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King Solomon's Dilemma: An Experimental Study on Implementation

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Abstract

This paper reports an experiment conducted to compare two mechanisms that provide solutions to the King Solomon's Dilemma. One of them is proposed by Moore (1992) and the other by Perry and Reny (1999). The objective of each mechanism is to allocate a single unit of an indivisible private good to the player with the highest reservation value at zero cost for her. Our results show that the Perry and Reny's mechanism performs on average as well as the Moore's mechanism allocating the object to the rightful player at zero cost. However, implemented under incomplete information or using an ascending-clock auction, the Perry and Reny's mechanism performs significantly better than the Moore's mechanism.

Keywords: Implementation theory, Implementation in iterative deletion of weakly dominated strategies, Implementation in sub-game perfection, and Laboratory experiments.

JEL classification: C7, C9.

Resumen

Este artículo reporta los resultados de un experimento realizado para comparar dos mecanismos que aportan soluciones al Dilema del Rey Salomón. Uno de estos mecanismos es propuesto por Moore (1992) y el otro por Perry y Reny (1999). El objetivo de cada uno de estos mecanismos es asignar una única unidad de un bien privado e indivisible al jugador con el mayor valor de reserva, sin costo monetario para este jugador. Nuestros resultados muestran que el mecanismo de Perry y Reny tiene un desempeño similar al mecanismo de Moore en asignar el objeto al jugador correcto sin costo monetario para éste. Sin embargo, cuando el mecanismo de Perry y Reny se implementa utilizando un ambiente de información incompleta o una subasta ascendente, se observa un mejor desempeño de dicho mecanismo comparado con el de Moore.

Palabras clave: Teoría de implementación, implementación con eliminación iterativa de estrategias débilmente dominadas, implementación en subjuego perfecto, experimentos de laboratorio.

Clasificación JEL: C7, C9.

King Solomon's Dilemma: An experimental study on implementation[1]

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This paper reports an experiment conducted to compare two mechanisms that provide solutions to the King Solomon's Dilemma. One of them is proposed by Moore (1992) and the other by Perry and Reny (1999). The objective of each mechanism is to allocate a single unit of an indivisible private good to the player with the highest reservation value at zero cost for her. Our results show that the Perry and Reny's mechanism performs on average as well as the Moore's mechanism allocating the object to the rightful player at zero cost. However, implemented under incomplete information or using an ascending-clock auction, the Perry and Reny's mechanism performs significantly better than the Moore's mechanism.

Keywords: Implementation theory, Implementation in iterative deletion of weakly dominated strategies, Implementation in sub-game perfection, Spiteful behavior, and Laboratory experiments.

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1 Introduction

Applications should guide developments in implementation theory in the light of the wide set of solution concepts available in game theory and the existing lack of consensus on how games are actually played, according to Moore (1992).

The evaluation of some of these applications and their assumptions requires frequently a clear specification of players' preferences and information settings, as well as the institutional environment in which players are embedded. Controlled environs created in laboratories are useful to keep track of some of these specifications and to trace the decision making process itself. How robust a mechanism is in terms of its predictions is often an empirical question[4] that is also related to the more theoretical discussion of the choice of the equilibrium concept that is used in a mechanism, as well as the mechanism's informational characteristics.

In this paper, we compare the relative performance of two mechanisms, and their respective equilibrium concepts, allocating a single unit of an indivisible private good among two players. One mechanism was designed by Moore (1992) and the other by Perry and Reny (1999).[5] The mechanisms' desired outcome must satisfy at least two conditions: i) the good must be given to the player with the highest valuation, and ii) no monetary transfer among players must occur in the final allocation. Our comparison includes the analysis of different informational settings for both mechanisms, and of the effect of the use of an ascending clock in the mechanism of Perry and Reny.

This allocation problem is based on the biblical story traditionally known as the King Solomon's dilemma: Solomon has to give a child to one of two women who claim to be the true mother. Solomon knows, as well as the two women, that only one of them is the true mother; but he does not know which the right one is. On

[4] Schotter (1998), Palfrey (2002) and Baliga and Sjöström (2007) include a discussion about implementation and mechanism design derived from experimental research.

[5] In recent years, there have been different theoretical contributions to improve upon the original work of Perry and Reny while reducing the number of rounds of elimination: Olszewski (2003), Bag and Sabourian (2005), Mihara (2008), and Qin and Yang (2009).

the other hand, both women know who the true mother is; but one of them, the false mother, does not want to disclose her true identity. Solomon wants to give the child to the true mother and to assign him at zero cost for her. Hereafter, this allocation will be referred to as the desired Solomonic allocation (SA).

Both mechanisms assume that the true mother has a higher valuation over the child. In Moore's mechanism (MM), the implementation of the desired allocation is achieved through the use of the sub–game perfect Nash equilibrium concept when it is common knowledge that both women know each other's valuations precisely. When it is common knowledge that they do not know more than their valuations' rank order, the implementation is achieved through the use of the sub–game perfect Bayesian–Nash equilibrium concept. Perry and Reny's mechanism (PRM), in contrast, implements the desired allocation by using the iterative elimination of weakly dominated strategies. Ponti *et al.* (2003) point out the well documented finding in the experimental literature that in experimental settings people, in general, do not play the equilibrium as one of the motivations of their work, and this is one of our motivations too. In particular, the notions of sub-game perfect equilibrium and the iterative elimination of weakly dominated strategies posit stringent requirements on the rationality of the players.

One important distinction between these mechanisms is the monetary cost imposed on the player with the lowest reservation value if she tries to get the object, given that the player with the highest reservation value is also interested in getting it. The way the cost is imposed and its size differ across mechanisms. In MM, players have to pay at least a small fee if both decide to claim the object. In PRM, players have to pay the second highest bid of a second price auction if the winner stays with the object. If the low value player (LVP) decides to be spiteful and make it costly for the high value player (HVP) to get the object in either mechanism, she can make it for a smaller amount of money in MM.

Previous experimental results in auctions show that the ascending-clock auction tends to be a more robust institution than the second-price auction (Kagel, 1995; Assef, 2004). In particular, subjects in second price auctions tend to bid consistently above their own valuations, while in ascending-clock auction they converge speedily to the expected behavior. Most of the studies have concluded that the ascending-clock works as a good device for helping subjects in the process of elimination of dominated strategies. Then, we consider a set of treatments where

PRM is implemented with an ascending-clock auction with different speeds, expecting a better performance in terms of a higher proportion of Solomonic allocations.

Our experimental results indicate that PRM, implemented under incomplete information or through an ascending-clock auction, achieves the desired allocation more frequently than MM, though neither mechanism obtains a proportion significantly above a threshold of fifty percent. These results seem to indicate that individuals seem to need less stringent informational requirements and external devices, such as the ascending clock, in order to behave as predicted by the mechanisms.

This paper is organized as follows. Section 2 discusses the related auction literature. Sections 3 and 4 describe the structure of the mechanisms and the experimental design, respectively. Section 5 summarizes the results and proposes further research as a conclusion.

2 Related implementation literature

Most of the experimental research on implementation evaluates different kinds of game rules under complete information that seek to implement a desired outcome using different solutions concepts.

Cabrales *et al.* (2003), for example, test the mechanism proposed by Maskin (1999) for Nash implementation, using 3 players in non–repeated groups, as well as 3 outcomes, states of nature, and integer choices. In contrast to our game, the social choice function they implement needs to be monotonic in order to be Nash implementable (Maskin, 1999), which is not the case for Solomon's dilemma (Moore, 1992; Corchón, 1996). They find a high rate of optimal outcomes, even though players did not play the Nash equilibrium quite frequently. This seems to be a good property since the mechanism still produces optimal outcomes even when players have deviated from predictions.[6]

[6] Schotter (1998) suggests seven desired properties, or criteria, that a mechanism should satisfy (at least partially) in order to be considered robust in real world applications: understandability,

Katok *et al.* (2002) test the mechanism designed by Abreu and Matsushima (1992) for virtual implementation in iteratively undominated strategies. Katok *et al.* report their experimental results under two different versions: a sequential version and a simultaneous version, using a two player symmetric coordination game under complete information, with different length periods of eliminations and an exogenous penalty fee for deviations. Consistent with Sefton and Yavas' seminal work (Sefton and Yavas, 1995), they find that for the simultaneous version the predicted outcome is rarely observed since subjects usually apply a limited number of iterations. For the sequential version, they find that subjects use a limited number of steps of backward induction. They also find that the sequential version does worse than the simultaneous version predicting the desired outcome.

Ponti *et al.* (2003) compare two mechanisms: the mechanism proposed by Glazer and Ma (1989) for sub–game perfect Nash implementation, and the mechanism designed by Ponti (2000) for evolutionary Nash implementation of the Solomonic allocation. Both games are extensive form representations similar to Moore's mechanism under complete information with an exogenous penalty fee. First, they do not find any difference between the Nash implementation and the sub-game perfect implementation. Finally, just a third of all the allocations satisfy the requirement of granting the object to the rightful player at zero cost.

3 Structure of the mechanisms

We start by characterizing the structure of these mechanisms in terms of their specific assumptions, set of rules, and solution concepts. For both mechanisms, we assume that it is common knowledge that the players' valuations are different with probability one and that, at least, each player knows her own valuation and who has the higher valuation.

fairness-strategic symmetry, trade-off efficiency, strategic robustness, personality robustness, agent profitability and collusion freeness.

3.1 Moore's mechanism

The Moore's mechanism begins giving an initial player, say player 1, the option to claim the object. This initial player has to announce whether or not she claims the object. If she does not claim the object, it is given to the other player, say player 2, and the game ends. If she claims the object, player 2 can either agree and the object is given to player 1, or challenge and bid, B, for the object. In such a case, player 1 is fined a fixed amount, F, and has to decide whether or to not match the bid. If she chooses to match the bid, she will get the object by paying B, and player 2 just pays the fixed amount F. If she chooses not to match the bid, the object is given to player 2 who pays B. Figure 1(a) shows an extensive form representation of the structure of MM. For more details, see Moore (1992).

To attain the Solomonic allocation, it is required that, after every history, the action prescribed by each player's strategy should be optimal, given the other player's strategy. Thus, each player can find out her best strategy by backward reasoning: If the HVP plays first claiming the object, the LVP would get the object if she bids, B, more than the HVP's valuation, θ_{HVP}, ($B > \theta_{HVP}$), so that the HVP drops later. But, since the bid is also greater than the LVP's valuation, θ_{LVP}, ($B > \theta_{HVP} > \theta_{LVP}$), she would be better off not challenging the HVP. Then at the equilibrium outcome, the HVP will claim the object and the LVP will agree. On the other hand, if the LVP moves first claiming the object, the HVP can claim the object too, bid safely below her own valuation ($\theta_{HVP} \geq B > \theta_{LVP}$), and get the object later. Then, the LVP would be better off not challenging the HVP. Although it would be a best response for the LVP to match the bid, B, it is not credible no matter how high the bid, B, is. Then at the equilibrium outcome, the LVP will simply not claim the object and the HVP will get it.

3.2 Perry and Reny's mechanism

3.2.1 Second-price auction version

The Perry and Reny's mechanism begins with both players simultaneously bidding in a second-price auction. The player who bids higher gets the object, but both players have to pay the losing bid. Additionally, the winner has the option to drop her bid and give the object to the other player. In such a case, nobody has to pay.

Should have both players bid the same price, one of the players is randomly selected with a probability of ½ and given the object at this price, without the option to drop her bid. In such a case, the other player pays nothing. Figure 1(b) shows an extensive form representation of the structure of PRM. For more details, see Perry and Reny (1999).

