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# Auctions and Fair Division Games - A Cross-Cultural Bidding Experiment-\*

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## Abstract

This paper presents the results of experiments carried out in two countries, Germany and Bulgaria, and for different allocation rules (first vs. second price - auction vs. fair division game). The data analysis of the sealed-bid, private value-contests compares the bid function in both countries, some features of the bidding behavior (learning of risk neutral equilibrium bidding, truthful bidding, decision time, bid adjustments) as well as the efficiency rates and the price expectations. The main results obtained in Germany were replicated with the Bulgarian subjects.

JEL classification: D44, C92, O57

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# 1 Introduction

As a result of the recent changes in the political and economic systems in East European countries life there is beginning to resemble life in West Europe. In general economic behavior can be expected to become more similar across countries. On the other hand the differences in cultural and economic history and in the current level of economic welfare among the European countries may influence it.

What seems interesting is a comparison of economic decision making behavior between Bulgaria (an ex-socialist country) and Germany (a country of the Western world). The two systems - the capitalist market economy and the socialist planned economy have used and still use quite different criteria for the valuation of economic results. Whereas in the market economy profitability and efficiency are perhaps the most fundamental criteria for economic activity, in the socialist planned economy political and social criteria were very important. The use of these different criteria resulted in differences in economic activities. This leads to the question how similar current behavior is when it comes to solving the same economic problem in different countries.

One can argue that the people in Bulgaria and East Germany possess similar economic experience. Admittedly this was the fact but only for the first years after the collapse of the socialist economic system. Due to the reunification the market economy was enforced in East Germany in a very short period of time. Whereas in Bulgaria the transition to the market economy is not even completed. Because of this, there are still tremendous differences in many fields of the economic life in both countries.

The study presents an experimental investigation of the bidding behavior in auctions and fair division games in two different social and economical environments<sup>1</sup>. Why this topic? Auctions are well known and widely used in many countries (all over the world) to solve allocation problems. Recently one observes a fast-growing number of on-line auctions on

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<sup>1</sup>For further experimental studies comparing economic decision behavior in different countries, see Roth et al (1991), as well as Fehr and Tougareva (1996).

Internet (see e.g. <http://www.ebay.com>, <http://www.ricardo.de>). This opens up quite new possibilities for people from different countries to participate in one auction at the same time. Although bidding behavior is a favorite topic in experimental economics (see e.g. Kagel, 1995), between-country differences have not been studied in greater detail. Fair division games may be less familiar, but there are examples like conflict settlements in case of inheritance, divorce, or the termination of a joint venture.

The aim is to find out if there is a structural equivalence of the bidding behavior in different cultures. Another interesting question is whether behavioral differences are based on different experience and cultural constraints. The analysis of bidding behavior in different European countries could also be helpful in the process of European integration. Auctions and fair division games are two kinds of bidding mechanisms by which an object is allocated among a group of bidders. In an auction, the object is offered for sale by an outside agent (the seller) who collects the revenue himself. In a fair division game, the object is collectively owned by the bidders. Accordingly, the revenue that is raised gets equally distributed among the bidders. While the use of auctions to solve allocation problems is common, fair division games may be less familiar. For instance, allocating inheritance is a real life situation which resembles a fair division game. The object is collectively owned by the heirs who, in many cases, are the only bidders. Similar problems result when a joint venture is terminated.

The experimental series was started first in Germany<sup>2</sup> and then continued in Bulgaria. In both countries the number of sessions was the same. Within a session each subject took part in 36 consecutive games of four different types - two types of auctions and two types of fair division games. The participants faced these four game types repeatedly in a particular sequence. They had to submit a complete bid function, which made it possible to observe the adjustment process of their bidding behavior<sup>3</sup>.

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<sup>2</sup>For a more detailed analysis of the German data see Güth et al (1999a,b).

<sup>3</sup>For other experiments in which subjects had to submit bid functions see Selten and Buchta (1998) as well as Güth (1998).

The experimental study dealt with sealed-bid private value bidding contests in which a single indivisible object was to be allocated and for which each potential buyer had an independent private value. All participants submitted their bids simultaneously without revealing them to each other. Four different allocation rules, i.e. game types were implemented (see table 1): *First Price Auction* (A1), *Second Price Auction* (A2), *First Price Fair Division Game* (F1) and *Second Price Fair Division Game* (F2). "First price" means that the object is sold to the highest bidder at the price equal to his bid, "second price" that it is sold to the highest bidder at the price of the second highest bid. Whereas in an auction this price is collected by the experimenter, who assumes the role of the outside seller, it is evenly distributed among all bidders in case of fair division.

Price Rule	Auction	Fair Division Game
price = highest bid	A1	F1
price = 2nd highest bid	A2	F2

Table 1: The four game types

Let  $v_i$  be a bidder's private value for the object to be sold, and suppose  $v_i$  is drawn for each player  $i = 1, \dots, n$  ( $n = 3$ ) independently from a uniform distribution on the unit interval. If all bidders are risk neutral and the number of bidders is  $n = 3$ , the equilibrium bid function  $b_i^*(v_i)$  and expected equilibrium price  $E(p^*)$  are as shown in table 2. For a derivation of these results see Güth and van Damme (1986).

Price	Auction	Fair Division Game
highest bid	$b_i^*(v_i) = \frac{2}{3}v_i$ $E(p^*) = \frac{1}{2}$	$b_i^*(v_i) = \frac{3}{4}v_i$ $E(p^*) = \frac{9}{16}$
2nd highest bid	$b_i^*(v_i) = v_i$ $E(p^*) = \frac{1}{2}$	$b_i^*(v_i) = \frac{3}{4}v_i + \frac{1}{4}$ $E(p^*) = \frac{10}{16}$

Table 2: Bid function  $b_i(v_i)$  and expected price  $E(p)$  of the equilibrium for risk neutral bidders and the four game types,  $n = 3$

## 2 Experimental Design

The subjects participated in a session of 36 consecutive games of the four different types (see table 1). The number of bidders per auction ( $n = 3$ ) was commonly known, but not the identity of the bidders. Every session consisted of nine subjects. In each of the 36 periods the bidders were randomly divided into three groups of three bidders. All subjects in all sessions played the same sequence of games. First they played three successive A1-games, then three A2-games, three F2- and finally three F1-games. The twelve games formed the first block. The participants played then two more blocks in the same sequence as block 1.

