)	0.106 (0.172)	0.025 (0.109)	0.444*** (0.111)	-0.027 (0.166)
*Hukou system reform	-0.001 (0.065)	0.003 (0.085)	0.009 (0.070)	-0.006 (0.051)	-0.000 (0.048)	0.001 (0.112)	-0.001 (0.054)	-0.003 (0.067)	-0.006 (0.049)	-0.003 (0.067)	-0.015 (0.072)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6546	1569	909	5970	3054	1803	5415	1806	3138	4740	1146
Adjusted R ²	0.010	0.036	-0.065	0.025	0.015	0.080	0.009	0.017	0.026	0.017	0.007

Note: The t-statistics are presented in parentheses; *p < 0.1, **p < 0.05, and ***p < 0.01

Columns (1) to (3) show that when farmers have lower levels of education, their employment in urban areas tends to be less stable, and their income levels are relatively low. As a result, they are more dependent on their homesteads and express greater concern about post-withdrawal living conditions, especially housing. These farmers tend to value the residential and social security functions of the homestead, which means that hukou and homestead system reforms do not significantly encourage them to withdraw. As the education level of farmers increases, their human capital improves, enabling them to obtain more stable and sustainable non-agricultural income. In this case, institutional reforms have a more significant effect in promoting homestead withdrawal. However, when farmers possess even higher levels of education, their ability to access and process information becomes stronger. They are more forward-looking in recognizing the potential value of the homestead and have more resources and capabilities to revitalize and utilize it to generate greater value. Therefore, compared to receiving compensation for withdrawal, they are more inclined to retain homesteads as a long-term appreciating asset.

Columns (4) and (5) indicate that owning urban housing discourages farmers from withdrawing from their homesteads. This suggests that, in the context of homestead withdrawal decisions, the wealth effect of urban housing outweighs its residential function. As the homestead system reform progresses, the use rights associated with the homestead are becoming increasingly strengthened, and the means of realizing its value are becoming more diversified. This leads to rising expectations among farmers regarding the future value of their homesteads. In addition, farmers who already own urban housing tend to be in a relatively better financial position. For them, the marginal utility of wealth gains from withdrawal compensation is lower, and their higher risk tolerance leads them to place more value on the long-term returns of retaining their homesteads. Moreover, as shown in Columns (6) to (8), the regression results also reveal that for farmers with higher household incomes, the

institutional reforms do not have a significant effect on their willingness to withdraw from homesteads.

Columns (6) to (8) show that hukou and homestead system reforms has the most significant positive impact on middle-income households. These households often have sufficient capacity to establish themselves in urban areas. By withdrawing from their homesteads, they can obtain additional economic resources, which not only help them cope with potential social risks in the future but also serve as financial support for self-employment or entrepreneurial activities. In contrast, low-income households typically lack the financial capacity to purchase housing in urban areas. Their employment opportunities are limited, and their ability to withstand risks is weak. As a result, they are highly dependent on the social security function provided by homesteads and are generally unable to withdraw from them.

Columns (9) to (11) show that younger, new-generation farmers generally have higher levels of education and a better understanding of policy compared to the older generation. They are more likely to comprehend the evolving trends of homestead reform and often hold optimistic expectations about the future value of homestead land. This suggests that they are less willing to withdraw from their homesteads. As farmers age, their average education level tends to be lower, and they commonly face greater financial pressure, such as the need to fund children's marriages or improve household living conditions. These circumstances make them more eager to obtain compensation through homestead withdrawal to address their immediate needs. However, among the oldest age group of elderly farmers, there is often a strong emotional attachment to their hometowns, driven by the traditional sentiment of “falling leaves returning to the roots.” As a result, they are more inclined to remain in their rural homes rather than move to urban areas.

In summary, for farmers, the current homestead withdrawal policy may represent a second-best choice. Those who are most qualified and capable of withdrawing are,

in fact, more likely to retain their homesteads. This finding is consistent with the conclusions drawn by Wang & Gu (2016).

4.7 Conclusions

This chapter, grounded in the theory of farmer behavior, employs the PSM-DID model to examine the impacts of the joint reform of hukou system and homestead system on farmers' homestead use behavior, and further investigates the pathways, dynamics, and heterogeneity of its potential impacts.

The major results are as follows:

First, the significant findings are that hukou system reform can significantly increase the effect of homestead system reform on rural migrants' homestead withdrawal by a sizable 14%, which indicates that their relationship is complementary to each other. Further mechanism analysis shows that their complementarity arises because the hukou system reform can weaken rural migrants' reliance on the homestead security function and strengthen the income effect of homestead withdrawal.

Second, as hukou system reform intensifies, changes in rural migrants' homestead withdrawal behavior under the joint reform of hukou system and homestead system may exhibit an "inverted U-shaped" pattern. When hukou restrictions are almost completely relaxed, farmers can more easily access urban welfare, making the security function of homesteads less of a priority. As a result, higher expectations of future value and emotional attachment to homesteads become more prominent, reducing the enthusiasm of rural migrants for withdrawing from their homesteads.

Third, a detailed analysis of the specific policies under the hukou system reform reveals that employment and housing policies play a critical role. In contrast, the unified urban-rural hukou policy, which blurs the concept of hukou without addressing the urban-rural divide, is unlikely to generate significant positive effects.

A deeper examination of the specific policies under the homestead system reform shows that the compensated withdrawal policy can significantly promote homestead withdrawal. Among various compensation models, the apartment compensation is more widely accepted, and the combination of cash compensation and apartment compensation is found to be more efficient than either approach alone.

Fourth, regional heterogeneity indicates that the complementarity between homestead system reform and hukou system reform is stronger in the central and western regions, non-minority areas, large cities, and outer suburban districts. In particular, the hukou system reform in second-tier cities shows better synergy with the homestead system reform in these areas. Farmer-level heterogeneity suggests that those with moderate levels of education, income, and age, as well as those without urban housing, are more likely to be positively influenced by the institutional reforms. However, the farmers who are most qualified to withdraw from homesteads tend to retain them instead.

Chapter 5: Design of a Simulation Model for Homestead Use under the Joint Reform of Hukou System and Homestead System

5.1 Introduction

The previous two chapters have analyzed the mechanisms through which hukou and homestead system reforms influence homestead use behavior from both theoretical and empirical perspectives. This chapter extends the analysis from micro-level behavioral responses to the spatio-temporal effects of homestead use. It focuses on the “behavioral responses→emergent effects” component of the analytical framework and develops a simulation model to examine the spatio-temporal dynamics of homestead use under institutional reforms.

At present, relative studies on homestead use evolution are gradually in-depth, mainly focusing on revealing the status quo and evolution characteristics of homestead use (Teulings et al., 2018; Tao et al., 2021), evaluation of homestead use efficiency and optimization potential (Rao et al., 2023; Wang et al., 2024), and driving factors and mechanisms analysis of homestead use evolution (Shi & Wang, 2021; Gao et al., 2023). However, the current literature predominantly employs statistical methods, including principal component analysis and econometric techniques such as regression analysis, to analyze the main factors affecting changes in homestead use, with attention to individual, household, and homestead characteristics. While those studies do not systematically analyze the mutual driving mechanism of multiple factors, they fail to reflect the mutual learning and adaptation between farmers and others, as well as between farmers and the environment. This makes it difficult to analyze the complex process of homestead use evolution. In addition, there are few studies on the interaction mechanism of multiple policies, such as the hukou system and the homestead system, on homestead use. A few studies that have paid attention

to policies mostly focus on the impacts of an individual system and its current requirements on farmers' migration and homestead transfer behaviors, and only analyzed the quantity of rural migrants and the area of homestead evolution (Kong et al., 2018; Wang & Yu, 2019; Li et al., 2023), lacking a systematic analysis of microscopic farmers' homestead use decision-making under the multiple system joint reforms from two dimensions of time and space, as well as the process simulation of homestead use evolution.

In essence, farmers are the basic unit of homestead use, and their decision-making behavior is influenced by the macro-institutional environment. The behavior of multiple farmers at the micro level emerges as the evolution of homestead use at the macro level, and subsequently, the evolution of large-scale homestead use will affect the subsequent adjustment of institutional policies. Therefore, the basis and driving force for homestead use evolution is fundamentally the interaction between the macro institutional environment and micro subject behavior (Lu et al., 2022). Related research is generally carried out in two aspects. Social economists mostly combine microeconomics and sociological theory and use qualitative or quantitative models to study the behavior of micro-subjects, which is helpful to understand the influence of farmers' own characteristics on their behavior and decision-making, but lacks the spatial connection between farmers and the geographical environment (Liu et al., 2021). Physical geographers mostly use remote sensing, geographic information systems, and statistical models to study the overall behavioral patterns of farmers from the landscape and regional scales, although they can help obtain spatial information, it's difficult to reflect the heterogeneity and dynamics of individual farmers (Li et al., 2020). Therefore, it is necessary to place farmers' homestead use decisions under the comprehensive framework of the coupled natural-human system and fully understand the complex interaction process between the two.

Multi-Agent System (MAS), as an important means of analyzing and simulating complex systems, can "bottom-up" explore the impacts of micro-subject decision on

macro-land use by simulating agent behaviors and their interaction with the environment, embodying the heterogeneity, nonlinearity, feedback, uncertainty, and other complex characteristics of the coupled natural-human system. Meanwhile, MAS can be used as a policy auxiliary tool for selecting policy solutions and predicting their effects, combined with scenario analysis, which has been widely applied in urban land use simulations (Li et al., 2013; Li & Liu, 2016). Nevertheless, MAS is not satisfactory in expressing the process of macro-scale land change, and most decision-making mechanisms of agents are based on the principle of benefit maximization, which cannot effectively represent the decision-making processes of micro-scale subjects (Abolhasani et al., 2023). As an effective spatial analysis tool, Geographic Information System (GIS) can provide support for complex spatial decision-making and realize spatial visualization (Zhai et al., 2020).

To this end, this chapter proposes an integrated approach combining Multi-Agent System (MAS) and Geographic Information System (GIS). By modeling the environment, land, agents, and their interactions, it constructs a coupled human-land system. Different institutional reform scenarios are designed, and multidimensional indicators are defined to characterize the spatio-temporal effects of homestead use. This provides a modeling foundation for simulating the spatio-temporal dynamics of homestead use under institutional reforms in subsequent chapters.

The key contribution is the development of a simulation model that focuses on individual rural households rather than treating the entire town or village as the unit of analysis, which distinguishes it from conventional approaches such as Conversion of Land Use and its Effects (CLUE), Cellular Automata (CA), and System Dynamics (SD) models commonly used for simulating geographic environmental dynamics. The model simulates major life events and decision-making processes throughout the human life cycle, including birth, aging, illness, death, marriage, and funeral practices, and incorporates features such as adaptation, perception, interaction, learning, randomness, and emergence within human-land systems. Based on field survey data

and rural land registration records, the model establishes spatial linkages between each household and its associated cropland and homestead parcels. By adopting a bottom-up modeling strategy, it integrates micro-level household decisions with land-use changes, captures interactions across multiple levels, including individual-household, household-land, inter-household, and household-village-group relations, to deepen the understanding of human-land system dynamics.

The rest of this chapter is organized as follows. Section 5.2 introduces the conceptual framework underlying the simulation analysis. Section 5.3 and Section 5.4 describe the structure, process, and development of the simulation model. Section 5.5 outlines the scenario settings for joint reform of the hukou and homestead systems. Section 5.6 defines the indicator system used to evaluate the spatio-temporal effects of homestead use. Finally, Section 5.7 concludes the chapter with a summary of key insights from the simulation analysis.

5.2 Conceptual Framework

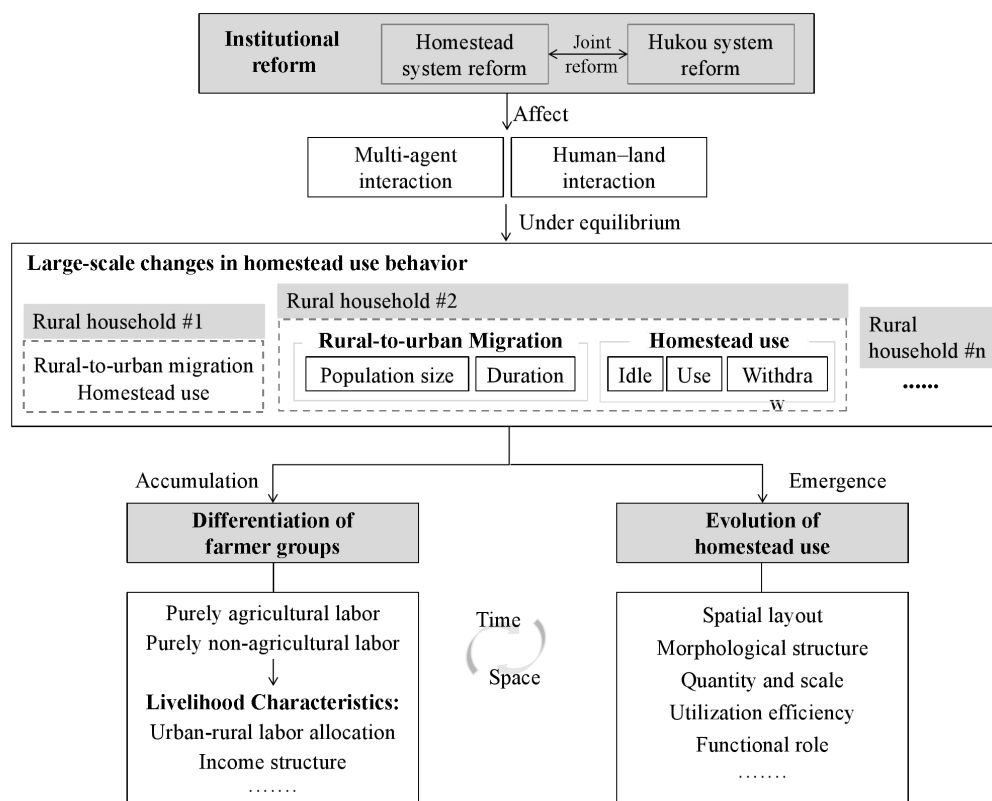


Figure 5.1 Conceptual framework for simulating spatio-temporal effects of homestead use evolution

Under the joint reform of hukou system and homestead system, continuous interactions occur among multiple agents, as well as between individuals and land. Through these interactions, the system ultimately reaches a stable state, during which farmers' migration between rural and urban areas and their homestead use behaviors undergo significant changes. The large-scale accumulation of homestead use behaviors gives rise to emergent spatio-temporal effects in homestead use, driving the dynamic evolution of the homestead use system. The diversity, nonlinearity, and hierarchical nature of behavioral responses among different types of rural households contribute to the complexity of this evolution process. Accompanying these changes are shifts in farmers' internal attributes and livelihood strategies, which gradually accumulate and lead to the social differentiation of farmer groups (Zhu et al., 2020).

Large-scale changes in farmers' homestead use behaviors give rise to the evolutionary process of homestead use. Farmers' behavioral choices are influenced by both internal attributes and external environmental conditions. On the one hand, individual characteristics, household structure, and social network relations vary among farmers; on the other hand, their access to homestead resources and the level of local socioeconomic development also differ. When facing institutional changes, farmers exhibit significant heterogeneity in their degree of dependence on homesteads, their perceived value, and preferences regarding property rights. As a result, they make diverse livelihood decisions, such as whether to migrate to urban areas, how many family members relocate, and the duration of migration. They also adopt different strategies for homestead use, including retaining, idling, or relinquishing their homesteads. This diversity in farmers' behavior contributes to the complexity of homestead use evolution. First, the functional role of homesteads varies depending on farmers' livelihood characteristics. For those who migrate to cities, the role of homesteads shifts from basic production and residential functions to asset functions, while also serving as a source of emotional attachment to their rural origins. Second, some rural migrants choose to leave their homesteads idle, affecting the evolution of

homestead use efficiency; others choose to withdraw from their homesteads, which influences the evolution of homestead scale. Furthermore, withdrawn homesteads can be used more intensively through unified planning, land reclamation, and revitalization efforts. Meanwhile, new generations of young farmers remaining in villages may apply for new homesteads, further contributing to the evolution of the spatial layout and morphological structure of homesteads. In summary, from a spatial perspective, institutional reforms have led to significant changes in homestead use, encompassing spatial layout, morphological structure, quantity and scale, efficiency, and functional roles. Moreover, from a temporal perspective, the human-land interaction remains continuous, resulting in a dynamic process of homestead use evolution over time.

The cumulative impact of large-scale behavioral changes among farmers also leads to the differentiation of groups. As farmers' behavioral choices accumulate over time, their internal attributes and livelihood structures continue to evolve, resulting in the differentiation of farmer groups. Some remain in rural areas as purely agricultural farmers, retaining their rural hukou, engaging in farming activities, and eventually settling in relatively concentrated residential areas through homestead optimization and consolidation. Others become purely non-agricultural farmers, withdrawing from their homestead, engaging in non-agricultural industries, and obtaining urban hukou, thus becoming potential or actual urban residents. Consequently, the distribution of labor and the structure of labor income across rural and urban areas become increasingly differentiated.

5.3 Structure and process design of the simulation model

5.3.1 Model framework integrating MAS and GIS

According to the preceding analysis, the homestead use system can be conceptualized as comprising two core components: “human” and “land.” The “human” refers to various types of farmers and other stakeholders, while the “land”

encompasses homestead use data, basic geographic information, infrastructure, and related attributes. Farmers with different characteristics form initial perceptions of homestead value based on their homestead endowments and surrounding geographic and environmental conditions. When external institutional reforms occur, interactions among stakeholders influence farmers' behavioral responses, leading them to adjust homestead use behaviors in response to the changing environment. These behavioral changes give rise to spatial evolution in homestead use, which, in turn, becomes part of the external environment influencing farmers' subsequent decisions. Through this dynamic process, the human-land system continuously interacts, responds, and reshapes itself, ultimately progressing toward a new state of equilibrium.

To simulate this complex evolutionary process, a Multi-Agent System (MAS) can be employed to capture the subjectivity, adaptability, and social interactions of agents, making it a widely used tool for modeling complex behavioral decision-making processes. However, MAS alone is often limited in effectively representing land use changes at a spatial scale. In contrast, the Geographic Information System (GIS) serves as a powerful spatial analysis tool, capable of supporting complex spatial decision-making and enabling spatial visualization, yet it generally lacks the capacity to depict the micro-level decision-making processes of individual agents. To address these limitations, this dissertation integrates MAS and GIS to construct a coupled human-land system, enabling the simulation of the spatio-temporal effects of homestead use. Its overall framework is illustrated in Figure 5.2.

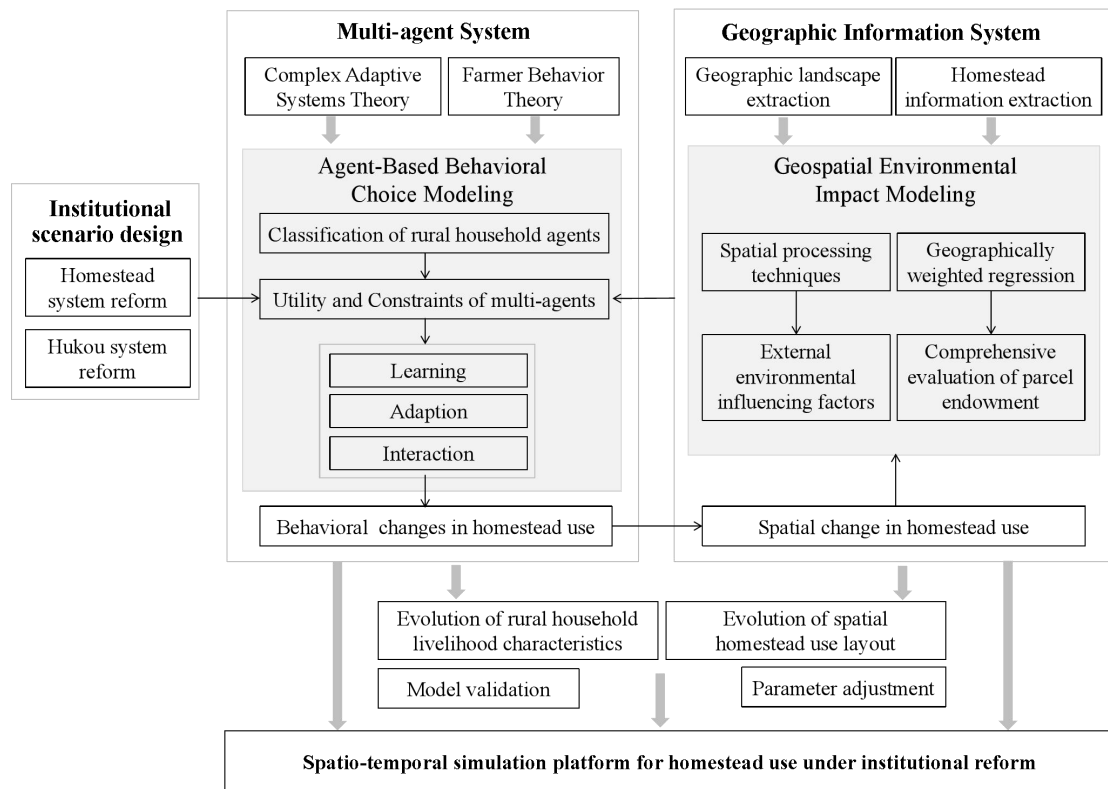


Figure 5.2 Integration framework of MAS and GIS

(1) The design of institutional reform scenarios

Institutional reform is a key driver of behavioral change among farmers. Given the wide scope of policies related to hukou and homestead system reforms, variations in reform models, implementation standards, and compensation mechanisms can significantly influence the behavioral responses of different types of farmers. Accordingly, this study designs a set of policy combination scenarios that reflect diverse approaches to hukou and homestead system reforms. Under these scenarios, the evolutionary trajectories of the farmer-homestead coupled system can be examined, with a focus on how different institutional settings shape farmers' decisions regarding urban-rural residential choices, household labor allocation between urban and rural areas, income structures, and other dimensions of livelihood, as well as the spatial evolution of homestead use.

(2) The settings of Multi-Agent System

The Multi-Agent System (MAS) comprises different types of farmers, as well as

other stakeholders such as the government and enterprises, and their interactions. Farmer agents are represented as grid agents within the homestead use space. Each agent corresponds to a specific plot of homestead, and multiple plots are potentially linked to the same agent, accurately reflecting real-world scenarios. According to complex adaptive system theory, for each grid agent, its internal attributes, external environmental factors, and the overall natural endowment of the homestead not only determine the farmer's value perception of the plot but also constitute the constraints of its spatial decision-making behavior. Based on this, the utility and constraint functions can be developed for each agent. According to Farmer Behavior Theory, farmers actively engage in information exchanges with one another, continuously acquiring new knowledge, learning through experience, and adapting their behaviors. This iterative process helps farmers optimize their decision-making with the ultimate goal of maximizing their family's overall utility. On the one hand, changes in farmers' behaviors can alter their own livelihood characteristics, affecting both their subsequent decisions and the choices of others. On the other hand, these behavioral changes directly shape the homestead, driving the evolution of homestead use as a central force.

(3) The settings of Geographic Information System

The Geographic Information System (GIS) serves as a fundamental platform for the storage, analysis, and processing of geographic spatial data, mainly including land use data, basic geographic information, and corresponding infrastructure information, such as transportation, education, healthcare, and entertainment centers. On one hand, the geographical and environmental factors need to be generated or processed with the help of relevant spatial technologies. On the other hand, the effect of the same geographic characteristic can vary across locations due to spatial heterogeneity, and its influence mechanisms differ for various types of stakeholders. Geographically weighted regression is employed to model the overall natural endowment of homesteads and farmers' value evaluations. This, in turn, influences farmers'

homestead use behavior and drives spatial-level changes in homestead use. Through this approach, the interaction mechanism between geographical environmental factors and stakeholder behavior can be established. Moreover, to describe the evolution of homestead use, it is essential to develop a homestead use transformation model that captures behavioral response mechanisms and apply geospatial technology to facilitate the transformation of homestead use status effectively.

(4) The establishment of model simulation platform

The operation of the simulation model for the spatio-temporal effects of homestead use requires both computer hardware and software to create a controllable, artificial experimental environment. This dissertation uses the NetLogo software platform. Built on the principles of Complex Adaptive System Theory, NetLogo provides a programming environment specifically designed for modeling complex systems that evolve over time, making it suitable for simulating both natural and social phenomena.

5.3.2 Outline, scheduling, and implementation of the simulation model

Based on the conceptual model, this dissertation proposes a comprehensive simulation model of homestead use evolution. As a coupled system comprising humans, nature, society, and the economy, this model consists of an environment layer derived from a geographic information system and a multi-agent layer in which individuals interact. In these modules, we provide the basic settings of the types, objectives, behaviors, decision-making methods and results of the agents, design diversified scenarios for external institutional reforms and define specific rules for how each agent makes decisions and interacts with other agents and with the spatial environment, so as to understand the interactive relationship between farmers and their corresponding homesteads, explore the potential synergies and trade-offs of hukou system and homestead system on household livelihood decision-making and landscape evolution over space and time.

The model sequence processes include all components involved in the scheduling process. Each process is activated by the corresponding agent, participant, or entity. Agricultural production on an annual basis determines farmers' labor allocation and land use decisions, so the temporal resolution of our simulation system is also in units of 1 year. At each time step, the scheduling order of the model remains unchanged. In the model simulation, we assume that (1) farmers are limited rational decision makers who aim to maximize their comprehensive interests, including economic interests, infrastructure, and public service convenience; (2) considering that large-scale infrastructure such as road planning, hospitals, and schools generally will not change significantly in a short period of time, we select relevant data in 2017 and assume that it remains unchanged.

