

論文審査の要旨及び担当者

No.1

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（論文審査の要旨）			
論文題名：Essays in Market Design			
This dissertation examines the design of matching mechanisms for allocating indivisible goods without monetary transfers, with applications to settings such as high school and college admissions. Chapters 1 and 4 provide an axiomatic analysis of these mechanisms, while Chapters 2 and 3 examine equilibrium behavior in preference revelation games under incomplete information. Drawing on market design principles, the study emphasizes how real-world matching markets should be designed.			
Chapter 1: When is a Sequential School Choice System (Non-)Deficient?			
This chapter examines the priority-based allocation model of indivisible goods, commonly known as the school choice model (Abdulkadiroğlu and Sönmez, 2003). Mr. Hatakeyama raises an important and natural question: most real-world student assignment systems operate sequentially – for example, private and public schools process applications in order. However, from a market design perspective, these systems are often deficient because they compromise incentives and can lead to inefficiencies. This raises a critical puzzle to which he provides a partial answer.			
The chapter first establishes an impossibility theorem, proving that wastefulness and incentive problems persist in sequential mechanisms under the general preference domain, even when individual rationality and non-wastefulness are satisfied at each stage. However, Mr. Hatakeyama demonstrates that these systems may not perform as poorly if students' preferences are correlated in some way. For example, Chinese colleges use sequential tier systems that almost perfectly align with the formal framework modeled in this chapter. This observation is particularly noteworthy, as it suggests that structured preference constraints can improve the efficiency of sequential mechanisms. The chapter further identifies that these inefficiencies disappear when preferences are restricted to the tiered domain, offering a			

theoretical foundation for better-designed sequential matching systems.

This chapter, which has already been published as a single-authored paper in *Review of Economic Design*, contributes to the literature by highlighting how preference domain constraints influence the performance of sequential school choice mechanisms and by opening new avenues for future research on sequential matching systems.

Chapter 2: School Choice with Limited Student Commitment

This chapter addresses an intriguing puzzle: while the deferred acceptance (DA) mechanism is theoretically more desirable when students can submit full preference lists, why do real-world implementations often impose constraints on list lengths? Despite the theoretical advantages of the unconstrained DA mechanism, constrained versions are widely used in practice. This chapter investigates this paradox and demonstrates that constrained mechanisms may have non-obvious advantages over their unconstrained counterparts.

To explore this issue, the chapter develops a Bayesian model in which each student's type consists of their valuation for schools (goods) and their priority rankings. The model also incorporates uncertainty in outside options, allowing students to pay a search cost to learn their valuation of these alternatives before making decision. This realistic framework captures the strategic constraints students face in actual matching markets, such as Keio University's exchange student program, where students can only submit up to six ranked choices.

A key contribution of this chapter is the introduction of withdrawal-proofness, a novel concept in the theory of matching. In this stylized Bayesian setting, a mechanism is withdrawal-proof if no student prefers to withdraw from their assigned school when search costs are below a certain threshold. Mr. Hatakeyama demonstrates that the constrained DA mechanism satisfies withdrawal-proofness much better than the unconstrained DA mechanism, in a set-inclusion sense. This finding provides a compelling theoretical rationale for why constrained mechanisms are commonly used in practice.

This chapter demonstrates Mr. Hatakeyama's ability to develop, formalize, and solve an original problem. Its rigorous equilibrium analysis and introduction of withdrawal-proofness significantly advance our understanding of constrained DA mechanisms. Given its depth and originality, the committee members expect this chapter to be published in a prestigious theoretical journal.

Chapter 3: Cardinal Utilities and Welfare Comparison of Matching Mechanisms

This chapter conducts an equilibrium analysis to examine the surprising theoretical result originally demonstrated by Abdulkadiroğlu, Che, and Yasuda (2011), which shows that the immediate acceptance (IA) mechanism (also known as the Boston mechanism) can exhibit welfare superiority over the deferred acceptance (DA) mechanism when evaluated ex ante under specific conditions. This result challenges the conventional wisdom in market design, as the DA mechanism is widely considered superior due to its incentive properties. However, when students have highly specialized preferences with identical rankings, the IA mechanism can theoretically yield higher welfare.

The chapter extends this analysis by demonstrating that this welfare superiority is not unique to the IA mechanism. In fact, it proves that any mechanism that satisfies non-wastefulness and anonymity – two relatively mild requirements – produces the same welfare outcome. This generalization significantly broadens the scope of the original finding, providing deeper insight into the welfare implications of different matching mechanisms.

