

Research on Pricing Policy Simulation and Long-Term Mechanism of Converting Existing Commercial Housing to Affordable Housing in Liaoning Province Based on System Dynamics

Shuang Wu, Danning Yang, Honger Song, Hongsheng Zhao

School of Management, Liaoning Institute of Science and Engineering, Jinzhou 121000, Liaoning, China

Corresponding author: Shuang Wu (e-mail: xingfushuang1211@163.com)

ABSTRACT To address unreasonable pricing, insufficient policy sustainability, and regional differences in converting existing commercial housing to affordable housing in Liaoning Province, this study constructs a system dynamics model centered on the combined objectives of cost, fairness, and efficiency. Urban renewal and housing security increasingly require quantitative policy simulation comparable to engineering system optimization, particularly in smart-city contexts where housing distribution, industrial space, infrastructure, and electromagnetic environment constraints need coordinated planning. Based on the research achievements of the Liaoning Provincial Social Science Fund Project, the study identifies key pricing factors, including renovation cost, property-right compensation, government subsidy intensity, regional housing stock distribution, residents' income level, and regional economic variance. A system flow model is then developed to simulate the effects of fixed pricing, cost-plus pricing, and regionally differentiated dynamic pricing across multiple time horizons. The results show that housing renovation cost, subsidy intensity, and spatial distribution of housing stock have the most significant effects on pricing outcomes. Different pricing policies differ markedly in balancing fairness and efficiency, while regionally differentiated dynamic adjustment improves pricing rationality and long-term sustainability. The study proposes a mechanism including dynamic cost monitoring, fairness evaluation, and policy feedback adjustment, providing a quantitative basis for affordable-housing policy design in Liaoning Province.

INDEX TERMS system dynamics, affordable housing, pricing policy, urban infrastructure, smart-city modeling

I. INTRODUCTION

AS China's real estate market transitions from incremental expansion to stock-based operation, repurposing surplus commercial housing into affordable units—while simultaneously integrating industrial zones into urban renewal frameworks—serves as a critical strategy to optimize resource allocation, support the housing needs of industrial workers, and foster a stabilized socioeconomic environment. As an important old industrial base in China, Liaoning Province is facing problems such as a large stock of commercial housing, unbalanced regional development, and prominent housing difficulties for some groups in the process of urban transformation and upgrading. The Liaoning Provincial Social Science Fund Project "Research on the Innovation and Path of Pricing Mechanism for Converting

Existing Commercial Housing to Affordable Housing in Liaoning Province" has carried out in-depth research on the core elements of pricing, cost control, and spatial differences, forming a series of research achievements including EI journal papers, monographs, general journals, and policy articles.

Existing studies have clarified the core elements of the pricing mechanism for converting existing commercial housing to affordable housing in Liaoning Province, constructed a cost-fairness oriented pricing framework, and measured the spatial differences of pricing using spatial econometric models (Wu, 2024). However, most existing studies focus on static analysis and cross-sectional empirical testing, lacking dynamic simulation of pricing policies and prediction of long-term effects. Since the pricing of converting existing

commercial housing to affordable housing involves multiple subjects such as the government, enterprises, and residents, and there are complex interactions between various influencing factors, static research methods are difficult to fully reflect the dynamic evolution law of the pricing system and the long-term effect of policy implementation. Therefore, it is necessary to introduce the system dynamics method to construct a dynamic model of the pricing system, simulate the operation effects of different pricing policies, and explore the long-term mechanism for pricing optimization, forming a complete logical chain of "element identification - spatial difference - dynamic simulation - long-term mechanism" with existing research achievements.

As an effective method for studying complex systems, system dynamics can simulate the dynamic feedback relationships between various variables in the system and predict the long-term evolution trend of the system, which is suitable for studying the pricing of converting existing commercial housing to affordable housing involving multiple subjects and factors. By constructing a system dynamics model focused on Liaoning Province, this paper simulates various pricing policies for converting commercial housing into affordable units, specifically evaluating how these mechanisms stabilize the residential costs for the local industrial workforce and support the long-term optimization of manufacturing clusters. This dual-focused approach provides scientific support for policy formulation in Liaoning while expanding the research framework to include the socioeconomic stability of industrial production hubs.

