The Reference Price Is Not the Limit: Analysis of Consumer Valuations in Second-price Vickrey Auction

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Abstract

We assess the role of perceived reference price (PRP) in consumers' valuations for four different bread types in second-price Vickrey auctions taking into account the presence of market substitutes. A possible censoring effect of perceived reference price is modeled using a random effects Tobit model with lower and upper thresholds. The estimates are compared to a random effects Tobit model censored at zero only. In contrast to the existing literature, our results indicate that including perceived reference price in upper threshold does not improve the model fit and thus question the role of PRP as an upper limit for auction bids.

Keywords: perceived reference price, Vickrey auction, market substitutes

1   Introduction

Value elicitation tasks such as the second-price Vickrey auction are often used in economics and marketing research to elicit consumer preferences and homegrown values. The second-price Vickrey auction and variants thereof such as the n-th price or random auction are tailored to reveal truthful valuations of auctioned goods. The theory behind the procedure states that the optimal strategy for the auction participant is to bid the amount that equals truthful valuation of a good (Vickrey, 1961), thus revealing the true preferences regarding the good. However, in the presence of market substitutes, censoring effects of perceived reference price can be critical. When substitute goods are available out of the lab, consumers do not have an incentive to bid higher than the perceived reference price, which might cause the demand curve to bend backward (Monroe, 1971).

It has been discussed in the literature that external market price can influence bids during lab experiments. Harrison, Harstad, & Rutström (2004) state that if participants are aware of the existence of substitutes outside the lab, which are priced lower than the ones in the experiment, being rational agents they prefer the outside option. Cherry, Frykblom, Shogren, List, & Sullivan (2004) coin the term "bid shaving" to describe strategies in a second-price auction. They find that the presence of outside option significantly lowers the bids and that this effect exists in both hypothetical and real auctions. Lusk & Shogren (2007) develop this idea by stating that if bids are censored by the market price of perfect substitutes, then bids are not equal to the value of the product. Alfnes (2009) supports this evidence by investigating weakly dominant strategies for Vickrey auction participants when market substitutes are available. According to the results of his study, the optimal bid is equal to or lower than the market price of the auctioned good. This result is supported by Colson et al. (2010) who assess if auction bids are censored by market or perceived prices. Results of their regression analysis show that not acknowledging the presence of upper censoring threshold in the bid data leads to diminished model fit and biased estimates.

The presence of reference prices for outside goods hence requires care with regard to the estimation of WTP in econometric models. Bids elicited in second-price Vickrey auctions are usually analyzed

with Tobit models that are censored at zero, as there are no negative bids. The literature on auctions for goods that have close market substitutes suggests that the perceived reference price can be included in the upper limit in Tobit models. What remains unclear, however, is how important reference prices are for a product with novel characteristics. Auctions are often employed to evaluate product characteristics for which not market exists (yet). Therefore market substitutes are not readily available if consumers evaluate characteristics as distinctive.

In this paper, we investigate if the existing evidence on perceived reference price as an upper limit for auction bids from above is supported by the data obtained from second-price Vickrey auction for four different bread types. Three types of breads resemble those that are currently available in the market, while the fourth one is currently not available. We employ the results of the experiment performed to elicit willingness to pay for healthy attributes in bread, where the perceived reference price was elicited before the auction. We fit Tobit models assuming different roles of perceived reference price in respondents' valuations and further analyze the correlations between predicted values and actual bids.

The paper is organized as follows: next section describes the experiment, in section 3 we analyze the results of the auction and in section 4 we present our conclusions and discussion.

2   The experiment

The data used in this paper are obtained from a set of experimental auctions, which were a part of a bigger project aimed at eliciting consumers' willingness to pay for health-enhancing properties in cereals. The auction sessions were conducted in December 2014 and employed four types of bread: conventional whole grain bread, organic whole grain wheat bread, whole grain purple wheat bread from an ancient wheat variety, and whole grain spelt bread. Participants of the auctions were 131 students from the University of Applied Sciences in Hamburg. In total eight sessions were performed with 10 to 20 participants per session. The participants received € 15 as an incentive and participation compensation. The socio-demographic characteristics of the participants are presented in Table 1.