Figure 5.3 shows the flowchart of the model simulation. The modeling process can be divided into three phases: initialization, simulation, and output. The main steps at the initialization phase include importing GIS files of individuals, households, and homestead parcels into the model, setting up initial states for individuals and households, importing environment layers, initializing household social networks, and defining the reform context of the hukou system and the homestead system. In the simulation phase, the modules are repeated at each time step, including the Institutional Reform Scenarios, the Demographic Module, the Individual Migration Decision-Making Module, the Household Homestead Use Decision-Making Module, and the Newly-Added Homestead Site Selection Module.

Firstly, the Demographic Module is an individual-level module comprising several submodules, including mortality, marriage, fertility, and enrollment, which simulate an individual's life history at one-year increments. Through this module, we can judge the household demographic change, including the increases in household size (due to birth and marriage) and decreases (due to death and marriage), thereby determining the entities to participate in migration decisions in the next step.

Subsequently, the model moves to the Individual Migration Decision-Making

Module. Under the institutional reforms, considering the surrounding environment and the social and economic status, farmers will choose the migration mode that maximizes individual utility. Whether farmers choose seasonal migration or permanent migration will result in the homestead being idle for different periods of time. Once a few family members choose to migrate. Although the homestead is always occupied, it is often inhabited by elderly people or children, which also leads to low land use efficiency. Furthermore, if farmers choose to transfer their hukou to migration destination cities, they have to relinquish their homestead. However, they still hold the property rights of the house built on the homestead; they can enjoy its asset value but cannot rebuild until it collapses. In addition, even if farmers do not migrate out, when their parents pass away, they can inherit the house on the homestead according to the law. To sum up, different migration patterns mean different rural household residential structures, which are a key prerequisite for following homestead use decisions.

If a household has an idle homestead, the Household Homestead Use Decision-Making Module is executed to simulate the evolution of homestead use. If this rural household has no intention of withdrawing from its homestead, it can choose to rent it out or keep the homestead idle. This will result in land waste and an amphibious population, thereby hindering both urbanization and rural revitalization.

If farmers choose to withdraw from idle homesteads, the homestead can be either reclaimed as cropland or used to develop other industries in rural areas, depending on market conditions. Alternatively, the government can also use it as a reserve homestead, as per relevant regulations. When there is a demand for a new homestead, this reserve homestead will be occupied with priority. If the new adults meet the requirements for applying for a homestead and do not move to cities, they can apply for a homestead from the village collective. The Newly-Added Homestead Site Selection Module is used to simulate this process. This is the direct cause of the expansion of rural settlements, and the withdrawal, reuse, and expansion decisions of

homesteads determine, to some extent, the direction of expansion, contraction, and the specific spatial distribution of rural settlements in that year.

Finally, the spatial environment is updated based on homestead use changes across the landscape at the end of each year, including spatial distributions of idle homestead, reused homestead, rented-out homestead and newly-added homestead. A large number of homestead use evolution can result in huge changes in the environmental landscape of rural settlements, which will further affect rural economic development, ecological environment, and even lifestyle, ultimately affecting the decision-making behavior of each agent. This also triggers changes in the structure of urban–rural labor allocation and income distribution among rural households.

Up to this point, the decision-making process for one time is complete. The dynamic variables of rural individuals, households, resident groups, and landscapes are updated, serving as the initial states for the next simulation.

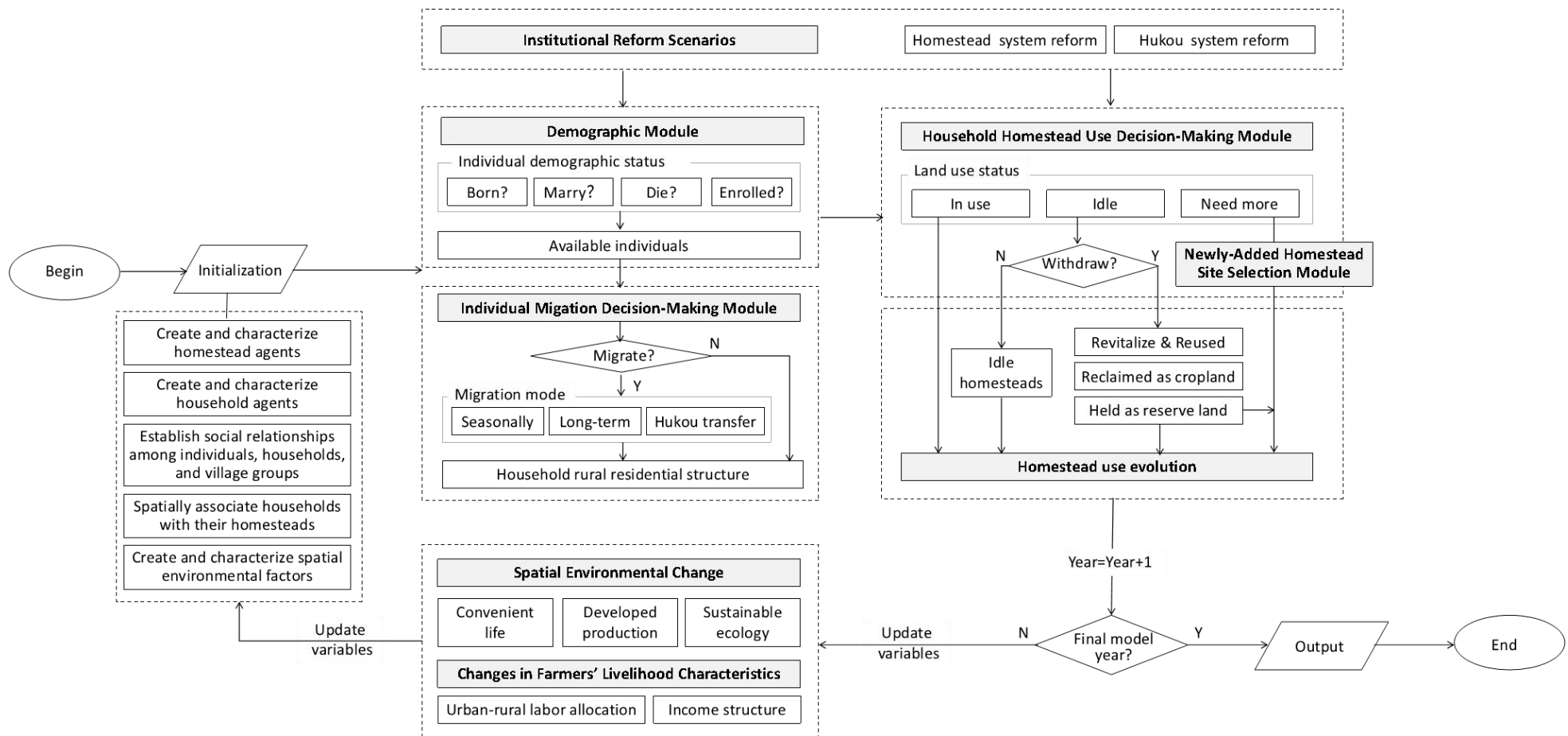


Figure 5.3 Flowchart of model simulation

5.4 Research and development of the simulation model

5.4.1 Decision-making models of rural household agents

The decision-making models of rural households mainly consist of several modules: demographic change module, individual migration decision-making module, household homestead use decision-making module, and new homestead site selection module. Since different types of rural households have different preferences, it is necessary to classify households before constructing the model.

(1) Attributes and classification of rural households

In recent years, with a large number of rural laborers migrating to cities, farmers' career choices and income structures have gradually shifted away from traditional agriculture, leading to a differentiation in farmers' attributes and shaping diverse perceptions of the functional value of homesteads. This, in turn, has influenced their decisions regarding homestead use (Liu et al., 2020). Therefore, to understand farmers' behavioral preferences, it is necessary to identify the attributes or factors that determine their ability to resist external risks and their perception of the value of their homesteads.

This dissertation adopts two classification criteria: the annual homestead occupation period as the primary criterion and income level as the secondary criterion. Both indicators are dynamic indicators that change over time, which can better characterize the way farmers manage their homesteads and reflect the changes in the human-land relationship. Additionally, these criteria provide insights into changes in farmers' career choices and livelihoods, highlighting their reliance on agriculture and rural land, the role of homesteads in their livelihoods, and the tendencies of farmer differentiation.

Combining these two indicators, farmers can be categorized into five groups (see Figure 5.4). P1 refers to farmers who live on their homesteads all year round, primarily consisting of traditional full-time farmers or part-time farmers who

commute between home and non-agricultural work. P2 refers to farmers who live on their homesteads for most of the year, primarily part-time farmers engaged predominantly in non-agricultural work. P3 refers to farmers who are away from their homesteads for most of the year, primarily part-time farmers engaged predominantly in non-agricultural work. P4 and P5 consist of farmers whose homesteads remain idle throughout the year, mainly non-agricultural farmers who have relocated to cities. Furthermore, to successfully urbanize and mitigate the risk of losing rural security after homestead withdrawal, farmers must at least secure a stable residence in the city they relocate to or possess sufficient savings to cover the down payment for local housing, ensuring a stable urban life (Gu et al., 2018). Based on this, P4 represents farmers who have moved to cities but lack strong risk resistance and still rely on the security provided by their homesteads, while P5 represents farmers who are fully established in urban areas and no longer dependent on rural homesteads.

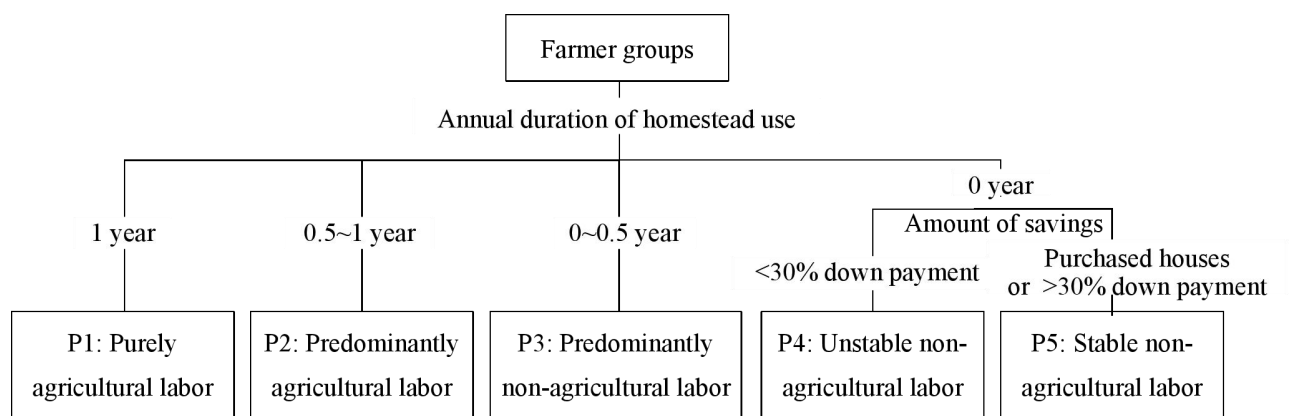


Figure 5.4 The classification standards of farmer groups

(1) Demographic module

To estimate the number of available laborers in a household and lay the foundation for the next step in urban-rural labor allocation decision-making, it is essential to assess fertility, mortality, education, and marriage status. The framework of the demographic module is illustrated in Figure 5.5.

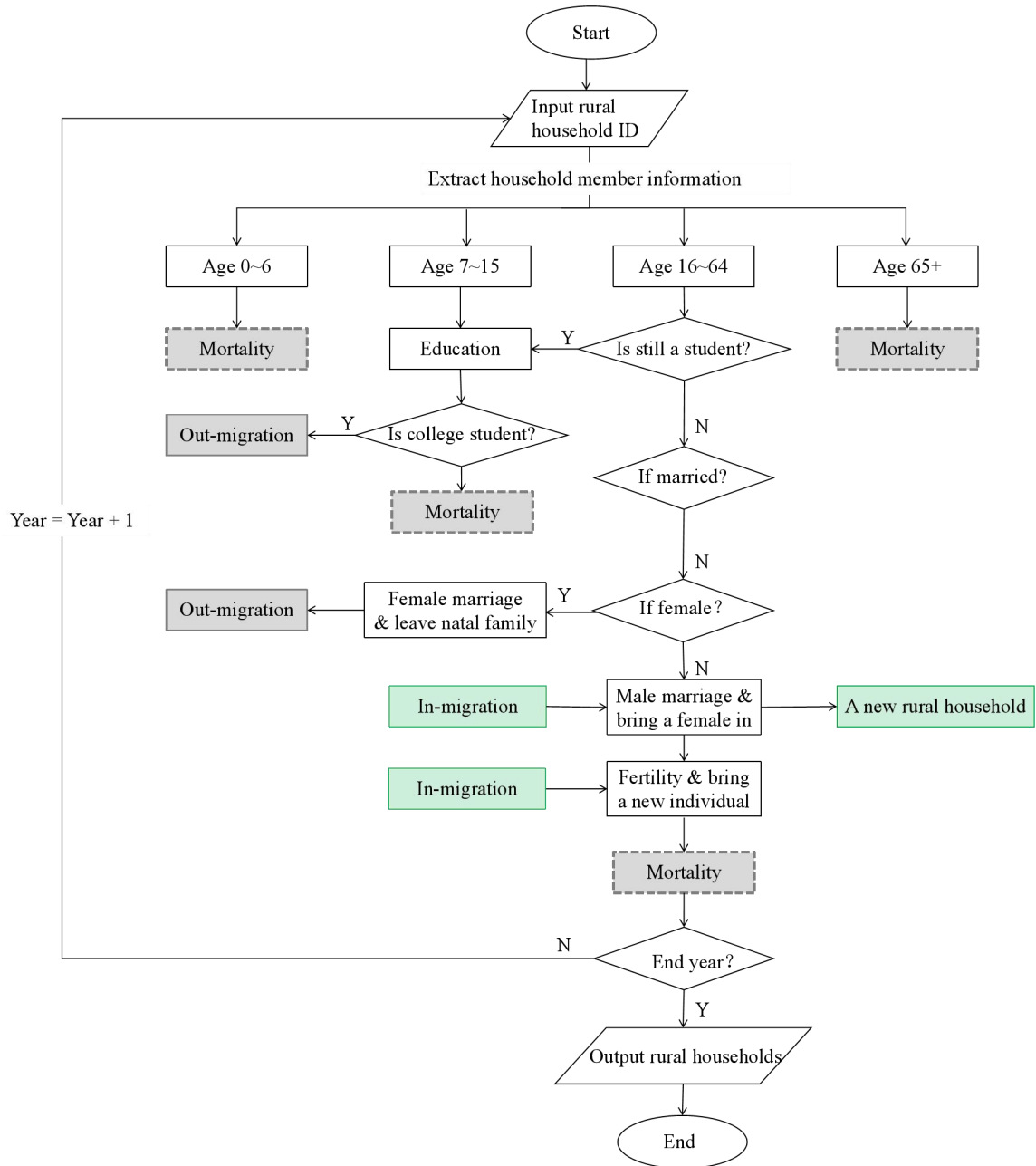


Figure 5.5 The framework of the demographic module

①**Fertility sub-model.** It is assumed that the fertility sub-model is applied to married females aged 20 to 45. Prior to 2016, China enforced a strict One-Child Policy. Under this policy, if the first child was a boy in a rural household, no additional births were permitted. If the first child was a girl, one more child was allowed. Violations of the policy were penalized: households that had one unauthorized child were fined twice their annual income, while those with two

unauthorized children faced fines amounting to three times their annual income. Between 2016 and 2021, China implemented a Two-Child Policy. After 2021, the transition to a Three-Child Policy was fully enacted.

Although China has implemented a strict fertility law for many years, the cultural preference for boys over girls has influenced family decisions. In rural areas of China, some households with two daughters may take the risk to give birth to another child and hope it will be a boy. Drawing on the findings of Wang (2018), this study incorporates factors such as female age, number of children in the household, whether the household already has a male child, the fine for exceeding birth limits, and the household income level. Based on the data of China Family Panel Studies (CFPS) collected biennially from 2010 to 2022, a binary logistic regression model is applied to estimate the likelihood of a household planning to have additional children $P_{plan-birth}$. Furthermore, whether a household can successfully obtain a newborn is also influenced by the local average birth rate $P_{local-birth}$. Combining the above indicators, the probability of a rural household successfully having a child can be expressed as:

$$P_{birth} = P_{plan-birth} \times P_{local-birth} \quad (5.1)$$

The regression coefficient estimation results for $P_{plan-birth}$ are presented in Table 5.1. The simulation achieves a high overall prediction accuracy of 94.4%, indicating that the model's fitting results are relatively reliable. The local average birth rate $P_{local-birth}$ is obtained by collecting data from statistical yearbooks specific to the study area. Finally, following Valbuena's probabilistic method (Valbuena et al., 2010), a random number between 0 and 1 is generated for each family. If the random number is less than the calculated probability value, the family will have a newborn.

Table 5.1 The estimated regression coefficients for the probability that a household plans to have additional children

Variables	$P_{plan-birth}$
Female age	-0.132** (0.064)
Number of children	-1.689** (0.850)
If has a male child	-1.331** (0.608)
Fine for excess births / household income	-0.206** (0.099)
Household income / living expense	0.909** (0.402)
Constant	5.096** (2.283)

Note: Standard errors are shown in brackets, *p < 0.1, **p < 0.05, ***p < 0.01.

②**Mortality sub-model.** Unlike fertility rates, mortality rates are primarily driven by physiological and objective factors, with minimal influence from subjective elements such as cultural beliefs. Meanwhile, with improvements in living standards and advancements in medical care, the overall mortality rate in China has remained relatively stable in recent years, except during special circumstances, such as the COVID-19 pandemic. However, it is worth noting that mortality rates vary significantly across different age groups and genders. Therefore, when simulating the mortality probability of individual farmers in this model, there is no need to infer based on complex influencing factors. Instead, mortality rates for different demographic groups should be directly categorized and organized using statistical yearbooks and census data from the specific study region. Subsequently, using Valbuena's probabilistic method, each farmer generates a random number between 0 and 1, which is compared with the mortality probability of the corresponding demographic group: if the random number is less than the mortality rate, the farmer is

assumed to have died and is removed from the model; otherwise, the farmer survives and his age increases by one year.

③ **Education sub-model.** To design a realistic education model, this study takes into account three related laws or regulations in China: the admission age for a child to attend school is 6 years old; all children are required to receive nine years of compulsory education, including primary school and middle school; and the legal minimum age for a person to work is 16 years old. Individuals of different ages are at different educational stages. For children under the age of 6, some families may offer a certain level of preschool education. In this study, they are uniformly categorized as not requiring formal compulsory education. Children aged 7 to 15 are required to complete nine years of compulsory education, corresponding to primary and middle school enrollment. For teenagers aged 16 and above, they can choose to either continue their education in high school or enter the workforce, at which point the probability of high school enrollment becomes a key consideration. Furthermore, at the age of 19, young adults face another decision: whether to pursue higher education at a college, at which point the probability of college enrollment becomes another key consideration. Therefore, young adults aged 19–23 are generally either working or studying in college. In this study, postgraduate and doctoral students are not included, as they are often economically independent and unlikely to return to rural areas after graduation.

Regarding high school enrollment rates, there is significant heterogeneity in learning abilities at the individual level and in overall educational standards at the regional level. Accordingly, this study begins by calculating the probability of each student entering high school or college based on individual differences. Referring to Hu & Li (2009), we selected individual-level indicators such as gender, whether attending at urban schools, and whether being a left-behind child, as well as family-level indicators, including parents' education level, household income, education investment, and parents' self-reported strictness of discipline. Using these

indicators, a binary logistic regression model is established to estimate the probability of a student successfully entering high school $P_{personal-highschool}$.

In particular, due to the vigorous development of higher education in recent years in China, college coverage rates are relatively high, meaning that as long as students successfully enter high school, they are likely to gain admission to college. Therefore, this study only focuses on predicting the individual enrollment rate for high school. Additionally, the final enrollment rate is influenced by the overall educational standards and the effects of the local average enrollment rates. $P_{local-highschool}$ and $P_{local-college}$, cannot be overlooked. Ultimately, these two indicators are combined to estimate the final enrollment rates, $P_{highschool}$ and $P_{college}$, as follows:

$$P_{highschool} = P_{personal-highschool} \times P_{local-highschool} \quad (5.2)$$

$$P_{college} = P_{local-college} \quad (5.3)$$

The probability of an individual entering high school $P_{personal-highschool}$ is estimated using a binary logistic regression, based on data from the China Education Panel Survey (CEPS), conducted between 2012 and 2018. The coefficient estimation results are presented in Table 5.2. The binary logistic regression model has a high overall prediction accuracy of 91.2%, indicating that the results are relatively reliable. The regional average enrollment rates $P_{local-highschool}$ and $P_{local-college}$ can be obtained based on officially published data from 2020 to 2024. Finally, following Valbuena's probabilistic approach, each household generates a random number between 0 and 1. If the random number is less than the simulated enrollment rate, the student successfully advances to the next level of education. Otherwise, the student enters the workforce, where they face employment choices.

Table 5.2 The estimated regression coefficients for the probability that a student can successfully enters high school

Variables	$P_{personal-highschool}$
Gender	-0.888*** (0.035)
Whether attending at urban schools	0.141** (0.068)
Whether being a left-behind child	-0.08** (0.040)
Highest parental education years	0.065*** (0.006)
Household income	0.011 (0.040)
Education investment/ household income	1.057*** (0.196)
Parents' self-reported strictness of discipline	0.253** (0.030)
Constant	-0.089 (0.146)

Note: Standard errors are shown in brackets, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

④ **Marriage sub-model.** Marriage has a significant impact on the composition of household laborer. In rural China, when a man marries, it typically means the addition of a laborer to his family; conversely, when a woman marries into another family, it results in the loss of a laborer to her original family. Whether a person can find a marriage partner is influenced by a variety of complex factors, which do not show obvious individual predictability. In view of this, when simulating the individual marital status, the probability of first marriage among farmers across different years and age groups in the specific study area should be determined based on national census data to ensure the rationality and accuracy of the model. Subsequently, Valbuena's probabilistic approach is applied to generate a random number between 0 and 1 for each eligible farmer. If the random number is less than the general marriage probability for the corresponding age group, the farmer is assumed to be married.

(3) Individual migration decision-making module

Rural households are defined as the builders and users of rural settlements, and their living and use requirements for rural settlements vary with the development of production and lifestyles. The subjective demand differences of peasant households are the main reason for the spatial differentiation of rural settlements. Building on the demographic model discussed in the previous section, the labor composition of each rural household has been updated. In this section, individuals aged 16 to 65 who are in good health are identified as the labor supply for a rural household. These laborers face decisions about their work mode, with each choice influencing their migration patterns. This study considers four common work modes: (1) Purely agricultural employment, (2) Predominantly agricultural employment, (3) Predominantly non-agricultural employment, and (4) Purely non-agricultural employment. The corresponding migration patterns are: no mobility or migration, short-term short-distance mobility, long-term long-distance mobility, and Permanent long-distance migration, respectively.

Regarding the migration choices of individual farmers, this study has established basic decision-making rules in Chapters 3 and 4. These rules are based on the principle of maximizing personal utility while taking into account migration costs and work-related income. This framework reflects the subjective needs of farmers and serves as the primary driver of urban-rural migration. However, this represents only the general decision-making approach adopted by most farmers when faced with the binary choice of whether to migrate. To enhance the accuracy and predictive power of the simulation model, it is necessary to further account for individual differences among farmers, the dynamic evolution of their decisions over time, and the spatial influence of geographical environments. These refinements aim to determine, with greater precision, the likelihood of farmers securing jobs at various wage levels, their subsequent choice of work type, and their preferred mode of migration. Such detailed considerations allow for a more accurate simulation of migration behavior among

different groups of farmers. The fundamental logic of this process is illustrated in Figure 5.6.

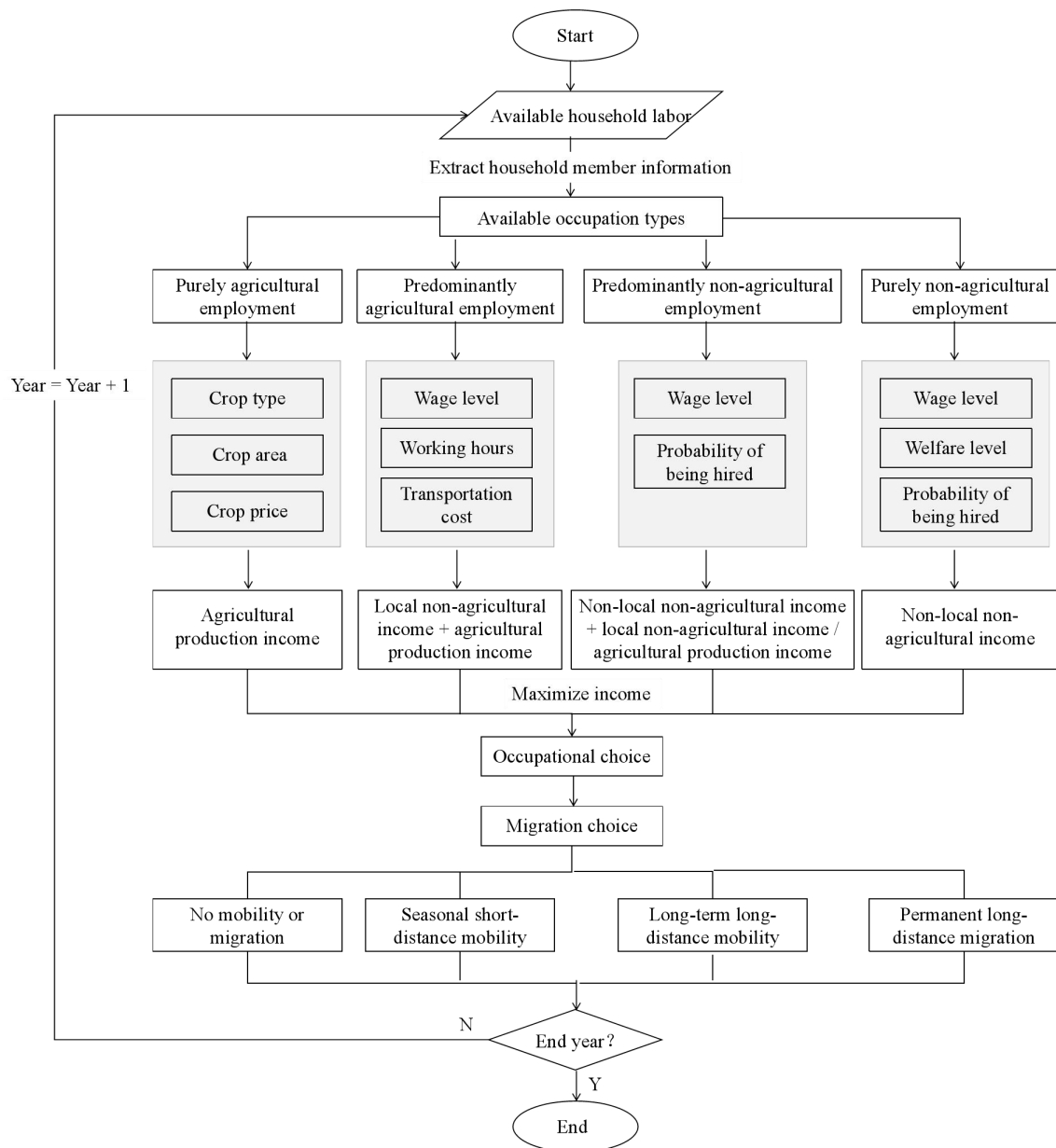


Figure 5.6 The framework of the individual migration decision-making module

① Purely agricultural employment (No mobility or migration) sub-model.

