

Master's Thesis

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Abstract

We use a between subjects design to compare the revelation properties of the referendum voting and the Vickrey auction, in terms of average revealed result, as well as hypothetical bias. Our results suggest that the Vickrey auction leads to the revelation of lower preferences, yet this result is not statistically significant. However, the Vickrey auction is more subject to the hypothetical bias than referendum voting, with a ratio of real to hypothetical vote of 6.12 against 2.88. This difference in result might be due to large rates of opting-out in Vickrey.

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1 Introduction

The elicitation of preferences has been an active research field for many years. Indeed, finding a price for non-market goods which have no market-price can lead to many concrete applications in diverse areas, such as environmental economics, health, public policy and so on. This can be especially useful while running a cost-benefit analysis (CBA) to evaluate a policy. In that case, the costs and benefits of a certain policy have to be weighted. A common way to do this is to give a monetary price to the different parameters, using surveys. This method is commonly named contingent valuation. To give an example, one might need to measure the value of an environmental good, for instance the value that people give to existing natural species.

While doing surveys to elicit the preferences of individuals, we use an elicitation mechanism. This aims at revealing as truthfully as possible the preferences of an individual, as well as helping individuals report accurately their individual preferences. The broad question is to know which mechanism performs better than the others. This is no easy question because the mechanisms can be compared according to two different axes. The first one are the theoretical properties. The second one are the empirical properties, which can be subdivided into the properties in a real or hypothetical context.

Eliciting preferences in a hypothetical context has a very concrete application in the case of a CBA. Indeed, while running surveys, subjects have to answer in a hypothetical context. Mostly for financial reasons, it is extremely difficult to ask subjects to answer a survey and then to make them

directly bear the cost of their answers. A myriad of mechanisms exists when it comes to eliciting the preferences, such as, for example, the Becker-De Groot-Marschak (BDM), the Take-It-Or-Leave-It (TIOLI), the English auction, and so on.

This paper focuses on two mechanisms, the Vickrey auction and the referendum voting. Comparing these two mechanisms is not straightforward and has not been extensively treated in academic work until now. The choice of these two mechanisms is not a mere coincidence. Indeed, the Vickrey auctions are well-known for their good empirical properties and allow for a great control over the preferences of the individuals (Kagel, 1995). The referendum offers the advantage to be easily implementable. It is also readily understood by the subjects as it is a real world device. In addition, it is considered to be efficient in a hypothetical context, and has been recommended by the authors of the NOAA panel (Arrow et al., 1993).

The Vickrey auction is a mechanism in which agents privately bid a value for a good. The winner of the auction is the one who bids the highest value, but the price paid will be the second-highest bid (Vickrey, 1961). In a referendum, subjects are asked to vote in favor or against the funding of a public good. If a majority votes in favor, meaning at least 50% of the subjects, then everybody will contribute, and the public good will be provided. On the contrary, if only a minority votes in favor of the public good, formally less than 50% of the subjects, then nobody will pay for the good and it will not be provided. The referendum is often used as a dichotomous choice device

to choose between two distinct alternatives.

In this paper, section 1 will present the main results in the literature about the revelation properties of Vickrey auction and referendum voting, both in theory and practice. The catchy aspect of the exercise lies in the fact that the revelation property of a mechanism mainly consists in its ability to reveal the private valuation of a good, yet this can not be observed.

2 The revelation properties of Vickrey auction and referendum voting in theory and practice

2.1 Both mechanisms are incentive-compatible

A revelation mechanism is a mechanism which links true underlying preferences to revealed preferences. One of the most attractive properties of referendum-voting and Vickrey auction is that they are both incentive-compatible, meaning that, using either mechanism, it is optimal for a subject to reveal her true preference when asked. This section will be devoted to the theoretical properties of the two mechanisms. More precisely, this section will be proving that the referendum (section 2.1.1) is approximately optimal for large populations and that the Vickrey auction (section 2.1.2) is incentive-compatible.

2.1.1 Proof of incentive compatibility of referendum voting

A binary choice referendum is strategy-proof, as it is the dominant strategy of an agent to vote yes in the referendum if her true preference is yes. As a matter of fact, a binary-choice referendum is incentive-compatible if it satisfies three conditions. First, the majority rule should be set at 50%. Second, the referendum should be closed, meaning that the potential provision of the offered good must not be available through another channel than the referendum itself (Gibbard, 1973); (Satterthwaite, 1975); (Moulin, 1991). In addition, the Gibbard-Satterthwaite theorem states that as soon as there are at least three alternatives in a range voting system, the n voters may choose to vote strategically and the social choice function might be a dictatorship. Thus, the incentive-compatibility of the referendum is limited to dichotomous choices, which is the case in our experiment, as subjects can vote either *yes* or *no*.

Closely related to the incentive compatibility of referendums is their characteristic to be approximately optimal for large populations in case of the production of public goods. This is because the per capita welfare of referendums converges to the per capita welfare of the optimal mechanisms (Ledyard and Palfrey, 2002). The intuition behind the proof is the following. The referendum will pass if a majority of agents vote yes. The agents vote yes if their utility is higher when they vote *yes* rather than *no*. As a consequence, the referendum for the provision of a public good will pass if the average of all utilities is equal to, or greater than, the average per capita welfare in the optimal mechanism. For large populations, this implies that

the outcome of a dichotomous referendum converges towards the outcome of optimal mechanisms.

To sum up, we have just seen that the major theoretical property of referendum is to be approximately optimal for large populations.

2.1.2 Proof of incentive compatibility of Vickrey auction

The Vickrey auction too has attractive theoretical properties and has been proven to be incentive compatible.

In a Vickrey auction, every agent bids secretly his highest value. The agent who wins the auction is the one with the highest bid, however, she will only pay the second highest price. This mechanism, also known as second-price sealed-bid auction, is incentive-compatible, as it drives people to reveal their true willingness to pay. In other terms, truthful bidding is dominant in this setting. This is the case because the bid of an agent might not directly impact the price paid, as will be demonstrated below.

Let WTP_i be the willingness to pay of the agent and B_i her bid. If the bid of agent i is above the bid of all other agents, then her payoff is WTP_i minus the second highest bid. If the bid of agent i is below the bid of at least one agent, her payoff is 0.

Now, let us prove by contradiction that truthful bidding is optimal for agent i , meaning that she should bid her true willingness to pay at optimum.

First, if agent i bids below her WTP, it is possible that she still wins the auction if the other players bid below this untruthful bid. But she would still pay the second price, so it does not change anything compared to the optimum. In the same vein, if agent i bids below her WTP, but that someone else bids above her true WTP, she would not have been able to win the auction anyways, so it does not change neither. Now, if agent i bids below her true WTP, but that another agent bids between her WTP and her bid, then she would lose the auction, whereas she would have been able to win, had she bid her true WTP. In that case, bidding below her true WTP brings her a payoff of zero, whereas it would have been WTP_i minus the second highest bid if she had bid her true WTP. As such, if an agent bids below her true WTP, she can get either the same payoff than at the optimum, or below. Bidding one's true WTP is thus optimal compared to underbidding.

