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When to use tournament incentives? Evidence from an investment experiment

Kun Zhang [a], Xiaolan Yang [b,c], Mei Gao [b,c,*]

[a] The Center for Economic Research, Shandong University, Jinan, 250100, China
[b] Shanghai Key Laboratory of Brain-Machine Intelligence for Information Behavior, Shanghai, 201620, China
[c] School of Business and Management, Shanghai International Studies University, Shanghai, 200083, China

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ABSTRACT

This paper theoretically and experimentally investigates how different tournament incentives affect managerial decision-making and firm value. Our theoretical model shows that when the economy is in a downturn, linear incentive and elimination contests can ensure that CEO-optimal investment (maximize personal income) is consistent with firm-optimal investment (maximize firm value), while a winner-take-all tournament makes CEO-optimal investment deviate from firm-optimal investment. When the economy is prosperous, a linear incentive and winner-take-all can ensure that CEO-optimal investment is consistent with firm-optimal investment, while elimination contests make CEO-optimal investment deviate from firm-optimal investment. The experimental results broadly support the above predictions. However, elimination contests (winner-take-all) are more efficient than linear incentives when the economy is in a downturn (i.e., prosperous). We conjecture that this result occurs because elimination contests and winner-take-all, which involve interactions between subjects, induce learning effects. In addition, winner-take-all and elimination contests lead to more rational behavior than linear incentives.

1. Introduction

One popular incentive scheme in organizations is rank-based tournaments. Dutcher et al. (2015) state that at least 60% of Fortune 500 companies currently adopt some kind of ranking system, which rewards top performers and eliminates bottom performers.[1] To filter out the systematic component of performance beyond the control of the CEOs and efficiently elicit sustained effort, tournament incentives are also widely adopted in top managers' compensation contracts. Given their common use, the issue of top managers' tournament incentives has attracted relatively substantial research attention in recent years (Berger et al., 2013; Choi et al., 2016; Kelly et al., 2017; Fang et al., 2017; Coles et al., 2018; Berger et al., 2018; Cui et al., 2022; Bao et al., 2021).

Winner-take-all and elimination contests are two important kinds of tournament incentives with extreme proportions of winners. Winner-take-all is a tournament where a minority wins, while an elimination contest is a tournament where a majority wins.[2] Previous experimental studies of tournaments have focused mainly on their effects on fund manager decision-making or effort provision. For instance, Kelly et al. (2017) find that tournaments having a proportion of winners at either extreme (e.g., 75 percent or 25 percent) can reduce effort, while Berger et al. (2018) argue that having a higher percentage of winners in a tournament will result in better performance than having a lower percentage of winners. It seems that the previous literature comparing different tournament incentives (winner-take-all versus elimination contests) provides an ambiguous picture. Moreover,

* Correspondence to: School of Business and Management, Shanghai International Studies University, 550 Dalian Road (W), Shanghai, 200083, China.
E-mail addresses: kunzhang_uk@163.com (K. Zhang), yangxiaolan@shisu.edu.cn (X. Yang), mgao@shisu.edu.cn (M. Gao).

1 See the article from the *Wall Street Journal* (WSJ) titled "'Rank and Yank' Retains Vocal Fans", which was published on Jan. 31, 2012, and can be accessed at https://www.wsj.com/articles/SB10001424052970203363504577186970064375222.

2 Tournament incentives are commonly adopted in contracts of CEOs and top managers. For instance, in Alphabet's 2021 stock plan, the performance stock units (PSUs) award will vest on December 31, 2023, based on the total shareholder return (TSR) performance of Alphabet relative to companies comprising the S&P 100 over a 2021–2023 performance period. More concretely, the number of PSUs vesting is determined by linear interpolation for relative TSR ranks between the 25th and 50th percentile and between the 50th and 75th percentile. Thus, if Alphabet's TSR percentile rank is lower than the 25th percentile, its CEOs cannot get any percentage of target PSUs vesting; if the Alphabet's TSR percentile rank is higher than the 75th percentile, its CEOs can get the maximum percentage (200%) of target PSUs vesting. Such stock plan compensation design is a real world example, in which the worst one (bottom 25th percentile, like elimination contests) will be eliminated from winning the reward and the best one (top 25th percentile, like winner-take-all) will be the winner.

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given the prevalence of both incentives in organizations, little is known about the effect of various tournaments (winner-take-all versus elimination contests) and the underlying mechanism from the perspective of CEOs' decisions and firm value, which constitutes a gap in our understanding of organizations.

Theoretical studies focusing on the association between tournament incentives and firm performance suggest that rank-order promotion tournaments encourage competition among top managers, thus leading to better performance and, ultimately, higher firm value (Lazear and Rosen, 1981; Bognanno, 2001). However, empirical evidence presents conflicting results regarding the association between firm value and CEO tournaments. Kale et al. (2009), Kini and Williams (2012) and Burns et al. (2017) conclude that there is a positive association between internal tournament incentives and firm value, while Bebchuk et al. (2011) find that internal tournaments are negatively associated with firm value. Coles et al. (2017) find that firm performance, firm risk, and the riskiness of firm investment and financial policies are positively associated with the external industry pay gap. Due to the limited disclosures about top management compensation contracts, there is a lack of evidence on whether and how different tournament incentives (specifically winner-take-all versus elimination contests) affect CEO decision-making and firm value.

The effects of tournaments on CEO decision-making and firm value may be conditional on the exogenous economic environment. This possibility is also a possible explanation for the conflicting results regarding the association between firm value and CEO tournaments in empirical studies since their samples differ with respect to the economic environment. Prior work suggests that firms that adopt tournament incentives in compensation contracting may have greater exposure to systematic risk (Bettis et al., 2010) but that tournament incentives induce lower investment volatility and possibly less exposure to investment risk during economic downturns (Tice, 2017). There are some real-world examples. Due to the slowdown of the domestic and global economy, China's State-owned Assets and Supervision and Administration Commission (SASAC) issued a new regulation on managerial tournament compensation in 2019, which replaced the former regulation from 2008. One of the important changes is that a winner-take-all-type tournament is no longer an obligation, and state-owned firms are able to set their own tournament structures.[3] The SASAC explains that this change was made due to the slowdown of the domestic and global economy. The SASAC encourages state-owned firms to design suitable and flexible tournament structures according to internal and external factors. However, the new regulation does not provide specific guidelines on how to set an optimal tournament structure. In a broad review, Burns et al. (2017) use a cross-country sample and find significantly larger tournament payoffs (winner-take-all-like tournaments) for U.S. CEOs than non-U.S. CEOs. They argue that tournament structures across countries are related to their cultural, legal, and economic environments. Thus, how to design an optimal tournament structure that is well suited to exogenous factors is a global question of practical and academic concern.