To attain the Solomonic allocation, it is required that each player eliminates by rounds every weakly dominated strategy, given that she knows her own valuation and the other player's valuation, and that it is common knowledge that all players are rational.[7] If a player wins the auction, the strategy also specifies her decision either to quit and give the object to the other player, or to stay and buy the object. The process starts for each player with the elimination of every strategy, given her valuation and her bid included in her strategy, that specifies either i) to quit if she wins and her valuation is above the other player bid, or ii) to buy the object if she wins and her valuation is below the other player bid. In the second round, the HVP eliminates any bid above her own valuation. All bids above her own value are weakly dominated by bidding her value. Then, she will be bidding at or below her valuation ($\theta_{HVP} \geq B_{HVP}$). In the third round, the LVP eliminates by weak domination all remaining strategies, except those when she submits a bid that she knows is strictly greater than the HVP's valuation. In fact, the LVP would bid above the HVP's valuation since she does not rule out the truth ($B_{LVP} > \theta_{HVP}$). Finally, the HVP eliminates all the remaining weakly dominated strategies, except those when she submits a bid that she knows is strictly above the LVP's valuation. Since the HVP does not rule out the truth, she would, in fact, bid above the LVP's valuation ($B_{HVP} > \theta_{LVP}$). The supported outcome would be such that the LVP wins the auction and chooses to exercise the option to quit. Thus, the HVP receives the object and neither player makes any payment.

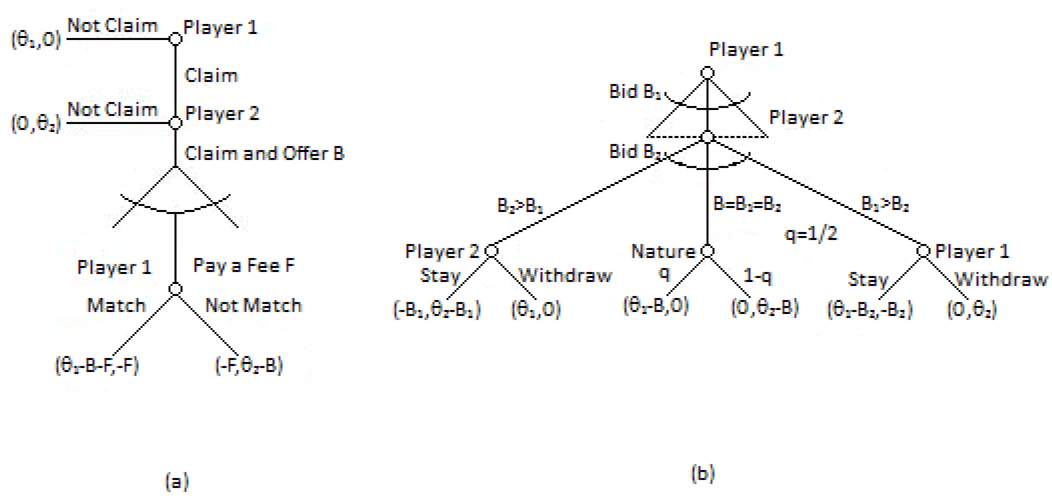
Perry and Reny (1999) consider that the order of elimination is irrelevant, meaning that there might be another order of elimination that implements the same allocation.[8] For instance, there is a different order of elimination where the

[7] For Perry and Reny (1999), if the players know by common knowledge that the initial eliminations have been done, later rounds of eliminations can be justified.

[8] In this respect, a weakness of the iterative elimination of weakly dominated strategies has been pointed out in the literature. For example, Mas–Colell et al. (1995) say "The iterated deletion of

HVP gets the object, with no monetary transfer and, at the same time, without players following the strategy just described: This would happen if the LVP bids zero ($B_{LVP} = 0$) and the HVP wins the auction and gets the object. There is, however, a strategic feature of the previous order of elimination in favor of the LVP bidding above the HVP's valuation ($B_{LVP} > \theta_{HVP}$): It might be the case that the HVP bids (out of equilibrium) either i) below the LVP's valuation ($\theta_{LVP} \geq B_{HVP}$) or ii) above the LVP's bid ($B_{HVP} > B_{LVP}$). Thus, in the first case, the LVP might get the object by staying with it after winning the auction. In the second case, the LVP might get it after the HVP has to exercise the option to exit after winning the auction.

Figure 1: Extensive form games for MM and PRM



3.2.2 Ascending-clock auction version

In this version, the mechanism begins with both players simultaneously participating in an ascending-clock auction. The clock starts at a price equal to

weakly dominated strategies is harder to justify. [...] the argument for deletion of a weakly dominated strategy for player *i* is that he contemplates the possibility that every strategy combination of his rivals occurs with positive probability. However, this hypothesis clashes with the logic of iterated deletion, which assumes, precisely, that eliminated strategies are not expected to occur. This inconsistency leads the iterative elimination of weakly dominated strategies to have the undesirable feature that it can depend on the order of deletion." (p. 240).

zero. Once the price increases, each player has the option to drop at any time. After one of the players has dropped out, the bidder still actively bidding earns her valuation minus the drop–out price. The player who has dropped out earns nothing but must also pay the drop–out price. The winner of the auction has the option to drop her claim and give the object to the other player. In such a case, nobody has to pay. Should have both players dropped out at the same price, one of the players is randomly selected and given the object at this price, without the option to drop her claim. In such a case, the other player pays nothing. A similar order of elimination of weakly dominated strategies to the one described for the second-price auction version will provide us the desired allocation.

4. Experimental design

The experimental design used directly measures the relative performance of MM and PRM under different auction rules and information environs. For all these mechanisms, two private values, one for each player, are drawn randomly from the interval $[\theta_{MIN},\theta_{MAX}]$, with the restriction that the difference between the high valuation, θ_{HVP}, and the low valuation, θ_{LVP}, would be greater than a exogenous parameter M: $\theta_{HVP} - \theta_{LVP} > M$. The details of the experimental design follow.

Subjects. For each session, the subjects were drawn from a wide cross–section of students at the Instituto Tecnológico Autónomo de México (ITAM). Subjects participated in only one session. The experiment was run at ITAM using computers.

Practice and real periods. In order to familiarize subjects with the procedures, two practice periods occurred before the 10 real periods played for money began.

Matching procedure. Before the practice periods started, each player was designated either as a HVP or as a LVP. Positions were fixed for the whole session. In each period, a HVP was paired with a LVP, and each pairing was randomized so that they were never paired with the same player more than two times, and were never paired with the same player in two consecutive periods. Further, they did not know who they were paired with in any given period.

Valuations. Valuations for each period were drawn randomly from the interval $[\theta_{MIN},\theta_{MAX}]$ = [$0,$200] pesos, with the restriction that the minimum difference between the high valuation and the low valuation, M, would equal to $50 pesos.[9]

Penalty Fee. A fine, F, of $10 pesos was used for the MM.

Initial capital. All players were endowed with an initial capital balance, which was the same for all periods. The initial capital balances were $70 pesos for the LVPs and $30 pesos for the HVPs. The reason for the difference in the initial capital of the LVPs and that of the HVPs is to compensate the asymmetry in their valuations and alleviate the possibility of envy driven actions.

Payoffs. The final payoff was determined selecting randomly one round out of the 10 periods played for money. Players were also informed that any profit earned would be added to the initial capital balance, and any loss will be subtracted from it. The initial capital balance plus any gain added to it or loss subtracted from it, was considered their possible payoff for each period, along with the participation fee of $50 pesos. The equilibrium expected payoffs were $243 pesos for the HVPs and $120 pesos for the LVPs, including the participation fee of $50 pesos.

Auction rules for PRM. For the PRM we use two different auction rules: a sealed bid second–price auction rule and an ascending–clock auction rule. For the ascending-clock rule, we consider two different clock speeds: i) 1 peso per second and ii) 1/5 peso per second. The difference in clock speed is motivated by the finding of Katok and Kwasnica (2008) that timing matters in auctions. Players were not informed about the speed of the clock with the purpose of not inducing a focal point in terms of strategies.

Information feedback. During the decision process, some of the calculations about possible payoffs were given privately by the computer to each player at different decision nodes. For the MM, if both players claimed the object and a bid was submitted by the second player, the payoff conditional on getting the object was calculated for the first player who had to decide whether to match the bid. For the PRM, after the bids were submitted for the second-price auction, or the first drop–

[9] By the time sessions were run, the exchange rate was approximately 10.5 pesos per dollar.

out occurred for the ascending-clock auction, the payoffs conditional on staying with or withdrawing the object were calculated for the winner. Finally, at the end of every round, each player received complete feedback about her own payoff, and no information about the other player's payoff.

Bidding restrictions. For PRM under the ascending-clock, players were informed that had the clock price reached the maximum level of $270 pesos without a player dropping out, the sale price for the item would be $270 pesos and the item would be sold to one of the claimants (chosen randomly by the computer) at this price, without the option to withdraw, and the other bidder would pay nothing. In order to compare the PRM under the ascending-clock with the other mechanisms, players were not allowed to bid above $270 pesos in the other two. The motivation for imposing this restriction is to avoid the situation in which players incur in losses. On the other hand, our subjects did not have the option of not participating in the auction of PRM because this mechanism does not actually have this option, as opposed to Mihara (2008).

Information conditions. We consider two different information conditions: In the first information condition – hereafter referred to as *complete information condition* – both players were informed about the exact amount of their valuations. In the second information condition – hereafter referred to as *incomplete information condition* –, both players were informed about the rank order of their valuations, whether they had the highest or lowest valuation, but were not informed about the exact amount of the other player's valuation. Under complete information, each player could see on the screen of the computer her own valuation and the valuation of the player she was paired with. Under incomplete information, each player could see on the screen of the computer her own valuation, but not the valuation of the player she was paired with. However, the players knew that the difference in valuations was 50 pesos.

Table 1 briefly summarizes the experimental treatments and the number of subjects per session. We ran three sessions for each mechanism under both complete and incomplete information conditions.

Table 1: Experimental design

Mechanism	Institution	Information	Treatment	Number of Subjects per Session
MM	Sequential game with a take-it-or-leave-it offer	Complete	MM-CI	22, 22 and 22
		Incomplete	MM-II	26, 22 and 22
PRM	Second-price all-pay auction	Complete	PRM-SPA-CI	18, 24 and 24
		Incomplete	PRM-SPA-II	26, 28 and 26
	Ascending-clock all-pay auction (1 peso per second)	Complete	PRM-ACA-CI	26, 14 and 26
		Incomplete	PRM-ACA-II	26, 28 and 26
	Slow ascending-clock all-pay auction (1/5 peso per second)	Complete	PRM-SACA-CI	28, 28 and 28
		Incomplete	PRM-SACA-II	24, 24 and 24

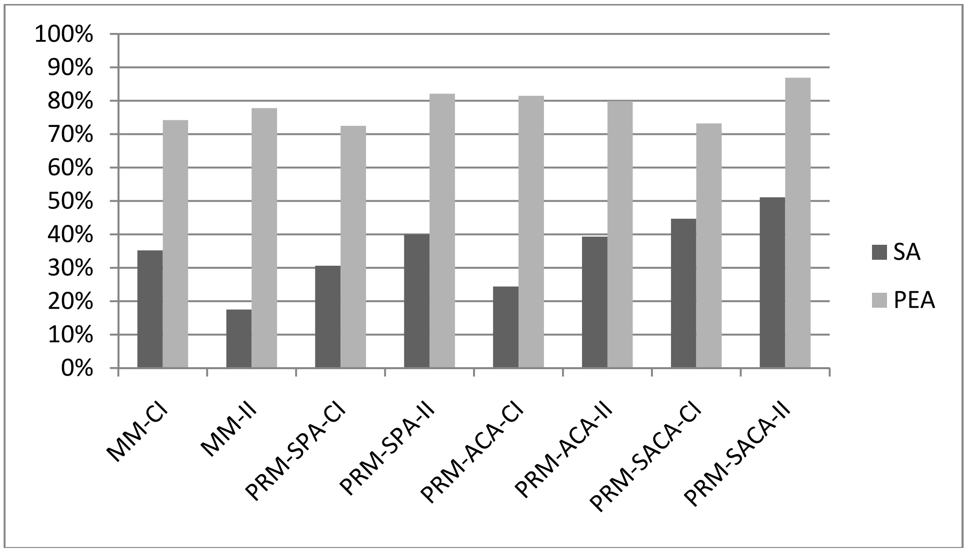
Table 2: Proportions of Solomonic allocations and Pareto efficient allocations

Treatment	Solomonic allocations[a]	Pareto efficient allocations[b]
MM-CI	35.2%	74.2%
MM-II	17.5%	77.8%
PRM-SPA-CI	30.6%	72.5%
PRM-SPA-II	40.0%	82.1%
PRM-ACA-CI	24.4%	81.5%
PRM-ACA-II	39.3%	79.9%
PRM-SACA-CI	44.7%	73.2%
PRM-SACA-II	51.1%	86.9%

[a] Proportion of objects going to HVPs at zero cost.