The second case is when the agent bids above her true WTP. If her bid is still below the bid of all other agents, then in any case she would not have been able to buy the auction. If her bid is still above the bid of all other agents, she wins the auction and pays the second highest price. If the second highest bid is below her true WTP, then the payoff is the same as in the optimum. But if the second highest bid is above her true WTP, then the payoff is negative, as the agent pays more than her true valuation for the good. With some non-zero probability, overbidding can make the agent worse-off compared to the optimum. Thus truthful bidding dominates overbidding.

As a consequence, both underbidding and overbidding are dominated by truthful bidding. Thus truthful bidding is an optimum in a Vickrey auction.

It has just been shown that the Vickrey auction is a strategy proof mechanism. This is its most important theoretical property.

To sum up, theory suggests that the Vickrey auction reveals optimally the preferences and that the referendum-voting converges to the optimum. Our results will allow to compare both and see if in practice they reveal differently the preferences in spite of their similar theoretical properties.

2.2 Reduction of hypothetical bias

As already explained in the introduction, the main potential application of elicitation mechanisms is to reveal the preferences of citizens while conducting public policies. Yet, one of the major issues while eliciting preferences is that subjects might not truthfully report their preferences if they are elicited in a hypothetical context.

This is a real concern because in practice, preferences are almost always elicited in a hypothetical context. Surveys are written using the conditional tense, that is prefacing the questions with the word “*would*”. Concretely, the hypothetical bias is the difference between the preferences in a hypothetical and a real context. Often, when agents are not constrained to take the decisions that they will take, they tend to overstate the amount they want to

give. There are many reasons that can explain such a behavior, for instance the fact that in hypothetical situations, their own budget constraint might not be binding.

As a consequence, one interesting way to compare the Vickrey auction and the referendum voting is to assume that their quality depends on how they successfully manage to reduce the hypothetical bias. We will be able to study this point of comparison thanks to our experiment.

The hypothetical bias, or the stated exaggeration of the true valuation, has been widely discussed in the literature, starting in the seventies (Bohm, 1972). It is actually rational for an economic agent to overstate his preference in a hypothetical situation. Indeed, if one is asked her willingness to pay for the provision of a public good, but that the declaration is not binding, stating a value higher than one's true preference increases the probability of production of a public good, without a need to pay for it (Harrison and Rutström, 2008).

The extent of the hypothetical bias is subject to debate in the literature. Two main meta-analyses aim at describing the extent of the hypothetical bias in revelation mechanisms. The first one examines the results of 29 experimental studies to conclude that the mean value in hypothetical treatments is statistically three times higher than the mean value in real treatments (List and Gallet, 2001). This results goes in the same direction as another meta-analysis (Murphy et al., 2005), which uses 83 observations. They find a ratio

of the median value in real against hypothetical treatments of 1.35. As we will see later using our own data, our results also suggest a gap between real and hypothetical experiments.

Hypothetical bias in the Vickrey auction The literature provides evidence that Vickrey auctions suffer from the hypothetical bias. This implies empirically that the incentive-compatibility property fades away.

One of the first experiments to compare the results of a hypothetical versus a real Vickrey auction in the field was carried out in the late nineties (Blumenschein et al., 1997). In this experiment, the subjects got a chance to buy specific UVEX sunglasses, those used in professional laboratories and not commonly available. The control group experienced a single real Vickrey auction, whereas the treatment group successively did a hypothetical and a real Vickrey auction. The mean bid in the real case is 11.97 dollars, against 3.24 dollars in the hypothetical treatment. Thus the hypothetical to real mean ratio is of 3.69. They reject the null hypothesis that the mean bid would be equal in real and hypothetical situations, for both between and within subjects design.

List (2001) conducts a field experiment in which sportscards are traded using a Vickrey auction. His design implies real and hypothetical treatments, distinguishing between experienced and non experienced card dealers. The results indicate that the mean bid is much lower in a real treatment compared

to a hypothetical treatment. The ratio of hypothetical to real mean is of 1.85.

Another experiment shows that Vickrey auctions are subject to hypothetical bias (Jacquemet et al., 2013b). In an experiment to assess the willingness to pay of subjects for adopting a dolphin by donating to the WWF, they show that there is a real difference in both the mean and the median bid between a real and a hypothetical treatment. As a matter of fact, in the real treatment, the mean bid was 2.98 euros, against 17.43 euros in the hypothetical treatment.

To conclude briefly, empirical studies show the presence of a strong hypothetical bias in the case of Vickrey auctions.

Hypothetical bias in the referendum According to the NOAA panel (Arrow et al., 1993), a referendum voting helps reduce the hypothetical bias compared to other revelation mechanisms, as stated in the introduction. However, empirically, referendum voting is not immune to hypothetical bias. Indeed, individuals have an incentive to represent truthfully their preferences if they anticipate that the outcome of the vote will impact their utility. But in a hypothetical case, it is unclear whether one's utility will be impacted. Here we present a review of experiments comparing real and hypothetical willingness to pay elicited using referenda.

An experiment by Krawczyk (2012) about a reforestation program in

Poland uses referenda to elicit the preferences of the population. They compare between- and within-subjects treatments and find respectively a hypothetical bias of 38% and 52%. These high rates of hypothetical bias are suggested to be explained by the unfamiliar aspect of the good to the subjects.

In another experiment, after having earned some money, subjects are asked to vote *yes* or *no* to a referendum for the provision of a public good (Cummings et al., 1997). If more than half of the subjects vote in favor of the provision, then all subjects have to contribute to the public good. They find that more people vote *yes* in the hypothetical than in the real referendum. Most importantly, as the probability that the referendum will have consequences increases, the revelation of preferences becomes more truthful.

Taylor (1998) organized experiments using referenda, in which the potential public good to be produced was an information booklet about contaminated water intended for low-income populations in Mexico. As this booklet was no longer edited, the referendum was closed, because there was no way for the subjects to contribute to this booklet once the experiment was over. The referendum being closed is one of the conditions for it to be strategy proof, as seen earlier in the literature review. Even in this setting, Taylor finds upward hypothetical bias. Her results indicate that the proportion voting *yes* in the hypothetical referendum is 17.9 percentage points higher than in the real referendum framework.

It seems that the results in the literature are all going in the same direction and indicate an upward hypothetical bias, both for the referendum voting and the Vickrey auction.

2.3 Use in practice and weaknesses

Weaknesses of Vickrey in practice On the contrary to referendum, the Vickrey auctions are complex and not intuitive at first sight. This makes it difficult to implement, and it might be one of the reasons why it is not often used in reality (Ausubel and Milgrom, 2004). Some auctions on Ebay seem to be the closest to a Vickrey auction but even they are not exactly a Vickrey auction. This is unfortunate as this auction allows a wide variety of adaptation and can be applied with constraints if required. It is also efficient as buyers and/or seller do not need to spend time collecting information about the strategy of the other agents (Vickrey, 1961).

Focusing on more practical issues, in spite of the revenue equivalence theorem, the Vickrey auction can lead to low seller revenues in practice (Vickrey, 1961). McMillan (1994) gives a salient illustration of the low revenues that can result from a second-price sealed-bid auction. In New-Zealand, the spectrum for radio, television and cellular-telephone use have been auctioned using this method. The results have been quite extreme, as a firm whose winning bid was NZ\$ 100000 ending up paying only NZ\$ 6. More generally, the seller's revenues are non-monotonic in the bids, as changing the value of the second-highest bid can induce a major change in the value of the price paid (Ausubel and Milgrom, 2004). This characteristic also makes the

second-price sealed-bid auction prone to collusion by bidders.

