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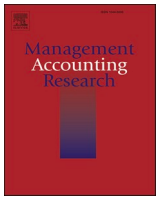

Cooperate or compete? The impact of vertical wage dispersion on employees' behavior in tournaments

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ABSTRACT

We investigate the effect of vertical wage dispersion, defined as the difference in wages between superiors and subordinates, on subordinates' behaviors in competition. We propose that higher vertical wage dispersion increases subordinates' desire to reduce the vertical pay gap through collusion against their superiors in a setting where collusion reduces subordinate effort while increasing subordinates' pay. Our two experiments test our prediction in one-shot (Study 1) and repeated (Study 2) tournament settings. In Study 1, we find that rather than increasing collusion, high vertical wage dispersion increases competitiveness and effort contribution. In Study 2, we find support for our prediction that high vertical wage dispersion increases collusion and reduces effort contribution due to the trust building between subordinates that is facilitated by repeated tournaments. We contribute to the growing research on pay dispersion by studying how vertical wage dispersion affects lower-level employees' interaction with their peers. We also extend tournament research by studying how a contextual variable outside the tournament, i.e., *ex ante* vertical wage dispersion, could affect employees' willingness to compete or to collude in tournaments. An implication of our finding is that high vertical wage dispersion may make competitive incentives more or less effective, depending on the context.

1. Introduction

Vertical wage dispersion represents the wage gap between employees at different levels of the organizational hierarchy. In most organizations, superiors receive a higher wage than subordinates, and the premium is legitimized, at least to some degree, by a formal hiring and promotion process. Vertical wage dispersion has been widening over time, especially the dispersion between high-wage and middle-wage workers (Autor et al., 2008, 2006). Prior research indicates that vertical wage dispersion likely accounts for most within-firm wage inequality (Baker et al., 1988; Cullen and Perez-Truglia, 2018; Medoff and Abraham, 1980). These pay differences are becoming more salient for employees due to recent legislative and social forces that have increased pay transparency. For example, the Dodd-Frank Wall Street Reform and Consumer Protection Act (2010) mandates that public companies disclose the CEO-to-median-employee pay ratio in SEC filings, and websites like Glassdoor and PayScale allow informal sharing of pay-related information between current, former and prospective employees. Relative wage information is therefore more readily available to employees than in the past, which may increase their sensitivity to widening vertical wage dispersion.

Recent accounting research using the budgeting setting finds that when vertical wage dispersion is high, perceived unfairness and inequity aversion increase subordinates' desire to reduce the vertical pay gap. This desire results in more opportunistic misreporting (Guo et al., 2017) and more peer influence from dishonest, rather than honest, colleagues (Guo et al., 2020). Our study extends this line of research by examining how high vertical wage dispersion may affect subordinates' behavior in a competitive setting where relative performance determines subordinates' payoffs. This effect is crucial to firms that depend on various forms of competition (e.g., for merit bonuses or other forms of recognition) to motivate employee effort (Gibbons, 1998; Lazear, 1999; Prendergast, 1999). Unlike the budget setting examined by prior studies, a competitive setting incentivizes subordinates to outperform their peers and thus heightens their sense of competition. As a result, the primary pay referent for social comparisons becomes fellow subordinates rather than the superior (Kulik and Ambrose,1992), suggesting that the magnitude of vertical wage dispersion may have little effect on

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subordinates' behavior in a competitive setting unless subordinates have an opportunity to collude.

We consider a setting where the firm introduces a rank-order tournament in which subordinates compete. Subordinates' joint effort deterministically increases the firm's production level and the superior's payoff. The subordinates have the opportunity to engage in collusion by coordinating their efforts via non-binding agreements and sharing the tournament prize. Successful collusion requires trust between subordinates operating under non-binding agreements. Thus, collusion is more likely in a repeated rather than a one-shot setting because repeat interactions facilitate trust-building and cooperation among individuals (Evans et al., 2016; Kelly and Tan, 2010; Rankin, 2004; Rowe, 2004). In addition to payoffs determined by the tournament outcome, both the subordinates and their superiors receive a fixed wage, and the wage levels are known to all.

We investigate whether and how the vertical dispersion in the fixed wage between the superior and the subordinates affects the subordinates' behaviors within the tournament. From a purely economic perspective, those behaviors should not depend on ex-ante wage levels nor the degree of vertical wage dispersion. But based on prior behavioral theory on pay dispersion and equity (Adams, 1965; Cowherd and Levine, 1992; Guo et al., 2020, 2017), we anticipate that when vertical wage dispersion is relatively high, subordinates will perceive more inequity, which will increase their desire to reduce the vertical pay gap. Collusion would be a more attractive strategy than otherwise predicted by economic theory because it not only increases the subordinates' joint payoff but also lowers the superior's compensation, reducing the vertical pay gap. However, without a sufficient level of trust in their peers' willingness to honor their collusive agreement, subordinates may fall back on competitive strategies to increase their chances of winning the tournament and decrease the pay gap with the superior by increasing their individual payoffs rather than the joint payoff.

Our investigation spans two effort-choice tournament experiments. Study 1 consists of a one-shot tournament where participants interact over eight rounds, but membership in each triad (one superior and two subordinates) changes each round. The one-shot setting isolates the effect of wage dispersion by limiting reputation formation and reciprocity among subordinates. To provide an opportunity for collusion, we allow communication between subordinates via electronic chat. We manipulate vertical wage dispersion by setting the superior's fixed wage at $2 ($12) more than the subordinates' fixed wage in the low (high) dispersion condition. We also examine chat data to determine whether subordinates attempt to collude and reach agreements. Study 1′s results indicate that, although subordinates try to reach collusive agreements with each other to reduce the vertical pay gap, trust among subordinates is insufficient for those agreements to materialize. Consequently, high (vs. low) wage dispersion increases subordinates' competitiveness and reduces collusion success.

Perhaps most important are results of Study 2, which tests the effects of vertical wage dispersion in a repeated tournament setting. Repeated tournaments are more representative of interactions in real organizations and thus, Study 2 has more external validity than Study 1. Following Hannan et al. (2013), the experiment in Study 2 has a total of 16 periods, and triads are re-matched four times. Subordinates are paired for four consecutive periods before re-matching; they know they will interact repeatedly and are informed of each other's past behaviors. Thus, this setting is more conducive to trust-building between subordinates than the one-shot setting.

Under repeated tournaments, we predict that collusion between subordinates happens more often, and overall effort contribution is lower when vertical wage dispersion is high than when it is low. Subordinates have similar desire to reduce the vertical pay gap in both the one-shot and repeated settings, but the higher levels of trust that can be built in the repeated setting better enables collusion attempts to come to fruition. The results on effort and collusion support our prediction. We also confirm that vertical wage dispersion increases subordinates' desire to reduce the vertical pay gap. This desire reduces subordinates' sense of competition, increases their trust in their peers, and increases their likelihood of honoring their collusive agreements.

This study has implications for both research and practice. First, it adds to the growing research on pay dispersion by studying how vertical wage structures may alter employee relationships. The combined results of our studies show greater vertical wage dispersion can reduce competitiveness and increase collusion among subordinates; however, the effect is conditional on the possibility for employees to interact repeatedly and establish trust. To that end, our study contributes to the literature stream examining the effect of control system design on trust among employees (e.g., Coletti et al., 2005; Hannan et al., 2013; Towry, 2003). From a practical perspective, prior research suggests that collusion among competing employees reduces the motivational benefit of tournaments (Dye, 1984; Hannan et al., 2013; Harbring, 2006; Harbring and Irlenbusch, 2003), and that collusion in tournaments is prevalent in the real world when internal controls have vulnerabilities (Bandiera et al., 2006, 2005). Our research shows that in a setting where employees have longer-term working relationships with frequent interactions, high vertical wage dispersion could generate a higher risk of collusion, reducing the effectiveness of competitive incentive schemes.

