

Knowing Your Opponent's Gender Changes Your Behavior in Contests?

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Abstract

We experimentally examine gender differences in contests. We used a Tullock contest because it described the practical competitive environments where both luck and efforts determined the winner of a contest. Each subject was randomly paired with another subject in each round and was explicitly informed about the gender of his/her opponent. Over-expenditures relative to the Nash equilibrium were observed in all treatments which were consistent with the literature. Males invested more than females in the single gender contest, but females invested more than males in the mixed-gender contest, which differed from the literature. We demonstrate that either risk attitude, or non-monetary value of the winning (willingness to win) did not play a major role, even though almost half subjects showed their values of willingness to win strictly positive. More than that, the difference in the self-worth of themselves as university students between males and females subjects played a significant role in the mixed-gender contest. Females invested 34% more when their opponents were males than when they were matched with other females. The result is applicable to the educational institutions and the labor market.

Key Words: contests, experiment, gender differences

JEL Classifications: C72, C91, D72, I20, J16

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1. Introduction

OECD Stat. (2020) reported female share on boards of the largest publicly listed companies among OECD countries in 2019. The highest was 45.2% in France. Then, 40.2% in Norway, 38.2% in New Zealand, . . . , 26.1% in the USA followed. The second worst was 8.4% in Japan and the bottom was 3.3% in Republic of Korea. OECD average was 25.5%. Furthermore, International-Parliamentary Union (2019) reported the women's share in lower or single house in 193 countries; 41.5% in France, 41.1% in Finland, 40.8% in Norway, 40.0% in New Zealand, 23.6% in USA, 17.1% in Republic of Korea, and 10.2% in Japan. Japan was the lowest among OECD countries. OECD average was 30.1%. Japan was far behind to utilize females both in business and politics. According to JOICEF (2019), World Economic Forum announced that the Gender Gap Index of Japan was ranked 121 out of 153 countries in 2019. The index was a weighted sum of four indices; economy, education, health, and politics. Japan was ranked 115th in economy, 91th in education, 40th in health, and 144th in politics among 153 countries. Although the Japanese labor market has been far behind of other developed countries in utilizing female workforce, male dominance in high level positions and according wage gap between males and females have been observed more or less all over the world. Norway was the first country which introduced quota system into politics in 1988 which required 40% representation of each sex in all public committees. Other countries followed Norway and introduced quota system into parliament. Japan, New Zealand, USA, and Turkey are the only countries which have not introduced quarter system yet. New Zealand is the only country where equal treat of both genders is established without quota system. As for business, Norway is again the first country to introduce a quota for women on company boards. Since the recent Norwegian quota amendment was introduced in 2003 to the Companies Act, the number of women on board has reached 40% as required by law. It regulates the gender composition of a wide spectrum of Norwegian company boards: public limited companies, state and municipality owned companies, as well as cooperative companies.

Varieties of methodologies including theory, empirics, experiments, historical analysis, sociology analyze the problem and offer solutions for this problem; however, gender gap is still observed. We use theoretical and experimental

methods to examine gender differences in a competitive environment.

There are two strands of literature which analyze gender differences in auctions, tournaments, and contests. The first strand compares gender differences between a competitive and a noncompetitive environment. The second strand examines gender differences of entry decision into a competitive environment.

In the first strand which compares gender differences in performances in a competitive and those in a noncompetitive environments, Gneezy et al. (2003) ran tournaments and concluded that there were no gender differences of performances in a noncompetitive environment where piece rate compensation scheme was employed, but there existed significant gender differences in a competitive environment where mixed-gender tournament was used and only the winner received the strictly positive payment and the losers could not receive any payment, but incurred costs of efforts. They also showed that females' performances improved when they were in the same gender tournament than in the mixed-gender tournament.

Sheremeta and Price (2011) pointed out females overinvested 25% more than males in contests. They did not compare performances of females and males in the single gender contests and in the mixed-gender contests because their main research topic was that making subjects earn their initial endowments rather than letting them have their initial endowments for free mitigated overinvestment. Ham and Kagel (2006) and Casari et al. (2007) found that females overbid more than males in common value auctions. Chen et al. (2013) showed that females bid significantly higher than males in the first-price auctions. Ong and Chen (2012) is the closest work to ours. They conducted all-pay auctions and examined differences of bidding behaviors in genders and across universities in different tiers. They recruited subject at Tsinghua Law School for their within top-tier school treatments and recruited subjects at Peking University Law School for their top-tier university subjects in their across tier school treatments. All the mid-tier subjects were students at Shenzhen University. They matched females and males in a top-tier university and in a mid-tier university. Accordingly, 6 cases within the same universities (3 cases of a female versus another female, a male versus another male, and a female versus a male for a top-tier university