Generally, there are two primary production methods: planting cash crops based on local industrial development or resource endowments, and planting food crops. Considering that soil conditions across different plots within the same region show minimal variation, and that crop planting practices are generally inherited, farmers'

planting skills tend to be relatively stable. Therefore, it is assumed that the per-acre yield of the same crop does not vary significantly among farmers. The primary factor contributing to differences in farmers' planting income is the size of cropland.

According to existing research, the maximum planting area that farmers can manage is influenced by individual attributes such as age, gender, health status, and the maximum number of laborers the rural households can allocate to agricultural production. It is also shaped by agricultural conditions, including the level of mechanization, irrigation conditions of specific plots, and the role of agricultural production cooperatives. Additionally, farmers' perceptions, such as last year's grain prices and natural disasters, as well as policy incentives like national grain planting subsidies, play a significant role. Another critical constraint is the availability of transferable land within the village. Under the household contract responsibility system, farmers can expand their planting area only by leasing idle farmland from other villagers (Yang et al., 2022; Zhang et al., 2021). For cash crops, in addition to the aforementioned constraints and influencing factors, planting technology becomes the most crucial determinant of yield and income. This study considers two key aspects to assessing the impacts of planting technology: whether the farmer or the elders have prior experience in planting cash crops, and whether the village collective provides relevant agricultural training. In summary, the area functions for farmers' decisions to plant cash crops or food crops are as follows:

$$Y_k = \sum_{i=1}^{nk} \omega_i x_i \quad (5.4)$$

$$s.t. \quad Y_k - y_k \leq Y_{k_transfer}$$

Where k represents cash crop or food crop; nk represents the number of factors influencing the area of cash crops or food crops; ω_i represents the weight of each influencing factor; x_i represents the value of each influencing factor; $Y_{k_transfer}$

represents the area of land available for transfer within the same village; y_k represents the area of land owned by the farmer.

This study uses a multiple regression model, based on survey data collected from the study area, to obtain the weights of factors influencing the area of food crops planted by farmers. The results are shown in Table 5.3. There are many types of cash crops in various locations, and predictions need to be made based on the specific data of the study area.

Table 5.3 The estimated regression coefficients for farmers' planting area

Variables	Y_k	Variables	Y_k
Age	-1.345** (0.648)	Performance level of cooperative	36.292* (21.769)
Health status	36.171** (14.389)	Grain price last year	60.578* (31.631)
Maximum available labor	20.609** (8.160)	Whether a natural disaster occurred last year	-72.498* (43.345)
Total power of agricultural machinery	0.313 (0.219)	Planting subsidies	0.038** (0.0169)
Irrigated area	1.118* (0.668)	Constant	-63.611** (71.245)

Note: Standard errors are shown in brackets, *p < 0.1, **p < 0.05, ***p < 0.01.

Furthermore, the final annual income that farmers can obtain by choosing pure agricultural planning in rural areas is:

$$W_{planting} = (p_k - c_k)Y_k - r_k(Y_k - y_k) - c_{repair} - c_{rural_living} \quad (5.5)$$

Where p_k represents the market price of cash crop or food crop, which can be obtained by the *National Agricultural Product Cost and Returns Compilation*; c_k represents the cost of materials and services such as seeds, fertilizers, pesticides, tools, etc.; r_k represents the average rental price per mu of cultivated land; c_{repair} represents the additional cost of machinery and its daily maintenance required to grow cash crops; c_{rural_living} represents the average annual cost of living in rural areas.

② **Predominantly agricultural employment (Short-term short-distance mobility) sub-model.** Generally speaking, non-agricultural jobs in rural areas primarily consist of informal occupations, including handicraft processing, retail, catering, and cleaning. These jobs typically enable workers to commute daily from home or occasionally stay overnight in nearby towns in the county. The entry barriers for such jobs are low, requiring only basic qualifications, such as gender and age. Field visits and investigations of recruitment notices from local companies reveal that young women and middle-aged men are preferred in the local non-agricultural labor market, with this group generally earning higher wages. Additionally, the primary costs associated with local non-agricultural work, beyond basic living expenses in rural areas, are transportation expenses. In summary, the income of farmers engaged in local non-agricultural work can be expressed as:

$$W_{local_offfarm} = w_{local_offfarm} - c_{rural_living} - c_{transportation} \quad (5.6)$$

Where $w_{local_offfarm}$ represents the average wage for local non-agricultural jobs, which should be sorted out according to the actual situation of labor market in specific study area and classified by age and gender; $c_{transportation}$ represents transportation expenses.

③ **Predominantly non-agricultural employment (Long-term long-distance mobility) sub-model.** The income farmers can earn from long-term non-agricultural work in other regions depends not only on the local average wage levels but also on concerns about whether they can secure a job smoothly and whether the local living costs are excessively high. The factors influencing a farmer's likelihood of finding a job primarily include individual attributes such as age, gender, education level, and skill level; overall labor market conditions such as city size and the number of enterprises; and social resources, such as the number of relatives and friends already working in the migration destination. In summary, the final income of farmers who choose long-term non-agricultural work in other locations can be expressed as:

$$W_{out_offfarm} = P_{out_offfarm} w_{out_offfarm} - c_{urban_living} \quad (5.7)$$

$$P_{out_offfarm} = \sum_{j=1}^7 \omega_j x_j \quad (5.8)$$

Where $w_{out_offfarm}$ represents the average wage level for non-agricultural jobs in other locations; $P_{out_offfarm}$ represents the probability that farmers can find a job; c_{urban_living} represents the average annual cost of living in the migration destination; ω_k represents the weight of each influencing factor; x_k represents the influencing factors. To simplify the calculations, this study focuses on destination cities where other villagers have previously migrated, which aligns better with real-world scenarios, as farmers often rely on referrals from relatives and friends when seeking work, making such job opportunities more accessible. Furthermore, to determine the specific weights of factors influencing farmers' success in securing non-agricultural jobs, a multiple regression model is employed, based on data from the China Labor-force Dynamics Survey (CLDS), conducted biennially from 2012 to 2018. The coefficient estimates are presented in Table 5.4.

Table 5.4 The estimated regression coefficients for the probability that farmers secure non-agricultural jobs in cities

Variables	$P_{out_offfarm}$	Variables	$P_{out_offfarm}$
Age	-0.033*** (0.007)	Size of migration destination city	-0.373 (1.536)
Gender	0.368** (0.147)	Number of enterprises in migration destination city	0.139*** (0.042)
Years of education	0.088*** (0.023)	Number of relatives in migration destination city	0.323*** (0.033)
skill level	0.143*** (0.028)	Constant	-0.291 (0.466)

Note: Standard errors are shown in brackets, *p < 0.1, **p < 0.05, ***p < 0.01.

④ **Purely non-agricultural employment (Permanent long-distance migration) sub-model.** The income from permanent non-agricultural work in other locations is generally comparable to that of long-term non-agricultural work in other regions. However, the key difference lies in the fact that permanent work often entails the relocation of the entire family. As a result, the migration cost includes not only basic living expenses but also additional welfare costs $c_{welfare}$, such as those related to healthcare, children's education, employment opportunities, housing, and other challenges arising from the lack of urban hukou. At this point, the utility function for farmers choosing permanent non-agricultural work in other locations can be expressed as:

$$W_{long_offfarm} = W_{out_offfarm} - c_{welfare} \quad (5.9)$$

During each iteration of the model, farmers decide which livelihood strategy to adopt by comparing the expected income of each work mode. Specifically, newly eligible laborers, such as those who have just turned 16 or have recently graduated and entered the workforce, will have the option to choose from the four available work modes. For existing laborers, they typically compare their earnings from the previous year with the expected income of the other three options. If last year's income was higher, they will maintain their current work status; otherwise, they will switch to the work mode offering higher income.

(4) Household homestead use decision-making module

Using the individual migration behavior model constructed earlier, it is evident that families engaging in long-term or permanent non-agricultural work in other regions will inevitably leave their homesteads idle. Focusing on these rural households, this study further explores whether they choose to withdraw from their idle homesteads. Based on the discussion in Chapter 3 regarding farmers' behavior, the utilization of homesteads is determined by the overall utility comparison at the household level. Factors such as the farmers' human capital, social capital, material

capital, natural capital, financial capital, and the surrounding economic and social environment significantly influence their decision-making process. The formula for calculating the probability of farmers withdrawing from their homesteads is:

$$p_{withdrawal} = \sum_{h=1}^{h'} \omega_h x_h \quad (5.10)$$

Where ω_h represents the weight of each influencing factor; x_h represents the values of each influencing factor; h' represents the number of influencing factors. The coefficients of each factor and its corresponding weight are based on the empirical results presented in Chapter 4.

(5) Household newly-added homestead site selection module

In China, every newly married rural couple is entitled to apply to the village collective for a plot of homestead, on which they can build a new house and establish their own household, separate from their parents. The land available for new families typically consists of unused construction land within the village, including reserve land reclaimed by the village collective from other villagers who have withdrawn from their homesteads. The size of the homestead allocated to new families is determined based on the standard homestead size specified by local regulations.

Generally, without the interference of industrialization and urbanization, villages would evolve naturally and expand into areas with flat terrain, good irrigation conditions, and high organic matter content. However, with the transformation and upgrading of rural industrial structures, agriculture-oriented industries are being transferred to secondary and tertiary industries. As rational economic men, peasant household agents will pursue the maximization of comprehensive interests as the premise. Consequently, rural settlements will generally relocate to areas with higher economic output, better infrastructure, and improved public services. This study considers five primary factors: natural conditions, transportation conditions, living conditions, employment conditions, and proximity to family. Farmers choose their

preferred location by comparing the overall scores of each available plot, aiming to maximize the composite score. Natural conditions include factors such as elevation and slope. Transportation conditions consider the distance to major roads and bus stations. Living conditions are considered in terms of proximity to schools, hospitals, and recreational centers. Employment feasibility encompasses factors such as whether the plot is located along a main street for easy small-business operations, the distance to personal farmland, proximity to industrial parks for casual labor during the off-season, and distance to tourist attractions for engaging in tourism-related side businesses. Proximity to family is measured as the distance to the parents' residence. In summary, the composite score of a plot can be expressed as:

$$S = \sum_{m=1}^{m'} \omega_m x_m \quad (5.11)$$

Where ω_m represents the weight of each influencing factor; x_m represents various factors affecting farmers' site selection; m' represents the number of influencing factors. This study employs the multi-criteria evaluation (MCE) model to determine the weights of each influencing factor, utilizing the expert scoring method to calculate these weights (see Table 5.5).

Table 5.5 Weights of factors influencing farmers' new homestead site selection

Influencing factors	Natural condition	Transportation condition	Living condition	Employment condition	Proximity to family
Weight	0.09	0.20	0.32	0.34	0.05

5.4.2 Decision-making models of other agents

The decision-making models of rural households constructed in the previous section represent their initial willingness to use the homestead, based on their own risk resistance and the perceived value of their homestead endowments. Based on the analysis of the evolution mechanism of homestead use behavior in Chapter 3, the

ultimate decision of whether rural households will withdraw from their homesteads is influenced not only by their personal factors but also by the interactions and dynamics involving other stakeholders, such as enterprises, government authorities, clan relatives, and members of the same residential group.

The influence of enterprises and governments on farmers' behavior is indirect. Enterprises affect farmers by changing urban and rural living costs through changing in the market prices of consumer goods or by influencing farmers' employment choices through adjustments in wage levels for urban jobs. Similarly, governments play a role by shaping farmers' decisions regarding rural-urban migration through changes in the level of public services available in urban and rural areas, or by influencing employment choices through modifications in urban and rural land allocation, which in turn impact the production decisions of enterprises. In the model constructed in the previous section, factors such as prices, public service levels, and the cost of living in the migration destination city have already been incorporated to reflect the indirect influence of enterprises and governments on farmers' decision-making.

The influence of relatives in the clan and members of the same village group on farmers is direct. In essence, the interactive influence among farmers follows two basic principles: the homogeneity principle and the heterogeneity principle (Lin, 1999). The homogeneity principle reflects interactions among farmers of the same type, primarily driven by imitation behavior. When a higher proportion of farmers with similar characteristics choose to withdraw from their homesteads, other farmers are more likely to be influenced by herd mentality, thereby increasing their own probability of withdrawal. The principle of heterogeneity reflects interactions among farmers of different types, primarily influenced by comparison psychology. If farmers who adopt different homestead disposal strategies achieve lower benefits, the impact of this difference on an individual farmer's decision is minimal. However, if those farmers achieve higher benefits, it increases the likelihood that an individual farmer

will align their decision with that of the higher-income farmers. Moreover, this tendency to converge grows stronger as the income gap widens. Based on this, the probability of a farmer withdrawing from their homestead can be further revised based on Equation (5.10) as follows:

$$P'_{i,withdrawal} = \begin{cases} P_{i,withdrawal} \times (1 + \beta_{1i}) \times (1 + \beta_{2i}) & \text{If another farmer } i' \text{ withdraws from his homestead} \\ P_{i,withdrawal} \times (1 + \beta_{1i}) \times (1 - \beta_{2i}) & \text{If another farmer } i' \text{ does not withdraw from his homestead} \end{cases} \quad (5.12)$$

$$\beta_{1i} = \frac{n_h}{N_h} \quad (5.13)$$

$$\beta_{2i} = \begin{cases} 0 & \text{if } In_{ih} \geq In_{i'h'} \\ \frac{In_{ih}}{In_{i'h'}} & \text{if } In_{ih} < In_{i'h'} \end{cases} \quad (5.14)$$

Where i, i' represent farmers; k, k' represent the types of farmers; β_{1i}, β_{2i} represent the influence coefficients of the same-type farmers and the different-type farmers on the individual farmer i respectively; n_h represents the number of farmers in the h -th category who have withdrawn from their homesteads; N_{ht} represents the number of farmers in the h -th category; $In_{ih}, In_{i'h'}$ represents farmers' income.

Finally, for simulating farmers' behavioral choices regarding whether to withdraw from homesteads, this study adopts a probabilistic approach. In each iteration of the simulation model, each rural household generates a random number between 0 and 1, which is then compared with the previously calculated probability of homestead withdrawal for that household. If the random number is less than the calculated probability, the household is considered to withdraw from this homestead; otherwise, the household retains the idle homestead.

5.4.3 Spatial environmental impact models

Macro-geographical and environmental factors can affect the functions,

efficiency, and patterns of regional land use, while micro-locational differences shape the market value of land. Together, these factors significantly affect farmers' cognition of the current and future value of homesteads, thereby influencing their decisions on whether to withdraw from them. Therefore, the study characterizes the macro-geographical conditions of homesteads in terms of topography, environmental quality, proximity to scenic areas, and levels of economic development. Simultaneously, it evaluates the micro-locational conditions based on factors such as distance to the central town, transportation accessibility, and living convenience, ultimately constructing spatial environmental impact models.

(1) Topography

Topography is a fundamental factor determining the functional spatial differentiation of homesteads. In this study, elevation and slope are used to evaluate the topographical conditions of homesteads, specifically:

$$E_{Terrain} = \lambda_1 E_{elevation} + \lambda_2 E_{slope} \quad (5.15)$$

Where $E_{elevation}$ and E_{slope} represent elevation and slope, respectively; λ_1 , λ_2 are the impact weight, $\lambda_1 + \lambda_2 = 1$.

(2) Environmental quality

Livability determines the value of the homestead's residential function, with air quality and distance to the river (water bodies) serving as key evaluation factors. Accordingly, this study assesses overall environmental quality using two indicators: the proportion of days in a year with an AQI rating of "good" or above, and the distance attenuation coefficient of the homestead relative to the nearest water source, specifically:

$$E_{air} = \frac{d_{perfect}}{365} \quad (5.16)$$

$$E_{water} = \eta_w e^{-\tau_w D_w} \quad (5.17)$$

$$E_{environment} = \lambda_3 E_{air} + \lambda_4 E_{water} \quad (5.18)$$

Where E_{air} , E_{water} , $E_{environment}$ respectively represent air quality evaluation, distance to water source, and overall environmental quality evaluation; $d_{perfect}$ represents days in a year with an AQI rating of "good" or above; η_w represents the intensity coefficient of the spatial impacts of water bodies; τ_w represents the attenuation coefficient of the spatial impacts of water bodies; D_w represents the distance from the location of the homestead to water bodies; λ_3 , λ_4 represent the weights of air quality and water bodies affecting environmental quality, $\lambda_3 + \lambda_4 = 1$.

(3) Proximity to scenic areas

If a homestead falls within the influence range of a scenic area, farmers can combine the local tourism and cultural characteristics to develop rural inns or homestays. In such cases, the value of the homestead's asset function becomes more prominent. This study uses the distance attenuation coefficient from the target homestead to the scenic area to measure this impact, specifically:

$$E_{attraction} = \eta_a e^{-\tau_a D_a} \quad (5.19)$$

Where η_a represents the intensity coefficient of the spatial impact of scenic areas; τ_a represents the attenuation coefficient of the spatial impact of scenic areas; D_a represents the distance from the location of the homestead to scenic areas.

(4) Economic development

Urban and rural economic development is a key driver of the spatial differentiation in the functional value of rural homesteads. As urban development continues to expand into rural areas, a significant number of farmers migrate to cities, leading to a diversification of their livelihood structures and a transformation in the functions of rural homesteads. According to the law of distance attenuation, the social, economic, and cultural center exerts a radiation effect on surrounding villages, with its influence diminishing in a predictable pattern as the distance between the village and the central town increases. This study characterizes this effect using an exponential distance attenuation coefficient, specifically:

$$E_{economy} = \eta_e e^{-\tau_e D_e} \quad (5.20)$$

Where η_e represents the intensity coefficient of the spatial impact of central towns; τ_e represents the attenuation coefficient of the spatial impact of central towns; D_e represents the distance from the location of the homestead to the central towns.

(5) Transportation accessibility

Traffic accessibility can be measured based on the distance from the homestead to the nearest road. Typically, two types of roads are considered in common evaluation metrics: expressways and general roads. Expressways reflect the connectivity of homesteads to other cities, serving as a critical foundation for the development of rural industries. General roads, on the other hand, indicate the convenience of farmers' day-to-day lives. The influence of these two road types differs in weight. In this study, an exponential distance decay function is employed to represent their spatial attractiveness to a given location, specifically:

$$E_{traffic} = \lambda_5 \eta_{eroad} e^{-\tau_{eroad} D_{eroad}} + \lambda_6 \eta_{hroad} e^{-\tau_{hroad} D_{hroad}} \quad (5.21)$$

Where λ_5, λ_6 represent the influence weights of the distance to each type of road, $\lambda_5 + \lambda_6 = 1$; $\eta_{eroad}, \eta_{hroad}$ represent the intensity coefficients of the spatial impact; $\tau_{eroad}, \tau_{hroad}$ represent the attenuation coefficients of the spatial impact; D_{eroad}, D_{hroad} represent the distance from the location of the homestead to the nearest expressways and general roads.

(6) Living convenience

As urban housing prices continue to rise and urban diseases intensify, the tranquil and leisurely lifestyle of farmyards has become increasingly appealing. In this context, homesteads located in areas with convenient transportation, comprehensive social services, and quality educational resources are highly sought

after. The opportunity cost for farmers to withdraw from homesteads is significant, resulting in a weaker willingness to give up them. This study employs an exponential distance attenuation coefficient to measure the utility of public service facilities surrounding homesteads, including schools, hospitals, cultural and sports centers, and commercial service centers, specifically:

$$E_{facilities} = \lambda_7 \eta_s e^{-\tau_s D_s} + \lambda_8 \eta_h e^{-\tau_h D_h} + \lambda_9 \eta_c e^{-\tau_c D_c} + \lambda_{10} \eta_b e^{-\tau_b D_b} \quad (5.22)$$

Where $\lambda_7, \lambda_8, \lambda_9, \lambda_{10}$ represents the influence weights of the distance to each type of public service facilities, $\lambda_7 + \lambda_8 + \lambda_9 + \lambda_{10} = 1$; $\eta_s, \eta_h, \eta_c, \eta_b$ represent the intensity coefficients of the spatial impact; $\tau_s, \tau_h, \tau_c, \tau_b$ represent the attenuation coefficients of the spatial impact; D_s, D_h, D_c, D_b represent the distance from the location of the homestead to the schools, hospitals, cultural and sports centers, and commercial service centers.

5.5 Scenario settings for hukou and homestead system reforms

This study serves as a policy laboratory to examine household-level decisions on rural-urban labor allocation, rural-urban migration, and homestead use under various institutional reform scenarios. It aims to enhance understanding of the dynamic changes in the coupled human-land system and to predict the evolution of homestead use, the transformation of farmers' livelihood characteristics, and the differentiation of farmer groups influenced by institutional reform.

This dissertation focuses on the two systems most closely linked to migration and rural land transfer: the hukou system and the homestead system. As mentioned above, hukou system reform can ease restrictions on farmers settling in cities, reduce the institutional friction costs of rural-urban migration, and increase farmers' willingness to migrate. The urban social welfare security obtained through the hukou system reform can help compensate for the loss of security value following the withdrawal from homesteads, thereby also increasing farmers' willingness to

withdraw from homesteads to a certain extent. Homestead system reform has opened up an institutional channel for realizing the value of homestead assets, removed the institutional barriers to the transfer of rural land, and increased farmers' willingness to withdraw from their homesteads. Additionally, the compensation received for homestead withdrawal can provide financial support for farmers' rural-urban migration. The joint reform of these two systems can play a significant synergistic and complementary role and improve the overall institutional efficiency. The theoretical and empirical analyses in the previous section have examined the interactive relationship between the two system reforms in facilitating homestead withdrawals and identified the specific policies that have a tangible impact within the institutional framework. Building on this, this section will design various reform scenarios for hukou and homestead systems, further explore the specific numerical settings of these key policies to maximize their effectiveness.

The institutional reform scenarios are described below:

First, the urban hukou registration thresholds prior to the 2015 nationwide hukou system reform, along with policies such as the free allocation and non-transferability of homesteads before the homestead system reform, are selected as the baseline. Based on this, the study explores the spatio-temporal effects of homestead use under the scenario where both systems remain tightly restricted and unchanged.

Then, focusing on the scenario where only the hukou system is reformed while the homestead system remains unchanged, four scenarios are designed with the threshold indexes for obtaining urban hukou reduced by 0%, 10%, 50%, and 100%, respectively. The spatio-temporal effects of homestead use are then compared and analyzed across these scenarios.

Next, the study focuses on the scenario where only the homestead system is reformed while the hukou system remains unchanged, with particular attention given to the policies of paid use and paid withdrawal within the homestead system reform. For the paid use policy, four scenarios are designed in which farmers are required to

pay 0 yuan, 5 yuan, 50 yuan, or 100 yuan per square meter for the portion of the homestead that exceeds the national standard area. For the paid withdrawal policy, two approaches are considered: a one-time cash compensation and an apartment compensation policy for homestead withdrawal. For the one-time cash compensation policy, due to significant variations in land and housing prices across regions, it is not feasible to use a uniform amount for simulation. To enhance comparability and derive more universally applicable conclusions, this study uses the local real estate prices in the research area as a benchmark, and the cash compensation for homestead withdrawal is expressed as a percentage of the average local real estate market price, with four scenarios designed at 0%, 5%, 50%, and 100%, respectively. For the apartment compensation policy, this study designs four scenarios in which each unit of withdrawn homestead can be exchanged for 0%, 5%, 50%, or 100% of a unit of township housing. Furthermore, the critical thresholds at which the two policies significantly enhance the effectiveness of encouraging farmers to withdraw from their homesteads are identified and combined, followed by a comparative analysis of the spatio-temporal effects of homestead use.

Finally, focusing on the scenarios of joint reform of hukou system and homestead system, the optimal policies derived from the above scenarios are selected and combined, followed by a comparative analysis of the spatio-temporal effects of homestead use across the previously designed scenarios of no reform and single-system reform.

All the scenarios are summarized in Table 5.6.