Each auction session consisted of three blocks:

1)   Upon arrival, participants received the first part of the questionnaire, participated in a blind tasting of all four breads and gave hedonic scores on look, smell, taste, and texture of each bread type. A first round bidding elicited WTP.
2)   Thereafter, participants filled in the second part of the questionnaire and were allowed further visual inspection of bread samples and received additional information as indicated in Figure 1. The second round of bidding followed.
3)   In the final round, participants underwent a full information tasting and were prompted for hedonic scores on all four breads. A third part of the questionnaire and a third round of bidding concluded the auction.

To avoid bias related to the fact that participants bid simultaneously on several substitute goods, we choose only one round and one type of bread to be binding, meaning that participants could purchase only one good during the auction (Roosen, Fox, Hennessy, & Schreiber, 1998; Rousu, Beach, & Corrigan, 2005).

As suggested by Alfnes (2009) participants should know the value of outside option and this value should be the same for all the auctioned goods given that relatively close attributes are evaluated during the auction. We control for the knowledge of the market value by only choosing participants who consume bread regularly. Following the procedure proposed by Hu, Adamowicz, & Veeman (2006), consumers' perception of the prices paid regularly for 500 gr. bread was asked in the first part

of the questionnaire, i.e. before the bidding procedure began, with the question: "How much do you usually pay for 500gr bread?" The mean value of perceived reference price (PRP) was 2.01 euro[1].

As stated above, the auction procedure was combined with blind (round 1) and full information tasting (round 3) and after each tasting participants submitted hedonic scores (Table 2). Participants were required to evaluate each bread type on a 7-point hedonic scale (from 1 – dislike very much to 7 – like very much) in the four dimensions look, smell, taste and texture.

The additional information about the breads that was provided between the rounds improved the hedonic scores for organic, purple and spelt breads significantly. However, for conventional bread there was only an insignificant increase in the scores for look, smell and texture, while the score for taste even decreased.

3   Analysis of results

Table 3 presents bids submitted in the first zero information round and the last full information round. In the first round, the highest average bid was submitted for conventional bread whereas the lowest bid was submitted for purple bread. The average bids increased for organic, purple and spelt bread, however for conventional bread the average bid decreased slightly in the third round, demonstrating that additional information regarding conventional bread almost did not change consumer valuations. This result corresponds to hedonic scores reported in Table 2.

Correlations between sensory and monetary valuations for the pooled data are (significant at 1% level): for organic bread 0.44, for purple – 0.39, for spelt – 0.45; and for conventional bread – 0.40. Considering rather weak correlations between monetary and hedonic valuations, we further investigate if the reference price played a significant role in the formation of bids. Table 4 shows the distribution of auction bids in relation to the reference price. Most of the bids are below or equal to the reference price, including a significant number of zero bids. This result might support previous evidence on the effect of reference price serving as an upper limit for auction bids. Participants bid below perceived reference price as they consider market substitutes easily available and, consequently, do not have an intention to purchase good at a higher price in the lab experiment.

Additional information increases the number of bids above the reference price and decreases zero bids. Bids above the reference price can be explained by individual preferences regarding the auctioned bread types or by subjective valuations of transaction costs (Bernard & He, 2010). In our experiment, the decreased number of zero bids might reflect individual preferences regarding different bread types, which surfaced after receiving additional information about the breads.

As suggested by Bernard & He (2010) and Harrison et al. (2004) it is optimal for the participant to submit a bid which is equal to the valuation of the good if this valuation is smaller than the price of the market option and transaction costs associated with purchasing the good outside the lab. However, in a situation where the valuation of the auctioned good is more than the sum of transaction costs and perceived price, then the optimal strategy is to purchase the good outside the lab. Assuming that transaction costs associated with bread purchase outside the lab are rather low, bids are determined mainly by the reference price.