Note that the model makes several strong assumptions: (1) all agents share a common ordinal preference ranking over schools, (2) each agent's cardinal utilities are private information, and (3) priority rankings are randomly assigned and common across all schools. While these assumptions are restrictive, they allow for a clearer theoretical perspective on the welfare implications of different matching mechanisms. Given the specialized nature of the model in Abdulkadiroğlu, Che, and Yasuda (2011) and subsequent literature suggesting this result is a knife-edge case, the core finding itself may not be entirely surprising. However, what is truly remarkable is that Mr. Hatakeyama identified the right question to ask – despite the paper being over a decade old, no one had yet raised this natural and fundamental issue. His contribution provides a more general and theoretically grounded framework for understanding when and why IA-like mechanisms can achieve superior welfare outcomes.

Chapter 4: Who Makes the Cut? Endogenous Priority Design for Heterogeneous Groups of Agents

This chapter proposes a protocol (mechanism) for constructing a fair overall priority ranking when agents are grouped into multiple categories and assigned priority only within their category. Many matching mechanisms require a unified priority ranking across categories, yet determining such an overall ranking is a fundamental challenge. A practical example of this issue arises at Keio University, where students within each faculty are ranked based on GPA, but there is no predefined method for determining an overall ranking across faculties. This

chapter provides a formal solution to this problem, which has been implemented in Keio University's exchange student matching program since 2022.

The problem is formulated as a prioritization problem, introducing two key desirable properties: (1) non-wastefulness – ensuring that available slots are allocated efficiently, and (2) respect of priority – preserving the relative rankings within each category in the overall ranking. To satisfy these properties, the chapter introduces a filling algorithm and proposes two central protocols – the uniform protocol and the proportional protocol – which determine the overall priority ranking based on parameters within the algorithm. A challenge in prioritization is how to compare agents across different categories, which the study addresses through two principles: (1) equal treatment of equal absolute positions – agents with the same absolute priority position should be treated equally in the overall ranking, and (2) equal treatment of equal relative positions – agents with the same relative positions should be treated equally in the overall ranking.

The main theorems of this chapter are that the uniform protocol is characterized by equal treatment of equal absolute positions, while the proportional protocol is characterized by equal treatment of equal relative positions, both under additional axioms. The proportional protocol was ultimately adopted in Keio University's exchange student matching program, with Mr. Hatakeyama developing an Excel-compatible system to facilitate smooth implementation by administrative staff.

Beyond exchange student matching programs, the proposed protocols can be applied to scholarship allocation, hospital surgery scheduling, research funding distribution, and visa allocation. By providing a theoretical foundation for prioritization problems, this chapter makes a significant contribution to market design and policy implementation.

Subjectively speaking, this chapter is the committee members' favorite part of the dissertation. From conceptualization to execution, the project has been carried out exceptionally well and efficiently. It clearly demonstrates Mr. Hatakeyama's ability to approach an original market design problem, ask the right questions, construct a suitable formal framework, and provide a rigorous axiomatic analysis driven by the key objectives of stakeholders in the market design project. Specifically, the research addresses the challenge of designing an optimal prioritization protocol for Keio University to allocate exchange program seats among students from different faculties.

Although this project involves two of the committee members as coauthors, Mr. Hatakeyama deserves the lion's share of the credit for his work. This project has led to a beautifully crafted paper, provided him with valuable insights and hands-on experience, and – perhaps most

impressively – resulted in a real-world application. This kind of success is rare, even for experienced professionals, let alone a Ph.D. student. For a market designer, this is truly a dream come true.

Mr. Hatakeyama excels at examining real-world institutions, assessing their designs, and evaluating outcomes. When identifying problems, he applies rigorous theory to propose institutional solutions – a key aspect of market design – while demonstrating the technical skills to solve complex issues in line with traditional economics principles.

During the dissertation defense, several points were raised regarding potential improvements and future extensions for each chapter.

- Chapter 1: While the study identifies conditions under which sequential mechanisms avoid inefficiencies, there were suggestions that a more positive theoretical justification for widely observed sequential mechanisms should be explored.
- Chapter 2: The model's assumption of uncertainty in the value of outside options was noted as somewhat specific, and a more general setting was recommended for further analysis. Additionally, there was a comment on insufficient discussion regarding the mechanisms that produce the results, highlighting a need for more explicit explanations.
- Chapter 3: It was pointed out that the analysis focuses only on conditions under which the DA mechanism is weakly dominated in terms of welfare, and further exploration of broader implications was encouraged. Moreover, the role of assumptions imposed in the model was considered unclear, suggesting a need for more explicit justification.
- Chapter 4: While various fairness concepts related to priority ordering were analyzed separately, there was a suggestion to organize them systematically and propose a more comprehensive protocol that integrates these fairness principles.

These comments were made on the premise that each chapter makes a significant contribution to the literature and that the dissertation is either already well-recognized or expected to receive high regard in the field of market design. The committee members shared the consensus that Tetsutaro Hatakeyama's dissertation represents an outstanding theoretical study.

With unanimous agreement, the committee recognizes the dissertation as an excellent piece of academic work and concludes that it is appropriate to award him the degree of Doctor of Economics.