Table 5.6 The scenario settings for hukou and homestead system reforms

Institutional scenarios	Decline rate of hukou threshold Index (%)	Paid use fee for homestead (Yuan)	Compensation for homestead withdrawal	
			Cash compensation (%)	Apartment compensation (%)
(1) No reforms	0	0	0	0
(2) Hukou system reform alone				
A1: Low reform intensity	10	0	0	0
A2: Medium reform intensity	50	0	0	0
A3: High reform intensity	100	0	0	0
(3) Homestead system reform alone				
B1: Low paid use fee	0	5	0	0
B2: Medium paid use fee	0	50	0	0
B3: High paid use fee	0	100	0	0
(4) Homestead system reform alone				
C1: Low cash compensation	0	0	5	0
C2: Medium cash compensation	0	0	50	0
C3: High cash compensation	0	0	100	0
(5) Homestead system reform alone				
D1: Low apartment compensation	0	0	0	5
D2: Medium apartment compensation	0	0	0	50
D3: High apartment compensation	0	0	0	100
(6) Homestead system reform alone				
E1: cash compensation × apartment compensation	0	0	The optimal value in Scenario (4)	The optimal value in Scenario (5)
(7) Joint reform of hukou system and homestead system				
F1: hukou system reform × homestead system reform	The optimal value across all scenarios	The optimal value across all scenarios	The optimal value across all scenarios	The optimal value across all scenarios

It is worth noting that this study does not take into account external driving factors such as rural land expropriation caused by infrastructure development, urban

expansion, or extreme one-off events like economic crises and pandemics. These events tend to have disruptive and transformative effects on homestead land use patterns. However, they are highly contingent, sudden, and unpredictable, making them difficult to model within a systematic analytical framework. The goal of this study is to explore the general patterns and long-term effects of institutional reforms. Including such exogenous shocks would obscure the underlying mechanisms and compromise the generalizability of the findings. Moreover, the analysis of such events lies beyond the intended scope of this paper and warrants a separate line of inquiry.

5.6 Indicator settings for spatio-temporal effects of homestead use

Based on the above analysis, under hukou and homestead system reforms, an increasing number of farmers are moving to cities, and a large number of idle homesteads will be transferred, withdrawn, or reused. This process will generate complex spatio-temporal effects. In the short term, at the micro level, it will be accompanied by changes in farmers' livelihood characteristics and human-land relationships. In the long term, at the regional level, it will manifest as the differentiation of farmer groups and the evolution of homestead use. Therefore, this study develops representative variables to capture the spatio-temporal effects of homestead use in two aspects: farmers and homesteads, and from two perspectives: horizontal institutional reform and vertical temporal changes.

To represent human system dynamics, indicators are selected at both the village and household levels. Specifically, household-level indicators include the proportion of household labor allocated to cash crop planting, grain crop planting, local non-agricultural work, temporary non-agricultural work in other areas, and stable non-agricultural work in other areas, as well as the corresponding income shares from these activities. These indicators are used to analyze the impacts of institutional reforms on the urban-rural labor distribution and the income structures of rural households, further reflecting the evolution of homestead functions. At the village

level, indicators such as total population and per capita income are used to analyze the impact of institutional reforms on the urban-rural income gap.

Regarding the homestead dynamics, indicators are selected at both household and patch levels. At the household level, changes in the areas of homestead occupation, idleness, newly-added, transfer, and withdrawal are tracked to assess the impacts of institutional reforms on homestead use decision-making. At the patch level, the spatial layout, morphological structure, and other map displays are used to analyze the impacts of institutional reforms on the spatial structure of homestead use.

5.7 Conclusions

This chapter, grounded in complex adaptive systems theory, integrates a multi-agent system and a geographic information system to develop a spatially explicit agent-based model for simulating the spatio-temporal effects of homestead use.

First, a general framework integrating a multi-agent system (MAS) and a geographic information system (GIS) is constructed from four dimensions: institutional reform scenarios, multi-agent system, geographic environment system, and simulation platform. Then, the simulation process of the model is designed. Next, behavior decision rules for different agents are defined through four modules: demographic change, individual migration decision-making, household homestead land-use behavior, and geographic environmental impacts. These modules also quantify the mechanisms through which geographic and spatial environments influence decision-making, thereby constructing a coupled human-land system. Finally, different scenarios for hukou and homestead system reforms are developed to form a policy experimentation environment.

This model captures the interactions, feedbacks, and trade-offs among institutional interventions, social networks, labor migration, homestead land-use decisions, and environmental changes by establishing social relationships among

individuals, households, and village groups, as well as spatial linkages between households and homesteads. This enables a clear representation of the complex phenomena, processes, and outcomes of rural homestead use evolution, and provides a solid foundation for subsequent simulations of spatio-temporal effects, evaluations of institutional reform impacts, and the proposal of optimized reform pathways.

Chapter 6: Simulation of the Spatio-temporal Effects of Homestead Use under the Joint Reform of Hukou System and Homestead System

6.1 Introduction

The previous chapter has developed a simulation model to examine the spatio-temporal effects of homestead use under hukou and homestead system reforms. This chapter aims to incorporate real-world case data to simulate both the micro-level mechanisms and macro-level dynamics of homestead use evolution under different reform scenarios. Based on the simulation results, policy recommendations are proposed to support the deepening of institutional reforms.

First, the model is initialized using the NetLogo platform. Second, homestead use changes in 2017 are simulated, and the results are validated by comparing them with actual survey data from the same year to assess the model's accuracy. Third, setting 2017 as the baseline year, the model simulates changes in household behavior under four institutional reform scenarios: the current policy status, hukou system reform alone, homestead system reform alone, and joint reform of both systems. These simulations encompass changes in rural-to-urban migration, labor allocation, and homestead land use, as well as spatial variations in land-use patterns, efficiency, and area by 2030. Finally, the spatio-temporal outcomes of different reform scenarios are compared and analyzed, and policy recommendations are proposed to support the deepening of institutional reforms.

The practical contribution of this study lies in providing a scientific basis for the formulation and implementation of territorial spatial planning and village planning in the new era, as well as for improving the quality of rural settlements and promoting the intensive and efficient use of homesteads. It also proposes differentiated pathways

for deepening reforms of hukou and homestead systems, offering policy insights to support the improvement of institutional frameworks.

The rest of this chapter is organized as follows. Section 6.2 introduces the study area and data sources. The initialization of model parameters is detailed in Section 6.3. Section 6.4 verifies the accuracy of the simulation. Simulation results and corresponding analysis are presented in Section 6.5. Finally, Section 6.6 concludes the chapter with a summary of key findings.

6.2 Study area and data sources

6.2.1 Study area

Yucheng County is located in the northwest of Shandong Province, China, at 116°22' - 116°44'E and 36°40' - 37°12'N (Figure 6.1). There are 120,000 rural households and 130,000 rural homesteads covering an area of 63,000 acres. However, the vacancy rate of rural houses exceeds 50%, and the issues of hollowing out villages and low homestead efficiency are particularly prominent.

In terms of homestead system reform, Yucheng County was selected as a national pilot area for rural homestead system reform in both 2017 and 2020. The main reform measures focus on three aspects. First, rural households with more than one piece of homestead or whose homestead area exceeds the regulations have to pay an annual usage fee of 1-5 yuan per square meter. Second, farmers are encouraged to voluntarily withdraw from their homesteads in exchange for compensation, which may consist of either cash compensation or apartment compensation. The cash compensation is assessed by certified property valuation agencies based on the local benchmark land price, while the apartment compensation is allocated at 40 square meters per registered member of the rural collective, as determined by the household registration record. Thirdly, the market-oriented homestead transfer and diverse homestead reuse methods are further explored, such as utilizing withdrawn homesteads to build agricultural parks and industrial parks, which can attract a large

number of farmers to start businesses and find employment on the spot.

In terms of hukou system reform, Yucheng County actively responded to the *Opinions on Further Advancing the Reform of the Hukou System* issued by the State Council. As a small city with a population of fewer than 500,000, Yucheng has fully removed restrictions on urban hukou. The Public Security Bureau issued the *Implementation Guidelines for Zero-Threshold Settlement*, aiming to establish a system that allows anyone with the intention to migrate to the city to do so freely, with no entry barriers and access to one-stop registration services. Both non-local and local residents who wish to live, work, or settle in Yucheng can apply for hukou at the local police station using only their national ID card. The joint reform of hukou system and homestead system is expected to significantly influence farmers' decisions regarding rural-to-urban migration and the use or withdrawal of their homesteads.

To characterize the change in homestead use among all households, we confine our study site to a small village named Douzhuang village that lies in the south-central part of Yucheng County (Figure 6.1). It covers a total land area of 3006.9 acres, including 337.9 acres of construction land, 1753 acres of cultivated land, and 283 vegetable greenhouses, with an average of 1.73 greenhouses per household. It is a well-known local village specializing in vegetable greenhouses. It consists of 226 households and approximately 700 residents. However, the permanent population is less than 300, and most young people choose to migrate out to work; they do not always apply for a homestead or keep their homestead idle all year round. And most of the elderly laborers grow vegetables in greenhouses, so their income is relatively high, and the village is only 7 km away from the county center, most of them buy commercial houses in the county, leaving their homestead idle. Since this village is close to two core streets, homesteads and above-ground houses can be rented out in some locations along the streets. Since the homestead system reform, Douzhuang Village has withdrawn and revitalized 109.4 acres of idle homesteads. Among them, the land close to cultivated areas has been reclaimed, and the land within the village

has been developed to cultivate honeysuckle and build high-quality vegetable seedling factories, thereby activating the endogenous power of rural revitalization.

This study area is highly representative. In terms of current homestead use, a large number of rural households have migrated to urban areas for work, resulting in over 50% of homesteads being left idle. This issue not only relates to household registration for rural migrants but also presents significant challenges for the withdrawal, revitalization, and reuse of idle homesteads. These challenges are common across the vast majority of rural areas in China and lie at the core of the hukou and rural homestead system reforms. In terms of functional classification, street-facing homesteads in the village possess considerable market potential and can serve commercial purposes. Homesteads located deeper within the village tend to serve residential and security functions. Long-term idle homesteads, on the other hand, retain only basic security and emotional value. This functional diversity reflects the varied values placed on homesteads by different households, which in turn leads to diverse behavioral strategies in how farmers choose to retain, transfer, or withdraw from their homesteads. Such complexity poses challenges for designing practical reform pathways and differentiated policy measures. At the same time, it makes this village a highly representative case that mirrors the diversity of rural homestead use patterns across the country. From the perspective of development conditions, the village is located in the suburban area of a small city on the North China Plain. While it has some development opportunities, the overall economy remains underdeveloped, making it a typical example of many rural areas in China and thus representative to a certain extent. Meanwhile, the village has a strong foundation in specialized agricultural industries, providing room for diversified reuse of withdrawn homesteads. Its close proximity to the urban core also gives it the potential to be gradually integrated into urban development. These factors make it an ideal site for comparative analysis and decision-making regarding various revitalization models for idle homesteads.

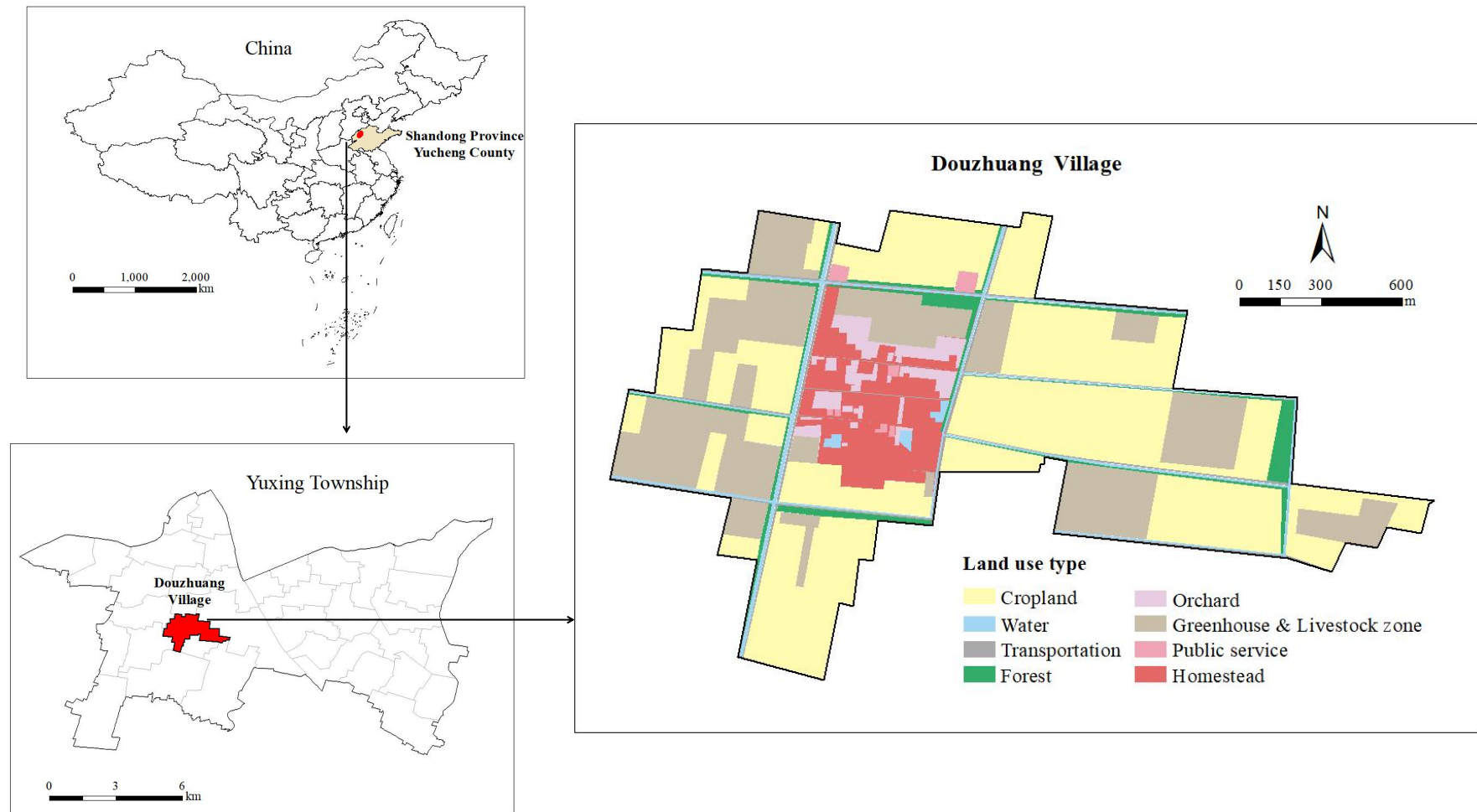


Figure 6.1 The study case: Douzhuang Village in Yucheng County of Shandong Province, China

6.2.2 Data sources

The data used in this study mainly include demographic and socioeconomic data, household survey data, farmers' social network information, geographic spatial data, and homestead use data.

The socioeconomic data primarily include indicators such as fertility rate, mortality rate, average age at first marriage, high school and college enrollment rates, the level of agricultural mechanization, and local economic development. These data were obtained from the *Yucheng Statistical Yearbook* and official records provided by the Yucheng municipal government.

Household survey data were collected through door-to-door interviews conducted in 2020, covering every household in the village. At the time of the survey, the village had already begun implementing the homestead system reform. To better understand the changes in household conditions before and after the reform, the questionnaire included retrospective questions covering both time periods. The questionnaire consisted of 20 pages and typically took about 1.5 hours to complete. Survey topics included household composition and member information, household asset holdings, land use and transfer, agricultural and non-agricultural activities, and household income and expenditures.

Data on farmers' social networks mainly include kinship ties and village group affiliations. Information on kinship relationships among villagers was obtained from the clan genealogies preserved in the village ancestral hall. In rural China, village groups are often formed based on geographic proximity and serve as the basic units for labor organization and collective decision-making. Members of the same group frequently interact in daily life and participate in social events, such as weddings and funerals, thereby forming close-knit social ties over time. These relationships can significantly influence household decision-making in both production and livelihood activities. Household membership in each village group was identified based on village records.

The geographic spatial datasets involved in this dissertation were provided by the Yucheng Natural Resources Bureau and include three main components:

i. Annual Worldview-2 images from 2010 to 2020, with a panchromatic band resolution of 0.5m and a multispectral band resolution of 2m. ii. GIS data layers, including elevation, slope, distances to the nearest infrastructure such as hospitals, schools, and shops, as well as road traffic data. iii. The spatial locations and boundaries of individual homesteads. The village has completed the confirmation and registration of homestead rights, and the village committee provided us with map photos containing homestead boundaries and owner information. Based on these maps, the positions and shapes of the homestead plots were manually delineated on the Worldview-2 images.

The homestead land use data are categorized into five types: idle, residential, reused, rented, and traded. For each household, the actual location of the homestead was identified and spatially mapped onto the village base map (see the black polygons in Figure 6.1). Additionally, the locations of each household's cropland and greenhouse facilities were identified, allowing for the establishment of spatial linkages between households and their associated farmland and agricultural infrastructure.

6.3 Model parameter initialization

6.3.1 Initialization of rural household attributes

Regarding the part of “human”, the following hierarchical levels can be distinguished: individuals, households, and resident groups. Several individuals form a rural household, several rural households form a resident group, and several resident groups form the whole village.

The individual agent represents a real person in the case study area, is assigned a unique ID, and is associated with a rural household, which also has its own unique ID. The household ID serves as a link between the household and individual agents. The state variables of an individual agent include whether the individual is the head of the

household, age, gender, health status, marital status, education level, skill level, work status, income, migration status, requirements for obtaining a hukou at the migration destination, living costs, education costs, medical expenses, and more. During each simulation, an individual agent undergoes a series of demographic processes and makes employment decisions, which in turn dynamically update their state variables. The initialization of individual agents within the NetLogo platform is illustrated in Figure 6.2.

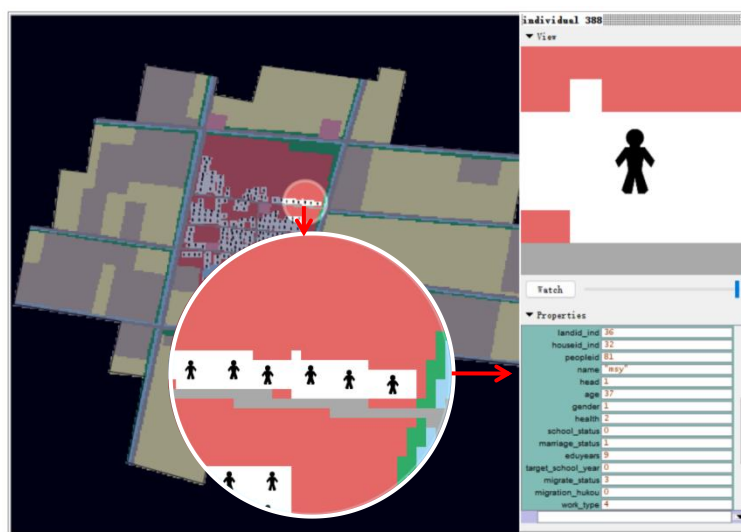


Figure 6.2 The farmer agent and its state variables in NetLogo interface

A rural household agent is formed by individuals with the same household ID. Household-level state variables include household size, whether they belong to the older generation, household dependency ratio, proportion of members working outside, the amount of arable land and homestead owned, grain planting area, vegetable greenhouse planting area, homestead usage and idle status, rural-urban labor allocation, income source composition, expenditure composition, as well as assets like houses and vehicles. The demographic variables (e.g., household size, composition, labor availability) at the household level can be updated after simulating individual-level demographic processes. Since households are the primary decision-making units for most livelihood decisions, our focus is on household labor allocation and decisions regarding the use of cultivated land and homesteads. During each simulation, dynamic indicators such as household income and expenditure will

be updated accordingly. The initialization of rural household agents within the NetLogo platform is illustrated in Figure 6.3.

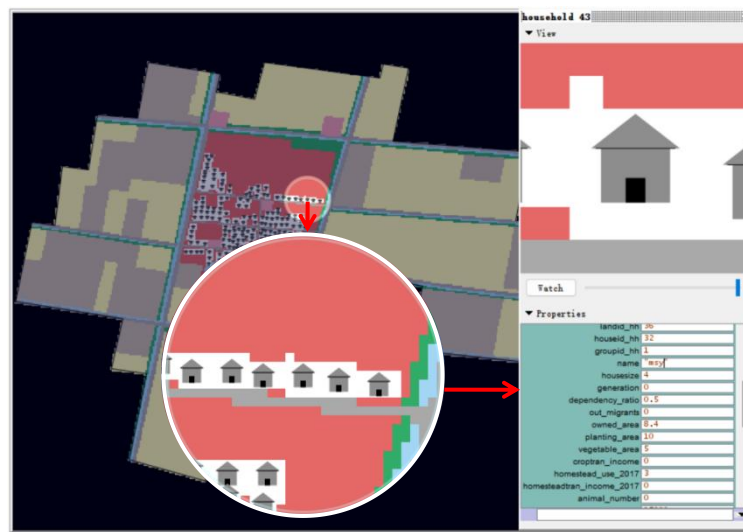


Figure 6.3 The rural household and its state variables in NetLogo interface

Resident groups are local collective management communities composed of dozens of households residing geographically close to one another. Households and resident groups are linked by their respective resident group IDs. Households within the same resident group tend to have stronger social interactions and socioeconomic connections, often learning from one another. The state variables at the resident group level include the number of member households, the proportion of the population engaged in non-agricultural work, the proportion of the population migrating to other cities, and the migration city with the largest migration proportion. Similarly, the dynamic state variables of households and resident groups are updated after the execution of various demographic processes and socio-economic decisions. The initialization of resident group agents within the NetLogo platform is illustrated in Figure 6.4.

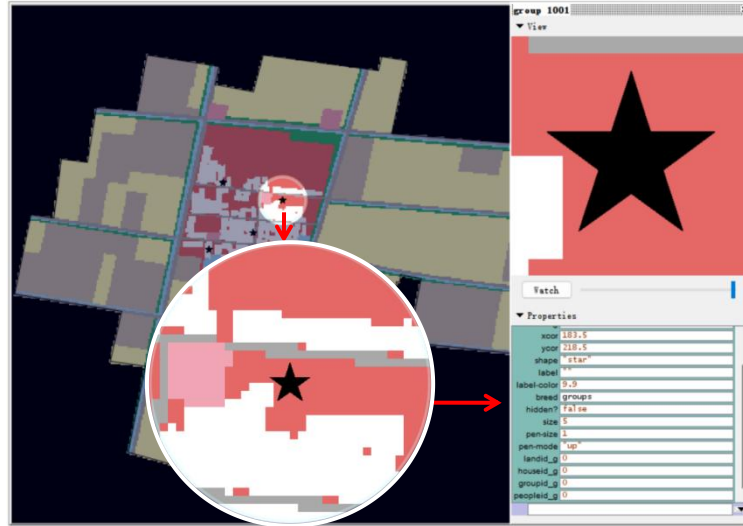


Figure 6.4 The resident group and its state variables in NetLogo interface

6.3.2 Initialization of social network between rural households and other agents

The other agents that influence farmers' behavior can be categorized into two main groups. First, government and enterprises indirectly affect farmers' utility by changing the rules of the labor, land, and production markets. Second, the homestead use behavior of other farmers can also have a direct impact by shaping social norms and influencing individual decision-making.

This dissertation examines the relationship between the government, enterprises, and farmers, which is shaped by factors such as product market prices, urban living costs, the quality of public services, and wage levels. Given the complexity and diversity of actors involved, including multi-level governments at farmers' migration destinations and various types of enterprises, their decision-making processes are influenced by numerous factors and are difficult to model directly or quantify accurately. As a result, this study uses local average values to approximate these interactions. Based on the currently collected data, linear regression models are used to predict changes in each indicator over the coming years.

Kinship networks and connections among members of the same relative group continue to play an important role in farmers' decision-making. Even when individuals leave their original rural households due to education, marriage, or

employment, familial ties often persist and remain influential. In addition, our household interviews indicate that families within the same relative group tend to display notable similarities in various aspects, such as migration destinations, types of employment, and the selection of grain crops. These patterns suggest that farmers benefit from observing and learning from one another, as they can estimate potential economic returns, gain practical experience, and access technical support through these networks, all of which help significantly reduce the risks associated with migration or entrepreneurship. Figure 6.5 illustrates the structure and scope of these kinship and village-based networks.

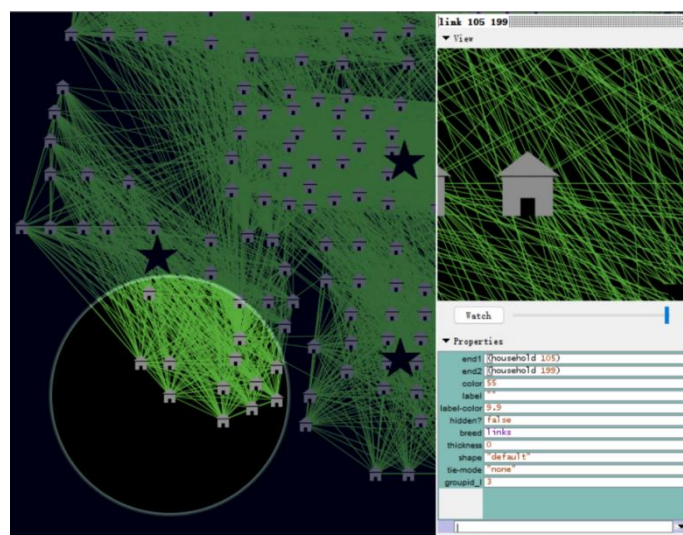


Figure 6.5 The social network in NetLogo interface

6.3.3 Initialization of spatial environmental attributes

The geographical environment factors influencing farmers' behavior consists of two components: landscape patches and homestead patches.

Each landscape patch is a raster grid with an area of $2 \text{ m} \times 2 \text{ m}$, which, in aggregate, forms the environment where human agents situate, interact, and make decisions. Four spatially explicit raster layers — elevation, slope, roads, and distance to public service facilities — are generated in ArcGIS 10.4 and imported into the NetLogo platform. Each landscape has its unique patch ID and these four state variables. Since large-scale infrastructure typically undergoes minimal changes over

short periods, all state variables are static and only need to be initialized at the start of the simulation. The related setup in the NetLogo platform is shown in Figure 6.6.

