APPENDIX A-H

FOR

TIGER WOMEN: AN ALL-PAY AUCTION EXPERIMENT ON GENDER SIGNALING OF DESIRE TO WIN

APPENDIX A: PROOFS OF INFERENCE RULES

MM VS FF

Proposition 2: If males have higher valuation than females (V:M>F) and are less risk averse, i.e., more risk prone (R:M>F), then MM>FF:

$$
\begin{aligned}
G_{MM}(b) &= \frac{U_M(0) - U_M(-b)}{U_M(V_M - b) - U_M(-b)} \\
&= \frac{U_M(0) - U_M(-b)}{U_M(V_F - b) + MU_M(V_M - V_F) - U_M(-b)} \\
&< \frac{U_M(0) - U_M(-b)}{U_M(V_F - b) - U_M(-b)} \\
&< \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{FF}(b)
\end{aligned}
$$

MF VS FM

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

$$
\begin{aligned}
G_{FM}(b) &= \frac{U_M(V_M - V_F) - U_M(-b)}{U_M(V_M - b) - U_M(-b)} \\
&= \frac{U_M(0) + MU_M(V_M - V_F) - U_M(-b)}{U_M(V_F - b) + MU_M(V_M - V_F) - U_M(-b)} \\
&> \frac{U_M(0) - U_M(-b)}{U_M(V_F - b) - U_M(-b)} \\
&> \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{MF}(b)
\end{aligned}
$$

MF VS MM

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

Proof:

$$
\begin{aligned}
G_{MF}(b) &= \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} \\
&> \frac{U_F(0) - U_F(-b)}{U_F(V_F - b) + MU_F(V_M - V_F) - U_F(-b)} \\
&= \frac{U_F(0) - U_F(-b)}{U_F(V_M - b) - U_F(-b)} \\
&> \frac{U_M(0) - U_M(-b)}{U_M(V_M - b) - U_M(-b)} = G_{MM}(b)
\end{aligned}
$$

Proposition 5: If males have lower valuations than females (V: M<F) and are less risk averse (R: M>F), then MF<MM

Proof:

$$
\begin{aligned}
G_{MM}(b) &= \frac{U_M(0) - U_M(-b)}{U_M(V_M - b) - U_M(-b)} \\
&< \frac{U_M(0) + MU_M(V_F - V_M) - U_M(-b)}{U_M(V_M - b) + MU_M(V_F - V_M) - U_M(-b)} \\
&< \frac{U_M(V_F - V_M) - U_M(-b)}{U_M(V_F - b) - U_M(-b)} \\
&< \frac{U_F(V_F - V_M) - U_F(-b)}{U_F(V_F - b) - U_F(-b)} = G_{MF}(b)
\end{aligned}
$$

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

MF VS. FF

Proposition 6: 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: 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 A.1.

Table A.1: Recent studies on gender difference in competitive attitude among children.

Authors	Tasks	Age	Country	Results
Booth & Nolan (2011)	Solving mazes (Gneezy, Niederle, and Rustichini, 2003)	Mean under 15	UK	*No difference* between single-sex school girls and boys from co-ed and single schools
Cotton, McIntyre & Price, 2009	Simple math, reading	9-12	US	*No difference* after 1st round of 5-round math contest. *No difference* in non-contest or reading treatments.
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, and boys more likely to choose to compete in general
Dreber, Von	Running;	7-10	Sweden	*No difference*

Essen, and Ranehill (2011):	skipping rope and dancing			
Gneezy & Rustichini (2004)	Running	9-10	Israel	Boys increase performance when competing, but girls do not.
Khachatryan (2011):	Running and skipping/jumping rope; Math or word search task	8-16	Armenian	*No difference* for physical and math task, but more competitive in word search task.
Savikhin (2011)	Electronic fishing task	3-5	US	*No difference*
Sutter & Rutzler (2010)	Younger: running; older: math	3-18	Austria	Men are much more willing to enter a competition than women in any age.
Zhang (2011b)	Simple math (NV2007)	15,16	Rural Han Chinese	*No difference* in competitive attitude, control for ability, confidence and risk attitude

