Tiger Women: An All-Pay Auction Experiment on Gender Signaling of Desire to Win[*]

Preliminary! Comments welcome!

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ABSTRACT: Women's lower wages and underrepresentation in the most competitive professions have been well documented. Numerous experiments suggest that women are less competitive. However, currently competitiveness is measured indirectly by using the residual of the choice of competitive payment after controlling for ability, confidence, and risk attitude econometrically. More recent results with different tasks, children, single sex schools, and Muslim countries have shown no gender differences, indicating the possible influence of cultural stereotypes in prior results. Furthermore, even in the west, women's superior academic achievement despite lower standardized test scores is not consistent with lesser competitiveness. We contribute to this literature by testing for gender differences in "desire to win" in a sealed bid all-pay auction at mid-tier and top-tier universities. Our treatments consisted of informing paired bidders of the gender and school rank of their opponent. We derived the implied valuations (desire to win) and risk attitudes using an extension of standard auction theory. In principle our method should be a direct measure of competitive attitude which eliminates ability, confidence and stereotype confounds. Contrary to the literature and our expectations, we found that women had higher desire to win, most significantly at the top tier school, where they were even less risk averse. Furthermore, this pattern of results was anticipated in across school bids, which is consistent with our signaling hypothesis. If willingness to pay to win is related to willingness to prepare, our results support other evidence showing that women's superior academic achievement is due to greater self-discipline. Our result could also help explain overbidding in apparently common value auctions.

Key Words: gender differences, all-pay auctions, laboratory experiment

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I. INTRODUCTION

Women's lower wages and underrepresentation in the most competitive professions is well documented. For example, only 2.5 percent of top five executives for a large group of U.S. firms were women (Bertrand and Hallock 2001). Only about 17 percent of partnerships at major law firms in the US were held by women in 2005 (O'Brien 2006). Flory et al. (2010) controlled for many possible confounds in the empirical data with a field experiment and still found that women tended to select out of competitive jobs. Their results confirmed a large body of laboratory experimental results initiated by Gneezy et al. (2003), who found that men's performance increased under a competitive payment scheme while women's did not. Niederle and Vesterlund (2007) showed furthermore that women were less likely to choose the competitive over the piece-rate incentive scheme controlling for ability, confidence in ability, and risk attitude. See Niederle and Vesterlund (2011), referred to as NV (2011) from now on, for a survey.

There has been some evidence showing that difference in competitiveness is due to gender differences in confidence. Conditional on actual performance, difference in beliefs can explain some of the difference in willingness to enter tournament incentives schemes (NV 2011). However, Grosse and Riener (2010) and Wozniak et al. (2010), Shurchkov (2011) find elicited beliefs do not explain differences in the choice of competitive payment. According to NV (2011), "more research is needed to determine the extent to which entry depends on the task itself, beliefs about one's relative performance, or stereotype driven beliefs about relative performance of men and women".

The evidence that difference in competitiveness may be due to gender differences in risk attitude is weaker. According to Eckel and Grossman (2008) and Croson and Gneezy (2009) women are more risk averse. However, Byrnes et al. (1999) in a meta-analysis of 150 psychology studies showed many studies found no gender differences in risk attitude. Furthermore, Wozniak et al. (2010) found that risk attitude did not significantly correlate with competitive entry. Sutter and Rutzler (2010) found risk aversion correlated significantly with tournament entry, but not enough to explain the gender gap in tournament entry. No gender difference in risk attitude was found in; Atkinson, Baird and Frye (2003); Johnson & Powell (1994) with fund managers; Dwyer, Gilkeson and List (2002) with fund managers after controlling for knowledge; Master & Meier (1988) with

small business owners. NV (2011) concluded that measures of risk attitudes play a limited role in explaining the gender gap in tournament.

Croson & Gneezy's (2009) survey of the gender difference literature characterized results on gender difference in altruism as mixed and dependent on women's choices being sensitive to context. One might expect that if women are less selfish, they would also be less competitive. In that case, women's lack of competitiveness should also depend on context. Some recent work has already begun to corroborate this logic. Gender differences in competitive attitude decreased in women against women competitions (Gneezy et al. 2003), at single sex institutions (Booth and Nolen 2009), in Muslim countries where schools were single sex (Fryer and Levitt 2009), for verbal tasks (Grosse and Riener 2010), when incentives were high (Antonovics et al. 2009), when women were competing for other people rather than themselves (Bowles et al. 2005), in matriarchical societies (Gneezy et al. 2008), among Han Chinese women (Zhang, 2011a) and among children where there is no consistent pattern (See Table 11 in Appendix E for a comparison). Even for studies which confirm greater male competitiveness within western culture, the level of variance seems disproportional for what Price (2010) characterized as "slight" changes in design. See Price (2010) for a taxonomy of treatment effects for 12 confirmatory studies where he also reports on his own failed replication of Neiderle and Vesterlund (2007). Boschini et al.'s (2009) result that women were only more generous than men after being subtly primed for their gender in a mixed gender context hints at a possible reason. The prime was the mere filling out of the subject's gender on a form before the experiment in mixed gender room. No effect was found if the form was filled out after the experiment or if before, then in a single gender room. These findings raise the possibility that culture and identity can interact with tasks to constrain or channel competition in women to uncompetitive "ladylike" behavior, or exaggerate male competitive attitude to "manly" bravado. See Bertrand (2011) for an interesting survey and discussion.

Most prior experimental tests of gender differences in competitive attitude among adults measured competitiveness by the choice of tournament payoffs as opposed to piecemeal payoffs and using real tasks, e.g., solving mazes or calculations. Thus, competitiveness was derived indirectly from the residual of probability of choosing

competitive payment (when ability, confidence in ability, and risk attitude are controlled for). There are a number of possible problems with the use of real tasks to measure competitive attitude, including gender differences in stress, and intrinsic motivation. Furthermore, beliefs and confidence measures are not without controversy. Selection into the experiment which are in effect gambles could confound results unless explicitly controlled for. More importantly however, deliberate sorting into competitive payment schemes may not only measure competitive attitude but also *self-consciously competitive* attitude, which unlike *mere* competitive attitude could have self-image or social-image motives, or other demand effects. For example, the choice of entering a bull fight or even a drinking competition may not be a good indicator of competitiveness in other areas, e.g., time preparing for high stakes standardized tests.

Our original motivation was to introduce a measure of competitive attitude which did not have these confounds. We originally hypothesized that greater male "desire to win" (DTW) may be the driving force of gender differences in performance and attitude towards real competitions, especially in the long run when some ability is endogenous (e.g. job promotion). We follow Parreiras and Rubinchik (2009) who modeled DTW as a positive term in payoffs from contests. Alternatively, Malhotra (2010) formulated it as a preference for maximizing the difference in *relative* payoffs. This interpretation would be supported by Dohmen et al. (2010) who showed that there were neural correlates to decreases in relative income for a given increase in absolute income. DTW in terms of relative payoffs as opposed to an extra term for absolute payoffs would add degrees of freedom to our model which we currently do not need to interpret our data. DTW is related to an earlier literature on the 'joy of winning" used to explain overbidding, which to our knowledge has not been formally modeled, nor used in all-pay auction settings. See Cooper and Fang (2008) for example.

DTW could be a function of outside options, e.g., an enemy fighting a defensive war is more formidable. History has many examples of combatants endogenously inducing greater DTW by 'burning their bridges'. DTW is different from the standard experimental measures of competitiveness through participation in competitive payment schemes. In particular, DTW should not measure competitive attitude where there are no winners. However, arguably mere participation in a Spanish bull run, or defiance in a losing

contest is a kind of victory. We do not use DTW in that sense.

To our knowledge, the only prior work measuring gender difference in competitive attitude through contests is Morgan et al. (2008), which did so incidentally in a repeated contest with endogenous entry. They found that women entered contests with more contestants and bid more aggressively (higher), as if they wanted to beat more people while lowering their own payoffs. However, they did not identify DTW. It would be hard to identify because of the multiplicity of players and reputational motives for bidding possible in repeated games. Furthermore, there are alternative explanations for why women behaved more aggressively. Establishing a reputation with a changing multiplicity of opponents, when only entry and bids but not identities were observable, would be a complex strategic and learning task. Their data is also consistent with women learning this complex game less quickly. Self-selection into the experiment was not controlled for. A more general problem with measuring competitive attitude using contests is that in contests, when players pay more, they only win with greater probability. Thus winning arguably requires explicit calculation of odds and therefore could introduce ability and confidence in ability as confounds in entry and bidding, as well as distortions in estimating probabilities (Baharad and Nitzan 2008).

We similarly presupposed that abstract contests, where subjects invest money to win money, capture incentives present in all contests, e.g., exams and job promotions. However, we greatly simplified the contest by using a one shot all-pay auction with a single opponent with observable gender. All-pay auctions have often been used to model real life contests. For complete information examples, see Ellingsen (1991); Baye (1996); Hillman and Riley (1989). For incomplete information examples, see Amann and Leininger (1996). For risk averse players, see Fibich et al. (2006).

Auctions have some important advantages for measuring DTW. All-pay auctions eliminate ability and confidence in ability confounds possibly present in real tasks used in prior gender differences studies. Winning in auctions is only a function of willingness to pay. Willingness to pay depends on DTW (which would be included in the total valuation of players) and risk attitude.

In principle, willingness to pay is a direct measure of competitive attitude, eliminating the need to infer competitive attitude as a residual (after controlling for ability,

confidence in ability, and risk attitude, which themselves may be measured with error). Furthermore, differences in intrinsic motivation and competitive stress should be minimal. More importantly perhaps, the decision to compete is hidden in the decision to bid above zero, while the choice of how hard to compete is camouflaged as the willingness to pay for the prize. Furthermore, though all-pay auctions are econometrically direct for measuring competitive, they are logically indirect. We inferred higher DTW from 4 relations between 4 gender pairs based upon what we found to be unintuitive consequences of standard auction theory. For our results to have arisen from demand effects, subjects would not only need an unusual level of rationality, but would also have to coordinate across each type of gender pairs in a highly implausible way. In any case, our results are contrary to our expectations based upon the literature and our understanding of gender stereotypes; we found that women were more competitive than men.

