Efficiency and Fairness in University Laundry Machine Slot Allocation

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1 Abstract

This study examines the efficiency of point based first-price and second-price auction mechanisms in allocating university laundry machine slots, comparing them with traditional reservation and first-come, first-served (FCFS) methods. My analysis, based on simulations over 1000 rounds, demonstrates that auction mechanisms, particularly second-price auctions, significantly enhance allocation efficiency due to truthful bidding incentives. Incorporating a rollover mechanism further improves efficiency, with a rollover factor of 0.8 balancing high efficiency and practical considerations like point hoarding. While traditional methods achieve lower efficiency, this study underscores the potential of auction-based systems to optimize resource allocation, specially in shared laundry spaces like dormitories.

2 Introduction

University dormitories are critical living spaces for students, providing essential amenities that support their daily activities and academic success. Among these amenities, laundry facilities are particularly valuable as they enable students to manage their personal hygiene and clothing needs conveniently. However, the allocation of laundry machines can be challenging due to high demand, especially during peak times such as weekends and evenings. Traditionally, universities have employed first-come, first-served systems or simple online booking platforms to manage laundry machine reservations. These systems typically allow students to reserve machines based on availability, often leading to early bookings by those who are quick to act. One significant issue is that they do not account for the varying levels of need or the different valuations that students place on laundry machine access. As a result, machines may be reserved by students who do not necessarily have the greatest need for them, leading to inefficiencies in the allocation process. For example, a student who books a machine well in advance may use it for a casual laundry load, while another student who urgently needs to wash clothes for a job interview might find all machines fully booked. This misallocation can lead to underutilization or misuse of valuable laundry facilities.

When laundry machines are allocated on a first-come, first-served (FCFS) basis or through simple reservation systems, several problems can arise. Students may place only a single piece of clothing in a machine to secure a slot, leading to underutilization of the machines. Additionally, conflicts and frustration can occur when students find their laundry removed by others due to the lack of clear ownership of the time slot. In my own dorm, I have seen these issues arise with the current laundry system. Students often leave their laundry unattended for extended periods, causing delays and frustrations for others who need to use the machines. There have been instances where students place a minimal amount of laundry in the machine just to secure a spot, leading to inefficient use of the machines. Additionally, conflicts sometimes occur when students remove other people's laundry to use the machines themselves. These problems highlight the need for a more structured and efficient system to allocate laundry machine slots.

Auction-based systems can provide a fairer and more transparent process for laundry machine reservations. Students can understand the allocation process better and feel that they have an equal opportunity to secure a machine based on their needs and willingness to bid points. Moreover, an auction system accounts for students' varying needs and financial situations. Unlike another common approach employed by universities, with a fixed-payment system, where students with more financial resources might dominate access, the point-based auction allows all students to participate fairly. Points are distributed equally at the beginning of each period (semester or quarter), ensuring that everyone starts with the same opportunity to bid. This paper aims to explore and compare the efficiency of two auction mechanisms for allocating laundry machines in university dormitories: first-price auctions and second-price auctions. In a first-price auction, each student submits a bid in points for a laundry machine time slot, and the highest bidder wins the slot and pays the amount they bid. In a second-price auction, each student submits a bid in points for a laundry machine time slot, and the highest bidder wins the slot but pays the amount of the second-highest bid. Through simulation this study seeks to answer the following questions: which auction mechanism results in higher allocation efficiency, how do bidding strategies differ between the two auction types, and what are the potential benefits and drawbacks of implementing auction mechanisms in university dormitories?

3 The Market

To fully understand this market, we need to consider the roles and motivations of buyers, the nature of the sellers, and the overall dynamics of supply and demand. The primary buyers in this market are the students, who can be categorized based on their needs for laundry machines. These needs can be divided into using the washing machine, the dryer, or both. Each category has distinct characteristics and motivations. The supply of laundry machines is fixed and limited, while the demand varies based on students' schedules and laundry needs. Students typically seek access to laundry machines to manage their clothing and hygiene needs efficiently. Their valuations for laundry machine time slots (v_i) can vary widely depending on factors such as upcoming social events, the frequency of their laundry needs, and personal schedules. For the purposes of this model, students' valuations are assumed to range between 5 and 25 points per hour.