APPENDIX C: INSTRUCTIONS (READ OUT LOUD)

Welcome to our experiment! In this experiment, you will need to make a decision which will affect your payoff. So please pay attention when I explain 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 off 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/her 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.
- Here are some examples to help you understand this auction
    - If you bid 3, and your opponent bids 7, you receive 7.
    - If you bid 5, and your opponent bids 4, you receive 15.
    - If you bid 10, and your opponent bids 9, you receive 10.
    - If you bid 6, and your opponent bids 6, you receive 9.
    - If you bid 8, and your opponent bids 10, you receive 2.
    - If you bid 0, and your opponent bids 0, you receive 10.
    - If you bid 2, and your opponent bids 1, you receive 18.
    - If you bid 1, and your opponent bids 8, you receive 9.
    - If you bid 7, and your opponent bids 2, you receive 13.
    - If you bid 10, and your opponent bids 10, you receive 5.

- 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 D: TIE BREAKING AND DISCRETIZATION

Let inc=the discrete increment of the bid. If ties are broken by equal probability of getting the prize (hereafter "flip", as flip of a coin), than in a mixed strategy equilibrium, player 1's expected utility equals the utility from the expected payoff from the auction:

$$U_1(V_1 - b_1)G_2(b_1 - inc) + U_1(-b_1)\big(1 - G_2(b_1)\big) + \left(\tfrac{1}{2}U_1(V_1 - b_1) + \tfrac{1}{2}U_1(-b_1)\right)(G_2(b_1) - G_2(b_1 - inc)) = U_1(expected\ payoff)$$

(1)

After rearrangement,

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

(2)

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

$$U_1(V_1 - b_1)G_2^*(b_1 - inc) + U_1(-b_1)\big(1 - G_2^*(b_1)\big) + U_1(\tfrac{1}{2}V - b_1)(G_2^*(b_1) - G_2^*(b_1 - inc)) = U_1(epected\ payoff^*)$$

(3)

After rearrangement,

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

(4)

Note that in our experiment, subjects received 5 CNY in ties: where V is the monetary prize of the auction, which is equal to both players..

It is easy to see that for risk averse players,

$$\frac{1}{2} < \frac{\left(U_1\left(\frac{1}{2}V - b_1\right) - U_1(-b_1)\right)}{U_1(V_1 - b_1) - U_1(-b_1)} \qquad (5)$$

(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, (assuming $V_1 > V_2$), which is the same as the no cap case. Thus, the mixed strategy equilibrium for both players in each case are:

Flip:

$$\begin{cases} G_1(b_2 - inc) = \frac{U_2(0) - U_2(-b_2)}{U_2(V_2 - b_2) - U_2(-b_2)} + \frac{1}{2} * pr_1(b_2) \\ G_2(b_1 - inc) = \frac{U_1(V_1 - V_2) - U_1(-b_1)}{U_1(V_1 - b_1) - U_1(-b_1)} + \frac{1}{2} * pr_2(b_1) \end{cases} \qquad (6)$$

Split:

$$\begin{cases} G_1^*(b_2 - inc) = \frac{U_2(0) - U_2(-b_2)}{U_2(V_2 - b_2) - U_2(-b_2)} + \frac{\left(U_2\left(\frac{1}{2}V - b_2\right) - U_2(-b_2)\right)}{U_2(V_2 - b_2) - U_2(-b_2)} * pr_1{}^*(b_2) \\ G_2^*(b_1 - inc) = \frac{U_1(V_1 - V_2) - U_1(-b_1)}{U_1(V_1 - b_1) - U_1(-b_1)} + \frac{\left(U_1\left(\frac{1}{2}V - b_1\right) - U_1(-b_1)\right)}{U_1(V_1 - b_1) - U_1(-b_1)} * pr_2{}^*(b_1) \end{cases} \qquad (7)$$

To see the difference between the flip and split CDFs in our experiment, we simulated them for 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 solved CDFs by the following systems of linear equations:

Flip: For each $b_1 \in (\frac{1}{2}, 1 \ldots\ldots 10)$, we have an equation with one unknown

$$\begin{cases} G_2(b_1 - inc) = \frac{10^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}}{(10 + V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}} + \frac{1}{2} * pr_2(b_1) \\ G_2(10) = 1 \end{cases} \qquad (8)$$

with a total of 20 equations for 20 unknowns.