As mentioned, we began with the opposite hypothesis that men had higher DTW and that this was signaled by maleness. We found what initially *seemed* positive marginally significant results with 92 subjects (46 male vs. female pairs); men bid higher when they knew they were bidding against women[3]. We used subjects from three top tier graduate schools (Peking, Tsinghua, and Harbin Universities) in Shenzhen University Town (UT). We presented these results at the Economic Science Association Meeting in Chicago summer 2011. However, this result became insignificant with an additional 64 more subjects. With a total pool for this first study of 156 subjects, we found no difference in bids between men and women in either control or treatment. This startling result, which was contrary to the whole gender difference literature as we knew it, led us to consider the following possible causes: a) selection from admissions process to top grad schools (our original fear), b) selection bias from poster recruitment since experimental payoffs are gambles. To test for these selection confounds, we recruited entire classes (of economics students) at a *mid-tier* university, Shenzhen University[4] (SZ). There we found results more consistent with the literature. SZ subjects bid higher against their men than against their women. The pattern of bids in different treatments allowed us to use

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[3] This actually implied that men believed that women higher DTW or more risk averse. We are grateful to Charles Zheng for pointing out this error to us.

[4] Rank 108/481 in China, *Chinese University Ranking*

modified standard all-pay auction theory for complete information to separate valuation from risk attitude effects in bids. The results implied that women *could be* more risk averse. However, they seemed to have higher DTW (marginally insignificant). We also tested whether perceptions at SZ were consistent with our initial unexpected finding at UT of no gender difference by having SZ students bid against UT students. Contrary to our expectations and what would be predicted by the literature, SZ bid higher against UT women than against UT men. According to the theory we developed, this meant that SZ students believed UT women were either *less* risk averse *or* had higher DTW. This was not a school effect because SZ subjects were not informed about how we recruited at the three graduate schools of UT. To test this new "SZ hypothesis" and to rule out possible selection effects in the initial study at UT, we retested at UT recruiting entire classes (of law students) this time. Again, contrary our expectations and even to our initial finding, but consistent with SZ hypothesis; UT men and women bid higher against UT women than against UT men. According to our theory, this means that UT women were less risk averse *and* had higher DTW than UT men. These results became even more significant when we pooled the data across gender pairs within each school.

Our results contribute to the experimental, auction, and gender difference literatures. To the experimental literature, the significant differences between our initial and final results at UT (p-value=7%) suggests that prior conflicting results in measuring gender differences in risk attitude or competitive behavior could have been driven by selection effects from poster recruitment, substantiating a concern of Croson and Gneezy (2009). See also for Krawczyk (2011), Eckel and Grossman (2000), and Falk and Heckman (2006) for other self-selection effects. To the all-pay auction/contest literature, our contribution is to conduct the first all-pay auction (or even contest) experiment with (gender) signaling[5]. We found a partially separating equilibrium. UT women were believed to be more competitive in either DTW or risk attitude by SZ students (in the across school treatments), and were in fact in both (in the within school treatment). We also developed theory to separate risk attitude from valuations in all-pay auctions. Our data showed systematic differences in bidding for a common value auction, conditional on gender of the bidder and the opponent, indicating a non-common value component to an apparently

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[5] We assume that gender difference in desire to win is signaled by gender.

common value auction. Thus, our results could help explain systematic overbidding found in auction experiments. See Heyman et al. (2004), Gneezy and Smorodinsky (2006) for examples. To the gender difference literature, we introduce a new method to directly measure competitiveness without ability and confidence as possible confounds. This method has the further advantage of being less provocative of gender stereotypes and logically opaque, and therefore less likely to induce culture/identity based demand effects. The use of willingness to pay to measure competitive attitude could be more relevant to real life competitions where forgoing leisure is often the cost of success. Even if men are more willing to compete when leisure is not an option, that may not make them more competitive when leisure is an ever present temptation.

We can make the contrast between our results and the rest of the literature less surprising if we distinguish between competitiveness in the sense of winning competitions, and "aggressiveness" in the sense of being eager to enter competitions, or even higher effort in an attempt to win *after* entry. Our results do not bring into question that men are more *aggressive* than women, nor that more aggressive males, especially physically aggressive males, may have had a competitive advantage before the 21st century. However, in our information age, male aggressiveness may not be more than a decorative symbol of competitive attitude, like the ceremonial sword is a symbol of warlikeness for officers in modern military parades. They will rarely experience combat, and never with a sword. In our time, victory, particularly in mentally taxing competitions, may not go to the most aggressive person, but rather to best prepared person, who may not be aggressive at all, and who even stereotypically now is a woman[6]. Nonetheless, people who are most eager to compete may *seem* most competitive, just as wearing a sword may *seem* warlike both to the wearer and to his audience. Thus, offering subjects a self consciously competitive choice may induce demand effects just as giving subjects swords may only inspire the males among them with the fighting spirit.

The use of gender signaling also exploits possible consistency within and across

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[6] Winning without aggressive action is more conventional in some cultures. The legendary strategist Sun Tzu is reported to have said, "To fight and conquer in all our battles is not supreme excellence; supreme excellence consists in breaking the enemy's resistance without fighting." "Victorious warriors win first and then go to war, while defeated warriors go to war first and then seek to win." http://www.brainyquote.com/quotes/authors/s/sun_tzu_3.html#ixzz1oUfIirlN"   or http://classics.mit.edu/Tzu/artwar.html

gender and institutions for validating measures of competitive attitude. To our knowledge, this is the first lab evidence that university women, and therefore the professional women which are from them, are more competitive than men, even to the extent that they are less risk averse at the top ranked graduate school. We find evidence that school rank/level in China may sort in less risk averse women and out less risk averse men. We discuss other possible expressions of female DTW in the context of evidence that women have higher educational attainment despite lower ability as measured by standardized tests because they are more self disciplined than men.

II.   THEORY

In a separating equilibrium, different genders at different schools 'signal' different DTW and risk attitudes. In that case, we can use the perfect information auction theory. Baye 1996; Ellingsen (1991); Hillman and Riley (1989) showed that the mixed strategy equilibrium for asymmetric all-pay auction with complete information and risk neutral players was:

$$(V_2 - b_2)G_1(b_2) + (-b_2)(1 - G_1(b_2)) = 0$$
$$(V_1 - b_1)G_2(b_1) + (-b_1)(1 - G_2(b_1)) = V_1 - V_2$$
$$where\ V_1 > V_2$$

where V_i is the value of prize, b_i is the bid, and $G_j(b_i)$ is the probability that player j bids lower than b_i. The risk averse bidding strategy in all-pay auction with complete information can be derived in a similar way. As with all-pay auctions with risk neutral players, there are only mixed strategy equilibrium when players are risk averse. In a mixed strategy equilibrium, each player's equilibrium strategy has to make the opponent indifferent across all his strategies. Therefore, the equilibrium condition of all-pay auctions with risk averse players requires that each player's expected utility equals the utility of the value of the auction for that player. For the higher valuation player, the value of the auction is the gap between the two players' valuations; for the lower valuation player, the value of the auction is zero. As with Bertrand competition, competition here results in both players exhausting their surplus, so that the lower valuation player achieves zero expected surplus, and the higher valuation player only achieves the

difference. Thus, the equilibrium conditions for risk averse players are:

$$U_2(V_2 - b_2)G_1(b_2) + U_2(-b_2)(1 - G_1(b_2)) = U_2(0)$$
$$U_1(V_1 - b_1)G_2(b_1) + U_1(-b_1)(1 - G_2(b_1)) = U_1(V_1 - V_2)$$

Therefore the cumulative distribution functions (CDF) of equilibrium strategies are:

$$G_1(b) = \frac{U_2(0) - U_2(-b)}{U_2(V_2 - b) - U_2(-b)}$$

$$G_2(b) = \frac{U_1(V_1 - V_2) - U_1(-b)}{U_1(V_1 - b) - U_1(-b)}$$

Note that because player 1 has the higher valuation, $G_1(b)$, his equilibrium strategy, is a decreasing function of V_2. Thus, the higher valuation player's bid is an increasing function of the lower valuation player's valuation. Correspondingly, player 2's bid decreases with V_1, the higher valuation player's valuation, but increases with V_2. Furthermore, both players' bids decrease with the opponents' risk aversion only. Their own risk aversion does not affect their own bids. This result can be made more intuitive. First, one should note that in a mixed strategy equilibrium, bids decrease with the opponent's risk aversion to keep the opponent indifferent. Though a mixed strategy equilibrium is conceptually more difficult to game theoretically analyze, subjects need not find it more difficult to implement in experiments. A mixed strategy equilibrium can be interpreted as pure strategy equilibrium in which players are unsure of what strategy the opponent chooses (Aumann and Brandenburger 1995). The subject's choice is conditional on uncertainty *in effect* randomizes. Thus, the mutual indifference condition of a mixed strategy equilibrium can be met by common knowledge of uncertainty of opponent's bid. Furthermore, for our purpose of inferring bidders' *beliefs about relative valuations and risk attitudes*, we only need assume that subjects are in equilibrium with their *subjective image* of their opponent. It so happens that this across school image is consistent, so far as we can tell, with the image within schools, confirming our signaling hypothesis. But even if it were not, we should still be able to infer beliefs about relative risk and competitive attitudes based upon within schools data only. Now, when the bidder's risk aversion increases, the mixed strategy to keep the opponent indifferent is unchanged. However, the opponent's strategy must change to compensate for the greater risk aversion of bidder. Hence, if the opponent's risk aversion increases, the bidders
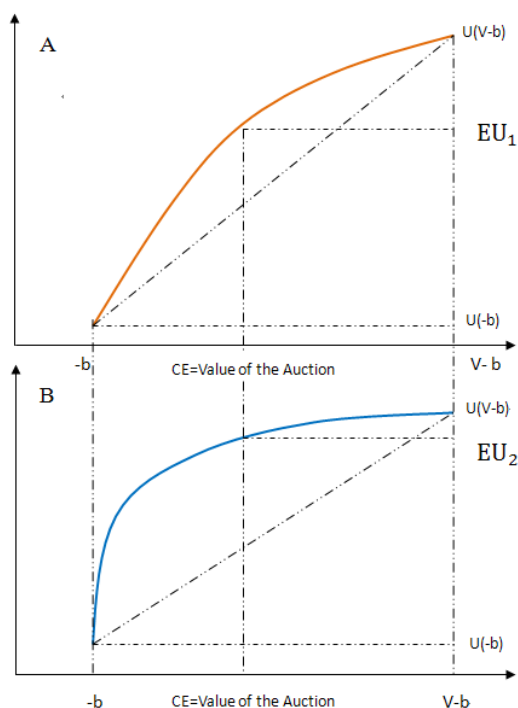
Figure 1: Effect of increased risk aversion.

strategy changes. To make this claim more intuitive, we now use graphical analysis in Figure 1 to show what happens when the opponent's risk aversion increases. In a mixed strategy equilibrium for an all-pay auction with complete information, players are indifferent between all bids; all bids give them the same expected value. In particular, they are indifferent to the bid which gives them the minimal value, 0 for sure, which would be given by a bid of 0. This is their certainty equivalent (CE in Figure 1) of the gamble. Thus, for the lower valuation player (player 2 in our example), in a mixed strategy equilibrium, where he gets an expected value from all other bids, indifference to 0 requires that the expected value from all other bids also be 0. See part A in Figure 1. Graphically, an increase in player 2's risk aversion increases the curvature of player 2's utility from Figure 1A to 1B. For concave functions which increase at a decreasing rate, an increase in the risk aversion must increase this rate of decrease in the slope. Thus, the gap between the utility of winning for player 2, $U_2(V - b)$, and the expected utility of wining, $G_1 * U_2(V - b)$, given the equilibrium strategy of player 1 must decrease. Therefore, the probability of winning G_1 must increase to G'_1 to keep player 2 indifferent to the CE. Thus, player 1 (player 2's opponent) must bid lower when player 2's risk aversion increases.