The university dormitory acts as the seller in this market, offering a limited number of laundry machines. The dormitory's objectives include maximizing utilization, ensuring that laundry machines are used efficiently and are occupied by students who need them the most, providing fair access to laundry machines for all students, regardless of their booking speed. In a first-price auction, students submit bids (b_i) in points for laundry machine time slots, and the highest bidder wins the slot and pays the amount they bid. This mechanism encourages strategic underbidding, where students bid less than their true valuation (v_i) to avoid overpaying. In a second-price auction, students also submit bids (b_i) in points, but the highest bidder wins the slot and pays the amount of the second-highest bid ($b_{(2)}$). This mechanism encourages truthful bidding, as students are incentivized to bid their true valuations (v_i) since they pay only the second-highest bid.

In my auction-based model for laundry machine reservations, the total utility of the system is defined as the sum of the valuations of the winning students for the slots they secure. Mathematically, if v_{ii} represents the valuation of student i for the slot they win, the total utility is expressed as:

$$Utility = \sum_{i=1}^{n} v_{ii}$$

To determine which students are interested in bidding for a particular slot, we use the condition $v_{ji} > v_{jj}$ for all $j \in S$, where S is the set of students interested in the slot offered by student i. This condition ensures that only students who value the slot more than their own will participate in the auction.

The winner of the auction is the student who bids the highest valuation for the slot, determined by:

$$\max_{j \in S} v_{ij}$$

The payoff for each student i who wins a laundry machine slot is calculated by the difference between their valuation of the slot and the amount they pay. For a first-price auction, the payoff is:

$$Payoff_i = v_{ij} - b_i$$

For a second-price auction, where the highest bidder pays the second-highest bid, the payoff is:

$$Payoff_i = v_{ij} - b_{(2)}$$

The total payoff for the entire market, representing the sum of all individual payoffs, is given by:

$$TotalPayoff = \sum_{i=1}^{n} Payoff_i$$

4 Auction Rounds and Timing

The auction process for reserving laundry machine slots will be structured in multiple rounds to ensure that students have fair and ample opportunities to bid for time slots. Initially, the auction round for laundry machine slots will take place 24 hours before the actual usage time. This timing allows students to plan their schedules in advance and participate in the auction with sufficient notice. Students will submit their bids during this initial round, either for a single washing machine slot, a single dryer slot, or sequential slots (one hour for washing followed by one hour for drying). The flexibility of this system is particularly suitable for laundry machine allocations, where the need for access can be planned in advance, unlike other resources such as showers, which may be required spontaneously. The structured bidding process ensures that laundry machine slots are utilized by those who have planned their need and are willing to allocate their points accordingly. If any slots remain vacant after the initial auction round or if cancellations occur, a series of subsequent rounds will be held at decreasing intervals before the usage time to allocate these remaining slots. These subsequent rounds will occur 12 hours, 6 hours, 3 hours, and 1 hour before the usage time. This structured approach ensures that vacant slots are filled as efficiently as possible and provides multiple opportunities for students to bid. In the event that some slots remain vacant after the auction rounds, these slots will be available on a FCFS basis starting 30 minutes before the usage time. This approach ensures that no resource goes unused and provides last-minute opportunities for students who need immediate access to laundry facilities. If a student cancels their reserved slot, the slot will be re-entered into the auction system for the next available auction round. Cancellations made more than 12 hours before the usage time will allow the slot to be re-auctioned in the subsequent 12-hour round. Cancellations made within 12 hours of the usage time will place the slot directly into the next available auction round or the FCFS pool if it is within 30 minutes of the usage time.

Students submit their bids online through a dedicated auction platform. Each bid corresponds to an hourly time slot and is expressed in points. The auction platform evaluates all submitted bids at the end of each auction round. Winning bids are determined based on the highest points offered for each slot, and students are notified of their winning or losing status immediately after the auction round ends. Points are deducted from the winning students' accounts based on the bid amounts in first-price auctions or the second-highest bids in second-price auctions. Unused points are carried over to the next semester or quarter with a rollover factor of 0.8, encouraging students to use their points strategically.