Split: For each $b_1 \in (\frac{1}{2}, 1 \ldots\ldots 10)$, we have an equation with one unknown

$$\begin{cases} G_2(b_1 - inc) = \frac{10^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}}{(10 + V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}} + \frac{\left((10 + 5 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}\right)}{(10 + V_1 - b_1)^{1-\gamma_1} - (10 - b_1)^{1-\gamma_1}} * pr_2(b_1) \\ G_2(10) = 1 \end{cases}$$

(9)

with a total of 20 equations for 20 unknowns.

The following examples show that these flip and split 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). As can be seen in Figure I below, the CDFs of bids under different tie breaking rules: flip a coin or split the prize are very similar.

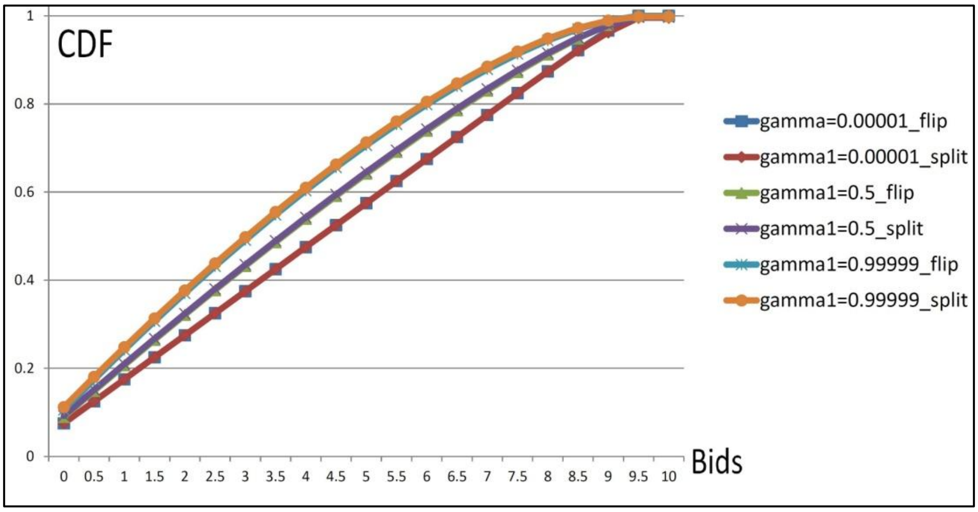


Figure I: Shape of G2 when V1=10, V2=10, cap=10

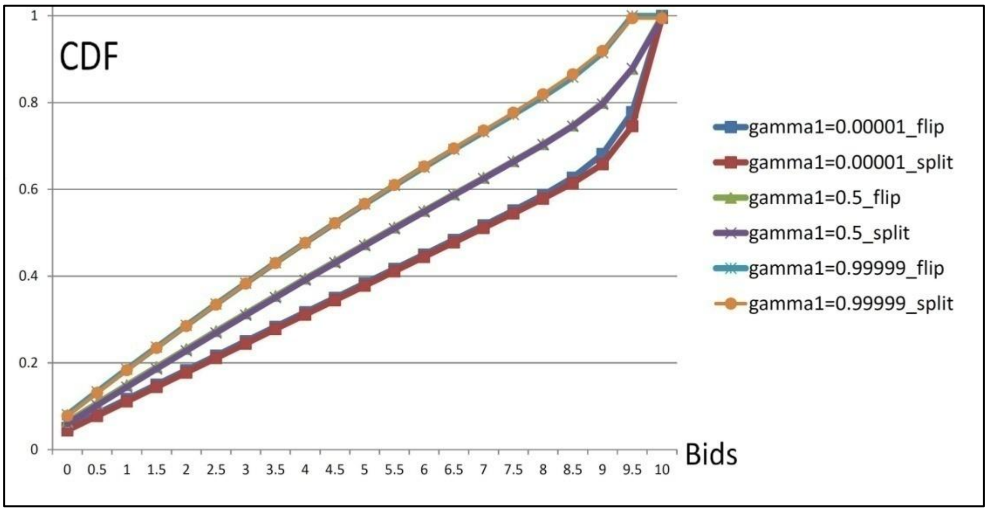


Figure II: Shape of G2 when V1=15, V2=10, cap=10

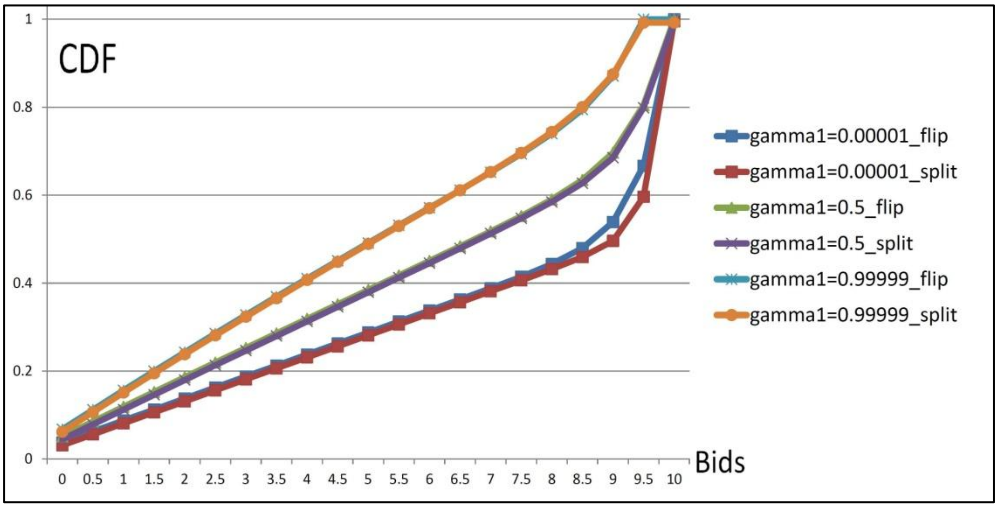