Here are the basic rules of inference which we follow. For convenience, we will use DTW synonymously with valuation. First, if all bids are the same, no difference in either valuations or risk aversion can be inferred. Now, for same gender pairs, e.g., if MM>FF, we can rule out F having both higher valuation and lower risk aversion. In other words, M must have either higher valuation or be less risk averse. For different bidders but fixed opponent, e.g., if MF<FF, M must have the lower valuation since the effect of risk aversion is fixed by the fixed opponent F. MF=FF iff M has higher valuation. See Proposition 5 in Appendix A for a proof. For bidders and opponents with different

genders, e.g., if MF>FM, either M has higher valuation or F has lower risk aversion. The reasoning can be seen in the following. We rewrite the equilibrium bidding function for F against M when F has a lower valuation than M. Here MU_i stands for the marginal utility of player i={M,F}.

$$G_{FM}(b) = \frac{U_M(V_M - V_F) - U_M(-b)}{U_M(V_M - b) - U_M(-b)}$$

$$= \frac{U_M(0) + MU_M(V_M - V_F) - U_M(-b)}{U_M(V_F - b) + MU_M(V_M - V_F) - U_M(-b)}$$

$$> \frac{U_M(0) - U_M(-b)}{U_M(V_F - b) - U_M(-b)}$$

$$> \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{MF}(b)$$

The complete set of implications is below in Table 2 and 3. Proofs are in Appendix A.

III.   EXPERIMENTAL DESIGN

We recruited a total of 582 subjects. The first 156 (78 of each gender) from UT were to test our initial hypothesis. 92 of these gave us what seemed to be preliminary confirmation that men had higher desire to win. This was disconfirmed when we added 64 more subjects in UT. See Figures 6 and 7 in Appendix C. All these subjects were recruited with posters around UT. For our 2nd set of studies, where we controlled for selection effects, one coauthor, (Charlie Chen) contacted the class monitors at SZ (economics majors) and UT (Tsinghua Law School for our UT within school treatments and Peking University Law School for our UT across school treatments[7]) to see if they would agree to announce the possibility of participating in the experiment at the end of class. These monitors sent all their students a message asking them to stay for 10 minutes longer after class to participate in our paid experiment on the following day. They also asked students not to leave unless they had an emergency. We recruited 416 subjects (201 male, 215 female), 213 of them (120 male, 93 female) came from SZ and 203 of them (81 male, 122 female) came from UT. We did not have perfect balance in genders because

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[7] We decided on these across school treatments (UT against SZ) after seeing the within UT data which corroborated the "SZ hypothesis". See figure 5.

monitors were given envelopes to hand out based upon estimates of the gender mix in their area of the lecture hall. 19 (2 male, 17 female) in SZ out of 232 and 21 (18 male, 3 female) out of 224 in UT from each class were dropped from our pool because the class monitors ran out the envelopes we had given them. We thus had no endogenous self-selection. The gender compositions were 52.6% male and 47.4% female in SZ, 44.2% male and 55.8% female.

Each envelope contained a bidding sheet with instructions in which subjects were informed that they had 10 CNY [8]and could bid for 10 CNY in the all-pay auction. The instructions are in Appendix F. Subjects were paired in two ways randomly, secretly and anonymously in the following treatments. In the cases in which we did not have gender balance, unmatched players faced a random draw from 0-10CNY.

The complete information treatments were:

1. With same gender opponent: (M,M) and (F,F), where the first coordinate is the bidder and the 2nd coordinate is the opponent. We will write these pairs without brackets for short.
2. With opposite gender opponent: MF and FM.
3. Subjects always knew the school of the opponent. However, to avoid clutter, we will put SZ or UT before the gender when bidding is with an opposing school's student.

The incomplete information controls were MC and FC.

On the bidding sheet, they could mark a bid ranging from 0-10 CNY in ½ CNY increments. The winner got the prize of 10 CNY. Following Gneezy and Smorodinsky (2006), we split the prize if there was a tie. Bids were necessarily discrete since money was discrete. Our budget also necessitated a bidding cap of 10CNY. Discrete bids with caps should decrease equilibrium bids slightly and should not have systematic effects on relative bids. See Appendix B for the theory.

There was also a place on the bidding sheet for students to write down their name and bank account information. The instructions told students to put the bidding sheet back into the envelope. We transferred payment to their account after we finished all sessions of the experiment. See Table 1 for a detailed breakdown of subjects for our 2nd

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[8] As a benchmark, student assistants make 10-15CNY per hour.

set of experiments with whole class recruitment.

SZ Treatments	Number of Subjects	UT Treatments	Number of Subjects
SZ-MM	26	UT-MM	16
SZ-FF	22	UT-FF	27
SZ-MF	25	UT-MF	23
SZ-FM	25	UT-FM	28
SZ-MC	23	UT-MC	19
SZ-FC	23	UT-FC	22
(SZ-M, UT-M)	23	(UT-M, SZ-M)	23
(SZ-M, UT-F)	23	(UT-F, SZ-M)	22
(SZ-F, UT-F)	23	(UT-F, SZ-F)	23

Table 1: Number of subjects per treatment.

IV.   MAIN RESULTS

1. DATA

Figure 1 shows the cross gender bidding behavior within each school. Within SZ, women bid higher against men (FM=7.4 CNY) than men against women (MF=4.8 CNY). In contrast, within UT, women bid lower against men (FM=3.7 CNY) than men against women (MF=5.2 CNY). See Figure 7 Appendix D for the distribution of bids.
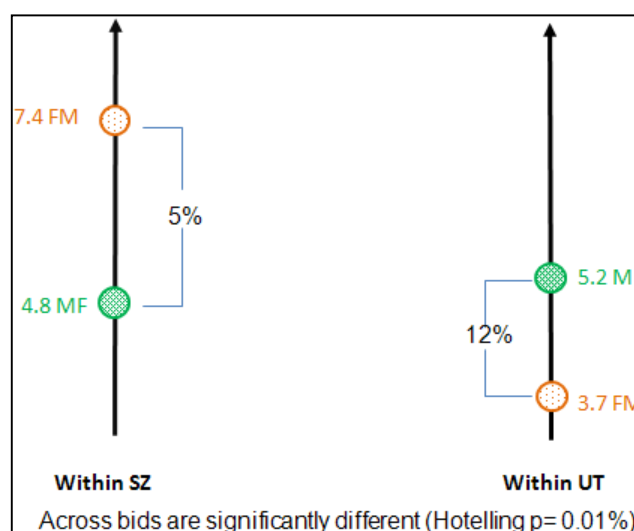

Figure 1: Cross gender bidding behavior within SZ and UT.

Figure 2 adds on the 'same gender' bidding behavior within each school. Within SZ, women and men bid about the same against the same gender opponent: FF=6.8 CNY and MM=6.2 CNY. In contrast, within UT, women bid higher against each other (FF=6.7 CNY) than men against men (4.8 CNY). From the drop in MM and FM from SZ to UT, it

seems that the main change as the tier of the school increased was that males in UT were much less competitive than at SZ. See Figure 8 Appendix C for the distribution of bids. However, the bidding behavior of SZ students against UT women in Figure 4 shows that women were at least perceived to be different in top graduate schools.
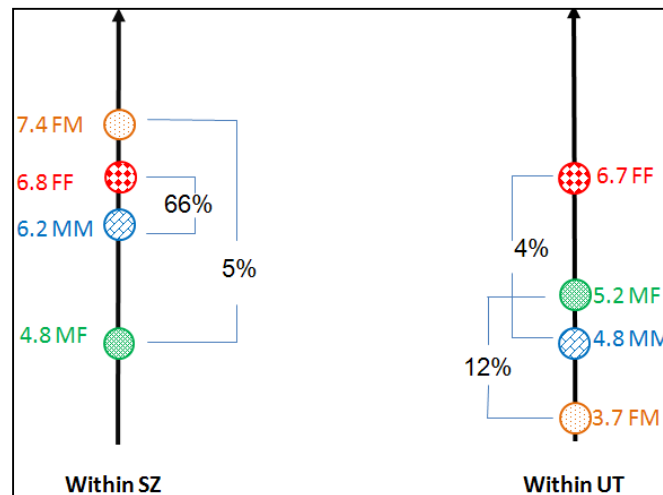

Figure 2: Same gender bidding behavior within SZ and UT.

