Can Uniform Price Auctions inform the design of Payments for Ecosystem Services schemes? Evidence from the lab and field [*]

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Abstract

Payments for Ecosystem Services (PES) are an instrument to stimulate the private provision of environmental conservation by offering financial compensation conditional on the realized conservation outcomes. One of the key challenges in PES design is to find the appropriate compensation level. More generous payments increase PES participation at the margin, but at the expense of excess rents being paid to the inframarginal environmental service providers. Setting the right price is thus key to maximize the amount of conservation obtained with a given budget. This paper builds on Kelsey Jack's (2013) study to test whether incentive-compatible valuation mechanisms – more specifically so-called Uniform Price Auctions (UPA) – are able to predict uptake in the field. We replicate Jack's results that UPA outcomes are a poor predictor of actual participation rates, and find suggestive evidence that the difference in actual and predicted take-up rates is due to more deliberate decision making in UPA than with take-it-or-leave-it offers. We subsequently design and conduct a laboratory experiment to further test this hypothesis.

Key words: Uniform price auctions, incentive compatible valuation techniques, conservation, payments for ecosystem services.
JEL codes: D04, D44, D82, O13, Q24, Q28.

1.   Introduction

Conservation payments have been advocated as both an effective and efficient means of protecting the planet's most valuable natural resources – especially if the payments are made conditional on the actual delivery of environmental outcomes above and beyond what would otherwise have materialized (Wunder 2007, Wunder et al. 2008). These conditional payments, typically referred to as Payments for Ecosystem Services (PES), have been implemented in developed and developing countries alike; prominent examples include the Conservation Reserve Program in the United States (Wu and Babcock 1995) and the *Pago por Servicios Ambientales* Program in Costa Rica (Pattanayak et al. 2010). The rationale behind PES is that without compensation, the resource owners incur the costs of conserving natural resources while they typically reap only a small share of the conservation benefits. That means that while the societal benefits of conservation typically exceed the costs, economic decision making is biased against conservation and towards resource degradation. Offering financial compensation, conditional on environmental service delivery, is thus a means of changing the resource owner's cost-benefit evaluation outcome in favor of conservation (Engel et al. 2008).

Typically, conservation contracts are offered take-it-or-leave-it style, with the contracts specifying what services the resource owner needs to deliver as well as the amount of money she will receive in compensation if the contractual requirements are met. One of the key challenges in the design of Payments for Ecosystem Services schemes is to find the optimal compensation price. Offering a higher price results in a larger share of the resource owners agreeing to participate in the PES scheme, but at the expense of the amount of rents earned by the inframarginal resource owners (Engel et al. 2008). That means that the amount of environmental services obtained with a fixed budget are a hump-shaped function of the price offered, and hence finding the optimal price is a key challenge for any PES scheme.

If the slope and location of the aggregate conservation cost schedule is known, the conservation agency (the government, or an NGO) can determine the optimal price to be offered. For example, if a large share of the resource owners can provide the conservation services at quite low cost while conservation is very expensive for the remaining ones, setting the price equal to the cost level of the most expensive among

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the low-cost farmers can result in high take up rates while limiting the excess compensation received by the infra-marginal resource owners. To implement this, three steps need to be taken: information should be collected on the location and slope of the aggregate conservation cost schedule, the optimal price should be determined given the available budget, and then conservation contracts can then be offered, take-it-or-leave-it style, to the resource owners.

This paper focuses only on the first step of the process – identification of the location and slope of the conservation cost schedule. Resource owners differ in the (opportunity) costs they incur when supplying environmental protection, and typically these owners have better information about their private conservation costs than the potential buyer. Two potential solutions have been proposed to overcome this information asymmetry problem in the literature. The first is to offer different take-it-or-leave-it compensation prices to different groups of randomly selected resource owners. Different price levels result in different sign-up rates, and hence this approach allows the conservation buyer to trace the conservation supply schedule so that she can identify the price that minimizes average conservation costs (see for example Kaczan et al. 2013, Swallow et al. 2009). This approach is both expensive and cumbersome because sample size needs to be fairly large for each price offered to have a precise estimate of the take-up rates associated with that price, and possibly quite many prices need to be tested to approximate the aggregate conservation supply schedule.

A second approach has been suggested by Jack et al. (2009) and Ajayi et al. (2012), and that is to use incentive-compatible valuation elicitation methods to uncover the levels and distribution of the conservation costs of a group of randomly selected resource owners. One candidate incentive-compatible valuation elicitation method is the (reverse) sealed-bid Uniform Price Auction (UPA), where potential service sellers are asked to indicate the minimum amount of money they need to receive to be willing to participate in the PES scheme. The potential sellers are informed that if their "ask" turns out to be below a predetermined (but undisclosed) "strike price" they are accepted into the program and will subsequently be paid the *predetermined strike price* if they meet the environmental requirements. If the amount they ask is above the predetermined price, they will not be offered the contract.

Submitting one's true opportunity costs is a dominant strategy in this set up (Vickrey 1961, Krishna 2002). Over-asking does not yield any benefits if asking more than one's true opportunity costs still results in one being admitted to the program. The

bidder is paid the predetermined price for her efforts – but this would also have been the case if she would have submitted an ask equal to her true opportunity costs. The bidder will regret having over-asked if (i) participating in the program is profitable for her at the predetermined price and (ii) her ask turns out to be so high that is not admitted to the program. So by over-asking the bidder cannot win but may actually jeopardize the chance to earn money. And a similar reasoning implies that submitting an ask below one's true opportunity costs is never a profitable strategy either, because doing so may result in the agent being signed into the program at too low a price for the program to be profitable for the agent.[1]

Submitting an ask equal to one's true opportunity costs is thus a dominant strategy in Uniform Price Auctions, and hence in theory the UPA approach allows the researcher to obtain precise values of the opportunity costs of resource owners. If resource owners know their conservation costs, the share of resource owners accepting a specific take-it-or-leave-it (TILI) price should be the same as the share of resource owners with asks equal to or below that price level in the UPA. After all, accepting a price offer that is higher than one's opportunity costs is a dominant strategy in take-it-or-leave-it contracts too, and hence this suggests that the UPA approach would be both a more precise and a more efficient way of uncovering the location and slope of the conservation costs schedule than the first approach in which the opportunity cost curve is traced out by offering different prices to many groups of randomly selected resource owners.[2] Yet there is some evidence that valuations obtained via UPA are poor predictors of take-up rates under TILI. Jack (2013) invited landowners in Malawi to participate in a tree planting project and finds that for a specific take-it-or-leave-it price offer take-up rates are more than twice as high than predicted by the UPA (99% actual uptake versus a predicated uptake of 37.5%). This suggests that UPA outcomes are a poor predictor of actual uptake when the contracts are offered take-it-or-leave-it style.

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[1] The Uniform Price Auction is thus very similar to the Becker-DeGroot-Marschak (BDM) mechanism, where bids are compared to a price that is randomly drawn for each individual (Becker et al. 1964). With BDM, subjects are thus paid different prices for the same service, which was deemed problematic for implementation in our context.