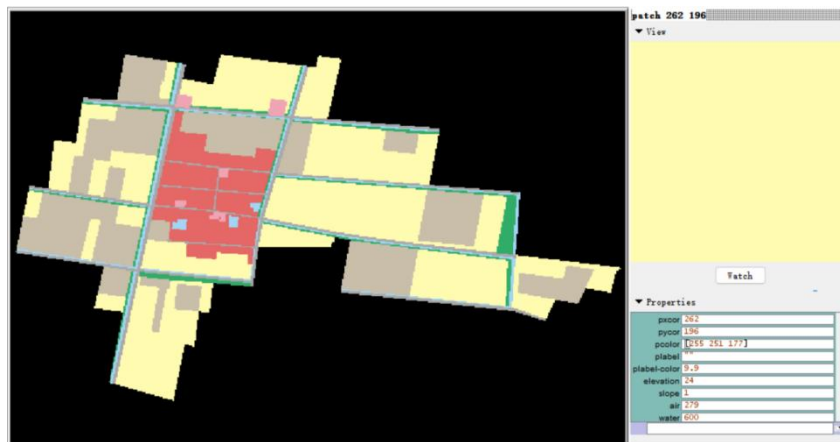


Figure 6.6 The landscape patch and its state variables in NetLogo interface

Homestead patches are delineated in ArcGIS 10.4 based on field survey and imported into NetLogo as a vector file. In this study, there are a total of 265 homestead patches. Each patch is linked to its owners by a patch owner ID. In addition, homestead patches have other attributes, e.g., area, distance to infrastructure, type of housing structure, and building area. After a household makes homestead use decisions, the homestead use status may change accordingly, resulting in a change in ownership. The related setup in the NetLogo platform is shown in Figure 6.7.



Figure 6.7 The homestead patch and its state variables in NetLogo interface

6.4 Simulation accuracy verification

Based on the 2010 land use data for Yucheng County as the baseline, the simulation model described above was used to simulate changes in homestead use in the study area prior to the reforms of the hukou and homestead systems in 2017. Specifically, although farmers had no legal channels to withdraw from or transfer their homesteads before reforms, informal or grey markets for homestead transactions were widespread in rural China. In this study, any instance of farmers selling their homestead plots to others, regardless of legality, is treated as a form of homestead withdrawal.

To verify the simulation accuracy, the simulated homestead use pattern of 2017 is compared with actual interpreted images of 2017 using a point-to-point comparison method (see Figure 6.8). This method aligns the simulation results with the actual situation by comparing the changed grids in the simulation results one by one to verify accuracy. Spatial overall fitness and change fitness are common indicators. Among them, the overall fitness $K_{overall}$ is used to evaluate the consistency between the simulated results and the actual situation in terms of the total scale of homestead use. The change-based fitness K_{change} assesses the degree of agreement between the simulated and actual changes in homestead land use over the study period (Pan et al., 2023; Liu et al., 2017). The formulas for these two indicators are as follows:

$$K_{overall} = \frac{N(P_s \cap P_r)}{N(P_s \cup P_r)} \quad (6.1)$$

$$K_{change} = \frac{N(\Delta P_s \cap \Delta P_r)}{N(\Delta P_s \cup \Delta P_r)} \quad (6.2)$$

Where P_r is the actual homestead raster cells in the study area; ΔP_r is the actual spatially changed raster cells during a given time period; P_s is the simulated homestead raster cells; ΔP_s is the simulated spatially changed raster cells; $P_s \cap P_r$ refers to the number of raster cells where the simulated and actual results are consistent; $P_s \cup P_r$ refers to the total number of raster cells involved in the logical

operation between the simulated and actual homestead data, $\Delta P_s \cap \Delta P_r$ and $\Delta P_s \cap \Delta P_r$ follow the same logic.



Figure 6.8 Comparison of simulation results with actual situation

In this study, the spatial overall fitness for simulating homestead use evolution from 2010 to 2017 is 90.79%, and the spatial change fitness is 62.5%. The main error sources can be divided into three aspects. First, the complexity of socioeconomic activities introduces numerous uncertainties into farmers' homestead use behavior. Although this study has incorporated individual-level micro factors, geographic spatial factors, and macro-level institutional factors as comprehensively as possible, there may still be unobservable influences that affect farmers' decisions. Second, the simulation model contains certain stochastic parameters, such as marriage, mortality, and other lifecycle events, which serve as sources of error in the simulation results. Third, in practice, some homestead locations are determined through prior village-level planning. As a result, actual site selection does not always strictly follow the parameters defined in the simulation, which introduces a degree of deviation between the model outputs and reality. Even though there are errors in the simulation, it is generally considered acceptable for land change simulations based on multi-agent models to have an accuracy of 60% or above (Lu et al., 2022). Our spatial fitness indicates that the constructed model is relatively reliable in simulation.

6.5 Simulation results and analysis

6.5.1 Spatio-temporal effects when without reforms

Based on the simulation model developed in the previous section, this dissertation uses the state of homestead use and household attributes prior to the 2017 reforms as the baseline. It simulates the spatio-temporal effects of homestead use in the study area by 2030 under a scenario in which both the hukou and homestead systems remain unreformed (as shown in Figures 6.9 and 6.10).

From the spatial perspective, both newly-added and idle homesteads are expanding. By 2030, the area of homesteads in this case study is expected to expand by 11,868 square meters, equivalent to 16.23% of the total area in 2017. The proportion of idle homesteads is expected to increase from 53.70% in 2017 to 63.20% in 2030, with approximately 40% being long-term, completely idle. Additionally, a small number of farmers privately purchase and sell homesteads, covering an area of approximately 1,680 square meters by 2030. This area is relatively small, and most of the sold homesteads are not left idle; they continue to serve their residential function. In terms of homestead layout, newly-added homesteads exhibit a certain degree of clustering. Some clusters are located near main roads of towns, which have the advantage of consumer markets to facilitate the establishment of small restaurants and supermarkets. Others are clustered in flat areas with convenient transportation near the homesteads of parents and relatives, to facilitate production, living, and caring for parents.

From the temporal perspective, the increasing idle rate of individual homesteads coexists with the gradually rising reuse rate. On the one hand, the rising idle rate of individual homesteads indicates that more family members are choosing to work outside the home. The restrictive hukou system has led to an unbridgeable gap in income and social welfare levels between urban and rural areas, prompting more rural households to engage in non-agricultural labor. Notably, the high idle rate of newly-added homesteads suggests that young farmers apply for a homestead when

establishing new families but prefer to work in cities after marriage. On the other hand, over time, some rural households return to their hometowns. The restrictive hukou system prevents those with low education and no advanced skills from settling in cities, and the restrictive homestead system fails to provide strong financial support for rural-to-urban migration, making it difficult for rural migrants to become urban residents. Therefore, Homesteads continue to play a vital role in livelihood security. From the labor migration wave starting in 2000 to 2030, the first batch of rural migrants has reached at least 50 years of age. Unable to settle in big cities, many choose to return to their hometowns to retire. Homesteads located near well-developed main roads of the town provide opportunities for returning farmers to make a living, potentially increasing the utilization rate of these homesteads in the later stages of the simulation.

From the perspective of the overall population structure of the village, the number of residents has significantly decreased and stabilized over time, with a slight increase at the end due to the anticipated return of some households. As a large portion of rural labor moves to urban areas for work, and since average urban wages are significantly higher than those in local agricultural or non-agricultural jobs, per capita income levels rise substantially. In contrast, for those remaining in the village engaged in agriculture or local non-agricultural work, the growth rate of per capita income is slower. A possible explanation is that, under the restrictive hukou system, a considerable number of households remain in the village to engage in farming. Even in the years with the highest labor migration, the per capita arable land only reaches a maximum of 4 acres, far from achieving large-scale farming. This fragmented farming method remains a significant obstacle to increasing agricultural income, which in turn widens the urban-rural income gap to some extent.

From the perspective of the income structure, with the outflow of the rural population, the proportion of agricultural income in overall rural income has significantly decreased. However, compared to grain cultivation, the income proportion from greenhouse vegetable cultivation has decreased less and even slightly

increased in the later stages. Field research shows that, on the one hand, greenhouse farming is a local specialty industry. Due to the rising prices of vegetables in the market, the income is considerable, leading many farmers who remain in this village to prefer greenhouse vegetable cultivation. On the other hand, advancements in greenhouse cultivation techniques have significantly increased tomato yields.

From the perspective of labor distribution, the proportion of laborers working outside their hometowns is increasing annually. However, the percentage of individuals engaging in stable non-agricultural work and achieving permanent family relocation has remained relatively unchanged. Restrictions from the hukou system make it difficult to afford the high costs of migration and living expenses. In contrast, the proportion of labor engaged in local non-agricultural work has significantly increased. Many families in this study area rent homes in nearby towns with fewer hukou restrictions to provide better education for their children. Mothers accompany their children for schooling and engage in simple, local non-agricultural jobs, such as handicrafts and services, returning to the countryside during holidays. This represents a form of labor allocation that enables households to obtain slightly higher income than from pure agricultural farming, while also accessing better urban welfare within their capacity. As a result, some families exhibit a "left-behind" living arrangement, where the father works away from hometowns for extended periods, and the mother migrates seasonally with the children between the county and the village in a "migratory bird" pattern.

In summary, if hukou system and homestead system remain restrictive, the mobility of labor and land factors will be severely hindered. In the long term, this severely hinders the growth of farmers' incomes and widens the urban-rural income gap, making it difficult for farmers to settle in cities, which could lead to a large return of the labor force, making China's urbanization development unsustainable. Additionally, the closed homestead system hinders land urbanization, leading to both the growth and underutilization of homesteads, which results in low land use efficiency and significantly impacts rural revitalization efforts.



Figure 6.9 Simulation of homestead use evolution when without reforms

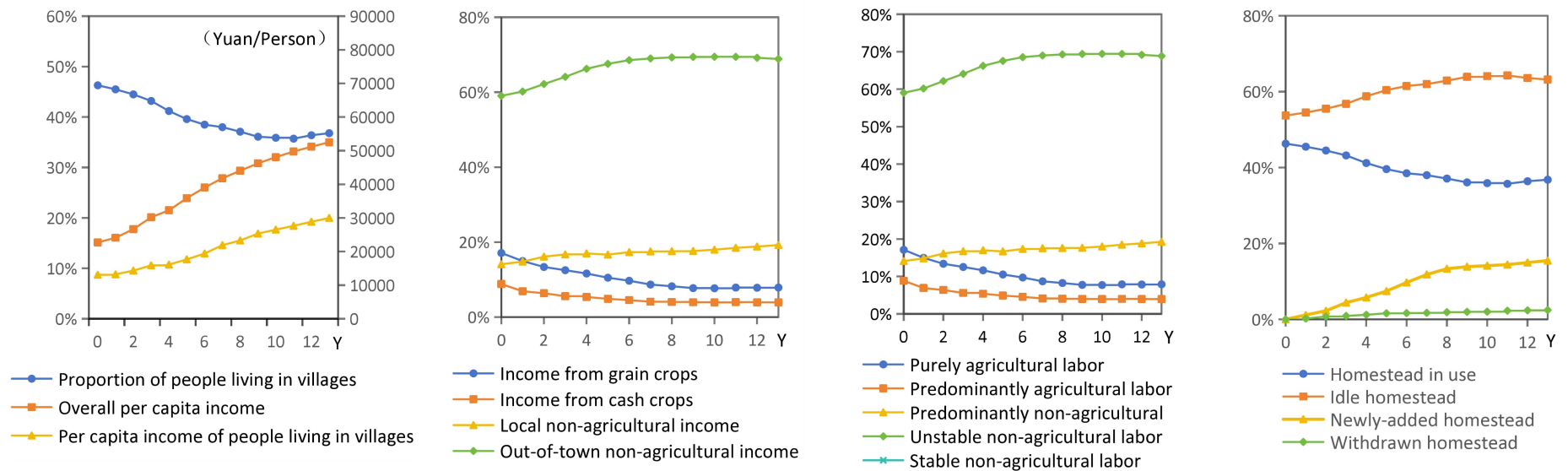


Figure 6.10 Simulation of the spatio-temporal effects of homestead use evolution when without reforms

6.5.2 Spatio-temporal effects under the hukou system reform alone

Assuming that only the hukou system is reformed while the rural land system remains closed, this section simulates the evolution of homestead use and its spatio-temporal effects in the case study in 2030. To represent the hukou system reform, we designed index thresholds for obtaining urban hukou to decrease by 0%, 10%, 50%, and 100%. The simulation results are shown in Figures 6.11 and 6.12.

From a spatial perspective, as the hukou system reform deepens, the area of homestead withdrawal increases slightly, the newly added homestead area decreases slightly, but the idle homestead area increases significantly. In the scenario where the hukou system is fully relaxed, by 2030, the area of homestead withdrawal will be approximately 2,470 square meters, while the newly-added homestead area will be about 9,068 square meters. However, the proportion of idle homesteads is expected to reach as high as 79.00%, which is 15.80% higher than under a fully restricted hukou system. In terms of spatial layout, homesteads privately transferred through informal transactions are concentrated along the main roads of towns in the eastern and western parts of the region. Located near consumption markets, these plots hold higher economic value and, once sold, can provide partial financial support for rural households to migrate to cities. According to China's homestead management regulations, for rural residents with the capacity to settle in urban areas, obtaining urban hukou entails the loss of collective membership and the obligation to withdraw from their homesteads without compensation. In such cases, if the housing structures on the homesteads are old, dilapidated, or in disrepair, the losses and opportunity costs of giving up the land are relatively low. Thus, some households might choose to withdraw from their homesteads after weighing the costs and benefits. These types of withdrawn homesteads are mostly located within village interiors, in areas with poor transportation access and aging, deteriorating housing structures.

From a temporal perspective, although the hukou system reform can promote the transfer or withdrawal of idle homesteads to a certain extent, its promoting effect is

very limited and, instead, will lower the efficiency of homestead use. At the same time, the effects of the hukou system reform do not show linear growth with the increase in the intensity of the reform. The main reason, according to Lu et al. (2022), is that housing accounts for the largest share of the costs associated with citizenship for rural migrants. In the study area, the average savings per rural resident is approximately 30,000 yuan, which is far below the 30% down payment required for purchasing new urban housing. Additionally, if the hukou system is completely relaxed, the annual income growth of rural residents would be only 8.5%, whereas the national average annual housing price increase rate is 10%. Rural households find it difficult to bear all the costs of urbanization through their own efforts, and homestead serve as a fundamental guarantee for production and livelihood when rural households cannot continue to live in cities. Therefore, when the hukou system is completely relaxed, the hindrance of the hukou system to the migration of rural households and the circulation of homesteads will be transformed into an obstacle of high housing prices. Rural households will still be unable to free themselves from reliance on rural land. Additionally, according to the results of Chapter 4, even if rural households have the financial foundation to settle in cities, when the protective role of homesteads is no longer emphasized, the emotional attachment of rural households to their hometown and their anticipation of higher future value of their homesteads will also become hindering factors for rural households to withdraw from their homesteads.

From the perspective of rural households' livelihood characteristics, the indicators reflecting household livelihood patterns tend to stabilize earlier as the hukou system reform deepens. The primary reason is that the relaxation of hukou restrictions lowers the cost of rural-to-urban migration, thereby accelerating labor mobility from rural areas to cities and leading to earlier industrial agglomeration in urban areas. This shift not only increases income for rural households but also expands the size of the urban consumer market, strengthens industrial linkages, and releases more pronounced economies of scale. At the same time, the acceleration of

industrialization contributes to the overall improvement of urban technological levels and enhances labor productivity, which in turn further facilitates rural-to-urban migration and promotes urban economic growth.

The changes in village income levels shown in Figures 6.12 (a)–(c), together with the shifts in rural-urban labor allocation depicted in Figures 6.12 (h)–(l), strongly support the above argument. As observed in the figures, the greater the intensity of hukou system reform and the lower the threshold for urban settlement, the higher the overall income level of rural households. Under a fully relaxed hukou system, the average per capita income increases by nearly 1.5 times compared to the fully restricted scenario. This income gap not only reflects the economic inefficiencies caused by institutional rigidity but also highlights the potential welfare gains that could be unlocked through hukou system reform. Moreover, the significant rise in the proportion of non-agricultural labor further indicates the large-scale migration of rural laborers to urban areas. In the fully relaxed scenario, the share of the population engaged in non-agricultural employment increases by 26.2% compared to the fully restricted scenario. However, only 14.84% of the fully non-agricultural households have permanently relocated their entire families to urban areas, which is only 3.67% higher than under the restricted hukou system. This suggests that, despite increased mobility, rural households still face considerable barriers to fully integrating into cities.

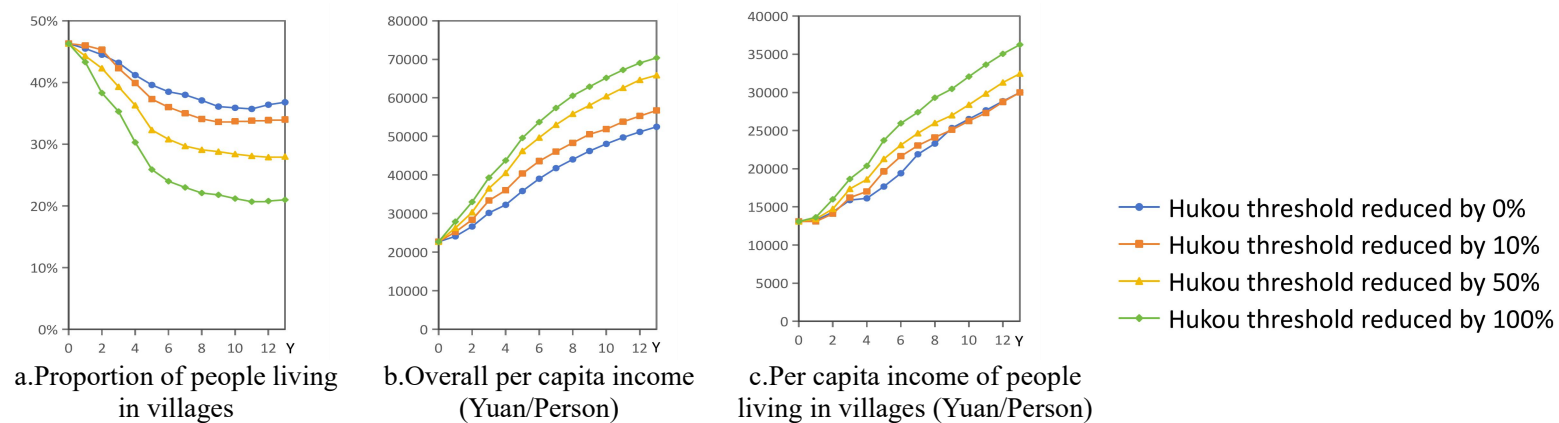
From the perspective of income structure, with hukou system reforms, rural households who choose to stay in the countryside and engage in farming have also maintained a rapid growth trajectory in per capita income. With population outflow, more cropland is transferred and consolidated into the hands of a few individuals. This trend is particularly evident in plain areas such as the study region, where the terrain is well-suited for large-scale mechanized farming. Under such conditions, large farm operators and agricultural cooperatives tend to emerge. By 2030, in a scenario where the hukou system is completely relaxed, the per capita cropland area

could reach approximately 10 acres, and the per capita agricultural income could reach around 50,000 yuan, about 50% of the urban non-agricultural income levels. Gradually, there will be a differentiation in the farmer groups: a large number of small-scale farming-focused households are likely to gradually withdraw from rural land and transition to non-agricultural production, becoming urban residents. Over time, the few households that remain in rural areas will evolve into large-scale farm owners, engaging in extensive agricultural production. This, to some extent, enhances labor productivity, fostering the modernization of agriculture in China.

In conclusion, if the hukou system is reformed alone, it can reduce institutional frictions in rural-to-urban labor migration, encourage a large number of rural households to move to cities, and significantly improve their income levels across both urban and rural sectors. However, this process ultimately leads only to the urbanization of the resident population. Without joint reform of the homestead system, farmers lack a legal and institutional pathway to withdraw from their homesteads. As a result, large quantities of homesteads remain idle, failing to generate asset value. This inability to capitalize on rural property prevents many rural migrants from affording housing in urban areas. In such cases, high urban housing costs have effectively replaced the hukou system as the primary barrier to the full integration of rural migrants into urban areas.



Figure 6.11 Simulation of homestead use evolution under the hukou system reform alone



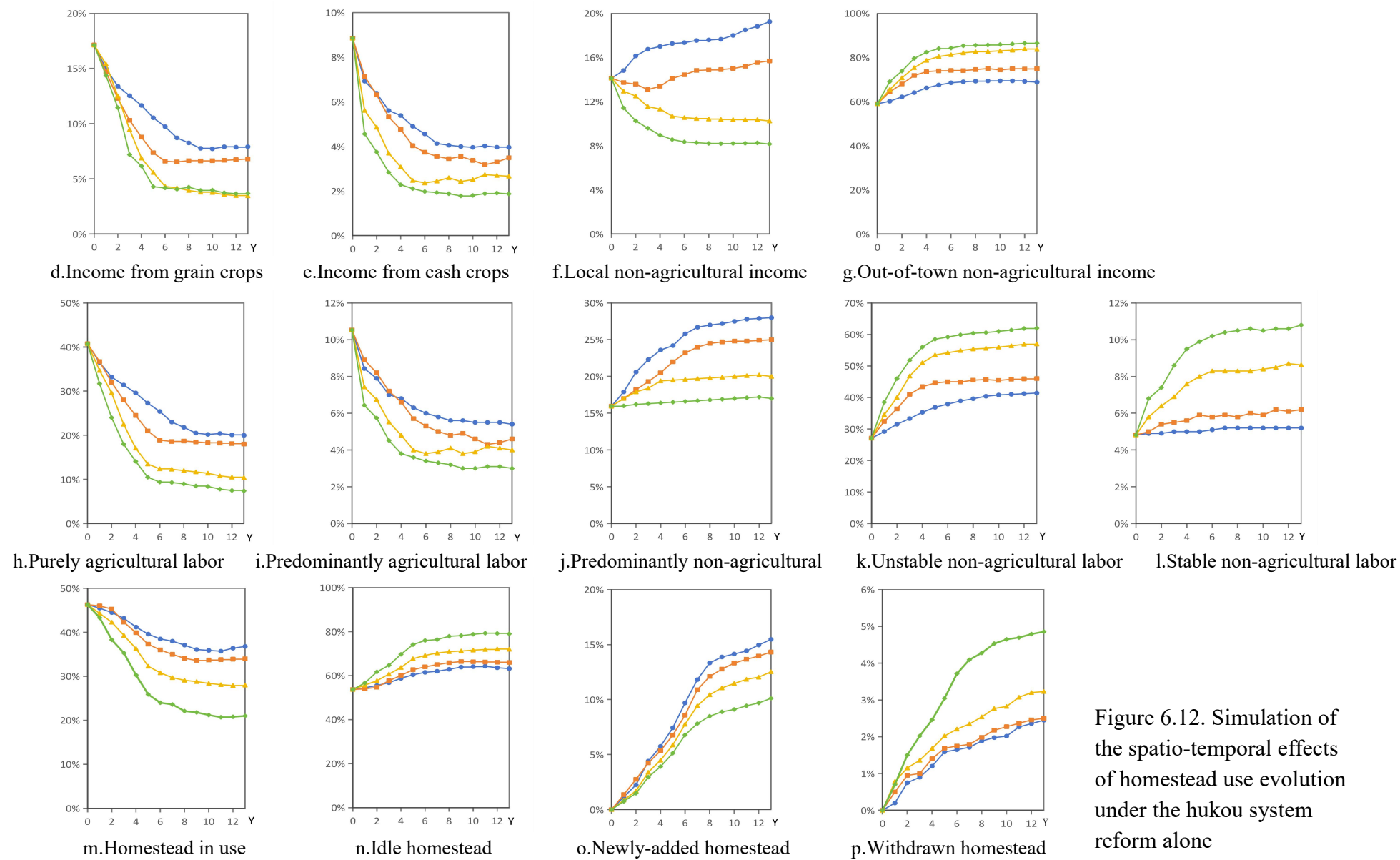


Figure 6.12. Simulation of the spatio-temporal effects of homestead use evolution under the hukou system reform alone

6.5.3 Spatio-temporal effects under the homestead system reform alone

Assuming that only the homestead system is reformed while the hukou system remains closed, this section simulates the homestead use evolution and its spatio-temporal effects in the case study in 2030. The homestead system reform includes two key policy components: the paid-use policy and the compensated withdrawal policy. In this section, simulation analyses are conducted separately for each of these policy scenarios.

6.5.3.1 Spatio-temporal effects under the paid use policy

In this study, four levels of fees for excessive homestead land occupation were designed: 0 yuan, 5 yuan, 50 yuan and 100 yuan per square meter, to investigate the evolution of homestead land use and its spatio-temporal effects under different policy scenarios. The simulation results are shown in Figures 6.13 and 6.14.

From the spatial perspective, regarding the scale of homestead, a low-level paid use fee does not significantly promote farmers' willingness to withdraw from excessive homesteads; however, as the fee increases, the area of withdrawn homesteads rises markedly, while the policy consistently shows no significant effect on newly-added homestead. Most of the withdrawn homesteads come from households with multiple homestead plots and dilapidated houses. Specifically, the paid use fee only applies to the portion of the homestead that exceeds the standard for free use. In this study case, the average excessive homestead area per household is 122 square meters. If the fee is set at 5 yuan per square meter, the average annual payment per household is only 610 yuan, accounting for less than 1% of the average household income in 2017. Assuming a 70-year period of homestead use and subtracting the years already used, the total one-time payment per household would be around 35,000 yuan. This cost has minimal impact on farmers' livelihoods and is insufficient to fundamentally incentivize homestead withdrawal. In contrast, if the fee is 100 yuan per square meter, over 10% of a household's income would be required annually to maintain idle homesteads with no

practical use. In such cases, farmers are more likely to make rational decisions to withdraw from them. In terms of spatial distribution, as the paid use fee increases, most of the withdrawn homesteads are located within the interior of the village, far from consumption markets, with low economic value and often accompanied by dilapidated houses, making them more likely to be prioritized for withdrawal.