Furthermore, the Vickrey auction might be less profitable for the public planner than the referendum. Indeed, if in a group, only one subject adopts the dolphin, then the average gain for the public planner might be lower than if everybody in the group contributed to the adoption, unless if the paid price by the Vickrey-winner is nine times higher than the total paid price by all subjects in the referendum.

Weaknesses of referendum in practice In practice, referendum voting presents a few weaknesses as well. The common critics towards a referendum is that the average citizen might not be informed enough about the political issue, or in case of public good, of the importance of the provision of that public good (Lacy and Niou, 2000). In addition, when it comes to referenda in large democracies, either the population as a whole votes, and thus only a fraction of the issues can be presented at a time, or the legislatures take decisions, and can vote issue by issue. In other terms, referenda are the superiority of quantity of voters over quality of voting. However, when it comes to provision of a public good, only one issue is presented at a time, so this issue should not arise in that case.

One last practical aspect deals with the type of data produced from either mechanism. The Vickrey auction and the referendum lead to different types of values. The former deals with a continuum of values, whereas the later

leads to a binary answer. It could be that getting only a threshold value produces somewhat less interesting data to exploit as it is less precise, but it depends on the framework of research.

To sum up, both referenda and Vickrey auctions have their own weaknesses in practice.

3 Research question

This paper aims at comparing the revelation properties of the Vickrey auction and the referendum voting. This can be done according to three main branches.

First, the theoretical properties of the two mechanisms can be put in perspective. It appears from the literature review that the Vickrey auction and the referendum voting both have very good theoretical properties. We will not discuss their theoretical properties again in the rest of this paper.

Second, the mechanisms can be compared for their empirical properties of preference revelation. Indeed, if both mechanisms have excellent theoretical properties, they might not be powerful enough for subjects to comply with them. For the purpose of comparing the empirical properties of both mechanisms with respect to the underlying preferences, it is useful to use homegrown values. These values leave the subject free to set his own preferences, meaning no indication of any kind is given by the experimenter. Some

experiments show that both Vickrey and referendum are revealing in practice (Cummings et al. (1997), Jacquemet et al. (2013a)). Our results will be able to compare the empirical revelation properties of the two mechanisms. We want to investigate to what extent subjects behave in accordance with the theoretical predictions.

There is a third way to compare the revelation properties of the two mechanisms: when it comes to hypothetical bias, as we have seen in the literature that both mechanisms suffer from it.

To sum up, this paper aims at answering two important questions concerning the revelation of preferences.

The first one is to what extent the Vickrey auction and the referendum voting are similar when compared with respect to their empirical properties.

The second one is to what extent both mechanisms can reduce the hypothetical bias.

These two questions allow to get a clearer idea of the relative revelation quality of these two mechanisms. Yet, this paper will not give hindsight about the true revelation properties. One should keep in mind that comparing the revealed preferences does not give any information about the underlying preferences leading to the revelation of preferences.

This research question is particularly interesting as it has never been studied before and the properties of these two mechanisms have never been

compared empirically. It would be very useful to strengthen the credibility of either mechanism. If the results of both mechanisms are different from each other, it means that one of the two mechanisms must be closer to the underlying preferences than the other one. However, if both mechanisms have similar empirical properties, it means that the two mechanisms have the same distance to the underlying preferences. Either result would be interesting for the comparison of these two mechanisms and would enhance our understanding.

4 Empirical strategy and research design

In order to compare the empirical properties of the two mechanisms, we will use the datasets previously used in two distinct papers by Jacquemet et al. (2013a and 2013b). In these datasets, preferences have been elicited for the same good (described below) using both referendum voting and Vickrey auction, in a real and hypothetical context. This allows us to get the form of the strategic interaction and the resulting behaviour. The data we use has never been used with the purpose of an explicit comparison between the two mechanisms and thus our paper is the first of its kind so far.

Jacquemet et al. (2013a) design an experiment in which subjects get a chance to adopt a dolphin thanks to a donation to the World Wide Fund (WWF). Thanks to this donation, this non-governmental organization can protect endangered species and their natural inhabitat. The experiment mea-

asures the revealed preferences for the adoption, which is a private good but whose characteristics are close to non-market goods. For a donation of 25 USD, people get a certificate of adoption as well as a picture of the adopted dolphin. Thus the adoption is materialized to ensure its credibility.

The adoption procedure is written in French and provides additional information about both the life of dolphins and WWF. The subjects in the experiment received the following information about the NGO:

“The World Wide Fund for Nature, better known as the WWF, is an international nongovernmental organisation for the protection of nature and of the environment, fully committed to sustainable development. The head office is in Gland, Switzerland, and the association has more than 4.7 million members worldwide, with an operational network in 96 countries. It is a private organisation aimed at protecting wild animals and their habitats as well as nature in general, which it does by collecting funds for specific programs. Principally, it keeps a watchful eye on whether international regulations are being respected, restores damaged natural areas and provides training. As a way of financing its environmental protection activities, the WWF offers private individuals the opportunity to adopt an animal from endangered species. The funds thereby collected enable the WWF to continue protecting the environment and preserving species diversity.”

After having read this information, the subjects answer a quizz, the answers to which determine the earnings of the subjects. They will later be given a chance to invest or not these earnings to adopt a dolphin. The quizz

is based on twenty multiple choice questions with four answers, among which only one is correct. These questions are based on a test for people willing to enter the civil service and holding at least a high school diploma (“Concours de Catégorie B de la fonction publique”). As the majority of the subjects are undergraduate students, the level of the quizz is appropriate to determine earnings. The position of the correct answer is randomized between questions and the ordering of questions is kept the same for all subjects in all treatments.¹

The subjects also answer some socio-demographic questions, to know more about about their age, gender, status, discipline, as well as elicit their familiarity with the NGO and experiments in economics.

The preferences of the subjects are then elicited using either a referendum voting or a Vickrey auction (see Table 1, page 22).

To improve the saliency of the experiment, meaning that the decisions must be directly linked to rewards, the experimenter rescales rewards using a fictitious currency. As a consequence, in this experiment the values are expressed in ECU (Experimental Currency Unit).

To avoid end-game effects, the subjects do not know how many rounds

¹From the previous work by Jacquemet et al. (2013b) using this procedure, the risk of a subject scoring in such a way that earned wealth is lower than 1 Euro is very unlikely. All subjects thus enter the referendum with earnings higher than 11 Euros.

Table 1: Structure of the data

	Vickrey	Referendum
Number of Sessions	2	6 at 11 euros 2 at 6 euros
Number of Treatments	2	2
Type of Treatments	Hypothetical, Real	Hypothetical, Real
Number of session per treatment	1	3 at 11 euros 1 at 6 euros
Number of subjects per session	18	20
Number of decisions per subjects	5 bids	5 votes
Total number of subjects	36	160
Total number of observations	180	800

Note: For referendum, the treatment of interest is the one at 11 euros, see subsection 4.2.

there are going to be. After each auction, they are informed about the (in)existence of a next round.

Finally, to respect the criterion of dominance, which states that the reward structure dominates any subjective cost associated with the participation into the experiment, the agents are compensated for their opportunity cost of being there by a 10 euro show-up fee.

In addition to participating in the auction or the referendum, subjects have also answered a questionnaire to elicit socio-demographic variables.