[2] A third approach to overcome the asymmetric information problem is to induce competition between potential conservation service providers via selling contracts using get-paid-what-you-ask auctions (Latacz-Lohmann and van der Hamsvoort 1998). These so-called discriminatory price procurement auctions result in resource owners receiving different amounts of compensation for the same type of conservation services supplied. This ex-post inequality reduces the mechanism's practical acceptability, and indeed discriminatory price procurement auctions are rarely used in PES programs (Engel et al. 2008).

But interestingly she also finds that the actual survival rate is 15% *higher* among the PES participants who had been randomized into the UPA treatment. The fact that UPA underestimates take-up under TILI sheds doubt on the usefulness of UPA in motivating PES design. But the fact that survival rates are higher in UPA than in TILI suggests that the higher take-up observed in TILI is actually wasteful, and that with TILI the additional participation among resource owners decide to participate is suboptimal, because not just the ones who have a good chance of meeting the contract specifications to receive payments. This may be wasteful because the financial payment is just part of the costs of a PES project – providing the seedlings and the materials for tree maintenance are costly too.

In this paper we replicate Jack's (2013) result that with TILI price offers the take-up rates are significantly higher than when using UPA. We do so in a field-experimental setting very similar to that of her study, as we test for the difference in sign-up rates between TILI and UPA for a tree planting program in Northern Ghana. Above and beyond replicating her result, we also try identify the mechanism causing UPA to be such a poor predictor of actual take-up.

Perhaps surprisingly, the poor predictive power of UPA has not been received much attention. Jack (2013) documents the lack of predictive power, but was not able to identify the cause. To the best of our knowledge there are only two other papers that test the predictive power of incentive-compatible valuation techniques. Berry et al. (2015) explicitly aimed to test whether incentive-compatible valuation mechanisms can indeed predict outcomes of TILI price offers, and constructed a series of experiments to identify the potential cause of any observed difference. Using the standard Becker-DeGroot-Marschak (1964) mechanism they find that households in Northern Ghana are, on average, about 15% more likely to purchase a water filter via TILI prices than via the BDM mechanism. They rule out that the difference in take-up rates is due to either anchoring or strategic considerations.[3] Cole et al (2016) report two field tests of BDM against TILI, one for rainfall insurance packages and the other for agricultural information, both in India. Unlike Jack and Berry et al, Cole et al report that they

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[3] Both Jack (2013) and Berry et al. (2015) not only tested whether UPA results in different take-up rates than TILI, but they also tested whether there are any consequences for behavior too. Jack (2013) finds that landowners who selected themselves into the tree planting program by means of UPA keep significantly more planted trees alive than those who signed up via TILI, and Berry et al. (2015) find that those households who bought the water filter via UPA use the water filter slightly more intensively than those who bought it via TILI (with the difference being significant at the 10% level only; they fail to detect any significant differences at 10% or better for other use indicators).

generally can not reject that BDM and TILI generate different implied demand functions with no systematic bias in the direction of differences between the two elicitation mechanisms.

We complement the work by Berry et al. (2015) in that we try to uncover the mechanism causing the difference in take-up rates we observe between the two mechanisms. We take a more cognitive (and behaviorally motivated) approach and argue that even if participants in TILI are instructed to carefully think through the consequences of saying yes or no to the price that will be offered to them in a moment – explicitly telling them to carefully think about the minimum amount of money they would need to receive to be willing to participate in the tree planting program – decision making is more careful and deliberate in UPA than in TILI. This mechanism would explain both the higher take-up as well as the lower survival rates in TILI, as documented by Jack (2013). We hypothesize that if decision-making is more deliberate, the explanatory power of economic variables (like land area and ease of access to water needed to water the tree saplings) and preferences (like risk attitudes and time preferences) is higher under UPA than under TILI. Our results provide suggestive evidence that indeed decision making is more careful and deliberate under UPA than under TILI. Key variables that should increase a farmer's propensity to participate in the program (such as sizeable land area, easy access to water, and, albeit to a lesser extent, farmer characteristics like risk preferences) are predictive of uptake in the UPA treatment, but not in TILI.

With these field-experimental results in hand we turn to further test the hypothesis by implementing similar tests in a laboratory experiment. Laboratory experiments have the advantage over field experiments that they allow for less noisy hypothesis testing as the decisions to be made are less complex and because preferences can be elicited with more precision. We endow student subjects with a chocolate bar and subsequently offer them the possibility to sell back their bar using either the TILI or the UPA approach. We not only document that the sell-back rates are not invariant to the approach taken, but also that characteristics that are expected to affect the decision to keep the bar have predictive power in the UPA decisions but not in the TILI outcomes – as was the case in the field experiment.

The set-up of this paper is straightforward. Section 2 presents the design and outcomes of the field experiment offering farmers in the arid Northern part of Ghana to participate in a tree planting project, and section 3 does the same for the laboratory

experiment implemented using student subjects from Tilburg University, the Netherlands. Section 4 concludes.

2.   Field experiment

Our field experiment is implemented as a subproject of Ghana's Sustainable Land and Water Management Project (SLWMP). This project aims to improve soil and water conservation in Ghana's arid North. This four-year project is implemented by the Government of Ghana, is co-financed by the World Bank, and consists of different types of interventions including agricultural soil erosion prevention methods such as intercropping of cash crops and leguminous food crops and the construction of bunds on field perimeters. It also includes a tree planting projects to improve soil and water retention, reduce siltation and sedimentation and enhance biological diversity (especially by providing habitat) and carbon sequestration. Trees thus provide global as well as local benefits, but in our case they also provide private benefits – the species available for plantation include mango, cashew and mahogany. Despite the presence of private benefits, voluntary uptake is quite limited – because there are opportunity costs associated with having trees. Saplings need to be planted, but more importantly, to keep them alive they need to be watered in the first two years during the dry season, and from the third year onward the yields of other crops start to decline as the trees start to block sunlight (by providing shade).

Because the number of farmers willing to engage in the SLWMP's voluntary tree planting was too low, the Government of Ghana agreed to experiment with a Payments for Ecosystem Services (PES) scheme where farmers receive financial compensation conditional on the number of trees surviving. The program is scheduled to run for four years (2016-2020), and the payments participants will receive is a declining function of the share of trees surviving. More specifically, farmers would be paid the full price if 75% or more of their trees are still alive at the end of the first year, one third of the fullof the full price if at least 37.5% of them survive. If less than 37.5% of the trees are still alive, the farmer is paid nothing. The payments for keeping 75% of trees alive were to be paid in two installments, with an initial 1/3 of the payment paid after 6 months and another 2/3 paid at 1 year.