In this paper, we combine a theoretical model with an experiment to identify the effects of different tournament incentives conditional on the external economic environment on CEOs' decision-making and firm value. We use a framework similar to that of Eriksen and Kvaloy (2014) to build our theoretical predictions with a 3 (three incentive schemes) $\times$ 2 (two exogenous economic environments) factorial design. Our first treatment variable is how subjects (acting as firm CEOs) are incentivized. A *winner-take-all* tournament rewards the subject who wins first place on the investment task with a high prize. An *elimination contest* tournament eliminates the payoff of the subject who comes last in the investment task. A *linear* scheme is an incentive where subjects' payoff is proportional to their performance on the investment task. Our second treatment variable is the exogenous economic environment: A *good* environment means a high expected income from investment projects, and a *bad* environment means a low expected income from investment projects. For each combination of incentive and environment, we derive firm-optimal investment maximizing firm value and CEO-optimal investment by maximizing personal income from the theoretical model and test these predictions in an experiment where subjects are told to act as firm CEOs to make decisions on investment projects (investment tasks).[4]

Our main experimental results broadly support the theoretical prediction. That is, elimination contest and linear incentives have significantly higher efficiency in enhancing firm value than winner-take-all when the external economic environment is in a downturn. Meanwhile, winner-take-all and linear incentives have significantly higher efficiency in enhancing firm value than elimination contest when the external economic environment is in prosperity. Second, we observe that CEOs' personal investment decisions under tournament incentives (both winner-take-all and elimination contest) are irrelevant to the external economic environment. This result is consistent with our theoretical implication as well as the standard relative performance evaluation theory. In addition, we find that tournament incentive mechanisms (regardless of whether the tournament is winner-take-all or elimination contest) lead to more rational behavior than linear incentive mechanisms. The learning effect in tournament incentives is observed in our experiment, which provides an explanation for more rational behavior in tournament treatments.

This paper contributes to the previous literature in several aspects. First, we contribute to the literature on relative performance evaluation, especially on corporate tournament incentives. The primary research method in this literature is empirical analysis. These empirical studies usually test the relationship between tournament incentives and firm outcomes directly without observing CEOs' efforts and decision-making. Therefore, it is difficult to identify the underlying mechanism linking tournament incentives, CEO behavior and firm outcomes. Our study uses a theoretical and an experimental approach to collect unique data on CEO compensation (limited disclosure in the real world) and isolates different tournament effects on CEO behavior and firm value. Second, it contributes to the literature on the experimental

3 SASAC's 2008 regulation required that state-owned firm performance must exceed the 50th percentile of peer firms for firm managers to obtain equity compensation, which resembles a WTA tournament. In practice, some firms choose the 50th percentile benchmark, while other firms choose the 75th percentile benchmark. The 2019 regulation eliminates this rigid requirement and grants state-owned firms the right to set their own tournament benchmark, which means that firms are able to choose a benchmark less than the 50th percentile of peer firms, which resembles an elimination contests tournament. However, the new regulation does not provide specific guidelines on how to set an optimal tournament benchmark.

4 This current framework may not only be suitable for investigation on CEOs' decisions making. However, CEOs (or top managers) are more representative for our current setting. The reasons are as follows: (1) Tournament-based incentives are commonly used in organizations for CEOs and managers. For example, Dutcher et al. (2015, GEB) design a laboratory experiment to investigate managers' effort provision under different tournament contracts. Coles et al. (2018, RFS) empirically assess industry tournament incentives for CEOs, as measured by the compensation gap between a CEO at one firm and the highest-paid CEO among similar (industry, size) firms. (2) In our current framework, we not only focus on individual investment decisions under different incentive schemes but also care whether their optimal decision is consistent with corporate benefit. While pure individual investment behavior studies only focus on the former. (3) In our experiment, we chose the investment task rather than the real effort task to better imitate CEOs' (or top managers') decision environment. Corporate investment decisions are usually made by CEOs (or top managers) rather than ordinary employees or individuals, while real-effort tasks can be used for CEOs or anybody.

study of winner-take-all tournaments and elimination contests. Previous experimental studies in this area focus mostly on fund manager decision-making or effort provision and fail to investigate managerial decision-making and firm value. Thus, our study extends previous experimental work. Finally, we investigate the effects of different tournament incentive conditions on external factors in novel settings, specifically downturns versus prosperity in the external economy. The results of this study have strong policy implications that firms should carefully design and dynamically adjust their compensation schemes according to external factors such as the economic environment. There is no single incentive scheme suited to all circumstances.

The remainder of the paper is organized as follows. In the next section, we review the related literature. Section 3 describes the experimental design and procedures. Section 3.3 presents the theoretical predictions. Section 4 presents the experimental results. Section 5 concludes the paper. Appendix provides the instructions for the experiment.

2. Literature review

Early theoretical examinations of tournament incentives include Lazear and Rosen (1981), Hvide (2002), and Hvide and Kristiansen (2003). Lazear and Rosen (1981) conclude that for risk-neutral workers, a tournament produces the same incentive as a piece rate. For risk-averse workers, tournaments are preferred to piece rates. Moreover, if workers are heterogeneous in their ability, tournaments yield more efficient allocation than piece rates.

A stream of studies has attempted to uncover a relationship between tournaments and risky behavior using lab experiments. A small-scale experiment by James and Isaac (2000) found suggestive evidence that a tournament with convex incentives yielded more pronounced asset-price bubbles than linear absolute-performance incentives. Eriksen and Kvaloy (2014) report that under convex tournament incentives, subjects take more risks the more frequently their investments are evaluated (the opposite of the implication of myopic loss aversion, as noted by Benartzi and Thaler (1995). Eriksen and Kvaløy (2017) find that subjects in convex tournaments take risks even when the only rationalizable strategy is to take no risk, and they take more risks the more competitive the tournament is. Feltovich and Ejebu (2014) find that individuals take more risks when provided with payoff-irrelevant ranking information, and Kirchler et al. (2018, 2020) find that payoff-irrelevant ranking information can increase risk-taking among underperformers.

Winner-take-all and elimination contests are two examples of extreme proportions of winners in tournaments. Winner-take-all is a tournament where a minority wins, while an elimination contest is a tournament where a majority wins. Gaba et al. (2004) and Fang et al. (2017) find more aggressive trading in winner-take-all but less aggressive trading in elimination contests, and Sato (2016) finds a similar connection between asset-price bubbles and winner-take-all tournaments among fund managers. Experimental studies pay more attention to the association between different tournaments and investment decision-making or effort provision. Fang et al. (2017) investigate the difference between winner-take-all and elimination contest. They find that investment managers employ more heterogeneous strategies in winner-take-all than in elimination contests but that this approach does not lead to significant differences in market prices. Dutcher et al. (2015) compare effort provision under winner-take-all, elimination contests or a tournament involving both mechanisms. They find that the tournament incorporating both winner-take-all and elimination contests induces the highest effort provision. An elimination contest produces the lowest variance in effort but higher effort provision than winner-take-all. As a winner-take-all is a tournament with a small percentage of winners, while an elimination contest is a tournament with a large percentage of winners, another related group of studies focuses on the percentage of winners in tournaments. Berger et al. (2018) find that having a higher percentage of winners in a tournament will result in better performance than having a lower percentage of winners by inducing more social comparisons. By using a real-effort experiment, Knauer et al. (2016) show that firms can increase employee effort (and performance) by increasing the proportion of winners (from 1 winner out of 30 to 3 winners out of 30 to 5 winners out of 30). Harbring and Irlenbusch (2008) compare tournaments with different fractions of winners (1/4, 1/2, 3/4) and find that a balanced fraction (50%) of winner and loser prizes appears to best enhance productive activities. Kelly et al. (2017) argue that tournaments having a proportion of winners at either extreme (e.g., 75 percent or 25 percent) can reduce effort, as too many competitors will perceive an extreme likelihood of winning (i.e., too high or too low). However, previous literature comparing different tournament incentives (winner-take-all versus elimination contests) seems to provide an ambiguous picture. Furthermore, given the prevalence of both incentives in organizations, there is a lack of research on how different tournament incentives (winner-take-all versus elimination contests) maximize firm value by affecting CEOs' decision-making, which constitutes a gap in our understanding of organizations.