and for a mid-tier university respectively) and 4 cases across different tier universities (a female at a top-tier university versus a female at a mid-tier university, a male at a top-tier university versus a male at a mid-tier university, a female at a top-tier university versus a male at a mid-tier university, a male at a top-tier university versus a female at a mid-tier university) were possible, but they did not run the mixed-gender auction with a female at a mid-tier university and a male at a top-tier university due to budget constraint. We would like to explain their results in detail because their paper is the closest work to ours although our experiment used a Tullock contest instead of an all-pay auction. Firstly, they compared the bidding behavior in the same university. In the single gender auctions where a female competed against another female and a male competed against another male, they observed that there was no gender difference in a mid-tier university, but females bid on average higher than males on average in a top-tier university. Their figure IV shows that females bid 6.8 on average and males bid 6.2 on average at a mid-tier university while females bid 6.7 on average and males bid 4.8 on average at a top-tier university. In the mixed-gender auctions at the same university, their figure IV tells us that females bid 7.4 on average and males bid 4.8 on average at a mid-tier university while females bid 3.7 on average and males bid 5.2 on average at a top-tier university. It is worth to emphasize that females at a mid-tier university bid double of females at a top-tier university in the mixed-gender auction in the same university. Secondly, they examined the bidding behavior across universities. In the single gender auctions across university where a male at a mid-tier university was matched to a male at a top-tier university, both mid-tier university and top-tier university males decreased their bids compared with the case where they were matched with a male at the same university as they were. Their figure IV tells that males at a mid-tier university bid 5.1 on average and males at a top-tier university bid 3.9 on average. When females at a mid-tier university was matched to a female at a top-tier university, females at a mid-tier university increased their bids on average to 7.7 while females at a top-tier university decreased their bids on average to 4.9. In the mixed-gender auctions across university where a male at a mid-tier university was matched to a female at a top-tier university, both females at a top-tier university and males at a mid-tier university increased their bids compared with the case they were matched to a different gender subject at the same university.

Females at a top-tier university to 4.8 on average and males at a mid-tier university bid 6.5 on average. Remember that they did not run the mixed-gender auction with a female at a mid-tier university and a male at a top-tier university due to budget constraint on their research project. They attribute observed differences between genders and across universities to desire to win (DTW) and risk attitude, but they did not explicitly measure DTW and risk attitude while we measured them and examined their effects on investment. In our single mid-tier university matching in Tullock contests, our females behaved close to their mid-tier university females and our males acted close to their top-tier university males. Therefore, even our experiment used a Tullock contest where luck played a role to determine the winner while theirs used an all-pay auction where the highest bidder won for sure and luck had no role to determine the winner, our analysis complemented theirs because they missed matching a female in a mid-tier university and a male in a top-tier university due to budget constraint. We measured self-worth of subjects and our female subjects' self-worth on average was statistically significantly lower than our male subjects' self-worth on average. We believe this was the reason our females behaved like their mid-tier university females and our males acted like their top-tier university males. Niederle and Vesterlund (2010) showed that risk attitude did not play a major role in gender difference in their experiment tournament and our regression outcome agreed with them. Ong and Chen (2012) might need further explanation about their results because all-pay auctions and tournaments are similar in the sense that both have common features of the winner-takes-all where the player who invests most wins for sure.

Further, Zhang (2011), Cardenas et al. (2011), Dreber et al. (2011), Khachatryan (2011), Savikhin (2011) showed that there was no gender difference in competitive attitude among children.

In the second strand of literature which examined gender differences in entry decision into competitive environments, Niederle and Vesterlund (2007) and Niederle et al. (2008) showed that women chose the piece rate compensation scheme more often than men over the tournament type compensation scheme. They attributed this to men's overconfidence in their relative ranking of the task. Niederle and Vesterlund (2007) showed that there were significant gender differences for compensation schemes, that was, women were shy away from

entering a competitive environment. Further, women's performance remained the same across different compensation schemes. In their experiments, there were 4 members in each group and 73% of men and 35% of women chose tournament where the winner-take-all compensation scheme was adopted rather than the piece rate compensation scheme. This was correlated with their self-evaluation where 75% of males thought they were the top among four group members while only 43% women thought they were the top. There was no significant gender gap in risk attitude. Identical results were shown by Healy and Pate (2011) and Niederle et al. (2011), but Price showed that not all of the results obtained in Niederle and Vesterlund (2007) were replicated in his replicated experiments of Niederle and Vesterlund (2007). Field data in the State Street Miles race by Garratt et al. (2011) supported Niederle and Vesterlund (2007). Niederle et al. (2012) demonstrated that affirmative action promoted women to enter competitive environments. Gneezy et. al (2003) conducted a field experiment and found that the effect of cultural differences on gender difference in a competitive environment was strikingly large. Cotton, McIntyre, Price (2009) conducted a field experiment at school math contest and showed that gender difference was observed only in the first round and it disappeared from the second round on. Therefore, repeated tournaments mitigated the gender differences. Lastly, although most papers examined gender differences from supply side of the labor market, Price (2012) considered the same problem from the demand side. He examined a managerial decision of the payment scheme to his/her workers and claimed that the difference was observed only when a male manager chose the payment system to a female worker. In this case only, the tournament was significantly infrequently chosen by workers. Therefore, he concluded that training male bosses to treat a male worker and a female worker equally, or choosing a female boss for a female worker would improve a female worker's entry to more competitive environments. Further, Morgan et al. (2012) showed that there was no gender difference for entry decision to repeated contest. Niederle and Yestrumskas (2008) found that males chose the hard task 50% more frequently than women even there were no gender differences in performances, or their beliefs about their relative performances, but high performing women chose the hard task at a similar rate as males under a sequential choice. Therefore, they concluded that an institution or an organizational scheme could help women to enter tour-