2.1   Design of the field experiment

In our randomized controlled trial (RCT), we implemented the two preference elicitation methods for PES programs, take-it-or-leave-it price offers (TILI) and Uniform Price Auctions (UPA), in twenty communities, and in two waves. The twenty communities were randomly selected from a set of 80 eligible communities in the country's Northern, Upper East and Upper West regions. In the first wave, which took place in May 2016, the RCT was implemented in six communities; in the second wave (April 2017) the other 14 communities were treated. The RCT was implemented as follows.

Two days before visiting a community the local extension worker announced our visit to the local chief, and requested that all households having the right to plant trees on their land would be invited to send one household representative above the age of 18 – preferably the household head – to the scheduled meeting.[4] Upon arrival at the session, only those household representatives were admitted to the session who were at least 18 years old, and whose households had the power to plant trees on their land. Because of time constraints, the maximum number of participants in each community was set at 48; if more than 48 representatives of individual households were present, a lottery determined who would be admitted to the session. To control for any (observable and non-observable) community characteristics, we randomly assigned half of the community's household representatives to the TILI treatment, and the other half to the UPA treatment, *i.e.* we use a between-subjects design where treatments were randomized within communities.

After having sent away all non-participant community members, we started by registering the names of all participants. We also implemented a short survey to elicit information on the respondent's personal characteristics (including gender and age), on his or her household's land size and tree ownership, on their perceived benefits of having trees on one's land, on some of their key preferences (including time preferences and risk preferences, elicited using non-financially incentivized multiple price lists), and on a series of possible decision biases (including self-determination, (lack of) self-control, and optimism). Interviews were conducted by extension workers (sometimes with the help of translators) who were trained on survey implementation as well as on the TILI and UPA procedure.

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[4] A household was defined as the group of individuals sharing the same pot at night.

After all participants had been interviewed, the actual PES session started. Participants were informed about the fact that they would be given the opportunity to participate in a tree planting project. They were informed that if they participated in the project, they would be given 40 saplings of a (mixture of) tree species they preferred: mango, cashew, teak, acacia, etc. They were also informed that they would be provided with materials to protect the saplings from being eaten by livestock or wild grazers (especially chicken wire) and that their community would be provided with a donkey and cart to collect the water needed to keep the saplings alive. They were stimulated to think hard about the (public and private) benefits of having trees on their land (e.g., mango is expected to start bearing fruit after two years), but also about the (private) costs of doing so – the time and effort required to water the saplings and to protect the saplings from grazing, the fact that trees take up land that can otherwise be used for agriculture, etc. We explained that in the first two years the main costs would be their time and effort to water the saplings (which needs to be done every two or three days in the dry season) and to protect them from being damaged by animals. After two years watering is no longer necessary because the trees' root system would by then have developed sufficiently to be able to extract water from the soils. We also stated that the most important costs from year 3 onwards would be reduced crop productivity because the trees would by then be sufficiently large to compete for both sunlight and water resources. The farmers could ask questions about the procedure privately, upon which the session leader would repeat the question in neutral terms for the group to hear before answering it aloud.[5]

Next, the participants were separated into two groups; the ones who would receive the TILI treatment, and the ones who would be offered to participate in the tree planting project via UPA. The groups convened in different locations in the community (usually in two areas close to the community's central area, at least 50 meters away from each other), and they were informed of the mechanism via which it would be decided whether they would participate in the tree planting program (and for what price), or not. Whereas the TILI procedure is quite straightforward, that of UPA is more difficult to understand. Therefore we also announced that each of the two groups would be

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[5] This is to control the exchange of information among participants. A farmer's question would be rephrased for the rest of the group in neutral terms, and the answer given would also be factual – explaining parts of the procedure that were unclear or explaining why asking one's minimum price is in their best interest, but never any statements about, for example, what specific amount they should ask (in UPA) or whether we recommend them to accept the price (in TILI).

carefully informed of the mechanism via which participation would be determined and that, as an illustration, we would do a practice round so that every participant would perfectly understand the procedures we would follow. Rather than risking anchoring participants on specific prices by doing a hypothetical example of the tree planting project, we chose to offer them the opportunity to sell us one of their shirts using the relevant procedure (TILI, or UPA). To ensure that the farmers would be paying close attention, the practice round was financially incentivized – if their decisions indicated that they would be willing to sell their shirt for the predetermined price that we were willing to pay, they would have to hand in their shirt, and they would be paid that predetermined price. We also told them that they were not allowed to communicate during the session (not with each other but also not with non-participants, and neither verbally nor non-verbally), and that they would be excluded if they violated this rule.

For both TILI and UPA it is essential that the prices the farmers in a community would be offered (for their shirt, but also the compensation they will receive depending on how many trees they keep alive over the season) are (i) predetermined, (ii) the same for all participants in a community (to avoid conflict), and (iii) unknown not just to them but also to the experimenters and their translators. We implemented this as follows. For every community, we chose four different prices from the range of prices that we were willing to buy their shirts (between 2 and 6 Ghana Cedis, that is between $0.50-$1.50), and we did the same for the range of prices the government of Ghana was willing to pay to each participant keeping 40 trees alive during the year (between 180 and 420 Cedis – or between $45 and $100).[6] Each price was written on two cards, each card was put in a small envelope, and the two small envelopes with the same price card were placed in a large envelope.

At the session we thus had two piles of five large envelopes (one pile of envelopes containing shirt prices, and the other one containing prices for the tree planting project), and a trusted member of the community was invited to come forward and choose one envelope from each of the two piles. The two selected large envelopes were opened, and each of the teams of extension workers implementing the TILI and UPA treatments received one small envelope containing the price we were going to pay for the shirts,

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[6] Half of the twenty communities are in Ghana's Sahel savanna (in the North-Eastern part of the country), and the half are in the Guinea savanna (in the North-West). Because the former is much drier than the latter, prices from the upper end of the range were offered to the communities in the North-East, and prices from the lower end were offered to those in the North-West.

and also another small envelope containing the tree planting compensation price. The small envelopes were not opened (and hence the price was kept secret) until either all participants had made their bid (in UPA) or until the moment just before subjects were asked to make their yes/no decision (in TILI).

The mechanism used in the UPA treatment was explained as follows. Participants were reminded that the price at which we were going to buy their shirts is predetermined and hidden in the small envelope. They were asked to think hard about how much the shirt is worth to them – do they like their shirt, is it old or new, how costly would it be to go to the market to replace it? We told them that they would be asked to submit a bid for which they are willing to sell their shirt. If the price they asked for was smaller than or equal to the predetermined price in the envelope, they would receive the predetermined price and we would take home their shirt. If the price they asked for turned out to be higher than the predetermined price, their shirt would be too expensive for us, and hence we would not buy it. They would keep their shirt, and they would not be paid the predetermined price. We then also told them explicitly what price they should ask for: the minimum amount of money that they would need to receive to be willing to sell their shirt to us. Asking a higher price than their minimum does not yield any benefits (if the price they ask is still lower than the predetermined price, they sell their shirt at the predetermined price, but this would also have been the outcome if they had asked their true minimum price), while it may turn out to be disadvantageous (if the predetermined price is in between the price they ask and the minimum price they need to receive, they would not sell their shirt, and hence they would fail to make a profitable trade). And similarly, we explained that asking for a price lower than their minimum price would never be advantageous either, but that it could be disadvantageous too. Participants were then given the opportunity to ask questions in private, which would then be answered in public.

