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RESEARCH ARTICLE OPEN ACCESS

Relative Performance Evaluation and Executive Compensation: Adding Fuel to the Fire

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ABSTRACT

In this experimental study, we compare the effects of a compensation scheme based on relative performance evaluation (RPE) and a compensation scheme based on absolute performance evaluation (APE) on decision-making in a market game. To this end, we conduct an online experiment using the strategy method to obtain individual responses in a duopoly market with quantity competition. Our results point to a causal effect of the RPE-based compensation scheme on quantity decisions: subjects opt for higher quantities when incentivised by the RPE-based compensation scheme. While this observation is consistent with the theoretical predictions, our data imply that subjects deviate from payoff maximisation under both compensation schemes. Specifically, we find strong evidence that the RPE-based compensation system, in particular, increases the likelihood that subjects sacrifice their payoffs to reduce the competitors' payoffs (i.e., behave *over-aggressively*). Our results suggest that RPE-based remuneration structures, which are gaining traction in practice, may have unintended behavioural effects and can be detrimental to the profits of firms that use them.

JEL Classification: J33, D43, C90, L13, L21

1 | Introduction

Performance-related pay for managers is a ubiquitous practice in modern companies, with performance bonuses accounting for more than half of executive pay (Do et al. 2022). Broadly, these performance-based compensation systems can be categorised into two types. First, there are performance-based compensation schemes that focus solely on the performance of the manager's company, for example, its profit. Second, competitor-oriented compensation schemes focus on the evaluation of the *relative* performance of the manager's own company compared with other companies, for example, its competitors. In recent years, bonuses based on relative performance evaluation (RPE) have become an increasingly important part of executive compensation. According to Feichter et al. (2022), the use of RPE more than doubled between 2006 and 2019, and Bizjak

et al. (2022) report that the majority of large US companies use some form of RPE in their executive compensation plans.

Although competitor-orientated executive compensation has gained considerable importance in practice, our understanding of its impact on managers' decisions is still very limited. While this form of executive pay can help solve problems of information asymmetry between owners and managers (Holmstrom 1979),¹ it can also have unintended side effects. A well-known problem with tying bonuses to employees' relative performance *within* an organisation, especially at lower levels, is the risk of encouraging sabotage (Lazear 1989). In the context of executive compensation, Gibbons and Murphy (1990) point out that RPE-based bonuses are unlikely to lead to sabotage *between* companies, as CEOs generally have limited interaction with CEOs of competing companies. While this

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argument might apply to monopolies or highly competitive markets, managers in oligopolistic industries often engage in strategic interactions through their firms' market strategies. In other words, using RPEs in oligopolistic markets may encourage managers to adopt sabotage-like aggressive behaviour, such as suboptimally low pricing or elevated output levels (Bloomfield et al. 2023).

On the one hand, it may be desirable from the owner's perspective to encourage a certain degree of aggressive behaviour through executive compensation, as this may lead to higher profits.² On the other hand, problems can arise if managers overreact to these incentives with costly acts of sabotage. For example, they may already favour aggressive competitive behaviour even without these incentives. In such cases, the introduction of RPE-based bonuses in executive contracts can add fuel to the fire and lead to a 'win-at-all-costs' mentality on the part of managers (Malhotra et al. 2008). This can result in managers sacrificing both their company's profits and their own remuneration in order to outperform the competitors. Such behaviour, often referred to as 'competitive irrationality'³ in management literature (Arnett and Hunt 2002; Graf et al. 2012; Graf-Vlachy 2021) or 'costly sabotage' in economic literature (Harbring and Irlenbusch 2011; Chowdhury and Gürtler 2015), is already a widely recognised problem in corporate governance.⁴ As RPE-based executive compensation models become more common in practice, it is important to better understand how bonuses based on relative performance influence managers' decisions.

This paper empirically examines how managerial behaviour is affected by RPE-based payment schemes compared with compensation based on an absolute performance evaluation (APE). Previous research on costly sabotage has focused primarily on the dynamics of *internal* firm dynamics and lower organisational levels, often treating costly sabotage *within* organisations as a distinct action of employees (see Chowdhury and Gürtler 2015 for a review). However, in strategic interactions between firms, costly sabotage is inherently embedded within managerial decisions. Therefore, it would be extremely difficult to determine from observational data whether managers *overreact* to the incentives offered by RPE-based compensation and make decisions that negatively affect their own company's profits or even their own pay. Furthermore, in the real world, many (unobserved) factors may influence management decisions, which further complicates the identification of the causal effect of RPE-based compensation.