3. Experimental design and procedures

3.1. Experimental task

Our experimental investment task is similar to Gneezy and Potters's (1997) and Eriksen and Kvaloy's (2014) designs. The experimental task consists of nine identical periods in which subjects could invest in a lottery-like investment project. Subjects are told to act as firm CEOs. On behalf of the firms, they need to make decisions on an investment project (investment task). At the start of each period, companies have an endowment of 100 experimental currency units, denoted tokens, and the CEOs (subjects) decided how much to invest in the project. For investment X, firm profit is 100-X with 50% and 100+0.5X with 50% in the bad state and 100-X with 50% and 100+1.5X with 50% in the good state. The lottery drawings are independent both between periods and subjects. The expected firm income (hereafter firm value) of the risky investment project (per period) is as follows:

$$E(V)_{Bad} = 100 - 0.25x$$

$$E\ (V)_{Good} = 100 + 0.25x$$

where V is the firm value after investment project realization (per period), x is the amount invested decided by the CEO, and $x \in [0, 100]$. E(V) is the expected firm value from investing in a project. From the perspective of the firm, the optimal investment to maximize firm value is (hereafter the firm-optimal investment) 0 in a bad state and 100 in a good state.

3.2. Treatments

The experiment uses a 2 × 3 factorial design, where we vary the economic environments and the incentive schemes. Our first treatment variable is the status of the exogenous economic environment: either bad (lower expected income from investment projects when the economy is in a downturn) or good (higher expected income from investment projects when the economy is prosperous). A bad environment means a lower expected income from investment projects when the economy is in a downturn. Specifically, with a probability equal to 1/2, companies would lose the amount invested, and with a probability of 1/2, they would win 0.5 times the amount invested. A good environment means a higher expected income from investment projects when the economy is prosperous. Specifically, with a probability of 1/2, companies would lose the amount invested, and with a probability of 1/2, they would win 1.5 times the amount invested (rather than the 0.5 times in the bad environment).

Our second treatment variable is how CEOs are incentivized: by linear incentives, by a winner-take-all tournament, or by elimination contests. Here, the tournament is an external tournament where CEOs compete with other CEOs from peer firms. A winner-take-all tournament is a tournament where a minority wins; specifically, in our design, the top 1 of 4 wins the tournament and obtains a bonus. An elimination contest is a tournament where a majority wins (that is, a minority will not receive a bonus as a reward); specifically, in our design, the top 3 of 4 win the tournament and obtain a bonus, that is, the player ranked last does not receive the bonus. Table 1 lists the parameters of the experimental treatments: (1) In the linear incentive scheme, the subject's earnings in the respective period (in CNY) = firm final income (in the respective period) *2.5% when the economic environment is bad, and the subject's earnings in the respective period (in CNY) = firm final income (in the respective period) *2% when the economic environment is good. The subject's total earnings are equal to the sum of their earnings over nine periods. (2) In the winner-take-all incentive scheme, subjects' earnings per period include a fixed payment and a bonus. Each subject receives a fixed payment of ¥1.5 per period. In addition, each subject competes with three other randomly drawn subjects, and the player who helps his or her firm earn the most tokens in the respective period is paid a bonus of ¥4. The other three only obtain the fixed payment without any bonus. If there is a tie, the winner is chosen by a random draw. Subjects' total earnings are equal to the sum of their earnings over nine periods. (3) In the elimination contest incentive scheme, subjects' earnings per period include a fixed payment and a bonus. Each subject receives a fixed payment of ¥1 per period. In addition, each subject competes with three other randomly drawn subjects, and the three participants who rank in the top three (of four) with respect to helping their firm earn tokens in the respective period are paid a bonus of ¥2 each. The last player receives only the fixed payment without any bonus (i.e., does not earn a bonus). If there is a tie, the winner is chosen by a random draw. Subjects' total earnings are equal to the sum of their earnings over nine periods. Thus, there are 6 treatments in our study, and the experimental instructions can be found in Appendix.

The reason why we use different incentive rates (2.5% in BL vs. 2% in GL) and different fixed payments (1.5 CNY in GW & BW vs. 2.0 CNY in BE & GE) is as follows: in Treatment BL, a rational and risk-neutral subject should invest 0 in the project, thus keeping the firm's income at 100 tokens and obtaining a reward of 2.5%*100 = 2.5 CNY as his or her personal earnings. In Treatment GL, a rational and risk-neutral subject should invest 100 in the project to maximize his or her own interest, thus making the firm's expected income 150 tokens and obtaining a reward of 2%*150 = 2.5 CNY as his or her personal earnings. In Treatments BW and GW, the winner-take-all incentive scheme guarantees that the expected earnings for each subject (CEO) are $1.5 + 4/4 = 2.5$ CNY per period. In Treatments BE and GE, the elimination contest incentive scheme makes the expected earnings for each subject (CEO) 1+2* 3/4 = 2.5 CNY per period. Hence, our design makes the subject's expected earnings equal (2.5 CNY per period) across all treatments, which helps to eliminate the income effect.

3.3. Theoretical predictions and hypothesis

To maximize personal income, different incentive schemes may lead CEOs' investment decisions to deviate from the firm-optimal investment. Here, assume that CEOs (subjects) are rational and risk neutral. Under the linear incentive (Treatments BL and GL), CEOs' personal earnings are consistent with firm value since they are proportional to firm value. Thus, their best choice (CEO's optimal investment) is the same as the firm optimal investment amount. Under the winner-take-all incentive scheme (one out of four will win the bonus), observe first that if the four competing subjects play the investment lottery game once, then the strategy profile (100, 100, 100, 100) is an equilibrium, i.e., the four competitors invest all the endowments in the risky lottery. In equilibrium, the probability of winning is 1/4, and no one can benefit by deviating and playing $x_i < 100$ since deviating will lead the probability of winning to decrease from 1/4 to 1/8. Under the winner-take-all incentive scheme, CEO income relates only to the probability of project success but not expected income. Thus, regardless of whether the economic environment is bad or good, the equilibrium of the CEO's optimal investment in the winner-take-all scheme is always (100, 100, 100, 100). Similarly, under the elimination contest incentive scheme, the equilibrium of the CEO's optimal investment is (0, 0, 0, 0). The probability of winning is then 3/4 in the equilibrium strategy profile. No one can benefit by deviating and playing $x_i > 0$ since the probability of winning will decrease from 3/4 to 1/2. One thing is worth to point out that under tournament incentives, there are only two possible real-money payments in each period: 5.5 CNY for winners vs 1.5 CNY for losers in winner-take-all tournament, and 3 CNY for winners vs 1 CNY for losers in elimination-contests tournament. Thus, as long as preferences are over only money amounts, all that matters to subjects will be the probability of winning. In particular, attitudes toward risk are irrelevant here. This theoretical predication is consistent with Eriksen and Kvaloy (2014) and Cui et al. (2022).