Before the bidders get to know their individual private value, they had to submit a bid function. They had to place a bid for every possible value. In both experiments the private values  $\tilde{v}_i$  did not vary continuously, but were drawn from the set

$$\tilde{V} = \{50, 60, \dots, 150\}$$

with all values  $\tilde{v}_i \in \tilde{V}$  being equally likely. Subjects could choose integer bids  $\tilde{b}_i$  as follows:

$$\tilde{b}_i \in \{0, 1, \dots, 200\}.$$

These values were denoted in a fictitious currency ECU (experimental currency unit) in which subjects could resell the object to the experimenter. After they had submitted their complete bidding strategy, the actual private value  $\tilde{v}'$  for every bidder was independently drawn from the set  $\tilde{V}$ . Payments were determined according to the game rules and using the submitted bidding strategies<sup>4</sup>. The bidders were informed about whether or not they were the buyer, about their private value  $\tilde{v}'_i$ , about their bid for this value  $\tilde{b}_i(\tilde{v}'_i)$ , about the price  $p$  at which the object was sold, and about their own payoff in the current round.

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<sup>4</sup>The strategy method obviously provides more information than collecting only one bid for a single value. But since ex-post only one component of the bid vector is payoff-relevant, it lowers the incentives of bidding at each single value. A reasonable compromise is achieved by restricting the set  $\tilde{V}$ .

Remember that over the 36 periods each game type appeared nine times. In the first of these nine games the bid screen was blank and each subject had to enter a vector of 11 bids (one for each  $v_i \in V$ ). In later periods the last bid vector for the same game type was displayed as default. It could be revised or submitted as it was. Of course, this may favor the status quo and may work against adjusting behavior over time. We did it for practical reasons. If subjects do not want to adjust all bids, this saves time and helps to prevent getting bored by the task. Altogether we ran 6 sessions in Germany and 6 sessions in Bulgaria, and collected 2 x 1944 bidding strategies (54 subjects times 36 games).

In order to justify the cross-cultural comparison and to exclude sample-specific differences the subjects from the different cultural groups were similar in terms of their relevant background characteristics. The participants in both experiments were students (in the German sessions from the Humboldt University in Berlin, in the Bulgarian sessions from the Technical University in Varna)<sup>5</sup>.

The same experimental design was applied in both countries. The use of the translation-backtranslation method makes sure that the instructions are the same in both languages. First the author who is a native speaker translated the instructions into Bulgarian. Then an independent bilingual speaker backtranslated them into German. Both, the backtranslation and the original version were compared. Some minor differences were found. They were discussed and some words were changed to make the translation easily readable and comprehensible.

	Germany*	Bulgaria**
Max. profit	96,32 DM	43,94 DM
Min.profit	31,31 DM	5,00 DM
Mean profit	54,22 DM	24,91 DM

\* incl. a show up fee of 10 DM

\*\* incl. a show up fee of 5 DM

Table 3: Profit comparison

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<sup>5</sup>Note that there still remain uncontrolled differences between subject pools that might not be regarded as "cultural". For instance, in Germany, most participants were students of economics or business administration, whereas in Bulgaria they were mainly students of computer science or engineering.

The conversion rate for ECU into DM was different in the two experiments. The aim was to guarantee equal monetary incentives for the participants, according to the economic situation in the corresponding country. Therefore the conversion rate for the Bulgarian experiment was decreased by fifty per cent, e.g. if the conversion rate in the German experiment was 1 ECU=0.05 DM, in the Bulgarian experiment 1 ECU was worth only DM 0.025. Table 3 shows the subjects' total earnings from the 36 games for both experiments. On average subjects' earnings in both experiment are similar with a slight overhang in favour of the German participants.

To avoid any influence of the experimenter the sessions were performed as computerized experiments. There was no interaction between the experimenter and the subjects in the time they made their choices. In order to eliminate between-country differences because of uncontrolled personal differences among the experimenters, the same person ran all sessions in both locations.

Subjects were invited by leaflets to participate in the experiment, without revealing more details. After entering the laboratory they were placed at isolated computer terminals. Communication among them was not allowed during the session. At the beginning they were allowed to ask privately for clarification or for help regarding the handling the PC. It was pointed out, that all decisions made by the participants would be anonymous and not to be traced to their persons. All sessions lasted about three hours.

### 3 Experimental results

For ease of comparison of the empirical bids  $\tilde{b}_i$  and values  $\tilde{v}_i$  with the theoretical solution given above (table 2) all analysis will be done for normalized bids  $b_i$  and values  $v_i$ :

$$\begin{aligned} v_i &= \frac{\tilde{v}_i - 50}{100} \\ b_i &= \frac{\tilde{b}_i - 50}{100} . \end{aligned}$$



Accordingly the space of possible values is  $V = \{0, 0.1, \dots, 1\}$ . In an experiment it is not possible to allow values  $v_i$  and bids  $b_i$  to vary continuously. By referring to the theoretical benchmark case as described in table 2, the discreteness of  $V$  is essentially neglected. Since the main point of interest is the comparison of the bidding behavior in both countries, the solution can nevertheless be used as a reasonable benchmark to compare actual bidding behavior.

### 3.1 Bid Function Comparison

The main result of this study is the observation of similar individual bidding behavior in both countries. This striking result is supported by the analysis of several features of the bid functions on different levels.