Next, the participants in the UPA treatment were called forward one by one. They were asked in private what minimum price they needed to receive to be willing to sell their shirt. After they stated their amount, the consequences of their asking price were explained once more[7], and they were also asked whether they would want to revise the

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[7] Defining Y as the price a participant had submitted, the relevant script was as follows. "The amount you ask is Y Cedis. So if the price in the envelope is Y Cedis or higher, you would sell your shirt and be paid the higher, predetermined price. If the price in the envelope is lower than Y Cedis, you would not sell your shirt at the predetermined price. Do you understand?"

price they asked.[8] After all participants in the UPA treatment submitted their asking price, the small envelope was opened and the price we were willing to pay for their shirt was revealed. Again, all UPA participants were called forward one by one to implement (or not implement) the trade. After this was completed we checked whether everyone understood the mechanism, whether (now that they learned the price) anybody regretted having asked the price they had asked and why, and whether everyone understood that it was in their best interest to ask the minimum price they needed to receive – not more, and not less. Again, all participants were allowed to ask their questions in private, which would subsequently be answered in public. We then continued with the tree planting bids, again explaining the benefits and costs, and emphasizing that they should think hard about the minimum amount of money they would need to receive to be willing to provide the service of keeping saplings alive for the 2016-2017 agricultural season.[9]

The procedures and script used in TILI only differed from that of UPA in the description of the mechanism. Participants were encouraged to think hard about the benefits and costs of selling their shirts, and they were also encouraged to determine the minimum amount of money they needed to receive to sell their shirt or participate in the program. After all, having considered what the minimum is they need to receive, they should be happy to accept if the predetermined price is higher; if the predetermined price is lower, they should (be happy to) reject the price we offer. We re-emphasized that the prices for both the shirt and the tree planting project had been predetermined, and that they would be informed of the price in private, but that everyone ultimately is offered the same, still unknown, price. Participants were then invited forward one by one. They were informed in private of the price in the envelope and were then asked whether they were willing to sell their shirt at that price, yes or no. Their answer was recorded, but trades were only implemented after all participants had made their decision.[10] After completion of the trades we again checked their understanding, and if

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[8] The script read as follows. "Would you regret having asked Y Cedis if the price in the envelope is less than Y Cedis? If so, would you like to revise your bid?"

[9] The program is renewed every year, with the compensation level remaining the same in at least the first two years; the price may change after the third year because the nature of the net opportunity costs would change (from time and effort in the first two years to foregone crop revenues from year three onward, with the trees being expected to start producing fruits and nuts from the fourth year onward). We were careful in emphasizing the long-run nature of the tree planting program, but also stressed that the decision they needed to make was how much money they needed to receive for the program's initial period.

[10] Because the trade does not take place at the same time as the decision is made, participants cannot observe what decisions their fellow participants made, and hence they can also not be influenced by the decisions of others.

necessary participants could ask clarifications in private (with the answer being given in public). An analogous approach was implemented for the TILI tree planting project.

Choosing what price to offer TILI (which is also to be used as strike price in UPA, to make sure that all participants in the program receive equal compensation) is complicated because the available information on opportunity costs was scarce and very imprecise. We proceeded as follows. First, in May 2016 we consulted close to 50 extension workers for their best guess of an "appropriate price", we set the price between 180 and 290 Cedis for the communities in the Guinea savanna regions in the North and North-West of Ghana, and between 380 and 480 Cedis for communities in the more arid Sahel savanna in the country's North-East. Second, we implemented these prices in four pilot communities in early May 2016. We noticed that signup rates were close to 100% in both TILI and UPA, and proposed to the government of Ghana's project team to reduce the actual payments to save budget. The government team decided, however, that lowering the prices offered to the remaining communities would be a potential source of unrest, and hence they decided that the prices offered should remain high – they even decided that in the 2017 wave the prices should be even higher. While good news for the farmers such high prices potentially jeopardize the research because they would result in very limited variation in outcomes – nearly all farmers were expected be willing to participate in the program, independent of whether they had been randomized into the UPA or TILI treatments.

As the government team was vehement that the prices should be kept very high, we decided to elicit take-up rates for much lower prices by asking TILI participants the following question: "if the conditional compensation offered is X Ghana Cedis, would you be willing to participate in the tree planting project?", where X was either 10, 30, 60 or 100 Cedis. This question was asked *before* the actual predetermined price (which was 180 Cedis, or higher) was retrieved from the sealed envelope. The question was non-binding, but we are confident that the respondents perceived the question as a legitimate inquiry into their willingness to accept.[11] Also note that the UPA protocol remained unchanged because by comparing the farmer's asking price to any of the

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[11] Participants were very much aware that their answers could not influence the price they would be offered – as the price was in the envelope. Hence, there is no reason for strategic misrepresentation. Also, comparing participation rates in the four pilot communities (without the extra question) to those in the last six communities of the 2016 wave (with the extra question), we do not find any evidence that this additional question affects the TILI participants' propensity to accept the actual price offer; these rates remain very close (if not equal) to 100%.

prices we can determine whether the farmer would have been accepted into the program at that price, yes or no.

The RCT was implemented in twenty communities, and in total 880 household representatives participated in this experiment – 438 in the TILI treatment, and 442 in the UPA treatment. The information on this entire set of households is used for the direct comparison of participation decisions, as they all completed their experimental session. Unfortunately, the sample included in the analysis aimed at explaining outcomes only consists of 788 households, as information about key variables was missing for 92 households. Because of the missing information, Table 1 presents the balance test of the set of 395 households in the TILI treatment and the set of 393 households in the UPA treatment for which we have complete surveys.

<Insert Table 1 about here>

As shown in Table 1 the treatments are balanced on most variables. This is not very surprising because of our fairly large sample size, and also the fact that randomization occurred at the within-village level was instrumental in obtaining balance. This holds for sure for the allocation of households across the 2016 and 2017 waves and also for the agro-ecological zone (Guinean savannah versus Sahel savannah). We also have balance on key observable respondent characteristics like gender and age (the latter was verified using voting card IDs), and also on most of the variables measuring individual preference and attitudes. The two key exceptions are Optimism and Impulsiveness. The two samples differ significantly in these two respects (at the 2% and 8% level, respectively), but the differences in the shares of optimistic and impulsive respondents are not too large (0.078 and 0.055, respectively). Still, because the differences are significant, we will include them in the regression analyses to mitigate the potential impact of these two imbalances.