Since the linear incentive scheme can make CEOs' (subjects') behavior always consistent with the firm-optimal investments and the elimination contest incentive scheme leads to the equilibrium strategy profile (0, 0, 0, 0), it can be expected that CEOs' average investments in Treatment BL (Bad Environment, Linear Incentive) and Treatment BE (Bad Environment, elimination contest) will be closer to firms' optimal investment when the economic environment is bad. Similarly, when the economic environment is good, it can be expected that to maximize their personal incomes, CEOs' average investments in Treatment GL (Good Environment, Linear Incentive) and Treatment GW (Good Environment, Winner-take-all) will be closer to firms' optimal investment. The above analysis is summarized in Table 1. Thus, we derive the following hypothesis:

H1: *When the economic environment is bad (economic downturn), elimination contests and linear incentive schemes make CEOs' investment decisions closer to the optimal level than winner-take-all. When the economic environment is good (economic prosperity), winner-take-all and linear incentive schemes make CEOs' investment decisions closer to the optimal level than elimination contests.*

The above theoretical prediction is that CEOs' best choice is to maximize their probability of winning, which relates only to projects' success probability and not expected firm value. Thus, the equilibrium of both winner-take-all and elimination contests is unaffected by the economic environment. The equilibrium of the winner-take-all scheme is always (100, 100, 100, 100), and that of elimination contests is always (0, 0, 0, 0), regardless of

Table 1
Treatment parameters.

Treatment	Environment	Incentive	CEO's optimal investment	Firm's optimal investment
BL	Bad	Linear: CEO's earnings in the respective period = firm final income × 2.5%	0	0
GL	Good	Linear: CEO's earnings in the respective period = firm final income × 2%	100	100
BW	Bad	Winner-take-all: CEO's earnings per period include a fixed payment (¥1.5 per period) and a bonus (the player who helps his or her firm earn the most tokens in the respective period is paid a bonus of ¥4)	100	0
GW	Good	Winner-take-all: same as above	100	100
BE	Bad	Elimination contest: CEO's earnings per period include a fixed payment (¥1 per period) and a bonus (the three participants who rank in the top three (out of four) with respect to helping their firm earn tokens in the respective period are paid a bonus of ¥2 each)	0	0
GE	Good	Elimination contest: same as above	0	100

Note: The CEO's optimal investment is the optimal investment that can maximize personal income. The firm's optimal investment is the optimal investment that can maximize firm value.

Table 2
Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Investment_Median	192	52.96	35.22	0	100
Investment_Average	192	51.11	28.72	0	100
Investment_Period8	192	53.98	38.52	0	100
Investment_Period9	192	55.03	40.95	0	100
Financial Literacy	192	6.65	1.67	2	10
Loss Aversion	192	3.01	1.53	0	6
Risk Aversion	192	5.52	1.92	0	10
Female	192	0.82	0.38	0	1

whether the economic environment is good or bad. Hence, we derive the following hypothesis:

H2: *The CEO's optimal investment under tournament incentives (both winner-take-all and elimination contest) is unaffected by the external economic environment.*

However, the CEO's optimal investment under tournament incentives will be affected by the risk of the investment project. For example, if we establish a new assumption that the probability of investment success is strictly less than 1/4 in the either a good or bad economic environment (rather than 1/2 in the current setting), then under winner-take-all, the 4 competing agents investing 0 (rather than 100) will sustain an equilibrium. Thus, the external risk of the investment project (probability of success) is able to affect the CEO's optimal investment, while the expected income of the investment project is unable to affect the CEO's optimal investment. Since this paper focuses on how the external economic environment (expected income of investment project) affects CEO investment decisions and firm value, an extended study on the effect of investment risk is beyond the scope of the current paper. (See Section 5 for a discussion of the limitations and future studies.)

3.4. Experimental procedures

The experiment was conducted at an experimental economics lab at Hebei University of Economics and Business (China). It comprised 6 treatments with 32 subjects for each treatment, 192 in total. Subjects were recruited from undergraduate and postgraduate courses. We employed a between-subjects design. Many of the subjects had participated in previous experiments, but none had participated in such an investment-task experiment, and none participated more than once in our study. The experiment was computerized using z-Tree (Fischbacher, 2007).

Each session lasted approximately 50 min (including instructions, all tasks, and payment). After the main investment task, we collected information on demographics, risk attitudes (Holt and Laury, 2002), loss aversion (Abeler et al., 2011) and financial literacy (van Rooij et al., 2011). Subjects were paid their earnings immediately at the end of the experiment, privately and in cash. Average payments were 21.88 CNY for the main investment task alone and approximately 25.69 CNY overall (which roughly equal to 3.54 US dollar or 3.56 Euro); for reference, the local minimum hourly wage was 17 CNY (which roughly equal to 2.34 US dollar or 2.35 Euro).

4. Result

4.1. Descriptive statistics

In total, 192 subjects (32 subjects for each of the 6 treatments) participated in our experiment. The experiment lasted approximately 50 min. The descriptive statistics for the main variables can be found in Table 2.

The average value of CEOs' investment in all periods (across all sessions) is 51.11, which is quite similar to the median value (52.96). The average investments in the last two periods are 53.98 (Period 8) and 55.03 (Period 9). Approximately four-fifths of the participants (82 percent) were female, reflecting the overall gender proportions at the university. The financial literacy score is 6.65 (out of 10). The average score of loss aversion is 3.01 (out of 6, where a higher value means more loss aversion), and the score of risk aversion is 5.52 (out of 10, where a higher value means more risk aversion). Other demographics, such as degree, major, whether the child is an only child, and whether the child is from a city, are also collected. We typically control for demographics and attitudes in the regressions below. We did not observe any significant differences in demographics and attitudes to risk or loss across treatments (Kruskal–Wallis test, session-level data, $p > 0.10$ for all variables, i.e. risk aversion, loss aversion, gender, age, major, degree and only child).

4.2. Main results

According to the theoretical predictions in Section 3.3, the optimal investment amount to maximize firm value is zero when

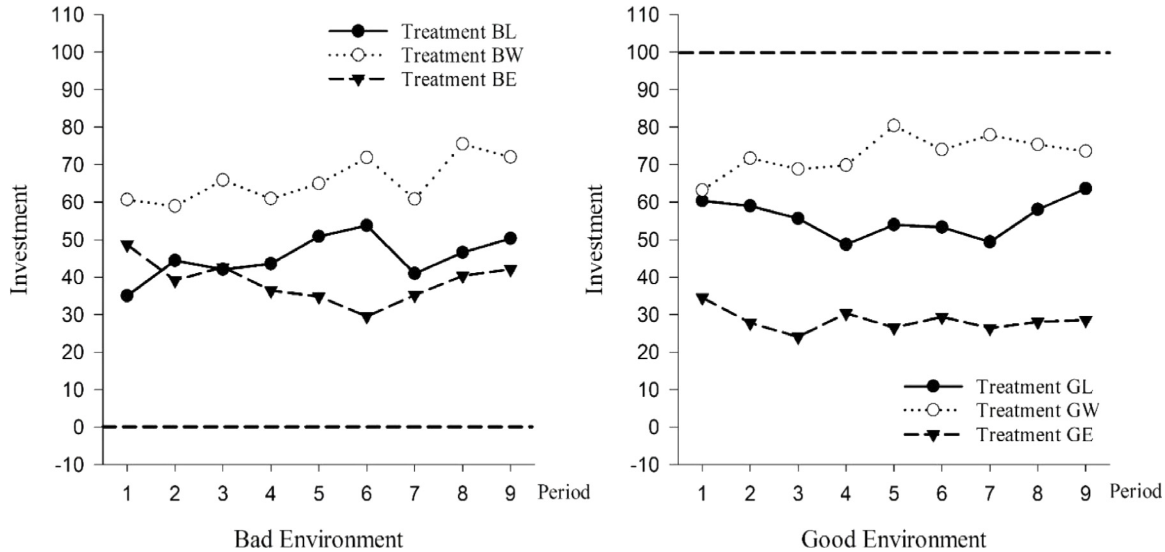

Fig. 1. Average investment amount in each period under different incentives and economic environments.