Understanding these limitations, we conduct a lab-in-the-field experiment to investigate the effects of the two pay systems. To determine the *causal* effects of the RPE-based compensation system on managerial decision-making, we use an experimental setting in which participants decide what quantities to produce in a Stackelberg duopoly. Each subject acts as a Stackelberg follower and chooses the production quantities for certain quantities of the Stackelberg leader. The choice of the Stackelberg duopoly as the experimental setting is crucial because it allows us to use the strategy method (Brandts and Charness 2011) to determine the response plans for each subject. We can then compare the observed response plans with those predicted by theory. Our treatment is the type of reward system, and subjects make their decisions under both RPE- and APE-based reward

systems. Thus, we use a within-subjects design. However, we can also perform a between-subjects analysis for a subset of observations. To the best of our knowledge, our study is the first experimental study to focus exclusively on the *causal* effects of RPE-based reward systems on managers' strategies.

Based on data obtained from an online experiment with 197 participants, we find a positive causal effect of the RPE compensation system on the quantity chosen by the subjects, consistent with the theoretical considerations of strategic delegation literature (Vickers 1985; Salas Fumas 1992; Aggarwal and Samwick 1999b; Jansen et al. 2008). We also compare each individual response with theoretical compensation-maximising choice and find a positive causal effect of the RPE compensation system on the probability of sacrificing *own payoff* to harm competitors. This finding implies that RPE-based compensation schemes exacerbate competitively irrational behaviours in managers. Our design also enables us to investigate whether the company's relative position plays a role. We find that participants are more likely to engage in costly sabotage when their company is behind in market share, consistent with behindness aversion (Fehr and Gächter 1998; Fehr and Schmidt 1999). However, we do not find significant evidence that the effects of RPE bonuses are stronger when the manager's firm is behind. Lastly, we report significant heterogeneity in the observed response functions, with almost 30% of the participants exhibiting *upward-sloping* response functions in stark contrast to theoretical predictions.

Studies closest to our work examine the effects of competitor-oriented objectives and information on managerial decisions and profitability (Armstrong and Collopy 1996; Armstrong and Green 2007; Griffith and Rust 1997). In contrast to experimental studies in this area, which examine how information about competitors' performance affects managerial decisions, subjects in our experimental design always receive information about competitors' profits, and competitors' profit directly affects the payoff of subjects under the RPE compensation scheme. By varying only the type of contract but not the information, confounding problems are avoided, which allows us to identify the causal effect of RPE- and APE-based compensation systems on quantity decisions. In addition, our experimental design is based on an economic model that allows us to compare the observed quantities or response curves with the best response curves derived from the theory, that is, assuming that managers maximise their compensation.

Our study is also related to experimental studies in the field of 'strategic delegation'. The works in this area are mainly concerned with the perspective of business owners and their choices of specific managerial compensation schemes.⁵ In these experiments, the type of manager compensation is an endogenous choice variable; thus, the causal effect of compensation schemes on the individual behaviour of managers can hardly be analysed with previous designs. In contrast, we aim to investigate how the managers react to specific compensation schemes; therefore, the type of compensation scheme is an exogenous treatment in our experimental setting. Our results align with some of the findings reported in experiments on strategic delegation, but we extend existing work by investigating the causal effects of compensation schemes on individual decision-making.

The remainder of this paper is organised as follows. Section 2 presents our introduces a general framework and testable hypotheses. Section 3 explains the experimental design and implementation. Section 4 reports the results, and Section 5 provides a discussion of the results. Conclusions and suggestions for future research are provided in Section 6.