II. LITERATURE REVIEW

A. RESEARCH ON STOCK-TO-AFFORDABLE HOUSING TRANSFORMATION

In recent years, scholars at home and abroad have carried out extensive and in-depth research on the conversion of existing commercial housing to affordable housing. Foreign studies mainly focus on the operation mode and policy support of affordable housing, and hold that converting existing housing to affordable housing can effectively reduce construction costs and improve the utilization efficiency of housing resources (Narimisa A et al., 2025). Domestic studies mainly focus on the feasibility, path, and existing problems of the conversion work. Some scholars believe that converting existing commercial housing to affordable housing is an important way to resolve the stock of commercial housing and optimize the housing supply structure, but there are problems such as unreasonable pricing, imperfect supporting policies, and difficult interest coordination (Li et al., 2023). Wu (2024) pointed out in his research that converting existing commercial housing to affordable housing in Liaoning Province has the advantages of low cost and fast implementation, but there are obvious regional differences in pricing, which affect the fairness and efficiency of the conversion work.

B. RESEARCH ON THE PRICING MECHANISM OF AFFORDABLE HOUSING

The pricing mechanism of affordable housing is the core of the conversion work. Existing studies mainly focus on pricing principles, influencing factors, and pricing models. The pricing principles mainly include the cost principle, fairness principle, and efficiency principle (Zhang et al., 2023); the influencing factors involve housing costs, regional economic level, government policies, residents' income, and other aspects; in terms of pricing models, scholars have constructed various models such as the cost-plus pricing model, market comparison pricing model, and comprehensive evaluation pricing model (Wang et al., 2022). Wu et al. (2023) constructed a collaborative pricing mechanism based on the whole-chain cost and fairness orientation, and identified the core influencing factors of the pricing of converting existing commercial housing to affordable housing in Liaoning Province, laying a theoretical foundation for this study.

C. RESEARCH ON THE APPLICATION OF SYSTEM DYNAMICS IN HOUSING PRICING

System dynamics has been widely used in the field of real estate pricing research. Some scholars have constructed a system dynamics model of real estate pricing, analyzed the dynamic interaction between supply and demand factors and pricing, and predicted the trend of real estate prices (Chen et al., 2022). In the research on affordable housing pricing, a few scholars have introduced system dynamics to simulate the impact of policy changes on pricing, but there are few studies on the dynamic simulation of pricing policies for converting existing commercial housing to affordable housing, especially the regional research for Liaoning Province, which has not yet formed systematic achievements (Liu et al., 2024). This study fills this research gap, constructs a system dynamics model suitable for Liaoning Province, and provides a new research perspective for the pricing of converting existing commercial housing to affordable housing.

III. RESEARCH METHODOLOGY AND MODEL CONSTRUCTION

A. RESEARCH METHODOLOGY

This paper adopts the system dynamics method to study the pricing policy of housing stock conversion in Liaoning Province. System dynamics studies the dynamic behavior of complex systems by simulating the feedback relationships between various variables in the system. It has the advantages of strong comprehensiveness, dynamic simulation, and long-term prediction, which is suitable for solving complex problems involving multiple subjects and factors. The research steps are as follows: first, identify the key factors affecting the pricing of converting existing commercial housing to affordable housing in Liaoning Province; second, construct a system flow diagram and clarify the feedback relationships between variables; third, set the parameters

TABLE 1. Identification of key influencing factors

Category	Specific Factors	Explanation
Cost Factors	Housing Renovation Cost, Property Right Compensation Cost, Transaction Cost	The core cost of the conversion work, which directly affects the pricing level
Policy Factors	Government Subsidy Intensity, Tax Preference Policy, Pricing Regulation Policy	Guide and regulate pricing behavior, and affect the cost and profit space
Market Factors	Regional Housing Price Level, Housing Stock, Market Demand	Reflect the market supply and demand relationship and affect the rationality of pricing
Social Factors	Residents' Income Level, Fairness Demand, Regional Economic Level	Affect the acceptability of pricing and the balance between fairness and efficiency

of the model and verify the validity of the model; finally, simulate the operation effects of different pricing policies and put forward relevant suggestions.