Table 3
Robust rank-order test for treatment level investment.

Treatment	Investment_Median (All period)	Investment_Average (All period)	Investment_Average (Period 8)	Investment_Average (Period 9)
BL vs. BW	0.0011***	0.0010***	0.0016***	0.0270
BL vs. BE	0.3002	0.3230	0.4377	0.5967
BE vs. BW	0.0002***	0.0000***	0.0003***	0.0084***
GL vs. GW	0.0027***	0.0041***	0.0293	0.0821
GL vs. GE	0.0000***	0.0000***	0.0004***	0.0002***
GW vs. GE	0.0000***	0.0000***	0.0000***	0.0001***

Note: p values based on robust rank-order tests, session-level data.
***Indicates significance at the 1% level.

the economic environment is bad and 100 when the economic environment is good, as shown by the short dashed lines in Fig. 1.

Fig. 1 displays the average investment amount in each period under the three incentive types when the economic environment is bad (left) and good (right). From the left panel of Fig. 1, it is obvious that the investment amount in Treatments BL and BE is significantly lower (closer to the firm-optimal investment level, i.e., the dashed line) than that in Treatment BW when the economic environment is bad. The right panel of Fig. 1 shows that the investment amount in Treatments GW and GL is significantly higher (closer to the firm-optimal investment level, i.e., the dashed line) than that in Treatment GE when the economic environment is good. The significance test (p value) of treatment differences is reported in Table 3. The robust rank-order test shows that the above differences are significant. Thus, these results support Hypothesis 1.

Result 1. When the economic environment is poor (economic downturn), elimination contests and linear incentive schemes make CEOs' investment decisions closer to the optimal level than winner-take-all. When the economic environment is good (economic prosperity), winner-take-all and linear incentive schemes make CEOs' investment decisions closer to the optimal level than elimination contests. Thus, H1 is supported.

To test whether the effect of different incentives on a CEO's investment decision is influenced by the external economic environment, we perform a subsample regression. The dependent variable is the CEO's average amount invested across all periods, and the independent variable represents the economic environment, which is defined as *Good_Environment*. When the economic environment is good, *Good_Environment* equals 1; otherwise, it is zero. All the other variables serve as control variables. We also cluster at the group level to adjust the standard error. As shown in Table 4, the coefficient of *Good_Environment* is significant only in columns (1) and (2), which is the subsample using the linear incentive, while the coefficient of *Good_Environment* is not significant in columns (3)-(6). Thus, the CEO's investment decision under winner-take-all and elimination contests incentives is unaffected by the economic environment. Hypothesis 2 is supported.

Result 2. The economic environment only significantly affects CEOs' investment decisions in linear incentive treatments but not in the winner-take-all or elimination contests treatments. Thus, H2 is supported.

4.3. Further study

Our theoretical predictions suggest that (1) Elimination contests and linear incentives are equally efficient in making CEOs' personal investment decisions consistent with firm value when the economic environment is bad and that (2) Winner-take-all and linear incentives are equally efficient when the economic environment is good. However, the experimental data indicate the following: (1) When the external economic environment is bad, the average investment amount in an elimination contest (Treatment BE) seems to be closer to the firm-optimal investment than that of the linear incentive (Treatment BL). (2) When the external economic environment is good, the average investment amount in winner-take-all (Treatment GW) seems to be closer to the firm-optimal investment than under the linear incentive (Treatment GL). To test whether these differences are significant,

Table 4
Regression results of the effect of the economic environment on CEOs' investment.

Dependent variable:	Linear		Winner-take-all		Elimination contests	
CEOs' average investment	(1)	(2)	(3)	(4)	(5)	(6)
Good_Environment	10.51**	9.08*	7.01	6.78	−10.35	−4.06
	(3.68)	(2.43)	(0.77)	(0.69)	(−1.50)	(−0.67)
Female		3.92		9.03		14.25*
		(0.25)		(0.90)		(2.01)
Age		3.74*		0.34		2.34
		(1.38)		(0.18)		(1.30)
Financial Literacy		−2.40		1.69		3.74**
		(−1.40)		(0.73)		(2.51)
Loss aversion		−0.97		−2.49		−5.58***
		(−0.39)		(−0.93)		(−4.71)
Risk aversion		2.66		0.57		−2.08
		(1.88)		(0.44)		(−1.30)
_cons	45.27***	−32.36	65.74***	44.98	38.743***	−21.26
	(21.55)	(−0.50)	(9.58)	(1.15)	(6.64)	(−0.53)
N	64	64	64	64	64	64
adj. R^2	0.03	0.05	0.00	−0.04	0.03	0.24
Group	Yes	Yes	Yes	Yes	Yes	Yes

***Indicate significance at the 1%.
**Indicate significance at the 5%.
*Indicate significance at the 10%.
Note: Standard error clustered in group level.

Table 5
Regression results on the effect of incentives.

Dependent variable:	Bad environment		Good environment	
| CEOs' average investment − Firm optimal investment |	(1)	(2)	(3)	(4)
Winner-take-all	20.48**	20.57***	−16.98**	−15.69**
	(2.88)	(4.06)	(−2.76)	(−2.36)
Elimination contests	−6.52	−11.45**	27.39***	26.37***
	(−1.07)	(−2.47)	(6.68)	(4.89)
Female		33.72***		1.95
		(3.14)		(0.27)
Age		3.84**		−0.74
		(2.45)		(−0.49)
Financial Literacy		1.44		−0.47
		(0.82)		(−0.28)
Loss aversion		−2.19		4.51**
		(−1.19)		(2.19)
Risk aversion		−0.32		−0.16
		(−0.23)		(−0.12)
_cons	45.27***	−63.95*	44.22***	48.46
	(24.12)	(−1.88)	(25.54)	(1.71)
N	96	96	96	96
adj. R^2	0.15	0.25	0.39	0.43
Group	Yes	Yes	Yes	Yes

***Indicate significance at the 1%.
**Indicate significance at the 5%.
*Indicate significance at the 10%.
Note: Standard error clustered in group level.

we regress the different incentives on the deviation of the CEO's average investment from the firm's optimal investment.

Table 5 shows that when adding the control variables to the regression, the coefficient of elimination contests in column (2) and that of winner-take-all in column (4) are significantly negative, which means that compared to linear incentives, elimination contests shift the CEO's average investment closer to the optimal investment when the external environment is bad, and compared to linear incentives, winner-take-all shifts the CEO's average investment closer to the optimal investment when the external environment is good. We conjecture that boundedly rational subjects behave broadly in line with the theoretical results but not perfectly so, such that elimination contest and winner-take-all involve interactions between subjects that induce learning effects to enhance rationality.

Result 3. When the external economic environment is bad, elimination contests make CEOs' investments closer to the firm-optimal investment level than linear incentives. When the external economic environment is good, winner-take-all makes CEOs' investments closer to the firm-optimal investment level than linear incentives.

Fig. 2 shows the deviation of actual personal investment from the theoretical CEO's optimal investment (to maximize personal income) in different treatments. In Fig. 2, the dashed bars represent the deviation of actual personal investment from the theoretical CEO's optimal investment in Period 8, and the blank bars represent the deviation in Period 1. If there are learning effects, the dashed bar should be lower than the blank bar in the respective treatment.