2.2 Results of the field experiment

We first test whether the share of participants accepting to participate in the tree planting program is significantly larger when offered a take-it-or-leave-it (TILI) price than when using the uniform price auction (UPA) approach. Participation rates under UPA and TILI for a selection of prices are presented in Table 2. For each respondent in

the UPA treatment we looked up whether her ask was above or below each of the specific prices, and subsequently calculated, for each of these prices, the share of participants who had submitted an ask less than or equal to that specific price. As the mechanism is incentive compatible, this is our best predictor of take-up rate in the group of respondents who were offered the contract with a specific price, take-it-or-leave-it style. For example, we observe that 31% of the participants in the UPA treatment submitted an ask less than or equal to 10 Cedis, and hence we expect 31% of the participants in the TILI group to be willing to participate when offered the contract with 10 Cedi compensation. The second column of Table 2 shows actual take-up rates as observed among the group of respondents who were offered the opportunity to participate take-it-or-leave-it style.

< Insert Table 2 about here>

Not surprisingly Table 2 shows that the share of respondents deciding to participate is a (weakly) increasing function of the conservation price offered, independently of whether the respondents participated in the UPA or TILI treatment. More importantly, we find that when offered a specific price take-it-or-leave-it style, respondents are (much) more likely to agree to participate in the PES program than those who are requested to submit their ask in the UPA treatment. We thus find that UPA systematically and significantly underestimates farmers' propensity to participate in the PES program when contracts are offered take-it-or-leave-it style. This difference is substantial, and even remains significantly different for the real prices offered (180 Cedis and higher) despite the fact that the share of respondents accepting the program under TILI already reached 100% at 180 Cedis. We thus replicate Jack's (2013) result that incentive-competitive value elicitation mechanisms underestimate, and substantially so, actual take-up rates in the field.

So what causes this difference between predicted and actual uptake? Jack (2013) documented the difference, but was unable to identify the mechanism. Berry et al. (2015) also test whether an incentive-compatible valuation mechanism – in their case Becker-de Groot-Marshack (BDM) – is a good predictor of agents' behavior respondents' propensity to purchase. They offer participants, poor farmers in northern

Ghana, the opportunity to buy a new water filter. They thus look at the buyer's side of the market (as opposed to our focus on the seller's side) and find that their incentive-compatible value elicitation mechanism underestimates their respondents' propensity to purchase the water filter.

Comparing the outcomes of Berry et al. (2015), Jack (2013) and ours, it is interesting to note that all three find that the incentive-compatible mechanisms *underpredict* market transactions that occur with take-it-or-leave-it offers, independent of whether the respondents are on the buyer's or the seller's side of the market. Berry et al. hypothesize that in their experiment the difference in take-up rates is due to strategic considerations playing (a more important) role in their BDM treatment than in the TILI treatment. They experimentally vary disclosure of the water filter's sales price at the markets in the regional capital (which may affect BDM bids via anchoring) and they also experimentally vary the provision of information that the study's outcomes will be used to determine the filter's future sales prices when their supply is scaled up in the villages. None of these manipulation significantly affects outcomes, suggesting the difference between predicted and observed purchase rates is due to neither strategic bidding nor to anchoring.

In this study we test the relevance of an alternative mechanism, based on the hypothesis that the UPA invites more deliberate and hence also more careful decision making than take-it-or-leave-it price offers. Even though we explicitly instruct our TILI participants to carefully think through the consequences of saying yes or no to the price that will be offered to them in a moment – explicitly telling them to carefully think about the minimum amount of money they would need to receive to be willing to participate in the tree planting program – the actual incentive to think through the consequences of one's decisions is more pronounced if one is asked to submit than if one knows the contract price will be revealed before one has to make a decision oneself. We hypothesize that if decision-making is more deliberate, the explanatory power of economic variables (like available land area and prior experience with the benefits of having trees on one's land) and preferences (like risk attitudes and time preferences, but also more psychological characteristics like optimism and impulsiveness) is higher under UPA than under TILI. To test this hypothesis, we focus our attention on analyzing differences in outcomes between TILI and UPA for the {10, 30, 60, 100} price set (as we do not have any variation in the TILI decisions for the actual prices). In the case of TILI we simply regress the yes/no decision on the price offered on a series of economic

variables influencing the costs and benefits of participating in the program (like land area, and whether one has experience with the benefits of having trees on one's land), and also on a series of personal characteristics like gender, age, and "behavioral" parameters like risk aversion, impatience, optimism.

We implement the same analysis for UPA, but the procedure is slightly more involved because the outcomes of the analysis may be dependent on whether an individual's participation decision is determined using a strike price of 10 Cedis, or of a 100 Cedis. For every participant in the UPA treatment in a community we randomly select one of the prices (10, 30, 60, 100) that had been offered to the TILI participants in her community. We compare the participant's asking price in the UPA to the randomly selected price, and the participant is coded as accepting to participate in the tree planting project if the former is less than or equal to the latter. Outcomes may depend on the assignment of prices to the participants, and hence we implement a Monte Carlo approach using 1000 replications for each model specification we use. [12]

Table 3 presents the probit regression results explaining the participants' decisions to be in the tree planting for the UPA and TILI households using two different specifications. The price offered is included in specification (i), and so are dummy variables for the wave in which the respondent participated and for the agro-ecological zone she is living in (Guinean savanna, as opposed to the Sahellian zone). Furthermore, specification (i) also includes key respondent characteristics like gender and age category, and also key farm characteristics that are very likely to affect the farmer's propensity to participate in the tree planting program – land area, and whether the participant has prior experience with the benefits of having trees on her land. In addition to all of the above variables specification (ii) also includes the two more psychological variables for which we found a slight imbalance between the UPA and TILI groups.

Focusing first on specification (i) in Table 3, none of the potential explanatory variables shows up significantly in the probit regression for TILI – not even the price offered has a significant impact on the participation decision. The results are markedly different for probit regressions aiming to explain the propensity of farmers to participate in the UPA treatments. The price at which the participation decision is evaluated has a significant impact on participation rates, and so do key variables like available land area

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[12] This procedure is similar to that implemented by Cole et al (2016). An alternative approach for dealing with the same issue would be to include the full menu of costs as separate observations but estimate using a seemingly unrelated regression (SUR) framework as done in Berry et al (2015).

and whether one has trees on one's land, or not. Perhaps surprisingly, respondents who are coded as impulsive are significantly less likely to participate in the program, and this is the case in both treatment groups. Optimistic individuals are more likely to agree to participate in the program, but this difference is significant only for the subsample of respondents in the UPA treatment.[13]

<Insert Table 3 about here>

Our findings thus suggest that key variables pertaining to the perceived costs and benefits of participating in the program (like available land area) have explanatory power in the UPA treatment but not in the TILI treatment, and there are also traces of evidence that also more behavioral parameters tend to affect decisions in the former whereas they are nowhere near significant in the latter. One possible explanation for this result may be that decision making is more deliberate in UPA than in TILI.[14] Deciding whether or not to participate in a program for a given price requires less mental effort than deciding what the minimum amount of money is that one needs to receive to be willing to participate in the program. If this is the case in the field, we should be able to find similar results in a laboratory environment, where the decision situation can be simplified and behavioral parameters can be measured with more precision.