However, from the perspective of farmers' livelihoods, the paid use of homesteads has limited effects beyond increasing the rate of withdrawal. Since no compensation is provided for the relinquishment of illegally occupied homesteads, this policy does not significantly promote rural-to-urban migration or lead to noticeable increases in household income. On the contrary, in some cases, a small amount of excessive homestead occupation caused by historical or uncontrollable factors results in additional financial burdens for low-income households.

In summary, the primary aim of the paid use policy for homesteads is to promote the rational allocation and efficient utilization of homestead, while also addressing long-standing issues related to excessive occupation. However, the effectiveness of the price mechanism is limited. Although economic tools can regulate villagers' demand for homesteads, the pricing does not fully reflect actual supply and demand conditions, nor does it accurately capture the true value of land. As a consequence, the policy may, in certain cases, undermine the fundamental interests of farmers. This outcome contradicts the original intent of land reform, which is to generate economic benefits from land resources and to improve the living standards of rural households.

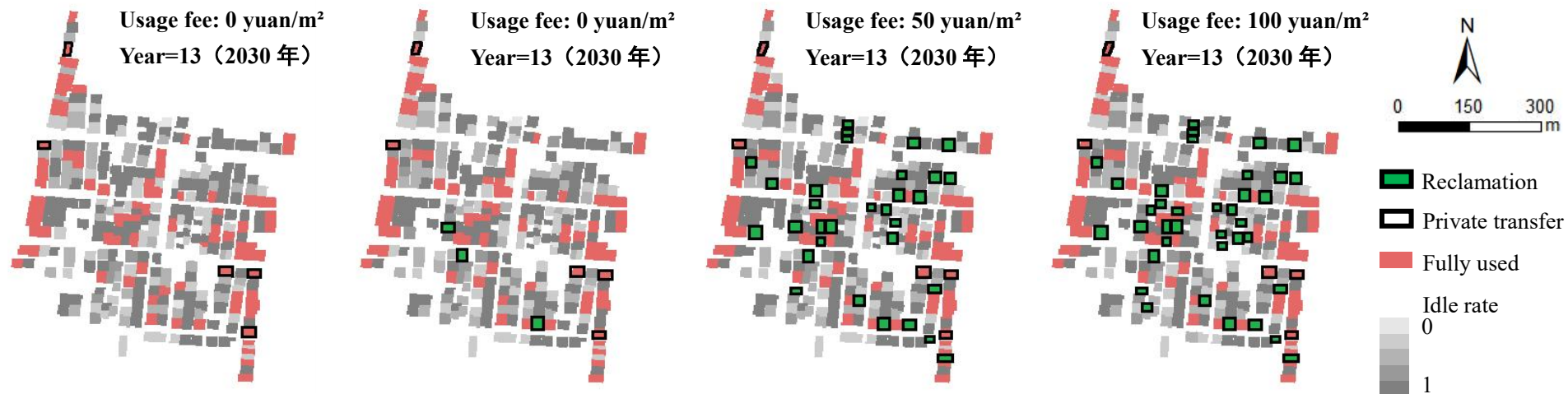
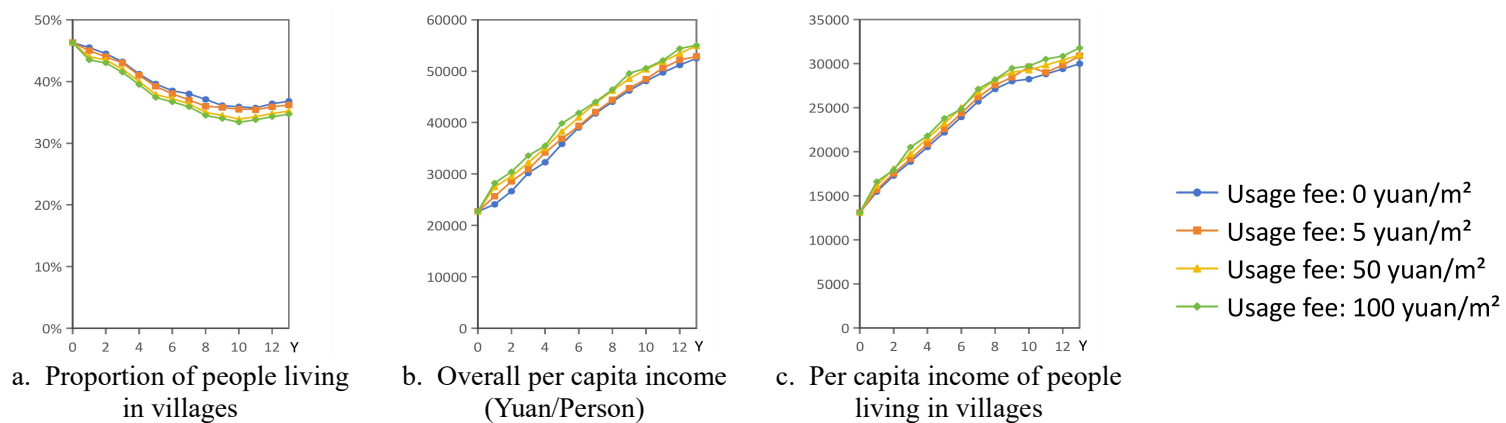


Figure 6.13 Simulation of homestead use evolution under the paid use policy



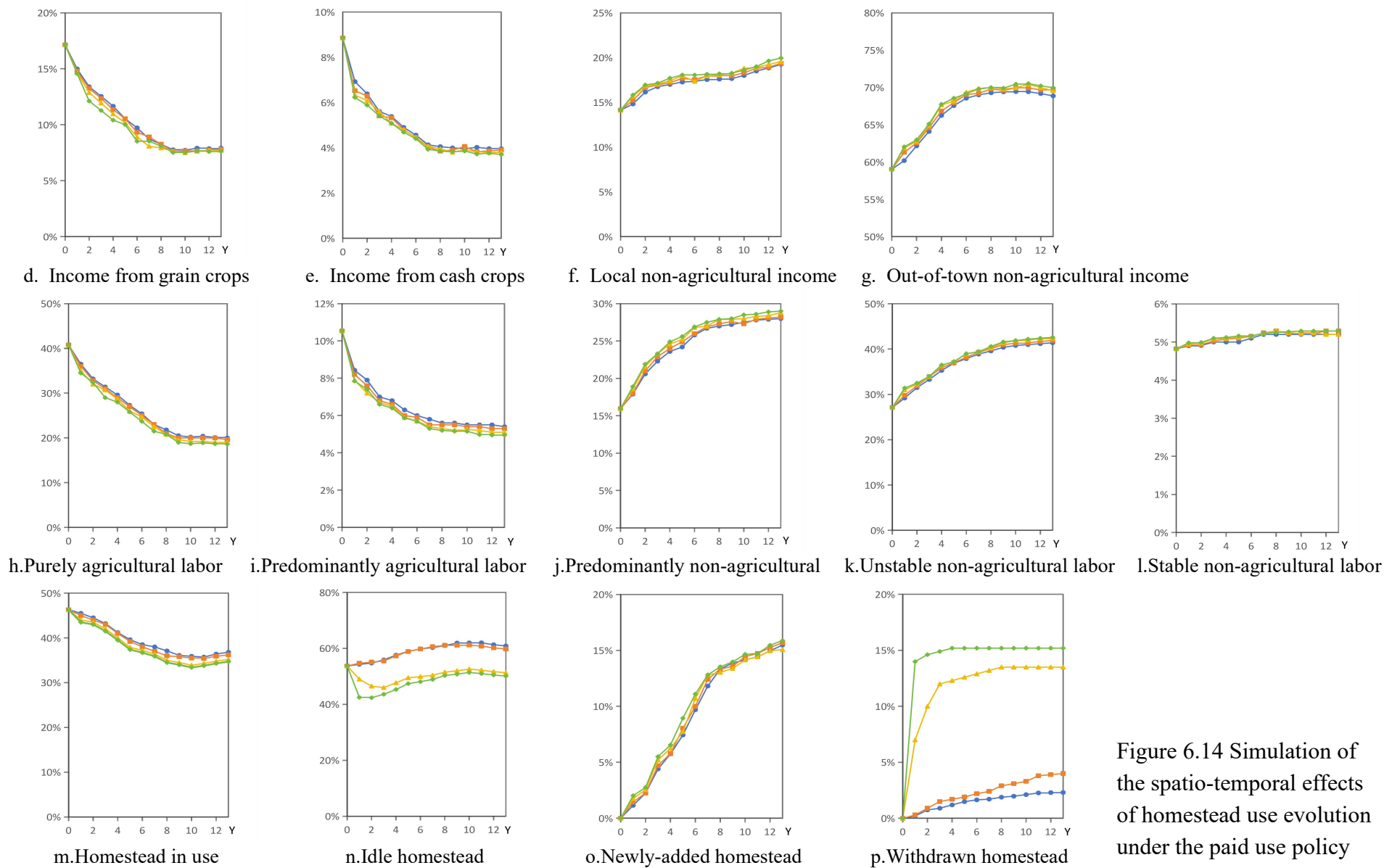


Figure 6.14 Simulation of the spatio-temporal effects of homestead use evolution under the paid use policy

6.5.3.2 Spatio-temporal effects under the compensated withdrawal policy

In the homestead system reform, there are several specific implementation policies within the homestead withdrawal mechanism. This dissertation focuses on the cash compensation policy and apartment compensation policy, with designs including cash compensation amounts equivalent to 0%, 5%, 50%, and 100% of the average price of local townhouses, as well as scenarios where each unit of homestead can be exchanged for 0%, 5%, 50%, or 100% of an apartment unit in towns. These scenarios are used to investigate the evolution of homestead use and its spatio-temporal effects under different policies.

(1) Spatio-temporal effects under the cash compensation policy

The simulation results under the cash compensation policy for homestead withdrawal are shown in Figures 6.15~6.17.

From the spatial perspective, as the cash compensation for homestead withdrawal increases, the area of withdrawn homesteads grows significantly. Notably, there appears to be a threshold effect: when the compensation reaches about 10% of the local township housing prices, the number of homestead withdrawals increases significantly, whereas the effect is limited before this point. Through analyzing the specific circumstances of the study area, it was found that in 2017, the per capita savings of rural households were approximately 30,000 Yuan, accounting for about 20.26% of the total price of local township real estate. When the cash compensation amount for a homestead withdrawal reaches 9.74% of the house price, combined with the savings, households can achieve the 30% down payment required for purchasing a new home locally, giving them the opportunity to buy property in the township. Once households have alternative housing and security after withdrawing from their homesteads, their willingness to relinquish the homestead significantly increases. In this scenario, by 2030, the area of homestead withdrawn is approximately 3,168 square meters, which is 88.57% more than that in a completely restrictive system, and the idle rate of homesteads decreases by 5.2%. In terms of homestead layout, when

the cash compensation is relatively low, the withdrawn plots are mainly concentrated in the inner areas of villages. In contrast, the withdrawal of homesteads located along the main roads in eastern and western townships, which have more prominent consumer market advantages, tends to be significantly restrained. The reason is that these homesteads, in addition to serving basic residential functions, also contribute to generating added value through productive reuse. The dual function of residence and production leads farmers to have higher expectations for their future value. Therefore, when the cash compensation does not meet these expectations, it becomes considerably more difficult to promote withdrawal. Besides, based on field research, the price of these homesteads in the gray market is about 450 Yuan/m², which is comparable to or even slightly higher than the compensation at 9.74% of township housing prices. This inevitably fails to meet the needs of the households. For homesteads within the village that lack a transaction market, compensated homestead withdrawal offers households a valuable opportunity to exchange a less useful homestead for funds to support their move to towns.

From the temporal perspective, the impacts of cash compensation for homestead withdrawal will remain stable in the later stages of the simulation, and the growth rate may even decrease slightly towards the end. On the one hand, this suggests that rural households willing to withdraw from their homesteads will do so promptly after the policy is introduced. Those unable or unwilling to leave due to attachment to their hometowns will ultimately not withdraw from homesteads, regardless of time passing or the influence of other households. On the other hand, if the cash compensation for homestead withdrawal remains unchanged, the growth rate of homestead withdrawal will decline as urban housing prices gradually increase. Official statistics indicate that household income and living costs increase by approximately 8% annually, while housing prices rise by 10% annually, resulting in a gap that savings can't keep up with in the face of urbanization costs. This shows that rising housing prices have eroded the benefits of the homestead system reform. Therefore, it is essential to link

homestead reform, urban housing system reform, and housing price control policies in China.

From the perspective of farmers' livelihoods, the cash compensation from homestead withdrawal provides financial support for farmers' migration, significantly reducing the costs of urbanization and greatly facilitating rural-to-urban migration. Meanwhile, in the study area, most withdrawn homesteads are reclaimed as vegetable greenhouses or used to grow specialty crops, such as honeysuckle, which has somewhat increased the income levels of rural households remaining in the villages. This shows that homestead reform enhances the security, stability, and mobility of land rights. It alleviates financial constraints on household migration and promotes the market circulation of idle rural homesteads, thereby improving land resource allocation efficiency. This has positive effects on both urbanization and rural revitalization in China. However, if the hukou system remains restrictive, farmers still face strict limitations on education, skill levels, social security contributions, and housing when moving to cities. This creates concern for households withdrawing from their homesteads. A direct piece of evidence can be found by comparing Figure 6.16(l) and Figure 6.17: the proportion of people who have obtained urban hukou and settled in cities is significantly lower than those who have withdrawn their homesteads.

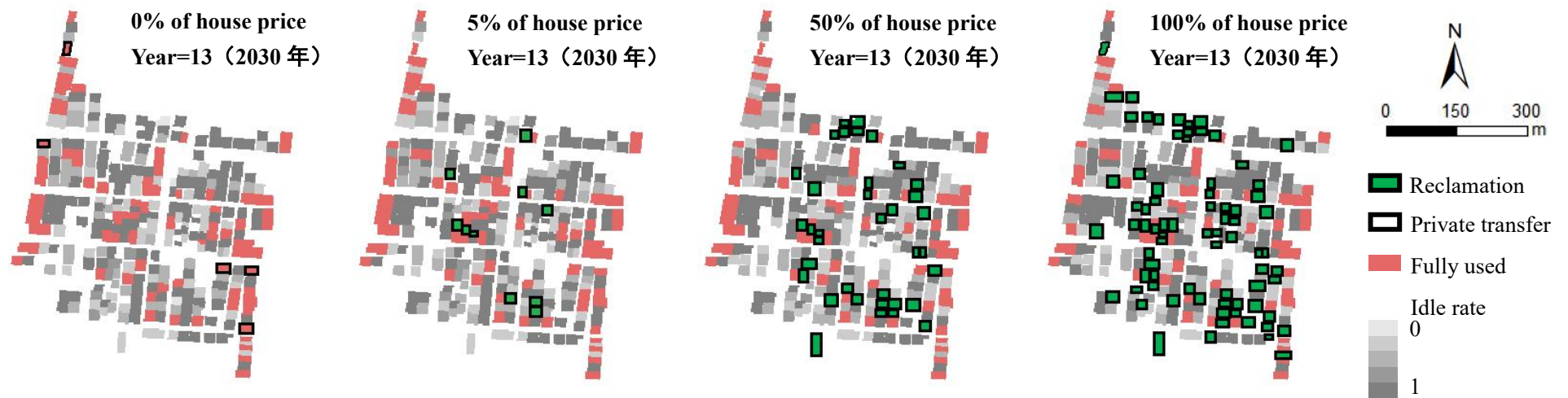
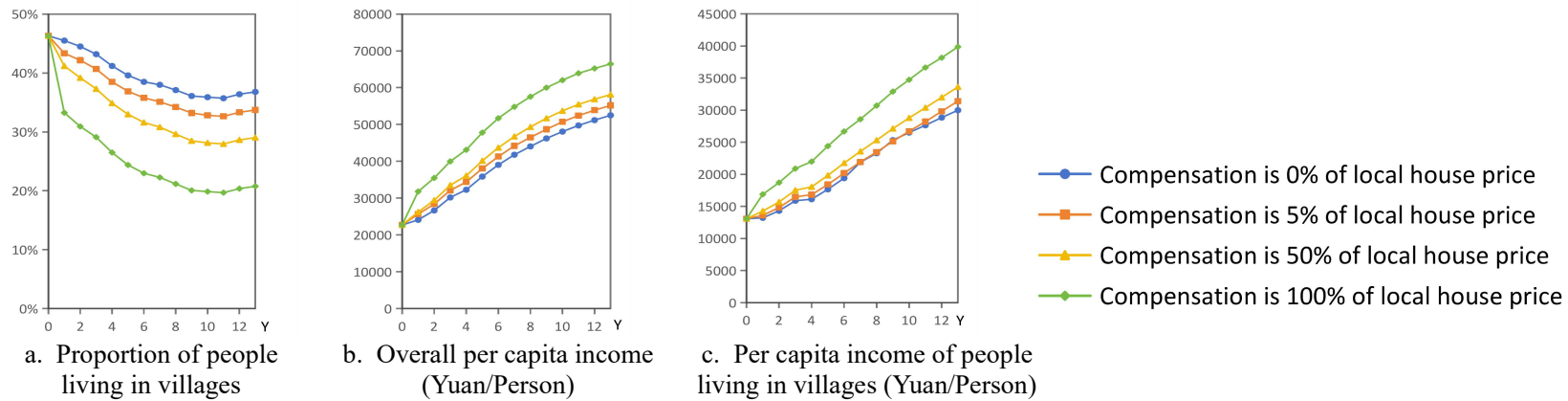


Figure 6.15 Simulation of homestead use evolution under cash compensation policy for homestead system reform alone



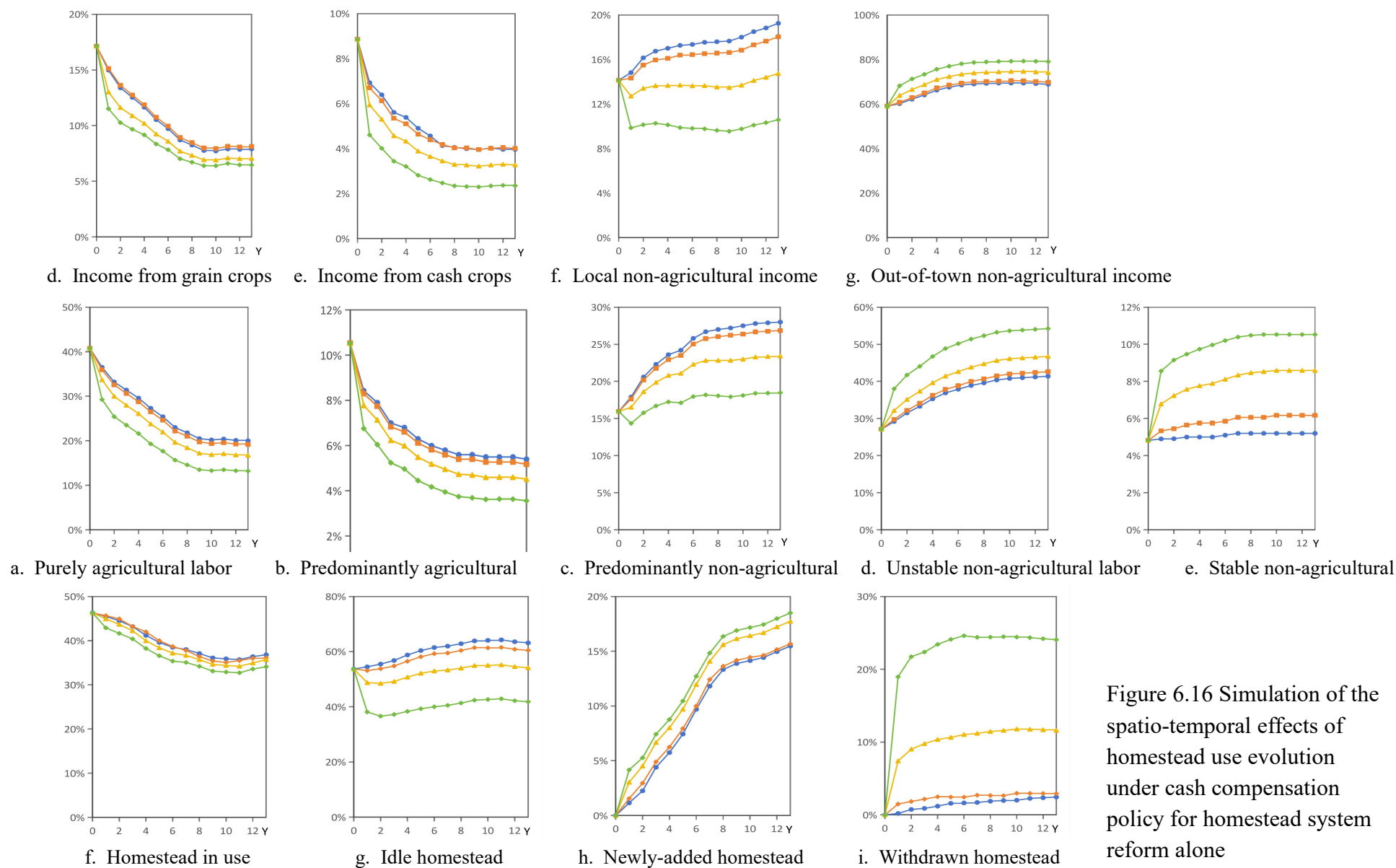


Figure 6.16 Simulation of the spatio-temporal effects of homestead use evolution under cash compensation policy for homestead system reform alone

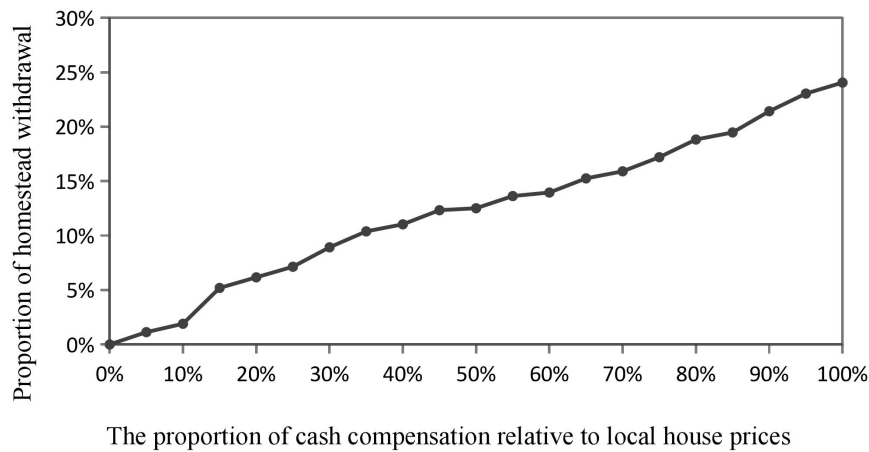


Figure 6.17. Trend in homestead withdrawal proportion with increasing cash compensation

(2) Spatio-temporal effects under the apartment compensation policy

The simulation result under the apartment compensation policy is shown in Figures 6.18~6.20.

From the spatial perspective, when each unit of withdrawn homestead can be exchanged for about 25% of a unit of housing in towns, the proportion of rural households that choose to withdraw from their homesteads significantly increases. In the study area, the average household size is 3.5 people, and it's generally believed that a minimum of 80 square meters of housing is needed for a family. Given that the average legal homestead area is 264 square meters, a 25% exchange rate means withdrawing from one homestead can be traded for 66 square meters of housing. Combined with additional purchases from household savings, this can basically meet the average requirement of 80 square meters.

Comparing the policy effects of cash compensation, it is found that when the compensation ratio is low, cash compensation is more popular. Smaller apartment exchanges do not fundamentally solve the living issues for households. By choosing cash compensation, rural households can use it for rural entrepreneurship, expanding production, or covering urbanization costs, playing a more significant role. When the homestead-to-apartment exchange ratio exceeds 25%, the apartment compensation policy becomes more effective in encouraging rural households to withdraw from

their homesteads. Although cash compensation can help alleviate production and living issues for some rural households, many do not know how to effectively plan cash investments or ensure asset preservation. Therefore, cash compensation is considered a secondary option. Meanwhile, from the temporal perspective, the effectiveness of the apartment compensation policy remains unchanged over time. Meanwhile, under this model, rural households can convert their rural hukou to urban hukou, improving benefits such as children's education, retirement, and healthcare. Thus, the proportion of rural-to-urban migration increases, and incomes rise significantly. However, this puts considerable pressure on government finances. According to Lu et al. (2022), the government needs to spend over 150,000 Yuan more per rural resident for urbanization compared to a non-reform scenario. Based on the annual urbanization rate of the county in the study area, the budget expenditure is expected to increase by over 12% by 2030. Therefore, reducing fiscal pressure and exploring reasonable financing mechanisms are key to ensuring economic and housing support for urbanization.