2 | Framework and Hypotheses Development

We start by considering theoretically optimal (i.e., compensation-maximising) decision-making in a quantity-setting duopoly with the following inverse demand function:

$$P(q_i, q_j) = a - q_i - q_j,$$

where $a > 0$, p is price, and q_i is firm i 's output. We assume firms to have symmetric costs given by $C(q_i) = cq_i$. Hence, firm i 's profit is given by

$$\pi_i = (a - q_i - q_j)q_i - cq_i$$

Each firm market strategy is decided by a manager, whose compensation (v_i) takes the following form:

$$v_i = w_{fixed} + \pi_i + \gamma_i(\pi_i - \pi_{-i}) \quad (1)$$

Where w_{fixed} is a fixed wage, π_i is the firm i 's profits, $\gamma_i(\pi_i - \pi_{-i})$ is the RPE-based bonus, π_{-i} is the profit of the direct competitor $-i$, and $\gamma_i \geq 0$ is the weight of relative performance component. In other words, we assume that the own-performance-bonus of manager i is a constant share of profits of his company and further normalise that share to be equal to 1. The RPE bonus depends positively on the performance of manager i 's company and negatively on the performance of the competitor.⁶ Although real-world contracts may rely on more complex forms—such as rank-order tournaments or distance-based schemes—the linear structure captures the change in the core strategic incentives.⁷ The use of profits is supported both by the empirical evidence of accounting-based RPE (Nam 2020; De Angelis and Grinstein 2020; Martin and Timmermans 2025) and by their correlation with stock-based metrics such as shareholder return, making them a suitable proxy. Thus, this bonus specification not only ensures tractability but also preserves the qualitative features of real-world incentive schemes while remaining accessible to experimental participants.

Based on Equation (1), we distinguish between two possible compensation systems. If $\gamma_i = 0$, then the manager's compensation only depends on the APE of his firm. If the weight is positive,⁸ that is, $\gamma_i > 0$, then the manager's compensation includes a relative performance component and is, thus, RPE-based. Assuming that the manager's goal is to maximise their own compensation (v_i), APE- and RPE-based compensation systems lead to the following two best-response functions:

$$q_i^{*APE}(q_j) = \frac{a-c}{2} - \frac{q_j}{2} \quad (2)$$

$$q_i^{*RPE}(q_j) = \frac{a-c}{2} - \frac{q_j}{2+2\gamma_i} \quad (3)$$

Under the APE response function, the manager i 's compensation-maximising strategy corresponds to the profit-maximising strategy of the firm. In contrast, the RPE-based contract leads to a manager's response function that deviates from the best response function of the profit-maximising owner. Figure 1 illustrates the resulting differences in the response functions under the RPE and APE compensation schemes. The response curve associated with RPE is flatter, suggesting that the manager will choose quantities that exceed profit-maximising quantities as long as the competitor produces at least one unit of output. For larger quantities of the competitor, the deviation increases in absolute terms. Therefore, we would expect compensation-maximising managers to choose larger quantities in the case of RPE-based compensation than in the case of APE-based compensation, leading to our first hypothesis.

Hypothesis 1. *Managers' strategies under RPE-based compensation will contain higher output quantities than managers' strategies under APE-based compensation.*

The change in the manager's best response function is the key mechanism of the strategic delegation approach, for example, (Vickers 1985; Salas Fumas 1992; Jansen et al. 2008). According to this strand of literature, by imposing a more aggressive objective function on their managers, firm owners can force their competitors into a less advantageous position in the market. However, the behavioural implications of such intensives and their interactions with managers' intrinsic preferences are largely overlooked in the current management literature (Pepper 2019).

Indeed, while the described response functions provide a straightforward benchmark for analysing behaviour, there is also ample empirical evidence that managers deviate from profit-maximising choices even without explicit incentives to do so. In a laboratory study by Armstrong and Collopy (1996), subjects were willing to sacrifice a portion of their firm's profits to beat or harm the competitor, and the likelihood of such behaviour increased with management education. Similarly, Griffith and Rust (1997) find that subjects in a prisoner's dilemma pricing experiment tended to base their decisions on a comparison with rivals, even though they were explicitly instructed to maximise their own firm's profits and had the incentive to do so. In the

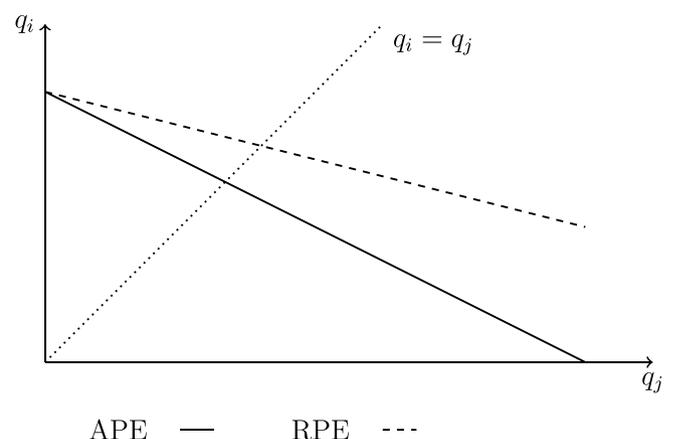


FIGURE 1 | Manager's optimal response functions under APE- and RPE-based compensation schemes.