4.1 Design Vickrey auction

The revealed preferences using the Vickrey auction have been elicited in two sessions, one using a real treatment, and the other using a hypothetical treatment (see Table 1, page 22). Each session is attended by eighteen subjects, who are divided into two random and independent groups of bidders. The auction is repeated five times within each group. Each bidder choose to bid between 0 and 100 for the adoption of a dolphin.

No information is available before the end of the round, but after each auction, the profits are displayed to the bidders. Most subjects see 0 as their profit, except for the winner who has access to the information concerning the two highest bids, the market clearing price and the hypothetical or real earnings.

The data concerning the Vickrey auctions implies that the subjects bid with their own private values, that are not observable by the experimenter.

4.2 Design Refendum

In the case of referendum, eight sessions have been run in total with twenty subjects in each session. Six sessions have been run with a value of adoption set at 11 euros (three real, three hypothetical). As a point of comparison, two sessions were run using an adoption value of 6 euros (one real, one hypothetical).

Each session of 20 subjects is subdivided into sessions of 5 subjects for the whole experiment. Within each group, the subjects vote either *yes* or *no* for the adoption of the dolphin by clicking on a webpage. If a majority of subjects vote yes, meaning at least 50% of the subjects, then everybody adopts the dolphin through a contribution.

In order to reduce the noise, each referendum within a group is repeated five times. Then, one out of the five rounds is selected at random and determines whether the group adopts the dolphin. If the group adopts the dolphin, then the cost of adoption is split equally between the subjects.

Setting the price of the adoption at 6 or 11 euros imply to subsidize it, as the true price is 25 USD. Cherry et al. (2004) show that bidders take into account the outside options while in the lab. As a consequence, to avoid the fact that subjects might let the subsidy affect their bid, the subjects are not aware of the subsidy.

4.3 Identification strategy

The underlying assumption that is required for the identification is that the true underlying preferences are the same in both contexts of referendum and Vickrey auction. This assumption is plausible even if the sample for referendum is much larger (160 subjects) than for Vickrey (36 subjects), thanks to the random selection of the subjects into either categories. In the following section, we will observe the characteristics of subjects in both

groups, and check that they are indeed comparable.

5 Results from experiments

5.1 Descriptive statistics of the characteristics of the subjects

The first part of this section will be devoted to analysing the socio-demographic variables from the questionnaire to make sure that the two groups, from the referendum and the Vickrey auction, are really comparable. Later, in section 5.3 (page 44), we will try to see if these statistics can explain the decisions of the subjects.

The experiment was carried out in a laboratory, thus suffering from the traditional limitations of lab experiments, meaning that the pool of subjects might not be representative of the population outside the laboratory. Yet the relatively large number of subjects in the pools for referendum and Vickrey auctions implies that the results from the experiment suggests a direction that is relevant.

5.1.1 Age Groups and Gender

The subjects in both experiments are young and the gender is relatively balanced within the most represented age groups. In both groups, the most represented age groups is from 18 to 22 years old, and the second most

represented the one from 22 to 25 years old (see Table 2, page 26). As a consequence, subjects from 18 to 25 years old represent 63.53% of the pool for referendum and 86.11% for Vickrey. All age groups are represented in the sample. The proportions in both pools of subjects are similar, so the identification strategy should not be violated with respects to the demographic characteristics of the subjects.

Table 2: Age groups by gender

	(a) Referendum (%)			(b) Vickrey auction (%)		
Age groups (years)	Male	Female	Age group /Total pop.	Male	Female	Age group /Total pop.
18 to 22	0.52	0.48	43.40%	0.59	0.41	61.11%
22 to 25	0.41	0.59	20.13%	0.89	0.11	25.00%
25 to 35	0.54	0.46	16.35%	0.50	0.50	11.11%
35 to 50	0.87	0.13	9.43%	0.00	1.00	2.78%
50 to 70	0.65	0.35	10.69%	0.00	0.00	0.00%
Total	0.55	0.45	100	0.64	0.36	100

We run a non-parametric Kolmogorov-Smirnov test to verify the null hypothesis that the distributions of ages and genders are the same among the Vickrey and the referendum groups (see Table 15, page 51). In the case of genders, we accept the null hypothesis that the two distributions are equal with a p-value of 0.959. In the case of ages, we find a p-value of 0.068, thus we reject the null hypothesis of equality of the distributions. This might be

due to the difference in sample size. We will later verify in section 5.3 (page 44) that the gender has no major impact on the results.

5.1.2 Budget and Financial Aid from Parents

The majority of the subjects had a monthly budget of less than 500 euros per month (see Table 3). Most of them would receive financial aid from their parents (variable “Aid” in the table), in the pool for the Vickrey auctions, but not in the pool for referendum. The relative small budget is peculiar to a population which is mainly composed of students. Even though the pool for Vickrey auctions is underrepresented for categories of budget above 500 euros per month, the proportions in terms of budget are comparable, hence suggesting similar financial characteristics.

To check that there are no composition effects, we choose to run a Kolmogorov-Smirnov test. We want to verify the null hypothesis that the distributions of budget and financial aid from parents are the similar in the two samples (see Table 15, page 51). We assume that the two distributions of financial aid from parents are statistically the same in the two groups with a p-value of 0.182. In the case of budget, we find a p-value of 0.006, thus we reject at 1% the null hypothesis of equality of the distributions. Yet, we will later see that this is unlikely to have a major impact on the results (see section 5.3, page 44).

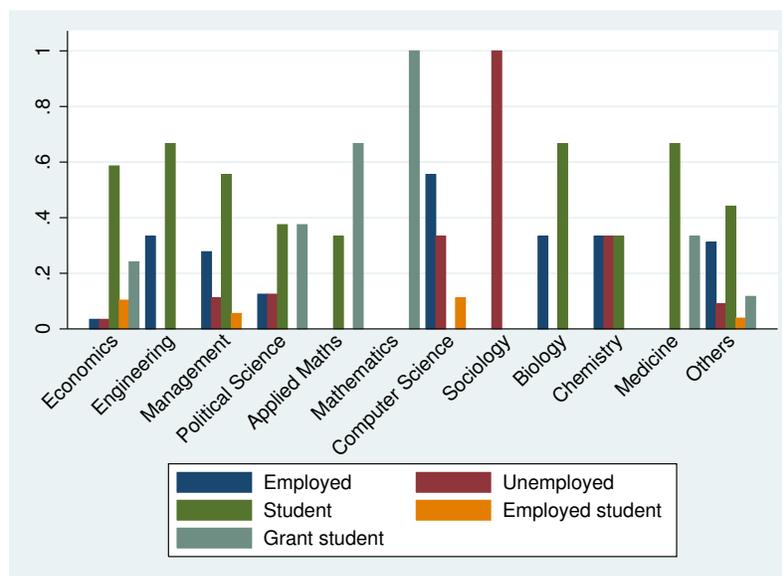
Table 3: Budget and financial aid from parents

Budget (euros per month)	(a) Referendum (%)			(b) Vickrey auction (%)		
	No Aid	Aid		No Aid	Aid	
Less than 500	0.46	0.54	45.28%	0.37	0.63	75.00%
500 to 750	0.33	0.67	13.21%	0.25	0.75	11.11%
750 to 1 000	0.53	0.47	10.69%	0.00	1.00	2.78%
1 000 to 1 500	0.82	0.18	13.84%	0.50	0.50	5.56%
1 500 to 2 000	0.94	0.06	10.69%	1.00	0.00	5.56%
More than 2000	0.90	0.10	6.29%			
Total	0.58	0.42	100	0.39	0.61	100