naments. We agree with them and it is critically important to set institutional and organizational support to motivate females to enter competitive environments to achieve their potential. It also improves efficiency because the literature demonstrates that there is no gender difference in performance. We need to consider an entry decision and performance after entry together to design the best system. As we noted in the first strand of the literature, Price and Sheremeta (2011) showed that females overinvested more than males in a contest. Ham and Kagel (2006), Casari et al. (2007), Ong and Chen (2012), Chen et al. (2013) observed that females bid higher than males in auctions. Our experiment uses a Tullock contest where effort and a luck determine the winner. As we already mentioned, we think that we face Tullock contest situations more often than tournaments and all-pay auctions in our daily lives. Anyone's experiences tell that luck plays some role in school exams, sport races, job promotions, job searches, and so on. Our data tell us that both females and males invested significantly more than the Nash equilibrium level both in the single gender contest and in the mixed-gender contest. If the aim of education is maximizing aggregate effort level of all the students, mixed-gender schools work better than single gender schools because both males and females invested more in the mixed-gender contest than in the single gender contest. On the other hand, single gender schools are recommended if an educational goal is achieving the Nash equilibrium effort level because both males and females less overinvested in the single gender contest.

We ran our experiment on November 29, 2011, independently from Ong and Chen (2012). Ong and Chen (2012) is more general than ours in the sense that they compared bidding behavior across different tier universities in addition to across genders; however, we believe that our work makes sense in two reasons. Firstly, we used a Tullock contest and we believe it is closer to practical situations. All-pay auction is suitable to measure DTW because luck plays no role in determining the winner and bids are the only factor to choose the winner. We used Tullock contests rather than all-pay auctions and tournaments because we thought Tullock contest was more practical in the sense that the winner was determined by the mixture of effort and luck rather than the winner being determined only by effort in all-pay auction and tournaments. When making a deci-

sion about effort level in a contest or in a tournament in real life such as in promotion races in firms, in sports tournaments, on exams at school, we know from our experiences that luck plays non-negligible role to determine the winner. We would like to analyze behaviors of subjects under a close enough condition to reality and chose a Tullock contest. Further, a subject often can observe his/her rivals' gender in real life situation. Therefore, we examine the effect of information about one's rival on one's effort level. Especially at school, it happens often that one cannot choose whether to enter a competitive environment, but has to do so without choice. For example, we have to compete against each other about our running time in P.E. in Japan, or we have to take exams and the result is reported as your score being the third highest among 60,000 students in the same grade in the same state. Rutzler and Sutter (2010) found in their field data that gender differences in willingness to compete was already observed at three-year old. Our findings tell us that mixed-gender schools might benefit if the aim of education is maximizing efforts because both a female and a male subjects invested more on average against the opposite gender rather than against the same gender in our experiment and the difference were quite large for females. On the other hand, single gender schools might work better if the objective of education is implementation of the Nash equilibrium effort level. Actually, top-tier public high schools in Saitama prefecture in Japan are mostly single gender schools. In addition, many of top-tier private middle and high schools are boys only or girls only in Japan.

2. Theoretical Result

This section summarizes theoretical model introduced by Tullock (1980) which serves as the base of our experimental design. As we explained in section1, we adopt Tullock contest to analyze gender differences in real life environments. The main reason is that both luck and effort invested by a subject play important roles in determining the winner of the contest in Tullock contest and this is likely the case in real life. For example, our own experiences told us that not only our effort, but luck played non-negligible role in sports tournaments, on school exams, on SAT, in admission decisions to universities, in promotions to a managerial positions, and so on. On the other hand, luck plays no role to determine the winner in tournaments and auctions which makes simpler to measure willingness

to pay and willingness to win separate from the effect of uncertainty. Though we understand these advantages of auctions and tournaments, we would like to examine behavior of subjects in a realistic environment and decided to use Tullock contest in our experiment.