context of a quantity-setting duopoly without an RPE bonus, such behaviour would manifest itself in managers choosing elevated levels of output compared with the profit-maximising objective function (APE).

Put differently, even without an RPE bonus, some managers behave aggressively *as if* they are incentivised with an RPE bonus.⁹ The question arises as to whether this behaviour is further encouraged by an explicit incentive based on RPE-based pay. If aggressive behaviour persists under the RPE-based scheme and managers overproduce relative to the compensation-maximising benchmark, the consequences for the firm would be even more devastating. Given the quadratic relationship between profits and the level of output, combined with the RPE-based contract already assuming a certain level of deviation from profit-maximising strategies, these *over-aggressive* choices would have significantly amplified negative effects on the firm's profitability.

RPE-based contracts introduce two countervailing factors that make it unclear, a priori, whether managers would be more or less likely to engage in over-aggressive behaviour. First, deviating from the compensation-optimal quantity under the RPE-based contract becomes more costly in absolute terms. Specifically, if a manager increases the output by x units, the loss incurred is x^2 under APE but rises to $(1 + \gamma)x^2$ under RPE. Based on this, we would expect the likelihood of observing over-aggressive behaviour to be lower under RPE (Hypothesis 2):

Hypothesis 2. *The likelihood that managers will act over-aggressively is lower in an RPE-based compensation system than in an APE-based one.*

Second, by increasing the compensation-maximising level of output from the manager's perspective, the RPE bonus also alters the resulting market share. Insights from behavioural economics suggest that relative position plays an important role in decision-making (see Fehr and Charness 2023, for a review). Envious or spiteful behaviour can be triggered when one receives fewer resources than a competitor (Wobker 2014).¹⁰ Therefore, managers whose firms are in a disadvantageous position might use any means to reduce or compensate for that disadvantage. This practice is also known as 'beating someone at any cost' (Malhotra et al. 2008; Graf-Vlachy 2021). When analysing the response function in a quantity-setting duopoly, we can distinguish between scenarios where manager i 's firm is ahead (i.e., has a larger market share) or behind. Figure 1 illustrates this distinction with the dotted line $q_i = q_j$. Any combination of quantities to the left of the dotted line results in a market outcome where firm i has a larger market share than firm j . Broadly, we hypothesise that under both compensation schemes, over-aggressive behaviour would be more prevalent in observed response functions when managers' firms are in a disadvantageous position (i.e., to the right of the $q_i = q_j$ curve).

Hypothesis 3a. *Managers are more likely to exhibit over-aggressive behaviour when the manager's firm is in a disadvantageous position.*

Furthermore, despite the deviations under RPE being more expensive in *absolute* terms, for a part of the response curve to the right of the line, it is cheaper to achieve a more favourable

relative position. In the RPE-based compensation system, some of the costs are already internalised, making it easier to 'beat' the competitor (or at least achieve an equal position) than in an APE-based compensation scheme. Against this background, we expect that RPE-based compensation schemes would intensify spiteful behaviour further than APE-based compensation schemes.

Hypothesis 3b. *The RPE compensation scheme has a positive effect on the likelihood of over-aggressive behaviour by a manager, particularly if the manager's firm is in an unfavourable position.*

It is not immediately clear which of these opposing forces—higher costs of deviation or heightened spitefulness in disadvantageous positions—will dominate the effects of RPE-based contracts, particularly in the disadvantageous part of the response curve. While our first hypothesis provides a clear directional prediction (quantities should increase under RPE), the interplay between costlier deviations and the heightened importance of relative standing under RPE poses a more complex empirical question. Therefore, our analysis of Hypotheses 2 and 3 is more exploratory, aiming to shed light on the balance of these competing effects rather than making definitive predictions.