5.1.3 Discipline and status

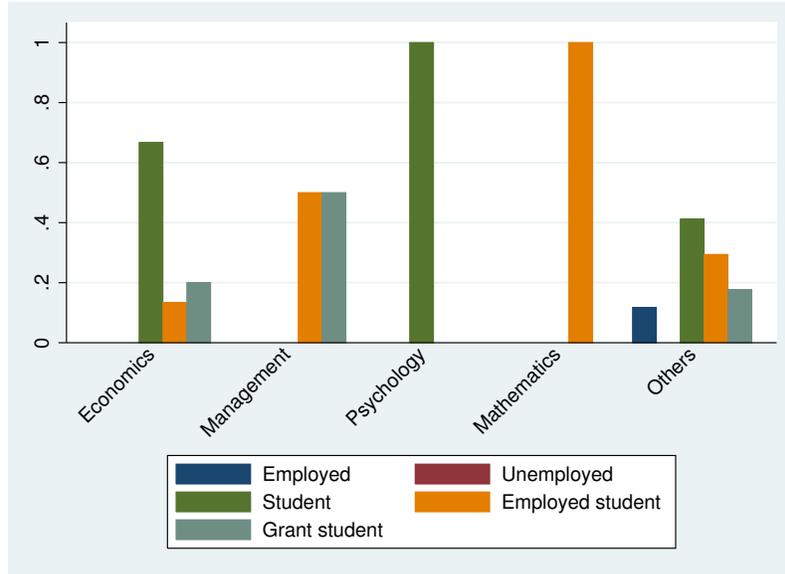
In terms of discipline and status, the smaller pool of subjects in the case of Vickrey auctions becomes apparent (see Figures 1 and 2 ; also see Table 11, page 46 and Table 12, page 47). The pool of subjects for referendum represents a higher variety of disciplines and status. Yet, in both groups, the majority of the subjects are students, with a majority of them studying economics and management.

Figure 1: Discipline and status (Referendum)



By running a Kolmogorov Smirnov test, we reject the null hypothesis that the distributions are statistically equal in terms of discipline and status, with p-values respectively equal to 0.053 and 0.007. Again, section 5.3, page 44, will show why this is unlikely to have a major impact on the results.

Figure 2: Discipline and status (Vickrey)



5.1.4 Familiarity with context

The two pools of subjects are again similar when it comes to their familiarity with context. Almost none of the subjects in both pools were a member of an association for the protection of the environment. More than 80% of them had heard of WWF, yet rare were the subjects who were familiar with the adoption program for dolphins of the NGO, and even fewer were the ones who had already adopted an animal for the protection of nature (see Table 4, page 31).

The difference between the two groups is that subjects who took part in the referendum experiment have on average a higher experience with experiments in economics than the ones from the Vickrey pool (respectively 72.30%

Table 4: Familiarity with context

Variable	Vickrey		Referendum	
	Mean	Std. Dev.	Mean	Std. Dev.
Exp Econ	0.583	0.494	0.723	0.448
Association for the environment	0.000	0.000	0.088	0.284
Has already heard of WWF	0.861	0.347	0.830	0.376
Knew adoption programme	0.056	0.230	0.119	0.325
Already adopted an animal	0.028	0.165	0.057	0.231

against 58.83%, see Table 4). However, the Kolmogorov Smirnov test accepts the null hypothesis of equality of distributions with a p-value equals to 0.532 (Table 15, page 51).

5.2 Outcomes

5.2.1 Results: Average Votes and Bids

For each subject, we have five observations of vote. Indeed, each subject was voting five times and then one period was picked at random to determine the final gain of this subject. Thus the data we have is panel data. In order to use the precision offered by panel data, we could have used the mean per subject. Yet, this would have been difficult to analyse for the referendum, as the variable of interest is binary. Indeed, it does not make sense for a subject to “vote yes at 40%”. Thus, we decided to keep only one period out of the five. We decided not to use the first period to avoid the learning aspect. Out of the four remaining periods, we could use indifferently either one,

especially as the results were very similar for each of them (does not appear in the paper). We could also have used the last period because subjects did not know the number of periods, precisely to avoid end-game effects. We randomly chose to use a period, in our case, period 2.

Results Referendum On average, 38.75% of the votes of subjects were in favor of the adoption of the dolphin, for the referendum either at 6 or 11 euros (see Table 5, 33). The distribution of votes is slightly right-skewed, with a positive skewness of 0.462. It is also leptokurtic, with a more acute peak and fatter tails. From the quizz, subjects earned on average 18.31 euros, with a total maximum of 22.50 euros. As the subjects get 10 euros initially, the previously expressed worry that a subject gets less than 1 euro from the quizz is eliminated as the lowest earning has been 12.50 euros.

The mean earnings from the quizz are very similar in both the Vickrey and the referendum groups, suggesting similar ability to answer the questions, respectively 18.74 and 18.31.

Results Vickrey To keep consistency in the comparison between the referendum and the Vickrey auction, we also only keep the bids from period 2.

On average, subjects bid 10.58 euros to adopt a dolphin (see Table 6 below). This average bid is slightly below the 11 subject to vote in the referendum, but with a lot of variation as the standard deviation is larger than 10. On average, the winner bids 19.25 euros but pays 19 euros, which means

Table 5: Results of referendum (Period 2)

Stats	Voted to adopt	One-period Gain	Earnings Quizz	Final gain
Mean	0.3875	-3.8438	18.31	14.4656
Median	0.000	0.000	18.50	15.750
Std Dev.	0.489	4.889	2.312	4.712
Range	1.000	11.000	10.000	18.000
Skewness	0.462	-0.610	-0.236	-0.396
Kurtosis	1.213	1.541	2.363	2.017
N	160	160	160	160
Range	1.00	11.00	10.00	18.00
Min	0	-11	12.50	4.50
Max	1	0	22.50	22.50

that there is not much difference between the first and second bid in general, even if again there is a lot of variation. Based on our results in this specific setting and for this peculiar good, the practical argument against Vickrey, stating that it generates low revenues, is left out. The distribution of bids is slightly right-skewed and leptokurtic, suggesting a relatively symmetric and slightly “peaked” distribution.

Table 6: Results of Vickrey

Stats	One-period Gain	Earnings Quizz	Bid	Group Highest Bid	Price paid By Winner
Mean	-2.11	18.74	10.58	19.25	19.00
Median	0.00	18.50	4.50	21.50	21.00
Stdv. Dev.	7.170	2.276	11.470	11.370	11.519
Skewness	-3.463	-0.033	0.677	-0.232	-0.180
Kurtosis	13.564	1.938	1.818	1.303	1.237
N	36	36	36	36	36
Range	30.00	8.50	30.00	26.00	26.00
Min	-30.00	14.00	0.00	4.00	4.00
Max	0.00	22.50	30.00	30.00	30.00

Comparaison Results Vickrey and Referendum in real context It is no easy task to compare the results from the Vickrey auction and the referendum, because the first one generates a continuous variable whereas the

second generates a dummy variable. In order to be able to compare the two, we decide to create a dummy variable “vote” for the Vickrey auction, which is equal to 1 if the bid was above 11 euros and equal to 0 if the bid was below 11 euros for the period 2 (see Table 7, page 35). We repeat the mechanism for the referendum with a value of 6 euros. Creating this dummy variable allows to better compare the two mechanisms even though the type of data is so different that even simple comparisons become complicated.