[b] Proportion of objects going to HVPs, not including ties for PRM.

Figure 2: Proportions of Solomonic allocations (SA) and Pareto efficient allocations (PEA)



5 Results and Discussion

This section compares the experimental results from the six treatments of PRM and the two treatments of MM described in the previous section.

5.1 How efficient are these mechanisms?

We consider two different measures of efficiency: i) the proportion of Solomonic allocations (SA) and ii) the proportion of Pareto efficient allocations (PEA). The first proportion is the result of dividing the number of objects given to HVPs *at zero* cost over the total number of allocations.[10] The second proportion is the result of dividing the number of objects given to HVPs *at any cost* over the total number of allocations. The second and third columns of Table 2 report the aggregate proportions of SA and PEA, while Figure 2 shows these proportions in bars.

[10] For PRM, we consider a Solomonic allocation those cases in which HVPs win the auction and stay after LVPs bid (or drop-out) a price lower than or equal to two pesos.

From Table 2, we can appreciate, firstly, that in all of our treatments the average proportion of Solomonic allocations is below or equal to a fifty percent threshold. This is an important threshold since it is equivalent to trying to allocate the desired object by just tossing a fair coin. Secondly, there is still a significant proportion of allocations in which the object goes to the wrongful players even though the average proportion of Pareto efficient allocations is above a seventy percent threshold. Thirdly, approximately fifty percent of these Pareto efficient allocations went to the rightful player at some cost.

These results are indications of LVPs' preferences for actively pursuing the desired object, for which, as we analyze later on, they were willing to spend a significant amount of monetary resources.

We now focus on measuring how different levels of information about players' valuations and different auction rules affect our measurements of efficiency. We consider the following logit model with random effects for estimating the likelihoods of allocating the object to the rightful player at any cost (PEA) and at zero cost (SA):

$$Pr(y=1) = F(Intercept + \beta_1 v_{HVP} + \beta_2 v_{LVP} + \beta_3 per + \gamma_1 d_{PRMii} + \gamma_2 d_{ACA} + \gamma_3 d_{SACA} + \gamma_4 d_{MM} + \gamma_5 d_{MMii})$$

In this model, v_{HVP} represents the valuation of the HVP; v_{LVP} represents the valuation of the LVP; d_{PRMii} is a dummy variable that takes the value of one when PRM is implemented and both players know the rank order of valuation, but do not know the exact valuation of the other player; d_{ACA} is a dummy variable that takes the value of one when PRM is implemented using an ascending-clock auction, instead of the second-price auction, while d_{SACA} is a dummy variable that takes the value of one when, in addition, the speed of the ascending clock is slow; d_{MM} is a dummy variable that takes the value of one when MM is implemented, while d_{MMii} is a dummy variable that takes the value of one when, in addition, both players know the rank order of valuation but do not know the other player's valuation precisely. The variable *per* represents the period (time trend), treating time as a continuous variable; and $F(.)$ is the cumulative logistic distribution function. In the second column of Table 3, we present the parameter estimates when y takes the value of one when the object is allocated to the rightful player at zero cost (SA), while in the third column we present the parameter estimates when y takes the value of one when the object is allocated just to the rightful player (PEA) at zero cost.

Result 1 (Solomonic allocations) On average, PRM performs as well as MM implementing the desired allocation. Under incomplete information, however, PRM performs better and MM performs worse allocating the object to the rightful player at zero cost. The implementation of PRM with a slow ascending-clock auction increases the proportion of desired allocations. Finally, the proportion of Solomonic allocations increases as players' valuations are lower and players get experience.

Table 3: Regression results for efficiency measurements

Coefficients	**Solomonic Allocations**	**Pareto Efficient Allocations**
Intercept	-0.257	1.105^{***}
	(0.255)	(0.300)
v_{HVP}	-0.005^{**}	0.004^{**}
	(0.002)	(0.002)
v_{LVP}	-0.005^{***}	-0.011^{***}
	(0.001)	(0.001)
Per	0.082^{***}	0.021
	(0.015)	(0.016)
d_{PRMii}	0.489^{***}	0.490^{***}
	(0.120)	(0.127)
d_{ACA}	-0.138	0.167
	(0.149)	(0.156)
d_{SACA}	0.747^{***}	-0.015
	(0.146)	(0.155)
d_{MM}	0.307	0.027
	(0.197)	(0.198)
d_{MMii}	-1.070^{***}	0.201
	(0.216)	(0.203)

*: p<0.05, **: p<0.01 and ***: p<0.001.

Note: Numbers in parentheses below each coefficient represent the coefficient standard error.

Support for Result 1 The coefficient for MM, γ_4, was positive but not significant. This means that the likelihood of granting the object to HVPs at zero cost using PRM did not differ from granting it by using MM. For the average valuations, the estimated probabilities of allocating the object to the rightful player at zero cost are 28.0% for PRM and 34.6% for MM.

Nonetheless, the coefficient for PRM under incomplete information, γ_1, was positive and significant, while the same coefficient for MM, γ_5, was negative and significant. That means that the likelihood of granting the object to HVPs at zero cost under incomplete information increases for PRM and decreases for MM. For instance, the estimated probabilities of allocating the object to the rightful player at zero cost under incomplete information are 38.8% for PRM and 15.3% for MM.

Even though the rate of desired allocations did not improve as an immediate consequence of adopting the ascending-clock, the likelihood of allocating the object to the rightful player at zero cost after slowing the ascending-clock down went up to 41.7%. This represents a significant improvement in the proportion of Solomonic allocations.

Finally, the significance of the estimated coefficients for players' valuations, β_1 *and* β_2, and time period, β_3, indicates that the likelihood of allocating the object to the rightful player at zero cost increases as a consequence of lower players' valuations over the object and larger participants' experience playing with the mechanism. The former is evidence that the likelihood of allocating the object as desired increases while players' eagerness in getting the object is lower.

Result 2 (Pareto efficient allocations) PRM performs on average better allocating the objet to the rightful player under incomplete information. Neither the implementation of PRM with an ascending-clock nor the implementation of MM has a significant impact over the rate of Pareto efficient allocations. Finally, the proportion of Pareto efficient allocations increases when HVPs' valuations are higher and LVPs' valuations are lower.

Support for Result 2 The positive sign and the statistical significance of the coefficient of incomplete information for PRM, γ_1, indicates an improvement in the proportion of allocations to the rightful players, although sometimes they do have to pay for them. On average, the likelihood of allocating the object to the rightful player went up to 83.1% for PRM under incomplete information. In contrast, the coefficients associated with the implementation of the ascending-clock for PRM, γ_2 and γ_3, and with the implementation of MM (either under complete or incomplete information), γ_4 and γ_5, are not significantly different from zero for a p-value less than 5%.

In contrast with our previous result, we find a tension regarding the efficiency with respect to players' valuations: An increment on the HVPs' valuations over the object has a positive impact on the likelihood of allocating the object to the rightful player, while a similar increment in the LVPs' valuations has a negative impact. This last result might be an indication that for larger valuations, LVPs are more willing to fight the object, increasing the likelihood of obtaining inefficient allocations.

Table 4: Proportions of net mean efficiency (NME), resource inefficiency (R-INEFF) and wrong-player inefficiency (WP-INEFF)

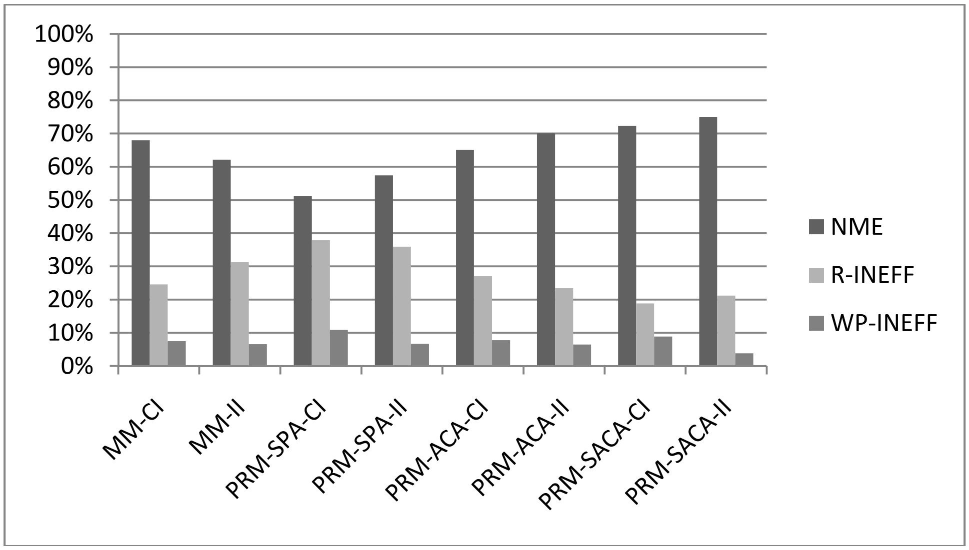
Treatment	**Net mean efficiency**[a]	**Resource inefficiency**[b]	**Wrong-player inefficiency**[c]
MM-CI	68.0%	24.5%	7.5%
MM-II	62.1%	31.3%	6.6%
PRM-SPA-CI	51.2%	37.9%	10.9%
PRM-SPA-II	57.4%	35.9%	6.7%
PRM-ACA-CI	65.1%	27.2%	7.7%
PRM-ACA-II	70.1%	23.4%	6.5%
PRM-SACA-CI	72.3%	18.8%	8.9%
PRM-SACA-II	75.0%	21.2%	3.8%

[a] NME = (Winner's valuation − Players' payments + Players' initial capital) / (Highest valuation + Players' initial capital) × 100.

[b] R-INEFF = (Players' payments) / (Highest valuation + Players' initial capital) × 100.

[c] WP-INEFF = (Highest valuation − Winner's valuation) / (Highest valuation + Players' initial capital) × 100.