Our choice of a quantity-setting duopoly environment is primarily motivated by theoretical considerations from strategic delegation literature, as Salas Fumas (1992) argues that owners have stronger incentives to use RPE-based compensation when managerial decisions involve strategic substitutes. However, it is also common for firm owners to implement RPE-based compensation schemes to address issues such as information asymmetry (Gibbons and Murphy 1990) or corporate governance concerns (Edmans et al. 2017; De Angelis and Grinstein 2020). While compensation-maximising response curves would differ under strategic complements, as long as the RPE bonus maintains its structure (positively tied to own profits and negatively to competitors'), the qualitative predictions of Hypotheses 1–3 would remain unchanged.

3 | Experimental Design

In order to test the hypotheses under consideration, it is necessary to obtain data regarding the individual best-response functions. However, this is problematic in the case of simultaneous quantity choice by managers (Cournot competition), as it is likely that parts of the best-response curves cannot be estimated due to missing observations (certain quantities would be selected very rarely). This would mean that our hypotheses can hardly be tested. For this reason, we use Stackelberg (1934) model, which features sequential decision-making¹¹ in a quantity-setting environment. Furthermore, we opt for the strategy method (Brandts and Charness 2011), where we ask the participants to create response plans for possible choices of the leader. This approach has clear advantages over using repeated sequential interactions. In the latter, we would only observe follower behaviour for a subset of leader choices, leading to identification and categorisation issues (Müller and Tan 2011).

Thus, we can summarise the experiment in the following way. After participants become familiar with the market

environment, they are randomly assigned to either the APE or RPE compensation scheme and create a response plan for different leader choices (between-subject design). In the next step, each participant also creates a response plan for the bonus system to which the participant was not assigned in the first round (within-subject design). These measurements produce two response functions for each subject (which are the main objective of our design). Then, participants submit two quantities as the leader firm (against each type of contract of the follower). After the decision-making phases are completed, the participants are brought together. The roles (leader or follower in the Stackelberg setting) and type of contract of the followers (APE or RPE) are chosen randomly. Then one participant's response plan is matched against the leader's quantity of the other, and both participants receive their respective payoff.

The rest of this section provides explicit details about the experimental market environment (Section 3.1), instructions and materials (Section 3.2) and sample information (Section 3.3).

3.1 | Experimental Market

First, we summarise the specific market environment based on the framework outlined in Section 2. For our experiment, we have used $a = 80$, $c = 0$ and $w_{fixed} = 100$ as values for our parameters, $\gamma = 0.33$ as the weight of the RPE component. Although the fixed part (w_{fixed}) of the compensation does not enter the optimisation problem, executive contracts in practice typically include a base salary component.¹² We set $\gamma = 0.33$ to ensure that compensation values in the RPE condition remained nonnegative across the entire strategy space.¹³ The market is characterised by Stackelberg competition, where the leader firm moves first, and then the follower firm moves second.

The inverse demand function is given by

$$P(q_l, q_f) = 80 - q_l - q_f$$

where the subscript l represents the leader and f the follower. The profits of both firms are given by

$$\pi_i = (80 - q_i - q_j) * q_i, \quad i=l,f$$

In both firms, only the manager decides on the quantity. The firm l chooses the quantity first, and firm f replies using a pre-constructed response plan. In the case of a bonus scheme based on the APE, it depends exclusively on the profits of the follower firm:

$$v_f^{ape} = \begin{cases} \pi_f + 100 & \pi_f > 0 \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

In the case of the RPE bonus scheme, the reward of the manager of the follower firm depends on the profits of both firms:

$$v_f^{rpe} = \begin{cases} \pi_f + 100 + 0.33 * (\pi_f - \pi_l) & v_f^{rpe} > 0 \\ 0 & \text{otherwise} \end{cases} \quad (5)$$