#### 3.1.1 Individual Bid Functions

If the bidders are risk neutral, the theory (see table 2) predicts bid functions which are (1) strictly increasing and (2) linear in  $v_i$ <sup>6</sup>. To compare the individual bidding behavior, both with their benchmark and between countries, the slopes and curvatures of the observed bid functions are investigated. To evaluate whether they were increasing and/or linear the following regression model is estimated:

$$b_i = \alpha_0 + \alpha_1 v_i^{low} + \alpha_2 v_i^{high} \quad (\text{model 1})$$

with

$$v_i^{low} = \begin{cases} v_i & \text{if } v_i < 0.5 \\ 0.5 & \text{otherwise} \end{cases}$$

and

$$v_i^{high} = \begin{cases} v_i - 0.5 & \text{if } v_i \geq 0.5 \\ 0 & \text{otherwise} \end{cases}$$

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<sup>6</sup> Assuming risk aversion in the sense that, bidders exhibit different constant relative risk aversion (CRRA) utility functions  $u_i(x) = x^{1-r_i}$ , where the parameter  $r_i$  is individual  $i$ 's coefficient of relative risk aversion, induces bid functions with the same characteristics. For example the equilibrium bid function in the first price auction in this case is  $b_i^* = \frac{2}{3-r_i} v_i$  (see e.g. Davis and Holt (1993), p. 287).

The rationale for this model is that it produces piecewise-linear approximations of convex or concave individual bid functions allowing for a kink at  $v_i = 0.5$ <sup>7</sup>. Model 1 is estimated for each individual  $i = 1$  to 54, each period  $t = 1$  to 36, and each country separately, giving a total of 3888 (1944 for each country) estimated individual bid functions.

In 1892 cases ( $\approx 97\%$ ) in Germany and in 1842 ( $\approx 95\%$ ) in Bulgaria the bid functions were strictly increasing, i.e.  $\alpha_1 > 0$  and  $\alpha_2 > 0$  (see table 4). The fit of these piecewise-linear approximations was remarkable: quite often the estimated individual bid function explained more than 90% of the variance ( $R^2 > 0.9$ ). In fact, this was the case for 3645 (94%) of the observed bid functions.

To determine the curvature of the bid functions the difference between the two slope coefficients  $\Delta \equiv \alpha_2 - \alpha_1$  is computed. A bid function is considered as linear if  $|\Delta| \leq \pm 0.05$ <sup>8</sup>. If  $\Delta < -0.05$  ( $\Delta > +0.05$ ), the respective bid function is classified as concave (convex). Due to these criteria about half of the estimated bid functions in both countries 49% (56% in Germany, 43% in Bulgaria) are linear, 32% (27% in Germany, 36% in Bulgaria) are concave and 19% (17% in Germany, 21% in Bulgaria) are convex (see table 4 for comparison)<sup>9</sup>.

	Slope			Curvature	
	D	BG		D	BG
strictly increasing:	97%	95%	concave:	27%	36%
weakly decreasing:	3%	5%	linear:	56%	43%
			convex:	17%	21%
(100% = 1944 estimated individual bid functions for each country)					

Table 4: Slope and curvature of the estimated individual bid functions  
(D - Germany, BG - Bulgaria)

<sup>7</sup> A slightly simpler formulation of a piecewise-linear regression model may be:  $b_i = \alpha_0 + \gamma_1 v_i + \gamma_2 v_i^{high}$  with all variables as defined above. However, this model is equivalent to model 1, and the latter is advantageous since  $\alpha_1$  and  $\alpha_2$  below have to be compared. For instance, if a bid function is perfectly linear, this results in  $\alpha_1 = \alpha_2$ .

<sup>8</sup> Admittedly, the chosen criterion for linearity is ad hoc. It could have been set more (or less) restrictively. However, this does not induce significant between-country differences. For instance, if the criterion for linearity is set more restricted ( $|\Delta| \leq \pm 0.025$ ) the share of concave (convex) functions increases in Germany with 5% (3%) and in Bulgaria with 6% (4%). By choosing the criterion less restricted ( $|\Delta| \leq \pm 0.075$ ) the respective shares decreases with 2% (2%) in Germany and 3% (2%) in Bulgaria.

<sup>9</sup> Of course, one could run formal tests for the theoretical restrictions imposed on  $\alpha_1$  and  $\alpha_2$ . The author prefers to simply report some descriptive measures since the usual assumptions for statistical testing are hardly satisfied here. Note that each regression is based on 11 data points drawn from a single subject. Furthermore 36 regressions for the same subject are estimated.

Based on these findings one can conclude:

**Observation 1:** The individual bidding behavior reveals the same qualities in both countries. The empirical bid functions are strictly increasing in  $v_i$  in almost all cases.

### 3.1.2 Estimated Aggregate Bid Functions

To investigate if there are any qualitative differences in the bidding behavior between both countries, the aggregate bid function for each game and each country according to model 1 are estimated<sup>10</sup>. The functions are presented in figure 1.

As already shown (see Section 3.1.1) the individual bid functions in both countries have similar slope and curvature. This similarity still remains on country level. Remarkable is the fact that in both first price games (except for very large values,  $v_i > 0.8$ , in case of A1) as well as in both fair division games the Bulgarian participants bid higher than the Germans. Dividing the  $v_i$ -interval into two subintervals - low if  $v_i \in [0.0, 0.5)$  and high if  $v_i \in [0.5, 1.0]$ , one observes following cross-country differences between the German and Bulgarian sessions (see table 5):