Figure 3: Proportions of net mean efficiency (NME), resource inefficiency (R-INEFF) and wrong-player inefficiency (WP-INEFF)



5.2 What are the sources of inefficiency?

We now consider the amount of resources used in the allocation process as a proportion of the maximal surplus. As we have mentioned before, these mechanisms were design with the goal that there will be enough penalties and incentives to dissuade LVPs from pursuing the object. If this is not the case, there will be two possible sources of inefficiencies: i) one that comes from allocating the object to the wrongful-player (wrong-player inefficiency) and ii) the other that comes from the use of monetary resources in the allocation process (resource inefficiency).

Before analyzing these two sources of inefficiency, let us introduce the notion of net mean efficiency (NME). The NME is the result of dividing the total amount of players' net benefits as a proportion of the total surplus. In other words, the proportion of NME tells us the quantity of resources compromised in the allocation process. The second column of Table 3 reports the aggregate proportion of NME.

At the equilibrium, the NME should be a hundred percent of the total surplus, otherwise there would be two types of inefficiencies: resource and wrong-player inefficiencies. The third and fourth columns of Table 3 report, respectively, the proportions of resource inefficiency (R-INEFF) and wrong-player inefficiency (WP-INEFF). For instance, in the first row of the table the average proportions of NME, R-INEFF and WR-INEFF for MM are, respectively, 68.0%, 24.5% and 7.5%. That means that 32.0% (24.5% + 7.5% = 100.0% - 68.0%) of the total surplus is wasted either by giving the object to LVPs or by using monetary resources in the allocation process.[11] From this table, we can observe that the R-INEFF is the main source of inefficiency. In particular, the average rate of inefficiency for this concept was 28.0%, while the average rate of inefficiency for giving the object to the wrongful player was around a quarter of this rate, 7.0%. Figure 3 shows each of these three average proportions in bars.

We now focus on measuring how different levels of information about players' valuations and different auction rules affect our sources of inefficiency. In the second and third columns of Table 4, we present, respectively, the parameter estimates of the following specification of a Tobit model with random effect for estimating the amount of inefficiencies coming from the use of monetary resources in the allocations and from allocating the object to the wrongful player:

$$y = Intercept + \beta_1 v_{HVP} + \beta_2 v_{LVP} + \beta_3 per + \gamma_1 d_{PRMii} + \gamma_2 d_{ACA} + \gamma_3 d_{SACA} + \gamma_4 d_{MM} + \gamma_5 d_{MMii}$$

All variables on the right-hand side of this equation have the same meaning as in the previous model.

Result 3 (Resource inefficiency) The ascending-clock seems to reduce the inefficiency due to the use of monetary resources in the allocation process. This is also true when MM is implemented. Thus, most of this kind of inefficiency comes from implementing PRM with a second-price auction. However, there is also a negative effect if MM is implemented under incomplete information. Finally, the proportion of this type of inefficiency decreases when LVPs' valuations decrease or players' experience increases.

Support for Result 3 As seen in Table 3, the coefficients for the ascending-clock, γ_2, and MM, γ_4, are negative and significant, indicating a reduction in the relative

[11] These proportions do include the players' initial capital.

use of monetary resources in the allocation process. As a numerical approximation, the implementation of the ascending clock for PRM and the implementation of MM reduce the proportion of resource inefficiencies from an average of 37.6% down to 25.6% and 24.4%, respectively. Although the coefficient associated with MM under incomplete information, γ_4, is negative in sign and significant, its negative impact is lower than the reduction due to the sole implementation of MM. For instance, the average proportion of resource inefficiency for MM under incomplete information is 31.3%, which is still below the unconditional average of 37.6%. Finally, since lower valuations of LVPs are indications of a lower willingness to fight for the object, there are lower payments in the allocation process and, consequently, the proportion of resource inefficiency is lower.

Table 5: Regression results for sources of inefficiency

Coefficients	**Resource Inefficiency**	**Wrong-Player Inefficiency**
Intercept	0.291***	0.068***
	0.040	0.015
v_{HVP}	2.E-04	2.E-04
	3.E-04	7.E-05
v_{LVP}	0.001***	-2.E-04*
	2.E-04	-1.E-04
Per	-0.010***	-0.001
	0.002	0.001
d_{PRMii}	-0.012	-0.027***
	0.019	0.007
d_{ACA}	-0.120***	0.001
	0.023	0.008
d_{SACA}	-0.052*	-0.015
	0.023	0.008
d_{MM}	-0.133***	-0.013
	0.031	0.011
d_{MMii}	0.070*	-0.008
	0.030	0.011

*: p<0.05, **: p<0.01 and ***: p<0.001.

Note: Numbers in parentheses below each coefficient represent the coefficient's standard error.

Result 4 (Wrong-player inefficiency) The inefficiency proportion for allocating the object to the wrongful player is lower when PRM is implemented under incomplete information. Likewise, the inefficiency proportion for allocating the object to the wrongful player decreases when HVPs' valuations decrease and LVPs' valuations increase.

Support for Result 4 For this regression, the only two negative and significant parameters are the ones associated to the LVPs' valuations, β_2, and the dummy for the PRM under incomplete information, γ_1. We find that when LVPs' valuations are higher, the inefficiency for allocation the object to the wrongful-player goes up. Finally, the implementation of PRM under incomplete information also seems to reduce the inefficiency for this concept.

In summary, from the last two sections we have found that the implementation under *incomplete information* has favored the performance of PRM granting the object to the rightful player both at zero cost and increasing the amount of efficiencies derived from assigning the object to the rightful-player at any cost. We have also found an opposite effect of incomplete information over the performance of MM. On the other hand, we have found that the implementation of PRM with an *ascending-clock auction* has affected positively the proportion of objects going to the rightful players and in terms of the monetary resources used in the allocation process. In this regard, we claim that the ascending-clock is a useful device for coordinating players' actions during the process of elimination of weakly dominated strategies.

When we look at the impact of LVPs' valuations over the performance of these mechanisms, we find that higher LVPs' valuations have opposite effects over the proportion of Solomonic and Pareto efficient allocations. Lastly, we find that the players' experience using the mechanisms favors their performance in terms of attaining the desired allocations and reducing the amount of resources wastefully used in the allocation process.

Table 6: Regression results for MM efficiency conditional on HVPs moving first

Coefficients	**Solomonic Allocations**	**Pareto Efficient Allocations**
Intercept	-0.474	-0.381
	(0.532)	(0.582)
v_{HVP}	0.005	0.010^{**}
	(0.003)	(0.004)
v_{LVP}	-0.022^{***}	-0.017^{***}
	(0.003)	(0.003)
per	0.071^{*}	0.108^{**}
	(0.035)	(0.034)
d_{ii}	-1.154^{***}	0.197
	(0.249)	(0.198)
d_{HMF}	0.341	1.244^{***}
	(0.206)	(0.198)

*: $p<0.05$, **: $p<0.01$ and ***: $p<0.001$.

Note: Numbers in parentheses below each coefficient represent the coefficient's standard error.

Table 7: Regression for PRM efficiency conditional on HVPs winning the auction

Coefficients	**Solomonic Allocations**	**Pareto Efficient Allocations**
Intercept	-2.079***	1.959***
	(0.377)	(0.369)
v_{HVP}	-0.005*	0.001
	(0.002)	(0.002)
v_{LVP}	-0.009***	-0.009***
	(0.002)	(0.002)
per	0.109***	0.002
	(0.022)	(0.020)
d_{ii}	0.937***	0.465***
	(0.147)	(0.135)
d_{ACA}	-0.637***	0.227
	(0.188)	(0.166)
d_{SACA}	1.164***	0.060
	(0.182)	(0.166)
d_{HW}	-3.553***	0.877***
	(0.177)	(0.137)

*: $p<0.05$, **: $p<0.01$ and ***: $p<0.001$.

Note: Numbers in parentheses below each coefficient represent the coefficient standard error.

5.3 Does order matter for efficiency?

In a previous study, Ponti *et al.* (2002) found in a simpler version of MM (Glazer and Ma, 1989)[12] that the proportion of efficient allocations is 65.0% if the HVP moves first and 95.0% if she moves second.

[12] For the Glazer and Ma's mechanism, the game starts as in MM, but then the object goes to player 2 who pays an amount, $B\in(\theta_L,\theta_H)$, if she decides to claim the object. In this case, player 1 pays a small fee and gets nothing.

In order to check the robustness of this result for MM, we proceed considering the following logit model with random effects for estimating the likelihoods of allocating the object to the rightful player (PEA) and to the rightful player at zero cost (SA) conditional on which player moves first:

$$Pr(y=1) = F(Intercept+\beta_1 v_{HVP}+\beta_2 v_{LVP}+\beta_3 per+\gamma_1 d_{ii}+\gamma_2 d_{HMF})$$

In this model, d_{HMF} is a dummy variable that takes the value of one when the HVP moves first, while other variables have the same meaning as in the previous regressions. In the second column of Table 6, we present the parameter estimates when y takes the value of one when the object is allocated to the rightful player at zero cost (SA), while in the third column we present the parameter estimates when y takes the value of one when the object is allocated just to the rightful player (PEA).

Result 5 (Order matters for MM) In contrast with Ponti *et al.* (2000), we find that in MM HVPs tend to get the object more often when they move first. However, this is not the case for the proportion of SA, where we did not find a statistically significant coefficient. On the other hand, the proportion of PEA increases when the LVPs' valuations decrease or HVPs' valuations increase. Finally, the proportions of PEA and SA tend to increase as players get experience.

Support for Result 5 As seen in the third column of Table 6, the coefficients for the HVPs moving first, γ_2, is positive and significant, indicating an increment of the likelihood of allocating the object to the rightful player. This is not the case for the same coefficient in the second column of Table 6. The other results are consistent with our previous estimations.

Notice, however, that our results would be consistent with that of Ponti *et al.* (2000) if we consider that in MM the first mover has also the option to move last if the second player decides to claim the object. Thus, the percentage of PEA would increase conditional on the HVPs having the last option to decide.[13]

[13] At the equilibrium, the HVP does not have to execute that option.

The next question we address for PRM is the following: Do HVPs get the object more often when they win the auction and decide whether to stay or withdraw?[14] We consider the following logit model with random effects for estimating the likelihood of allocating the object to the rightful player (PEA) and to the rightful player at zero cost (SA) conditional on HVPs winning the auction:

$$Pr(y=1) = F(Intercept + \beta_1 v_{HVP} + \beta_2 v_{LVP} + \beta_3 per + \gamma_1 d_{ii} + \gamma_2 d_{ACA} + \gamma_3 d_{SACA} + \gamma_4 d_{HW})$$

In this model, d_{HW} is a dummy variable that takes the value of one when the HVP wins the auction, while other variables have the same meaning as in the previous regressions. In the second column of Table 7, we present the parameter estimates when y takes the value of one when the object is allocated to the rightful player at zero cost (SA), while in the third column we present the parameter estimates when y takes the value of one when the object is allocated just to the rightful player (PEA).

Result 6 (Last mover advantage) HVPs get the object more often when they win the auction and have to exercise the decision to either stay or withdraw. This is not the case, however, for the proportion of Solomonic allocations, where we obtain a reduction in the likelihood of HVPs getting the object at zero cost as they win the auction.

Support for Result 6 The dummy coefficient associated to HVPs winning the auction, γ_4, in the third column in Table 7 is positive and statistically significant, while the same coefficient in the second column is negative and statistically significant.

[14] The proportions of auctions won by the HVPs for PRM under complete information are, respectively, 62.5% (200/320), 61.4% (197/321) and 41.1% (172/418) for the SPA, ACA and SACA. Under incomplete information the corresponding proportions are, respectively, 61.1% (239/391), 49.6% (198/399) and 61.5% (220/358) for the SPA, ACA and SACA.