Figure 3 adds on the incomplete information bidding behavior within each school, where the bidder did not know the gender of the opponent. Within SZ, women bid between the perfect information cases at FC=7.3 CNY, as one would expect. In contrast, men bid lower than either perfect information cases at MC=4.5 CNY. Within UT, women and men bid about the same: MC=6.1 CNY and FC=6.0 CNY, but again, men bid higher than in either of the perfect information cases. We are not sure how to interpret male behavior in either SZ or UT for the imperfect information cases. In any case, none of these differences between male bidding with incomplete information and the closest point of male bidding with perfect information are significant.
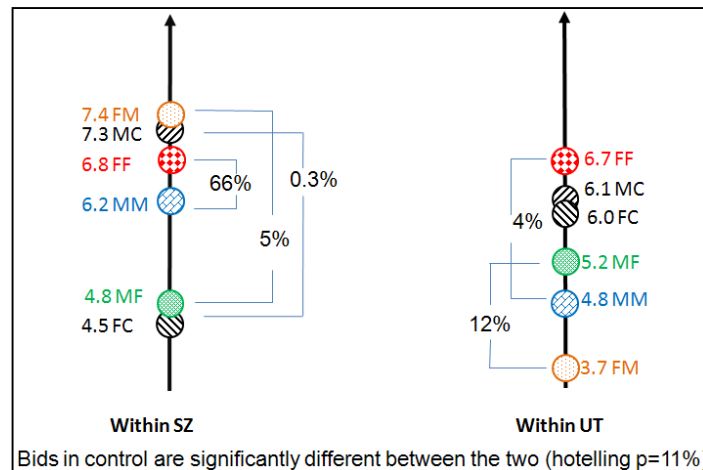
Figure 3: Incomplete information bidding behavior within SZ and UT.

Figure 4 shows how SZ women and men bid higher against UT women, (SZ-F, UT-F) =7.7 CNY, (SZ-M,UT-F)=6.5 CNY, than against UT men, (SZ-M, UT-M)=5.1 CNY. Due to our budget constraint, we do not have (SZ-F, UT-M) treatment). See Figure 9 Appendix C for the distribution of bids.

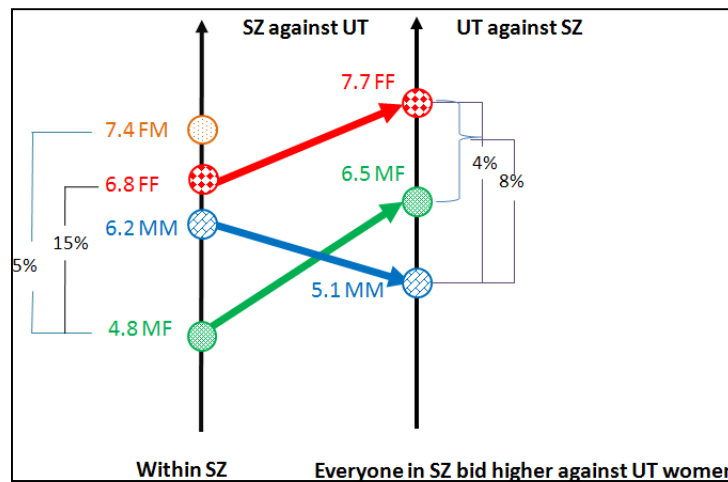
Figure 4: SZ bid higher against UT women than against UT men.

Figure 5 shows how UT women bid lower against SZ men, (UT-F, SZ-M)=4.8 CNY, than against SZ women (UT-F, SZ-F)=4.9 CNY.

The rough pattern of across school bidding, ignoring statistical significance, is as follows. Everyone bid higher against males at SZ. Everyone bid higher against females at UT. See Figure 5 for all the data.
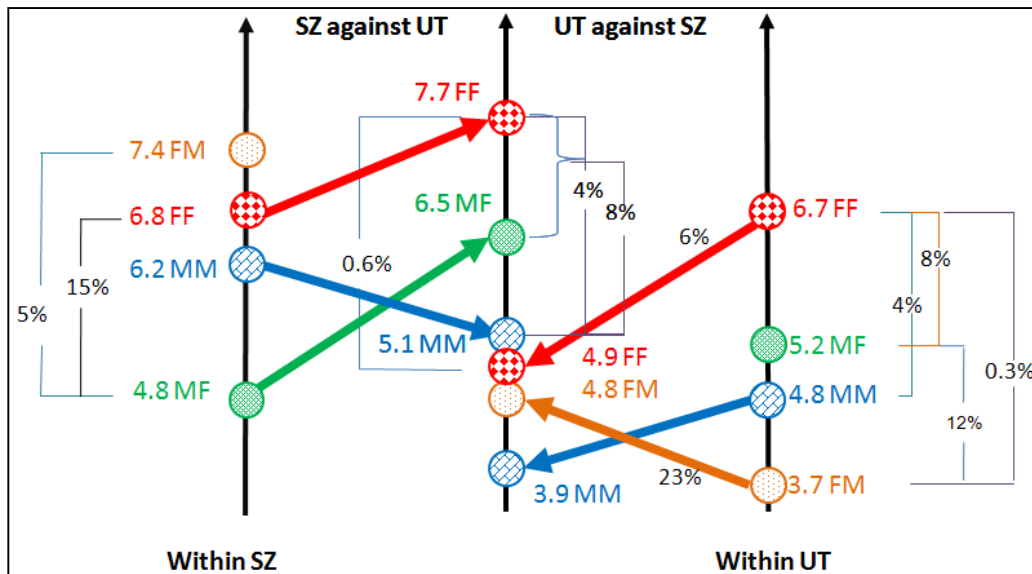
Figure 5: All data.

The payoffs for all players are in Figure 11 in Appendix D. UT males (UT-M in the left most column) made the most money with an average payoff of 11.4 CNY, and that against UT females (UT-F in the highest row). However, as can see from Figure 5, though UT males tend to bid low, UT females bid even lower against them at 3.7CNY.

2. IDENTIFICATION OF DESIRE TO WIN AND RISK ATTITUDE

Below in Table 2 we worked out all of the predictions of standard all-pay auction theory for each gender pair (left most column) given assumptions of their risk attitude (R) and valuations (V) (top of columns 2-5). V:M>F denotes that the valuation of males is greater than that of females. R:M>F denotes that the risk aversion of males is greater than females. Table 3 shows the theoretical predictions when valuations and risk aversion can be different across genders. The theoretical prediction for the relation between bids when women have higher desire to win (V:M<F) is marked by red boxes. This uniquely predicts FM=MM and MF<FF. These predictions are marked in the smaller boxes within the larger boxes.

Data Result 1: Women have higher desire to win than men.

Gender Pairs	Diff valuation (V), risk neutral		Same valuation, diff risk aversion (R)	
	V:M>F	V:M<F	R: M<F	R: M>F
MM VS. FF	>	<	>	<
FM VS. FF	<	<	>	<
MF VS. MM	<	<	<	>
FM VS. MM	<	=	=	=
MF VS. FF	=	<	=	=
MF VS. FM	>	<	<	>

Table 2: Theoretical predictions for the a) different valuations, risk neutral, b) same valuation different risk aversion cases.

Gender Pairs	Different valuation (V), different risk aversion (R)			
	V:M>F,R:M<F	V:M>F,R:M>F	V:M<F,R:M<F	V:M<F,R:M>F
MM VS. FF	>	<=>	<=>	<
FM VS. FF	<=>	<	<=>	<
MF VS. MM	<	<=>	<	<=>
FM VS. MM	<	<	=	=
MF VS. FF	=	=	<	<
MF VS. FM	<=>	>	<	<=>

Table 3: Theoretical predictions for the different valuations and different risk aversion case.

The pooled data showing that women have higher DTW is shown in Table 4. FF-MF is significantly different from zero at less than the 1% level, while the difference FM-MM is not significantly different from zero. These are one tailed tests. P-values are always from the Mann-Whitney (MW) test.

Gender Pairs	SZ	SZ-across	UT	UT-across	Pooled	Predicted
FF-MF	>0 (15%)	>0 (25%)	>0 (8.7%)		>0 (p=0.03%)	>0
FM-MM	>0 (28%)		<0 (42%)	>0 (45%)	>0 (p=32%)	=0

Table 4: Pooled data showing that women have higher DTW.

Data Result 2: Everyone bids higher against UT women. Everyone bid lower against UT men.

In Table 5, we show all of the pairs relevant to the prediction that everyone bids higher against UT women than UT men. Here we merely combined all the data into pairs which should yield a positive value if the prediction were correct. We will write the bidder

opponent pair as a function of the school. (UT-M,UT-F) – (UT-M,UT-M) should be greater than zero if UT men bid higher against UT women than against themselves. (SZ-M, SZ-M) – (SZ-M,UT-M) should also be greater than zero if SZ men bidding against UT men bid higher than when they bid against themselves. (UT-M,SZ-M) – (UT-M,UT-M) should be greater than zero if UT men bidding against SZ men bid higher than they bid against themselves. (UT-F,UT-F) – (UT-F,UT-M) should be greater than zero if UT women bid higher against themselves than they bid against UT men. We exhibit the level of significance of the one sided MW in the right most column. The p-value is 0.8%. Similarly, (SZ-F,UT-F) – (SZ-F,SZ-F) should be greater than zero if SZ women bidding against UT women bid higher than they bid against themselves. (UT-F,UT-F) – (UT-F,SZ-F) should be greater than zero if UT women bid higher against themselves than against SZ women. (SZ-M,UT-F) – (SZ-M,SZ-F) should be greater than zero if SZ men bid higher against UT women than against SZ women. The p-value for these differences is 0.1%. This result is not consistent with UT women being less rational than UT men and bidding too much. Again, the lowest bid FM=3.7 CNY came from UT women against UT men.

Relevant pairs				One sided MW
(UT-M,UT-F) – (UT-M,UT-M)	(SZ-M, SZ-M) – (SZ-M,UT-M)	(UT-M,SZ-M) – (UT-M,UT-M)	(UT-F,UT-F) – (UT-F,UT-M)	**p=0.8%**
(SZ-F,UT-F) – (SZ-F,SZ-F)	(UT-F,UT-F) – (UT-F,SZ-F)	(SZ-M,UT-F) – (SZ-M,SZ-F)		**p=0.1%**

Table 5: Everyone bids higher against UT women, lower against UT men.

Data Result 3: SZ women have higher desire to win than SZ men, and may be more risk averse.

Tables 6 and 7 shows how we inferred that SZ women have higher DTW than SZ men and may be more risk averse. First, notice from Figure 5 that FM=7.4>MF=4.8 (p=5%). This eliminated columns 2 and 5 in Table 6 and column 3 in Table 7, ruling out the case where men have higher DTW and are more risk averse. Furthermore, FF=6.8>MF=4.8 (p=15%) is not consistent with column 4 in Table 6, where women are more risk averse and have the same valuation as men. Another way to see this is: fixing the opponent fixes the effect of risk attitude. The fact that SZ women bid higher against SZ women than SZ men against SZ women implies that SZ women have higher DTW. Column 3 in Table 6 and column 4 and 5 in Table 7 are what remain. These are consistent with women having higher DTW. However, MM=6.2=FF=6.8 is not consistent with column 5 in Table 7.