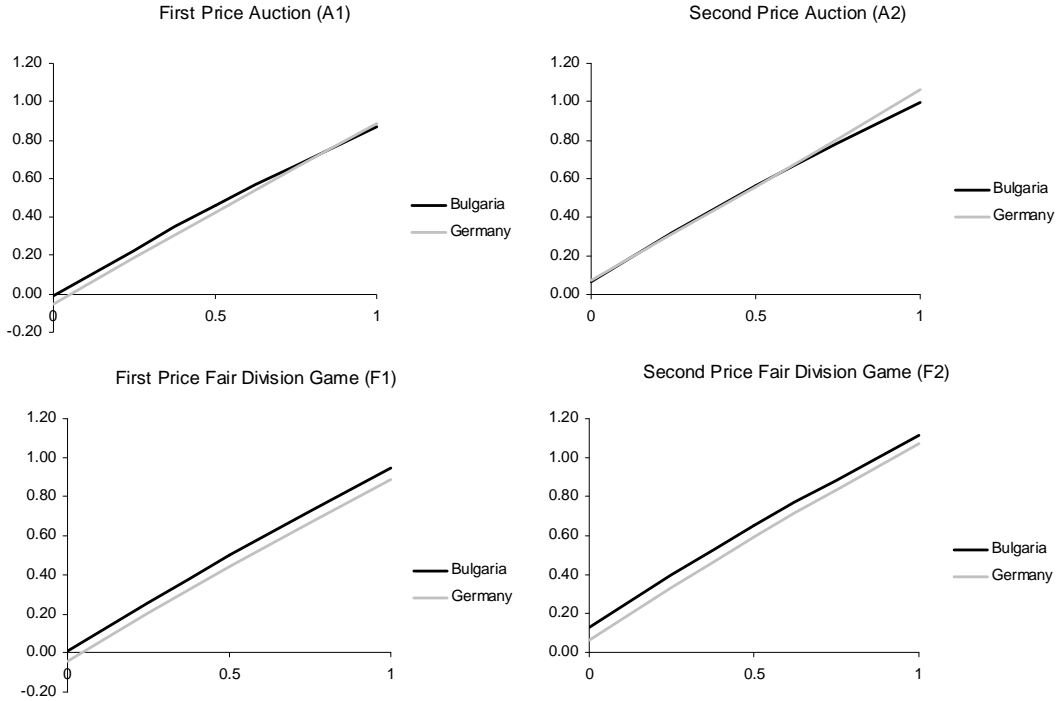


Figure 1: Estimated aggregate bid functions

<sup>10</sup> I.e. one piecewise-linear regression for each game instead of one for each subject and each period

- in the low  $v_i$ -subinterval: overbidding by the Bulgarian subjects (significant in 3 cases for A1 and F1 at 10% level, and in 2 cases for F2 at 10% level);
- in the high  $v_i$ -subinterval: overbidding by the Bulgarian subjects (significant in 4 cases for F1 at 10% level, and in 2 cases for F2 at 10% level); as well as overbidding by the German subjects (significant in 3 cases for A2 at 5% level);

One can summarize

**Observation 2:** In first price auctions Bulgarian participants overbid the Germans if the reselling values are low ( $v_i < 0.5$ ). The opposite is the case in auctions if the reselling values are high ( $v_i \geq 0.5$ ). In both fair division games the Bulgarian bidding behavior is more aggressive.

$v_i$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
A1	.090	.066	.066	.155	.242	.294	.294	.294	.294	.469	.409
A2	.350	.409	.350	.409	.409	.469	.350	.155	.066	.013	.008
F1	.066	.090	.120	.120	.066	.066	.090	.090	.090	.120	.120
F2	.242	.242	.197	.090	.090	.090	.090	.120	.155	.197	.197

Table 5: Significance of the cross-country differences  
(Mann-Whitney  $U$  test,  $N = 12$ , one-tailed)

### 3.1.3 Risk Neutral Equilibrium Bidding

To investigate if the subjects with experience learn and change their bid functions according to RNE (see table 2) the time paths of the deviation from the RNE strategy in both countries for all sessions are analyzed.

Figures 2 presents the time paths of the average deviations for a low value  $v_i = 0.3$  and a high value  $v_i = 0.7$  for the four game types. There are no obvious movements towards RNE over time in both countries. The time paths for other reselling values ( $v_i \neq 0.3$  and  $v_i \neq 0.7$ ) which are not presented here, lead to the same conclusion. So, one can conclude