5.4 How do players behave and bid in these mechanisms?

We begin this section presenting a brief description of the players' decisions in each of these mechanisms.

For the MM, conditional on HVPs moving first, Figure 4(a) shows the distribution of LVPs offers and Figure 4(b) shows the distribution of HVPs decisions to match LVPs' offers. Let's consider, for example, the first three bars in Figure 4(a). They show that, after both players decide to claim the object for MM under complete information, 59% of the offers made by LVPs are lower than their own valuations; 19% are higher than their own valuation and lower than the other players' valuations minus the fee; and 22% are higher than the other players' valuations minus the fee. In Figure 4(b), we can appreciate the HVPs' decisions to stay after winning the object. For the first range of offers, HVPs decide to match them in 90% of the occasions; for the second range, they decide to match them in 100%; and for the last range, they decide to match them in 39% of the occasions. For the latter, HVPs are actually losing money. Conditional on LVPs moving first, Figure 4(c) shows the distribution of HVPs offers and Figure 4(d) shows the distribution of LVPs decisions to match the HVPs' offers.

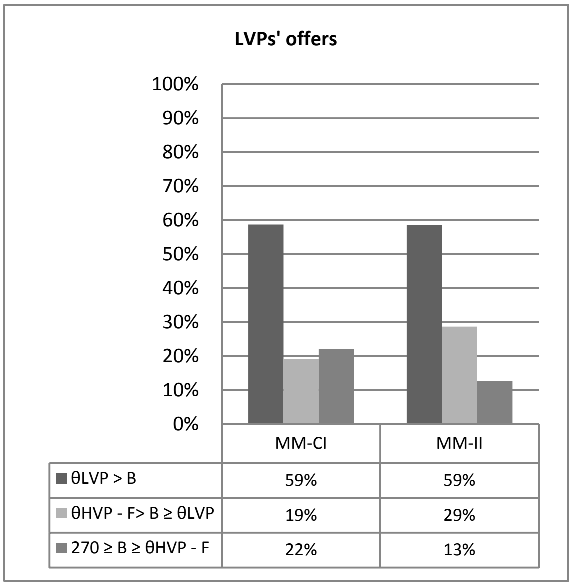
In Figures 4(a) and 4(b), we can appreciate that when HVPs move first, LVPs tend to offer mostly below their own valuations. In response, HVPs tend to take the LVPs' offers in approximately 95% of the occasions when they are below their own valuations minus the penalty fee. Notice that once both players have decided to claim the object, the best response for HVPs is to match anything below their own valuations minus the penalty fee, while for LVPs it is to offer anything below their own valuations.

In Figures 4(c) and 4(d), we can appreciate that when LVPs move first, HVPs tend to offer mostly below their own valuations and above the LVPs' valuations minus the penalty fee. Although in those cases LVPs tend to leave the offer, there are still positive percentages of matching rates (from 12% up to 31%).[15] That means that LVPs are willing to match the bid even though they are getting a

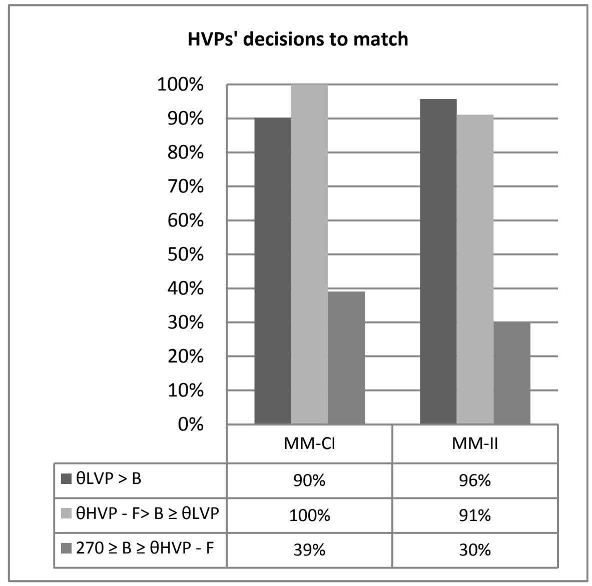
[15] Although matching would be a Nash equilibrium for LVPs, it is not a credible threat.

negative payoff. A similar pattern is observed for both information treatments. Notice that once both players have decided to claim the object, the best response for LVPs is to match anything below their own valuation minus the penalty fee, while for HVPs it is to offer anything below their own valuations and above the other players' valuations minus the penalty fee.

Figure 4: LVPs' offers and HVPs' decisions conditional on HVPs moving first and HVPs' offers and LVPs' decisions conditional on LVPs moving first



(a)



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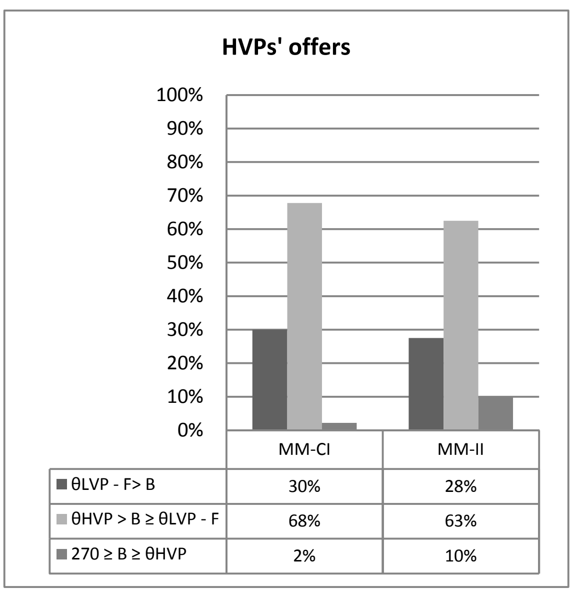
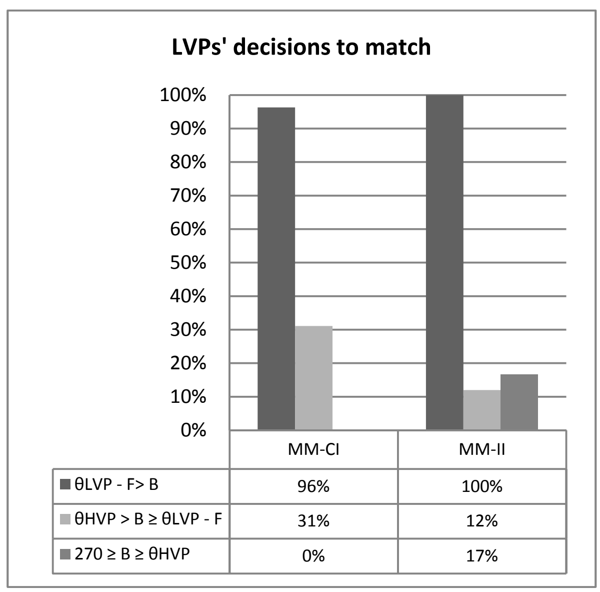
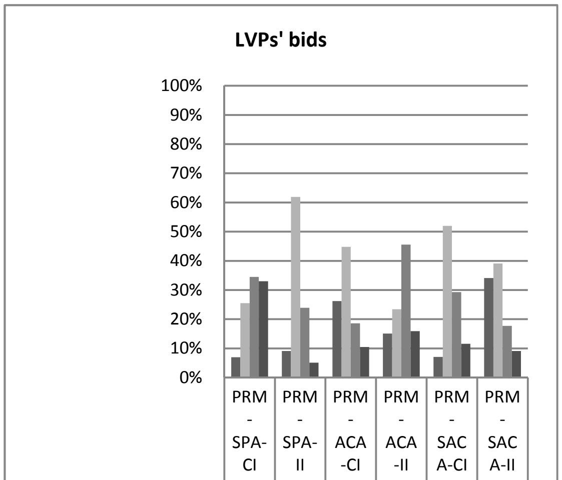


(c)



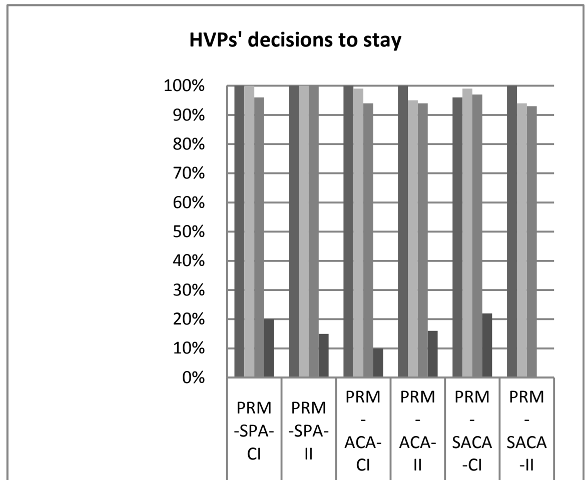
(d)

Figure 5: LVPs' bids and HVPs' decisions to stay conditional on HVPs winning and HVPs' bids and LVPs' decisions to stay conditional on LVPs winning



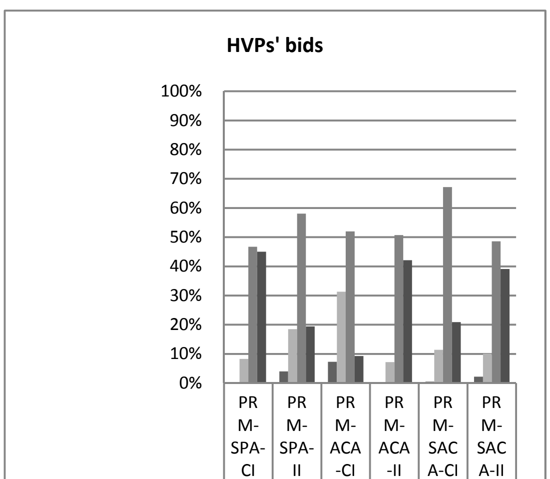
	PRM-SPA-CI	PRM-SPA-II	PRM-ACA-CI	PRM-ACA-II	PRM-SACA-CI	PRM-SACA-II
2 ≥ SHB	7%	9%	26%	15%	7%	34%
θLVP ≥ SHB > 2	26%	62%	45%	23%	52%	39%
θHVP ≥ SHB > θLVP	35%	24%	19%	46%	29%	18%
270 ≥ SHB > θHVP	33%	5%	11%	16%	12%	9%

(a)



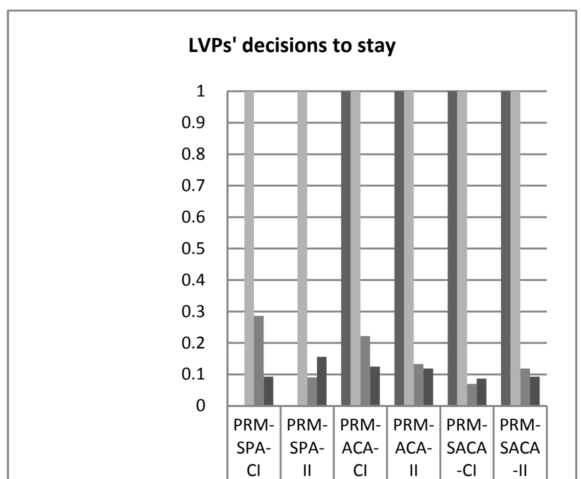
	PRM-SPA-CI	PRM-SPA-II	PRM-ACA-CI	PRM-ACA-II	PRM-SACA-CI	PRM-SACA-II
2 ≥ SHB	100%	100%	100%	100%	96%	100%
θLVP ≥ SHB > 2	100%	100%	99%	95%	99%	94%
θHVP ≥ SHB > θLVP	96%	100%	94%	94%	97%	93%
270 ≥ SHB > θHVP	20%	15%	10%	16%	22%	0%