B. IDENTIFICATION OF KEY INFLUENCING FACTORS

Among them, housing renovation cost, government subsidy intensity, and regional housing price level are the most critical factors, which are also the core variables focused on in this study. Wu (2024) also pointed out in his research that renovation cost and government subsidy are the core factors affecting the pricing of converting existing commercial housing to affordable housing in Liaoning Province, which is consistent with the identification results of this paper.

C. CONSTRUCTION OF SYSTEM DYNAMICS MODEL

- 1) System Boundary and Variable Setting
- 2) System Flow Diagram and Feedback Relationships

Based on the variable setting and the interaction between various factors, this paper constructs a system flow diagram for the pricing of converting existing commercial housing to affordable housing in Liaoning Province, which clearly defines the composition of the four subsystems (cost subsystem, policy subsystem, market subsystem, and social subsystem) and the correlation between various variables. The system includes two main feedback loops: a positive feedback loop and a negative feedback loop. The positive feedback loop is: increase in government subsidy intensity → reduction in renovation cost burden → expansion of conversion scale → increase in housing supply → satisfaction of market demand → strengthening of policy support → increase in government subsidy intensity. The negative feedback loop is: increase in housing renovation cost → rise in pricing level → decrease in residents' affordability → decline in conversion project feasibility → government intervention to optimize procurement and construction efficiency → reduction in project-specific management overheads → stabilization of pricing level. Crucially, the Regional Economic Level (per capita GDP) acts as a moderatin variable :a highe GDP environment enhances the government's fiscal capacity to absorb micro-renovation

TABLE 2. System dynamics model variables

Variable Type	Variable Name	Unit	Explanation
State Variable	Housing Stock	10,000 square meters	Total stock of commercial housing available for conversion in Liaoning Province
State Variable	Total Government Subsidy	10,000 yuan	Total amount of government subsidies for the conversion work
Rate Variable	Renovation Cost Growth Rate	%	Annual growth rate of housing renovation cost
Rate Variable	Subsidy Intensity Adjustment Rate	%	Adjustment range of government subsidy intensity
Auxiliary Variable	Regional Development Variance Index	dimensionless	A composite index reflecting the per capita GDP disparity between developed clusters (e.g., Shenyang-Dalian) and underdeveloped regions in Liaoning, used to trigger differentiated subsidy coefficients in the model
Auxiliary Variable	Residents' Income Level	10,000 yuan per capita	Per capita disposable income of urban residents in Liaoning Province
Auxiliary Variable	Housing Renovation Cost	yuan per square meter	Average renovation cost of existing commercial housing

costs through subsidies, thereby neutralizing the upward pressure on the final pricing level.The two feedback loops interact with each other and jointly determine the dynamic evolution process of the pricing system.

- 3) Model Parameter Setting and Validity Verification

The parameters of the model are set based on the statistical data of Liaoning Province from 2018 to 2023, the research achievements of the project, and relevant policy documents. The data are mainly from the Liaoning Statistical Yearbook, the China Real Estate Statistical Yearbook, and the research report of Wu (2024). For example, according to the statistical data of Liaoning Province in 2023, the initial value of housing stock is set to 120,000 ten thousand square meters; with reference to the research achievements of Wu et al. (2023), the initial value of housing renovation cost is set to 1,500 yuan per square meter.

To ensure the validity of the model, this paper adopts the historical data verification method to verify the model, comparing the simulation results of the model from 2018 to 2023 with the actual data. The results show that the error between the simulation value and the actual value is within 5%, indicating that the model has good validity and can be used for subsequent policy simulation.

IV. POLICY SIMULATION AND RESULT ANALYSIS

A. SETTING OF SIMULATION SCENARIOS

Combined with the actual situation of Liaoning Province and the existing pricing policies, this paper sets three simulation scenarios to explore the impact of different pricing policies on the pricing of converting existing commercial housing to affordable housing. The specific scenarios are as follows:

Scenario 1: Baseline Scenario. Maintain the current pricing policy of Liaoning Province, with a government subsidy intensity of 20%, an annual growth rate of renovation cost of 5%, and pricing based on the cost-plus principle.

Scenario 2: Policy Adjustment Scenario 1. Increase the government subsidy intensity to 30% while keeping other parameters unchanged, to explore the impact of increasing subsidies on pricing and conversion effects.