We use the simple Tullock contest with two players. There are two contestants, 1 and 2 and they compete against each other to win the prize whose value is common and v for both contestants. We denote contestant 1's effort invested in the contest by x and contestant 2's effort invested in the contest by y . After the contestants make non-refundable investment decisions simultaneously and non-cooperatively, the winner is determined by a Tullock type contest success function. Accordingly, the winning probability of contestant 1 when he invests x and contestant 2 invests y is expressed as follows.

$$p_1(x, y) = \frac{x}{x + y} \quad \dots(1)$$

Similarly, contestant 2's winning probability when he invests y and contestant 1 invests x takes the following form.

$$p_2(x, y) = 1 - p_1(x, y) = \frac{y}{x + y} \quad \dots(2)$$

Therefore, contestant 1's maximization problem is expressed as follows when we assume investment cost is liner.

$$Max_x \pi_1(x, y) = \frac{x}{x + y} v - x \quad \dots(3)$$

Similarly, contestant 2 solves the following problem.

$$Max_y \pi_2(x, y) = \frac{y}{x + y} v - y \quad \dots(4)$$

The F.O.C. of (3) w.r.t. x is

$$\frac{y}{(x + y)^2} = v - 1 = 0 \quad \dots(5)$$

Similarly, the F.O.C. of (4) w.r.t. y is

$$\frac{x}{(x + y)^2} = v - 1 = 0 \quad \dots(6)$$

(5) and (6) yield the equilibrium effort levels of contestant 1 and 2 as follows.

$$(x^* = y^*) = \frac{1}{4}v \quad \dots(7)$$

3. Experimental Design

Based on theoretical result in section 2 which summarizes the results obtained by Tullock (1980), we ran our simple experiment on November 29, 2011. We examined gender differences in a competitive environment in our experiment. Subjects were recruited from the students at Aoyamagakuin university in Tokyo, Japan. We conducted three types of matchings; a male versus another male, a female versus another female, and a male versus a female. Subjects were allocated to groups each of which had ten subjects. Each subject took a seat which was numbered 1, 2, 3, . . . , 10 and was randomly assigned a seat. They played a Tullock contest 10 rounds after one trial. We take a male versus male to explain our experiment, but the other 2 cases are similar. Each subject was informed about his opponent's gender (male in this case) at the beginning of this part and was told that the opponent's gender did not change. We told each subject that he matched to another male subject randomly in every period and he was not matched with the same opponent more than twice. We set the prize value, $v = 20$ experimental yen and gave 20 experimental yen to each subject at the beginning of every round so that the budget constraint never bound. Two male subjects were asked to decide their investment levels simultaneously and noncooperatively and to record his investment level. They were told that the investment level should take a non-negative integer number. After both subjects recorded their investment levels, the computer decided the winner according to the rule specified in (1) and (2) in section 2. After the winner was determined, each subject was informed whether he won or lost, but he was not informed about the investment level of his opponent. This process was repeated 10 times after one trial. After 10 rounds were over, 4 out of 10 rounds were randomly chosen and payments were privately made to each subject at the rate of 1 experimental yen = 5 Japanese yen. Furthermore, we measured risk attitude of subjects, willingness to win, and self-worth of each subject. For self-worth, we offered two questions, question 1 and question 2. Half the subjects played in the order of self-worth question 1, Tullock contests, risk attitude, willingness to win, self-worth question 2 and the other half subjects played in the order of self-worth question 2, Tullock contests,

risk attitude, willingness to win, self-worth question 1. We took this procedure to minimize the effects of the order of two self-worth questions without damaging their effects on investment decisions. Instructions to subjects for the case where a male is matched with another male are available in Appendix¹⁾.

4. Outcomes of the Experiments

This section reports the data obtained from our experiment in 4-1, the outcomes of regressions in 4-2, the outcomes of hypotheses tests in 4-3, and interpretations of the outcomes in 4-4. Throughout this section, we need to remember section 2 tells us that the theory predicts that a rational player invests 5 experimental yen.

4-1. Summary of the outcomes

Following Ong and Chen (2012), we abbreviate a male in a male versus a male contest as MM, a female in a female versus a female contest as FF, a female in a male versus a female contest as FM, and a male in a male versus a female contest as MF for simplicity. Figure 1 shows the distribution of investment for 10 rounds.

Figure 1 tells that all four groups overinvested (the Nash equilibrium investment level was 5 experimental yen.) and it follows the literature. Figure 1 also tells us that subjects invested all their initial endowment often. It is partly because we gave subjects their initial endowment for free at the beginning of every period. Price and Sheremeta (2011) showed that overinvestment was mitigated by letting subjects earn their initial endowments rather than letting subjects get their initial endowment for free. Baba (2015) also observed the similar effect.

Figure 2 shows that MM is the only group which shows the learning effect. We examine learning effect explicitly in 4-2 by using regressions and our regression outcomes confirms it.

1) We only include MM version in this appendix because other 2 cases are very similar to MM. There is no intention of sexual discrimination to choose MM. It is just both she and female have more letters than he and male.