For example, consider a student named Alex who needs to do laundry on a Friday evening. Alex logs into the auction platform on Thursday evening and places a bid of 15 points for a washing machine slot at 6 PM on Friday. During the initial auction round, Alex's bid is among the highest, so Alex wins the slot and pays 15 points in a first-price auction or the second highest bid in a second-price auction. If Alex had bid for a slot but did not win, Alex would have another chance to bid in the subsequent rounds at 12 hours, 6 hours, 3 hours, and finally 1 hour before the usage time, provided there were cancellations or other vacant slots. If any slots are still available 30 minutes before the usage time, Alex can book them on a first-come, first-served basis. This system ensures that Alex and other students have multiple opportunities to secure laundry machine slots, maximizing the efficient use of these facilities.

5 Literature Review

Auctions have long been recognized for their efficiency in allocating resources to those who value them the most. Vickrey's work on auctions in 1961 introduced the concept of the second-price auction, demonstrating that it incentivizes truthful bidding and leads to efficient outcomes. This finding has been supported by numerous studies, including those by Milgrom and Weber (1982), who further explored the strategic behavior of bidders in different auction formats. Their work highlighted the advantages of second-price auctions in promoting efficiency and reducing the winner's curse, where bidders overpay for the auctioned item.

In the context of educational institutions, resource allocation often involves balancing efficiency and fairness. The application of auction theory to educational settings has gained traction in recent years. Budish (2011) introduced the concept of the "course match" system, an auction-based mechanism for course allocation at universities. This system uses a modified version of the Gale-Shapley algorithm to match students to courses based on their preferences and bids. The course match system has been adopted by several institutions, including the University of Chicago Booth School of Business, demonstrating its effectiveness in improving allocation efficiency and student satisfaction. Furthermore, a study conducted at Reykjavik University explored the use of combinatorial auctions with a second price foundation for allocating study rooms. This research suggested that combinatorial auctions, which allow bidders to place bids on combinations of items, can improve allocation efficiency by considering the interdependencies between resources. However, the complexity of combinatorial auctions poses significant implementation challenges, particularly in ensuring bidder participation and understanding (Reykjavik University, 2023).

Recent advancements in auction theory have also focused on the impact of behavioral factors on bidding strategies and auction outcomes. Studies by Kagel and Levin (2002) and Camerer (2003) have examined how factors such as risk aversion, bidder experience, and information asymmetry influence bidding behavior. These insights are crucial for designing auction mechanisms that not only achieve efficient allocations but also account for the diverse behaviors and preferences of participants. Furthermore, the concept of rollover mechanisms, where unused resources or points carry over to future periods, has been studied in the context of dynamic auction environments. Cramton (1998) explored the use of rollover mechanisms in spectrum auctions, showing that they can enhance efficiency by allowing participants to manage their resources strategically over time. While the idea of rollover mechanisms has been applied in various contexts, its direct application to the allocation of university resources like laundry machines remains relatively unexplored. Implementing rollover mechanisms in laundry machine auctions could potentially encourage strategic point management and improve overall resource utilization.

While there is limited specific literature on the use of auction mechanisms for laundry machine reservations, related studies provide valuable insights. For example, the use of online booking systems for university resources, as described in research on library study rooms, highlights the potential for auctions to improve resource allocation. Furthermore, the incorporation of rollover mechanisms offers a promising avenue for enhancing efficiency and fairness, allowing for dynamic and strategic management of resources over time. The principles from these studies can be adapted to develop and implement auction-based systems for laundry machines, addressing common issues such as overbooking, inefficient usage, and lack of fairness in access.

6 Assumptions

The model relies on several key assumptions to simplify the analysis and focus on the core dynamics. Firstly, students' valuations for laundry slots are assumed to follow a uniform distribution, ranging between 5 and 25 points per hour. This ensures diverse but bounded valuations, although real-world distributions might be more complex. Each student starts with a fixed number of 100 points at the beginning of each semester or quarter, with unused points rolling over to the next semester or quarter at a factor of 0.8. This provides a fair starting point, encourages strategic point management, and prevents excessive accumulation of points over time. The model assumes a total of 100 students participating, with an equal number of laundry machines and dryers available, and the top 20 bidders winning the slots in each round. Overall, total efficiency is calculated as the sum of the valuations of winning bids, representing the overall utility achieved by the auction system and allowing comparison between different mechanisms and rollover factors.