(b)



	PRM-SPA-CI	PRM-SPA-II	PRM-ACA-CI	PRM-ACA-II	PRM-SACA-CI	PRM-SACA-II
2 ≥ SHB	0%	4%	7%	0%	1%	2%
θLVP ≥ SHB > 2	8%	19%	31%	7%	11%	10%
θHVP ≥ SHB > θLVP	47%	58%	52%	51%	67%	49%
270 ≥ SHB > θHVP	45%	19%	9%	42%	21%	39%

(c)



	PRM-SPA-CI	PRM-SPA-II	PRM-ACA-CI	PRM-ACA-II	PRM-SACA-CI	PRM-SACA-II
2 ≥ SHB			100%	100%	100%	100%
θLVP ≥ SHB > 2	100%	100%	100%	100%	100%	100%
θHVP ≥ SHB > θLVP	29%	9%	22%	13%	7%	12%
270 ≥ SHB > θHVP	9%	16%	13%	12%	9%	9%

(d)

For the PRM, conditional on HVPs winning the auction, Figure 5(a) describes LVPs' distribution of bids and Figure 5(b) describes HVPs' decisions to stay. Consider, for example, the first four bars of Figure 5(a), which correspond to PRM with the second-price auction under complete information (PRM-SPA-CI). The distribution of the second-highest-bids is the following: 7% are below or equal to 2 pesos; 26% are below or equal to the LVPs' valuations and above 2 pesos; 35% are below or equal to the HVPs' valuations and above the LVPs' valuations; and 33% are above the HVPs' valuations. Now, let us observe the first four bars in Figure 5(b): For the first two ranges of the second-highest-bids, HVPs have decided to stay with the object in 100% of the occasions; for the third range, they have decided to stay with the object in 96% of the occasions; and for the last range, they have decided to stay with the object in 20%, even though they are losing money to cost money to the LVPs. Conditional on LVPs winning the auction, Figure 5(c) describes HVPs' distribution of bids and Figure 5(d) describes LVPs' decisions to stay.

In Figures 5(a) and 5(b), we can appreciate that for PRM, when HVPs win the auction, LVPs' tend to bid mostly below the HVP's valuation and above the LVP's valuation when the second-price (or the simple ascending-clock) is the implemented auction. When the auction format is the slow ascending-clock, the distribution of bids tend to move to a range below the LVP's valuation. A similar pattern is observed for both information treatments. Notice that the best response for LVPs is to bid above the others players' valuations and for HVPs the best response is to match anything below their own valuations.

In Figures 5(c) and 5(d), we can appreciate that for PRM, when LVPs win the auction, HVPs' tend to bid mostly above the LVP's valuation for all auction formats. A similar pattern is observed for both informational treatments. Although in those cases LVPs tend to withdraw, there are still positive percentages of staying rates (from 7% up to 29%). Notice that the best response for HVPs is to bid below their own valuations and above the others players' valuations, and for LVPs it is the best response to match anything below their own valuations.

In summary, we observe, first, a bidding pattern that seems to be affected by the auction format in the PRM and, secondly, behavior patterns seemingly driven by a need of just performing some activity from the LVPs when they move first in the MM.

5.4.1 Bidding behavior

As we mentioned above, the MM and PRM introduce some bidding procedures (a second-price auction rule for PRM and a take-it-or-leave-it offer with a small penalty for MM) in order to endogenize the cost imposed on LVPs when they want to get the object. Part of the success of these mechanisms in attaining their goal will depend on how well HVPs can use these bidding procedures to dissuade LVPs from trying to obtain the object at a reasonable cost. In this section, we analyze the impact of different bidding rules and information conditions over the bidding distributions generated within these mechanisms.

For the MM, we should expect HVPs to claim the object and LVPs to give it away. In the case that the LVP moves first claiming the object, we should expect the HVP to make an offer somewhere below her own valuation and above the LVP's valuations minus F, so that the LVP would not be interested in matching the offer. In the case that the LVP moves second claiming the object, she should be making an offer somewhere below the HVP's valuation minus F. In this case, the LVP would be making it costly for the HVP to get the object for a small cost of F.

In Table C.1 in the Appendix C, we can appreciate the actual bid distributions for the MM. When LVPs move first, HVPs tend to bid below their own valuation and above the LVP's valuation minus F, somewhere between 63 and 68% of the cases. When HVPs move first, LVPs tend to bid below the HVPs' valuation, somewhere between 78 and 87% of the cases. However, we still have a significant number of biddings out of what could be a best response behavior.

In order to assess what factors might be affecting the players' bidding behavior, we proceed to estimate the following multinomial logit models with random effects (Hole, 2007) for calculating the likelihoods of bids falling within each of the three categories defined in Table C.1:

$$Pr(y = m) = F(Intercept_{m/M} + \beta_{1,m/M} v_{HVP} + \beta_{2,m/M} per + \gamma_{1,m/M} d_{ci} + \gamma_{2,m/M} d_{ci} v_{LVP})$$

$$Pr(y = m) = F(Intercept_{m/M} + \beta_{1,m/M} v_{LVP} + \beta_{2,m/M} per + \gamma_{1,m/M} d_{ci} + \gamma_{2,m/M} d_{ci} v_{HVP})$$

For the first specification, we consider the cases when LVPs move first. In this model, y is equal to the response category m ($m = 0,1,2$) when the bid falls within each of the following bidding ranges: $[0,\theta_{LVP}–F)$, $[\theta_{LVP}–F,\theta_{HVP})$ and $[\theta_{HVP},270]$. For the second specification, we consider the case when HVPs move first. For this model, y is equal to the response category m (m = 0,1,2) when the bid falls within each of the following bidding ranges: $[0,\theta_{LVP})$, $[\theta_{LVP},\theta_{HVP}-F)$ and $[\theta_{HVP}-F,270]$. For both specifications, v_{HVP} represents the valuation of the HVP; v_{LVP} represents the valuation of the LVP; *per* represents the period (time trend), treating time as a continuous variable; d_{ci} is a dummy variable that takes a value of one when both players know the rank order of valuation and the exact valuation of the other player; *F(.)* is the cumulative logistic distribution function; and, finally, M indicates the reference category against which all other response categories are compared.

Result 7 (Bidding distribution) When HVPs move first, the distribution of offers made by LVPs tends to be located below their own valuations, $[\theta_{LVP} > B]$. However, when their own valuations increase, the distribution of offers shifts to the other two offer zones. The distribution of offers made by HVPs tends to be located below their own valuations and above the LVPs' valuations minus F, $[\theta_{HVP} > B \geq \theta_{LVP} - F]$. Finally, information about the other players' valuations does not seem to affect offer proposals.

Support for Result 7. Table 8 shows the multinomial-logit results for the bid distribution for MM. In this table, the intercept coefficients when HVPs move first are positive and significant, indicating that the offers' distribution shifts downward. The negative value of the first coefficient corresponding to the LVPs' valuations and the positive value of the second coefficient indicate that the distribution of offers shifts to the right to the other two offer zones.

For PRM, if the LVPs win the auction, we should expect that the second-highest bids (SHB) (or first-drop-out price) to be distributed along the range between the HVPs' and LVPs' valuations, $(\theta_{LVP}, \theta_{HVP}]$. If the HVPs win the auction, we should expect that the second-highest bids (or first-drop-out price) to be distributed around the value of zero from above.

Table 8: Multinomial-logit results for the bid distribution for Moore's mechanism

	HVPs move first			LVPs move first	
	Bid[θ_{LVP}, θ_{HVP}-F) vs. Bid[θ_{HVP}-F,270]	**Bid[0, θ_{LVP}) vs. Bid[θ_{LVP}, θ_{HVP}-F)**		**Bid[θ_{LVP}-F, θ_{HVP}) vs. Bid[θ_{HVP},270]**	**Bid[0, θ_{LVP}-F) vs. Bid[θ_{LVP}-F, θ_{HVP})**
Intercept	1.572**	0.847*	*Intercept*	1.044	-1.808
	(0.565)	(0.371)		(1.173)	(0.843)
v_{LVP}	-0.019***	0.009**	v_{HVP}	0.003	0.007
	(0.005)	(0.003)		(0.008)	(0.004)
per	-0.033	0.069	*per*	-0.032	0.097*
	(0.069)	(0.048)		(0.095)	(0.047)
d_{ii}	1.083	0.150	d_{ii}	1.759	0.091
	(1.533)	(0.953)		(0.995)	(0.413)
$d_{ii}\times v_{HVP}$	-0.002	-0.009	$d_{ii}\times v_{LVP}$	-0.009	0.003
	(0.014)	(0.009)		(0.009)	(0.004)

*: $p<0.05$, **: $p<0.01$ and ***: $p<0.001$.

Note: Numbers in parentheses below each coefficient represent the coefficient standard error.

In Tables C.2 and C.3, we can appreciate the actual distribution of the second-highest bids. When HVPs win the auction, the second-highest bids are concentrated below the HVP's valuation and above the LVP's valuation, (θ_{LVP},θ_{HVP}], when second-price is the auction format, somewhere between 35 and 46% of the cases. When the auction format is the ascending-clock, the distribution of second-highest bids tend to move to a range below the LVP's valuation, (2,θ_{LVP}], and when the ascending-clock is slow close to zero, [0,2]. When LVPs win the auction, the second-highest bids are concentrated below the HVP's valuation and above the LVP's valuation, (θ_{LVP},θ_{HVP}], for all auction formats, and in some cases equally split with the range above the HVP's valuation, (θ_{HVP},270].

In order to assess what factors might be affecting the second-highest bid distribution, we proceed estimating the following multinomial logit models with random effects (Hole, 2007) for calculating the likelihood of second-highest bids (or first-drop-out prices) falling within each of four categories defined in Tables C.2 and C.3:

$$Pr(y = m) = F(Intercept_{m/M} + \beta_{1,m/M} v_{HVP} + \beta_{2,m/M} per + \gamma_{1,m/M} d_{ci} + \gamma_{2,m/M} d_{ci} v_{LVP} + \gamma_{3,m/M} d_{ACA} + \gamma_{4,m/M} d_{SACA})$$

$$Pr(y = m) = F(Intercept_{m/M} + \beta_{1,m/M} v_{LVP} + \beta_{2,m/M} per + \gamma_{1,m/M} d_{ci} + \gamma_{2,m/M} d_{ci} v_{HVP} + \gamma_{3,m/M} d_{ACA} + \gamma_{4,m/M} d_{SACA})$$

For the first specification, we consider the cases when LVPs win the auction. For the second specification, we consider the cases when HVPs win the auction. For both specifications, y is equal to the response category m ($m = 0,1,2,3$) when the second-highest bid (or first-drop-out price) falls within each of the following bidding ranges: [0,2], (2,θ_{LVP}] (θ_{LVP},θ_{HVP}] and (θ_{HVP},270]; v_{HVP} represents the valuation of the HVP; v_{LVP} represents the valuation of the LVP; *per* represents the period (time trend), time is treated as a continuous variable; d_{ci} is a dummy variable that takes the value of one when both players know the rank order of valuations and the exact valuation of the other player; d_{ACA} is a dummy variable that takes the value of one when PRM is implemented using an ascending-clock auction, instead of the second-price auction; while d_{SACA} is a dummy variable that takes the value of one when the speed of the ascending clock is slow; *F(.)* is the cumulative logistic distribution function; and, finally, M indicates the reference category against which all other response categories are compared.

