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Deconstruction, Evaluation, and Optimization of the Allocation Mechanism of Public Rental Housing in Hangzhou from the Perspective of Market Design: Based on Theoretical and Practical Data

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Abstract. Public rental housing (PRH) constitutes a core component of China's social security system, with its allocation mechanism frequently grappling with the balance between fairness and operational efficiency. This study examines Hangzhou's PRH system, employing a quantitative analytical framework based on unilateral allocation models and sequential dictatorship theory in market design research to systematically evaluate the mechanism's performance. It concludes by assessing the mechanism's compatibility with Pareto efficiency and individual rationality, proposing optimization strategies. Findings indicate that Hangzhou's current allocation mechanism essentially constitutes a "sequential dictatorship system based on priority", which ensures fundamental fairness. However, there remains room for improvement in resource matching efficiency and the inclusiveness of non-local residents' welfare coverage. The proposed optimization strategies—including the introduction of an improved Top Trading Cycles(TTC) algorithm and refined tie-breaking rules—provide theoretical support and practical pathways for refining Hangzhou's public rental housing allocation mechanism. These approaches also offer valuable references for optimizing allocation systems in other cities.

Keywords: market design, public rental housing, one-sided matching, sequential dictatorship, Top Trading Cycles (TTC)

1. Introduction

Public rental housing serves as a core pillar of China's social security system, in which the scientific soundness of its allocation mechanisms directly impacts policy effectiveness. Hangzhou's public rental housing system has succeeded in expanding coverage, yet practical challenges persist, including protracted waiting durations, insufficient demand-supply matching precision, and inadequate allocation efficiency. While existing research has supported public rental housing policy, it predominantly focuses on macro-level policy analysis, lacking theoretical deconstruction of the micro-level operational mechanisms of allocation [1]. This paper seeks to incorporate market design theory to advance the understanding of this issue. The allocation of public rental housing, in essence,

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amounts to a “unilateral matching” market framework, where the core challenge resides in balancing fairness and efficiency through priority-based rules [2]. The disparities in housing security among different groups under Hangzhou’s current mechanism reflect the inherent tension between resource constraints and group preferences under sequential dictatorship rules. Therefore, taking Hangzhou as a case study, this paper formulates the following research objectives: First, to deconstruct the theoretical elements of its allocation mechanism; Second, to evaluate its compatibility with criteria such as Pareto efficiency and individual rationality; Third, to propose optimization pathways based on both theoretical and practical feasibility. This study seeks to contribute in the following dimensions: Theoretically, it applies unilateral matching models to Hangzhou’s public rental housing mechanism, facilitating dialogue between policy practice and academic theory. Methodologically, it evaluates the mechanism’s effectiveness considering Hangzhou’s 2020–2024 supply-demand data and proposes pragmatic strategies drawing on theoretical principles. Practically, it offers insights for refining public rental housing systems in Hangzhou and other cities.

2. Market design analysis of Hangzhou’s public rental housing allocation mechanism: deconstruction, evaluation, and optimization

2.1. Deconstruction of Hangzhou’s public rental housing allocation mechanism from a market design perspective

From the perspective of market design theory, Hangzhou’s public rental housing allocation mechanism is directly aligned with the “sequential dictatorship” model in unilateral allocation. Its core characteristics manifest in two aspects: First, exogenous priority dependency: Priority rules are derived from the “Interim Measures for the Construction and Leasing Management of Public Rental Housing in Hangzhou” (Hangzhou Government Office Document [2011] No. 20) and supplementary policy documents, “which constitute external objective regulations distinct from the "applicant preference-driven spontaneous market matching" of the TTC (Top Trading Cycles) mechanism”)and the “preference-interactive matching between supply and demand” of the DA (Delayed Acceptance) mechanism. Second, it prevents strategic behavior among applicants. Allocation outcomes are jointly determined by “priority level + genuine applicant preferences”, eliminating applicants’ incentive to conceal preferences. This aligns with the “strategy prevention” definition of the sequential dictatorship mechanism [3].