**Observation 3:** There is no general learning process towards RNE.

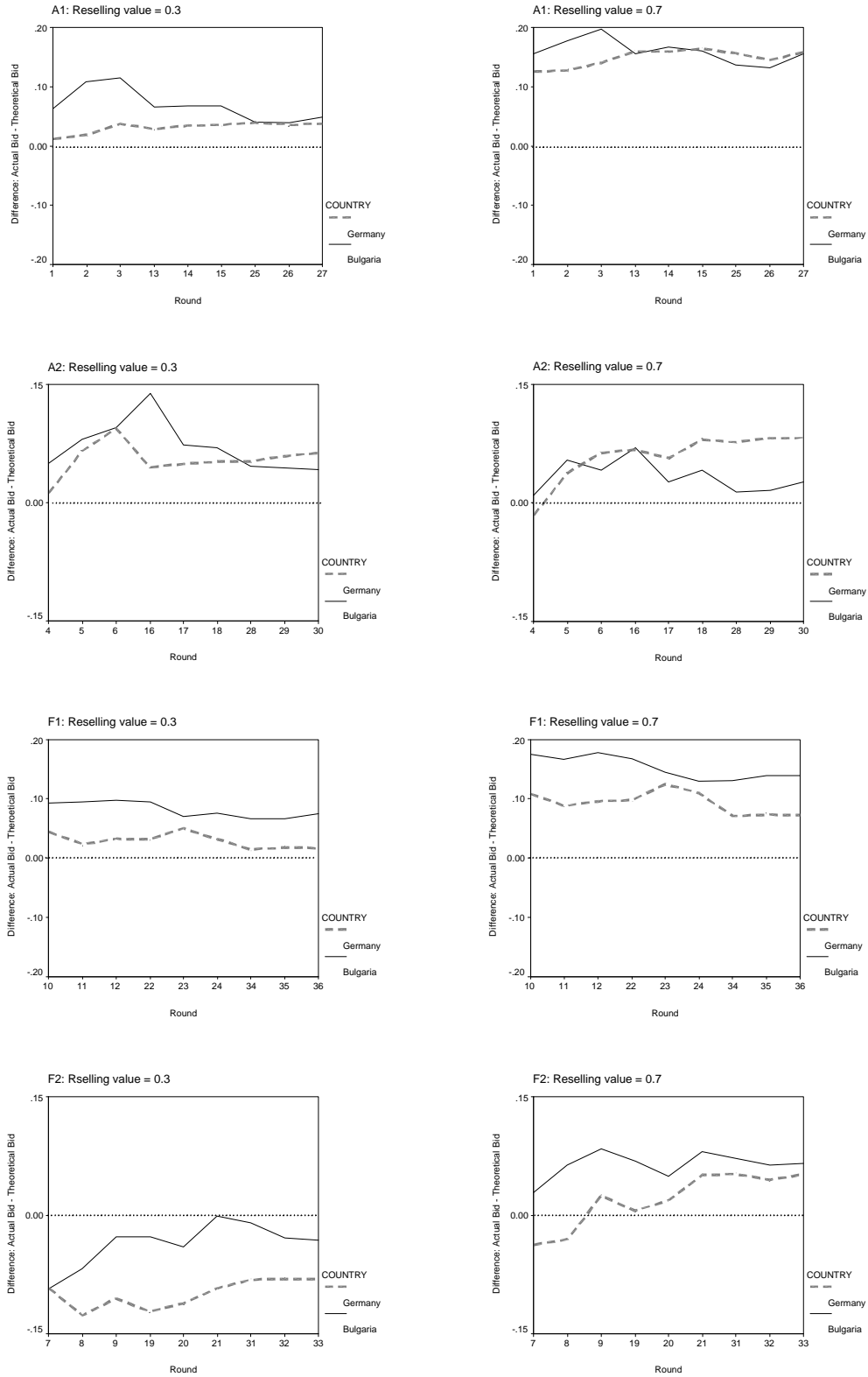


Figure 2: Time paths for each game type and each country

### 3.1.4 Truthful bidding

Related to the results from the previous section the comparison is continued by analyzing the truthful behavior in both countries. Remember that in second price auction (A2) “true value”-bidding  $b_i(v_i) = v_i$  is the dominant strategy (it is never worse and sometimes better than any other bidding strategy). It does not depend on the risk attitudes one assumes, on the number of bidders, or on the bidders’ beliefs. Particularly in this case it is interesting to find out whether there are any detectable differences between countries. Besides for A2 this is done for A1, F1 and F2 as well. For all other game types (except A2) bidding one’s reselling value is not the optimal behavior. Nevertheless it can be interesting to know how far the observed bid functions are based on truthful bidding in all four game types.

As shown in table 6 (last row) in general the German participants use more often the “truthtelling”-strategy<sup>11</sup>. In the case of second price auction this is significant at 5% level (Kolmogorov-Smirnov Test,  $N = 12$ ,  $p = 0.026$ , two-tailed). Worth mentioning is also the completely different distribution of these strategies in both countries. In Germany, as theory predicts, most truthful bidding strategies (43%) are submitted in second price auctions. In Bulgaria the results reveal quite equal distribution between second price auction (32%) and both fair division games (40% respectively 23% in F1, respectively F2).

Game Type	A1		A2		F1		F2	
Session	D	BG	D	BG	D	BG	D	BG
1	2	1	12	-	9	-	8	-
2	-	2	16	21	5	22	-	4
3	6	-	12	-	12	-	15	-
4	1	2	17	8	-	6	-	6
5	3	-	13	1	2	9	14	11
6	5	-	15	-	16	-	16	-
All	17	5	85	30	44	37	53	21

Table 6: Number of submitted strategies  $b_i(v_i) = v_i$  for each game type and country

<sup>11</sup>Note that the total number of submitted strategies for each session is always 81, i.e. the total number of submitted strategies for each game type and country is 486.

### 3.2 Decision Time and Game Structure Comparison

According to the experimental design subjects face the four game types repeatedly in a particular pattern. Each game type is played for three periods before the next one. So twelve games (4 game types times 3 periods) form the first block. The participants then play another two blocks in the same sequence as block 1. The game type sequence of each block is: A1, A2, F2, F1. The format of subjects' decisions is the same for all games. Figure 3 displays the average decision time over all periods for both countries. The decision time jumps with every change of the game type (periods 1, 4, 7, 10, ... 34). In the first block (periods 1, 4, 7, and 10) this is absolutely natural, since the subjects face the game type for the first time. In the following periods, however, they could use the former strategy of the same game type (see Section 2). But, this explanation does not hold for the spikes in periods 13, 16, ..., 34. This would mean that the four games are analyzed separately and independently from each other by the participants. There are no substantial differences between the displayed paths for both countries.

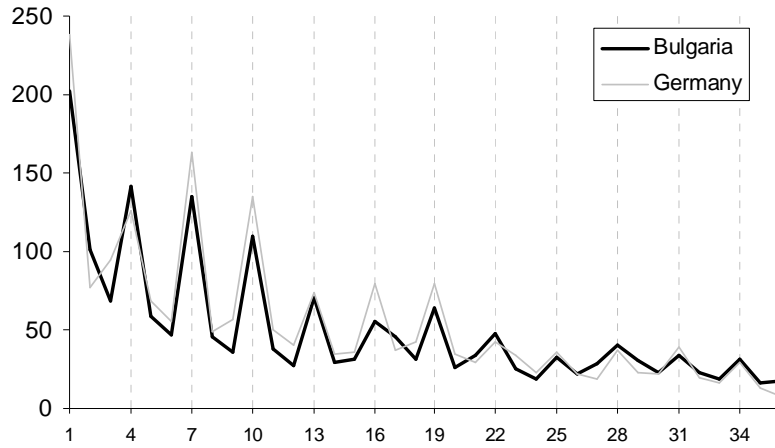


Figure 3: Average decision time for all periods (1 to 36)

**Observation 4:** Decision time matches the sequencing structure of the four game types.

Participants take the structural differences between the game types into consideration when making their decisions by investing more deliberation time when the game types changes. This is true for both countries.