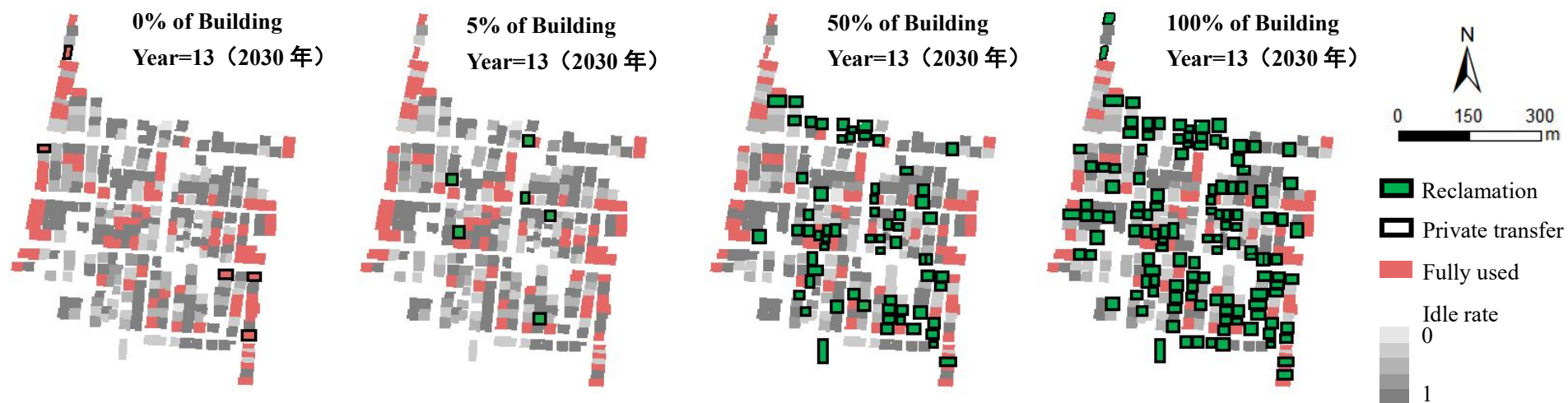
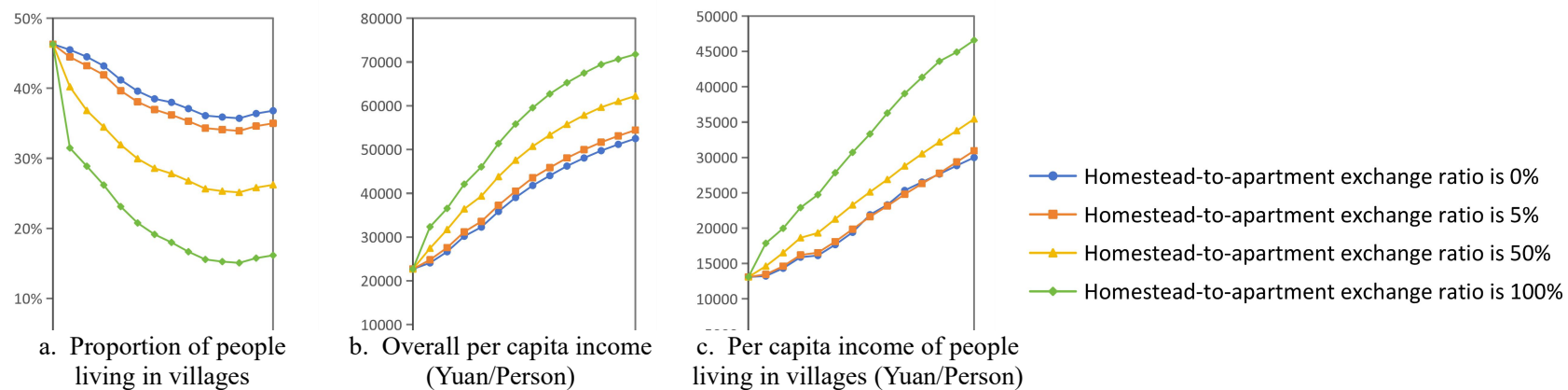


Figure 6.18 Simulation of homestead use evolution under apartment compensation policy for homestead system reform alone



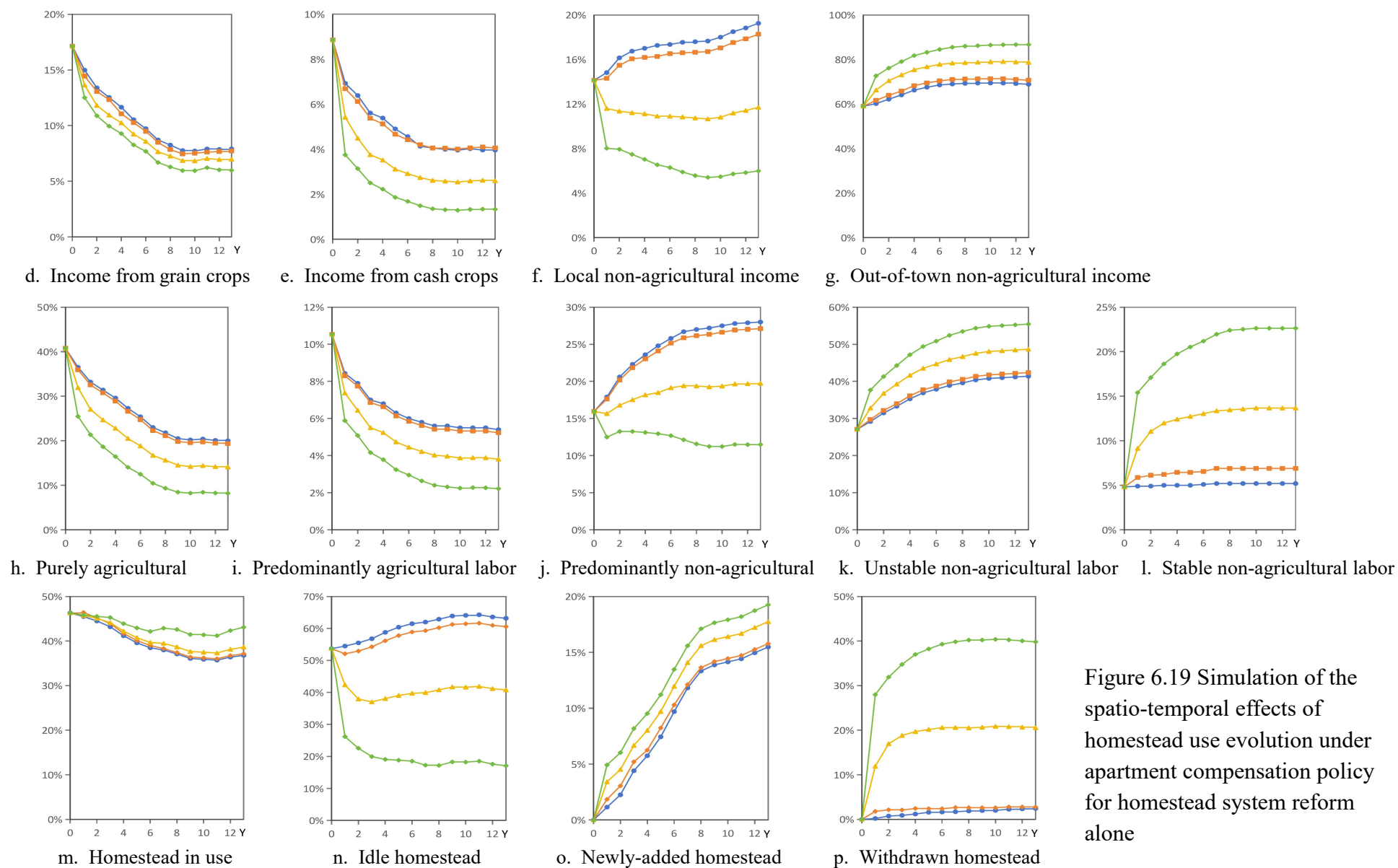


Figure 6.19 Simulation of the spatio-temporal effects of homestead use evolution under apartment compensation policy for homestead system reform alone

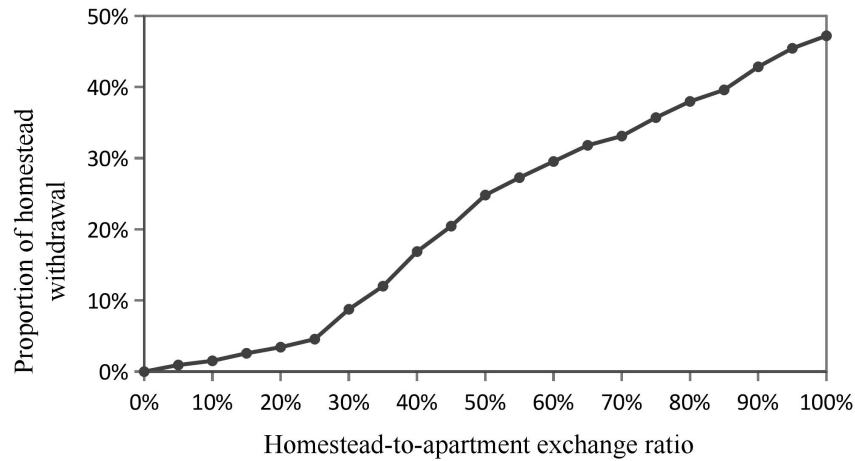


Figure 6.20 Trend in homestead withdrawal proportion with increasing apartment compensation

6.5.3.3 Spatio-temporal effects under multiple policy scenarios of homestead system reform

When combining cash compensation and apartment compensation policies for homestead withdrawal, the cash compensation amount is set at 10% of the local house price, and each unit of homestead withdrawn can be exchanged for 25% of an apartment unit in towns. This scenario examines the evolution of homestead use and its spatiotemporal effects under various compensated withdrawal policy combinations. The simulation results are shown in Figure 6.21.

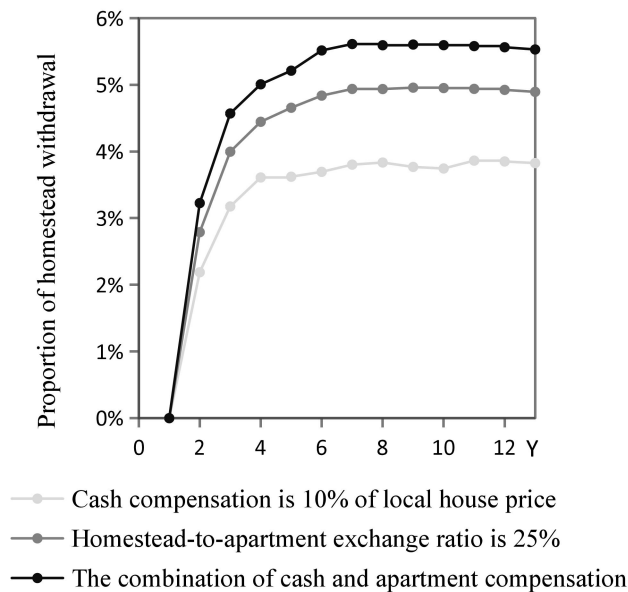


Figure 6.21 Trend in homestead withdrawal proportion under multiple compensated withdrawal policy combinations

As shown in the above figure, when both policies are implemented simultaneously, the total area of homestead withdrawal reaches 4,488 square meters, which is 41.67% higher than under the cash compensation-only scenario and 13.33% higher than under the apartment compensation-only scenario. Therefore, compared to single-policy approaches, a combination of multiple compensated withdrawal policies not only meets farmers' housing needs but also provides financial support for rural-to-urban migration and even self-employment. This combined approach better accommodates the diverse needs of different types of rural households and proves more effective in promoting homestead withdrawal.

In summary, homestead system reform has expanded the bundle of property rights associated with rural homesteads, opened institutional channels for realizing the asset value of homesteads, provided financial support for farmers, facilitated rural-to-urban migration, and improved the efficiency of homestead use. However, if the hukou system remains restrictive, farmers who withdraw from their homesteads may still be unable to access urban social security and services, making it difficult for them to achieve full integration in urban areas. As a result, concerns about exiting homesteads remain significant, which greatly limits the effectiveness of homestead system reform.

6.5.4 Spatio-temporal effects under the joint reform of hukou system and homestead system

Assuming that the hukou and homestead systems are reformed jointly, this section simulates the evolution of homestead use and its spatio-temporal effects in the case study for 2030. The policy scenario includes full relaxation of the hukou system, an annual homestead usage fee of 50 yuan per square meter, a cash compensation rate of 10%, and a homestead-to-apartment exchange ratio of 25% for homestead withdrawal. The simulation results are shown in Figures 6.22 and 6.23.

From a spatial perspective, by 2030, the total area of withdrawn homesteads is

projected to reach 17,952 square meters. This amount is 7.2 times greater than that under the scenario where only the hukou system is reformed, and 4 times greater than that under the scenario where only the homestead system is reformed. The joint reform of both hukou system and homestead system can greatly unlock the asset value of the homestead, so the newly-added homestead area doesn't significantly decrease, and rural households have higher expectations for the future value of homesteads. Regarding the idle homestead rate, it significantly decreases at the start of the reforms. However, as more rural population moved out, the rate rises slightly but remains relatively low. By 2030, the idle homestead rate is projected to be 48.61%, which is 38.47% lower than under the scenario where only the hukou system is reformed, and 11.62% lower than under the scenario where only the homestead system is reformed. This shows that the joint reform of these two systems has significantly improved the efficiency of homestead use.

From a temporal perspective, the joint reform of hukou system and homestead system makes it more likely for rural households to relocate to cities, gaining better social security and living environments, and achieving full urbanization. Therefore, in this scenario, the proportion of households returning to rural areas is smaller, greatly enhancing the sustainability of urbanization.

From the perspective of the overall village population structure, the joint reform of hukou system and homestead system further promotes rural-to-urban migration. At this point, the average labor income rises to approximately 78,081 Yuan, which is 10.94% higher than that under the scenario where only the hukou system is reformed, and 28.93% higher than that under the scenario where only the homestead system is reformed. This is because the hukou system is fully relaxed, freeing farmers from identity discrimination, making it easier to find stable, high-paying jobs. With compensation or exchanged housing from homestead withdrawal, farmers have stable housing, significantly reducing urban living costs. Meanwhile, the income of labor remaining in the village increases to 54,248 Yuan, due to the increased availability of

farmland resulting from the outflow of farmers, allowing for large-scale operations. Additionally, for farmers in the study area, the rural-urban income gap narrows from about 2.5 times in a fully closed system to about 1.5 times.

From the perspective of labor distribution, farmers are gradually being divided into two groups: those who are primarily engaged in agricultural labor and those who are primarily engaged in non-agricultural labor. Firstly, most farmers choose to work in cities. Part-time farmers with a non-agricultural focus are more likely to secure stable full-time non-agricultural jobs. Within this group, a small portion are young people with higher education or skills, holding stable jobs and social security in cities. Most work in nearby township enterprises, which provide stable income sources, making them a potential group for urbanization. Secondly, some farmers choose to stay and farm in the village. A very small number of traditional farmers are elderly people who farm as a leisurely lifestyle, holding a sentimental attachment to the land. A large number of primarily agricultural farmers are likely to expand their operations and are key targets for large-scale farming. Most of these farmers are aged 50-65, with extensive agricultural experience and strong social networks.

From the perspective of human-land relationships, the differentiation of farmer groups is inevitably accompanied by changes in the relationship between people and land. In the process of rural land transfer, most farmers have withdrawn from agricultural production and transformed into non-agricultural households. With the ongoing reform of the hukou system, an increasing number of rural residents are able to work and settle in cities. However, a considerable proportion of rural households still rely heavily on rural land, due to low educational attainment, limited job skills, and older age. These rural households retain their agricultural hukou and continue to hold rural land-use rights, forming a group known as “off-land but not off-hometown” households. Although they no longer directly engage in farming, they obtain rental income from their land-use rights, and rural land still serves an important function as social security. Therefore, the urbanization process of non-agricultural households

will take a relatively long time. However, this connection to land tends to weaken across generations, and such households remain the most direct targets of urbanization. The human–land relationship to some extent reflects the social structure and the stage of economic development in a given region. In the context of rural social transformation, land transfer is a spontaneous adaptation by rural households to socioeconomic development and urbanization. Sound policies should align with the level of economic development and the growth of non-agricultural industries, respect farmers’ preferences and the dynamics of human–land relationships, and provide a favorable institutional environment for land transfer.

In summary, the joint reform of hukou system and homestead system gradually changes the nature of rural land rights, weakening rights based on hukou and introducing market-oriented rights. This allows farmers to gain land asset value and enjoy urban benefits equally, or to gain more cropland for higher agricultural yields. This significantly reduces the institutional costs of labor and land allocation, enabling farmers to allocate resources freely based on their personal and family circumstances. It protects farmers' interests while enhancing the efficiency of resource allocation.

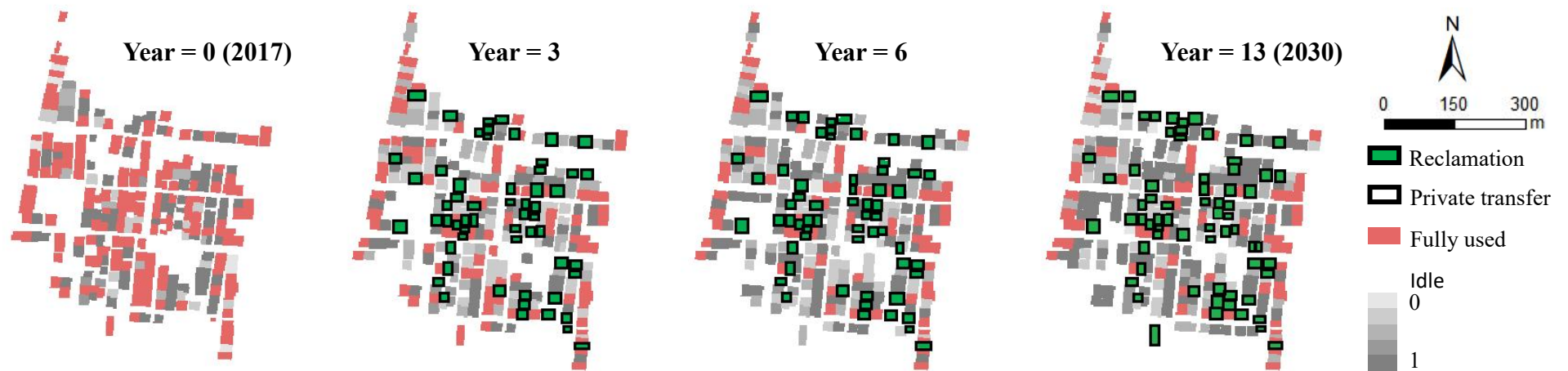


Figure 6.22 Simulation of homestead use evolution under the joint reform of hukou system and homestead system

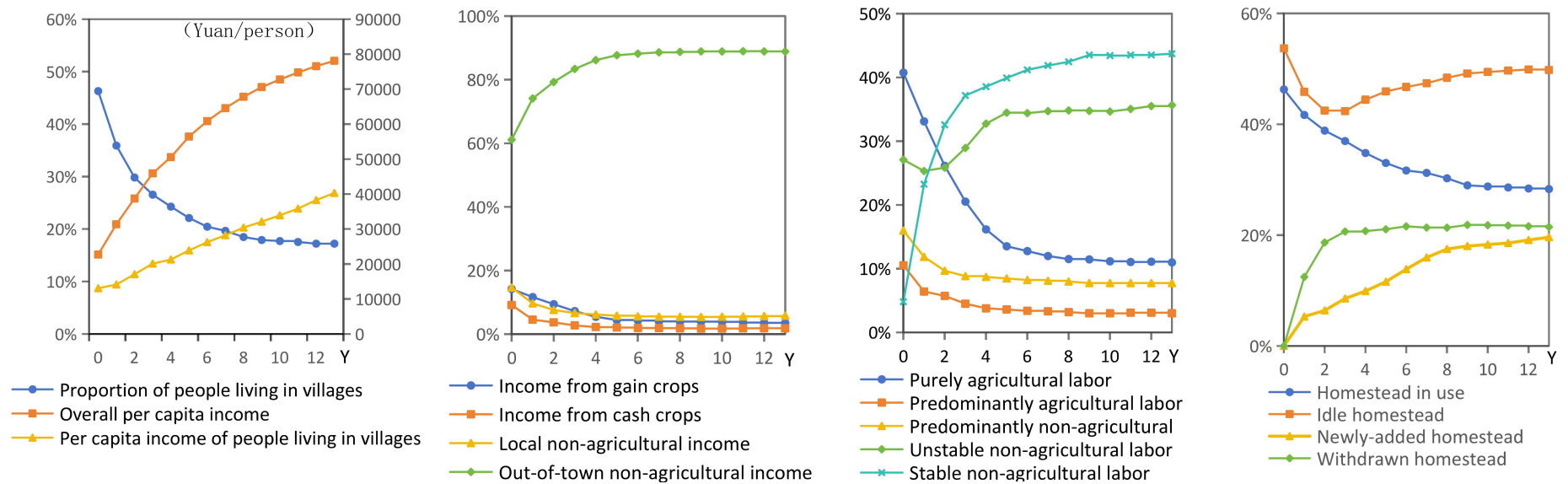


Figure 6.23 Simulation of the spatio-temporal effects of homestead use evolution under the joint reform of hukou system and homestead system

6.6 Conclusions

Based on the previously developed simulation model, using Yucheng City in Shandong Province as a case study, this dissertation simulates the evolution of homestead use in terms of spatial layout, morphological structure, quantity, scale, use efficiency, and functional roles under different hukou and homestead system reform scenarios. It also examines the impacts of these changes on the livelihood characteristics of rural households, including the allocation of labor between urban and rural sectors, income levels, and income structure.

Simulation results derived from this model are as follows.

First, this model's accuracy reaches 90%, indicating its reliability.

Second, when neither the hukou system nor the homestead system is reformed, both the expansion of new homesteads and the accumulation of idle ones occur simultaneously, leading to inefficient land use. Meanwhile, institutional barriers continue to constrain rural–urban mobility, hinder income growth among rural households, and ultimately exacerbate the rural–urban divide.

Third, although hukou system reform can promote rural-to-urban migration of farmers to a certain extent, the high cost of urban housing has replaced the hukou system as a new constraint on farmers' urban integration.

Fourth, with the relaxation of the homestead system, the paid use policy only addresses the issue of excess homestead withdrawal. However, its pricing mechanism fails to reflect market supply and demand or land value, thereby harming farmers' interests. When the cash compensation for homestead withdrawal, combined with farmers' savings, covers a down payment for commercial housing, the proportion of farmers withdrawing from their homesteads significantly increases. The effect is more pronounced when the homestead-to-apartment exchange area meets farmers' basic housing needs, and the combined effect of both policies is more efficient.

Fifth, the joint reform of hukou system and homestead system can significantly promote rural-to-urban migration, improve homestead use efficiency, and increase farmers' income.

Chapter 7: Conclusions

7.1 Major findings

China's existing hukou system and homestead system significantly restrict the flow of human-land factors between urban and rural areas, resulting in the dual occupation of urban and rural residential spaces by rural migrants, the extensive expansion and severe idleness of homesteads, and an inefficient allocation of land resources across the entire region. Since the Third Plenary Session of the 18th CPC Central Committee in 2013, China has focused on advancing major strategies such as comprehensively deepening reform and rural revitalization. Against this background, deepening reforms to the hukou and homestead systems will inevitably promote rural-to-urban migration and the paid use, compensated withdrawal, and transfer of homesteads, profoundly impacting the evolution of homestead use. However, the lack of forward-looking evaluation of the impacts of institutional reforms has significantly hindered the implementation of rural planning and affected sustainable rural development. To achieve effective forward-looking evaluation and guide the rational evolution of homestead use, it is essential to have a comprehensive understanding of the evolutionary mechanisms underlying homestead use behavior and a clear understanding of potential future institutional intervention scenarios.

Based on this, the dissertation integrates the macro-level institutional environment, micro-level behavioral responses, and spatial patterns. By comprehensively employing a combination of theoretical frameworks and methodological tools, including spatial equilibrium models, econometric models, multi-agent systems, and geographic information systems, it reveals the evolutionary mechanisms and spatio-temporal effects of homestead use behavior under the joint reform of hukou system and homestead system. The major findings are as follows:

(1) This dissertation systematically reviews the reform trajectories and policy practices of hukou and homestead systems, analyzes the underlying logic of their joint reform, and constructs an analytical framework for the

evolutionary mechanisms and spatio-temporal effects of homestead use behavior under institutional reform.

The major results are as follows. First, historically, almost major homestead system reforms have been jointly advanced with hukou system reforms, which can be divided into four phases: the “migration-permissive” hukou system facilitated the homestead system reform toward “private ownership and private use”; the “migration-restrictive” hukou system strengthened the implementation of the “public-and-shared” homestead system; the “migration-restrictive” hukou system strengthened the homestead system reform toward “public ownership and shared use”; the “migration-conditionally-permissive” hukou system promoted the homestead system reform toward the exploration of “two-rights separation”; the “nominally urban-rural unified” hukou system fails to support efficiency-oriented homestead system reform from “two-rights separation” to “three-rights division”. Second, the policy practices of hukou and homestead system reforms can be summarized into three types: villages with strong endowments attract talents to rural areas and explore non-agricultural operations of homestead; villages with moderate endowments encourage farmers to leave their land and explore the withdrawal and consolidation of homesteads; villages with weak endowments promote centralized residential settlements and explore the reclamation and reallocation of homestead for agricultural use. Third, the underlying logic of the joint reform of hukou system and homestead system lies in two dimensions: in terms of land rights, it changes the nature of rural land property rights, weakens hukou-based rights, and introduces market-oriented rights; in terms of land interests, it essentially dismantles the hukou-based land closure protection mechanism and replaces it with urban security systems. Fourth, the joint reform of hukou system and homestead system affects the interactions and equilibrium state among market entities, alters the utility and constraints of rural households, and prompts changes in their homestead use behaviors. The accumulation of numerous micro-level homestead use behaviors results in the differentiation of farmer groups and emerges as spatial-level homestead use evolution, following the logical route of “external shock→behavioral response→effect emergence”.

(2) This dissertation develops a spatial equilibrium model, conducts comparative statics analysis, and theoretically derives how the joint reform of hukou system and homestead system influences multi-agent interactions and constrains rural households' homestead use utility, thereby revealing the evolutionary mechanisms of homestead use behavior under institutional reform, and proposes propositions.