Second, we extend tournament research by studying how a contextual variable outside the tournament (i.e., *ex-ante* vertical wage differences) affects employees' willingness to compete or collude inside the tournament. Past tournament research focuses on the impact of various *within-tournament* features on contestants' effort and performance (e.g., Newman and Tafkov, 2014; Becker and Huselid, 1992; Harbring and Irlenbusch, 2003). As Luft (2016) argues, tournaments can also be more or less effective in promoting organizational performance depending on the context in which they operate. To that end, Hannan et al. (2013) find that mutual monitoring amplifies competition (collusion) when employees are inclined to compete (collude) with one another. Our study finds that vertical wage dispersion similarly amplifies competition (collusion) when employees cannot (can) develop a sufficient level of trust in their peers. Therefore, we contribute to the tournament literature on the effect of contextual variables on firm performance.

The remainder of this paper is organized as follows. In the next section, we review the related literature, describe the research setting and propose the research question for the one-shot tournament setting. Section 3 includes a description of our Study 1 and reports its results. Section 4 proposes the hypothesis for the repeated tournament setting, describes Study 2 and reports its results. In the final section of the paper, we discuss the implications of our results for research and practice and avenues for future research.

2. Background, setting and economic predictions

According to Autor et al. (2008, 2006), pay dispersion has been increasing over time. In addition, increased pay transparency makes relative wage information more available to employees than in the past (Loudenback, 2017), likely increasing employees' sensitivity to pay dispersion. A number of empirical studies on pay dispersion show that pay dispersion usually contains both explained and unexplained components (e.g., Fredrickson et al., 2010; Shaw and Gupta, 2017; Shaw et al., 2002; Trevor et al., 2012). *Explained pay dispersion* is the portion of pay variance that is driven by normatively acceptable factors or legitimate factors that create pay differences (e.g., performance, job responsibilities and expertise), and it often leads to positive organizational and individual outcomes (cf., Shaw and Zhou, 2021). In contrast, *unexplained pay dispersion* is the residual portion of pay variance that cannot be explained by those normatively acceptable factors, and it usually results in negative consequences (cf., Shaw and Zhou, 2021). This is because individuals are inequity averse; that is, they experience disutility when they perceive inequitable or unfair outcomes, especially when they are worse off than the relevant reference group (e.g., Fehr and Schmidt, 1999; Loewenstein et al., 1989).

Compared with horizontal pay dispersion, vertical pay dispersion usually contains a larger portion of unexplained (vs. explained) pay dispersion. This is because vertical pay dispersion can be driven by factors such as market forces, status, and organization politics (Sengupta and Yoon 2018). As Shaw and Zhou (2021, p.56) put it, "it is difficult to reasonably and logically create a set of normatively accepted factors to justify gigantic wage gaps within organizations, or to explain extreme inequality among members of the same organization (Bapuji, Ertug, and Shaw, 2020)." In addition, even when vertical pay dispersion can be explained by formal hiring and promotion processes, lower-paid rank-and-file employees may still view it as inequitable. This is because considerable differences in experience required and responsibilities exist across job levels, making vertical pay comparison not as straightforward as with horizontal pay comparison (Fredrickson et al., 2010) and leaving room for self-serving biases (Cook and Yamagishi, 1983).

Prior research in management and organizational behavior indicates that vertical pay dispersion, when not well explained, generates equity concerns for lower-level employees (Bloom, 1999; Cowherd and Levine, 1992; Main et al., 1993; Pfeffer and Langton, 1993; Yu and Van Luu, 2017). Prior studies in the accounting literature also suggest that employees' equity concerns due to vertical wage dispersion may lead to negative outcomes for firms. Guo et al. (2017) find that when vertical wage dispersion is high, perceived inequity gives subordinates an incentive to reduce the vertical pay gap by creating budgetary slack for personal consumption. Using the same misreporting setting, Guo et al. (2020) further examine how vertical wage dispersion alters behavior among subordinates. They find that peer influence is asymmetric; therefore, when vertical wage dispersion is high (low), subordinates' reporting honesty is influenced more by their less (more) honest peers. They attribute their findings to subordinates' fairness concerns, which activate a dishonest (honest) social norm when vertical wage dispersion is high (low). Prior literature, taken as a whole, establishes that high levels of vertical wage dispersion increase subordinates' desire to reduce the vertical pay gap through opportunistic behaviors and the actions of peers can influence the extent of this opportunism.

Prior research, however, has paid little attention to the effect of vertical wage dispersion in competitive settings. The focus of prior research about competition has been on horizontal pay dispersion among competitors. For instance, prior tournament research examined how tournament outcomes are affected by the prize spread between winners and losers (e.g., Becker and Huselid, 1992), the number of prize tiers (e.g., Newman and Tafkov, 2014), and the percentage of winners (e.g., Berger et al., 2018). These within-tournament features all have effects on the *horizontal* pay dispersion among contestants and consequently affect their in-game behaviors. However, it is also important to examine the effect of *vertical* pay dispersion in competitive settings because the desire to reduce the vertical pay gap can influence how individuals at the same level compete with one another. To better understand subordinates' decision-making processes in competitive settings and how vertical wage dispersion may affect their behaviors, we first describe our research setting.

2.1. Basic setting

Our research setting is similar to several prior studies that examine rank-order tournaments in which employee collusion could occur (Hannan et al., 2013; Harbring, 2006; Prendergast, 1999). In our setting, the firm consists of three employees: two subordinates and one superior. Two subordinates are assigned to report to the same superior. The firm sets fixed wages for all three employees, independent of the tournament outcomes.

The subordinates are identical in their ability to compete in the tournament. Effort, e_i, is abstractly modeled such that subordinates simultaneously and independently choose integers from the set {0, 10, 20, …, 100}. Cost of effort is an exponential function of effort provided such that $c(e_i) = e_i^2 / 2000$. The two subordinates are awarded tournament prizes according to the ranking of their effort. The subordinate choosing the higher effort receives M ($15), while the other subordinate receives m ($5). In the event of a tie, each subordinate is rewarded ½ * (M + m) or $10.[1] Following Harbring (2006), we set the relation between effort and tournament outcome as deterministic (i.e., free of random shocks) to induce competitiveness among subordinates and direct their attention to strategic considerations. Subordinates' tournament pay is calculated by subtracting the cost of effort from the tournament prize. Collusion is enabled through communication: prior to effort choices, the two subordinates can communicate with each other to coordinate their efforts.

Firm profit equals the sum of the two subordinates' effort, i.e., P = e1 + e2. As a partial residual claimant of firm profits, the superior receives five percent of firm profit.[2] The firm profit ranges from $0 (if both subordinates choose zero effort) to $200 (if both choose an effort level of 100), and thus, the superior's performance pay ranges from $0 to $10, depending on the sum of effort contributed by both subordinates.

2.2. Economic predictions

In theory, our tournament incentive structure induces a high level of competition in the subordinates. The difference between the two tournament prizes (i.e., $10) is greater than the maximum cost of effort (i.e., $5). Hence, each subordinate is motivated to exert the maximum effort to maximize the expected payoff. Accordingly, the Nash equilibrium is an effort contribution of (100, 100), and after deducting the cost of effort, the two subordinates each receive $5. The superior receives five percent of the firm's profit of 200, or $10. The subordinates can improve their joint payoff by coordinating effort or colluding. Subordinates' Pareto optimal action is to exert the minimal level of effort of 0 so that each receives a tournament prize of $10 without incurring any costly effort. In this case, the superior would receive five percent of the firm profit of zero, or $0. In a finitely repeated tournament, the same Nash equilibrium and Pareto optimal would hold with backward induction (Falk et al., 1999).

Importantly, the collusive outcome is not an equilibrium because a subordinate can defect from the non-binding collusive agreement and increase effort slightly to win the tournament (Hannan et al. 2013). The trust subordinates have for each other is thus a crucial determinant of their collusive behaviors (Harbring, 2006). Trust involves putting oneself in a vulnerable position and believing that the other party will not take advantage (McAllister, 1995). In a one-shot setting, subordinates do not have the opportunity to establish a reputation or to reciprocate kind or unkind peer actions (Charness and Kuhn, 2010; Mayer et al., 1995). In contrast, in a repeated setting, trust level should be significantly higher for three reasons. First, in a repeated setting, subordinates establish a track record and observe that of paired subordinates. Prior research

[1] In our setting, tournament prizes are split evenly in the case of ties. In some prior experimental studies (e.g., Harbring, 2006; Hannan et al. 2013), a random draw determines the winner in the case of a tie. In our experiments, the subordinates cooperate by either submitting equal effort (in both Study 1 and Study 2) or taking turns winning the winner's prize (only in Study 2). We maintain that, regardless of the specific collusive strategy used, adopting a collusive (vs. competitive) strategy will reduce subordinates' effort contribution and the effectiveness of tournament incentives.