Result 8 (Second-highest bids (or first drop-out price) distribution when HVPs win the auction) The distribution of second-highest bids (or first drop-out) made by LVPs tend to be located below HVPs valuations and above their own valuations, (θ_{LVP},θ_{HVP}], far from what it is expected. When the ascending-clock is implemented, the distribution of drop-out prices made by LVPs tends to move downward toward the range below their own valuations and above two pesos, (2,θ_{LVP}]. When the ascending-clock is slow, the distribution of drop-out prices shifts downward toward bidding between zero and two pesos. We did not find any effect on bidding of the information about the HVPs' valuations. When LVPs' valuations increase, this distribution tends to move to the upper range above the HVPs' valuations, (θ_{HVP},270], and to the lower range below their own valuation and above two pesos, (2,θ_{LVP}].

Table 9: Multinomial-logit results for the second-highest bid (SHB) distribution for Perry & Reny's mechanism

	HVPs win the auction				LVPs win the auction		
	SHB(θ_{LVP},θ_{HVP}] vs. SHB(θ_{HVP},270]	SHB(2,θ_{LVP}] vs. SHB(θ_{LVP},θ_{HVP}]	SHB[0,2] vs. SHB(2,θ_{LVP}]		SHB(θ_{LVP},θ_{HVP}] vs. SHB(θ_{HVP},270]	SHB(2,θ_{LVP}] vs. SHB(θ_{LVP},θ_{HVP}]	SHB[0,2] vs. SHB(2,θ_{LVP}]
Intercept	2.854***	-1.849***	-0.238	*Intercept*	-0.482	-1.917*	-16.603
	(0.327)	(0.298)	(0.347)		(0.507)	(0.694)	(1.212)
v_{LVP}	-0.013***	0.015***	-0.013***	v_{HVP}	0.002	0.001	-0.005*
	(0.002)	(0.002)	(0.002)		(0.003)	(0.004)	(0.007)
per	-0.200***	0.015	0.118***	*per*	0.009	-0.094**	0.073
	(0.035)	(0.027)	(0.033)		(0.029)	(0.034)	(0.076)
d_{ci}	-1.742*	0.077	0.659	d_{ci}	0.950***	-0.565*	2.176**
	(0.787)	(0.586)	(0.772)		(0.305)	(0.288)	(0.779)
d_{ci}×v_{HVP}	0.008	0.001	-0.007	d_{ci}×v_{LVP}	-0.007*	0.016***	-0.017**
	(0.005)	(0.004)	(0.004)		(0.003)	(0.003)	(0.008)
d_{ACA}	0.560	1.397***	-1.288***	d_{ACA}	1.086***	0.347	14.597***
	(0.293)	(0.241)	(0.382)		(0.193)	(0.316)	(0.512)
d_{SACA}	-0.524	0.024	1.678***	d_{SACA}	-0.331	0.605**	0.364
	(0.335)	(0.207)	(0.319)		(0.297)	(0.264)	(0.526)

*: $p<0.05$, **: $p<0.01$ and ***: $p<0.001$.

Note: Numbers in parentheses below each coefficient represent the coefficient standard error.

Result 9 (Second-highest bids (or first drop-out price) distribution when HVPs win the auction) The distribution of second-highest bids made by HVPs tends to be located below their own valuations and above the LVPs valuations, (θ_{LVP},θ_{HVP}], as expected. When either the ascending-clock is implemented or information about the LVPs' valuation is precise, the distribution of drop-out prices made by HVPs tends to move to the range below their own valuations and above the LVPs' valuations, (θ_{LVP},θ_{HVP}] and to the lower range around zero. When the ascending-clock is slow or the LVP's valuation is higher, the distribution of drop-out prices shifts slightly toward the range below the LVPs' valuations and above two pesos (2,θ_{LVP}].

In summary, the results in this section indicate that for the PRM, the distributions of bids for both the LVPs and the HVPs tend to move downward the second-highest bid support when the ascending and the slow ascending clock are implemented, making it more probable for the HVPs to win the object. For the MM, when the HVPs move first the offers of the LVPs tend to move upwards when their own valuations increase and seem not to be affected by different information environs.

Table 10: Likelihood of players' decisions to match the bid and stay with the object for MM

	HVPs decide		**LVPs decide**
Intercept	-1.373	*Intercept*	4.708**
	(1.477)		(1.608)
v_{HVP}	0.018*	v_{LVP}	0.008
	(0.008)		(0.008)
per	0.209**	*per*	-0.118
	(0.086)		(0.095)
d_{MEDB}	0.650	d_{MEDB}	-7.507***
	(0.661)		(1.758)
d_{HIGHB}	-3.683***	d_{HIGHB}	-7.340***
	(0.557)		(1.846)
d_{ci}	-0.446	d_{ci}	-6.027
	(0.950)		(3.612)
$d_{ci} \times v_{LVP}$	0.007	$d_{ci} \times v_{HVP}$	0.044*
	(0.010)		(0.022)

*: p<0.05, **: p<0.01 and ***: p<0.001.

Note: Numbers in parentheses below each coefficient represent the Coefficient's standard error.

Table 11: Likelihood of players' decisions to stay with the object after winning the auction for PRM

	HVPs decide		**LVPs decide**
Intercept	5.075***	*Intercept*	4.255***
	(0.985)		(0.687)
v_{HVP}	-0.006	v_{LVP}	0.003
	(0.005)		(0.003)
per	0.034	*per*	-0.100*
	(0.053)		(0.042)
d_{MEDB}	-1.080**	d_{MEDB}	-6.118***
	(0.395)		(0.556)
d_{HIGHB}	-6.487***	d_{HIGHB}	-6.465***
	(0.566)		(0.603)
d_{ci}	0.733	d_{ci}	-1.571
	(0.482)		(0.982)
$d_{ci} \times v_{LVP}$	-0.004	$d_{ci} \times v_{HVP}$	0.010
	(0.005)		(0.006)
d_{ACA}	-0.702	d_{ACA}	0.068
	(0.386)		(0.383)
d_{SACA}	0.470	d_{SACA}	-0.884*
	(0.412)		(0.403)

*: $p<0.05$, **: $p<0.01$ and ***: $p<0.001$.

Note: Numbers in parentheses below each coefficient represent the coefficient's standard error.

Conclusion

This paper reports an experiment performed with the goal of comparing two mechanisms, one proposed by Moore (1992) and the other by Perry and Reny (1999), to allocate a single unit of an indivisible private good to the player with the highest reservation value at zero cost for her. We find, firstly, that their structure of incentives and punishments does not seem enough for dissuading LVPs from pursuing the desired object even by getting it at the expense of their own resources. Secondly, sometimes the structure of the bidding procedure seems to be so complex that it is difficult for the player with the higher valuation to prevent the player with the lower valuation from getting the object.

However, the introduction of different institutional rules and of an environment with incomplete information enhances the possibilities of PRM of allocating the object to the rightful player at zero cost. In particular, the implementation of the (slow) ascending-clock auction increases the proportion of desired allocations and reduces the proportion of inefficiencies due to the use of monetary resources in the allocation process. On the other hand, the implementation under incomplete information about the other player's valuation increases the rates of desired allocations in PRM. However, it also affects negatively the performance of MM allocating the object to the rightful player. Thus, PRM seems to be a more robust mechanism than MM under incomplete information. Moreover, PRM is a mechanism originally designed with an informational generalization that lowers the information requirements on the players. Our results seem to validate this generalization as a tool to ensure a better implementation of the social choice function.

There seem to be other factors associated with the bidding procedure that seem to hamper the capacity of PRM of increasing the proportion of desired allocations. As an assessment of the impact of some of these factors in the performance of these mechanisms, we calculate the probability of players making mistakes by either matching a bid or offering above their own valuations or by bidding (or making an offer) away from the best response (See the Appendix B for a calculation). For example, for MM the average probability of HVPs of making a mistake is 21.6%, while for LVPs the probability of making a mistake is 24.2%. For PRM, the average probability of HVPs of making a mistake is 10.6%, while for LVPs the probability of making a mistake is 12.4%.

We also find that when LVPs move first there is a higher probability of inefficient outcomes for both the MM and the PRM under all the specifications. We believe that a weakness of both mechanisms is that they do not have the option of not participating in the game, an option that is incorporated in the mechanism proposed by Mihara (2008) along with the payment of a small participation fee. This introduces a devise that might provide an incentive to the LVPs for not trying to win the object and that should be experimentally tested.

In summary, a robust and successful implementation not only requires the introduction of proper incentives that disincentives LVPs from trying to get the object in the allocation process, but it also entails the need of implementing proper devices (slow ascending-clock) that might keep players away from making bidding mistakes that hamper the possibility of a desired allocation.

Appendix A: Experimental instructions

The following is the verbatim translation (from Spanish into English) of experimental instructions administered to subjects at ITAM (the Spanish original is available from the authors upon request).

Instructions

This is an experiment on decision-making in the field of economics. Several organizations have provided funding for conducting this research. The instructions are simple and if you follow them carefully and makes good decisions, you could win a CONSIDERABLE AMOUNT OF MONEY, which you will be paid in cash at the end of the experiment.

This experiment investigates the rules of assigning an indivisible object between two participants. In all cases, one of participant has a greater valuation than the other participant. You will always know whether you are the agent with the HIGH-VALUE or the LOW-VALUE. Information about each participant's valuation over the object will be described shortly.

The experiment consists of 12 periods: 2 practice sessions and 10 periods to be played for money, one of which will be selected randomly at the end of the experiment to determine your final payment.

At each period, all participants will receive an initial capital, which will be the same for the relevant periods. Any gain obtained will be added to this initial capital; any loss will be removed from it. The sum of any gain (or the subtraction of any loss) to your initial capital shall be considered as its possible payment for each period, together with the amount of $50 for participation.

At each period, a HIGH-VALUE participant form pair with a LOW-VALUE participant. The formation of pairs will be randomly, such that you will never be paired with the same participant more than twice, and never will be paired with the same participant in two consecutive periods. Additionally, you will not know the name of the participant who is paired in any given period.

Your appointment as HIGH-VALUE participant or as a LOW-VALUE participant will be determined by the computer randomly at the start of the experiment. Even though your valuations will change from one period to another, you will always be an agent of HIGH-VALUE or LOW-VALUE. You will not be permitted to talk or communicate with others during the experiment.

Treatment under complete information

At each session, you will be assigned a monetary valuation of the object. Valuations will be generated in randomly within the range of 0 to 200 pesos. New valuations will be generated in each period. You will always know your valuation of the object. You will also know the other agent's valuation with which you have been paired. The minimal difference between HIGH-VALUE and LOW-VALUE participants will be always 50 pesos.

Treatment under incomplete information

At each session, you will be assigned a monetary valuation of the object. Valuations will be generated in randomly within the range of 0 to 200 pesos. New valuations will be generated in each period. You will always know your valuation of the object. You will not know the other participants' valuation with which you have been paired. You will only know that the minimal difference between HIGH-VALUE and LOW-VALUE participants will be always 50 pesos.

At the end of the experiment, one period will be randomly selected and it will be paid to you in cash. Therefore, that you should consider each period as "selected period" for the payment.

Specific procedure (Moore Experiment)

Demands for the object and payments for each period will be determined according to the following procedure:

1. At the beginning of each period, one participant of each pair will be randomly designated by the computer as the participant 1 or participant 2. The assigned number indicates the order in which participants may make decisions. Either participant has the same probability of starting the process in each period.

2. In the first stage, participant 1 must decide whether or not to claim the object for himself/herself.

2.1 If participant 1 decides not to claim the object for himself/herself, participant 2 will then get his/her valuation and the decision-making procedure ends.