The major results are as follows. First, if neither system is reformed, rising urban land rents and falling wages jointly lead to a decline in the overall utility of rural migrants. Consequently, rural migrants have neither achieved permanent settlement in urban areas and equal access to urban public services, being gradually crowded out, nor have they fully transitioned out of agriculture with compensation for withdrawing from rural land rights, resulting in a serious, inefficient mismatch of labor and land factors between urban and rural areas. Second, the joint reform of hukou system and homestead system can play a complementary role, significantly promoting rural migrants to withdraw from their homesteads. Third, the complementarity between these two systems arises because the hukou system reform grants farmers full urban employment rights and welfare benefits, enhancing the income effect of the homestead system reform and reducing farmers' reliance on the homestead. The two channels work together to encourage farmers to withdraw from their homesteads. Fourth, further analysis reveals that the joint reform of the two systems can lead to a larger scale of rural-to-urban labor migration and the withdrawal of homesteads, increase the utility for farmers, and enhance the total socioeconomic output, thus turning the negative "crowding-out effect" into a positive "agglomeration effect."

(3) This dissertation employs national rural household panel data and the PSM-DID method to empirically test the theoretical hypotheses concerning the impacts of hukou and homestead reforms on homestead use behavior, and further investigates their effectiveness, dynamics, and heterogeneity.

The major results are as follows. First, hukou system reform can enhance the promotion effect of homestead system reform on farmers' homestead withdrawal, resulting in a 14% increase. This conclusion confirms the theoretical hypothesis that

the two system reforms complement each other. Additionally, the more important revelation is that formal land property rights are a prerequisite for promoting land withdrawal. Without secure rights and a well-functioning land market, high transaction costs, risks, and low transaction prices can hinder land liquidity, even when other external conditions are favorable. Second, through an in-depth analysis of the specific policies of the system reform, it's found that only employment and housing policies within the hukou system reform play an effective role. The unified urban and rural hukou policy, which blurs the concept of hukou without bridging the urban-rural gap, is unlikely to produce positive effects. In the homestead system reform, the paid-use policy for homesteads has a negligible effect on promoting homestead withdrawal, whereas the compensated withdrawal policy significantly increases farmers' willingness to withdraw from homesteads. Among them, the homestead-to-apartment exchange policy is more popular, and a combination of multiple measures proves more efficient. Third, dynamic analysis of the complementary relationship between the two systems indicates that blindly deepening hukou reform alone cannot generate sustained effects. As the hukou system reform deepens, the promotive effects of the joint reform of these two systems on farmers' homestead withdrawal behavior exhibit an inverted U-shape. At this point, the homestead security function is replaced by urban welfare and is no longer a concern for farmers. Meanwhile, farmers' high expectations for the future value of their homesteads, along with their attachment to their hometowns, reduce their willingness to withdraw from their homesteads. Fourth, heterogeneity analysis reveals that complementarity is stronger between homestead reform in the central and western regions, non-minority areas, large counties, and distant suburban areas, and hukou system reform in second-tier cities. Farmers with medium levels of education, income, and age, as well as those without urban housing, are more positively influenced by reforms.

(4) This dissertation integrates multi-agent system (MAS) and geographic information system (GIS) to build a simulation model that captures the

spatiotemporal effects of homestead use under the joint reform of hukou and homestead systems.

This dissertation extends the economic analysis of homestead use behavior to the spatial-scale investigation of homestead use evolution. Guided by complex adaptive systems theory and adopting a bottom-up modeling strategy, it first develops an integrated modeling framework that combines a spatially explicit agent-based model with a geographic information system. Second, based on the theoretical and empirical findings of homestead use evolution under institutional reforms, methods such as projection, regression, and probability are used to build the model. This model depicts the demographic dynamics of rural households, behavioral choices regarding labor allocation and rural-to-urban migration, as well as decisions related to homestead use and site selection for new residential land, and integrates objective changes, behavioral rules, and decision-making mechanisms. By employing a Geographically Weighted Regression model, it quantifies the localized effects of geographical factors, interprets the social relationships among individual farmers, households, and village groups, as well as the spatial connections between farmers and their farmland or homesteads, thereby revealing the coupling mechanisms between human and natural systems. Thus, a coupled human-land system is constructed. Third, different scenarios of hukou and homestead system reforms are designed, and variables representing the spatio-temporal effects of homestead use are identified. This model can be applied to policy experiments to support policy formulation and impact evaluation.

(5) This dissertation uses the NetLogo platform and selects Yucheng City in Shandong Province as a case study to simulate the homestead use evolution and its spatio-temporal effects under different institutional reform scenarios and proposes policy recommendations for deepening institutional reform based on the simulation results.

The major results are as follows. First, through point-by-point comparison, the model developed in this dissertation achieves a simulation accuracy of up to 90%, demonstrating its reliability. Second, when neither the hukou system nor the homestead system is reformed, both the expansion of new homesteads and the

accumulation of idle ones occur simultaneously, leading to inefficient land use. Meanwhile, institutional barriers continue to constrain rural–urban mobility, hinder income growth among rural households, and ultimately exacerbate the rural–urban divide. Third, although hukou system reform can promote rural-to-urban migration of farmers to a certain extent, the high cost of urban housing has replaced the hukou system as a new constraint on farmers' urban integration, which is destined to prevent farmers from taking root in cities and force them to adopt a "migratory bird" approach of rural-urban migration, further causing a more serious decline in the homestead use efficiency. With the relaxation of the homestead system, the paid use policy only addresses the issue of excess homestead withdrawal. However, its pricing mechanism fails to reflect market supply and demand or land value, thereby harming farmers' interests. When the cash compensation for homestead withdrawal, combined with farmers' savings, covers a down payment for commercial housing, the proportion of farmers withdrawing from homestead significantly increases. The effect is more pronounced when the homestead-to-apartment exchange area meets farmers' basic housing needs, and the combined effect of both policies is more efficient. Fifth, the joint reform of hukou and homestead systems can significantly promote rural-to-urban migration, enhance homestead utilization efficiency, and increase farmers' incomes.

7.2 Discussions

Both urbanization and rural revitalization are global interests. Despite boosting economic prosperity, China's urbanization primarily focuses on rural-urban migration without corresponding land or property transfers, resulting in human-land mismatch and inevitable rural decline (Wang et al, 2015). To promote rural migrants' land withdrawal, although there is a consensus on the necessity of simultaneously reducing migration restrictions and perfecting rural land property rights in China's hukou system and homestead system, feasible implementation pathways remain unclear to policymakers and are still being explored in practice. This study's findings not only provide empirical evidence on the reform effects of these two systems but also inspire discussions on how to carry out the reforms in developing countries effectively.

The main results demonstrate that homestead system reform aimed at formalizing land property rights can promote rural migrants to withdraw from homestead on a national basis. Its positive income effect is strong enough to counterbalance the negative impact of potential social risks and the loss of homestead appreciation. These findings can enrich the traditional Land Property Rights Theory, suggesting that even without land ownership, clear and secure land use rights can also foster positive market expectations and encourage individuals to engage in land transactions. Conversely, simply reforming the hukou system to relax rural-urban migration restrictions without strengthening land rights proves largely ineffective in facilitating land transfer. In other words, although restrictive migration policies can limit land liquidity (Zhang, 2017; Zhang et al., 2020; Zhang, 2020), easing these restrictions doesn't necessarily lead to positive outcomes. The more important revelation is that formal land property rights are a prerequisite for promoting land withdrawal. Without secure rights and a well-functioning land market, high transaction costs, risks, and low transaction prices can hinder land liquidity, even when other external conditions are favourable.

Although easing restrictions on the hukou system alone has a minimal effect, our empirical results highlight that when it is reformed alongside the homestead system, the positive effect on rural migrants' homestead withdrawal can be significantly enhanced, demonstrating their complementary relationship. Specifically, hukou system reform reduces rural migrants' access restrictions on urban welfare and equal employment rights, thereby partially offsetting the potential risks of homelessness or unemployment that may arise after withdrawing from homestead. The increase in returns combined with the reduction in costs can significantly increase rural migrants' enthusiasm to withdraw from homestead. These findings provide empirical evidence for previous theoretical conjectures (Tao et al., 2011; Zhu, 2014; Han et al., 2019) and have significant policy implications. Further unpacking of specific policies of system reforms identifies that the alignment points between the two systems lie in housing security and employment, which sheds light on the practical and feasible paths to realize more cost-effective joint reform. China is a microcosm of many developing

countries, like Vietnam, Mexico, and various African regions, where state or collective land ownership, imperfect land systems, and undeveloped markets lead to conflicts between poor land liquidity and low land utilization rate. Previous studies often use neoclassical views, like Push-Pull Theory and Cost-Benefit Theory, to analyze the factors influencing land use behaviour but fail to explore their complicated mutual influences and compound effects. Our research goes beyond single-system studies, incorporates migration restrictions and land property rights into a unified theoretical framework, verifies that the joint reform of these two systems can achieve the complementary effect that produces more with less effort, and offers new insights for these developing countries to improve land liquidity and achieve efficient matching of human and land resources.

Furthermore, analyzing the dynamics and heterogeneity of the interactive relationship between these two systems also contributes to the understanding of the neoclassical perspective in land use studies by considering the long-term cost-benefit trade-off. An unexpected finding is that the relationship between hukou system reform intensity and rural migrants' homestead withdrawal follows an "inverted U-shaped" pattern. Currently, China's annually increasing gap between the urbanization rate of the registered population and the permanent population indicates that hukou system reform is still incomplete, situated on the left side of the curve (Chu, 2020). There is significant potential to facilitate the citizenization of rural migrants to achieve efficient human-land factor allocation. After the inverted U-shaped peak, once hukou restrictions are completely relaxed and urban security for rural migrants is guaranteed, their enthusiasm for homestead withdrawal diminishes. This outcome contradicts the original reform goals, as the farmers most qualified to withdraw from homesteads often retain their land use rights. A critical reason is that imperfect or insecure homestead property rights are often bolstered through informal transactions, leading to farmers' inflated and unrealistic expectations about the future homestead values, which is essentially land speculation by rural migrants (Kan and Chen, 2021). Perfecting homestead property rights bundles and offering reasonable compensation for withdrawal are expected to weaken land speculation. Land use studies from the

neoclassical perspective need to consider such long-term costs or returns, contributing to a comprehensive understanding of rural migrants, decision to transfer rural land.

7.3 Policy implications

7.3.1 Continuously advance the joint reform of hukou and homestead systems

This study emphasizes the unwavering promotion of the joint reform of the hukou and homestead system. The key to achieving positive complementarity between the two systems lies in establishing property rights connections that mutually reinforce and complement each other, thereby enhancing the alignment of land and labor factors and forming a positive feedback system where rights structures are interconnected and supportive. Combining the analysis results of policy heterogeneity, we propose two feasible pathways for their joint reform.

Path 1: Integrate the stability of homestead tenure rights with the security of rural migrants' subsistence rights, ensuring they can “have land when returning to rural areas and access to welfare when migrating in urban areas”. Regarding the homestead system reform, the qualification for homestead use rights can be integrated with membership in collective economic organizations. By implementing long-term, stable land rights policies and promoting the certification of homestead ownership, farmers can retain secure homestead rights even after relocating to urban areas, thereby significantly reducing the risk of losing their rural land. Regarding hukou system reform, the survival rights of rural migrants should be safeguarded by providing them with social insurance and assistance in times of severe hardship. In cases where their basic needs are not met and they are unable to access urban social protection systems, they should have the option to return to rural areas and rely on land-based security, thereby preventing the simultaneous loss of both employment and land rights. Finally, efforts should be made to further improve the rural social security system and gradually replace the land's function as a social safety net, which would help safeguard the basic survival rights of farmers and mitigate their livelihood risks.

Path 2: Integrate the flexibility of homestead transfer rights with the protection of rural migrants' development rights, ensuring they can “have channels for land transfer

in rural areas and have opportunities for employment and development in urban areas". In the homestead system reform, the "three-rights separation" system distinguishes the right to use the homestead from the right to homestead qualification. This separation helps decouple the homestead's social security function from its auxiliary production function, lifting identity-based restrictions on qualification rights. As a result, it expands the potential user base of homesteads, facilitates the standardized and orderly transfer and withdrawal of homestead use rights, revitalizes their utilization, and ultimately promotes the relocation of farmers from rural areas. However, whether the rural labor force can successfully integrate into urban areas still depends on further reforms of the hukou system to safeguard their freedom and equal rights. From the perspective of freedom, rural migrants should have the right to move freely, and the excessively high entry restrictions in large cities should be gradually lowered to enable them to settle more easily. From the perspective of equality, rural migrants should enjoy equal rights in employment and access to social security services, including housing, healthcare, elderly care, and education, to reduce their cost of living after urban relocation and provide greater opportunities for survival and development.

7.3.2 Strategically differentiate reform measures based on local conditions

Although we emphasize the importance of jointly reforming the hukou system and systems, the "inverted U-shaped" relationship between rural migrants' homestead withdrawal behavior and the intensity of reform cautions against hastily deepening reforms without regard for urban development practices. Cities should accurately assess their stage in hukou system reform by evaluating how well the difficulty of obtaining local hukou matches the ability of rural migrants to acquire it. Besides, the varying effects of institutional reforms across different city tiers also indicate the need for targeted policy design and implementation to enhance overall reform efficiency. Therefore, efforts should focus on the following areas.

First-tier cities should intensify efforts to relax urban settlement restrictions, offer reasonable compensation for farmers' withdrawal from homesteads, and reduce

their dependence on the homestead's function as a social safety net. In cities with strict hukou constraints, typically those in the first-tier cities like Beijing and Shanghai, rural migrants encounter significant challenges. Although these cities offer better social welfare and public services, the intense competition and pressure in both work and daily life are considerable. As a result, migrants are reluctant to sever ties with their rural homestead, which serves as a crucial safety net for them. Under such circumstances, greater efforts should be made to advance hukou system reform, enabling farmers to obtain local household registration and access to urban social security benefits. Furthermore, a unified social welfare system for urban and rural residents should be developed, particularly in terms of housing and employment security, to prevent high urban housing costs from becoming a new barrier to rural-urban migration and homestead withdrawal. This will also reduce waiting costs and risks associated with seeking urban employment. In addition, local governments should improve the homestead transfer pricing mechanism, establish a reasonable compensation range, and design diversified compensation methods to accommodate farmers' varying dependencies on their homesteads.

Low-tier cities should prioritize enhancing social welfare systems, deepening the reform of the homestead property rights system, and stabilizing farmers' expectations regarding the value of homestead assets. In cities with a more comprehensive hukou system reform, particularly those in lower-tier cities or the hometowns of rural migrants, people experience greater familiarity and less pressure in their daily lives. Further hukou system reform should enhance the expected benefits of hukou for rural migrants by improving public services, social welfare, and formal employment opportunities. More importantly, to mitigate land speculation by rural migrants who can fully enjoy urban benefits, the reform should be accompanied by efforts to strengthen farmers' land interests and deepen homestead property rights reform. Based on instituting lawful property rights certificates to clarify property boundaries and ownership, farmers' homestead property rights bundles should be further expanded to enrich homestead value realization forms and fully unlock homestead value, thereby stabilizing farmers' value expectations.

7.3.3 Systematically strengthen the supporting mechanisms for institutional reform

To achieve more effective outcomes in the hukou and homestead system reforms, relevant supporting mechanisms still need to be further improved to protect the rights and interests of farmers and guide them to withdraw from idle homesteads in an orderly manner.

On the one hand, to optimize and integrate the social security system, the following measures should be taken:

Strengthen the housing security for rural migrants. Empirical evidence from the specific hukou reform policies discussed in Chapter 4 indicates that relaxing the requirement of purchasing urban housing as a precondition for obtaining urban hukou can significantly increase the likelihood of farmers withdrawing from their homesteads. Meanwhile, the simulation results of the spatio-temporal effects of individual hukou system reform in Chapter 5 further suggest that access to stable urban housing is a key factor influencing farmers' decisions to migrate to cities and withdraw from their rural homesteads. To enhance urban housing security for rural migrants, several policy approaches can be considered. First, compensation received from rural homestead withdrawal can be allocated to establish a Farmer Cooperative Housing Construction Fund, which would be used to uniformly develop new commercial housing in urban areas to address the housing demands of rural migrants. Second, in alignment with the current urban housing destocking policies implemented by local governments, the government can take responsibility for the centralized acquisition of surplus commercial housing and offer it to homestead-withdrawing farmers through targeted preferential sales. Third, we can explore the implementation of a virtual housing ticket system for resettlement. Under this system, farmers who withdraw from their rural land rights can use housing tickets to purchase urban housing within designated areas, effectively shortening the resettlement period, accommodating the diverse housing needs of rural migrants, and easing the financial burden on local governments. Fourth, governments should accelerate the development

of the urban rental housing market, and incorporate rural migrants into the urban rental housing security system. A variety of measures should be implemented to ensure that farmers relocating to cities have access to sufficient and affordable housing, such as low-rent housing, public rental options, and rental subsidies.

Improve the employment security for rural migrants. Empirical evidence from the specific hukou system reform policies analyzed in Chapter 4 indicates that lowering the requirement of securing stable employment as a precondition for urban hukou can lead to higher wage incomes for rural migrants and significantly strengthen the effectiveness of homestead system reform. Therefore, rural migrants should be fully incorporated into the urban employment security system, and continuous efforts should be made to improve and adapt relevant employment protection mechanisms. First, free vocational skills training programs should be implemented to improve the adaptability of rural migrants to urban employment demands and industrial transformation. These programs should also facilitate skill-level complementarity between rural migrants and urban residents. Second, a standardized labor market intermediary system should be established to provide employment information and consulting services through multiple channels, thereby expanding employment opportunities for rural migrants. Third, labor protection mechanisms should be established for unemployed rural migrants to mitigate the costs and risks associated with job-seeking during transitional periods.

On the other hand, to strengthen the protection of farmers' rights and interests, the following measures should be taken:

Establish a mechanism for farmers' interest expression in homestead withdrawal. A key prerequisite for promoting homestead withdrawal is the protection of farmers' rights and interests, which requires establishing institutionalized channels for the expression of interests. By enabling farmers to communicate their concerns and preferences through formal mechanisms, the policy implementation process can safeguard their legitimate interests, build trust in local governments, and ultimately generate sustained positive momentum for reform. First, farmers should be granted equal negotiating status and substantive decision-making power. In the process of

homestead withdrawal, farmers must have a meaningful voice in key matters that directly affect their interests, such as withdrawal schemes, compensation standards, and compensation methods. This participatory approach can help prevent local governments from making biased decisions that result in inefficient implementation and undermining farmers' rights. Second, local public service departments should actively respond to national policy directives and explore effective pathways for the market-oriented allocation of rural land. By providing farmers with secure and reliable platforms for land transfer, land use efficiency can be significantly improved.

Establish screening criteria to reduce the risk of homestead withdrawal. As indicated by the heterogeneity analysis in Chapter 4, farmers with moderate levels of education, no urban housing, medium income level, and middle age are more likely to respond positively to institutional reforms and exhibit a strong willingness to withdraw from their homesteads. Given the significant externalities associated with rural homesteads, which affect not only farmers' production and living conditions but also carry broader social implications, the reform process must be approached with caution and gradual implementation. Since there is no turning back from reform, it is essential to set appropriate screening criteria to identify suitable participants. At the same time, efforts should be made to ensure that farmers planning to withdraw from their homesteads have access to stable non-agricultural employment and improved income sources, to avoid overly aggressive or irrational policy implementation.

Pay attention to regional differences in customs and culture. The regional heterogeneity analysis in Chapter 4 reveals that farmers in ethnic minority areas exhibit stronger emotional attachment to their hometowns and a heightened sense of community identity, which limits the effectiveness of homestead system reform in these regions. Therefore, from a spatial and cultural perspective, policymakers should address the irrational use of homesteads stemming from deep-rooted social relations, customs, and cultural norms. When designing and promoting region-specific policies for homestead system reform, it is crucial to coordinate administrative measures with changes in rural customs and practices, curb the "rural house-building fever" driven

by marriage traditions, and eliminate the illegal or excessive occupation of homesteads associated with social status or symbolic prestige in rural society.

7.4 Contributions

This dissertation advances existing knowledge by offering theoretical insights, introducing innovative methodologies, and providing practical implications for policy and reform.

(1) Expanding the research perspective to the organic integration of spatial evolution and economic mechanisms

The traditional one-dimensional spatial perspective is expanded into a two-dimensional approach that combines spatial development with economic mechanisms and constructs a spatial equilibrium model more aligned with China's urban-rural dual macroeconomic and institutional environment. Innovatively, this model provides a "spatial-economic" research tool that connects the evolution of residential space at the spatial level with micro-level residential location decisions, enabling both theoretical and empirical analysis of complex human-land interaction mechanisms. This spans from institutional reform shocks to behavioral responses in homestead use, ultimately leading to the emergence of spatio-temporal effects. The main findings help address the limitations of current research perspectives, bridging the gap where spatial studies often lack an economic theoretical foundation and economic studies lack spatial connections.

(2) Deepening the research contents to explore the combined impacts of the joint reform of the two systems

Studies on the effects of individual hukou or homestead system reforms are extended to the combined effect studies of their joint reform across multiple stages and scenarios. Using multi-period survey data at the national level, this dissertation not only verifies the necessity of their joint reform but also reveals the dynamic and heterogeneous interactions between the two systems and further analyzes the roles and mechanisms of key policies. The main findings can help fill the gap in current institutional studies, which often focus exclusively on the current status of individual

systems, rely heavily on logical deduction, and infrequently use national-level data for empirical research with broader significance.

(3) Improving the research methods for constructing the coupled human-land system model

The research methods of general regression analysis and spatial analysis are extended to integrate a multi-agent system with a geographic information system, thereby constructing a comprehensive coupled human-land system. This system illustrates the interactive relationship between farmers and other stakeholders, as well as the spatial connections between farmers and their homesteads. It captures the game, influence, and feedback processes under policy intervention, the behavior choices of multiple stakeholders, and geographical environment changes, enabling the spatially explicit expression of micro-decision-making behaviors. Furthermore, this dissertation designs multiple institutional reform scenarios and establishes a policy laboratory to simulate potential changes in homestead use under various policy conditions. The main findings can help address the shortcomings of existing spatial economics models, which struggle to examine the effects of institutional exogenous shocks on the spatial evolution of land use.

7.5 Limitations and further research directions

Based on multidisciplinary theories and methods, this study not only enriches the relevant theoretical system of the evolutionary mechanisms of homestead use under institutional reforms at the theoretical level, but also simulates the spatio-temporal effects of homestead use evolution under different institutional reform scenarios at the practical level, providing a more intuitive and scientific basis for the preparation and implementation of village planning, and puts forward suggestions for deepening the joint reform of hukou system and homestead system. However, the evolution of homestead use is a complex and systematic process, and the impacts of the joint reform between multiple systems are even more intricate and difficult to fully capture. As an exploratory study, limited by the research time and research conditions, this

study inevitably has several limitations that require further improvement and expansion in future studies. These limitations are summarized as follows.

Further expand the equilibrium model and enrich the mechanism analysis. After weighing the accuracy and complexity, this study only describes the three fundamental markets of the labor market, land market, and product market, and simplifies some institutional details. However, in practice, the evolution of homestead use is quite complex, with many other influencing factors that deserve attention, such as the coercive power of government planning and the deep-rooted nostalgia of farmers, among others. On the one hand, these factors fall outside the primary scope of this study. On the other hand, social and cultural factors are indeed difficult to quantify or incorporate directly into data-driven models. Although proxy indicators, such as farmers' age, are used to partially capture the effects of nostalgia, these simplifications inevitably affect the model's overall accuracy to some extent. In future research, the model can be further optimized and expanded in several aspects. First, additional factors such as the impact of the urban housing market and government planning objectives could be incorporated. Second, the institutional environment can be enriched by incorporating elements such as the tax system and social welfare system, enabling a deeper exploration of the trade-offs or synergistic relationships among multiple institutional reforms. Third, a dynamic equilibrium framework can be constructed to examine institutional evolution over time. Finally, the introduction of local government competition may help facilitate the investigation of strategies for coordinated regional institutional reform. These extensions would contribute to a more robust theoretical foundation for designing effective and adaptive reform pathways.

Further expand the data sample and enrich the empirical analysis. To obtain quantitative results of national significance, enrich the discussion of regional heterogeneity, and propose more practical policy recommendations, this study utilizes the China Rural Household Survey Data, a national-level dataset. Although this dataset features annual tracking and a sufficiently large sample size, and is generally considered highly representative, it still exhibits several limitations. First, the survey

period is relatively short, and missing values in the early waves of data, particularly prior to institutional reform, may lead to endogeneity. Although this study applies methods such as propensity score matching and instrumental variables to address these issues, the potential for bias cannot be entirely ruled out. Second, due to limited access to some variables, direct investigation of certain potential mechanisms is not possible. While the study has identified the mechanisms, dynamics, and heterogeneity underlying the evolution of homestead use driven by the joint reform of two systems, and has largely fulfilled its research objectives, further in-depth investigation is still warranted. In future research, the data sample can be further expanded to enrich the empirical research results. For instance, we could examine how factors such as the village collective governance structure moderate the effects of institutional reforms, as well as explore the potential spatial spillover effects of these reforms.

Further expand the simulation cases and enrich the universality of policy recommendations. This study selects Yucheng City in Shandong Province, a developed region in eastern China, as a case study. Two rounds of village-level surveys were conducted, with all rural households tracked to collect detailed information on basic demographic characteristics, production and living patterns, and their willingness to transfer homesteads. Efforts were also made to capture complex interpersonal networks among villagers. This process involved substantial workload and time commitment. However, due to limited research capacity, it is currently difficult to extend the study to a broader range of case regions. As a result, the simulation analysis in this study is confined to different institutional policy scenarios within a single region, without enabling comparative analysis across multiple regions under the same institutional framework. Future research could include field visits to a wider range of villages and select case studies from different regions in central, western, and southern China. By designing more refined institutional scenarios, it would be possible to conduct a more comprehensive comparative analysis of simulation results along two dimensions: horizontally across multiple regions and vertically across multiple institutional scenarios. Such an approach would help enhance the generalizability and policy relevance of the research findings.

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