[2] In this setting, subordinates' choices have economic consequences for both the superior and the firm. Our setting, though stylized, has implications for other situations where the firm and the superior benefit from competition among employees (e.g., competition for merit awards and recognition) and could suffer from collusion among them (e.g., joint shirking).

shows that information about partners in general facilitates trust building (Evans et al., 2016; Kelly and Tan, 2010; Luft, 2016). Second, subordinates can reciprocate peers' cooperative and uncooperative behaviors (Falk et al., 1999). Prior research shows that the presence of a punishment threat increases cooperation (Fehr and Schmidt, 1999). Third, from a game-theoretic perspective, repeated interactions also create reputation concerns that are absent in one-shot interactions (Falk et al., 1999; Kreps et al., 1982; Macleod et al., 2017). When anticipating future interactions, subordinates have the incentive to develop a cooperative reputation, regardless of their "true" type (that is, being cooperative or not) so that their peers are willing to work with them. Empirical evidence indeed suggests that repeated interactions facilitate collusion in tournaments (Berger et al., 2013; Harbring and Irlenbusch, 2003).

Since our setting generates the same economic incentives for the subordinates to compete or collude independent of ex-ante wage levels, from a purely economic perspective, subordinates' behavior within the tournament should not depend on vertical wage dispersion.

2.3. Behavioral prediction: effects of vertical wage dispersion in one-shot tournament

Contrary to the economic predictions, recent behavioral research suggests that vertical wage dispersion may affect behaviors in competitive settings. Specifically, high vertical wage dispersion can generate feelings of unfairness and a desire to reduce this inequity (Downes and Choi, 2014; Guo et al., 2017). The superior is a partial residual claimant to firm profits, so if the subordinates compete by increasing effort, they also increase the firm's profits and the superior's pay, possibly further increasing the vertical pay gap. If, instead, the subordinates collude, they not only increase their joint payoff but also lower the superior's compensation, reducing the vertical pay gap and the sense of inequity. Therefore, when the ex-ante vertical wage dispersion is high rather than low, collusion becomes a more attractive strategy for subordinates.

There is no guarantee, however, that the motivation to reduce pay dispersion will necessarily induce subordinates to collude. If the trust level between subordinates is insufficient, the alternative course of action for reducing the vertical pay gap is to compete against the other subordinate. By so doing, one subordinate may win the tournament and reduce the pay gap between themselves and the superior at the expense of the other subordinate, who will fall further behind. Therefore, in theory, both collusion and competition are plausible strategies subordinates can take when facing high vertical wage dispersion.

We first examine a one-shot tournament setting, which allows us to observe subordinates' behaviors free of reputational or reciprocity concerns (Charness and Kuhn, 2010). In a one-shot setting, it is unknown whether the trust level between subordinates is sufficiently high to maintain a collusive relationship. Though a purely selfish and rational subordinate will not choose cooperation at all, results from other one-shot games demonstrate certain levels of trust between players, and the trust level varies depending on factors such as the payoff and risk structure (e.g., Charness et al., 2016; Schmidt et al., 2003). Thus, although fairness perceptions motivate subordinates to reduce the vertical pay gap, the trust level between them is unknown *ex ante*. We propose the following research question:

RQ:. *How will high (vs. low) vertical wage dispersion affect collusion and effort contribution among subordinates who compete in a one-shot rank-order tournament?*

For the ease of understanding, we summarize the economic predictions (Panel A), to be contrasted with the behavioral predictions (Panel B), in the Appendix. In the next section of the paper, we first describe the experimental design for Study 1, designed to test our research question, and then report the results.

3. Study 1

3.1. Participants and compensation

Due to group interaction requirements, we randomly assign one experimental session to each experimental condition,[3] and each session lasts about 90 min. We recruit 48 participants from a paid-participant pool in a large public university. Since our study focuses on the roles of subordinates, we exclude data from 16 superiors from further reporting.[4] Participants have an average of 2.5 years of work experience (including part-time work), 71.9% of participants are female, and their average age is 20.8 years old. We randomly select one of the eight reporting periods for payment at the end of the experiment. On average, subordinates earn $15.60 while superiors earn $20.31.

3.2. Procedure

The experiment uses parameters outlined previously in Section 2.1. Prior to the tournament, participants perform a slider bar task.[5] Performance on this task determines the participant's role in the tournament that involves an effort selection task. Specifically, we assign the top third of performers on the slider bar task as superiors, the middle third as RED subordinates, and the bottom third as BLUE subordinates.[6] Some prior research considering the effects of pay dispersion on judgments and behavior in the accounting literature has randomly assigned participants to superior and subordinate roles (e.g., Fisher et al. 2019; Guo et al., 2017). In contrast, we follow Guo et al. (2020) and Liu, Tian and Zhang (2020) who attempt to legitimize the assignment of participants to the higher paid superior role, at least to some degree, by disclosing to participants that those who were promoted to the superior role performed higher on a task other than the focal experimental task (e.g., the slider bar task, performance on a set of GMAT questions). We also inform the participants that the superiors and subordinates have different job responsibilities in the main task. Therefore, one could use the promotion procedure (which is based on past success) and the job responsibilities to justify vertical wage dispersion. However, we do not provide a specific rationale for the magnitude of the vertical wage dispersion, much like in practice where employees are usually not provided such rationales.

After completing the slider bar task, participants are re-seated with the superiors on one side of the room and the subordinates on the other. All participants then learn about their roles, their fixed wages (our manipulation), the effort selection task, and how to earn tournament-

[3] In both studies, sessions, rather than participants, are randomly assigned to experimental conditions. Consequently, we acknowledge that the observed effects of our manipulation could be confounded by imbalanced participant characteristics or session effects (e.g., different time of the day or minor differences in how the experiment is administered). To address the risk of imbalanced participant characteristics, we collect demographics including gender, age, and work experience and test for their effects. In Study 1 (but not in Study 2), we find a lower proportion of males (12.5% vs. 43.8%, χ^2=3.86, p = 0.05) and more work experience (3.19 years vs. 1.66 years, F(1,29) = 5.50, p = 0.03) in the high (vs. low) vertical wage dispersion condition. Including gender and work experience does not change any of the results reported at the individual level.

[4] The superiors do not make decisions in the tournament although they are provided with performance feedback at the end of each round. While waiting for their subordinates' decisions, they work on an unrelated cognitive task using paper and pencil. Although the superiors are silent, we use "real" superiors so that the subordinates are cognizant of the consequences of their decisions on superiors.

[5] We thank Eric Chan for providing his z-Tree codes, which he adapted from Gill and Prowse (2012).

[6] This reduces noise by ensuring that all hypothetical firms consist of one higher-performing and one lower-performing subordinate. We do not disclose the basis behind the RED vs. BLUE assignments to the subordinates.

based performance pay. All participants must pass a quiz to ensure they understand the instructions. In the effort selection task, programmed using z-Tree (Fischbacher, 2007), we group each superior with one RED and one BLUE subordinate. We refer to these superior-subordinate triads as "firms." The cost of effort ranges between $0.05 and $5, and effort increases in 10-unit intervals. Table 1 shows the cost of effort for each possible choice of effort level. All participants learn that superiors will receive performance pay that equals five percent of the sum of the effort level selected by their two subordinates.

Participants interact over eight rounds. Superiors and subordinates are re-grouped each round such that no two subordinates interact more than once during the experiment. At the start of each new round, RED and BLUE have 150 s to communicate in a two-person virtual chat room before selecting an effort level independently. After both subordinates have made their selections, they receive a report detailing both subordinates' effort choices, the payoffs of both subordinates, firm profit, and the payoff to the superior. At this point, the chat room re-opens for one minute. After each round, the superior also receives a report on the sum of the effort contributed by both subordinates (but not their individual effort), firm profit and the superior's payoff. Participants are aware that one round will be selected at random at the end of the experiment to be the payment period. After the final round, each participant reviews the payoffs over the eight rounds, answers post-experimental questions about their experience in the effort choice task, and receives cash on exit. Fig. 1A summarizes the experimental procedures for Study 1.