In first-price auctions, students bid less than their true valuations to avoid overpaying, with a bid shading factor between 0.5 and 0.7. This reflects realistic bidding behavior where bidders aim to avoid the winner's curse by underbidding. In second-price auctions, students are assumed to bid their true valuations as truthful bidding is the dominant strategy. The model assumes that bidders act independently, without collusion or influence from others, reflecting a fair competitive environment. Additionally, the bidding behavior remains consistent across all rounds of the simulation, simplifying the analysis but potentially not capturing changes in strategy over time as students learn from previous rounds.

The model assumes that all laundry machine slots and bidders are homogeneous, meaning all slots are equally valued by bidders and all bidders have similar valuation distributions. This ignores potential variations in slot quality or specific bidder preferences. The simulation is conducted over 1000 rounds to ensure robustness in the results, with points adjusted based on the rollover factor and any points spent during the auctions. This ensures that unused points are carried over. The simulation environment assumes perfect information and rational behavior, ensuring results are not influenced by external factors and reflect the theoretical performance of the auction mechanisms.

7 End Goal and Trade Offs

The primary goal of this study is to measure the efficiency of different auction mechanisms—specifically, first-price and second-price auctions—in allocating university laundry machine time slots. Efficiency, in this context, refers to the optimal allocation of laundry machines to those who value them the most, as reflected by their bids. Achieving high efficiency ensures that the limited resource of laundry machines is utilized in a way that maximizes overall effectiveness within the dormitory. However, this objective is accompanied by trade offs that must be carefully considered.

While auction mechanisms can enhance efficiency, they may also exacerbate inequalities among students. Students with more points or better knowledge of the auction system may consistently secure slots, leaving others at a disadvantage. This can create perceptions of unfairness and reduce overall accessibility to the laundry facilities. To combat this, another goal is to create an auction with the careful design of the point allocation and rollover policies to prevent significant disparities and promote fairness. However, another trade off remains, as the auction system may not accommodate spontaneous access needs well. Some students may prefer or need to use laundry facilities on short notice, and a structured auction system could limit their ability to do so, reducing the overall convenience and flexibility of access.

8 The Models

First-Come, First-Served System

In the FCFS system, laundry machine slots are allocated to students based on the order of their requests. This method aims for simplicity and fairness by treating all students equally, regardless of their valuations for the slots. For each simulation round, students submit requests for laundry machine slots, and the order of requests is determined randomly, simulating the arrival times of students. However, to better match the urgency and immediate need of students, it is assumed that higher valuation students are more likely to arrive earlier. This is modeled by dividing the random arrival times by the students' valuations, giving a higher probability for students who value the slots more to get them sooner. Laundry machine slots are then allocated to students in the order their requests are received until all slots are assigned. The total efficiency of this allocation is calculated as the sum of the valuations of the students who receive the slots, reflecting how well the allocation matches the students' valuations.

Traditional Reservation System

In the traditional reservation system, laundry machine slots are allocated based on a predetermined schedule or reservation process without considering the varying valuations students place on the slots. This method allows students to reserve a machine if it is available, regardless of their immediate need or the urgency of their request. For simplicity, it is assumed that reservations are made randomly among students who check for available slots, simulating a process where availability is based on timing rather than the students' actual need or valuation. This approach often leads to inefficiencies as it does not dynamically respond to the students' valuations or urgency of need. The total efficiency of this system is calculated as the sum of the valuations of the students who receive the slots, reflecting how well the allocation matches the students' valuations.

First-Price Auction Model

For each simulation round, random valuations (v_i) are generated for bidders within their respective ranges.

These valuations are drawn from a uniform distribution, reflecting the diverse but bounded preferences of the bidders. Each bidder i submits a bid (b_i), which is a fraction of their true valuation (v_i) adjusted by the bid shading factor (between 0.5 and 0.7). This strategic underbidding is common in first-price auctions, where bidders aim to maximize their payoff by bidding less than their true valuation to avoid overpaying. The highest bids determine the winners. The top bids among individual bidders win the slots. This ensures that the slots are allocated to the bidders who value them the most, even if they bid less than their true valuations. The total efficiency is calculated as the sum of the valuations of the winning bids $\sum_{i \in W} v_i$, where W is the set of winning bidders. This measure of efficiency reflects the overall utility achieved by the auction system. Points are adjusted based on the rollover factor and any points spent during the auction.