Fig. 2 shows contrary results for Treatment BL, and there was no significant difference in Treatment GL. Thus, there are

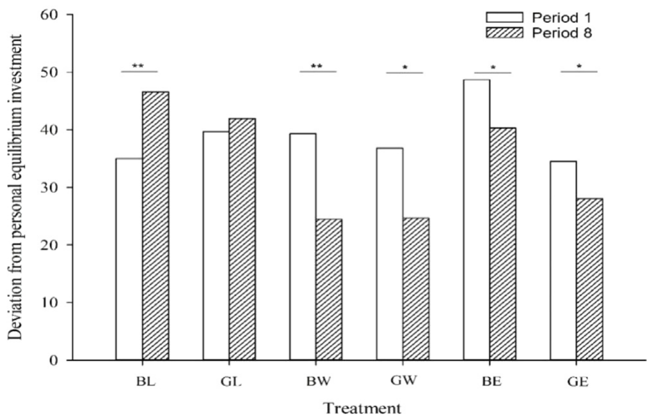

Fig. 2. Learning effect in different treatments.

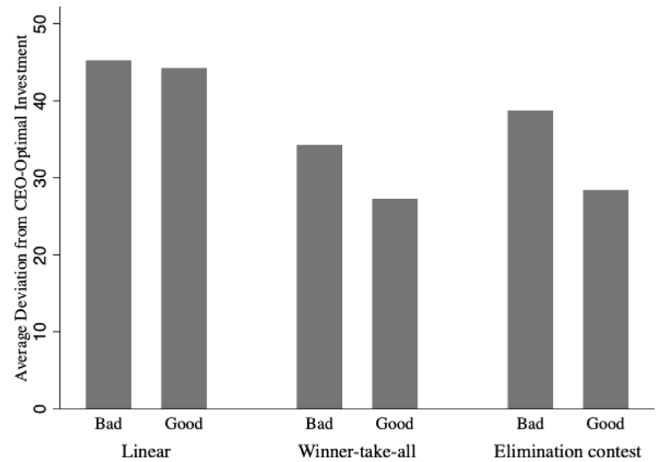

Fig. 3. Subject's deviation from rationality.

no learning effects in linear incentive treatments (BL and GL). Notably, all the dashed bars are significantly lower than the blank bars in tournament incentive treatments (Treatment BW, Treatment GW, Treatment BE, and Treatment GE). In all of the winner-take-all and elimination contests treatments, subjects' investment decisions are closer to equilibrium in Period 8 than in Period 1. Thus, these results provide evidence that there are learning effects in tournament incentives.

Result 4. There are learning effects in tournament incentive treatments (winner-take-all and elimination contest) but not in linear incentive treatments.

The rational subjects should choose 0 (to maximize personal incomes) in Treatments BL, BE and GE and choose 100 in Treatments GL, BW, and GW. To test the rationality of subjects in different treatments, we calculated the average deviation from the equilibrium investment to maximize personal income. Fig. 3 below presents the subjects' average deviation from rationality, which shows that there are more rational behaviors in Treatments BW, GW, BE, and GE than in Treatments BL and GL. Thus, regardless of whether the economic environment is bad or good, compared to linear incentives, tournament incentives (winner-take-all and elimination contest) can improve the rationality of subjects (Mann–Whitney test, Winner-take-all vs. Linear: $p < 0.01$; Elimination contest vs. Linear: $p < 0.01$). A possible explanation is that in addition to the learning effect, the tournament incentive contract itself might evoke deeper thinking about the experimental task.

Result 5. Tournament incentives (winner-take-all and elimination contests) lead to an investment level that is closer to the rational level than the linear incentives.

5. Conclusion

This paper investigates how different tournament incentives affect managerial decision-making and firm value. The two tournament incentives are winner-take-all tournaments, in which a minority of CEOs win, and elimination contests, in which a majority of CEOs win. We use a combined theoretical and experimental approach to obtain a comprehensive picture of the effects and their underlying mechanism.

Our theoretical model shows that when the economy is in a downturn, linear incentives and elimination contest tournaments can ensure that a CEO makes the optimal investment consistent with firm-optimal investment and thus can maximize firm value and reduce agency problems, while winner-take-all makes the CEO's optimal investment deviate from the firm-optimal investment, which leads to reduced firm value. When the economy is prosperous, a linear incentive and winner-take-all tournament can ensure that the CEO's optimal investment is consistent with the firm's optimal investment and thus can maximize firm value, while an elimination contest makes the CEO's optimal investment deviate from the firm's optimal investment, which leads to reduced firm value.

Our experimental results can be summarized as follows. First, consistent with the theoretical results, elimination contests and linear incentives have significantly higher efficiency in enhancing firm value than winner-take-all when the external economic environment is in a downturn. Moreover, winner-take-all and linear incentives have significantly higher efficiency in enhancing firm value than elimination contests when the external economic environment is prosperous. Second, we observe that CEOs' personal investment decisions under tournament incentives (both winner-take-all and elimination contest) are unaffected by the external economic environment. This result is consistent with our theoretical findings and standard relative performance evaluation theory (which argues that the purpose of RPE is to remove the systematic component of performance due to uncontrolled external systematic factors, such as unexpected shocks to the industry or economy). Third, the experimental data show that elimination contests are even more efficient than a linear incentive when the economy is in a downturn, and winner-take-all is even more efficient than a linear incentive when the economy is prosperous. While our theoretical implications (under the assumptions of risk neutrality and rationality) are that elimination contests and linear incentives are equally efficient in enhancing firm value during economic downturns, winner-take-all and linear incentives are equally efficient in enhancing firm value when the economy is prosperous. Such a difference between the theoretical and experimental results might be explained by the fact that, in our experiment, boundedly rational subjects behave broadly in line with the theoretical results but not perfectly so. We conjecture the underlying reason is that tournament incentives (elimination contests and winner-take-all) involve interaction between subjects, eliciting a learning effect, which helps subjects under tournament treatments behave more rationally than those in linear incentive treatments. The experimental data provide support for the learning effect conjecture. Finally, we find evidence that tournament incentive mechanisms (winner-take-all or elimination contests) lead to more rational behavior at the aggregate level than linear incentive mechanisms. A possible explanation is that in addition to the learning effect, the tournament incentive contract itself might evoke deeper thinking about the experimental task.

The results of this paper have at least two real-world implications. First, they are relevant to policy discussions concerning the regulation of executive compensation. Our theoretical and experimental results show that whether winner-take-all or elimination contests work efficiently to reduce agency problems and enhance firm value depends on external factors such as the economic environment. Thus, fixed and obligatory regulation of executive compensation is improper. A good example is that China's SASAC issued a new regulation on managerial tournament compensation in 2019, which replaced the former regulation from 2008. The 2019 regulation encourages state-owned firms to freely set their own tournament structures according to internal and external factors (in contrast to the obligatory winner-take-all-type tournament in the 2008 regulation; for further details, see the Introduction). Second, our results have implications for how firms set optimal executive compensation contracts. Our theoretical model predicts that linear incentives are equally efficient as the respective tournament incentives (according to the status of the external economic environment). It seems that linear incentives are a simple and universal mechanism for executive compensation. However, considering the bounded rationality and different risk attitudes of real-world executives, firms should set dynamic compensation contracts according to external factors. Specifically, elimination contests should be chosen when the external economic environment is in a downturn, and winner-take-all should be chosen when the external economic environment is prosperous.