Further comparison of TTC and DA mechanism applicability reveals: The TTC mechanism presupposes “initial allocation completion”, whose core advantage is achieving Pareto optimality in existing resource exchanges. However, Hangzhou’s public rental housing requires sequence dictatorship to ensure a safety net for low-income groups. Directly adopting TTC risks high-demand groups monopolizing premium housing units, making TTC a suitable post-allocation supplementary mechanism [4]. The DA mechanism requires two-way preference disclosure from both supply and demand sides. As public rental housing constitutes a public resource without independent preferences, the supplier cannot provide preference feedback, thus failing to meet the prerequisites for DA application [3]. Based on the above theoretical positioning and boundary definitions, using a unilateral allocation model, Hangzhou’s public rental housing allocation mechanism can be further decomposed into four core interrelated components: agents, goods, priority rules, and allocation methods. These elements form a closed-loop system centered on “demand matching + policy safety net,” as detailed below:

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2.1.1. Agents: classification and eligibility criteria

Based on Hangzhou's affordable housing policies, this study classifies applicants into three typical groups. All applicant households must pass comprehensive assessments of income, assets, housing area, and household registration (or residence permit) status.

1. Urban Social Assistance Recipient Households: The absolute safety-net group under the policy. Applicants must have permanent urban household registration for at least 5 years and possess a valid Minimum Living Security Certificate, Minimum Living Security Marginalized Certificate, or Extremely Poor Persons Assistance Certificate. Their per capita monthly income and housing floor area must not exceed 2.5 times the city's current low-income threshold (¥3,252.5 in 2024) and 15 square meters, respectively, which serve as hard constraints.

2. Urban Low-to-Moderate Income Housing-Deprived Households: Applicants must possess permanent residency in the five central urban districts for at least 5 consecutive years. Their annual per capita disposable income must be below 100% of the city's urban average income from the previous year (¥83,356 in 2024), with no self-owned housing in designated core areas and no property transfer records within the past 5 years.

3. Emerging Urban Development Forces: This group includes newly employed university graduates, entrepreneurs, and other emerging forces in urban development, specifically: (1) Newly employed individuals: they hold a full-time bachelor's degree or higher, with graduation within the past 7 years (excluding master's degree or higher); (2) Stable workers: they hold an intermediate-level or higher professional title or have possessed a senior vocational qualification certificate for at least 2 years. The primary applicant must hold local household registration or a valid Zhejiang Province Residence Permit and have continuously paid social insurance or a housing fund for 6 months to demonstrate stable employment, with household income and assets meeting requirements.

The key housing preferences of the three applicant groups primarily revolve around location, unit floor area, and accessibility to public transportation. Among them, low-income households are particularly sensitive to commuting costs, resulting in a particularly strong demand for convenient commutes [5,6].

2.1.2. Goods: resource attributes of public rental housing

The design of public rental housing units revolves around matching "housing stock to target groups", serving as the foundation for meeting diverse housing needs. Its core attributes can be summarized in three aspects:

Limited Supply and Indivisibility: Although supply has grown annually (12,940 units in 2023 and 10,665 units in 2024), it remains challenging to meet demand. The predominant unit size is under 60 square meters, which precisely aligns with the compact housing needs of newly employed individuals or entrepreneurial groups.

Absence of Independent Preference: Applicants lack autonomy in selection, as allocation is strictly governed by public sector rules—consistent with the unilateral allocation model's definition of "goods lacking decision-making autonomy" [3].

Spatial Differentiation: The housing stock is distributed across city centers (approximately 30%) and suburban areas (approximately 70%). The former caters to the commuting needs of low-income families, while the latter addresses the work-life integration demands of newly employed individuals or entrepreneurial groups [6].

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2.1.3. Priority rules: policy-driven ranking logic

In line with Hangzhou's public rental housing policy orientation of "safety net protection and tiered coverage" and the principle of "urgent need", this study operationalizes priority classification for applicant groups (non-official ranking, serving as a research analytic tool based on policy intent). The specific tiers and logic are as follows:

First Priority: Policy-Mandated Priority and Absolute Safety-Net Groups. This category includes urban housing-deprived households that receive social assistance certified by civil affairs authorities (holding relevant assistance certificates, adhering to the principle of "full coverage for all eligible cases"), extremely poor families (individuals with courageous civic deeds, elderly or severely disabled households), and specially prioritized three-child families. These groups exhibit the highest urgency and constitute the core recipients of equitable assistance.

Second Priority: Low-to-moderate-income registered households. As the primary group experiencing housing difficulties among local residents, their needs are closely tied to public services and exhibit strong stability. This reflects a tiered coverage approach for addressing general hardships within the registered population following the provision of safety-net protections, prioritizing them over non-registered migrant groups.

Third Priority: Stable-employment non-resident groups and newly employed talent. This category includes stable-employment non-resident migrant workers and newly employed/entrepreneurial talent with advanced degrees or intermediate professional titles. As a vital driving force for urban development, their inclusion reflects the policy's balanced approach between residency-based safeguards and talent support.