Figure III: Shape of G2 when V1=20, V2=10, cap=10

APPENDIX E: CUMULATIVE DISTRIBUTION FUNCTIONS

FOR INITIAL STUDY

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

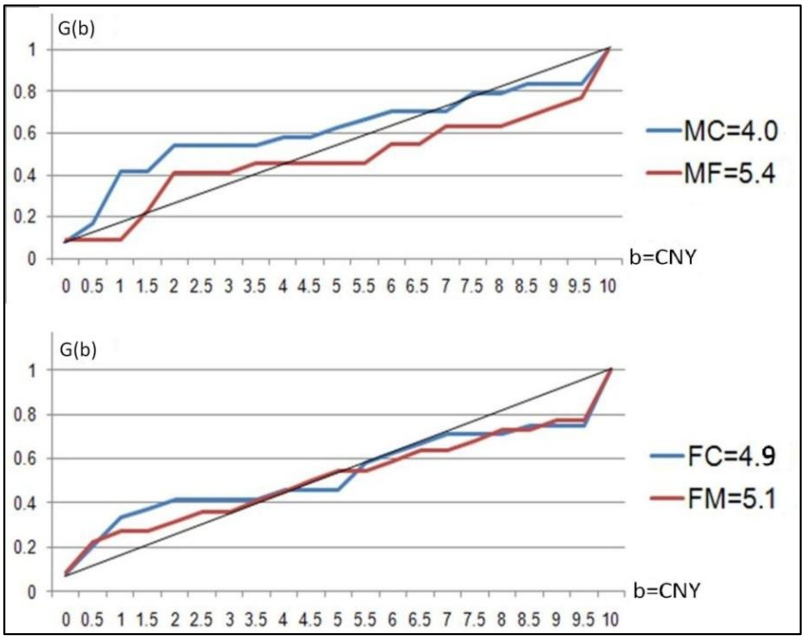


Figure IV: CDF of initial study with initial sample of 92 subjects

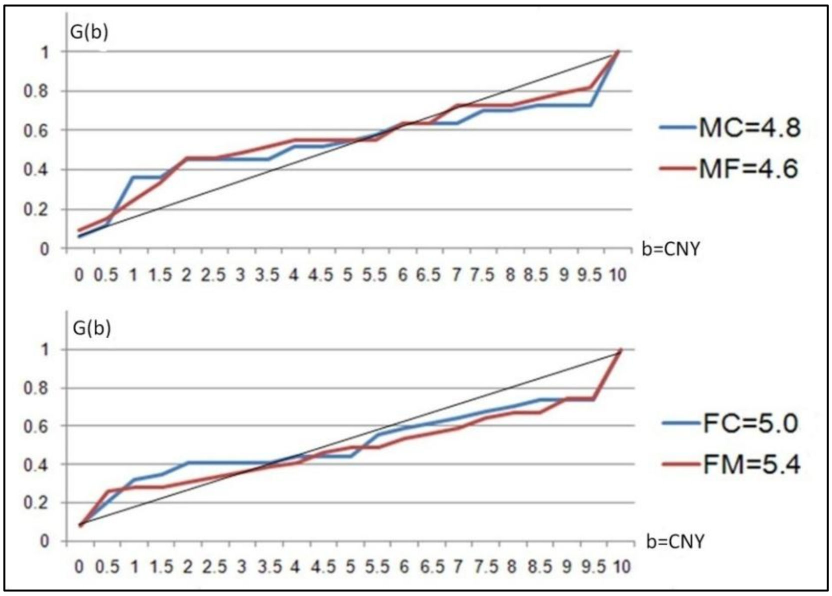


Figure V: CDF of initial study with enlarged sample 156 subjects.

APPENDIX F: CDF OF BIDS IN TREATMENTS

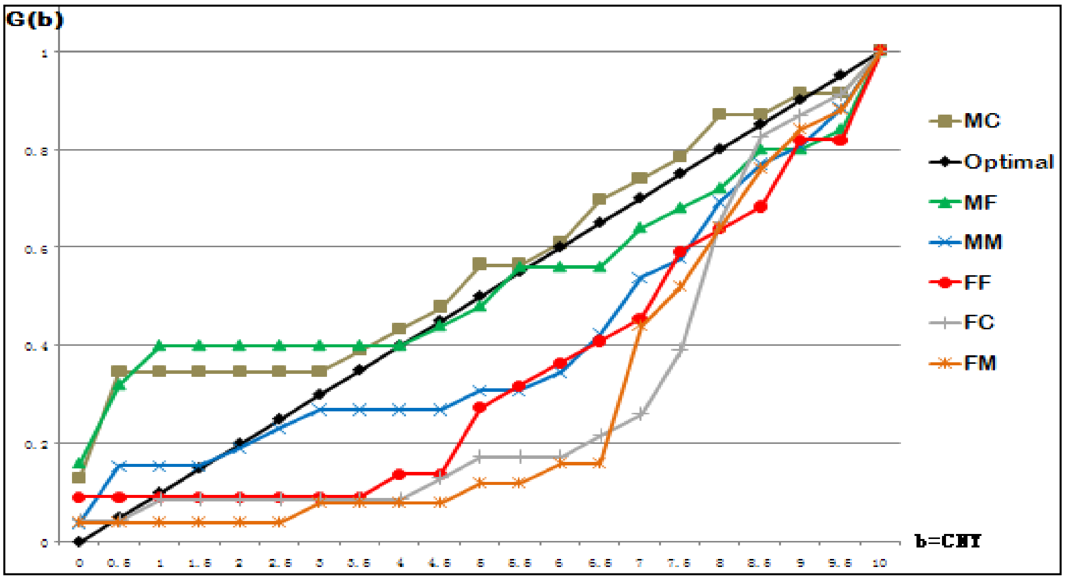


Figure VI: CDF of bids within SZ.