Table 5 presents mean differences between bids in the first and third round, respectively, and perceived reference price. Differences between bids and reference price decreased between rounds, which can be attributed to the information effect. Specific information about healthy attributes in auctioned breads reduces the uncertainty about the type of bread participants are bidding for. As a result, it can either decrease the substitution effect or increase transaction costs associated with

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[1] The average consumer price for a 500 g loaf of bread in Germany in 2014 was at € 1.16 (http://de.statista.com/statistik/daten/studie/425381/umfrage/brotpreis-in-deutschland/).

purchasing the bread outside the lab. Again, bids for conventional bread exhibit different dynamics than the bids for the other bread types. The difference between bids for conventional bread and the reference price slightly increased, which is perhaps related to the fact conventional bread is perceived as some kind of staple product.

Tobit models are often employed to analyze the effect of posted reference prices on bids in repeated trials Vickrey auction (Cherry et al. 2004; Drichoutis, Nayga, & Lazaridis, 2011; Drichoutis, Lazaridis, & Nayga, 2008) to take into account the censored nature of the data. We estimate models for each bread type and for two auction rounds. The full list of variables included in the estimations is presented in Table 6.

First, we assume that the observed data is censored at both lower and upper thresholds. The lower threshold is zero, while the upper threshold is equal to the reference price if the bid is equal to reference price or lower and if the bid exceeds reference price, then the threshold is equal to the bid (Harrison et al., 2004; Colson et al., 2010). Hence, Bid_i^* is the observed value censored at 0 and τ according to the latent variable Bid_i as shown in the following equation.

$$(1) \qquad Bid_i^* = \begin{cases} 0 \; if \; Bid_i \leq 0 \\ Bid_i \; if \; 0 < Bid_i \leq \tau \; ; \\ \tau \; if \; Bid_i > \tau \end{cases}$$

where $\tau = \begin{cases} RP \; if \; Bid_i \leq RP \\ Bid_i \; if \; Bid_i > RP \end{cases}$

Second, to measure the effect of the reference price we also estimate random effects Tobit models censored only at 0.

$$(2) \qquad Bid_i^* = \begin{cases} 0 \; if \; Bid_i \leq 0 \\ Bid_i \; if \; Bid_i > 0 \end{cases}$$

The results of the estimations are presented in Tables 7 (model 1) and 8 (model 2).

The models provide a good fit and the signs of the coefficients are as expected. Negative coefficients are observed for consumption frequency and gender indicating that lower bids are submitted by males frequently consuming bread. Coefficients for the reference price are insignificant for purple bread in the first round and for organic and conventional bread in the third round in Tobit models with lower and upper limits. In models with censoring at the lower limit only, the coefficients for reference price are significant in all estimations. It can also be observed that taste is significant in all the estimations which is an expected result regarding consumer preferences.

To evaluate model performance, we report the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). According to these criteria, traditional Tobit models with censoring only at zero provide a better fit in describing the data for all four bread types in the first auction round. The result is the same for the third round with the exception of organic bread. Results indicate that previous evidence on the role of perceived reference price as an upper limit for auction bids is not supported by our data. We further look at the correlations between the predicted values and actual bids (Table 9). Correlations support the evidence that Tobit with upper and lower limits does not provide an improvement in the model fit over a Tobit estimation with censoring at zero only.

4   Conclusion and discussion

The aim of this paper is to investigate the role of perceived reference price in consumers' valuations of different bread types during second-price Vickrey auction. The perceived reference price is included in Tobit models as an explanatory variable, thus reflecting consumer preferences for bread and as an upper limit reflecting the presence of outside substitutes. We specifically explore if the inclusion of reference price in upper threshold in Tobit model provides an improvement in model fit.

We estimate Tobit models with lower and upper limits, where the lower limit censors data at zero and the upper limit censors data at the reference price if the bid is equal or below reference price and at the bid if the bid is higher than the reference price. These models for each bread type and each auction round are compared to Tobit models with only lower limit at zero. A comparison of the models demonstrates that inclusion of the reference price as an upper limit does not provide any improvement in model fit and in some cases even decreases the fit. This finding contradicts previous literature on the topic.