2.2 If participant 1 decides to claim the object for himself/herself, the second stage of the decision procedure will follow.

3. In the second stage, participant 2 must decide whether or not claim the object for himself/herself.

3.1 If participant 2 decides not to claim the object for himself/herself, participant 1 will then get his/her valuation and the decision-making procedure ends.

3.2 If participant 2 decides to claim the object for himself/herself, he/she must provide a bid to pay for the object and the third stage of the decision-making procedure will continue.

4. In third stage, participant 1 must pay a fee of 10 pesos and decide whether or not to match the bid of participant 2.

4.1. If participant 1 decides to match the bid, he/she will get their valuation less the amount of the bid and participant 2 will have to pay the fee of 10 pesos.

4.2 If decide not to match the bid, participant 2 will get his/her valuation less the amount of the bid.

5. All winnings will be added to the initial capital and all losses will be subtracted from the initial capital.

Specific procedure (Perry and Reny Experiment with a second-price auction)

Demands by the object and payments for each period will be determined according to the following second-price auction:

1. Both agents must simultaneously offer a position by the object. The position cannot be larger than 270 pesos.

2. The participant with the highest bid is eligible for the object at the price the other participant bid. After winning the auction, the highest bidder will know the selling price of the object and will have the opportunity to confirm his/her demand for the object:

3.1. If the highest bidder decides to confirm his/her demand, he/she will get his/her valuation less the amount of the second highest bid (i.e., the other bidder's bid). The other participant will have to pay his/her without receiving his/her valuation.

3.2. If the highest bidder decides not to confirm his/her demand for the object, he/she won't have to pay. Then, it will be the other participant who gets the object at zero price and he/she will get his/her valuation minus the selling price of zero pesos.

4. If both participants bid the same price, the computer will select randomly one of them as the winner at the price bid, without the option to confirm its demand for the object. In this case, the unselected participant won't have to pay.

5. All winnings will be added to the initial capital and all losses will be subtracted from the initial capital.

Specific procedure (Perry and Reny Experiment with an ascending-clock auction)

Demands by the object and payments for each period will be determined according to the following auction, with an ascending-clock:

1. The price of the object begins at 0 pesos and it increases according to the watch counter located in the center of your screen.

2. You will be regarded as an active bidder for the object until you ceased to offer a bid for the object. You can drop-out from the auction pressing any key on the dashboard. Exit from the auction is not reversible, so you cannot enter again once you are out.

3. The participant that is still an active-bidder (i.e. did not drop) is eligible for the object at the price the other bidder exit. Upon the departure of the first bidder, the active bidder will know the selling price of the object and will have the opportunity to confirm his/her demand for the object:

3.1. If the active bidder decides to confirm his/her demand, he/she will get his/her valuation less the drop-out price. The other participant will have to pay the drop-out price without receiving his/her valuation.

3.2. If the active bidder decides not to confirm his/her demand for the object, he/she won't have to pay. Then, it will be the other participant who gets the object at zero price and he/she will get his/her valuation minus the selling price of zero pesos.

4. If both participants leave the auction at the same price, the computer will select randomly one of them as the winner at the drop-out price, without the option to confirm its demand for the object. In this case, the unselected participant won't have to pay. This same rule applies if the clock counter reaches the peak of 270 pesos without any participant quitting the auction. The price of the object 270 pesos and object sold to one of the participants (chosen randomly by a computer) at this price, without the option to confirm his/her demand for the object. Furthermore, the other participant won't have to pay.

5. All winnings will be added to the initial capital and all losses will be subtracted from the initial capital.

Appendix B: Players' mistake probability

Moore's mechanism: Let q be the probability of Player 1 of claiming the object after moving first. Let p be the probability of Player 2 of claiming after Player 1 claim the object. If the HVP moves first, let s_1, s_2 and s_3 be the probabilities of Player 2 of bidding, respectively, within the following offer ranges: $[0,\theta_{LVP}–F)$, $[\theta_{LVP}–F,\theta_{HVP})$ and $[\theta_{HVP},270]$. If the HVP moves second, let r_1, r_2 and r_3 be the probabilities of Player 2 of bidding, respectively, within the following offer ranges: $[0,\theta_{LVP})$, $[\theta_{LVP},\theta_{HVP}–F)$ and $[\theta_{HVP}–F,270]$. Finally, let t_1, t_2 and t_3 be the probability of Player 1 of accepting the offer within each of the describe offer ranges.

Thus, if the HVP moves first, the probability of the HVP of making a mistake is equal to $(1 – q) + qp(s_1(1 – t_1) + s_2(1 – t_2) + s_3t_3)$, while the probability of the LVP of making a mistake is equal to qps_3. If the LVP moves first, the probability of the HVP of making a mistake is equal to $q(1 – p) + qp(r_1 + r_3)$, while the probability of the LVP of making a mistake is equal to $qp(r_1(1 – t_1) + r_2(1 – t_2) + r_3t_3)$.

Perry and Reny's mechanism: Let s_1, s_2 and s_3 be the probabilities of the second-price falling within each the following offer ranges: $[0,2)$, $(2,\theta_{LVP}]$, $(\theta_{LVP},\theta_{HVP}]$ and $(\theta_{HVP},270]$. Finally, let t_1, t_2 and t_3 be the probability of the winner of accepting the offer within each of the described bidding ranges.

Thus, if the HVP win the auction, the probability of the HVP of making a mistake is equal to $P(B_L<B_H)[s_1(1 – t_1) + s_2(1 – t_2) + s_3(1 – t_3) + s_4t_4]$, while the probability of the LVP of making a mistake is equal to $P(B_L<B_H)(1 – s_4)$. If the LVP win the auction, the probability of the HVP of making a mistake is equal to $P(B_L>B_H)(s_1 + s_2)$, while the probability of the LVP of making a mistake is equal to $P(B_L>B_H)[s_1(1 – t_1) + s_2(1 – t_2) + s_3t_3 + s_4t_4]$.

Table C.1: High and Low value players' decisions for Moore's mechanism

	Information			**Information**	
	Complete	**Incomplete**		**Complete**	**Incomplete**
i) HVPs moving first			i) LVPs moving first		
No. of allocations	181	200	No. of allocations	149	150
%	54.8%	57.1%	%	45.2%	42.9%
ii) HVPs' decisions			ii) LVPs' decisions		
Not claim	7.2%	3.0%	Not claim	33.6%	14.7%
Claim	92.8%	97.0%	Claim	66.4%	85.3%
iii) LVPs' decisions			iii) HVPs' decisions		
Not claim/HVP claim	38.1%	19.1%	Not claim/LVP claim	9.1%	6.3%
Claim/HVP claim	61.9%	80.9%	Claim/LVP claim	90.9%	93.8%
iv) LVPs' bidding			iv) HVPs' bidding		
$270 \geq B \geq \theta_{HVP} - F$	22.1%	12.7%	$270 \geq B \geq \theta_{HVP}$	2.2%	10.0%
$\theta_{HVP} - F > B \geq \theta_{LVP}$	19.2%	28.7%	$\theta_{HVP} > B \geq \theta_{LVP} - F$	67.8%	62.5%
$\theta_{LVP} > B$	58.7%	58.6%	$\theta_{LVP} - F > B$	30.0%	27.5%
v) HVPs' decisions/B			v) LVPs' decisions/B		
$270 \geq B \geq \theta_{HVP} - F$			$270 \geq B \geq \theta_{HVP}$		
Match	39.1%	30.0%	Match	0.0%	16.7%
Not match	60.9%	70.0%	Not match	100.0%	83.3%
$\theta_{HVP} - F > B \geq \theta_{LVP}$			$\theta_{HVP} > B \geq \theta_{LVP} - F$		
Match	100.0%	91.1%	Match	31.1%	12.0%
Not match	0.0%	8.9%	Not match	68.9%	88.0%
$\theta_{LVP} > B$			$\theta_{LVP} - F > B$		
Match	90.2%	95.7%	Match	96.3%	100.0%
Not match	9.8%	4.3%	Not match	3.7%	0.0%

Table C.2: High value players' decisions for Perry & Reny's mechanism

	Complete information			Incomplete information		
	SPA	**ACA**	**SACA**	**SPA**	**ACA**	**SACA**
i) HVPs winning the auction						
Number of allocations	200	197	172	239	198	220
%	62.5%	61.4%	41.1%	61.1%	49.6%	61.5%
ii)Second highest bid (SHB)						
2 ≥ SHB	7.0%	9.1%	26.2%	15.1%	7.1%	34.1%
θ_{LVP} ≥ SHB > 2	25.5%	61.9%	44.8%	23.4%	52.0%	39.1%
θ_{HVP} ≥ SHB > θ_{LVP}	34.5%	23.9%	18.6%	45.6%	29.3%	17.7%
270 ≥ SHB > θ_{HVP}	33.0%	5.1%	10.5%	15.9%	11.6%	9.1%
iii)HVPs' decisions/winning						
2 ≥ SHB						
Stay	100.0%	100.0%	95.6%	100.0%	100.0%	100.0%
Withdraw	0.0%	0.0%	4.4%	0.0%	0.0%	0.0%
θ_{LVP} ≥ SHB > 2						
Stay	100.0%	99.2%	98.7%	100.0%	94.6%	94.2%
Withdraw	0.0%	0.8%	1.3%	0.0%	5.4%	5.8%
θ_{HVP} ≥ SHB > θ_{LVP}						
Stay	95.7%	93.6%	96.9%	100.0%	93.6%	93.0%
Withdraw	4.3%	6.4%	3.1%	0.0%	6.4%	7.0%
270 ≥ SHB > θ_{HVP}						
Stay	19.7%	10.0%	22.2%	15.0%	15.8%	0.0%
Withdraw	80.3%	90.0%	77.8%	85.0%	84.2%	100.0%

Table C.3: Low value players' decisions for Perry & Reny's mechanism

	Complete information			Incomplete information		
	Second -price	**Ascendin g-clock**	**Slow ascendin g-clock**	**Second -price**	**Ascendin g-clock**	**Slow ascendin g-clock**
i) LVPs winning the auction						
Number of allocations	120	124	246	152	201	138
%	37.5%	38.6%	58.9%	38.9%	50.4%	38.5%
ii)Second highest bid (SHB)						
2 ≥ SHB	0.0%	4.0%	7.3%	0.0%	0.5%	2.2%
θ_{LVP} ≥ SHB > 2	8.3%	18.5%	31.3%	7.2%	11.4%	10.1%
θ_{HVP} ≥ SHB > θ_{LVP}	46.7%	58.1%	52.0%	50.7%	67.2%	48.6%
270 ≥ SHB > θ_{HVP}	45.0%	19.4%	9.3%	42.1%	20.9%	39.1%
iii)LVPs' decisions/winning						
2 ≥ SHB						
Stay	-	100.0%	100.0%	-	100.0%	100.0%
Withdraw	-	0.0%	0.0%	-	0.0%	0.0%
θ_{LVP} ≥ SHB > 2						
Stay	100.0%	100.0%	84.4%	100.0%	100.0%	100.0%
Withdraw	0.0%	0.0%	15.6%	0.0%	0.0%	0.0%
θ_{HVP} ≥ SHB > θ_{LVP}						
Stay	28.6%	22.2%	7.0%	9.1%	13.3%	11.9%
Withdraw	71.4%	77.8%	93.0%	90.9%	86.7%	88.1%
270 ≥ SHB > θ_{HVP}						
Stay	9.3%	12.5%	8.7%	15.6%	11.9%	9.3%
Withdraw	90.7%	87.5%	91.3%	84.4%	88.1%	90.7%

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