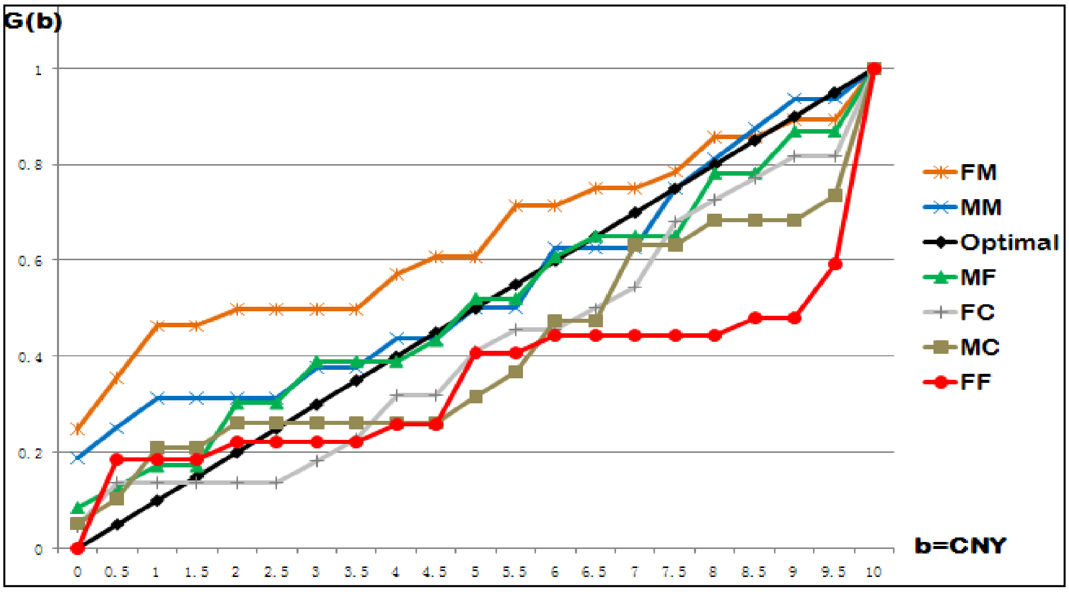


Figure VII: CDF of bids in UT

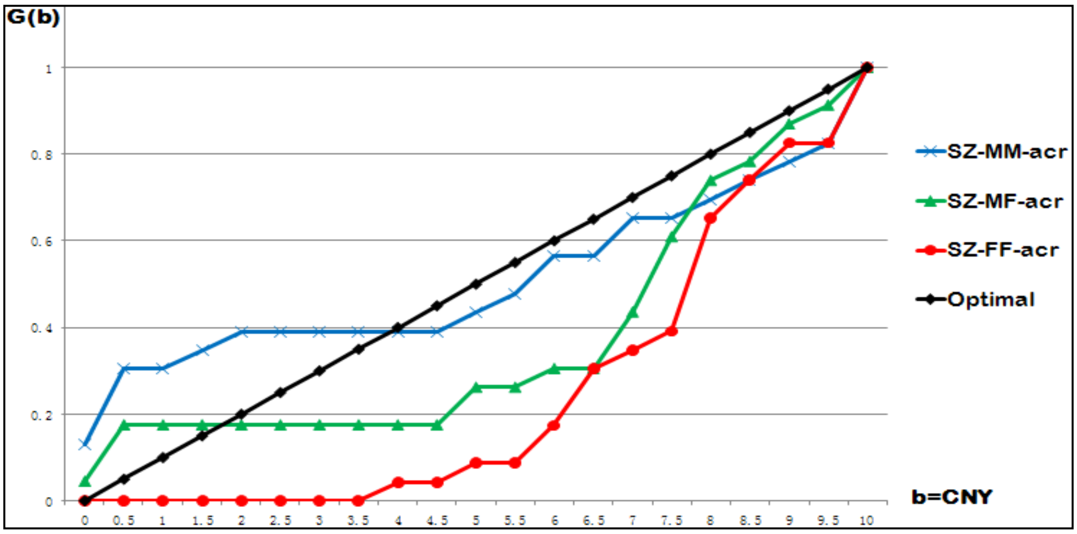