Figure 1. Distributions of investments

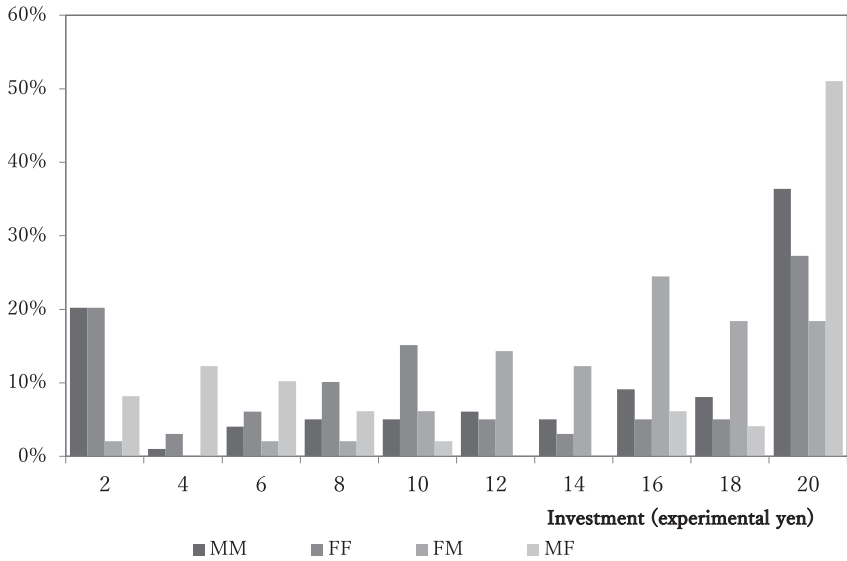


Figure 2. Learning effect

Investment(experimental yen)

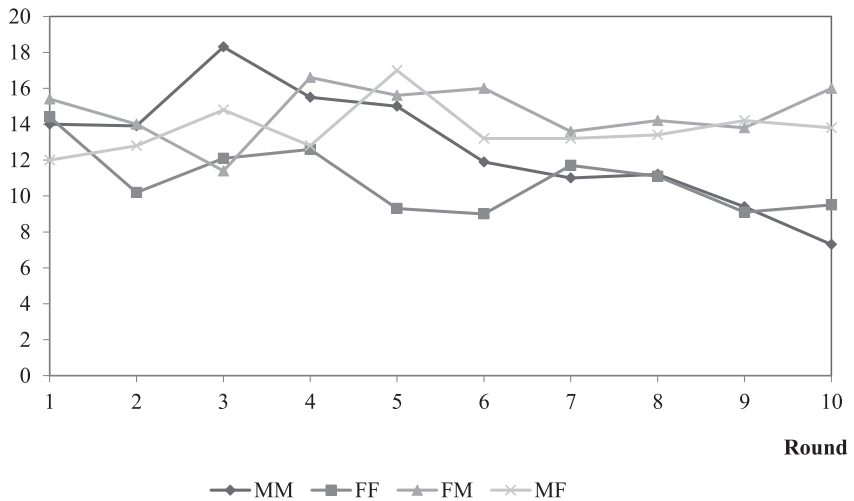


Table 1 summarizes the outcome of the investment of each group. We conduct hypotheses testing in 4–3.

Table 1. Investments

	Number of samples	Mean	Variance
MM	100	12.7	56.0507
FF	100	10.9	53.5048
FM	50	14.6	16.6782
MF	50	13.66	57.8208

It is interesting to observe that FF invested least since females bid higher than males regardless of their opponents' gender in Ong and Chen (2012), Price and Sheremeta (2012), Ham and Kagel (2006), and so on. Although most previous works insisted that females were more risk-averse than males, our data told us we failed to reject the null hypotheses that both female and male subjects were risk-neutral.

For simplicity, we denote willingness to win as WW, risk attitude as Risk, and self-worth as SW. Table 2 shows willingness to win, risk, and self-worth of females and males regardless of the groups they were randomly assigned.

Table 2. Willingness to win, risk, and self-worth

	WW	Risk	SW
Male	4.67	9.47	3.8
Female	5.93	7.6	3.267
Hypothesis test of Female = Male	Not rejected at 5%	Not rejected at 5%	Rejected at 5%

We used a method introduced by Holt and Laury (2002) to measure each subject's risk attitude. Instructions are available in Appendix where Part 2 measures risk attitude. We offered two alternatives, A and B, for 15 questions. We