Additionally, we look at the correlations between predicted values from all the models and the real bids. Correlations vary between 52% and 68% and support the same evidence – the inclusion of reference price in upper limit does not add the validity to the models.

Moreover, in the models with an only lower limit, the coefficient for the reference price is significant in all estimations, while in the models with both lower and upper limits the coefficient before reference price is insignificant in some cases. This result gives an indication that the role of perceived reference price might not be limited to serving as an upper threshold because of market substitutes, but more as a reference point or an anchor. Hence, the anchoring effect can potentially explain the relationship between perceived reference price and auction bids. However, in this case, the bids are not censored from above but vary around reference price, both in positive and negative directions. The direction of deviation from reference price, in this case, is determined by individual preferences.

These effects are likely to be observed when consumers are faced with the task of valuating novel or unfamiliar foods and when unknown product attributes create the uncertainty. The range of adjustment changes with the degree of knowledge that consumers have about the product - the lower the level of knowledge – the wider the range of possible values (Strack et al., 1997). In our experiment the distance between perceived reference price and bids also reduced, when additional informational information about the breads was provided, which reduced the uncertainty level.

The presence of anchoring effect questions the property of Vickrey auction as a mechanism for truthful product valuations. If the anchoring effect is present in the willingness to pay estimates then consumers' ability to rationally respond to information is altered (Ariely, Loewenstein, & Prelec, 2003), and estimated demand can potentially be market dependent in the sense that it more reflects the market situation than that it provides information about consumer preferences. This effect is also known as context-dependence (Mazar, Koszegi, & Ariely, 2014).

It has already been stated before that not accounting for the reference price in empirical analysis can provide inaccurate conclusions about consumer behavior (Boztug & Hildebrandt, 2005; Miljkovic & Effertz, 2010). The present study provides further support for this statement.

The obvious limitations of this research are the size and the characteristics of the sample. Further investigations on the role of perceived reference price could be performed on larger, representative samples.

5 References

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Tables

Table 1. Socio-demographic characteristics of participants (N=131)

Variable	Definition	Mean (SD)
Gender	0 - male, 1 – female	0.68 (0.47)
Age	Participant's age in years	26.37 (5.87)
HH-Income	Household income: 1 = <1000€, 2 = 1001-1500€, 3 = 1501-2000€, 4 = 2001-2500€, 5 = 2501-3000€, 6 = >3000€	1.88 (1.43)

Table 2. Hedonic scores

	First, no information round				Third, full information round			
	Organic	Purple	Spelt	Conventional	Organic	Purple	Spelt	Conventional
Look	5.08	4.14	4.78	5.17	5.16	4.28	4.92	5.19
Smell	4.74	4.30	4.56	4.81	4.85	4.34	4.71	4.83
Taste	4.44	4.14	4.43	4.80	4.82	4.61	4.94	4.68
Texture	4.77	4.03	4.44	4.93	5.12	4.31	4.76	4.95

Table 3. Descriptive statistics of bids in the zero and full information rounds (N=131)

Bread	First, no information round		Third, full information round	
	Mean	Std.dev.	Mean	Std.dev.
Organic	0.80	0.77	1.19	0.89
Purple	0.69	0.71	1.01	0.97
Spelt	0.78	0.66	1.19	0.92
Conventional	1.04	0.84	1.03	0.86

Table 4. Distribution of bids with regard to reference price

	Organic	Purple	Spelt	Conventional
First (blind) round				
Number of bids above reference price	8	8	10	17
Number of bids equal or below reference price,	123	123	121	114
including zero bids	43	43	33	27
Third (full information) round				
Number of bids above reference price	35	15	28	23
Number of bids equal or below reference price,	96	116	103	108
including zero bids	28	35	26	33

Table 5. Mean differences between bids and reference price

Bread type	First (no information) round		Third (full information) round	
	Mean	Std. err.	Mean	Std. err.
Organic	-1.21	0.09	-0.82	0.11
Purple	-1.32	0.09	-0.99	0.10
Spelt	-1.23	0.09	-0.82	0.10
Conventional	-0.97	0.10	-0.98	0.11