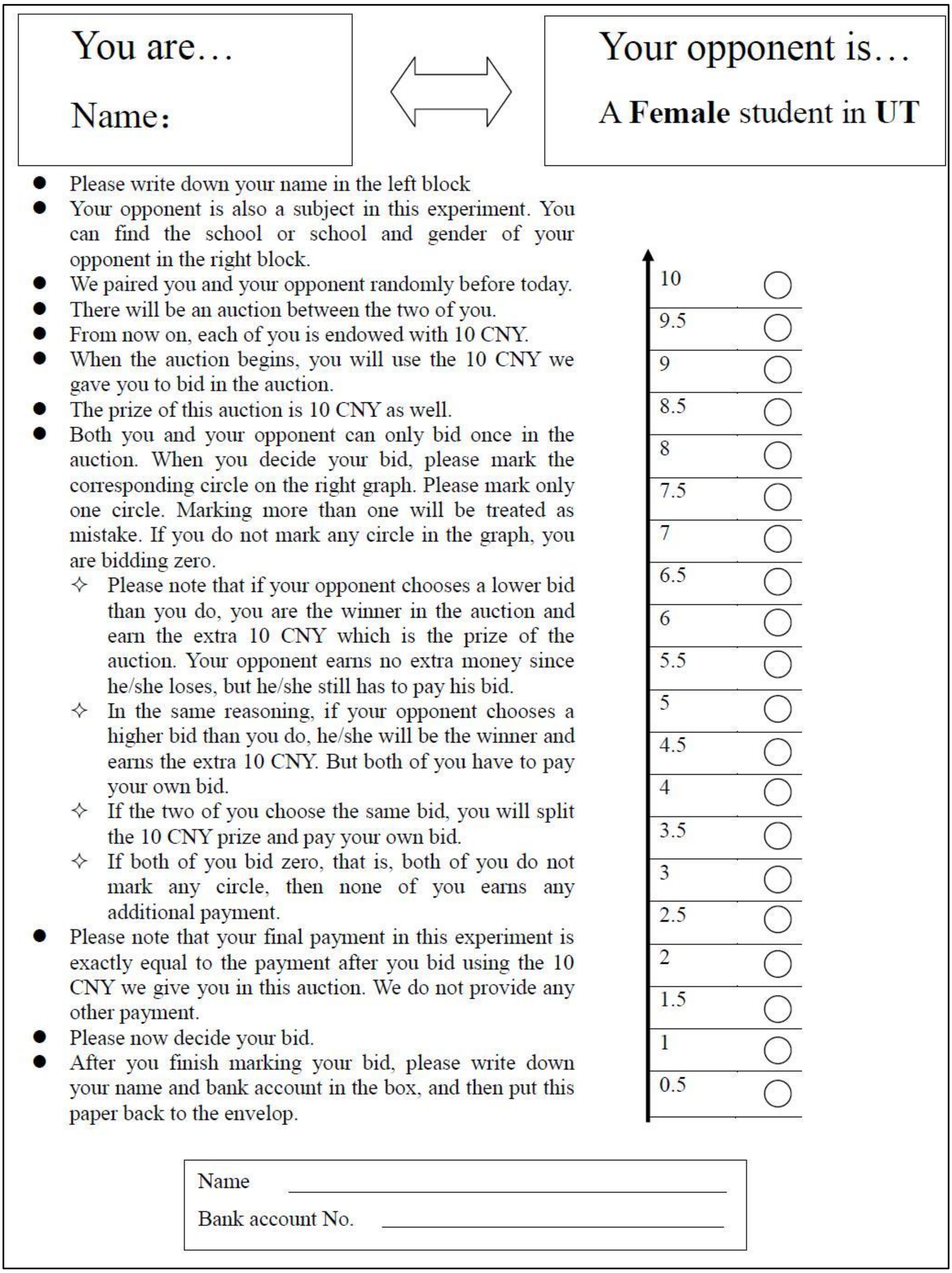


Figure VIII: CDF of SZ bids against UT.