### 3.3 Bid Adjustments (global versus local) Comparison

In each game each subject has to place a bid for every possible value, i.e. a complete bid function. However, payoff relevant in this game are only the actually drawn private value  $v'_i$  and the bid  $b_i(v'_i)$  submitted for this value. Remember that after every round bidders are informed about whether or not they bought the object, their actual private value  $v'_i$ , the corresponding bid  $b_i(v'_i)$ , the price  $p$ , and their own profit. The following question arises: If the subjects changed their bid functions, did they do this "locally" at  $v'_i$  or rather "globally" at all values simultaneously (in spite of the missing feedback information concerning the bids  $b_i(v''_i) \neq b_i(v'_i)$ ).

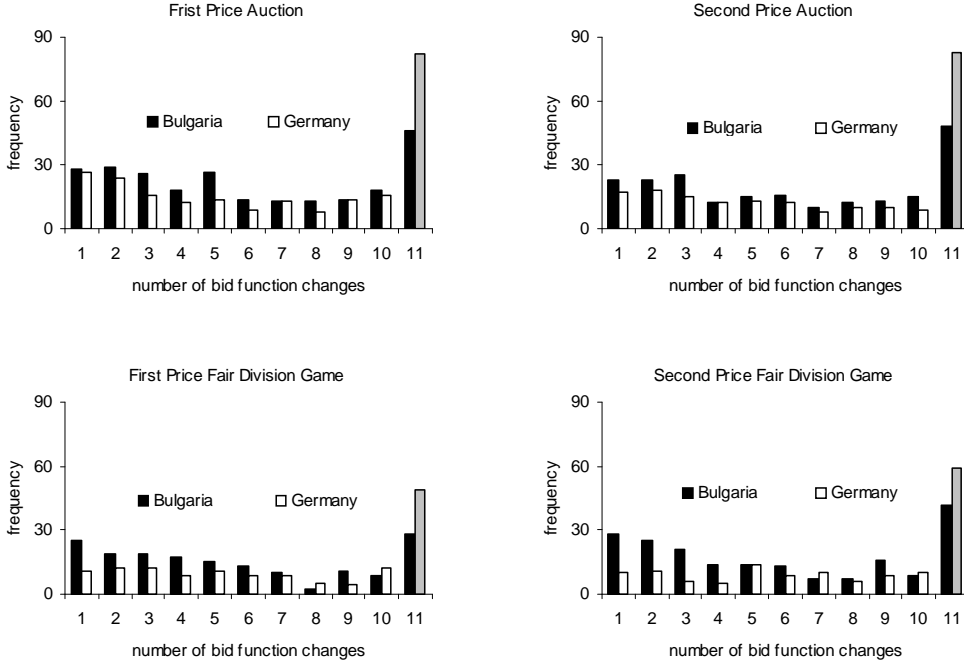


Figure 4: Frequency distribution for the number of bid functions changes for each game type and country

To find an answer in each session and for both countries the number of completely changed bid vectors (in each component) are compared<sup>12</sup> (see Figure 4). Using the Mann-Whitney  $U$  test one can reject the null hypotheses that there is no difference between the German

<sup>12</sup>Note that global adjustment of bid functions means a completely changed bid function, i.e. the maximal number of changes is 11.



and Bulgarian sessions concerning the global adjustments of bid functions for A1 ( $p = .019$ , one-tailed,  $N = 12$ ). The same holds for all other game types (A2 with  $p = .049$  and F1 with  $p = .096$ ) but F2. This leads to

**Observation 5:** There is a significant difference in adjusting behavior in both auctions as well as in both first price games between the two countries. German subjects tend to make more "global", Bulgarian subjects more "local" bid adjustments.

### 3.4 Price and Efficiency Comparison

A further interesting question is how the price at which an object is sold and the efficiency of the game types are influenced by the price rule. Given risk neutral equilibrium bidding as proposed in many theoretical models, the first price auction and the second price auction are payoff equivalent (see e.g. Wolfstetter, 1996). So, both risk neutral sellers and bidders (regardless of their values), have to be indifferent between the two auction types. However, empirically, there could be substantial differences in the average selling prices. Usually it will be up to the seller to choose the auction type, and he might want to choose the type (from the two, A1 and A2) which yields the higher price. On the other hand the use of different political and social criteria for the assessment of economic activities among countries could influence the bidders' decisions. If bidding mechanisms differ in the social welfare they generate, this can be important e.g. for the government or other public authorities<sup>13</sup>.

The expected price and efficiency rate for each group of 3 bidders is determined by considering all possible combinations of reselling values that could have occurred in the experiment. So, each vector  $v = (v_1, v_2, v_3)$  where  $v_1$  to  $v_3$  represent the values of the three bidders that form a bidder group is considered. Since each  $v_i$  can take one of 11 values this may result in 1331 ( $= 11^3$ ) different vectors  $v$ .

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<sup>13</sup>For a discussion of these questions and some evidence from previous laboratory experiments see the survey by Kagel (1995).

The price  $p(v)$  for each  $v$  is determined. The mean of these prices could stand for the expected price  $p_j^e$  for the respective bidder group  $j$ . Table 8 reports means of the prices  $p_j^e$  for each type of auction and each country (standard deviations in parentheses).