used cash in this part. If a subject chose A, he always obtained 150 Japanese yen. Alternative A had no risk. If he chose B, then he obtained 0 Japanese yen with probability p and obtained 300 Japanese yen with probability $1 - p$, $p = 1$ in question 1, $p = 14/15$ in question 2, $p = 13/15$, in question 3, $\dots$, and $p = 1/15$ in question 15. So, starting from 1, p decreased by $1/15$ from the previous question. To make sure that subjects understood that each question was chosen with probability $1/15$ for actual payment and that p was chosen randomly for actual payments, we made the following announcement at the beginning of part 2. Firstly, we decided which question among 15 questions was chosen for actual payments. We wrote number 1, 2, 3, $\dots$, 15 on 15 cards. Each number was written on only one card and we showed each card to the subjects. Then, we put all the 15 cards into a nontransparent bag, tied the bag's mouth, and let the student who took the seat numbered 1 shuffled the bag 30 times in front of the other subjects. Then, the subject who took the seat numbered 10 closed his eyes and picked one card from the bag which the subject whose seat was number 1 held. The number written on the picked card was the number of the question for the actual payment to subjects. Then, we used the same procedure to determine the actual payments for subjects who chose B. The subject who took the seat numbered 6 shuffled the bag and the subject who took the seat numbered 5 picked one card. Suppose a subject who took seat 10 picked card numbered 12 and a subject who took seat 5 picked card numbered 5. Then, part 2 of the instruction available in Appendix told that a subject who chose A received 100 yen and a subject who chose B received 300 yen. The higher the number of the question where a subject switched from choosing A to choosing B, a subject was more risk averse and a risk neutral subject chose A from question 1 to 7 and chose B from question 8 to 15. We use the last question number a subject chose A as his/her risk attitude.

To measure self-worth, we asked two questions; question 1 asked how you evaluated yourself on a scale of 1 to 5 and question 2 asked how you evaluated yourself as a university student from 1 to 5. 1 was the lowest self-worth and 5 was the highest. Half of the subjects played in the order of question 1 of self-worth, one of FF, FM, MF, or MM Tullock contests, risk attitude, willingness to win, self-worth question 2. The other half played in the order of question 2 of self-worth, one of FF, FM, MF, or MM Tullock contests, risk attitude, willingness

to win, self-worth question 1. We use the outcome of the question 2 for regression without loss of generality since almost everyone chose the same number for both questions and everyone knew everyone was a student at the same university as oneself was. TABLE IV in Niederle and Vesterlund (2007) reported that males overestimated their performances more than females. Males evaluated themselves higher than females also in our experiment.

We evaluated willingness to win by setting $v = 0$. All other features of the contest were the same as the main experiment where $v = 20$. Subjects played this contest only one time without trial. Since this was played 2 parts after the main experiment, we were sure that every subject understood what they played. Our instruction highlighted that $v = 0$ in this part. Therefore, we evaluate willingness to win directly while desire to win is included in the value of the item in Ong and Chen (2012).

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 was implicitly included in the value of the winning in addition to the value of the prize and the effect of DTW on investment could not be analyzed. We measured DTW as willingness to win (WW) and examined its effect on investment by regression.

4-2. Regression outcomes

This subsection shows the regression outcomes of the experiment. Following the literature, we use random effect regression. We use eViews as a software since it is user friendly to examine panel data. Table 3 below is the regression outcome. The dependent variable is investment and the independent variables are win/lose in the previous round (WL), risk attitude (Risk), willingness to win (WW), round (Round), self-worth (SW), and constant (C). The independent variable, Round, measures the learning effect. The literature reports over investment is observed in the early rounds and sometimes it is mitigated over time. Table 3 summarizes the regression outcomes.

Table 3. Regression outcomes

	C	WL	WW	SW	Risk	Round
MM	15.719***	4.360***	0.156*	-1.028	0.306	-0.864***
FF	23.981***	3.084***	0.365*	-2.940*	-0.473	-0.325*
FM	20.644***	3.219***	-0.187	-2.391**	0.110	0.135
MF	17.923***	1.697***	1.124***	-2.167**	-0.465**	0.077*

* significant at 10% level

** significant at 5% level

*** significant at 1% level

Table 3 shows that winning or losing in the previous round (WL) is the driving force to determine investment level in all contests. In addition, self-worth is significant at 5% level for both male and female subjects when his/her opponent was a different gender. 10 rounds seemed to be too short to observe learning effect, but MM shows significant learning effect. Our female subjects' behaviors were close to those of mid-tier university females and our male subjects acted like top-tier university males in Ong and Chen (2012). This result that self-worth matters for mixed-gender contests complements their work which did not run a male in a top-tier university vs. a female in a mid-tier university due to budget constraint.

4-3. Testing hypotheses about investment

This subsection tests the null hypothesis that the population means of two different groups are the same.

The null hypothesis takes the following form.

$$H_0^{ij,kl}: \mu_{ij} = \mu_{kl},$$

where $kl \neq ij$ and $(kl, ij) \in \{ (FF, MM), (FF, FM) (MM, MF), (FM, MF), (MM, FM), (FF, MF) \}$ and μ_{ij} is population mean of investment for ij .

We use Welch's test because the hypothesis of the two population variances being equal is rejected at 5% significant level in (a), (b), (d), and (e) below. Table 1 tells us that the sample means are; 12.75 in MM, 10.9 in FF, 14.66 in FM, and 13.72 in MF. Note that FM is a female's behavior in a female vs. a male contest and MF is a male's behavior in a female vs. a male contest.