APPENDIX G: 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. Marking more than one will be treated as mistake. 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.

Name ______________________

Bank account No. ______________________

Figure IX: Bidding sheet

As discussed in the main text, the only thing which changed in our bidding sheets for different treatments was the gender or school of the opponent, or both. Subjects in the incomplete information treatments did not know either.

APPENDIX H: PAYMENT IN TREATMENTS

	SZ-M		SZ-F		SZ-C		UT-M		UT-F		UT-C
SZ-M	8.8	56%	8.8		7.5		9.7	74%	9.4		
	63%	73% 26%	87%		0.05%			83%	63%		
SZ-F	9	48%	8.2		10.8				8.6		
UT-M	11.3						10.3	29%	11.4		8.1
	27%	7.5%					78%	2.7% 18%	0.68%		29%
UT-F	9.5	74%	8.8				9.8	8%	8.1		9.4

Figure X: Average payoffs of bidders in CNY and p-values. % between numbers are p-value of differences.

APPENDIX I: OTHER EVIDENCE OF WOMEN'S GREATER SELF-DISCIPLINE

We now discuss how our main result, that women have a higher DTW, aligns with empirical evidence suggesting that women are more self-disciplined than men. DTW, derived from willingness to pay to win in auctions should be predictive of willingness to pay to win 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, Quinn, and Tsukayama (2011) 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, McIntyre, and Price (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. Girls are graduating high school, college and graduate schools at higher rates in the US (Buchmann, DiPrete, and McDaniel 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 et al., 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 and the exceptionally high suicide rate of girls in China[1]. Consistent with this, Zhang (2011b) found no gender differences 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 very tedious preparation. In contrast, US schools may exert less gender specific selection by IQ like tests, grades, recommendations, interviews, and extracurricular activities all of which may be difficult to prepare for. Furthermore, a man's marriageability is often a matter of his income. Graduate school is not known for it's lucrativeness. These factors may select out more daring men who

[1] http://www.who.int/mental_health/prevention/suicide_rates/en/

might want to try their luck in the market.

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. Shafer (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 Ours, 2009). Charles (2011) showed that women in richer countries tended to adopt more traditional gender roles.

Finally, risk attitude may be more important than educational attainment for becoming a top executive. Capelli and Harmoni (2005) found in 2001 that only 10% of top executives at Fortune 500 companies had ivy-league educations. Selection by risk attitude may be even more important for founding CEOs in high tech industries like Bill Gates[2], Steve Jobs[3], or Larry Ellison[4], who were all conspicuous college dropouts. Male lower self discipline could be an advantage for the most able men for such positions. The susceptibility to the temptation for salient competitions, i.e., showing off, could drive low ability men into street fights, basketball games, or dropping out of highschool, at the same time that it drives high ability men to the "workaholism" that might be required to become top executives. It may be to women's credit that they are "under-represented" in risky winner takes all fields that require an all consuming investment of effort to even have a chance of success. To make a valid assessment, we would also need to find the proportion of women among the failed Gates, Jobs and Ellisons, who subsequently regretted dropping out of college. To our knowledge, no such data exists.

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[2] http://en.wikipedia.org/wiki/Bill_Gates#Early_life

[3] http://en.wikipedia.org/wiki/Steve_Jobs#Early_life_and_education

[4] http://en.wikipedia.org/wiki/Larry_Ellison#Career

Women's greater risk aversion may be the key to reconciling the data prior to what we presented in this paper, both empirical and experimental. Greater risk aversion makes women put in less effort in competitions in which they cannot prepare, like those in the laboratory setting. At the same time, it could make them prepare more if they could prepare, like in academic competitions. Costly preparation allows women to simultaneously raise their grades, while lowering the variance of their performance, but at the cost of decreasing their total surplus from lost leisure. Women would be more willing to make that trade-off than men if they are more risk averse. In such an equilibrium, they would have a higher mean performance, but be under-represented in the top tail of the distribution.