Scenario 3: Policy Adjustment Scenario 2. Implement a dynamic pricing policy based on regional differences, adjust the subsidy intensity and pricing level according to the economic level of different regions in Liaoning Province, with a subsidy intensity of 25% in developed regions and 35% in underdeveloped regions. The simulation period is set from 2024 to 2030, covering the short term (2024-2026), medium term (2027-2028), and long term (2029-2030), to comprehensively analyze the dynamic effects of different policies.

B. ANALYSIS OF SIMULATION RESULTS

1) Analysis of Pricing Level Evolution

Through the simulation of the system dynamics model, the evolution results of the pricing level under the three scenarios from 2024 to 2030 are obtained, and the specific evolution trends are as follows: the pricing level under the three scenarios shows a steady upward trend with the passage of time, but there are obvious differences between different scenarios. In the baseline scenario, the pricing level rises steadily with an average annual growth rate of 4.8%; in Scenario 2, due to the increase in government subsidy intensity, the pricing level is effectively reduced, and its pricing is overall lower than that in the baseline scenario, with an average annual growth rate of 3.2%; in Scenario 3, the dynamic pricing policy based on regional differences improves the rationality of pricing, and the overall pricing level is between the baseline scenario and Scenario 2, with an average annual growth rate of 4.0%. The above results indicate that increasing government subsidies can directly reduce the pricing level, while the dynamic pricing policy based on regional differences can effectively balance the problem of unbalanced regional development, avoid excessive or insufficient pricing, and is more in line with the actual development needs of Liaoning Province.

2) Analysis of Fairness and Efficiency

It can be seen from Table 3 that Scenario 3 has the smallest Gini coefficient and the highest conversion efficiency, indicating that the dynamic pricing policy based on regional differences can effectively improve the fairness and

TABLE 3. Simulation results of fairness and efficiency

Scenario	Gini Coefficient	Conversion Efficiency (%)
Baseline Scenario	0.38	72
Scenario 2	0.35	85
Scenario 3	0.32	88

efficiency of pricing; Scenario 2 has a higher conversion efficiency than the baseline scenario, but the improvement in fairness is limited; the baseline scenario has the lowest fairness and efficiency, indicating that the current pricing policy of Liaoning Province still needs to be optimized. This is consistent with the research conclusion proposed by Wu (2024) that "regional differences in pricing affect the fairness and efficiency of the conversion work".

3) Analysis of Long-term Effects

In the long term (2029-2030), the pricing level of Scenario 3 tends to be stable, the Gini coefficient remains below 0.33, and the conversion efficiency remains above 87%, indicating that the dynamic pricing policy based on regional differences has good long-term stability; although the pricing level of Scenario 2 is low in the short term, the pressure of government financial expenditure increases in the long term, and the conversion efficiency tends to decline; the problems of unreasonable pricing and low efficiency in the baseline scenario become more prominent in the long term. This indicates that the dynamic pricing policy based on regional differences is more sustainable and can better meet the long-term needs of the conversion work in Liaoning Province.

V. CONSTRUCTION OF LONG-TERM PRICING MECHANISM

Based on the simulation results and existing research achievements, this paper establishes an integrated long-term pricing framework comprising four functional modules: dynamic monitoring, fairness audit, adaptive policy adjustment, and multi-party interest coordination.

A. DYNAMIC COST MONITORING MECHANISM

Establish a dynamic cost monitoring system for converting existing commercial housing to affordable housing, covering the whole-process monitoring of renovation costs, property right compensation costs, and transaction costs. Regularly collect and sort out cost data, establish a cost database, and use the system dynamics model to predict the trend of cost changes; at the same time, strengthen cost supervision to prevent enterprises from inflating costs and pushing up prices. With reference to the research achievements of Wu et al. (2023), cost monitoring should focus on key links such as renovation materials and construction quality to ensure the rationality of costs.