(a) FF and MM (unequal variances)

$\mu_{FF} = \mu_{MM}$ is **rejected** at 5% level (p-value = 0.0397).

(b) FF and FM; F's behavior (unequal variances)

$\mu_{FF} = \mu_{FM}$ is **rejected** at 1% level (p-value = $8.8E^{-05}$).

(c) MM and MF; M's behavior (equal variances)

$\mu_{MM} = \mu_{MF}$ is **not rejected** (p-value = 0.229).

(d) FM and MF (unequal variances)

$\mu_{FM} = \mu_{MF}$ is not rejected (p-value = 0.219).

(e) MM and FM; against M (unequal variance)

$\mu_{MM} = \mu_{FM}$ is **rejected** at 5% level (p-value = 0.0229).

(f) FF and MF; against F (equal variance)

$\mu_{FF} = \mu_{MF}$ is **rejected** at 5% level (p-value = 0.0145).

The outcome (a) tells that males invest more than females in the single gender contests. The results (b) and (c) show that a male on average did not change his behavior regardless of his opponent was a male or a female while a female on average did change her behavior a lot and invested 34% more on average when she competed against a male than against another female.

4-4. Interpretation of the results

4-1, 4-2, and 4-3 show that a male on average did not change his behavior regardless of his opponent was a male or a female while a female on average did change her behavior and invested 34% more on average when she competed against a male than against another female. This result is not observed in the literature. The literature shows that females usually invest more than males, but previous works on contests do not explicitly tell each subject about the gender of his/her opponents. Ours is the first work which explicitly tells each subject about the gender of his/her opponents in repeated Tullock contests. As Table 1 shows, FM invests most on average, then MF comes second, then MM follows,

and FF invests least. When we compare this result with that of Ong and Chen (2012), our female subjects acted close to female subjects in a mid-tier university at their experiment while male subjects behaved close to male subjects at top-tier universities in their experiment. Males show higher self-worth than females in our experiment. Our university is ranked on the boundary of the mid-tier and the top-tier and it is interesting to observe that male and female students identify his/her university in different ways. Nakely, an average female student ranks her university as a mid-tier university while an average male student ranks the same university at a top-tier university. As an application to educational institutions, we recommend mixed-gender schools if our aim of education is to maximize aggregate effort of students because both males and females invested more in the mixed-gender contest than in the single gender contest. If the aim of education is to achieve the Nash equilibrium effort investment level, single gender schools are better both for females and males because both males and females invested less in the single gender contest than in the mixed-gender contest. Still, but females invested 10.9 on average and males invested 12.7 on average in the single gender contests while the Nash equilibrium investment level was 5. So, we need another mechanism to implement the Nash equilibrium.

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Appendix: Instructions

Part 1.

This part consists of 1 trial and 10 rounds. In each round, you are matched with one other male subject randomly. In each round, you are matched with a different person. You are not matched with the same person more than twice. At the beginning of each round, you and your match are given **20 experimental yen as initial endowment**. You and your match make nonrefundable investment to win **the prize valued 20 experimental yen**. You and your match decide how much to invest simultaneously without knowing each other’s decision. You should choose investment from {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20}. In each round, you will write down your investment and whether you win or lose. 4 out of 10 rounds are chosen randomly, your earning is converted at the rate of **1 experimental yen = 5 Japanese yen**, and you are paid in cash without being known by anyone.

Are there any questions?

Your payoff is calculated as follows in experimental yen.

When you win the prize, your payoff is calculated as

$$\begin{aligned}\text{Your payoff} &= \text{initial endowment} + \text{the prize} - \text{investment} \\ &= \text{initial endowment} + 20 - \text{investment} \\ &= 20 + 20 - \text{investment}\end{aligned}$$

When you do not win the prize, your payoff is calculated as

$$\begin{aligned}\text{Your payoff} &= \text{initial endowment} - \text{investment} \\ &= \text{initial endowment} - \text{investment} \\ &= 20 - \text{investment}\end{aligned}$$

Your winning probability is expressed as follows.

$$\text{Your winning probability} = \frac{\text{your investment}}{\text{your investment} + \text{your opponent's investment}}$$

The more you invest, the more likely you win the prize given your opponent's investment level. The less you invest, the less likely you win the prize given your opponent's investment level. For example, if you invest 6 experimental yen and your opponent invests 4 experimental yen, your winning probability is.

$$\frac{6}{6 + 4} = 0.6. \text{ If you invest 10 experimental yen and your opponent invests 15 experimental yen, your winning probability is } \frac{10}{10 + 15} = 0.4.$$

Are there any questions?

Part 2.

In this part, **we use Japanese yen**. You will be asked to make a series of choices in decision problems. How much you receive will depend partly on **chance** and partly on the **choices** you make. There is no correct or wrong answer. The only right answer is what you really prefer.