Table 7: Votes in Referendum (a) and Vickrey (b)

Stats	Real		Hypothetical	
	(a)	(b)	(a)	(b)
Mean	0.183	0.111	0.567	0.667
Std. Dev.	0.390	0.323	0.500	0.485
Skewness	1.637	2.475	-0.269	-0.707
Kurtosis	3.679	7.125	1.072	1.500
N	60	18	60	18

Using these dummy variables, we can compare the revelation properties of the two mechanisms and the extent of the hypothetical bias in both situations. For example, the mean vote in the case of real Vickrey is 11.10% against 18.30% for the real referendum, with a similar standard deviation. Both mechanisms do not reveal preferences in the same way. The Vickrey auctions seem to underestimate the preferences compared to referendum in real contexts. However, this difference is not statistically significant, as the

Kolmogorov-Smirnov test gives a p-value of 4.474 when testing the equality of distributions (see Table 10, page 43).

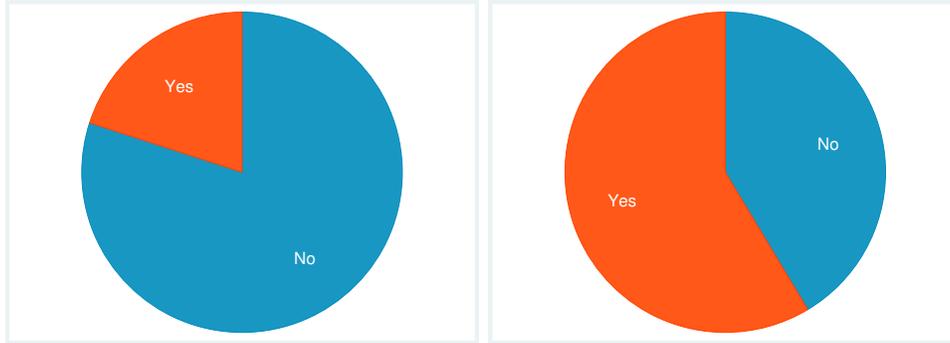
Subsequent to the research question, we now know that the two mechanisms are statistically equally close to the true underlying preferences in a real context. However, this does not tell anything about the true underlying preferences. This result is interesting because it shows that the revelation properties of Vickrey and referendum are empirically similar in a real context.

5.2.2 Hypothetical Bias

After having shown that both mechanisms have similar performances in real contexts, we will now compare them in a hypothetical context. As the literature review suggested, both the referendum and the Vickrey auction are subject to hypothetical bias.

Hypothetical Bias in Referendum In case of the referendum, 57.50% of the subjects voted in favor of the adoption of the dolphin when the referendum is hypothetical, against only 20% of the subjects in case of a real referendum (see Table 8, page 37). There is a difference of 37.50 points between the two situations, which is graphically striking (see Figure 3). It is interesting to underline that the real votes are left-skewed, whereas the hypothetical votes are right-skewed. The ratio of the mean vote in real versus hypothetical bias using the referendum is of 2.88. These results are above the

Figure 3: Referendum: Real (left) and Hypothetical (right) Votes



ones found in the literature. For example, the experiment by Taylor (1998) indicated a proportion of *yes* in the real case of 17.9 percentage points higher than in the hypothetical case, along with Krawczyk (2012), who finds a ratio of hypothetical to real of about 1.37.

Table 8: Referendum: Real and Hypothetical Votes

Stats	All votes	Real Votes	Hypothetical Votes
Mean	0.388	0.575	0.200
Std. Dev.	0.489	0.497	0.403
Skewness	0.462	-0.303	1.500
Kurtosis	1.213	1.092	3.250
N	160	80	80

Hypothetical Bias in Vickrey The Vickrey auctions are also very prone to the hypothetical bias. By translating the bids into votes for the refer-

endum, we can conclude that the ratio of the mean votes in a hypothetical context versus a real context is of 6.12. In order to avoid threshold effects, we changed the value of a bid of 11 for a “*yes*” vote to 10 or 9, but this does not change much to the ratio of real to hypothetical. This is because of the very uneven distribution of the bids, as shown in Figure 4 (page 40). There is only a very marginal change in the bids around the value 11.

Here again, the results of hypothetical bias are higher than previous results found in the literature. Let’s recall that the results by List (2001) and Blumenschein et al. (1997) were giving a real to hypothetical ratio in the case of Vickrey auctions of respectively 1.85 and 3.69.

Two graphs depict the hypothetical bias very well. The first one shows the distributions of the bids in the Vickrey auctions (Figure 4, page 40). The difference is eye-catching, with a lot of subjects bidding zero in the case of the real auction, both in absolute terms and in comparison with the hypothetical case. This is backed up by Figure 5 (page 41), which shows that on average, more than 50% of the bids were between 0 and 1 euro when the auction was real. This means that a lot of subjects refused to take part in the auction when it became real, or chose to opt-out, whereas only a fraction of them showed no interest in a hypothetical situation. More precisely, the average bid when the auction is real was worth 2.97 euros, against 18.19 euros in the hypothetical case (see Table 9, page 39). Contrastingly, the distribution of real bids is left-skewed whereas the distribution of hypothetical bids is left-skewed.

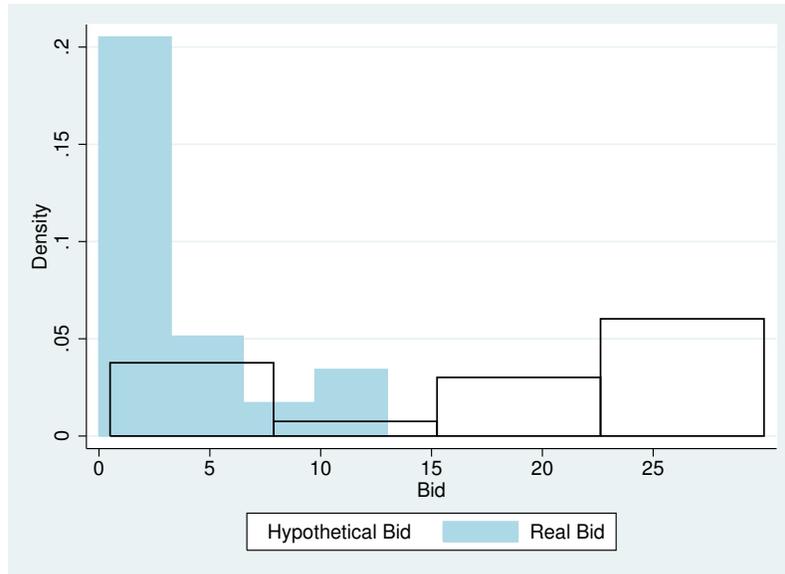
Table 9: Vickrey: Real and Hypothetical Bids

Stats	All Bids	Real Bids	Hypothetical Bids
Mean	10.583	18.194	2.972
Std. Dev.	11.470	11.474	4.067
Skewness	0.677	-0.444	1.486
Kurtosis	1.818	1.597	4.035
N	36	18	18

Comparison Hypothetical Bias Vickrey and Referendum From pure descriptive statistics, we can observe that the hypothetical bias seems higher in the Vickrey auctions than in the referendum, for both values of 6 and 11 euros. There is a higher proportion of people voting “yes” in the hypothetical case with Vickrey, yet a lower proportion of people voting “yes” in the real case. This difference is graphically stratling, as in the Figures 6 (page 42) and 7 (page 48). The ratio of real to hypothetical votes in Vickrey is more than twice as much than the one in referendum, which is of 2.88.