The subgame-perfect equilibrium suggests that for each possible level of output q_l of the leader, the follower would respond by maximising $v_f^{ape}(q_l)$ or $v_f^{rpe}(q_l)$. Therefore, the best-response functions for follower for the two bonus schemes are

$$q_f^{ape}(q_l) = 40 - 0.5 q_l \quad (6)$$

$$q_f^{rpe}(q_l) = 40 - 0.376 q_l \quad (7)$$

Creating a best-response plan for every possible leader choice is not feasible in the context of our experiment. Therefore, we restrict the possible action domain of the leader to a discretised set of the Stackelberg game with $q_l \in \{1, 7, 14, 20, 27, 33, 40, 48, 56\}$. The action space of the follower firm (q_f) is only restricted to integers in the range $[0, 80]$. The manager of the leader firm will receive compensation based on the APE contract. As the manager of the leader firm knows what type of compensation the manager of the follower firm will receive, it is optimal in terms of maximising his own compensation to commit to a quantity of 40 if the manager of the follower firm is paid under the APE contract and 33 if it is under the RPE contract.¹⁴

3.2 | Materials and Procedures

The instructions have presented the above market conditions to the participants using nonneutral language, for example, referring to 'firms', 'managers', 'products' and 'profits'. This approach is favoured in the experimental IO literature¹⁵ and is supported by methodological surveys (Aleksseev et al. 2017). The introduction page also included a description of a profit calculator that showed profits resulting from any given combination of the quantities. The use of the profit calculator is not a novel idea,¹⁶ but because the strategy space of the experiment is relatively large, we have modified the profit calculator with 'sliders' that show profits in real-time. Thus, instead of manually typing the number each time, participants could change the slider's position and see the immediate change in the payoffs both for themselves and their opponents (see Appendix D for an example and complete instructions). This calculator was available to participants throughout the entire experiment.

We have added a *learning phase* before the actual experiment, as it is essential that the participants understand exactly how the profits of both firms depend on their actions (and those of the other player). Participants were given time to familiarise themselves with the environment and how the sliders work, and were free to try out how different output combinations affect the firms' profits. At the end of the learning phase, subjects had to answer three mandatory control questions to test their attention and comprehension. These control questions were the same for all participants and could be answered using the profit calculator with sliders. For example, one question was: *Suppose firm A chooses 25, how much profit would firm B make if it chooses 27?* Participants were only allowed to continue if they answered all three control questions correctly.

After the introduction to the environment, participants received information about the decision stages, which included details

about payments and matching procedures. The experiment used an experimental point (EP) as a currency with an exchange rate of 100 EP=1 GBP (British Pound).

Throughout the decision stages, participants were asked to first assume the role of manager of firm B (the follower firm) and then firm A (the leader firm). Completing the stages as firm B's manager required subjects to submit a 'response plan' for every possible node in the strategy space of the leader. The starting condition (either APE or RPE) was chosen randomly to control for potential order effects.

After the participants completed the response plans of followers for both types of contracts, they made two decisions as managers of firm A. Even though the main objective of the design is to elicit the response functions of the follower, collecting the choices for the leaders shows whether participants anticipate the strategies of the followers and adjust their choices accordingly. As the leader's choice is made after completing follower decision stages and there is no control for order effects, these data points are not a reliable metric.

By the end of the experiment, each participant submitted 20 data points: nine for each type of contract as the manager of a follower firm and two decisions as the manager of a leader firm against two types of contracts.

3.3 | Experimental Sample

To test our hypotheses, we employ a lab-in-the-field experiment conducted online in six sessions between September 2021 and January 2022. We conducted an online experiment instead of a laboratory experiment mainly for two reasons. First, due to the COVID-19 pandemic, it was almost impossible to conduct laboratory experiments during the study period. Second, contrary to the majority of market experiments, which are based on samples of students, our online experiment permits the utilisation of a sample from the general population. Consequently, our sample selection addresses the prevalent criticism of employing students as subjects. Although online experiments are now relatively widespread and accepted in experimental economics, they also present some challenges from a methodological perspective. In Appendix B, we briefly describe these challenges and explore their implications for our experimental design.

The participants were recruited via Prolific.ac (Palan and Schitter 2018), and the interface has been programmed using LIONESS platform (Giamattei et al. 2020), along with standard tools for website design (HTML, CSS and JavaScript). To minimise cultural differences between participants, we have restricted the experiment to participants from the United Kingdom, the US and Ireland. A total of 330 people participated in the experiment. However, due to strict data quality policy, this number has been reduced to 197.¹⁷

On average, participants completed the experiment in 25 minutes and received an amount of £7, depending on the decisions made in the experiment, and £2.2 as participation compensation. Column 1 in Table A1 provides complete demographic information about our sample (see Appendix A).