Column 4 in Table 7 is uniquely consistent with all of the data, though some of the data which identify it are not significant. Thus, the unique intersection of these sets suggests women have higher DTW and are more risk averse: V:M<F,R:M<F.

Gender Pairs	Diff valuation (V), risk neutral		Same valuation, diff risk aversion (R)	
	V:M>F	V:M<F	R: M<F	R: M>F
MM VS. FF	>	<	>	<
FM VS. FF	<	<	FM=7.4>FF=6.8	<
MF VS. MM	<	MF=4.8<MM=6.2		>
FM VS. MM	<	FM=7.4=MM=6.2		=
MF VS. FF	=	MF=4.8<FF=6.8	=	=
MF VS. FM	>	MF=4.8<FM=7.4		>

Table 6: Identification for SZ: a) different valuations and risk neutral, and b) same valuation, different risk aversions cases.

Gender Pairs	Different valuation (V), different risk aversion (R)			
	V:M>F,R:M<F	V:M>F,R:M>F	V:M<F,R:M<F	V:M<F,R:M>F
MM VS. FF	>	<=>	MM=6.2=FF=6.8	<
FM VS. FF	<=>	<	FM=7.4>FF=6.8	<
MF VS. MM	MF=4.8<MM=6.2	<=>	MF=4.8<MM=6.2	
FM VS. MM	<	<	FM=7.4=MM=6.2	=
MF VS. FF	=	=	MF=4.8<FF=6.8	
MF VS. FM	MF=4.8<FM=7.4	>	MF=4.8<FM=7.4	

Table 7: Identification for SZ: different valuations and different risk aversions case.

Data Result 4: SZ believed that UT women have higher desire to win or lower risk aversion than UT men.

Assume SZ students believe they have higher desire to win then we can make the following inferences. Recall from the theory section that the stronger (higher valuation) player's bid increases with the weaker player's valuation. Furthermore recall that a less risk averse opponent will increase the bidder's bid. Thus, SZ men and women bidding higher against UT women than against UT men implied they believed that UT-women were either less risk averse or had higher DTW than UT men (p=8%). See figure 5. This implication makes a within school prediction at UT shown in the large red boxes in Tables 8 and 9. These boxes include the columns where either men have lower DTW; V:M<F, or men are more risk averse; R:M>F, and excludes the columns with the

assumption V:M>F and R:M>F in Table 9. If within school results are consistent, then they should be within the included columns. This is indeed what we see. This suggest across school signaling. Furthermore, consistent with the mentioned assumption that SZ students have higher valuations than UT students: UT women bid (4.9) lower against SZ women (7.7) (p=4%), and UT men bid (5.1) lower against SZ men (3.9) (p=40%).

Data Result 5: UT women have both higher desire to win and lower risk aversion than UT men.
MF=5.2<FF=6.7 (p=8%) is only consistent with the 3rd column of Table 8 and the 4th and 5th columns of table 9. MF=5.2>FM=3.7 (p=12%) is only consistent with column 5 of Table 9, which is the column that is uniquely consistent with all the data. This is also supported by FF=6.7>MM=4.8 (p=4%) which ruled out column 4 in Table 8.

Gender Pairs	Diff valuation (V), risk neutral		Same valuation, diff risk aversion (R)	
	V:M>F	V:M<F	R: M<F	R: M>F
MM VS. FF	>	<	>	<
FM VS. FF	<	<	>	<
MF VS. MM	<	<	<	>
FM VS. MM	<	=	=	=
MF VS. FF	=	MF=5.2<FF=6.7	=	=
MF VS. FM	>	<	<	>

Table 8: Identification for SZ: a) different valuations and risk neutral, and b) same valuation, different risk aversions cases.

Gender Pairs	Different valuation (V), different risk aversion (R)			
	V:M>F,R:M<F	V:M>F,R:M>F	V:M<F,R:M<F	V:M<F,R:M>F
MM VS. FF	>	<=>	MM=4.8<MF=5.2	
FM VS. FF	<=>	<	FM=3.7<FF=6.7	
MF VS. MM	<	<=>	<	MF=5.2=MM=4.8
FM VS. MM	<	<	FM=3.7=MM=4.8	
MF VS. FF	=	=	MF=5.2<FF=6.7	
MF VS. FM	<=>	>	<	MF=5.2>FM=3.7

Table 9: Identification for SZ: different valuations and different risk aversions case.

The across school bidding of UT women also corroborated the pattern of bids of SZ students against them and UT men. UT-women bid lower against SZ women (4.9) than

UT women (6.7) (p=6%) implying that they believed SZ women were either more risk averse or had lower DTW than UT women. This is consistent with the estimate of SZ women against UT women mentioned just above. Furthermore, UT women bid higher against SZ men (4.8) than UT men (3.7) (p=23%) *weakly implying* that they believed that SZ men are either less risk averse or have higher DTW than UT men. However, we did not match SZ men against UT men due to our budget constraint. We do not have data to confirm this estimation. In any case, these bids from UT women do not have within school implications for SZ because unlike SZ bids against UT men and women, these relate UT women to SZ women and UT men to SZ men.

Data Result 6: The simultaneous test of: a) the assumption that SZ women have higher desire to win and are more risk averse than SZ men, and b) the assumption that UT women have higher desire to win and are less risk averse than UT men are highly significant.

We used separate data from different combinations of genders to indentify which of the 4 combinations of desire to win and risk attitudes were most likely. However, we can also test all of the data within each school against the null simultaneously. We test first the hypothesis which we indentified above in Data Result 3 that SZ women have higher desire to win and are more risk averse; V:M<F, R:M<F in column 4 of upper part of table 10. Note that the first two rows of this column are not predictive. The 4th row predicts equality, but that cannot be tested by a test of significance. However, the 3rd predicts MF<MM, the 5th predicts MF<FF, and the 6th predicts MF<FM. The one tailed MW test at the bottom of Table 10 shows a level of significance that is less than 1% (0.36%). We next test the hypothesis that UT women have higher desire to win and are less risk averse; V:M<F, R:M>F in column 5 of upper part of table 10. Note that the 3rd and 6th rows of this column are not predictive. Again, the 4th row predicts equality, but that cannot be tested by a test of significance. However, the 1st predicts MM<FF, the 5th predicts MF<FF, and the 5th predicts MF<FF. The one tailed MW test shows a level of significance that is less than 1% (1.8e-05). When we pool all of the data, we get an even greater level of significance <1e-06. This indicates that our model fits the data very well.

Gender Pairs	Different valuation (V), different risk aversion (R)			
	V:M>F,R:M<F	V:M>F,R:M>F	V:M<F,R:M<F	V:M<F,R:M>F
MM VS. FF	>	<=>	<=>	<
FM VS. FF	<=>	<	<=>	<
MF VS. MM	<	<=>	<	<=>
FM VS. MM	<	<	=	=
MF VS. FF	=	=	<	<
MF VS. FM	<=>	>	<	<=>

Treatments	Pairs			MW (one tail)	Pooled
SZ within	MF < MM	MF < FF	MF < FM	0.36%	<1e-06
UT within	MM < FF	FM < FF	MF < FF	1.8e-05	

Table 10: Pooled within school data.

V. DISCUSSION

DTW, understood as willingness to pay in auctions should be predictive of willingness to pay in other domains of competition. Perhaps the most important expression of DTW is the willingness to forgo leisure in the preparation for real life competitions, where leisure is a constant temptation. Assuming that studying was the cost of doing well on exams, our results would be consistent with women being more competitive than men for exams for which they can prepare/forgo leisure. In fact, Duckworth and Seligman (2006), Duckworth et al. (2007) showed that girls do better than boys in non-IQ type tests, e.g., spelling competitions, and that due to greater self-discipline or "grit". The greater persistence of women was also suggested by Cotton et al. (2009), which showed that the male advantage in math competition against females in the US disappeared after the 1st round. Desjarlais (2009) showed that girls selected into math competitions (AMC 8 Contest) at virtually the same rate as boys (183,857 males vs. 178,857 females) with no differences in measured abilities. In general, women have higher educational attainment though they have lower average ability as measured by standardized tests. (This is true irrespective of whether it's due to them having lower ability or because more lower ability girls are writing these tests.) Girls are graduating high school, college and graduate schools at higher rates in the US (Buchmann et al. 2008), though males do better than females in most standardized tests including SAT,

GRE, GMAT, AP (Coley 2001). The pattern is similar for grade school education in less developed countries (Grant and Berhman 2010) including China (Lai 2010). Even when fixing the course of study to law, the only field for which we could find data, the almost equal number of women LSAT test takers (Dalessandro, Stilwell, Lawlor, Rees, 2010), though women have lower measured ability on the LSAT, suggests that women are in fact more competitive than men. Lower ability with higher achievement implies that women are paying more in effort and leisure than men. Chinese girls may be particularly willing to pay due to the traditional Chinese cultural preference for boys which has been recently exacerbated by the one child policy. This is supported by anecdotal evidence that girls may have to "prove their worth" to the family. Consistent with this, Zhang (2011a) found no gender difference in competitive attitude among Han Chinese women, but did find it with their neighboring non-Han (minority) Chinese women, who were less restricted by the one child policy.

The significant change in risk attitude from SZ and UT could be due to Chinese universities reliance upon entrance exams with predictable content. For these exams, success is mostly a matter of studying. Within this system, elite institutions may admit super competitive women, who have higher DTW and are less risk averse, while they lose comparable men to the market. In contrast, US schools use IQ like tests, grades, recommendations, interviews, and extracurricular activities all of which may be difficult to prepare for.

The fact that women are apparently less competitive in their labor market outcomes, given greater competitiveness in school, could be due to other factors like marriage to even more competitive husbands and motherhood. Ancetol (2011) showed that labor market participation of white women is non-monotonic on their level of education. This could be due to their education being correlated with their husbands' education and ambition. Shaffer (2011) showed that women's labor force participation is decreasing on the income gap with their husband's income. Australian women's reported life satisfaction increased if their partner worked full time but decreased if they worked full time (Booth and Ors 2009). Charles (2011) showed that women in richer countries tended to adopt more traditional gender roles, consistent with wealth better revealing women's preferences. Women's higher self discipline could still be consistent with lower

representation in the most competitive profession. Male lower self discipline could be an advantage for the most able men in the most competitive professions. The susceptibility to the temptation for salient competitions ,i.e., showing off, could drive low ability men into street fights at the same time that it drives high ability men to "workaholism."