This study has some limitations. First, winner-take-all and elimination contest tournaments feature extreme proportions of winners (too high or too low). Tournaments with a more balanced proportion of winners could be tested in future studies. Second, other tournament characteristics (such as the size of the tournament prize and information feedback) may jointly affect CEOs' behavior along with the proportion of winners. Future studies on the joint effect of different tournament characteristics will provide a deeper understanding of organizations. Third, compared to the real world, the external economic environment is relatively simple in the experimental design, and we caution the reader when extrapolating our results to other settings. Follow-up work on how other external factors (such as external risks and uncertainty) would also be a promising avenue for research.

CRediT authorship contribution statement

Kun Zhang: Conceptualization, Methodology, Writing – original draft, Supervision, Funding acquisition. **Xiaolan Yang:** Software, Formal analysis, Data curation, Visualization. **Mei Gao:** Validation, Investigation, Resources, Writing – review & editing, Project administration.

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Appendix. Experimental instructions (English translation)

Instruction for Treatment BL

You are about to participate in a decision-making experiment. Please read these instructions carefully. If you have a question at any time, please feel free to ask the experimenter. We ask that you not talk to the other participants during the experiment and that you put away your mobile phones and other devices at this time.

In this experiment, you act as a company CEO, who actively makes decisions on investment projects for 9 periods. At the end of the experiment, you are paid according to your performance. The experiment consists of 9 successive periods. In each period, your company will receive 100 tokens (experimental currency unit). As the CEO, you must decide how much of this amount you wish to invest in a lottery-like investment project. The lottery (project) is the same for all periods and proceeds as follows:

Assume you choose to invest an amount X in the lottery (project):

- With a probability of 1/2 (50%), your company loses the amount X invested in the lottery (project). Your company's final income in the respective period is then 100 - X.
- With a probability of 1/2 (50%), your company wins 0.5 times the amount X invested in the lottery (project) in addition to your company's initial endowment. Your company's final income in the respective period is then 100 + 0.5X.

Example 1: Suppose that in period N, you invest 0 tokens. Then, your company's final income in this period will remain unchanged, i.e., 100 tokens.

*Example 2: Suppose that in period N, you invest 50 tokens. If your company loses the lottery (project), your company will lose 50 tokens. Thus, your company's final income in this period will be 50 (= 100-50) tokens. If your company wins the lottery, your company wins 25 (= 50*0.5) tokens in addition to your company's initial endowment of 100 tokens. Thus, your company's final income in this period will be 125 tokens.*

*Example 3: Suppose that in period N, you invest 100 tokens. If your company loses the lottery, your company will lose 100 tokens. Thus, your company's final income in this period will be 0 (= 100-100) tokens. If your company wins the lottery, your company wins 50 (= 100*0.5) tokens in addition to your company's initial endowment of 100 tokens. Thus, your company's final income in this period will be 150 tokens.*

The outcome of the lottery depends on a random drawing made by the computer. In each consecutive period, the computer will make a new draw, and each draw is random and independent between periods and participants.

Your earnings: 2.5% of company's final income will be rewarded to you. Thus, your earnings in the respective period (in CNY) = your company's final income in the respective period *2.5%. Your total earnings are the sum of your earnings over nine periods.

Instruction for Treatment GL

You are about to participate in a decision-making experiment. Please read these instructions carefully. If you have a question at any time, please feel free to ask the experimenter. We ask that you not talk to the other participants during the experiment and that you put away your mobile phones and other devices at this time.

In this experiment, you act as a company CEO, who actively makes decisions on investment projects for 9 periods. At the end of the experiment, you are paid according to your performance. The experiment consists of 9 successive periods. In each period, your company will receive 100 tokens (experimental currency unit). As the CEO, you must decide how much of this amount you wish to invest in a lottery-like investment project. The lottery (project) is the same for all periods and proceeds as follows:

Assume you choose to invest an amount X in the lottery (project):

- With a probability of 1/2 (50%), your company loses the amount X invested in the lottery (project). Your company's final income in the respective period is then 100 - X.
- With a probability of 1/2 (50%), your company wins 0.5 times the amount X invested in the lottery (project) in addition to your company's initial endowment. Your company's final income in the respective period is then 100 + 1.5X.

Example 1: Suppose that in period N, you invest 0 tokens. Then, your company's final income in this period will remain unchanged, i.e., 100 tokens.

*Example 2: Suppose that in period N, you invest 50 tokens. If your company loses the lottery (project), your company will lose 50 tokens. Thus, your company's final income in this period will be 50 (= 100-50) tokens. If your company wins the lottery, your company wins 75 (= 50*1.5) tokens in addition to your company's initial endowment of 100 tokens. Thus, your company's final income in this period will be 175 tokens.*

*Example 3: Suppose that in period N, you invest 100 tokens. If your company loses the lottery, your company will lose 100 tokens. Thus, your company's final income in this period will be 0 (= 100-100) tokens. If your company wins the lottery, your company wins 150 (= 100*1.5) tokens in addition to your company's initial endowment of 100 tokens. Thus, your company's final income in this period will be 250 tokens.*

The outcome of the lottery depends on a random drawing made by the computer. In each consecutive period, the computer will make a new draw, and each draw is random and independent between periods and participants.

Your earnings: 2% of company's final income will be awarded to you. Thus, your earnings in the respective period (in CNY) = your company's final income in the respective period *2%. Your total earnings are equal to the sum of your earnings over nine periods.

Instruction for Treatment BW

You are about to participate in a decision-making experiment. Please read these instructions carefully. If you have a question at any time, please feel free to ask the experimenter. We ask that you not talk to the other participants during the experiment and that you put away your mobile phones and other devices at this time.

In this experiment, you act as a company CEO, who actively makes decisions on investment projects for 9 periods. At the end of the experiment, you are paid according to your performance. The experiment consists of 9 successive periods. In each period, your company will receive 100 tokens (experimental currency unit). As the CEO, you must decide how much of this amount you wish to invest in a lottery-like investment project. The lottery (project) is the same for all periods and proceeds as follows:

Assume you choose to invest an amount X in the lottery (project):

- With a probability of 1/2 (50%), your company loses the amount X invested in the lottery (project). Your company's final income in the respective period is then 100 - X.
- With a probability of 1/2 (50%), your company wins 0.5 times the amount X invested in the lottery (project) in addition to your company's initial endowment. Your company's final income in the respective period is then 100 + 0.5X.

Example 1: Suppose that in period N, you invest 0 tokens. Then, your company's final income in this period will remain unchanged, i.e., 100 tokens.

*Example 2: Suppose that in period N, you invest 50 tokens. If your company loses the lottery (project), your company will lose 50 tokens. Thus, your company's final income in this period will be 50 (= 100-50) tokens. If your company wins the lottery, your company wins 25 (= 50*0.5) tokens in addition to your company's initial endowment of 100 tokens. Thus, your company's final income in this period will be 125 tokens.*

*Example 3: Suppose that in period N, you invest 100 tokens. If your company loses the lottery, your company will lose 100 tokens. Thus, your company's final income in this period will be 0 (= 100-100) tokens. If your company wins the lottery, your company wins 50 (= 100*0.5) tokens in addition to your company's initial endowment of 100 tokens. Thus, your company's final income in this period will be 150 tokens.*

The outcome of the lottery depends on a random drawing made by the computer. In each consecutive period, the computer will make a new draw, and each draw is random and independent between periods and participants.