3.3. Independent and dependent variables

In addition to the variable payments determined by the tournament outcome, each participant receives a fixed wage. Across conditions, the fixed wage of the subordinates is set at $8. Our manipulated variable affects the superiors' fixed wages only. When vertical wage dispersion is low, the superior receives a fixed wage of $10, and when vertical wage dispersion is high, the superior receives a fixed wage of $20. The magnitude of the wage gap is comparable with that used in prior studies (e.g., Guo et al. 2017, 2020).

Our main dependent variables are *Group-Effort* and *Collusion-Success*, both of which are dyad-level variables. *Group-Effort* is the sum of effort contributed by both subordinates in each firm dyad (or each round). As for *Collusion-Success*, two coders unfamiliar with the goals of our study code the chat logs to determine whether a verbal agreement on collusion has been struck between the subordinates and whether the collusive agreement is eventually successful. Coding discrepancies are reconciled by one of the authors in consultation with the coders. There is only one possible strategy for collusion: two subordinates submit equally low effort, and each receives a tournament prize of $10 (hereafter labeled the "matching-effort" strategy). We identify the collusion as successful when the following two conditions are satisfied: (1) subordinates in the same firm-dyad reach a verbal agreement on the "matching-effort" strategy and on the specific levels of effort for both subordinates, and (2) they subsequently choose effort levels as agreed. *Collusion-Success* is coded as a binary variable taking the value of 1 if these two conditions are satisfied and 0 otherwise.

Table 1
Cost of effort table.

Effort Level	Effort Cost	Effort Level	Effort Cost
0	$0.00	60	$1.80
10	$0.05	70	$2.45
20	$0.20	80	$3.20
30	$0.45	90	$4.05
40	$0.80	100	$5.00
50	$1.25		

Effort Cost ($) = (Effort Level)^2 / 2000

3.4. Results

First, we check the effectiveness of our experimental manipulations of vertical pay dispersion. In the post-experimental questionnaire, subordinates indicate their perception of the vertical wage gap, on a scale of 1 (Far too little) to 5 (Far too much). The average response is significantly higher when vertical wage dispersion is high (mean=4.56, sd=0.63) than when it is low (mean=3.13, sd=0.89, $F(1,30) = 28.04$, $p < 0.01$), supporting the effectiveness of the pay dispersion manipulation.[7] We also ask the subordinates to indicate, on a five point scale (1: Unfair; 5: Fair), their view of fairness of the overall wage system (i.e., the wages paid to the three employees in the firm). Consistent with our theoretical argument, subordinates in the high vertical wage dispersion condition (mean=1.69, sd=1.01) view the wage system to be less fair than those in the low vertical wage dispersion condition (mean=3.44, sd=1.09; $F(1,30) = 22.02$, $p < 0.01$).

Next, we examine the descriptive statistics for Study 1 in Table 2 panel A. The average *Group-Effort* is 89.22 (sd=77.87) when vertical wage dispersion is low and 107.66 (sd=71.40) when it is high. In terms of *Collusion-Success*, in the low vertical wage dispersion condition, the collusion success rate is 21.88%, and it drops to 9.38% when vertical wage dispersion is high.

To investigate how vertical wage dispersion affects total effort contributed by employees and collusion, we run an OLS regression on *Group-Effort* and a binomial logistic regression on *Collusion-Success*, both with *Vertical Wage Dispersion* as the independent variable. As shown in Table 2 panel B, high (vs. low) vertical wage dispersion results in no significant change in *Group-Effort* (B=18.44, $t = 1.40$, $p = 0.17$). In Table 2 panel C, results indicate that high (vs. low) vertical wage dispersion marginally reduces the likelihood of *Collusion-Success* (Odds ratio = 0.37, $z = -1.90$, $p = 0.06$). Because the main results on *Group-Effort* and *Collusion-Success* are different in significance, we closely examine the results by graphing both variables by round. As shown in Fig. 2, *Group-Effort* is consistently higher and *Collusion-Success* is consistently lower when *Vertical Wage Dispersion* is high, except for Round 3 in which *Group-Effort* is lower when *Vertical Wage Dispersion* is high. Removing Round 3 from the analysis results in a marginally significant positive effect of *Vertical Wage Dispersion* on *Group-Effort* (B = 25.00, $t = 1.78$, $p = 0.08$, untabulated).

Next, we investigate the motivation of the subordinates using process variables. In the post-experimental questionnaire, we measure the *Desire to Reduce Vertical Pay Gap* using the question "How important was it to you to reduce the pay gap between you and the superior?" on a five-point scale (1: Not at all important; 5: Extremely important). The results in Table 2 panel D indicate that as expected, subordinates have a stronger *Desire to Reduce Vertical Pay Gap* when vertical wage dispersion is high than when it is low (3.50 vs. 2.25, $F(1,30) = 6.36$, $p = 0.02$). We measure *Competitiveness* using responses to the question "How important was it to you to choose a higher effort level than the red/blue subordinate you were paired with?" on a five point scale (1: Not at all important; 5: Extremely important). We find that the mean of *Competitiveness* in the high vertical wage dispersion condition is greater than the mean in the low condition, but the difference is not statistically significant (3.75 vs. 2.94, $F(1,30) = 2.48$, $p = 0.13$). We measure *Trust* by averaging subordinate responses to the following three questions on a five-point scale (1: strongly disagree; 5: strongly agree): "I trusted the blue/red subordinate I was paired with," "The blue/red subordinate I was paired with was

[7] All p values reported in the text are two-tailed, unless otherwise noted.