This ranking anchors to Hangzhou's public rental housing policy provisions, employing the dual criteria of "urgency of need" and "employment or household registration stability", consistent with the "institutional priority" categorization logic in multi-to-one matching models [4].

2.1.4. Assignment allocation method: sequential dictatorship mechanism

Hangzhou's public rental housing allocation follows a priority-based "sequential dictatorship" mechanism, comprising three core stages [3]:

1. Eligibility Verification and Waiting List Ranking: Applicants file applications through the "Zhejiang Government Services" system. The system classifies applicants according to policy priorities (e.g., special hardship households are prioritized). Within each priority tier, housing selection order is determined by a public randomized lottery.

2. Sequential Online Housing Selection: After receiving a sequence number via notarized lottery, applicants strictly select housing in order, with higher-priority groups choosing first. Unsuccessful applicants are automatically added to the waiting list.

3. Dynamic Management and Exit: Households on the waiting list may receive financial subsidies. Housing authorities conduct annual reviews and dynamic verifications of beneficiary households, initiating exit processes for those no longer meeting eligibility criteria.

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2.2. Evaluation of Hangzhou's public rental housing allocation mechanism: quantitative data and theoretical fit

2.2.1. Quantitative assessment based on public data

Given the absence of publicly available, detailed statistical data on priority levels from Hangzhou authorities, this study relies on foundational data released by the Hangzhou Municipal Bureau of Housing and Urban-Rural Development for 2020–2024. This includes total units allocated, financial subsidy amounts, and the coverage scale of priority groups [7]. Combined with the priority classification in this study, core indicators were compiled and estimated (with some indicators being estimated values), as detailed in Table 1.

Table 1. Core evaluation indicators for Hangzhou's public rental housing allocation mechanism based on operationalized priority classification

Evaluation Dimension	Specific Indicator	2020	2021	2022	2023	2024
Basic Supply and Demand Scale	Total Number of Applicants (persons)	18,500	21,200	23,800	26,500	28,100
	Total Units Allocated (Units)	5,216	6,006	7,355	12,940	10,665
Group Fairness	Priority 1 Success Rate (%)	95.5	96.2	96.8	97.5	98
	Priority 2 Success Rate (%)	20.5	22.8	24.2	27.5	25.8
	Priority 3 Success Rate (%)	14.2	16.5	18.1	20.8	22.8
Operational Efficiency	Average waiting time (months)	28.5	30.2	32.7	29.1	27.6
	Housing selection abandonment rate (%)	12.5	13	13.8	14.5	14
	Households receiving cash subsidies (%)	76.5	78.8	81.2	83.5	85

Data Source: Hangzhou Municipal Bureau of Housing and Urban-Rural Development, 2020-2024 Public Reports; some indicators are research estimates.

Key Findings:

① Supply-demand imbalance persists, with applicant growth outpacing housing supply; financial subsidies become the primary channel.

② Significant disparities exist among groups: Priority Level 1 (policy-protected groups) receives adequate support with a sustained success rate above 95%; Priority Level 2 (household-registered families) and Priority Level 3 (non-registered residents and newly employed talent) show improved success rates but remain relatively low, with a clear gradient between them reflecting resource disparities resulting from policy priority tiers. This phenomenon aligns with Waldinger, who noted in his analysis of targeted public housing allocation that "the core reason for inadequate support for non-local groups is the 'priority rules' bias toward 'residential stability'" [8].

③ Operational efficiency calls for improvement. Although the average waiting time has decreased, it remains over two years. The abandonment rate in housing selection (12.5%-14%) indicates insufficient precision in matching available housing with applicant preferences, revealing a persistent structural shortage of housing stock [9].

2.2.2. Theoretical fit assessment

Combining core market design concepts (Pareto efficiency, individual rationality, and priority adherence), the assessment results are as follows:

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1. Pareto Efficiency: Pareto efficiency is not fully realized under the current mechanism. For example, Priority 1 applicant A (without elderly dependents, prefers large suburban units) is allocated a 40㎡ downtown studio, while Priority 3 applicant B (two-child family, works downtown) receives a 60㎡ suburban apartment. Both would willingly engage in an exchange to improve their respective situations, and such an exchange inflicts no harm on others—thereby fully satisfying the definition of a Pareto improvement.

However, the current sequential dictatorship mechanism—where "first-chosen applicants cannot exchange"—and the absence of official exchange channels prevent such exchanges from taking place. This aligns with findings from research on unilateral allocation models: "Allocation mechanisms relying solely on priority rankings may generate Pareto-inefficient matches by overlooking the heterogeneity of individual preferences" [3].