4 | Experimental Results

We begin the presentation of our results with Figure 2, which illustrates the average observed response plans for both the APE and RPE compensation schemes with 95% confidence intervals. The linear response curves (dashed lines) derived under the assumption of compensation maximisation serve as reference points. This graph highlights three initial findings. First, observed quantities are higher when subjects make their decisions under the RPE-based contract than under the APE-based contract, particularly for larger quantities of the leader. Second, the average quantities chosen by the subjects in both compensation schemes tend to deviate from the compensation-maximising amounts. These deviations are particularly significant for large and small quantities of the competitor. Third, the observed average response plans show flatter response curves than the respective theoretically predicted linear 'optimal' response curves derived under the assumption of compensation maximisation.

While Figure 2 provides prima facie support for Hypothesis 1, it does not allow for the explorative analysis (Hypotheses 2–3b) as it fails to consider the implied differences in optimal behaviour under each contract. Indeed, even if the choices under RPE are higher than under APE, it does not mean that participants are overly aggressive towards their opponent (as is the case for low quantities of the leader in Figure 2).

To explore whether RPE leads to more *over-aggressive* behaviour, we introduce Figure 3, which presents the distribution of each type of behaviour for every possible output of the leader. We categorise 'over-aggressive behaviour' ('above optimal') as any choice Q_{fi} which exceeds the payoff-maximising quantity for the respective choice of the leader firm (Q_{lj}) by more than 1 unit (to allow for the discretisation of payoffs), 'optimal' as any choice within 1 unit interval above or below payoff-maximising quantity, and 'below optimal' otherwise. Two patterns emerge. First, overly aggressive behaviour seems to be more frequent *in general* under the RPE compensation scheme contradicting our Hypothesis 2. Second, under both contracts, subjects exhibit a greater tendency for over-aggressive behaviour ('above optimal') when the leader puts them in a disadvantageous position, supporting our Hypothesis 3a. However, the potentially moderating effect of the RPE compensation scheme, suggested by Hypothesis 3b, is less clear.

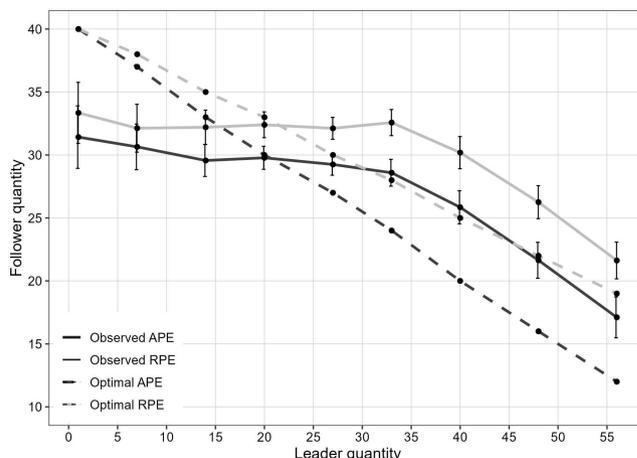


FIGURE 2 | Optimal and observed average response functions.