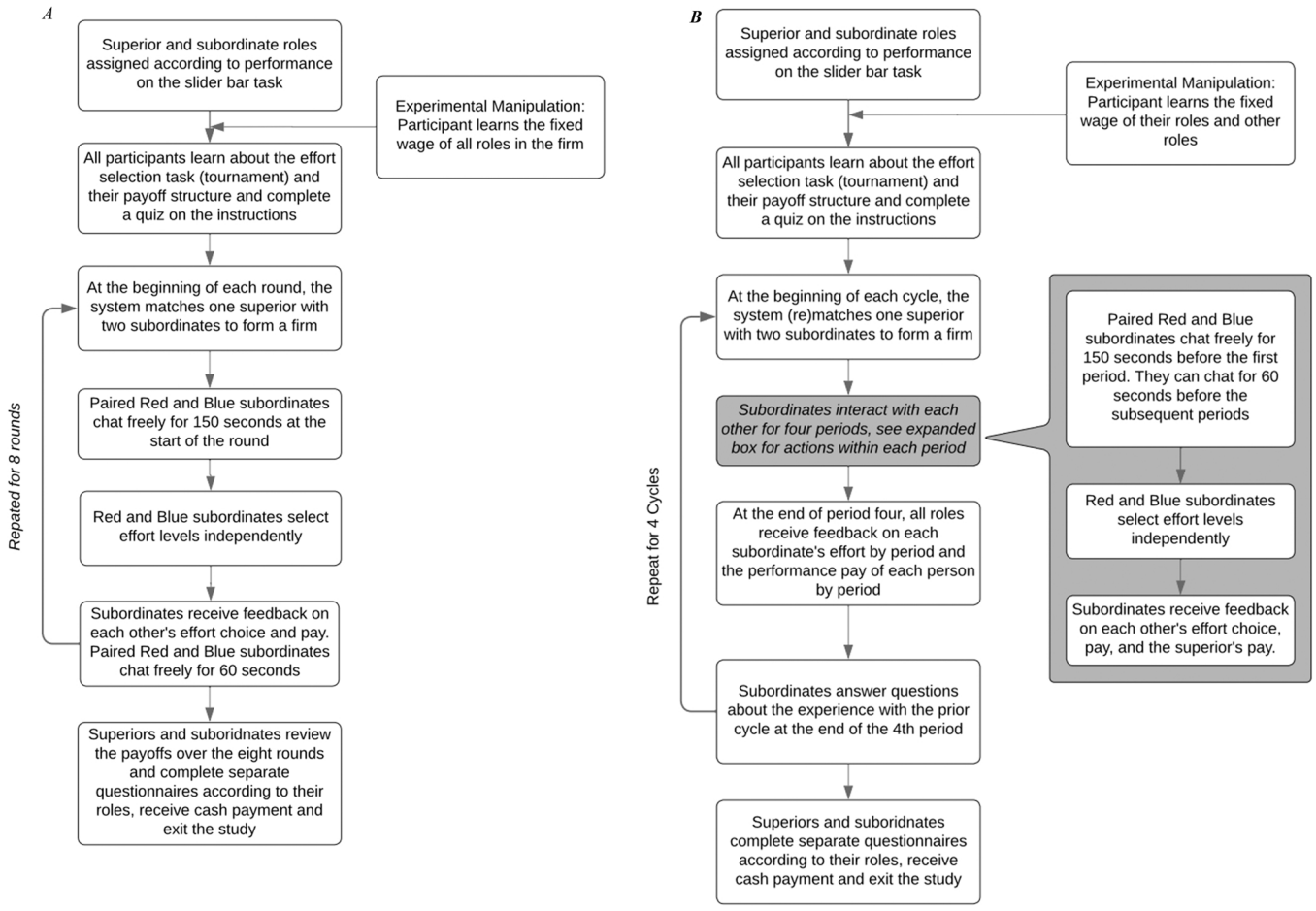

Fig. 1. Experiment Procedures. Panel A: Study 1 Procedures. **Panel B:** Study 2 Procedures.

truthful in their communications with me," and "I behaved as though the blue/red subordinate I was paired with was honest."[8] Subordinates' *Trust* is marginally lower (2.35 vs. 3.10, F(1,30)= 3.59, p = 0.07) in the high than in the low *Vertical Wage Dispersion* condition. Because *Trust* is measured after the eighth round, the pattern of results likely reflects that fewer individuals successfully collude when *Vertical Wage Dispersion* is high. Nonetheless, the low average score across both conditions suggests subordinates do not have sufficient trust in one another in this one-shot setting.

We find that subordinates verbally agree to collude 70% (63%) of the time in the high (low) vertical wage dispersion condition, but only 13% (35%) of those agreements are honored by both subordinates. Furthermore, looking at individual subordinates' in-game behaviors across eight periods, the effect of *Vertical Wage Dispersion* on their decision to defect from the collusive agreement (if such an agreement is reached with their matched peer) is positive and significant (Odds ratio=2.14, z = 2.43, p = 0.02). In the meantime, the effect of *Vertical Wage Dispersion* on individuals' average effort is positive and approaching significance (B=9.22, t = 1.63, p = 0.11). These results suggest that while the desire to reduce the vertical pay gap is strong, collusion is rarely successful because a significant proportion of subordinates opt to defect and invest more effort instead.

[8] Exploratory factor analysis shows that all three *Trust* items load on one factor (eigenvalue=2.20), explaining 73.3% of the variance. The Cronbach's alpha of the 3-item scale is 0.82, indicating a reasonable degree of reliability.

4. Study 2

4.1. Behavioral prediction: effects of vertical wage dispersion in repeated tournaments

From Study 1, we find that the subordinates are highly motivated to reduce the pay gap with the superior when facing high vertical wage dispersion. However, it appears that they are unable to carry out the collusive strategy and select the competitive strategy instead. As noted previously, the one-shot setting is not conducive of trust-building between subordinates because they cannot observe the outcomes of their peers' previous interactions, nor can they reciprocate kind or unkind peer actions.

In an organizational setting, employees often have the motivation and opportunity to establish trust in each other through repeated interaction. The economic prediction and empirical evidence are that trust between subordinates and their collusion levels are higher in a repeated tournament setting than in a one-shot tournament setting (Berger et al., 2013; Harbring and Irlenbusch, 2003). While we expect a higher level of collusion in a repeated tournament setting, the key question we try to address in Study 2 is whether vertical wage dispersion would drive up collusion and reduce effort, contrary to the findings in the one-shot setting of Study 1.

From a purely economic perspective, ex-ante vertical wage dispersion should not affect subordinates' in-game behaviors, but as shown in prior studies (Downes and Choi, 2014; Guo et al., 2017) and in Study 1, high (vs. low) vertical wage dispersion raises concerns for fairness and increases subordinates' desire to reduce the vertical pay gap. Since the superior is a partial residual claimant to firm profits, collusion can

Table 2
Study 1 Results.

Panel A: Mean (standard deviation) of Group-Effort[a] and Collusion-Success Rate[b] by condition		
	Low Vertical Wage Dispersion[c]	*High Vertical Wage Dispersion*[c]
Group-Effort	89.22 (77.87)	107.66 (71.40)
Collusion-Success	21.88% (0.42)	9.38% (0.29)
# of Unique Dyads[d]	n = 64	n = 64

Panel B: OLS regression results - Effect of Vertical Wage Dispersion on Group-Effort				
	B	SE	t-value	p-value
Intercept	89.22	9.34	9.55	< 0.01
Vertical Wage Dispersion	18.44	13.20	1.40	0.17
Number of obs.	128			
Adjusted R-Squared	0.01			

Panel C: Logistic regression results - Effect of Vertical Wage Dispersion on Collusion-Success				
	Odds Ratio (OR)	SE	Z	p-value
Intercept	0.28	0.08	-4.21	< 0.01
Vertical Wage Dispersion	0.37	0.19	-1.90	0.06
Number of obs.	128			
Pseudo R-Squared	0.04			
Log Likelihood	-53.53			

Panel D: Mean (standard deviation) of subordinates' Desire to Reduce Vertical Pay Gap, Competitiveness and Trust			
	Low Vertical Wage Dispersion	*High Vertical Wage Dispersion*	*Comparison F-statistic (p value*)*
Desire to Reduce Vertical Pay Gap[e]	2.25 (1.24)	3.50 (1.55)	F (1,30) = 6.36 (0.01)
Competitiveness[f]	2.94 (1.53)	3.75 (1.39)	F(1,30) = 2.48 (0.13)
Trust[g]	3.10 (1.07)	2.35 (1.17)	F(1,30) = 3.59 (0.07)
Number of obs.[h]	n = 16	n = 16	

Table notes:
[a] *Group-Effort* is defined as the sum of effort contributed by RED and BLUE subordinates in the same firm/dyad in any particular round. Theoretical range is 0–200.
[b] *Collusion-Success* is a binary variable and it equals 1 when two subordinates in the same firm/dyad reach a verbal agreement about the "matching-effort" strategy and both subsequently choose effort levels consistent with their agreement, and 0 otherwise. *Collusion-Success Rate* is the mean of *Collusion-Success* divided by the number of rounds.
[c] *Vertical Wage Dispersion:* either low (superior receives $10 fixed wage) or high (superior receives $20 fixed wage). Subordinates always receive a wage of $8.
[d] In each experimental session, participants form eight unique firms/dyads in each round, and there are in total eight rounds.
[e] *Desire to Reduce Vertical Pay Gap* is the response to the question of "how important was it to you to reduce the pay gap between you and the superior" on a five-point scale (1: Not at all important; 5: Extremely important).
[f] *Competitiveness* is the response to the question of "how important was it to you to choose a higher effort level than the red/blue subordinate you were paired with" on a five-point scale (1: Not at all important; 5: Extremely important).
[g] *Trust* is the mean response to three questions about trust, measured on five-point scale (1: Strongly disagree; 5: Strongly agree).
[h] Each subordinate, RED or BLUE, answers the questions above only once, at the end of the experiment.
*All p-values are two-tailed.

increase the subordinates' joint payoff while lowering the superior's compensation and thereby reducing the vertical pay gap. Hence, as long as the trust between them is sufficiently high to maintain the collusive relationship, subordinates can not only reap the economic benefit from exerting low costly effort but also derive the psychological benefit from the reduced vertical pay gap. As a result, we predict that in more realistic