Before doing so (in section 3), we provide additional suggestive evidence that UPA may be a poor predictor of actual uptake under TILI, but that uptake is actually suboptimally high. We do so making use of the (limited) information that we have on actual survival rates. We have this information only for participants in the six communities that were treated in the first wave. Finding treatment differences is challenge because the actual compensation price offered was very generous – so

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[13] We also tested the impact on participation of variables like risk aversion and the rate at which one discounts the future. These variables are not found to significantly affect decisions in either the TILI or UPA treatments. In the 2016 wave we used multiple price lists (see Holt and Laury 2002) to measure these preferences. Because these questions turned out to be very time consuming, were perceived by the respondents as quite confusing and did not have any explanatory power in the 2016 statistical analyses, we decided to replace these multiple price lists by more qualitative preference elicitation questions; see Falk et al. (2016). Whether the lack of a significant impact of these preference variables is due to the fact that these preferences are not salient for the participation decision or that it is caused by the (change in) methods used to measure these preferences, is an open question.

[14] Of course, more considerate decisions are not necessarily better decisions if "behavioral biases" are dominant. We will come back to this issue later on in this paper.

generous that almost all respondents ended up participating in the program – all participants in TILI, and 89% of the respondents in UPA. These very high participation rates have the advantage that our analysis is not much affected by self-selection. But because these high participation rates are caused by the very generous payments, the incentives to keep one's trees alive are very strong – even if the non-financial benefits of having trees are perceived to be negligible, or even negative. Still we are able to document an interesting finding regarding the survival rates – one that sheds doubt on whether indeed TILI invites sufficiently careful decision making.

If decision making is sufficiently careful and deliberate, one would expect that those participants who have the lowest reservation prices have the highest survival rates. The reasoning would be that the higher the net private benefits are of having trees, the lower the net compensation one needs to receive the be willing to take good care of the trees. So let us compare the survival rates for those individuals for whom we can identify whether they are willing to take care of the trees even if compensation is near-zero – that is, if the compensation is 10 Cedis. We can identify 88 respondents for who we can determine whether they would have accepted to be in the program for a price of 10 Cedis, yes or no. Of these 88 respondents, 54 indicated that they would be willing to participate in the program for that price, and 34 indicated that they would not be willing to take care of the trees for that price. Of course, participants from the TILI treatment are overrepresented in the first group. Contrary to economic reasoning, the survival rates are *lowest* for the group who indicated that they were willing to participate if the price is 10 Cedis. For this subgroup, the survival rate is 39.3%, whereas the rate is 56.2% among the farmers who are not willing to participate in the program if compensation is as low as 10 Cedis. This difference is significant at $p = 0.015$ on the basis of a standard non-parametric MannWhitney test. The test on survival rates suggests that indeed respondents are too eager to accept any price offered in TILI, compared to the participation decisions of the group of respondents in UPA.

3. The laboratory experiment

To further test whether decision making is more deliberate in UPA than in TILI, we decided to implement a laboratory experiment in which we would endow our subjects with an item that we would subsequently buy back using either UPA or TILI. For this test, the choice of the item to be sold by the participants is crucial. For the

laboratory experiment to be able to reflect the outcomes of the field, we should endow participants with an item where (i) observable personal characteristics are (expected to be) predictive of individual subject's valuation of the item under consideration (similar to the role of observables like land area and access to a water in the field experiment), and where (ii) behavioral parameters (like patience and risk preferences in the field experiment) are expected to be predictive too. Identifying such an item is not trivial. After all, subjects in the lab are predominantly WEIRD[15], and hence it is not straightforward to find specific observables that are predictive of the decision to sell (or not to sell) a specific item.

Gender is an obvious individual characteristic of any randomly selected sample of WEIRD subjects, and hence we searched the literature to find an item that tends to be evaluated differently by different genders. Rozin et al. (1991) analyzed gender differences in the appreciation of various food items and identified chocolate as one of the items where the gender difference in appreciation is largest – with female students appreciating chocolate better than male students. Knetsch (1989) documented that the propensity to sell chocolate bars in the laboratory is affected by the degree of loss aversion, and hence we decided to endow student subjects with chocolate bars, and buy them back using either UPA or TILI.

The stakes in and complexity of selling a chocolate bar in the laboratory are negligible compared to the considerations involved in the decision whether or not to participate in a multi-year tree planting program in the field. This means that asking WEIRD subjects to sell their chocolate bars under either UPA or TILI in the laboratory is a strong test of the hypothesis that decision making is more considerate in the UPA treatment than in TILI.

3.1 Design of the laboratory experiment

The chocolate bar we selected is a high-end one, and of a brand that was introduced in the Netherlands just a few weeks before the implementation of the experiment. That means that our subjects did not have prior information on sales values they might anchor their bids on.[16] Also, at the time of the experiment the taste was new for the Dutch market (salty fudge and brownie). Upon entering the lab the subjects

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[15] White, Educated, Industrialized, Rich and Democratic; Henrich et al. (2010).
[16] Coincidentally, the chocolate was produced in cooperation ('fair trade') with Ghanaian farmers.

received their chocolate bar (wrapped and sealed), and were offered the opportunity to sample the chocolate by taking a piece from a plate which was passed around. Unbeknown to the subjects we recorded whether a subject did or did not decide to taste the chocolate.

The actual implementation of the UPA and TILI treatments mimicked the field procedures as closely as possible. In the general introduction subjects were informed that the chocolate bar they received was theirs, but that they would be offered the possibility to sell it back during the session. We emphasized that they should carefully consider how they appreciated the bar; do they like the taste, etc. We also announced that the price at which we were willing to buy back, had already been determined. We then proceeded with the treatment-specific instructions, informing the subjects of the way (UPA, or TILI) in which they would be offered the choice to sell back their bar to us. We implemented the same scripts of informing subjects (about the incentive-compatibility) of the two mechanisms as we used in the field. We elicited risk and loss aversion preferences using a financially incentivized multiple-price list approach (Holt and Laury 2002).

In total, 132 subjects participated in 7 sessions; 73 in the UPA treatment and 59 in the TILI treatment. We recorded their gender, country of origin, what study program they were in, and whether they were willing to sample the chocolate. We hypothesize that decision making is more deliberate in UPA than in TILI, and this hypothesis can be tested in two ways. First, deliberate decision-making takes time, and hence we test whether the amount of time needed to take a decision differs between the two treatments. The second approach is via regressions similar to the ones presented in the field – if UPA induces more deliberate decision making than TILI we expect key explanatory variables like gender and loss aversion (measured using a financially incentivized multiple price list) to have more explanatory power in UPA than in TILI.