Second-Price Auction Model

For each simulation round, random valuations (v_i) are generated for bidders within their respective ranges. These valuations are drawn from the same uniform distribution used in the first-price auction model. Each bidder i submits a bid (b_i), equal to their true valuation (v_i). This truthful bidding strategy is encouraged by the second-price auction mechanism, where bidders do not need to worry about overpaying. The highest bids determine the winners. The top bids among individual bidders win the slots. This ensures that the slots are allocated to those who value them the most. The total efficiency is calculated as the sum of the valuations of the winning bids $\sum_{i \in W} v_i$, where W is the set of winning bidders. This measure of efficiency reflects the overall utility achieved by the auction system. Points are adjusted based on the rollover factor and any points spent during the auction.

Tie-Breaking Mechanism

In the event of a tie, where two or more students submit identical bids for the same slot, a tie-breaking mechanism is required to determine the winner. The tie-breaking mechanism employed in this study is based on a random selection process. When a tie occurs, the system randomly selects one of the highest bidders to win the slot. This approach ensures fairness and simplicity, avoiding any complex rules or additional bidding rounds. Introducing additional bidding rounds to resolve ties could complicate the auction process, potentially discouraging participation. Moreover, additional rounds could prolong the auction process, making it less efficient and timely. In the case of second-price auctions, if there is a tie, the winning bidders will indeed pay the amount they bid, as there is no lower bid to refer to for setting the price. This ensures that the winning bidders still gain the slot without any additional complexity.

9 The Results

In the FCFS system, laundry machine slots are allocated to students based on the order of their requests. This method, while straightforward and fair in treating all students equally, does not account for the varying valuations students place on laundry machine slots. As a result, the FCFS system shows an average total efficiency of 171.61 points. The main limitation of this approach is that it can lead to suboptimal allocation, where some students may receive slots they value less highly than others who were unable to secure a slot due to timing. In contrast, the traditional reservation system allows students to reserve laundry machine slots in advance if they are available, without necessarily considering their immediate need or the varying valuations students place on the slots. While this system ensures that any student can reserve a machine if it is free, it does not dynamically respond to the urgency or higher valuations of students who may need the slots more critically. Consequently, the traditional reservation system has a higher average efficiency of 239.21 points. However, this approach still falls short in fully optimizing the allocation of resources because it does not prioritize reservations based on the students' needs or valuations.

The introduction of auction mechanisms marks a significant improvement in allocation efficiency. In the first-price auction mechanism, students submit bids for laundry machine slots, and the highest bidder wins the slot and pays the amount they bid. This mechanism encourages strategic underbidding, where students bid less than their true valuation to avoid overpaying. The efficiency of the first-price auction mechanism ranges from 402.56 points with no rollover to 456.23 points with full rollover. Notably, significant efficiency jumps are observed with the introduction of a rollover mechanism. The efficiency increases substantially from no rollover to a rollover factor of 0.5, showing an improvement of 26.28 points. Further, increasing the rollover factor from 0.5 to 0.8 results in an additional improvement of 18.84 points. However, the increase from 0.8 to 1.0 is significantly smaller, at 8.55 points, indicating diminishing returns as the rollover factor approaches full rollover.

Similarly, the second-price auction mechanism shows improved efficiency by encouraging truthful bidding. The efficiency of the second-price auction mechanism ranges from 405.82 points with no rollover to 468.12 points with full rollover. As with the first-price auction, significant efficiency improvements are observed with higher rollover factors. The efficiency increases from no rollover to a rollover factor of 0.5 by 25.30 points, and from 0.5 to 0.8 by 21.79 points. The increase from 0.8 to 1.0 is significantly smaller, at 15.21 points, suggesting that the most significant efficiency gains are achieved with a rollover factor of 0.8.