However, in order to show the robustness of this result, we need a reliable statistical test. We choose to use a non-parametric test, the Wilcoxon test, to verify the null hypothesis that the two distribution functions are identical. We choose not to use a classical t-test as we can not assume that our distributions are normally distributed and the variances are not the same. In

Figure 4: Distributions of Vickrey auctions: Real and Hypothetical

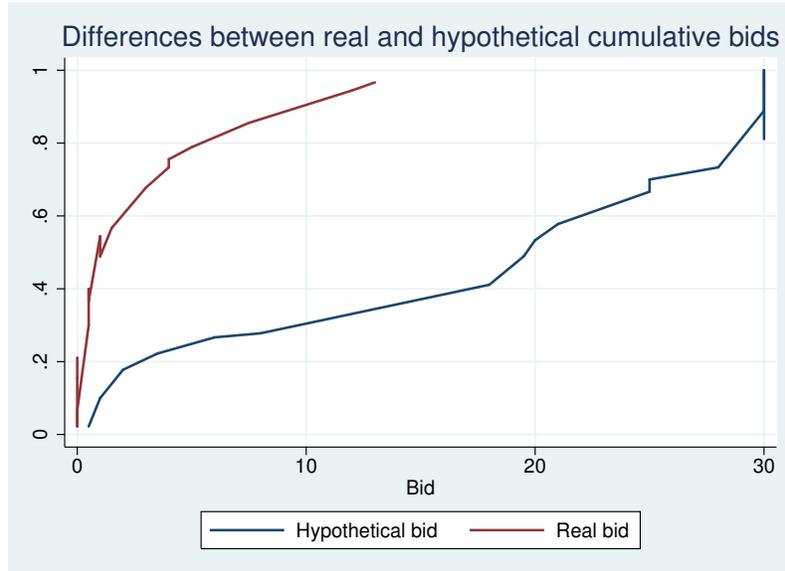


addition, the groups from the two treatments are independent, so the conditions for this test are not violated.

For the real and hypothetical bids in Vickrey, we check the null hypothesis that the mean difference between the two groups is equal to zero. By running the Wilcoxon test, we find a p-value equal to 0.000, meaning that we reject the null hypothesis at the 1% level (Table 10, 43). We do this test again dropping the 10% of downwards and upwards values and we find the same (does not appear on the table).

For the real and hypothetical votes in referendum, we do the same and verify the null hypothesis that both votes are equal. We again reject the null hypothesis at 1% (Table 10). From this perspective, the results in terms

Figure 5: Vickrey auctions: Difference between cumulative real and hypothetical votes

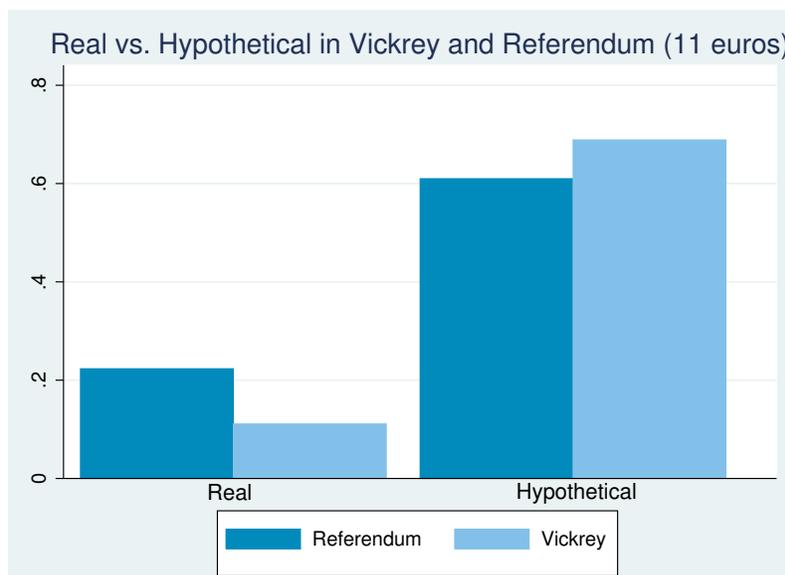


of hypothetical bias can be confirmed in the sense that they are not due to random sampling.

Now we want to test if the hypothetical votes in the Vickrey and the referendum case are equal. Here we can not use the Wilcoxon test because of the dichotomous nature of the data and thus we choose to use a Kolmogorov-Smirnov test, to check the possibility of the two groups following the same distributions. In the hypothetical case, we find a p-value of 0.452, thus we reject the null hypothesis that the votes in Vickrey and referendum follow the same distribution.

Interestingly, we show that the distributions of votes for referendum and

Figure 6: Vickrey auctions and Referendum at 11 euros: Hypothetical Bias



Vickrey are not statistically different, neither in real nor hypothetical context.

5.2.3 Opting-Out Effect

In the results, we have seen that there were a lot of zeros in the case of Vickrey auctions. In that case, the opting-out effect might be at play. This effect is the fact that people vote zero as a way to go out of the mechanism. These zeros are false zeros, thus we are wrong when we think they contribute to the revelation of preferences. Yet, there are also true zeros. As a consequence, the bottom of the distribution is constituted by both false and true zeros and makes the interpretation of the zeros very difficult. The opting-out effect disturbs the revelation of preferences. This would be one of the reasons explaining the difference between real and hypothetical bids.

Table 10: Statistical Tests

Test	Situation	P-value
Wilcoxon	Vickrey real=hyp	0.000
	Referendum real=hyp	0.000
Kolmogorov-Smirnov	Real Vickrey=Referendum	0.474
	Hyp Vickrey=Referendum	0.452

The opting-out effect potentially exists for both Vickrey and referendum. Yet, there are even fewer ways to identify the false zeros in the case of referendum as the outcome is binary. Thus, we can not compare the two mechanisms under the light of the opting-out effect, but we should keep in mind that it exists.

Herein we propose a few elements of interpretation for the potentially large rates of opting-out effect, which are not conclusive. On the one hand, adopting a dolphin is a private good with specific characteristics. This good has a political dimension. Thus, it could be that there is only a small incentive to adopt a dolphin, as the subjects know that anyways someone will adopt the dolphin. The personal reward for personally adopting a dolphin is relatively small. As a consequence, it could be that there is an incentive to bid lower than one's true valuation. This would be a way to understand why the zeros, and potentially false zeros, are high.

On the other hand however, this explanation does not really hold as

money goes to more global actions, so there is still an incentive to bid more. In addition, there is no reason to think that this would interact with the treatment, thus the political dimension does not pollute the effects of the treatments. This is because the good is largely privatized, as the bids influence the true amount of money given to the WWF.

To sum up, subjects have an incentive to reveal their true values. Yet, it could be that the genuine private aspect of the good has been underestimated by the subjects.