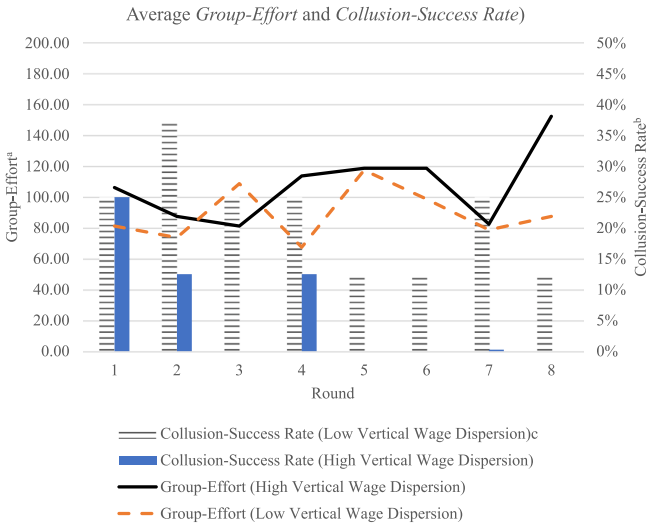

Fig. 2. Round by Round Results for Study 1. Figure Notes:[a] *Group-Effort* is defined as the sum of effort contributed by RED and BLUE subordinates in the same firm/dyad in any particular round. Theoretical range is 0–200.[b] *Collusion-Success Rate* is the sum of all collusion-successes divided by the number of interactions in each round. Collusion-Success is a binary variable and it equals 1 when two subordinates in the same firm/dyad reach a verbal agreement about the "matching-effort" strategy and both subsequently choose effort levels consistent with their agreement, and 0 otherwise.[c] *Vertical Wage Dispersion:* either low (superior receives $10 fixed wage) or high (superior receives $20 fixed wage). Subordinates always receive a wage of $8. [d] In each experimental session, participants form unique firms/dyads in each round, and there are in total eight rounds.

settings with repeated interactions, high (vs. low) vertical wage dispersion will trigger subordinates' desire to reduce the vertical pay gap, which will increase collusion between them and reduce their overall effort contribution. We develop the following hypothesis for the repeated tournament setting:

Hypothesis:. *Higher (lower) vertical wage dispersion will lead to higher (lower) collusion and lower (higher) effort among subordinates who compete in repeated rank-order tournaments.*

Again, in the Appendix, we summarize the economic predictions (Panel A) and the behavioral predictions (Panel B) for the repeated tournament setting. We design Study 2 to test this hypothesis. In the next sections of the paper, we describe aspects of our experimental procedures where Study 2 differs from Study 1, and then we report the results.

4.2. Participants and compensation

Forty-five participants are recruited for Study 2 from the paid participant pool at the same university from which participants are recruited for Study 1. Because the recruitment occurred at a different time of the year, the demographics of Study 2′s participants are different from those of Study 1. Specifically, participants have an average of 5.7 years of work experience, 60% are female, and their average age is 26.9 years old. We conduct two sessions per condition and each session lasts between 100 and 110 min. With an additional show-up fee of $5, on average subordinates earn $18.77 and superiors earn $24.21. Compensation is determined by randomly selecting one out of 16 periods and participants are paid in cash.

4.3. Procedure

Fig. 2 panel B summarizes, in flowchart form, the experimental procedures of Study 2. Study 2 uses the same procedures to determine the participants' role and to describe the effort selection task as used in Study 1. Participants also receive the same manipulation of vertical wage dispersion like in Study 1. Unlike Study 1, the effort selection task contains four cycles, and each cycle consists of four periods, making 16 periods in total. RED and BLUE subordinates within a firm interact for four consecutive periods before being randomly re-matched and forming a new firm in the next cycle. As indicated in the greyed boxes on the right side of Fig. 2 panel B, at the beginning of the first period of each cycle, the two subordinates have 150 s to chat online before submitting their effort choices. At the beginning of the three remaining periods in that cycle, they have 60 s to chat online. After each period, the subordinates learn each other's effort choice, performance pay, and their superior's performance pay. At the end of each cycle, both superiors and subordinates receive a summary report on subordinates' effort choices and all three employees' performance pay across the four periods. Then superiors and subordinates answer questions about their experience in the past cycle (and thus answer those questions four times, once per cycle/firm).[9] After the final cycle, we give the participants a post-experimental questionnaire and pay them in cash upon exit.

In the repeated tournament, to improve their joint payoff, subordinates could collude not only by investing the same low level of effort but also by taking turns to receive the winner's prize of $15. For example, they may agree to let BLUE win in periods one and three and RED win in periods two and four, with the "chosen winner" submitting a slightly higher effort than the "chosen loser." Regardless of the collusive strategy adopted, colluding rather than competing will reduce their effort contribution and compromise the effectiveness of the tournament incentive.

4.4. Dependent variables

The main dependent variables, *Group-Effort* and *Cooperation-Success* are constructed differently in Study 2 due to differences in study design. *Group-Effort* is the *average sum* of effort contributed across the four periods in each firm dyad (or each *Cycle*).[10] As for *Collusion-Success*, subordinates can adopt the matching-effort strategy and/or take turns to win (hereafter "take-turns" strategy). We identify the "take-turns" strategy as successful when two conditions are satisfied: (1) subordinates in the same firm-dyad reach a verbal agreement on taking turns to win, with specific effort levels for the "chosen winner" and "chosen loser", and (2) they subsequently choose effort levels as agreed upon. *Collusion-Success* is a count variable with values ranging from zero to four, counting the number of successful collusions, regardless of whether the "matching-effort" or "take-turns" strategy is used, within the four periods of one *Cycle*.

[9] Different from in Study 1, to capture subordinates' thought process after interacting with each peer, we measure these process variables after each cycle instead of after all eight rounds are completed. We recognize that by showing a summary report and asking questions after each cycle, we may have caused the participants to pay more attention to tournament outcomes than they otherwise would have. To address this issue, we test for potential trend effects across cycles and the possibility of non-independence of the dependent variables between cycles in Section 4.4.

[10] Our choice of dependent variable follows Hannan et al. (2013) who use the average of the dyad effort contribution for each cycle. We treat each dyad observation as independent because our experiment uses the same "turnpike" matching protocol such that no participant is paired with the same person twice or with any person who has been paired with anyone the participant has interacted with previously. This design reduced the possibility that decisions of participants in current dyads would influence decisions made in future dyads (Cooper et al., 1996).

4.5. Results

As in Study 1, at the end of the experiment, subordinates indicate their perception of the wage difference between themselves and their superiors on a five-point scale (1: Far too little; 5:Far too much). On average, those in the high vertical wage dispersion condition (mean=4.50, sd=0.82) respond with higher scores than those in the low vertical wage dispersion condition (mean=3.43, sd=0.94) and the difference in average scores is significant ($F(1,28)= 11.20$, $p < 0.01$). This result supports the effectiveness of our manipulation. In addition, subordinates in the high vertical wage dispersion condition (mean=2.06, sd=1.24) view the wage difference with their superiors to be marginally less fair (1: Unfair; 5: Fair) than those in the low vertical wage dispersion condition (mean=2.93, sd=1.33; $F(1,28) = 3.42$, $p = 0.08$).

Table 3 panel A presents the descriptive statistics for *Group-Effort* and *Collusion-Success*. Consistent with the hypothesis, the average *Group-Effort* level is 113.57 (sd=59.67), out of a maximum of 200, when vertical wage dispersion is low and 59.77 (sd=66.30) when it is high. The collusion success rate is 36.61% when vertical wage dispersion is low, and it rises to 59.38% when vertical wage dispersion is high. In Fig. 3, we show the cycle-by-cycle average *Group-Effort* and the rate of *Collusion-Success*. Visually, we observe a gradual increase in the gap between the low and high vertical wage dispersion conditions over time.