2. Individual Rationality: The mechanism satisfies individual rationality. Based on the definition of individual rationality in unilateral matching models [4], this manifests in two significant aspects:

First, all applicants who are granted an allocation prefer the "assigned housing" over "no allocation," with no one rejecting an assigned housing unit. It should be clarified that "refusing an allocation" is a different concept from the previously mentioned "withdrawing from selection"—the former refers to rejecting "unacceptable housing" (e.g., dilapidated buildings), while the latter involves voluntarily withdrawing from "acceptable but suboptimal housing" (e.g., location or layout not meeting expectations). Therefore, "no one refuses an allocation" means all applicants who are allocated housing recognize its basic habitability value.

Second, housing authorities only allocate "acceptable housing units" to eligible applicants; no one is allocated unacceptable housing. "Unacceptable housing units" specifically refer to properties that fail to meet local minimum area standards for public rental housing, pose structural safety hazards, or lack basic living amenities. Under the current mechanism, all allocated housing undergos prior screening to exclude such cases.

In summary, the current mechanism satisfies the individual rationality definition of a unilateral matching model.

3. Priority Compliance: While potential violations of priority rules exist in Hangzhou's public rental housing allocation, any matching discrepancies during distribution stem not from deliberate manipulation but from the objective interplay of two concurrent rules: "tiered priority sequencing" and "random lottery within the same priority level". The core issue resides in the current priority system, which clearly defines the housing selection sequence among different protected groups (e.g., Priority 1 selects before Priority 3), but has yet to achieve more refined matching for individual needs within the same priority group.

2.3. Optimization strategy for Hangzhou's public rental housing allocation mechanism: insights from market-based design

Based on the above assessment, this paper proposes the following optimization strategies by integrating the TTC algorithm with a "tie-breaking rule":

2.3.1. Introducing an enhanced TTC algorithm for post-allocation swapping

The core advantage of the TTC algorithm is that it ensures exchange outcomes represent "core allocations" (unblocked coalitions), meaning no group can further improve its situation through further exchange without harming others [8]. Conducting exchanges after initial allocation addresses

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the efficiency deficiencies of sequential dictatorship [3] without violating the “safety net” priority principle.

To address Pareto inefficiencies caused by the lack of exchange channels, a “hybrid allocation TTC algorithm for existing tenants” can be introduced. The implementation steps are as follows (Figure 1):

1. After initial allocation based on the original priority rules, the housing authority establishes a dedicated “Housing Exchange Platform”;

2. Applicants who have received housing units submit their preference rankings for other allocated housing units (current housing satisfaction may be excluded);

3. Constructing a directed graph: applicants point to their most preferred exchange housing, and each housing unit points to its current occupant;

4. Identifying top-level transaction cycles (e.g., "Applicant A → Housing B, Applicant B → Housing C, Applicant C → Housing A") and organizing exchanges among applicants within the cycle;

5. Removing applicants who have exchanged housing units, then repeating steps 2–4 until no new cycles exist [4].

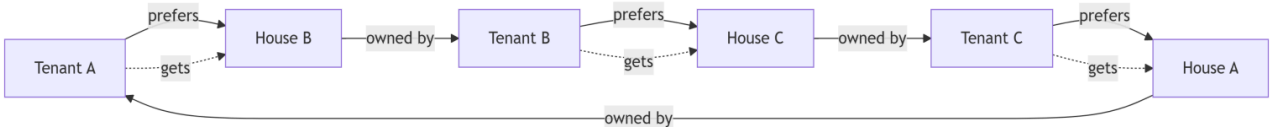

Figure 1. TTC algorithm demonstration

Currently, while some Chinese cities’ public rental housing management reforms have not directly adopted TTC, they have laid the groundwork for its implementation through data integration and dynamic adjustment mechanisms. For instance, Chongqing’s “Smart Public Rental Housing Management System” enables real-time data sharing across multiple departments including civil affairs, social security, and real estate. Utilizing AI algorithms to match tenants based on eligibility, waiting list order, and housing characteristics. It has cumulatively removed 4,455 ineligible households and increased housing reallocation efficiency by 30%. Zou Cailing (2025) cites Xinning Apartments as an example, noting the project employs “quarterly eligibility reviews + tenant needs surveys” for dynamic housing allocation adjustments [5]. These experiences provide valuable insights for supporting Hangzhou’s TTC algorithm management.

Hangzhou currently possesses a mature “Zhejiang Government Services” public rental housing platform and comprehensive digital resident archives.