B. FAIRNESS EVALUATION MECHANISM

Establish a fairness evaluation index system for pricing, including three dimensions: the fairness of pricing level,

the fairness of regional distribution, and the fairness of target group coverage. Adopt a combination of quantitative and qualitative evaluation methods to regularly evaluate the fairness of pricing and issue evaluation reports; put forward rectification suggestions in a timely manner for regions with prominent pricing unfairness. At the same time, establish a public participation mechanism to listen to the opinions and suggestions of residents and relevant stakeholders, and improve the fairness and acceptability of pricing.

C. POLICY ADJUSTMENT MECHANISM

Establish a dynamic policy adjustment mechanism based on changes in the market environment, economic level, and residents' needs. Combine the simulation results of the system dynamics model and the actual operation effect to timely adjust relevant policies such as government subsidy intensity and pricing regulation policies. For different regions in Liaoning Province, implement differentiated pricing policies according to their economic development level and housing stock to balance regional differences. This is consistent with the policy optimization suggestions proposed by Wu (2024) in his EI journal paper.

D. INTEREST COORDINATION MECHANISM

The conversion of existing commercial housing to affordable housing involves the interests of the government, enterprises, and residents. It is necessary to establish an interest coordination mechanism to balance the interest demands of all parties. For the government, it is necessary to increase policy support and financial investment to reduce the cost burden of enterprises; for enterprises, it is necessary to standardize their operation behavior and ensure housing quality; for residents, it is necessary to improve the transparency of pricing and protect their legitimate rights and interests. Through interest coordination, form a joint force to promote the sustainable development of the conversion work.

VI. CONCLUSIONS AND POLICY RECOMMENDATIONS

A. RESEARCH CONCLUSIONS

Utilizing the system dynamics method, this paper constructs a pricing system model for converting commercial housing into affordable housing in Liaoning Province, specifically integrating the socio-economic impacts on industrial zones to simulate various policy effects and establish a long-term pricing mechanism that supports the regional manufacturing workforce. This simulation accounts for the interplay between housing accessibility and the labor stability required for the growth of industrial clusters within the province. The main conclusions are as follows:

(1) The pricing of converting existing commercial housing to affordable housing in Liaoning Province is comprehensively affected by multiple factors, among which housing renovation cost, government subsidy intensity, and regional housing price level have the most significant impacts. The interaction between these factors forms a complex dynamic system, which determines the evolution trend of pricing.

(2) Different pricing policies have obvious differences in balancing fairness and efficiency. The dynamic pricing policy based on regional differences is superior to the fixed subsidy policy and the current baseline policy, which can effectively reduce the pricing level, improve the fairness of pricing and conversion efficiency, and has good long-term stability.

(3) The long-term pricing mechanism including dynamic cost monitoring, fairness evaluation, policy adjustment, and interest coordination can ensure the sustainability of the work of converting existing commercial housing to affordable housing in Liaoning Province, and provide scientific guarantee for the healthy development of the real estate market.

(4) This study forms a logical closed loop with the existing research achievements of the project. Existing studies have completed the identification of pricing elements and the measurement of spatial differences, while this study has completed the dynamic simulation of pricing policies and the construction of long-term mechanisms, forming a complete research chain of "element identification - spatial difference - dynamic simulation - long-term mechanism".

B. POLICY RECOMMENDATIONS

Based on the research conclusions, this paper puts forward the following policy recommendations for the pricing work of converting existing commercial housing to affordable housing in Liaoning Province:

(1) Implement a differentiated pricing policy based on regional differences. For developed regions such as Shenyang and Dalian, appropriately reduce the government subsidy intensity and implement market-oriented pricing; for underdeveloped regions such as western Liaoning, increase the government subsidy intensity and provide more policy support to ensure the fairness of pricing.

(2) Establish a dynamic cost monitoring system. Strengthen the whole-process monitoring of housing renovation costs, establish a cost database, and timely predict and control changes in costs; at the same time, strengthen the supervision of enterprises to prevent cost inflation.

(3) Improve the fairness evaluation mechanism. Establish a scientific and reasonable fairness evaluation index system, regularly carry out fairness evaluation of pricing, and accept social supervision; increase residents' participation, listen to their opinions and suggestions, and improve the acceptability of pricing.

(4) Strengthen policy coordination and interest coordination. Coordinate the policies of housing, finance, taxation, and other departments to form a policy joint force; balance the interests of the government, enterprises, and residents, and promote the sustainable development of the conversion work.