VI.   CONCLUSIONS

To our knowledge, this is the first study to separate ability, confidence in ability from competitive attitude – a priori. Our measure of competitive attitude has the further advantages of being econometrically direct and logically opaque. The latter should minimize possible demand effects based upon social or self-image. Consistent with the literature, we found that women *could* be more risk averse, but only at mid tier undergraduate institution. In contrast to the literature, in a sample of nearly 600 subjects, we found no evidence that women had less desire to win and were more risk averse – consistent with the usual finding in the West. Furthermore, when selection into the experiment was controlled for with 400 subjects, we found that women had greater DTW, even at the mid tier school. Women were believed to be and were in fact more competitive than men at the top tier university showing both higher desire to win and lower risk aversion. To our knowledge, we provide the first evidence that women, in particular, professional women, are even more competitive than men. This is consistent with other empirical results which showed that women are more competitive than men in the sense that they have higher levels of educational attainment despite lower ability as measured by standardized tests. The contrast between our initial where we used poster recruitment and our final study where we recruited whole classes suggests self-selection could have a significant impact on measured gender differences. That could help explain past conflicting results. Our finding of systematically different bids in a common value all-pay auction could also help explain overbidding behavior found in prior studies.

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APPENDIX A: PROOFS OF INFERENCE RULES

MM VS FF

Proposition 1: If males have a higher valuations than females (V:M>F) and are less risk averse，i.e., more risk prone (R:M>F), then MM>FF:

$$G_{MM}(b) = \frac{U_M(0) - U_M(-b)}{U_M(V_M - b) - U_M(-b)}$$

$$= \frac{U_M(0) - U_M(-b)}{U_M(V_F - b) + MU_M(V_M - V_F) - U_M(-b)}$$

$$< \frac{U_M(0) - U_M(-b)}{U_M(V_F - b) - U_M(-b)}$$

$$< \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{FF}(b)$$

MF vs FM

Proposition 2: If males have a higher valuations than females (V: M>F), and are more risk averse (R: M<F) , then MF>FM.

Proof:

$$G_{FM}(b) = \frac{U_M(V_M - V_F) - U_M(-b)}{U_M(V_M - b) - U_M(-b)}$$

$$= \frac{U_M(0) + MU_M(V_M - V_F) - U_M(-b)}{U_M(V_F - b) + MU_M(V_M - V_F) - U_M(-b)}$$

$$> \frac{U_M(0) - U_M(-b)}{U_M(V_F - b) - U_M(-b)}$$

$$> \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{MF}(b)$$

MF vs MM

Proposition 3: If males have a higher valuations than females (V: M>F) and are less risk averse (R: M>F), then MF<MM.

Proof:

$$G_{MF}(b) = \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)}$$

$$> \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) + MU_F(V_M - V_F) - U_F(-b)}$$

$$= \frac{U_F(0) - U_F(-b)}{U_F(V_M - b) - U_F(-b)}$$

$$> \frac{U_M(0) - U_M(-b)}{U_M(V_M - b) - U_M(-b)} = G_{MM}(b)$$

Proposition 4: If males have lower valuations than females (V: M<F) and are less risk averse (R: M>F), then MF<MM

Proof:

$$G_{MM}(b) = \frac{U_M(0) - U_M(-b)}{U_M(V_M - b) - U_M(-b)}$$

$$< \frac{U_M(0) + MU_M(V_F - V_M) - U_M(-b)}{U_M(V_M - b) + MU_M(V_F - V_M) - U_M(-b)}$$

$$< \frac{U_M(V_F - V_M) - U_M(-b)}{U_M(V_F - b) - U_M(-b)}$$

$$< \frac{U_F(V_F - V_M) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{MF}(b)$$

Therefore, as long as male are less risk averse, MF should be lower than MM.

MF VS. FF

Proposition 5: If males have higher valuations than females (V: M>F), then MF=FF

Proof:

$$G_{FF}(b) = \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{MF}(b)$$

Proposition 6: If males have lower valuations than females (V: M<F), then MF<FF

Proof:

$$G_{MF}(b) = \frac{U_F(V_F - V_m) - U_F(-b)}{U_F(V_F - b) - U_F(-b)}$$

$$= \frac{U_F(0) + MU_F(V_F - V_m) - U_F(-b)}{U_F(V_F - b) - U_F(-b)}$$

$$> \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{FF}(b)$$

Therefore, whenever males have higher valuation, MF=FF; whenever males have lower valuation, MF<FF.

APPENDIX B: TIE BREAKING AND DISCRETIZATION

If ties are broken by equal probability of getting the prize (hereafter "flip", as flip of a coin), then in a mixed strategy equilibrium, player 1's expected utility equals the utility

from the expected payoff from the auction:

$$U_1(V_1 - b_1)G_2(b_1 - inc) + U_1(-b_1)(1 - G_2(b_1)) + \left(\frac{1}{2}U_1(V_1 - b_1) + \right.$$

$$\left.\frac{1}{2}U_1(-b_1)\right)(G_2(b_1) - G_2(b_1 - inc)) = U_1(expected\ payoff)$$

After rearrangement,

$$G_2(b_1 - inc) = \frac{U_1(expected\ payoff) - U_1(-b_1)}{U_1(V_1 - b_1) - U_1(-b_1)} + \frac{1}{2} * pr_2(b_1)$$

If ties are broken by splitting the prize (hereafter "split"), the mixed strategy equilibrium relation becomes:

$$U_1(V_1 - b_1)G_2^*(b_1 - inc) + U_1(-b_1)(1 - G_2^*(b_1)) +$$

$$U_1(\tfrac{1}{2}V_1 - b_1)(G_2^*(b_1) - G_2^*(b_1 - inc)) = U_1(expected\ payoff^*)$$

After rearrangement,

$$G_2^*(b_1 - inc) = \frac{U_1(expected\ payoff^*) - U_1(-b_1)}{U_1(V_1 - b_1) - U_1(-b_1)} + \frac{\left(U_1\left(\frac{1}{2}V_1 - b_1\right) - U_1(-b_1)\right)}{U_1(V_1 - b_1) - U_1(-b_1)}$$
$$* pr_2{}^*(b_1)$$

It is easy to see that for risk averse players,

$$\frac{1}{2} < \frac{\left(U_1\left(\frac{1}{2}V_1 - b_1\right) - U_1(-b_1)\right)}{U_1(V_1 - b_1) - U_1(-b_1)}$$

(Che and Gale 1998) showed that when there was a cap m in an all-pay auction, and $m \in (\frac{V_2}{2}, V_2)$, then the expected payoff of player 1 is $V_1 - V_2$, and that of player 2 is 0, which is the same as the no cap case. Thus, the mixed strategy equilibrium for both players are:

Flip:

$$\begin{cases} G_1(b_2 - inc) = \dfrac{U_2(0) - U_2(-b_2)}{U_2(V_2 - b_2) - U_2(-b_2)} + \dfrac{1}{2} * pr_1(b_2) \\[2ex] G_2(b_1 - inc) = \dfrac{U_1(V_1 - V_2) - U_1(-b_1)}{U_1(V_1 - b_1) - U_1(-b_1)} + \dfrac{1}{2} * pr_2(b_1) \end{cases}$$

Split:

$$
\begin{cases}
G_1^*(b_2 - inc) = \dfrac{U_2(0) - U_2(-b_2)}{U_2(V_2 - b_2) - U_2(-b_2)} + \dfrac{\left(U_2\left(\frac{1}{2}V_2 - b_2\right) - U_2(-b_2)\right)}{U_2(V_2 - b_2) - U_2(-b_2)} * pr_1{}^*(b_2) \\[4mm]
G_2^*(b_1 - inc) = \dfrac{U_1(V_1 - V_2) - U_1(-b_1)}{U_1(V_1 - b_1) - U_1(-b_1)} + \dfrac{\left(U_1\left(\frac{1}{2}V_1 - b_1\right) - U_1(-b_1)\right)}{U_1(V_1 - b_1) - U_1(-b_1)} * pr_2{}^*(b_1)
\end{cases}
$$

To see how different the two CDFs are (G_2 and G_2^*) in our experiment, we simulated them by introducing CRRA utility function:

$$
U(x) = \frac{x^{1-\gamma}}{1 - \gamma}
$$

Based on the settings in the experiment, initial wealth w=bidding cap=10, increment=0.5, then we can solve CDFs by the following systems of linear equations:

Flip:

$$
\begin{cases}
G_2(b_1 - inc) = \dfrac{10^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}}{(10+V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}} + \dfrac{1}{2} * pr_2(b_1) \\[3mm]
G_2(10) = 0
\end{cases}
$$

Split 1: (gain half of each player's valuation)

$$
\begin{cases}
G_2(b_1 - inc) = \dfrac{10^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}}{(10+V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}} + \dfrac{\left((10 + \frac{1}{2}V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}\right)}{(10+V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}} * pr_2(b_1) \\[3mm]
G_2(10) = 0
\end{cases}
$$

Split 2: (gain half of initial wealth or cap: 5)

$$
\begin{cases}
G_2(b_1 - inc) = \dfrac{10^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}}{(10+V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}} + \dfrac{\left((10 + 5 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}\right)}{(10+V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}} * pr_2(b_1) \\[3mm]
G_2(10) = 0
\end{cases}
$$