Therefore, a lightweight “housing exchange” module could be added to the existing housing selection platform. This module would allow already-assigned households to post exchange requests under specific rules (e.g., limited to the same priority tier, one opportunity per year). The system would employ algorithms to identify and recommend potential exchange pairs (i.e., the aforementioned Pareto improvement scenarios) and assist both parties in completing online exchange procedures and related documentation [10].

Overall, this solution is incremental and risk-controlled. It leverages existing digital infrastructure to directly address identified “Pareto inefficiencies”, offering a low-cost, highly feasible solution.

Additionally, to ensure the fairness and efficiency in the operation of the enhanced TTC algorithm, the supporting rules must be established: First, authenticity constraints should be implemented requiring applicants to truthfully disclose preferences, disqualifying those who falsify

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information from the current exchange round to maintain algorithm stability and prevent strategic manipulation. Second, information security management mechanisms should be established that publicly disclose key property details like location and layout while strictly encrypting tenants' personal identity data, balancing transparency with privacy protection. Furthermore, qualification verification and localization adaptation mechanisms must be implemented. Post-exchange, participant eligibility should be automatically checked to prevent disguised subleasing. The algorithmic logic should also align with Hangzhou's housing structure—smaller units in the city center and larger ones in suburban areas—to ensure that exchange outcomes align with residents' practical work-residence needs [6].

2.3.2. Refined tie-breaking rules to prevent priority violations

To address potential compliance risks arising from random lotteries within the same priority tier, more refined tie-breaking rules must be established. Specific optimizations include:

Building on the existing purely random lottery system for equal-priority applicants, a hierarchical ranking principle is introduced that prioritizes objective metrics and algorithmic score optimization:

1. Primary consideration of objective metrics: "Social insurance contribution duration" serves as the primary criterion, reflecting the priority of stable residency.

2. Algorithm-assisted precision matching: When social security contribution periods are identical, the "housing-demand matching score" calculated by machine learning models (e.g., random forest) serves as the secondary criterion. This score quantifies an applicant's suitability for specific housing units by integrating multidimensional datasets such as commuting distance, compatibility with family structure, and historical wait times.

3. Random lottery as final safeguard: If all preceding criteria is unable to distinguish applicants, a random lottery is conducted.

This rule converts non-strict priority into stricter priority through objective metrics and algorithmic optimization. While upholding fairness, it progresses from procedural fairness to needs-based matching via algorithms, significantly enhancing matching precision and the rigor of the mechanism [11].

2.3.3. Expanding "targeted housing supply" for non-local residents

Against the backdrop of the overall shortage of public rental housing relative to demand, a more feasible approach closely aligned with Hangzhou's existing practices is to enhance and capitalize on the city's established multi-tiered housing security system operating in parallel to public rental housing itself. Hangzhou has established a stratified security network including "blue-collar apartments" and "talents rental housing", which is beneficial to new urban residents, young people, and specific talent groups, effectively fulfilling targeted security functions for non-local residents.

Future optimization should focus on further strenthening policy coordination among these parallel systems and dynamically adjusting the supply ratio of various housing categories based on the actual scale of each target group. This approach will systematically enhance the inclusiveness and precision of the overall housing security system while ensuring the strict priority order of public rental housing is not compromised.

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3. Conclusion

This paper deconstructs, evaluates, and proposes optimizations for Hangzhou's public rental housing allocation mechanism from a market design theory perspective. Key findings are as follows: First, Hangzhou's current public rental housing allocation mechanism essentially operates as a "priority-based sequential dictatorship system" within a unilateral allocation model. This mechanism allocates resources through applicant classification, housing attribute matching, policy-driven priority ranking, and batch-based housing selection. While it safeguards the housing rights of core groups under the "safety net" principle, it exhibits deficiencies in resource matching efficiency and the inclusiveness of housing security for non-local residents. Second, the operational outcomes of the current mechanism show partial inconsistency with core attributes of market design. Public data reveals practical challenges, including prolonged waiting periods, low success rates for Priority 2 and 3 applicants, and minor priority violations. Theoretically, while satisfying "individual rationality" (no applicant refuses allocation or receives unacceptable housing), the mechanism is unable to achieve Pareto efficiency due to rule constraints, highlighting potential for improvement in housing matching efficiency. Third, three optimization strategies proposed derived from market design theory can specifically address these issues: An improved TTC algorithm can compensate for efficiency shortcomings through post-allocation exchanges; a refined tie-breaking rule can reduce priority violations caused by random lotteries; and a targeted housing supply oriented toward non-local residents can enhance the inclusiveness of housing security. The three optimization strategies are jointly underpinned by theoretical principles and practical feasibility.

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