5.3 Explaining Results with characteristics of subjects

In order to explain the choices of subjects, we regressed the decisions of subjects in referendum and Vickrey on the socio-demographic characteristics of the subjects, as well as those who relate to the familiarity of context. We did so for both real and hypothetical contexts. We decided to omit the variables “is part of an association for the protection of the environment” as well as “has already adopted an animal for the protection of nature”, as those were equal to 0 for all subjects (or all minus one subject) in the case of both Vickrey and referendum.

Interestingly, we find that in the case of referendum, the decisions are only very marginally affected by these characteristics. The explanatory power of these characteristics is very low, around 6% in the case of referendum (see in annex Table 13, page 49). In the case of Vickrey, the explanatory power

of the characteristics is much higher, around 30% (Table 14, page 50). This is partly due to the very high constant, it gives some hindsight about the factors affecting the bid, but none of those are statistically significant.

These results give some direction to explain the results but the explaining rates remain low. It might be due to the relative homogeneity of the characteristics of the subjects.

6 Conclusion

The results from the experiment tells us that the two mechanism have comparable properties. The Vickrey auction seems to understate the true underlying preferences compared to the referendum but this is not statistically significant. We have no way to know the true underlying preferences, but we know that both mechanisms are statistically as close to the true preferences. The non significant underestimation for the Vickrey auction might be partly explained by the strong rates of opting-out in the real experiments. Whether these drop-outs reflect the preferences of subjects remains unresolved.

In addition, the Vickrey auctions seems more prone to the hypothetical bias than the referendum, as the gap between real and hypothetical bids is higher in the case of a Vickrey auction than a referendum. Thus, with respect to the hypothetical bias, it seems that referendum voting is a more accurate mechanism than Vickrey auctions.

7 Annex

7.1 Status and Discipline

Table 11: Status and disciplines, Vickrey auction

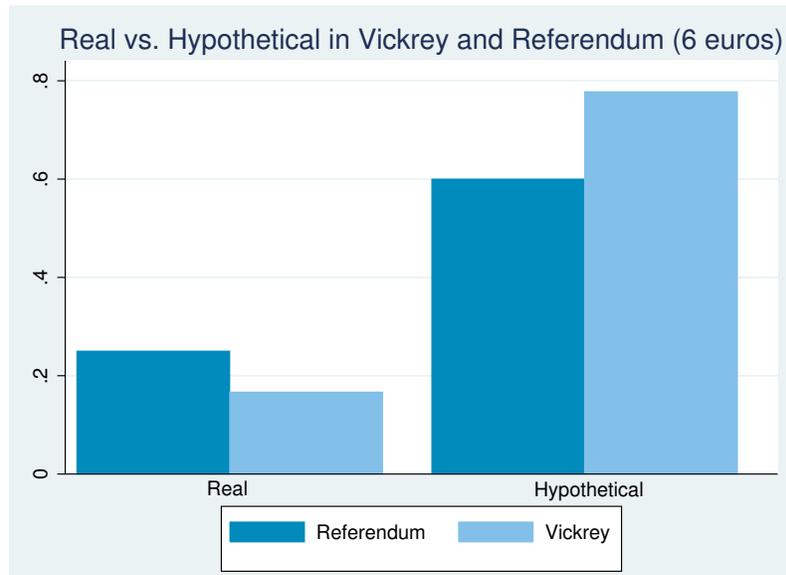
	Employed	Student	Empl. student	Grant student	Total
Economics	0	10	2	3	15
Management	0	0	1	1	2
Psychology	0	1	0	0	1
Mathematics	0	0	1	0	1
Others	2	7	5	3	17
Total	2	18	9	7	36

Table 12: Status and disciplines, Referendum

	Employed	Unempl.	Student	Empl. stud.	Grant stud.	Total
Economics	1	1	17	3	7	29
Engineering	1	0	2	0	0	3
Management	5	2	10	1	0	18
Political Science	1	1	3	0	3	8
Applied Maths	0	0	1	0	2	3
Mathematics	0	0	0	0	1	1
Computer Science	5	3	0	1	0	9
Sociology	0	2	0	0	0	2
Biology	1	0	2	0	0	3
Chemistry	1	1	1	0	0	3
Medicine	0	0	2	0	1	3
Others	24	7	34	3	9	77
Total	39	17	72	8	23	159

7.2 Comparisons with Referendum at 6 euros

Figure 7: Vickrey auctions and Referendum at 6 euros: Hypothetical Bias



7.3 Explaining results by characteristics

Table 13: Explaining Factors Referendum (explained variable: vote)

	(1)	(2)	(3)	(4)
VARIABLES	REALSocioEcon	REALContext	HYPSSocioEcon	HYPContext
Age	0.00563 (0.00488)	0.00539 (0.00498)	0.00795 (0.00604)	0.00802 (0.00620)
Gender	0.0306 (0.0969)	0.0252 (0.0989)	0.142 (0.115)	0.150 (0.118)
Exp econ	0.00115 (0.110)	0.00234 (0.123)	-0.0108 (0.136)	-0.0126 (0.139)
Budget	0.0171 (0.0382)	0.0160 (0.0388)	-0.00668 (0.0461)	-0.00165 (0.0489)
Aid parents	0.0933 (0.111)	0.0843 (0.113)	0.0841 (0.127)	0.0981 (0.131)
Knows WWF		0.111 (0.114)		-0.127 (0.203)
Knows adopt		-0.0591 (0.138)		-0.102 (0.195)
		(0.00668)		(0.00516)
Constant	-0.0566 (0.185)	-0.130 (0.219)	0.275 (0.218)	0.392 (0.292)
Observations	79	79	80	80
R-squared	0.047	0.060	0.045	0.056

Table 14: Explaining Factors Vickrey (explained variable: bid)

	(1)	(2)	(3)	(4)
VARIABLES	REALSocioEcon	REALContext	HYPsocioEcon	HYPContext
Age	-0.791 (0.560)	-1.012 (0.604)	-0.166 (0.533)	-0.289 (0.542)
Gender	-0.577 (2.460)	-0.323 (2.531)	-2.948 (7.690)	1.095 (8.794)
Exp econ	0.419 (2.741)	2.028 (3.119)	3.861 (6.463)	11.78 (8.802)
Budget	-0.470 (0.914)	-0.535 (0.979)	1.753 (3.361)	2.595 (3.102)
Aid parents	1.019 (2.079)	1.259 (2.335)	-2.101 (7.697)	0.110 (7.137)
Knows WWF		1.820 (3.699)		-19.27 (11.75)
Knows adopt		-5.335 (4.815)		10.13 (14.70)
Constant	20.49* (11.37)	23.01* (12.40)	19.60 (14.01)	29.05* (15.13)
Observations	18	18	18	18
R-squared	0.309	0.395	0.109	0.380

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 15: Statistical Tests Characteristics

Test	P-value
Kolmogorov-Smirnov	0.068
Age groups Vickrey=Referendum	0.068
Gender Vickrey=Referendum	0.959
Budget Vickrey=Referendum	0.006
Aid Parents Vickrey=Referendum	0.182
Discipline Vickrey=Referendum	0.053
Status Vickrey=Referendum	0.007
Experiment Econ Vickrey=Referendum	0.532
Earnings Vickrey=Referendum	0.000

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