The introduction of rollover mechanisms significantly enhances the efficiency of both auction types. Allowing students to carry over unused points encourages strategic point management, ensuring that points are used more effectively across multiple periods. The results indicate that a rollover factor of 0.8 strikes an optimal balance, providing substantial efficiency improvements while mitigating potential issues such as point hoarding. Specifically, with a rollover factor of 0.8, the first-price auction achieves an average total efficiency of 447.68 points, and the second-price auction achieves 452.91 points. The combination of truthful bidding and strategic point management in the second-price auction leads to consistently higher efficiency compared to the first-price auction.

The simulation results clearly demonstrate that both auction mechanisms significantly outperform traditional reservation and FCFS systems in terms of efficiency. The second-price auction mechanism, in particular, consistently achieves higher efficiency due to its encouragement of truthful bidding. By adopting auction-based allocation mechanisms, universities can enhance the allocation of scarce resources like laundry machine

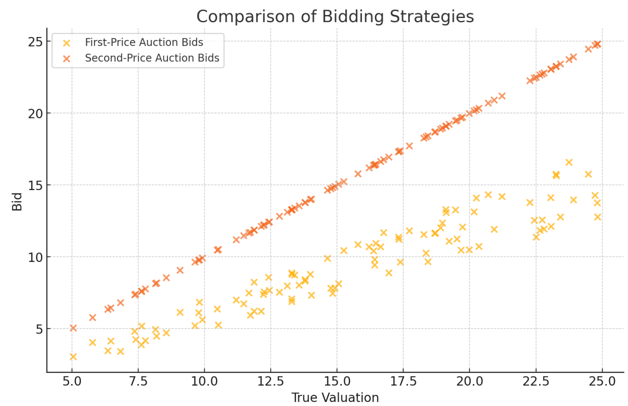

Figure 1: Bidding Strategies Comparison

slots, leading to higher overall student satisfaction and better utilization of resources.

Figure 1 compares the bidding strategies of first-price and second-price auctions. It shows that bids in second-price auctions closely align with true valuations, indicating truthful bidding, while bids in first-price auctions are strategically underbid, with a greater variance. This reflects the difference in bidding behavior between the two auction types, showing that the second-price auction remains more consistent.

10 Limitations

While the models and simulations presented in this study provide valuable insights into the efficiency of first-price and second-price auction mechanisms for allocating university laundry machine slots, there are several limitations that should be considered when interpreting the results. Firstly, the models rely on several simplified assumptions, such as uniform distribution of valuations and homogeneous bidders and slots. In reality, the distribution of valuations may follow more complex patterns, and there could be significant variations in slot desirability and bidder preferences. These factors could influence the bidding behavior and overall efficiency of the auction mechanisms. For example, some students might highly value slots at specific times, which the model did not account for. Furthermore, another limitation is the assumption of starting each student with a fixed number of points (100) and a rollover factor, which may not fully capture the diversity of point accumulation and usage strategies among students. Additionally, the fixed rollover factor does not account for potential changes in students' strategic behavior over time as they become more familiar with the auction system. In first-price auctions, the model assumes a bid shading factor between 0.5 and 0.7. This range, while reasonable, may not fully capture the variability in individual students' risk preferences and strategic behavior. Some students may bid more conservatively or aggressively, leading to different outcomes than those predicted by the model.

The assumption that bidders act independently without collusion or influence from other bidders simplifies the analysis but may not reflect real-world scenarios. In practice, students may form alliances or share information, which could affect the bidding process and the resulting allocation of laundry slots. Furthermore, the model assumes that students' bidding behavior remains consistent across all simulation rounds. However, students are likely to adapt their strategies based on past experiences and outcomes, leading to dynamic changes in behavior that are not captured by the model. The simulation environment also assumes perfect information and rational behavior, which may not always be realistic. In real-world settings, students may have incomplete information, make mistakes, or behave irrationally, all of which could impact the auction outcomes.

Finally, although higher rollover factors generally lead to increased efficiency, there is a risk of point hoarding, where students accumulate points excessively without spending them, potentially distorting the allocation process. The model does not fully address the long-term implications of such behavior. However, I did try to address this limitation by using a rollover factor of 0.8 compared to 1.0 where we would still get the efficiency gains with the lower risk of point hoarding. Another challenge was the lack of modeling for behavioral factors, such as risk aversion, bidder experience, and information asymmetry. These factors can significantly influence bidding strategies and auction outcomes. For instance, risk-averse students might underbid more conservatively in first-price auctions, leading to lower efficiency than predicted by our model. While these limitations show the oversights of the model and this specific study, it does overall provide a strong analysis of the different auction strategies in addressing laundry machine slot allocations.