We predict that high (vs. low) vertical wage dispersion will lead to lower levels of *Group-Effort*. To examine the effect of vertical wage dispersion on *Group-Effort*, we run an OLS regression with high (vs. low) *Vertical Wage Dispersion* as the independent variable. Table 3 Panel B presents the results. We find that high (vs. low) *Vertical Wage Dispersion* results in significantly lower *Group-Effort* ($B=-53.81$, $t = -3.28$, $p < 0.01$). We perform two tests to understand the potential effect of cycle on *Group-Effort*. First, we test for trend effects by including *Cycle* as an additional regressor. We do not find a significant trend effect ($p = 0.18$, untabulated). Second, we include each cycle as individual fixed effects. We find that the Cycle 2 has a higher effort than Cycle 1 ($B = -48.00$, $t = -2.11$, $p = 0.044$, untabulated), suggesting possible effects of learning. Importantly, the effect of *Vertical Wage Dispersion* remains unchanged in the fixed effect model.

We also predict that high (vs. low) vertical wage dispersion will increase the frequency of *Collusion-Success*. To examine the effect of vertical wage dispersion on *Collusion-Success*, we run a Poisson regression.[11] As shown in Table 3 panel C, we find that high (vs. low) *Vertical Wage Dispersion* results in higher *Collusion-Success* ($B=0.48$, $z = 2.50$, $p = 0.01$). We take the same approach to understand the potential effect of cycle on *Collusion-Success* as we do with *Group-Effort*. We do not find a significant trend effect as *Cycle* is not a significant regressor ($p = 0.20$, untabulated). In a fixed effects test, which is untabulated, we find that Cycle 2 ($B = 0.67$, $z = 2.36$, $p = 0.02$) and Cycle 4 ($B =.52$, $z = 1.80$, $p = 0.07$) has higher *Collusion-Success* than Cycle 1. Importantly, the effect of *Vertical Wage Dispersion* remains unchanged in the fixed effect model. These results support our hypothesis in the repeated tournament setting.

Next, we investigate the motivation of the subordinates using process variables. Note that different from Study 1, in Study 2 we measure *Desire to Reduce Vertical Gap, Competitiveness,* and *Trust* after each *Cycle*, i.e., after subordinates interact with each paired peer for four periods. Table 3 panel D presents statistics by condition. We find that subordinates have a stronger average *Desire to Reduce Vertical Gap* when vertical wage dispersion is high than when it is low (3.55 vs. 2.82, $F(1118)= 2.47$, $p = 0.02$).[12] We find that, motivated by the stronger

[11] Poisson regression is suitable for count variables especially when the odds of being 0 are high (Coxe et al., 2009).

[12] Recall that *Desire to Reduce Vertical Gap, Competitiveness,* and *Trust* are scaled 1 through 5 with lower/higher values indicating lower/higher perceived levels of each variable.

Table 3
Study 2 Results.

Panel A: Mean (standard deviation) of Group-Effort[a] and Collusion-Success Rate[b] by condition

	Low Vertical Wage Dispersion[c]	*High Vertical Wage Dispersion*[c]
Group-Effort	113.57 (59.67)	59.77 (66.30)
Collusion-Success	36.61% (1.88)	59.38% (1.50)
# of Unique Dyads[d]	n = 28	n = 32

Panel B: OLS regression results - Effect of Vertical Wage Dispersion on Group-Effort

	B	SE	t value	p-value*
Intercept	113.57	11.96	9.49	< 0.01
Vertical Wage Dispersion	-53.81	16.38	-3.29	< 0.01
Number of obs.	60			
Adjusted R-Squared	0.14			

Panel C: Poisson regression results - Effect of Vertical Wage Dispersion on Collusion-Success

	B	SE	Wald z	p-value*
Intercept	0.38	0.16	2.44	0.01
Vertical Wage Dispersion	0.48	0.19	2.50	0.01
Number of obs.	60			
Pseudo R-Squared	0.03			
Log Likelihood	-115.43			

Panel D: Mean (standard deviation) of subordinates' *Desire to Reduce Vertical Pay Gap, Competitiveness* and *Trust*

	Low Vertical Wage Dispersion	*High Vertical Wage Dispersion*	*Comparison F-statistic (p value*)*
Desire to Reduce Vertical Pay Gap[e]	2.82 (1.73)	3.55 (1.49)	F(1118) = 6.10 (0.02)
Competitiveness[f]	3.30 (1.74)	2.66 (1.46)	F(1118) = 4.92 (0.03)
Trust[g]	3.14 (1.62)	3.96 (1.31)	F(1118) = 9.44 (0.01)
Number of obs.[h]	n = 56	n = 64	

Table notes:
[a] *Group-Effort* is defined as the average of the sum of effort contributed by RED and BLUE subordinates in the same firm/dyad across four periods of one cycle. The theoretical range is 0 – 200.
[b] *Collusion-Success* is a count variable, ranging from 0 to 4. For each period, collusion is coded as successful when two subordinates in the same firm/dyad reach an agreement on a collusive strategy (either "matching-effort" or "take-turns") and both subordinates subsequently choose effort levels consistent with their agreement. *Collusion-Success Rate* takes *Collusion-Success* and divides by four, i.e., the number of total interactions between two paired subordinates.
[c] *Vertical Wage Dispersion:* either low (superior receives $10 fixed wage) or high (superior receives $20 fixed wage). Subordinates always receive an $8 fixed wage.
[d] Participants form new firms/dyads after each cycle of four rounds. Within each cycle, the same matched subordinates compete in the tournament repeatedly. In the low (high) vertical wage dispersion condition, there are 7 (8) firms/dyads in each cycle, and there are in total four cycles.
[e] *Desire to Reduce Vertical Pay Gap* is the response to the question of "how important was it to you to reduce the pay difference between the superior and yourself" on a five-point scale.
[f] *Competitiveness* is the response to the question of "how important was it to you to choose a higher effort level than the red/blue subordinate you were paired with" on a five-point scale.
[g] *Trust* is the is the mean response to three questions about trust measured on a five-point Likert scale.
[h] Each subordinate answers *Desire to Reduce Vertical Pay Gap, Competitiveness* and *Trust* questions four times, once after each cycle. There are in total 14 (16) subordinates in the low (high) vertical wage dispersion condition.
*All p-values are two-tailed.

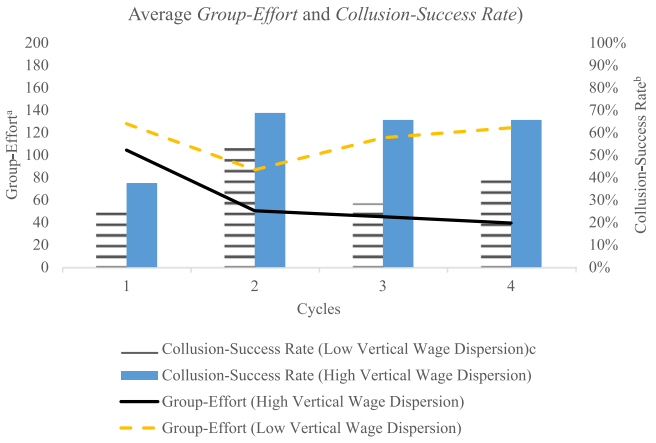

Fig. 3. Cycle by Cycle Results for Study 2. Figure Notes:[a] *Group-Effort* is defined as the sum of effort contributed by RED and BLUE subordinates in the same firm/dyad across four rounds in a particular cycle (this is different from Study 1). Similar to Study 1, the theoretical range of group-effort is 0–200.[b] *Collusion-Success Rate* is the sum of all collusion-successes divided by the number of interactions across four rounds in a particular cycle. Collusion-Success is a binary variable, and it equals 1 when two subordinates in the same firm/dyad reach a verbal agreement about the "matching-effort" strategy and both subsequently choose effort levels consistent with their agreement, and 0 otherwise.[c] *Vertical Wage Dispersion:* either low (superior receives $10 fixed wage) or high (superior receives $20 fixed wage). Subordinates always receive a wage of $8.
[d] Participants form new firms/dyads after each cycle of four rounds and within each cycle, the same matched subordinates compete in the tournament repeatedly. In the low (high) vertical wage dispersion condition, there are 7 (8) firms/dyads in each cycle, and there are in total four cycles.