For each question in the next page, please state whether you prefer option A or option B. For each of 15 questions, you have to choose A or B. Circle 150 yen if you choose option A and circle both 0 yen and 300 yen if you choose B. Notice that there are total of **15 questions** but just **one question** will be randomly selected for actual payment. Each question is equally likely to be chosen (each question is chosen with probability 1/15), so you should pay equal attention to

the choice you make in every question. Your earning to a question depends on your answer. You will **always** receive **150 yen** if you choose **option A**. If you choose **option B** in that question, you will receive either **300 yen** or **0 yen**, conditional on the number on the card picked from the bag containing 15 cards numbered from 1 to 15. For example, if you choose option B in question 5 and the card numbered 3 is picked up, your earning is 300 yen. If you choose option B in question 11 and the card numbered 5 is picked up, your earning is 300 yen. If you choose also option B in question 2 and the card numbered 13 is picked up, your earning is 0 yen. Regardless of the number in the card picked up, you always receive 150 yen if you choose option A.

Your earning is paid in cash to you privately without being known by anyone.

Are there any questions?

Questions	Option A	Option B
1.	150 yen	300 yen Never. 0 yen if 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
2.	150 yen	300 yen if 1. 0 yen if 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
3.	150 yen	300 yen if 1, 2. 0 yen if 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
4.	150 yen	300 yen if 1, 2, 3. 0 yen if 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
5.	150 yen	300 yen if 1, 2, 3, 4. 0 yen if 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
6.	150 yen	300 yen if 1, 2, 3, 4, 5. 0 yen if 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.

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- | | | | |
|-----|---------|---------|---|
| 7. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6.
0 yen if 7, 8, 9, 10, 11, 12, 13, 14, 15. |
| 8. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6, 7.
0 yen if 8, 9, 10, 11, 12, 13, 14, 15. |
| 9. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6, 7, 8.
0 yen if 9, 10, 11, 12, 13, 14, 15. |
| 10. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6, 7, 8, 9.
0 yen if 10, 11, 12, 13, 14, 15. |
| 11. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.
0 yen if 11, 12, 13, 14, 15. |
| 12. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11.
0 yen if 12, 13, 14, 15. |
| 13. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.
0 yen if 13, 14, 15. |
| 14. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13.
0 yen if 14, 15. |
| 15. | 150 yen | 300 yen | if 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14.
0 yen if 15. |

Part 3.

This part is the same as part 1 except prize value is 0 here and you play only once without a trial.

You are matched with one other male subject randomly. Firstly, you and your match are given **20 experimental yen as initial endowment**. You and your match make nonrefundable investment to win **the prize valued 0 experimental yen**. You and your match decide how much to invest simultaneously without

knowing each other's decision. You should choose investment from $\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20\}$. You will write down your investment and whether you win or lose. Your earning is converted at the rate of **1 experimental yen = 5 Japanese yen**, and you are paid in cash without being known by anyone.

Are there any questions?

Your payoff is calculated as follows in experimental yen.

When you win the prize, your payoff is calculated as

$$\begin{aligned}\text{Your payoff} &= \text{initial endowment} + \text{the prize-investment} \\ &= \text{initial endowment} + 0 - \text{investment}\end{aligned}$$

When you do not win the prize, your payoff is calculated as

$$\begin{aligned}\text{Your payoff} &= \text{initial endowment} - \text{investment} \\ &= \text{initial endowment} - \text{investment}\end{aligned}$$

Your winning probability is expressed as follows.

$$\text{Your winning probability} = \frac{\text{your investment}}{\text{your investment} + \text{your opponent's investment}}$$

The more you invest, the more likely you win the prize given your opponent's investment level. The less you invest, the less likely you win the prize given your opponent's investment level. For example, if you invest 6 experimental yen and your opponent invests 4 experimental yen, your winning probability is.

$$\frac{6}{6 + 4} = 0.6. \text{ If you invest 10 experimental yen and your opponent invests 15 experimental yen, your winning probability is } \frac{10}{10 + 15} = 0.4.$$

Are there any questions?

SW question 1²⁾.

You will be asked to evaluate yourself. You are expected to choose from {1, 2, 3, 4, 5} to evaluate yourself.

1 is the lowest evaluation to yourself and 5 is the highest evaluation to yourself.

I evaluate myself as ().

Are there any questions?

SW question 2³⁾.

You will be asked to evaluate yourself **as a university student**. You are expected to choose from {1, 2, 3, 4, 5} to evaluate yourself.

1 is the lowest evaluation to yourself and 5 is the highest evaluation to yourself. Write your answer in the parentheses below.

I evaluate myself as ().

Are there any questions?

2) It was written just "Question 1" in the instructions to subjects. We add SW (self-worth) here to show what this question means.

3) It was written just "Question 2" in the instruction to subject. We add SW (self-worth) here to show what this question means.