11 Future Research Directions

Future research could address these challenges by incorporating more complex valuation distributions that better reflect real-world preferences. For instance, using a another statistical model to represent students' valuations could provide a more accurate depiction of their preferences. Additionally, modeling dynamic changes in bidding behavior over time could provide a better representation of actual auction environments. For example, incorporating learning algorithms that adjust bidding strategies based on past auction outcomes could simulate how students adapt their strategies over time. Furthermore, investigating behavioral factors and their impact on bidding strategies and outcomes would also enhance the understanding of these mechanisms. For instance, studies could explore how different levels of risk aversion or experience affect bidding behavior and auction efficiency.

The auction-based allocation system described in this study can also be extended to other university resources, ensuring efficient and fair distribution. For instance, tennis courts and sports facilities can be reserved by those who value and need them most, while study rooms and conference rooms can be efficiently allocated during peak times. University parking spaces, often limited and highly valued, can be auctioned to ensure those with the greatest need secure them. Music practice rooms can be managed to prioritize dedicated students, and event spaces can be allocated to organizations with significant events. This can be used to promote fair access across various campus resources.

12 Conclusion

Through this paper, I explored the efficiency of first-price and second-price auction mechanisms for allocating university laundry machine slots, comparing these methods with traditional reservation systems and FCFS approaches. This showed that both auction mechanisms significantly outperform traditional methods in terms of efficiency, with the second-price auction consistently yielding the highest efficiency due to its encouragement of truthful bidding. Additionally, I found that with a rollover factor of 0.8, students are incentivized to save points for future periods without excessively hoarding them. This balance ensures that the system remains both fair and efficient over time.

As a student, this new system means no more frustration with finding available machines or dealing with others taking out your clothes prematurely. Instead, you bid for time slots based on your need and valuation, ensuring fair access. With the added rollover mechanism, you can strategically manage your points across semesters, preventing resource monopolization and promoting equitable use. This system streamlines the entire process, making laundry time predictable and hassle-free, significantly improving the dormitory living experience. By encouraging strategic point management and truthful bidding, it can enhance the allocation of scarce resources like laundry machine slots, ultimately leading to higher overall student satisfaction, a more fair process, and efficient resource allocations.

References

[1] Budish, Eric. "The Combinatorial Assignment Problem: Approximate Competitive Equilibrium from Equal Incomes." *Journal of Political Economy*, vol. 119, no. 6, 2011, pp. 1061-1103.

[2] Camerer, Colin F. *Behavioral Game Theory: Experiments in Strategic Interaction.* Princeton University Press, 2003.

[3] Cramton, Peter. "Spectrum Auctions." *Handbook of Telecommunications Economics*, vol. 1, 2002, pp. 605-639.

[4] Kwasnica, Anthony M., and Katerina Sherstyuk. "Collusion in Multi-Object Auctions." *Economic Inquiry*, vol. 41, no. 4, 2003, pp. 644-655.

[5] Milgrom, Paul, and Robert Weber. "A Theory of Auctions and Competitive Bidding." *Econometrica*, vol. 50, no. 5, 1982, pp. 1089-1122.

[6] Parkes, David C., and Lyle Ungar. "Iterative Combinatorial Auctions: Theory and Practice." *Proceedings of the 17th National Conference on Artificial Intelligence and 12th Conference on Innovative Applications of Artificial Intelligence*, AAAI Press, 2000, pp. 74-81.

[7] Lúvíksdóttir, Ásta, and Jónasson, Kristinn. "Efficiency of Combinatorial Auctions in Allocating University Study Rooms." *Reykjavik University Journal*, vol. 23, no. 2, 2011, pp. 98-115.

[8] Vickrey, William. "Counterspeculation, Auctions, and Competitive Sealed Tenders." *Journal of Finance*, vol. 16, no. 1, 1961, pp. 8-37.