Desire to Reduce Vertical Pay Gap, subordinates become less competitive and more trusting toward their peers. Specifically, we find that the mean of *Competitiveness* in the high vertical wage dispersion condition is less than the mean in the low condition (2.66 vs. 3.30, F(1118)= 4.92, $p = 0.03$). The mean of *Trust* is higher (3.96 vs. 3.14, F(1118) = 9.44, $p < 0.01$) in the high (vs. low) vertical wage dispersion condition. Individual subordinates' in-game behaviors also indicate that vertical wage dispersion reduces defection rates. Specifically, those in the high wage dispersion condition defect on an average of 12.66% of collusive agreements while those in the low wage dispersion condition defect on an average of 30.73% of collusive agreements (F(1,99) = 7.57, $p < 0.01$). Correspondingly, those in the high vertical wage dispersion condition decrease their individual effort (B=−26.90, t = −4.55, $p < 0.01$).

It is worth noting that, when facing high vertical wage dispersion, mean *Trust* is 3.96 (sd=1.50) in Study 2 and 2.35 (sd=1.17) in Study 1. The difference in these means is significant (t (25) = 4.83, $p < 0.01$). We conjecture that the difference is mainly caused by the repeated vs. one-shot interaction. However, we recognize that other factors such as different experimental procedures and participants with different demographic characteristics could also contribute to this difference.

Taken together, the results from Study 2 suggest that in a repeated tournament setting where subordinates can establish a sufficient level of trust, high vertical wage dispersion increases subordinates' desire to reduce the vertical pay gap and they tend to accomplish this objective by colluding rather than competing with their peer.

5. Discussion

Our study provides behavioral theory and empirical evidence for how and why a firm's vertical wage structure can alter employee's behavior in a competitive setting. Firms introduce competitive incentives, such as tournaments, to encourage employees to exert high

effort while controlling the cost of effort. Thus, collusive behavior in this setting can reduce the profitability of the firm. Our two studies indicate that high (vs. low) vertical wage dispersion can increase collusion, but only if subordinates can establish and maintain sufficient levels of trust. The results derived from the two studies suggest that the ability to interact repeatedly plays a key role in determining how vertical wage dispersion affects the behavior of competing employees in tournaments. While subordinates from both studies have a stronger desire to reduce the vertical pay gap when facing high (vs. low) vertical wage dispersion, only those who repeatedly interact with their peers tend to adopt collusive strategies. In other words, competing subordinates must have sufficient motivation and opportunity to establish trust before collusive strategies are effective at reducing the vertical pay gap.

Our study provides important insights for both research and practice. First, we contribute to the growing research on pay dispersion in accounting (Brown et al., 2019; Guo et al., 2017, 2020; Liu et al., 2020; Matuszewski, 2010) by examining the effects of vertical wage dispersion on employee behaviors in a competitive setting. This research is important because to the extent that competitive settings heighten employees' sense of competition with their peers, vertical pay dispersion may not be as important as in other settings if superiors are not the key pay referents for social comparisons. Our study finds that even in rank-order tournaments, vertical wage dispersion still changes subordinates' behaviors due to a desire to reduce the vertical pay gap. Further, we find that the elevated desire to reduce the vertical page gap reduces competitiveness and increases cooperation among subordinates, provided that the level of trust between them is sufficient.

Second, we contribute to the tournament literature by demonstrating that *ex-ante* vertical wage dispersion can change tournament outcomes through collusion. We respond to Luft's (2016) call for more research examining the efficacy of competitive incentives in different contexts. Like Kelly and Presslee (2017) and Harbring and Irlenbusch (2011), who investigate the effect of contextual variables on employee behavior in tournaments, we examine how *ex-ante* fixed wage differences may cause employees to react to tournament incentives in different ways.

Third, we contribute to practice by providing evidence that employers must consider pre-existing wage structures when designing tournament incentives. With the growing level of pay transparency due to changing technology, regulation, and social attitudes (Dodd-Frank Wall Street Reform and Consumer Protection Act, 2010; Mercer, 2021; Ontario, 2018), organizations need to understand what would happen if employees learn about the pay gap between themselves and their supervisors. While some firms continue to enforce a norm of pay secrecy, various degrees of pay transparency exist in organizations today (see for example, Morgan, 2021; Payscale, 2021; Potter, 2020). Our results suggest that employers should consider additional controls against collusive behavior given that collusion in competitions is prevalent in the real world when internal controls have vulnerabilities (Bandiera et al., 2005, 2006).

We also recognize limitations of our study that provide opportunities for future research. First, we examine a setting where pay levels are fully transparent to all parties within the firm. While there is evidence that pay transparency has increased over time, pay amounts are not so clearly known in many firms. While pay transparency is increasing, there are various degrees of transparency. Therefore, future research is needed to examine settings where there is some uncertainty over the actual size of the wage gap. Recent research on misperceptions of relative income and pay suggests that individuals tend to underestimate the difference between their own pay and that of others when pay structure is opaque (e.g., Cullen and Perez-Truglia, 2018; Karadja et al., 2017; Perez-Truglia, 2015). If so, pay opaqueness will likely cause subordinates to underestimate vertical wage dispersion, leading to weaker effects than observed in our study. Second, to ensure sufficient differences in pay would result in perceptions of unfairness in our lab setting, we relied on prior experimental research (e.g., Guo et al. 2020, 2017) to set the wage gap between the superiors and subordinates in our study. This gap may be larger than typically observed between lower-level employees and mid-level managers in real organizations, potentially limiting the generalizability of our results to wage gaps between lower-level employees and upper-level management. Thus, future research is necessary to examine whether a smaller pay gap would generate similar results. Finally, to strengthen the external validity of our study, we use a promotion task to determine the participant's roles. However, this promotion task does not bear any clear connection with the effort choice task used in the main experiment and thus, participants may not view their role assignment and the subsequent wage differences to be fully justified. Shaw and Zhou (2021) review prior literature indicating that employees often react positively (negatively) to explained (unexplained) pay differences. Thus, in situations where vertical wage dispersion is fully explained, i.e., the wage dispersion is fully justified by normatively accepted practices, our results may not hold.

Notwithstanding these limitations, we find that vertical wage dispersion increases collusion in a repeated, but not in a one-shot, tournament setting. Supplemental analysis links these behaviors to subordinates' motivation to reduce the vertical pay gap as well as to their trust in one another. With increasing levels of pay transparency, pay dispersion in organizations is becoming more apparent in many organizations. We document the influence of vertical wage dispersion on the effectiveness of competitive incentives in motivating performance in organizations.

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Appendix

Summary of Predictions for One-Shot and Repeated Tournament Settings.

Panel A: Economic Predictions	
1. In a rank order tournament in which the prize spread is greater than the maximum cost of effort, the Nash Equilibrium effort choice for the subordinates is (100,100), and the Pareto Optimal effort choice is (0,0). 2. Pareto Optimal is however not an equilibrium. Trust between subordinates is a crucial element in forming a non-binding collusive relationship. 3. *Ex-ante* vertical wage dispersion should not affect subordinates' effort choice nor collusion between them.	
One-Shot Tournament (Study 1)	**Repeated Tournament (Study 2)**
The One-Shot setting is not conducive to trust-building between subordinates because there is no opportunity for reputation building or reciprocity. Thus, collusion may or may not be a viable strategy for subordinates.	Repeated interactions between subordinates facilitate trust building between them. Prior empirical evidence also suggests that repeated interactions facilitate collusion in tournaments.
Panel B: Behavioral Predictions for the Effects of Vertical Wage Dispersion	
1. High (vs. low) vertical wage dispersion increases subordinates' desire to reduce the vertical pay gap. 2. Because the superior is a partial residual claimant to firm profits, collusion allows the subordinates to reap both an economic benefit (by reducing costly effort) and a psychological benefit (by reducing the superior's compensation and the vertical pay gap). 3. Though high (vs. low) vertical wage dispersion makes collusion an attractive strategy. If the trust between subordinates is insufficient, they may adopt a competitive strategy instead to increase their own payoff and reduce the vertical pay gap.	
One-Shot Tournament (Study 1)	**Repeated Tournament (Study 2)**
Research Question: In a one-shot tournament setting, how vertical wage dispersion affects collusion and effort contribution will depend on the trust level between subordinates, which may or may not be sufficient to sustain a collusive relationship.	**Hypothesis**: In a repeated tournament setting, vertical wage dispersion will increase collusion and reduce effort contribution because the repeated interactions facilitate trust building between subordinates.

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