The following examples show that different tie breaking rules have similar effect on CDF of bids. Given the CRRA risk aversion coefficient, γ, equals to 0.00001 (nearly risk neutral), 0.5 (normally risk averse), and 0.99999 (extremely risk averse). The CDFs of bids under three tie breaking rules: flip a coin, split valuation for each player, and split the cap (as in the experiment), can hardly be distinguished.
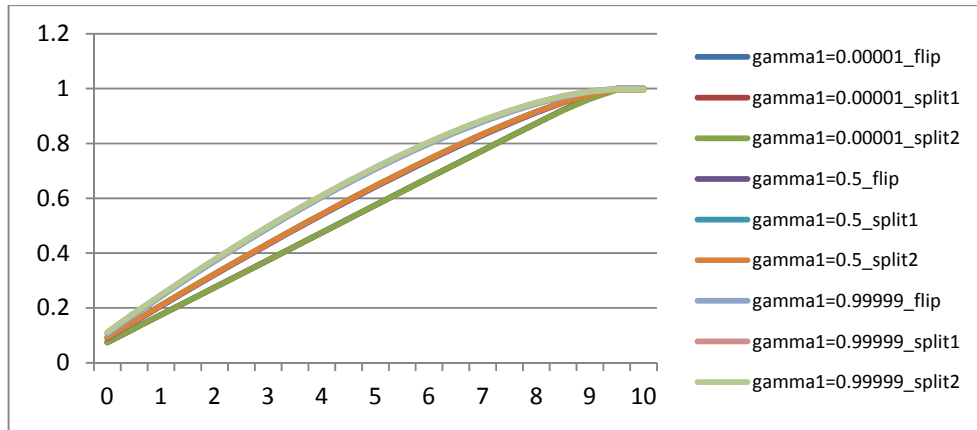
Figure 1: Shape of G2 when V1=10, V2=10, cap=10

"Flip" means equal probability of winning when ties

"split1" means each player receive half of their valuation when ties

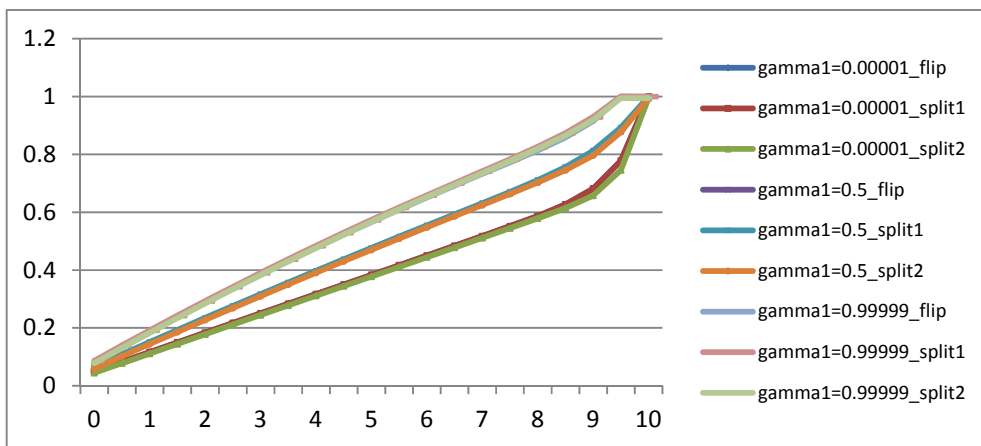"split2" means both players receive 5 when ties
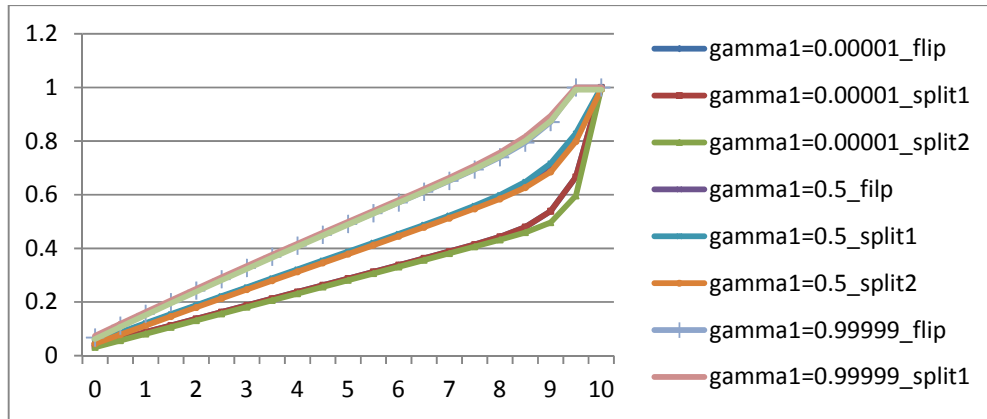

Figure 2: Shape of G2 when V1=15, V2=10, cap=10

Figure 3: Shape of G2 when V1=20, V2=10, cap=10

APPENDIX C: CUMULATIVE DISTRIBUTION FUNCTIONS FOR INITIAL STUDY

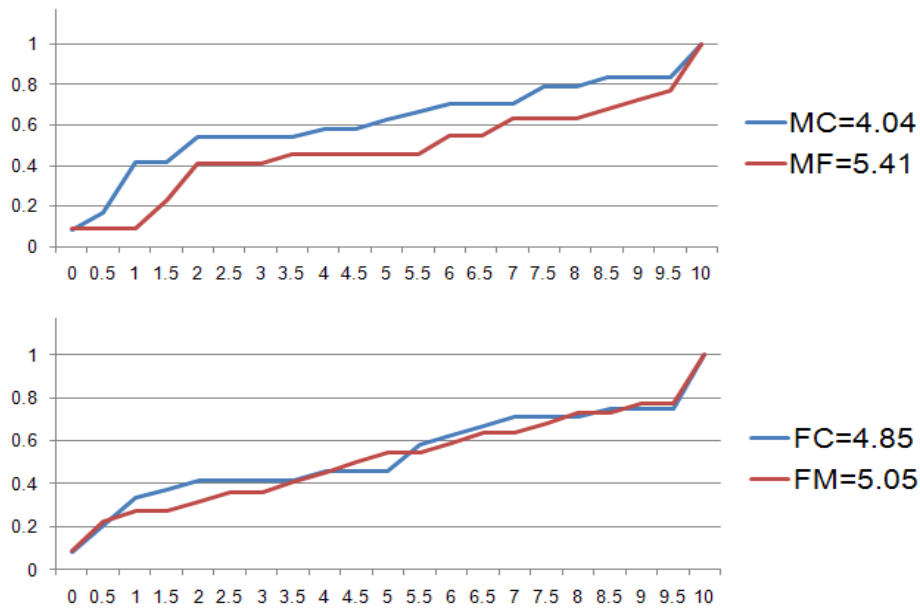Only males' bids increased significantly after finding out gender of opponent (p=10%).

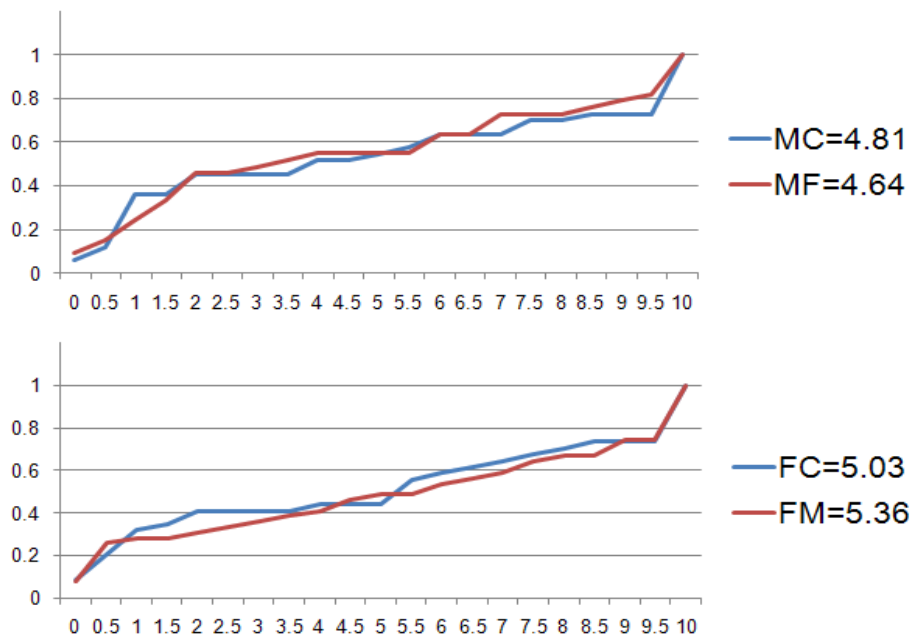**Figure 6: CDF of initial study with initial sample of 92 subjects**

Figure 7: CDF of initial study with enlarged sample 156 subjects.
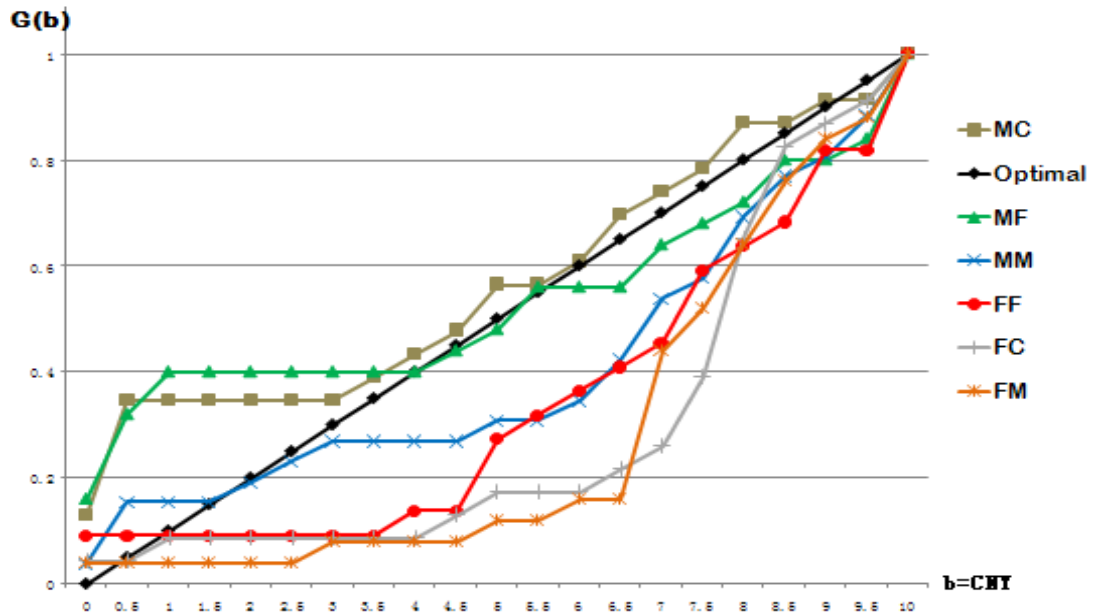
APPENDIX D: CDF OF BIDS IN TREATMENTS
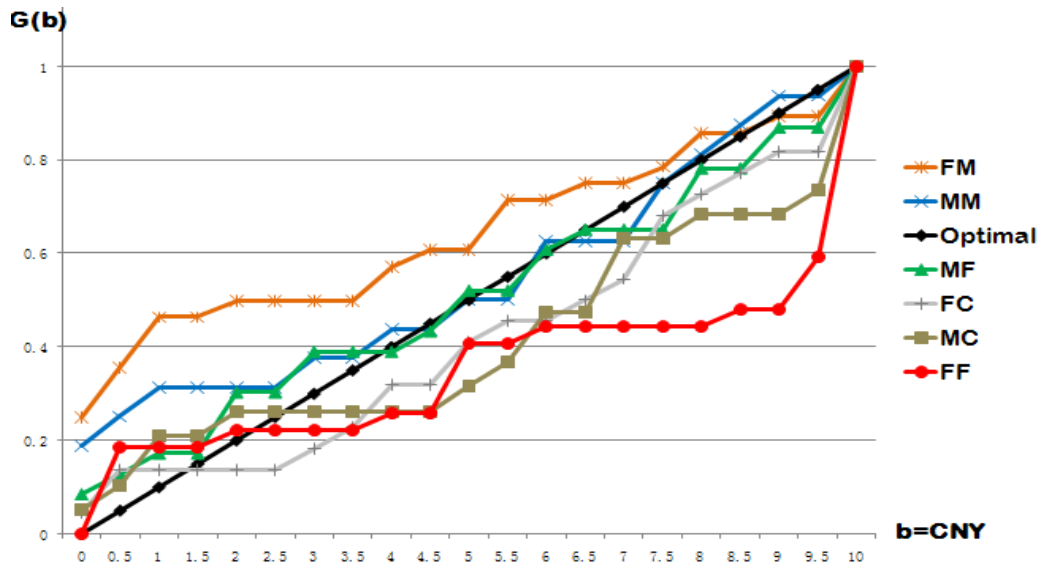