Your earnings: Your earnings per period = [fixed payment] + [bonus]. You will receive a fixed payment of ¥1.5 per period. In addition, you compete with three other randomly drawn participants, and the one who helps his or her company earn the most tokens in the respective period is paid a bonus of ¥4. The other three participants receive only the fixed payment without any bonus. If there is a tie, the winner is chosen by a random draw. Your total earnings are equal to the sum of your earnings over nine periods.

Instruction for Treatment GW

You are about to participate in a decision-making experiment. Please read these instructions carefully. If you have a question at any time, please feel free to ask the experimenter. We ask that you not talk to the other participants during the experiment and that you put away your mobile phones and other devices at this time.

The experiment consists of 9 successive periods. In each period, you will receive 100 tokens (experimental currency unit). You must decide how much of this amount you wish to invest in a lottery. The lottery is the same for all periods and proceeds as follows:

Assume you choose to invest an amount X in the lottery:

- With a probability of 1/2 (50%), you lose the amount X invested in the lottery. Your payoff in the respective period is then 100 - X.
- With a probability of 1/2 (50%), you win 1.5 times the amount X invested in the lottery in addition to your initial endowment. Your payoff in the respective period is then 100 + 1.5X.

Example 1: Suppose that in period N, you invest 0 tokens. Then, your payoff in this period will remain unchanged, i.e., 100 tokens.

*Example 2: Suppose that in period N, you invest 50 tokens. If you lose the lottery, you will lose 50 tokens. Thus, your payoff in this period will be 50 (= 100-50) tokens. If you win the lottery, you win 75 (= 50*0.5) tokens in addition to your initial endowment of 100 tokens. Thus, your payoff in this period will be 175 tokens.*

*Example 3: Suppose that in period N, you invest 100 tokens. If you lose the lottery, you will lose 100 tokens. Thus, your payoff in this period will be 0 (= 100-100) tokens. If you win the lottery, you win 150 (= 100*1.5) tokens in addition to your initial endowment of 100 tokens. Thus, your payoff in this period will be 250 tokens.*

The outcome of the lottery depends on a random drawing made by the computer. In each consecutive period, the computer will make a new draw, and each draw is random and independent between periods and participants.

Your earnings: Your earnings per period = [fixed payment] + [bonus]. You will receive a fixed payment of ¥1.5 per period. In addition, you compete with three other randomly drawn participants, and the one who helps his or her company earn the most tokens in the respective period is paid a bonus of ¥4. The other three participants receive only the fixed payment without any bonus. If there is a tie, the winner is chosen by a random draw. Your total earnings are equal to the sum of your earnings over nine periods.

Instruction of Treatment BE

You are about to participate in a decision-making experiment. Please read these instructions carefully. If you have a question at any time, please feel free to ask the experimenter. We ask that you not talk to the other participants during the experiment and that you put away your mobile phones and other devices at this time.

In this experiment, you act as a company CEO, who actively makes decisions on investment projects for 9 periods. At the end of the experiment, you are paid according to your performance. The experiment consists of 9 successive periods. In each period, your company will receive 100 tokens (experimental currency unit). As the CEO, you must decide how much of this amount you wish to invest in a lottery-like investment project. The lottery (project) is the same for all periods and proceeds as follows:

Assume you choose to invest an amount X in the lottery (project):

- With a probability of 1/2 (50%), your company loses the amount X invested in the lottery (project). Your company's final income in the respective period is then 100 - X.
- With a probability of 1/2 (50%), your company wins 0.5 times the amount X invested in the lottery (project) in addition to your company's initial endowment. Your company's final income in the respective period is then 100 + 0.5X.

Example 1: Suppose that in period N, you invest 0 tokens. Then, your company's final income in this period will remain unchanged, i.e., 100 Tokens.

*Example 2: Suppose that in period N, you invest 50 tokens. If your company loses the lottery (project), your company will lose 50 tokens. Thus, your company's final income in this period will be 50 (= 100-50) tokens. If your company wins the lottery, your company wins 25 (= 50*0.5) tokens in addition to your company's initial endowment of 100 tokens. Thus, your company's final income in this period will be 125 tokens.*

*Example 3: Suppose that in period N, you invest 100 tokens. If your company loses the lottery, your company will lose 100 tokens. Thus, your company's final income in this period will be 0 (= 100-100) tokens. If your company wins the lottery, your company wins 50 (= 100*0.5) tokens in addition to your company's initial endowment of 100 tokens. Thus, your company's final income in this period will be 150 tokens.*

The outcome of the lottery depends on a random drawing made by the computer. In each consecutive period, the computer will make a new draw, and each draw is random and independent between periods and participants.

Your earnings: Your earnings per period = [fixed payment] + [bonus]. You will receive a fixed payment of ¥1.5 per period. In addition, you compete with three other randomly drawn participants, and the three participants who help their company earn the top three (out of four) number of tokens in the respective period is paid a bonus of ¥2 each. The remaining participant receives only the fixed payment without any bonus. If there is a tie, the winner is chosen by a random draw. Your total earnings are equal to the sum of your earnings over nine periods.

Instruction of Treatment GE

You are about to participate in a decision-making experiment. Please read these instructions carefully. If you have a question at any time, please feel free to ask the experimenter. We ask that you not talk to the other participants during the experiment and that you put away your mobile phones and other devices at this time.

The experiment consists of 9 successive periods. In each period, you will receive 100 tokens (experimental currency unit). You must decide how much of this amount you wish to invest in a lottery. The lottery is the same for all periods and proceeds as follows:

Assume you choose to invest an amount X in the lottery:

- With a probability of 1/2 (50%), you lose the amount X invested in the lottery. Your payoff in the respective period is then 100 - X.
- With a probability of 1/2 (50%), you win 1.5 times the amount X invested in the lottery in addition to your initial endowment. Your payoff in the respective period is then 100 + 1.5X.

Example 1: Suppose that in period N, you invest 0 tokens. Then, your payoff in this period will remain unchanged, i.e., 100 tokens.

*Example 2: Suppose that in period N, you invest 50 tokens. If you lose the lottery, you will lose 50 tokens. Thus, your payoff in this period will be 50 (= 100-50) tokens. If you win the lottery, you win 75 (= 50*1.5) tokens in addition to your initial endowment of 100 tokens. Thus, your payoff in this period will be 175 tokens.*

*Example 3: Suppose that in period N, you invest 100 tokens. If you lose the lottery, you will lose 100 tokens. Thus, your payoff in this period will be 0 (= 100-100) tokens. If you win the lottery, you win 150 (= 100*1.5) tokens in addition to your initial endowment of 100 tokens. Thus, your payoff in this period will be 250 tokens.*

The outcome of the lottery depends on a random drawing made by the computer. In each consecutive period, the computer will make a new draw, and each draw is random and independent between periods and participants.

Your earnings: Your earnings per period = [fixed payment] + [bonus]. You will receive a fixed payment of ¥1.5 per period. In addition, you compete with three other randomly drawn participants, and the three participants who help their company earn the top three (out of four) number of tokens in the respective period is paid a bonus of ¥2 each. The remaining participant receives only the fixed payment without any bonus. If there is a tie, the winner is chosen by a random draw. Your total earnings are equal to the sum of your earnings over nine periods.

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