3.2   Results of the laboratory experiment

We first test whether indeed subjects in TILI are more prone to selling their bar than those in UPA. Figure 1 presents the opportunity cost schedule of the asks in UPA (the upwardsloping, non-interrupted line), the predetermined strike price (the dashed, horizontal line), as well as the share of subjects willing to sell their bar at that predetermined price. As was the case in the field, the share of subjects willing to sell is higher in TILI than in UPA. The respective shares are 0.64 and 0.48, and this difference

is significant at p = 0.059 according to a standard two-sided Chi-squared test. So, we find a difference in take-up rates of about 16 percentage points (or 33% higher in TILI than in UPA).

<Insert Figure 1 about here>

Having established that the UPA outcomes are a poor predictor of actual TILI participation rates, we test whether the decision making is indeed more deliberate in the former than in the latter. Figure 2 shows the means of times taken to make the decisions (whether to accept selling one's bar for the predetermined price in TILI, and one's asking price to be willing to part with one's chocolate bar in the UPA treatment). The results found are in line with our expectations. The mean time taken in UPA is 43.5 seconds, as compared to 23.5 seconds in TILI. This difference is significant at $p < 0.0001$ according to a two-sided Mann-Whitney U test.

<Insert Figure 2 about here>

Next, we test whether key characteristics like gender and loss aversion can explain at least some of the variation in sales outcomes in UPA, and not in TILI. To do this, we ran several specifications of a probit regression model (analogous to those presented in Table 3 for the field experiment); results are presented in Table 4.[17] The results are quite striking. None of the explanatory variables we collected has any predictive power in TILI, while we find both the observable variable (gender) as well as the behavioral parameter (loss aversion, for men) significantly affect a subject's propensity to sell in UPA. Consistent with Rozin et al. (1991) we find that male students have a lower appreciation of chocolate (and hence are more willing to sell) than female students. And we also find that male students with above-median levels of loss aversion are less likely to sell than below-median loss averse men. Female students and loss averse male

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[17] Two subjects switched columns more than once in their loss aversion multiple price list, and hence their choices are inconsistent. We excluded these two observations from the regression analysis. Also, we decided to not include risk aversion as a control variable in the regression analysis. No fewer than 107 of our 131 participants were found to be risk neutral, and hence the variance in this variable is too small to be included in the analysis.

students are thus less eager to sell their bars than "loss neutral" male students. The fact that behavioral and observable (or economic) characteristics are predictive of decisions in UPA but not in TILI parallels the outcomes of the field experiment, and thus adds credibility to the claim that decision making is more considerate in the former than in the latter.

< Insert Table 4 about here>

4.   Conclusions

Payments for Ecosystem Services (PES) schemes have rapidly gained importance as an instrument to stimulate environmental conservation on private land. Typically, the purchaser of nature conservation services (the government, or an NGO) offers landowners a contract, take-it-or-leave-it (TILI) style, specifying the types of activities a landowner should undertake and the amount of compensation she will receive in return.

One of the key challenges for PES design is to find the appropriate compensation level. Offering too low a price does not induce conservation, a price that is too high quickly exhausts the PES budget. Economic theory has developed several "truth-telling mechanisms", so-called incentive compatible value elicitation methods, in which revealing one's actual (opportunity) costs of service provision is the optimal strategy. In this paper we replicate Jack's (2013) result that for a given compensation price, the share of landowners agreeing to participate in a PES program is substantially higher when offering them a contract take-it-or-leave-it style than predicted using an incentive-compatible elicitation method.

We hypothesize that the difference is caused by the fact that indicating one's true willingness to accept is much more cognitively demanding than making the decision whether one is willing to participate in the program for a specific price. We find some evidence for this claim in the field experiment on reforestation we implemented in Northern Ghana, as we find that variables that plausibly predict participation (like land area) show up significantly in the regressions explaining participation using the incentive-compatible elicitation method (the Uniform Price Auction), but that the coefficients on these variables are not significant in the regressions explaining participation in the take-it-or-leave-it treatment. We proceed by

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running a laboratory experiment with (i) a much easier decision problem (whether subjects are willing to sell back the bar of chocolate that they received before, (ii) where we have priors on observable characteristics (gender) and behavioral parameters (loss aversion) that plausibly affect outcome of the decision variable (sell, or not sell), and (iii) where we can easily observe how much time it takes to make the decision – which is arguably correlated with how difficult the decision task is considered to be. Consistent with our expectations, we find that both gender and attitudes to losses predict the outcome in the Uniform Price Auction treatment but not in the take-it-or-leave-it treatment, and we also find that the time needed to make the decision in nearly twice as long in the former than in the latter treatment.

Combined, the results of this study and that of Jack (2013) suggest that whereas Uniform Price Auctions and take-it-or-leave-it price offers are both incentive-compatible methods of eliciting values, the former are unable to predict uptake under the latter – probably because of differences in cognitive efforts invited by the two methods.

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Table 1: Balance test for the field experiment

	TILI	UPA	Difference	p-value joint orthogonality test
2017 Wave	0.749	0.730	0.019	0.542
	(0.022)	(0.022)	(0.031)	
Agro-ecological zone	0.489	0.511	-0.023	0.522
	(0.025)	(0.025)	(0.036)	
Female	0.354	0.354	0.001	0.983
	(0.024)	(0.024)	(0.034)	
Age	39.691	39.649	0.042	0.964
	(0.669)	(0.668)	(0.945)	
Land area	13.258	11.919	1.340	0.220
	(0.864)	(0.664)	(1.091)	
Owns trees	0.749	0.771	-0.022	0.478
	(0.022)	(0.021)	(0.030)	
Perceived benefits of trees (number)	3.825	3.760	0.065	0.570
	(0.081)	(0.081)	(0.115)	
Risk averse	0.471	0.445	0.026	0.472
	(0.025)	(0.025)	(0.036)	
Impatient	0.324	0.305	0.019	0.572
	(0.024)	(0.023)	(0.033)	
Optimistic	0.742	0.664	0.078**	0.017
	(0.022)	(0.024)	(0.032)	
Impulsive	0.284	0.229	0.055*	0.080
	(0.023)	(0.021)	(0.031)	
N	395	393	788	

Table 2: Shares of subjects accepting actual (180 and higher) and virtual (100 and lower) price offers in the TILI and UPA treatments

Price offered	Sh. Accepted UPA	Sh. Accepted TILI	p-value [a]
380	0.934	1.000	0.000
250	0.896	1.000	0.000
180	0.833	1.000	0.000
100	0.767	0.995	0.000
60	0.609	0.979	0.000
30	0.466	0.944	0.000
10	0.313	0.747	0.000

[a] p-values obtained using two-sided two-proportions tests.