Figure 8: CDF of bids within SZ.

Figure 9: CDF of bids in UT
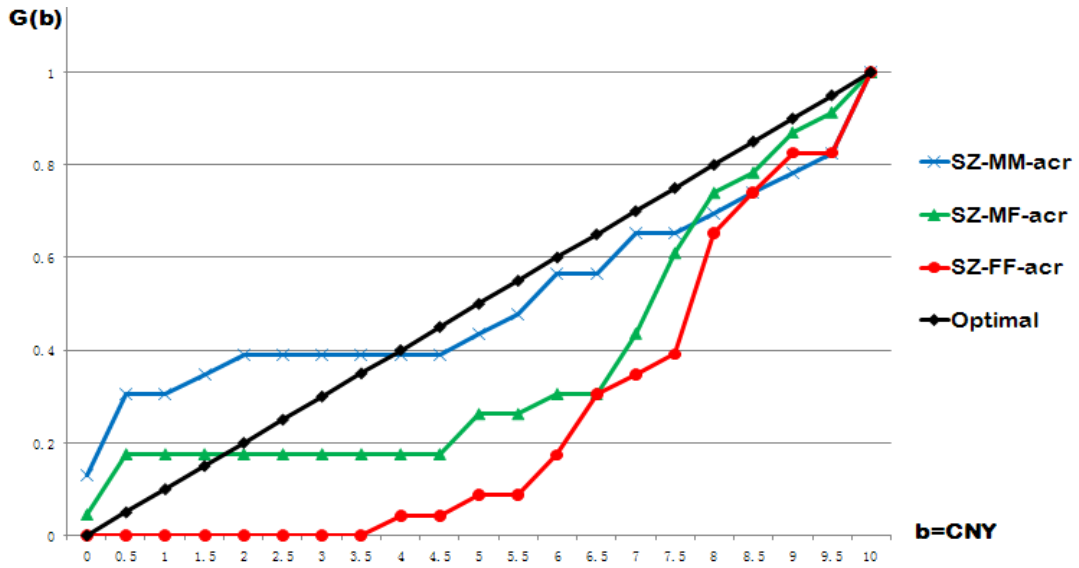
Figure 10: CDF of SZ bids against UT.

Figure 11: Average payoffs for all players.

APPENDIX E: STUDIES ON GENDER DIFFERENCE IN CHILDREN

Changing the culture, the task and the age of gender may mitigate the possible

demand effects of self-consciously competitive choices, as apparently changing the task from math to verbal in adults. A number of studies show no gender difference in competitive attitude among children. See Table 11.

Authors	Tasks	Age	Country	Results
Zhang (2011b)	Simple math (NV2007)	15,16	Rural Han Chinese	No gender difference in competitive attitude, control for ability, confidence and risk attitude
Cárdenas et al. (2011)	Running, skipping rope, math and word search	9-12	Colombia and Sweden	No difference in Colombia; Swedish girls were more competitive than boys in some tasks, boys more likely to choose to compete in general
Dreber et al. (2011)	Running; skipping rope and dancing	7-10	Sweden	No difference
Khachatryan (2011)	Running, skipping rope; math and word search task	8-16	Armenian	Girls are more competitive in the running task, while there are no statistically significant gender differences in all the other tasks.
Savikhin (2011)	Electronic fishing task	3-5	US	No difference
Gneezy and Rustichini (2004)	Running	9-10	Israel	Boys increase performance when competing, but girls do not
Sutter and Rutzler (2010)	Younger, running; older, math	3-18	Austria	Men are much more willing to enter a competition than women in any age.

Table 11: Recent studies on gender difference in competitive attitude among children.

APPENDIX F: INSTRUCTIONS

Welcome to our experiment! In the experiment, you will need to make a decision which will affect the pay you get after the experiment. So please be careful when I describe the rules of the experiment, if you miss any details, please raise your hand. Please do not talk to other subjects sitting around you and please shut down your cell phone. Any behavior that violates the rules of the experiment is prohibited, and we will refuse to pay the subject. The whole experiment will be finished within 15 minutes. Now please open your envelope and take out the paper.
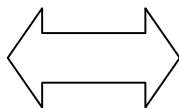
- Please write down your name in the left block.
- Your opponent is also a subject in this experiment, you can find the school or school and gender of your opponent in the right block.
- We paired you and your opponent randomly before today.

- There will be an auction between the two of you.
- From now on, each of you is endowed with 10 CNY.
- When the auction begins, you will use the 10 CNY we give you to bid in the auction.
- The prize of this auction is 10 CNY as well.
- Both you and your opponent can only bid once in the auction. When you decide your bid, please mark the corresponding circle on the right graph. Please mark only one circle. Mark more than one will be treated as a mistake. If you do not mark any circle in the graph, then you are bidding zero.
- Please note that if your opponent chooses a lower bid than you do, you are the winner in the auction and earn the extra 10 CNY, which is the prize of the auction. Your opponent earns no extra money since he/she loses, but he/she still has to pay his bid.
- In the same reasoning, if your opponent chooses a higher bid than you do, he/she will be the winner and earns the extra 10 CNY. But both of you have to pay your own bid.
- If both of you choose the same bid, you will split the 10 CNY prize and pay your own bid.
- If both of you bid zero, that is, both of you do not mark any circle, none of you earns any additional payment.
- Please note that your final payment in this experiment is exactly equal to the payment after you bid using the 10 CNY we give you in this auction. We do not provide any other payment.
- Please now decide your bid.
- After you finish marking your bid, please write down your name and bank account in the box, and then put this paper back to the envelop.

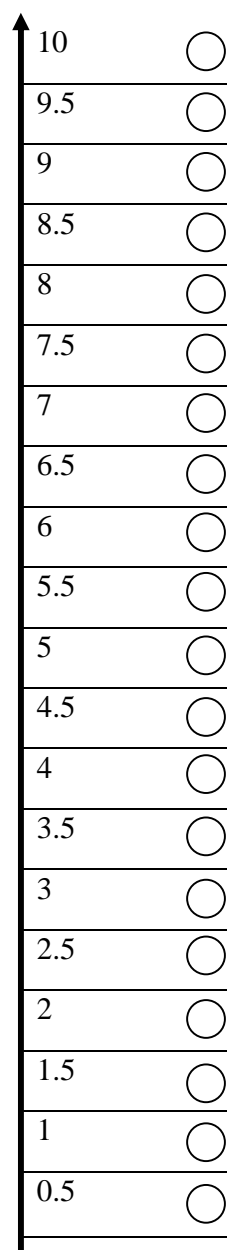## APPENDIX E: AN EXAMPLE OF BIDDING SHEET

You are… Name：	⟷	Your opponent is… A **Female** student in **UT**

- Please write down your name in the left block
- Your opponent is also a subject in this experiment. You can find the school or school and gender of your opponent in the right block.
- We paired you and your opponent randomly before today.
- There will be an auction between the two of you.
- From now on, each of you is endowed with 10 CNY.
- When the auction begins, you will use the 10 CNY we gave you to bid in the auction.
- The prize of this auction is 10 CNY as well.
- Both you and your opponent can only bid once in the auction. When you decide your bid, please mark the corresponding circle on the right graph. Please mark only one circle. Mark more than one will be treated as foul. If you do not mark any circle in the graph, you are bidding zero.
  - ✧ Please note that if your opponent chooses a lower bid than you do, you are the winner in the auction and earn the extra 10 CNY which is the prize of the auction. Your opponent earns no extra money since he/she loses, but he/she still has to pay his bid.
  - ✧ In the same reasoning, if your opponent chooses a higher bid than you do, he/she will be the winner and earns the extra 10 CNY. But both of you have to pay your own bid.
  - ✧ If the two of you choose the same bid, you will split the 10 CNY prize and pay your own bid.
  - ✧ If both of you bid zero, that is, both of you do not mark any circle, then none of you earns any additional payment.
- Please note that your final payment in this experiment is exactly equal to the payment after you bid using the 10 CNY we give you in this auction. We do not provide any other payment.
- Please now decide your bid.
- After you finish marking your bid, please write down your name and bank account in the box, and then put this paper back to the envelop.

Value	
10	○
9.5	○
9	○
8.5	○
8	○
7.5	○
7	○
6.5	○
6	○
5.5	○
5	○
4.5	○
4	○
3.5	○
3	○
2.5	○
2	○
1.5	○
1	○
0.5	○

Name	_____
Bank account No.	_____