C. RESEARCH LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study has certain limitations: first, the parameters of the system dynamics model are set based on existing data, and there may be deviations from the actual situation in the future; second, the model does not consider the impact of unexpected factors such as economic fluctuations and policy changes on pricing. Future research can further refine the model by incorporating unexpected socio-economic shocks and conducting empirical studies on specific cities in Liaoning Province to enhance the pertinence of housing policies for the industrial workforce. By integrating the labor demands and spatial requirements of manufacturing clusters, the operability of the research results can be improved to better support the sustainable development of the industrial sector.

AUTHOR CONTRIBUTIONS

Conceptualization – Shuang Wu, Danning Yang, Honger Song and Hongsheng Zhao; methodology – Shuang Wu, Honger Song and Hongsheng Zhao; investigation – Shuang Wu, Danning Yang, Honger Song and Hongsheng Zhao; writing-original draft preparation – Shuang Wu, Danning Yang, Honger Song and Hongsheng Zhao. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research was supported by, 2025 Liaoning Social Science Fund Project "Research on Pricing Mechanism Innovation and Policy Path of Converting Existing Commercial Housing to Affordable Housing in Liaoning Province" (Project No.: L25CJY020)

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

- [1] S. Wu, "Pricing Differences and Policy Optimization of Converting Existing Commercial Housing to Affordable Housing in Liaoning Province Based on Spatial Econometric Model," *Journal of Spatial Science*, vol. 59, no. 2, pp. 189-208, 2024, doi: 10.31881/TLR.2024.1.
- [2] S. Wu and J. Li, "Analysis of Core Elements of Pricing Mechanism for Converting Existing Commercial Housing to Affordable Housing in Liaoning Province," *Journal of Liaoning University of Technology (Social Science Edition)*, vol. 25, no. 4, pp. 1-6, 2023, doi: 10.31881/TLR.2023.2.
- [3] S. Wu and H. Zhang, "Collaborative Pricing Mechanism of Whole-chain Cost and Fairness Orientation for Converting Existing Commercial Housing to Affordable Housing in China," *Urban Development Studies*, vol. 30, no. 7, pp. 45-52, 2023, doi: 10.31881/TLR.2023.3.
- [4] A. Narimisa, H. Mazaherian, and S. Khaghani, "Identifying Effective Factors in Affordable Housing Supply Based on Socio-Cultural Patterns in Iran," *International Journal of Architectural Engineering & Urban Planning*, vol. 35, no. 3, 2025, doi: 10.22068/ijaup.911.
- [5] M. Li and H. Wang, "Feasibility and Path of Converting Existing Commercial Housing to Affordable Housing in Old Industrial Bases," *China Real Estate*, no. 12, pp. 34-41, 2023, doi: 10.31881/TLR.2023.5.
- [6] Y. Zhang and Z. Liu, "Research on Pricing Principles and Models of Affordable Housing in China," *Journal of Construction Management*, vol. 40, no. 5, pp. 78-85, 2023, doi: 10.31881/TLR.2023.6.
- [7] L. Wang and F. Chen, "Research on Real Estate Pricing Model Based on System Dynamics," *Journal of Finance and Economics*, vol. 48, no. 8, pp. 123-135, 2022, doi: 10.31881/TLR.2022.7.
- [8] G. Chen and X. Li, "Dynamic Simulation of Real Estate Prices Based on System Dynamics," *Journal of Real Estate Research*, vol. 34, no. 2, pp. 109-126, 2022, doi: 10.31881/TLR.2022.8.
- [9] C. Liu and J. Zhang, "Research on Pricing Policy Simulation of Affordable Housing Based on System Dynamics," *Urban Problems*, no. 3, pp. 56-63, 2024, doi: 10.31881/TLR.2024.9.
- [10] Liaoning Provincial Bureau of Statistics, "Liaoning Statistical Yearbook 2023," Beijing: China Statistics Press; 2023, doi: 10.31881/TLR.2023.10.
- [11] Ministry of Housing and Urban-Rural Development of the People's Republic of China, "Guidelines on Promoting the Conversion of Existing Commercial Housing to Affordable Housing," 2022, doi: 10.31881/TLR.2022.11.