Table 3: Probit regression results explaining farmers' decision to (not) accept to be in the tree planting program.[a]

	(i)		(ii)	
	TILI	UPA	TILI	UPA
Price Offered	0.006	0.013***	0.007	0.014***
	(0.005)	(0.003)	(0.005)	(0.003)
2017 Wave	0.439	-0.525	0.272	-0.711*
	(0.480)	(0.371)	(0.506)	(0.364)
Agro-ecological zone	-0.336	-0.506	-0.355	-0.488
	(0.318)	(0.335)	(0.333)	(0.323)
Female	-0.188	0.039	-0.188	0.089
	(0.252)	(0.143)	(0.261)	(0.137)
Older	-0.159	0.392	-0.0783	0.361
	(0.215)	(0.311)	(0.231)	(0.332)
Land area	-0.002	0.015**	-0.001	0.017**
	(0.005)	(0.007)	(0.005)	(0.007)
Owns trees	-0.128	0.413**	-0.0678	0.418**
	(0.409)	(0.180)	(0.437)	(0.192)
Optimism			0.152	0.308*
			(0.362)	0.145
Impulsiveness			-0.740***	-0.578**
			(0.252)	0.170
N	395	393	395	393
Pseudo- R^2	0.108	0.145	0.167	0.174

[a]Robust standard errors in parentheses, clustered at the community level.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Probit regression results explaining student participants' decision to (not) accept to sell their chocolate bar.

	(1) UPA	(2) TILI
Unwilling to taste	0.379	0.064
	(0.750)	(0.834)
Western European	-0.149	0.295
	(0.293)	(0.205)
Male	0.696**	0.692
	(0.353)	(0.582)
Loss Averse	0.500	-0.013
	(0.378)	(0.240)
Loss Averse x Male	-1.082***	0.084
	(0.360)	(0.910)
Intercept	-0.371***	-0.111
	(0.135)	(0.369)
N	71	56
adj. R^2	0.045	0.069

$^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Figure 1: The chocolate bar opportunity cost schedule, the predetermined TILI price and the shares of subjects in UPA and TILI who are willing to sell their bar at the predetermined price in the laboratory experiment.
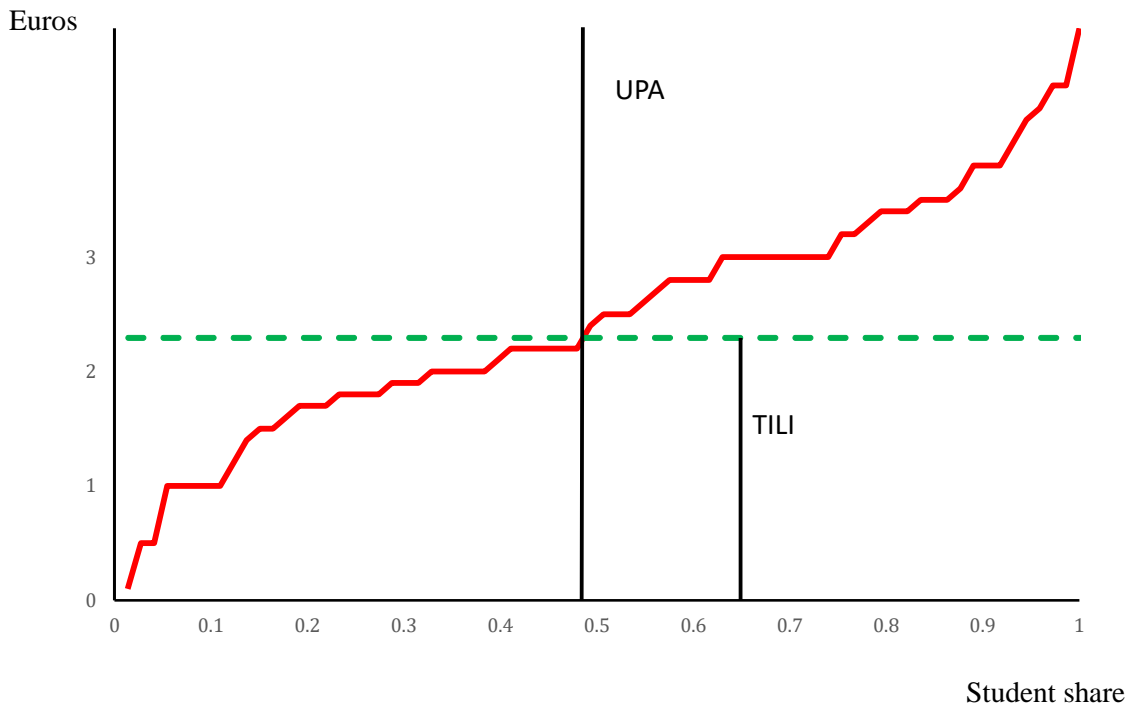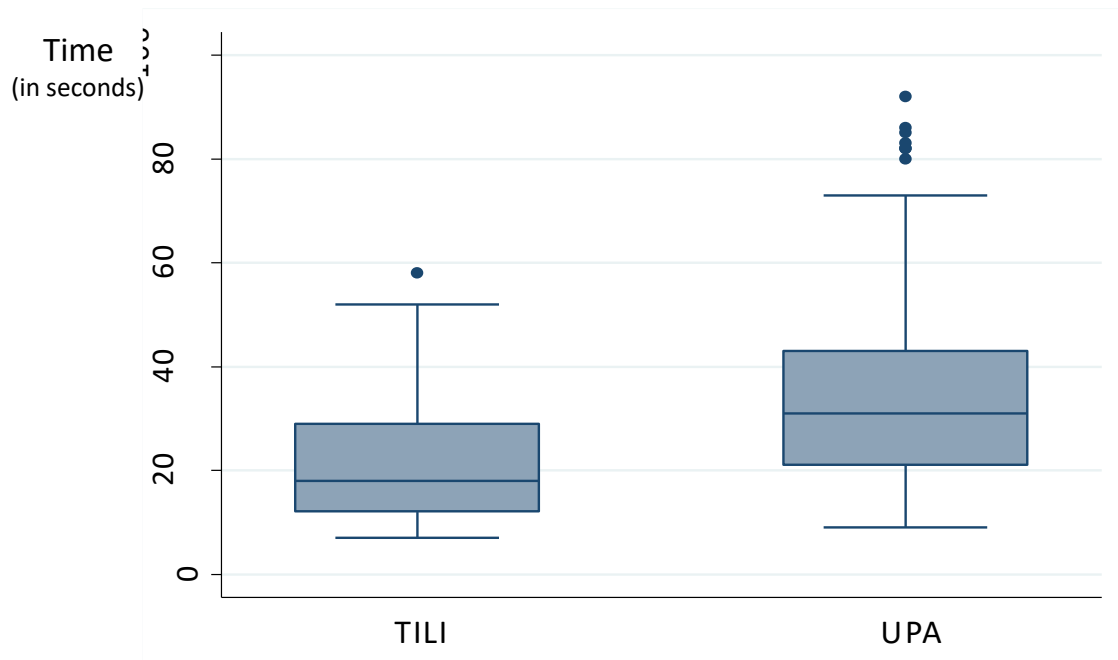
Figure 2: Box plots of decision times in UPA and TILI (in seconds).

Note: The plots show the intervals containing the middle 50% (in the boxes) and 90% (the barred lines) of the observations, as well as the outliers in terms of time taken. The horizontal lines in the boxes give the median times.