Table 6. List of explanatory variables

Variable	Definition	Mean (Std. Dev.)			
		Organic	Purple	Spelt	Conv.
PRP	Perceived reference price of 500 gr. bread loaf	2.01 (0.95)			
Look	Hedonic score: 7- I extremely like to 1- I extremely dislike	5.07 (1.13)	4.14 (1.47)	4.78 (1.12)	5.17 (1.10)
Smell	Hedonic score: 7- I extremely like to 1- I extremely dislike	4.74 (1.13)	4.30 (1.10)	4.56 (1.19)	4.81 (1.05)
Taste	Hedonic score: 7- I extremely like to 1- I extremely dislike	4.44 (1.48)	4.14 (1.40)	4.43 (1.25)	4.80 (1.44)
Texture	Hedonic score: 7- I extremely like to 1- I extremely dislike	4.77 (1.37)	4.04 (1.64)	4.44 (1.50)	4.93 (1.50)
Consumption frequency	1 – few times in a year; 2 – once in a month; 3 – few times a month; 4 – once a week; 5 – few times a week; 6 – once a day; 7 – few times a day	5.67 (1.08)			
Gender	1 - male, 2 – female	1.68 (0.47)			
Age	Participant's age in years	26.37 (5.87)			
Income	Household income: 1 = <1000€, 2 = 1001-1500€, 3 = 1501-2000€, 4 = 2001-2500€, 5 = 2501-3000€, 6 = >3000€	1.88 (1.43)			

Table 7. Parameter estimates for the first (no information) round

	Random effects Tobit with lower and upper limits				Random effects Tobit with lower limit			
	Organic	Purple	Spelt	Conv.	Organic	Purple	Spelt	Conv.
PRP	0.23***	0.10	0.21***	0.31***	0.27***	0.12*	0.24***	0.36***
	(0.09)	(0.08)	(0.08)	(0.09)	(0.08)	(0.07)	(0.07)	(0.07)
Look	0.03	0.05	0.11	0.27***	0.05	0.04	0.11 (0.08)	0.20 ***
	(0.10)	(0.06)	(0.08)	(0.10)	(0.09)	(0.06)		(0.08)
Smell	0.19**	0.00	0.17**	-0.04	0.14*	0.02	0.15**	-0.05
	(0.09)	(0.08)	(0.07)	(0.10)	(0.08)	(0.08)	(0.07)	(0.08)
Taste	0.31***	0.31***	0.20***	0.28***	0.30***	0.26***	0.18***	0.23 ***
	(0.08)	(0.08)	(0.07)	(0.09)	(0.07)	(0.08)	(0.07)	(0.07)
Texture	0.16**	0.22***	0.05	0.21***	0.13*	0.20***	0.05	0.19***
	(0.08)	(0.06)	(0.06)	(0.08)	(0.07)	(0.06)	(0.06)	(0.07)
Cons. frequency	-0.23	-0.22***	-0.16**	-0.11	-0.24***	-0.20***	-0.16***	-0.11*
	(0.08)	(0.08)	(0.07)	(0.08)	(0.07)	(0.07)	(0.06)	(0.07)
Gender	-0.35*	-0.19	-0.34**	-0.30*	-0.30*	-0.16	-0.36***	-0.30**
	(0.18)	(0.16)	(0.15)	(0.18)	(0.16)	(0.15)	(0.14)	(0.15)
Age	0.02	0.01	-0.00	-0.00	0.02	0.01	-0.00	-0.00
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
Income	-0.10	0.04	-0.01	-0.05	-0.09	0.05	-0.00	-0.05
	(0.07)	(0,06)	(0.05)	(0.07)	(0.06)	(0.05)	(0.05)	(0.06)
Intercept	-1.44*	-0.88***	-0.67	-1.84**	-1.25*	-0.89	-0.51	-1.40**
	(0.78)	(0.64)	(0.65)	(0.84)	(0.70)	(0.58)	(0.58)	(0.70)
AIC	274.35	254.63	277.25	283.77	264.87	247.32	259.37	274.93
BIC	307.90	288.08	310.80	317.22	298.42	280.77	292.92	308.38

*,**,*** indicate statistical significance at the 95%, 99%, and 99.9% level, respectively. Standard errors are reported in parentheses.