Game Type	A1		A2		F1		F2	
Session	D	BG	D	BG	D	BG	D	BG
1	.70 (.07)	.67 (.10)	.57 (.08)	.50 (.06)	.74 (.10)	.81 (.10)	.53 (.20)	.62 (.09)
2	.72 (.03)	.81 (.12)	.54 (.12)	.57 (.05)	.77 (.06)	.88 (.09)	.54 (.10)	.63 (.08)
3	.70 (.04)	.63 (.06)	.55 (.08)	.53 (.03)	.77 (.10)	.66 (.05)	.72 (.16)	.65 (.11)
4	.72 (.05)	.78 (.09)	.57 (.07)	.60 (.10)	.72 (.08)	.88 (.07)	.59 (.13)	.76 (.32)
5	.70 (.03)	.78 (.15)	.54 (.06)	.56 (.22)	.74 (.07)	.79 (.16)	.50 (.17)	.51 (.11)
6	.63 (.07)	.71 (.05)	.53 (.07)	.50 (.11)	.71 (.05)	.76 (.07)	.55 (.06)	.60 (.10)
All	.70 (.06)	.73 (.12)	.55 (.08)	.54 (.12)	.74 (.08)	.80 (.12)	.57 (.16)	.63 (.17)

Table 8: Mean expected price (std. deviation) for each game type and each country

Similarly as the prices the expected efficiency for each game type is determined. Theoretically, an allocation is efficient if the bidder with the highest reselling value gets the object. In the empirical analysis the “efficiency rate” as measure of efficiency is applied. For a given realization of reselling values the efficiency rate shall be defined as

$$\text{efficiency rate} = \frac{v_i(\text{buyer})}{\max \{v_1, v_2, v_3\}}$$

where  $v_i(\text{buyer})$  is the private value of the buyer. Note that the efficiency rate is bounded between 0 and 1. It is 1 if the bidder with the highest value gets the object. Table 9 shows the mean efficiency rate for each game type, each country, and each session.

Game Type	A1		A2		F1		F2	
Session	D	BG	D	BG	D	BG	D	BG
1	97.4	94.2	93.3	96.0	92.9	97.8	88.9	87.0
2	98.4	94.4	94.3	96.1	96.9	95.2	90.3	96.3
3	98.2	94.9	95.9	98.7	96.5	93.8	91.5	96.2
4	98.3	91.6	90.5	89.9	96.9	91.7	91.4	82.6
5	99.4	95.6	97.1	89.8	96.6	92.2	92.5	89.5
6	96.5	97.9	95.2	92.9	95.1	94.9	96.3	94.9
All	98.0	94.8	94.4	93.9	95.8	94.3	91.8	91.1

Table 9: Mean efficiency rates (in %)

Remember that in each session each type of auction was played 9 times by three groups of three randomly matched bidders. So in each session we collected 27 observations of both, expected prices and efficiency rates. And, the 6 sessions gave us 162 (= 6 times 27) observations altogether for each country.

### 3.4.1 Auctions

The expected price is higher for A1 as compared to A2 (see table 8). This is the case for all 12 sessions. A binomial test based on the session means therefore indicates statistical significance ( $p = 0.000$ ,  $N = 12$ , two-tailed) of these findings. A seller should clearly prefer the first price auction. This conclusion is in line with the result e.g. in Cox et al (1982). There is no significant difference between the expected prices in both countries. One can summarize

**Observation 6:** In both countries expected auction prices are higher under the first price rule.

The results in table 9 reveal higher expected efficiency in A1 compared with A2 in 9 out of 12 sessions (significant at 10% level, binomial test, one-tailed). This is the case for all sessions in Germany, but only for 3 (out of 6) in Bulgaria. Furthermore, the analysis reveals significant difference between the mean efficiency rates in the German and Bulgarian sessions for A1 (Mann-Whitney  $U$  test,  $p = .009$ , one-tailed,  $N = 12$ ).

Considering three levels of experience (block 1 to block 3)<sup>14</sup> one observes for A1 in both countries an increase of the efficiency rates with experience, i.e. the mean efficiency rate in block 3 is significantly higher than in block 1 (Wilcoxon test,  $p = .016$  for Germany, and  $p = .031$  for Bulgaria, one-tailed).

**Observation 7:** The efficiency of first price auction is significantly lower in Bulgaria than in Germany. In first price auctions experience general "pushes" participants towards higher efficiency.

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<sup>14</sup>For the definition of blocks 1,2, and 3 see section 2.

### 3.4.2 Fair Division Games

Regarding fair division games, table 8 reports that the expected price is higher in F1 than in F2. Again, this holds for all 12 sessions. One may argue that in fair division games differences in expected prices between these price rules are of minor importance. The price serves only to redistribute money within the group of bidders. However, there may be third parties who are interested in differences in expected prices. Such third parties may also influence or even determine the choice of the pricing rule.

Table 9 shows the mean efficiency rate as well as the relative frequency of efficient games for both fair division types. By and large expected efficiency is higher in F1 compared with F2. Similar to the auction case this holds in 9 out of 12 sessions and varies among the two countries. However, the country differences are insignificant.

## 4 Conclusions

The most important result of the presented cross-country comparison is that the bidding behavior in auctions and fair division games in both countries possesses the same fundamental features. The Bulgarian experiment replicated the main results of the German experiment (see Güth et al, 1999a,b). The different economic histories of both countries do not appear to have a major effect on personal economic decisions in auctions and fair division games. Given such an allocation game subjects behave in a similar way irrespective of their nationality.

More specifically, submitted individual bid functions are monotonically increasing in almost all cases. Generally the data of both experiments do not confirm learning of RNE bidding. Considering decision time as representing the cognitive effort, all subjects, Bulgarian as well as German, use the same cognitive approach for decision making by thinking harder (longer) when a new game type comes up. The expected prices in both experiments lead to the conclusion that every risk neutral seller should prefer first to second

price auctions. Furthermore, the expected price in F1 is higher than in F2 in Germany as well as in Bulgaria.