Table 8. Parameter estimates for the third (full information) round

	Random effects Tobit with lower and upper limits				Random effects Tobit with lower limit			
	Organic	Purple	Spelt	Conv.	Organic	Purple	Spelt	Conv.
PRP	0.03	0.33***	0.30***	0.14	0.17**	0.37***	0.39***	0.20**
	(0.11)	(0.11)	(0.11)	(0.12)	(0.08)	(0.09)	(0.08)	(0.10)
Look	0.17	-0.05	-0.02	0.25**	0.10	-0.03	-0.02	0.17*
	(0.13)	(0.11)	(0.12)	(0.13)	(0.10)	(0.09)	(0.09)	(0.10)
Smell	-0.06	0.20	0.07	0.05	-0.05	0.16	0.06	0.05
	(0.11)	(0.14)	(0.11)	(0.15)	(0.08)	(0.12)	(0.09)	(0.11)
Taste	0.61***	0.44***	0.45***	0.51***	0.46***	0.38***	0.40***	0.40***
	(0.12)	(0.13)	(0.11)	(0.13)	(0.08)	(0.11)	(0.09)	(0.10)
Texture	0.08	0.18*	0.24**	-0.18	0.07	0.14	0.17**	-0.13
	(0.12)	(0.10)	(0.10)	(0.13)	(0.09)	(0.09)	(0.08)	(0.10)
Consumption frequency	-0.23**	-0.09	-0.15*	-0.11	-0.17**	-0.10	-0.15**	-0.09
	(0.10)	(0.11)	(0.09)	(0.11)	(0.07)	(0.09)	(0.08)	(0.09)
Gender	-0.19	-0.46**	-0.14	-0.56**	-0.09	-0.40**	-0.07	-0.43**
	(0.22)	(0.23)	(0.22)	(0.25)	(0.16)	(0.20)	(0.17)	(0.19)
Age	0.05***	0.00	-0.01	-0.04*	0.03**	0.00	-0.01	-0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)
Income	0.01	-0.10	-0.06	-0.05	0.03	-0.05	-0.03	-0.04
	(0.08)	(0.09)	(0.08)	(0.09)	(0.06)	(0.07)	(0.06)	(0.07)
Intercept	-2.48***	-1.85*	-1.43	0.29	-1.74***	-1.57*	-1.22*	0.07
	(0.97)	(0.10)	(0.94)	(1.12)	(0.70)	(0.82)	(0.75)	(0.85)
AIC	277.38	318.15	306.56	316.93	287.66	312.18	297.39	312.22
BIC	310.93	351.70	340.00	350.38	321.21	345.73	330.84	345.67

*,**,*** indicate statistical significance at the 95%, 99%, and 99.9% level, respectively. Standard errors are reported in parentheses. Standard errors are reported in parentheses.

Table 9. Correlations between the predicted values and actual bids

	No information round				Full information round			
	Organic	Purple	Spelt	Conv.	Organic	Purple	Spelt	Conv.
Tobit with lower and upper limits	0.64	0.67	0.60	0.66	0.64	0.63	0.64	0.52
Tobit with lower limit	0.64	0.68	0.60	0.68	0.67	0.64	0.66	0.54

Figures

Bread A: Conventional whole grain wheat bread, naturally rich in fiber

Bread B: Organic whole grain wheat bread, naturally rich in fiber,
all ingredients are produced organically

Bread C: Whole grain purple wheat bread, naturally rich in fibre and anthocyanins

Additional info:

"Purple wheat is naturally rich in Anthocyanins. Anthocyanins are secondary substances, which are considered to be health promoting due to their antioxidative features."

Bread D: Whole grain spelt bread, naturally rich in fibre; spelt is a so-called ancient grain variety and contributes to preserving biodiversity.

Figure 1. Information about bread samples provided to the participants.