However, some qualitative differences are also present. In Germany subjects exploit more frequently the local feedback (at only one reselling value) to adjust their bid functions globally (for all reselling values). In Bulgaria the opposite is the case (local adjustment). German participants in second price auction use significantly more often the "truthtelling"-strategy than Bulgarian ones. In first price auction as well as in both fair division games Bulgarian subjects bid higher than the German ones. Possible explanations for this country effect could be different risk attitudes or inequality aversion as well as existing cultural differences. In Germany the first price auction is significantly more efficient than in Bulgaria. The impact of economic experience on people's behavior could be an appropriate justification of this result.

Of course, the robustness of these findings, as in any other empirical study, has to be replicated. Especially, to find out if the described bidding behavior holds not only in these two countries but rather internationally, more countries have to be included.

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# Appendix:

## A. Instructions<sup>15</sup>

Please read these instructions carefully. They are identical for all participants.

During the experiment you will take part in several auctions. In every auction a fictitious commodity is for sale which you can resell to the experimenters. You are one of three bidders. Each bidder has his own private reselling value  $v$  which can be 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, or 150 ECU (Experimental Currency Unit) and is independently drawn. Each value appears with the same probability.

Before you get to know your individual reselling value  $v$  you have to place a bid for every possible  $v$ :

$$b(50), b(60), b(70), \dots, b(150).$$

After every bidder in your group has placed his bid vector your actual bid is determined by  $b(v)$ . The bidder with the highest bid buys the commodity and pays a price according to the pricing rule. Then he sells the commodity to the experimenter and receives his reselling value. The other bidders do not pay anything and do not receive anything. If there are two or three highest bids, the buyer is chosen by random.

There are 4 different types of auctions. In type 1 and 2 the auction revenue is kept back by the experimenter whereas in type 3 and 4 the auction revenue is equally divided among the bidders. In auction types 1 and 4 the price corresponds to the highest actual bid. In auction types 2 and 3 the price which has to be paid corresponds to the second highest actual bid.

### **Type 1 (First Price Auction)**

- Price = highest bid ( $p = b_1$ )
- Bidder with highest bid becomes buyer. He pays  $p$ .
- Revenue ( $p$ ) is kept back by the experimenter.
- Profit of buyer:  $v - p = v - b_1$
- Profit of non-buyers: 0

### **Type 2 (Second Price Auction)**

- Price = second highest bid ( $p = b_2$ )
- Bidder with highest bid becomes buyer. He pays  $p$ .

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<sup>15</sup>This is a shortened and translated version of the instructions. For the instructions (in German and/or in Bulgarian), please contact the author.

- Revenue ( $p$ ) is kept back by the experimenter.
- Profit of buyer:  $v - p = v - b_2$
- Profit of non-buyers: 0

### **Type 3 (Second Price Fair Division Game)**

- Price = second highest bid ( $p = b_2$ )
- Bidder with highest bid becomes buyer. He pays  $p$ .
- Revenue ( $p$ ) is distributed among the bidders.
- Profit of buyer:  $v - p + \frac{1}{3}p = v - b_2 + \frac{1}{3}b_2 = v - \frac{2}{3}b_2$
- Profit of non-buyers:  $\frac{1}{3}p = \frac{1}{3}b_2$

### **Type 4 (First Price Fair Division Game)**

- Price = highest bid ( $p = b_1$ )
- Bidder with highest bid becomes buyer. He pays  $p$ .
- Revenue ( $p$ ) is distributed among the bidders.
- Profit of buyer:  $v - p + \frac{1}{3}p = v - b_1 + \frac{1}{3}b_1 = v - \frac{2}{3}b_1$
- Profit of non-buyers:  $\frac{1}{3}p = \frac{1}{3}b_1$

Altogether you play 36 auctions. In each auction the bidder groups are formed randomly. After you have placed your bid you get information about the price, your private reselling value, whether or not you bought, and how much you have earned. Any decision you make is anonymous and can not be related to your person. If you have questions, please, don't ask loud, but raise your hand. We will then clarify problems privately.



## B. Sample screen shots

The screen in Figure B.1, respectively in Figure B.2, was used in Germany, respectively in Bulgaria, by the subjects to place their bids. In the upper right corner one finds information about the type of the game. When subjects face a certain type of game for the first time all bid fields are empty. In later rounds subjects faced their strategy which they used in the last play of the same game type. They did not have to retype their strategy if they did not want to change it.

Bitte geben Sie Ihre Gebotsfunktion ein:

ERSTPREIS-AUKTION

Wieder- verkaufswert	Gebot
50	<input type="text"/>
60	<input type="text"/>
70	<input type="text"/>
80	<input type="text"/>
90	<input type="text"/>
100	<input type="text"/>
110	<input type="text"/>
120	<input type="text"/>
130	<input type="text"/>
140	<input type="text"/>
150	<input type="text"/>

OK

Figure B.1: Example for a bidding screen (Germany)

Моля, въведете предложенията си :

ВАРИАНТ 1

Стойност на предмета	Предложена цена
50	<input type="text"/>
60	<input type="text"/>
70	<input type="text"/>
80	<input type="text"/>
90	<input type="text"/>
100	<input type="text"/>
110	<input type="text"/>
120	<input type="text"/>
130	<input type="text"/>
140	<input type="text"/>
150	<input type="text"/>

OK

Figure B.2: Example for a bidding screen (Bulgaria)

Figure B.3, respectively Figure B.4, shows the screen in Germany, respectively in Bulgaria, which subjects receive after an auction. It informs the participant whether (s)he became the buyer, the price, the individual value  $v_i^*$ , the own bid for this value, and the payoff resulting from all this events.

Figure B.3: Example for an information screen (Germany)

Figure B.4: Example for an information screen (Bulgaria)