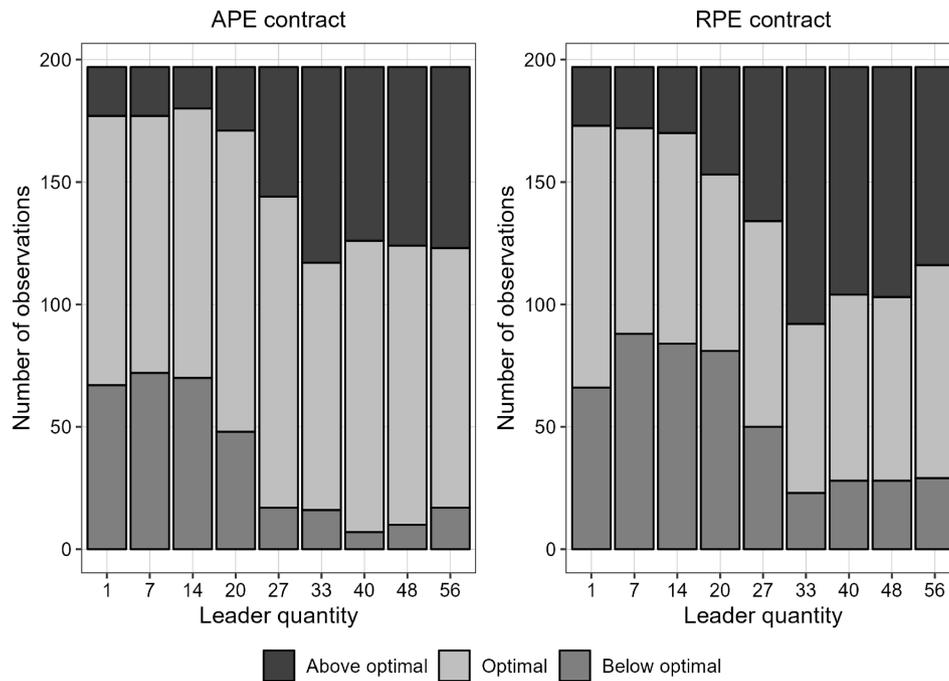


FIGURE 3 | Observed behaviour for different leader quantities.

We now turn to more formal statistical tests of our hypotheses.

4.1 | Hypothesis 1

Figure 2 already provides compelling evidence in favour of Hypothesis 1; however, for the sake of completeness, we also provide results of a regression analysis. Based on individual response plans and the corresponding competitor (leader) quantities, we estimate the causal effect of the RPE treatment on the quantities chosen by the follower. To this end, we employ the following econometric model:

$$Q_{jji} = \alpha_0 + \alpha_1 Q_{lj} + \alpha_2 (Q_{lj} \times RPE_{ji}) + u_{ji}$$

where Q_{jji} are the *observed* quantities chosen by subject i ($i=1, \dots, n$) in response to the leader quantity Q_{lj} , where j represents the nine quantities of the leader ($j = 1, \dots, 9$) for which the subjects made their response plan. RPE represents a dummy variable that takes the value one if the choice is made under the RPE compensation scheme and is zero otherwise. The error term is u_{ji} . The second term is the interaction between leader quantity and RPE, that is, the treatment. Our theoretical considerations suggest that the sign of the estimated value of parameter α_1 is negative, implying a downward-sloping best-response curve, and according to Hypothesis 1, the sign of the estimated value of parameter α_2 is positive.

Table 1 reports coefficients obtained from OLS regressions and robust errors clustered at the individual level.¹⁸ To set the scene, we first present the results of a regression where we assume that the contract based on RPE does not affect subjects' response plans differently than the contract based on APE (Model 1). As theoretically expected, the estimated value of parameter α_1 is negative, implying that the average response curve is downward-sloping. Moreover, the estimated

TABLE 1 | Estimated linear response functions of followers.

	Model 1	Model 2	Model 3
Intercept	34.235*** (0.947)	34.235*** (0.947)	33.443*** (1.014)
Q_l	-0.202*** (0.029)	-0.253*** (0.031)	-0.232*** (0.032)
$RPE \times Q_l$		0.101*** (0.010)	0.060** (0.021)
RPE			1.585* (0.771)
Num. of Obs.	3546	3546	3546
R^2	0.096	0.117	0.118

Note: Significance levels at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Cluster-robust standard errors are in parentheses.

coefficient is statistically significant at the 1% level. Next, we allow for differences in the effects of APE- and RPE-based compensation schemes on subjects' response plans. As hypothesised, the coefficient α_1 is negative in Model 2, implying that the average response function is downward-sloping for the APE contract. The estimate of parameter α_2 is positive and statistically significant at the 1% level, indicating that the RPE environment results in relatively higher quantities than APE contracts, that is, the causal effect of RPE is positive. According to our theoretical considerations (Equations 6 and 7), the RPE contract should only affect the slope of the best response curve and not shift it. Nevertheless, we also run a model that allows for a change in intercept (Model 3). In the latter case, the total causal effect of the treatment RPE on the

subjects' response plans is given by the main effect of RPE plus the interaction with leader quantity ($1.585 + 0.060Q_{ij}$). While the main effect of the RPE contract, that is, the estimated value of the parameter of the RPE dummy variable, is positive, it is only statistically significant at the 5% level. The estimated effect of the interaction term is still positive, although the estimated value is somewhat lower. Thus, despite the observed response functions being different from theoretical predictions, our results strongly support Hypothesis 1.

4.2 | Hypotheses 2 and 3

For the statistical tests of Hypotheses 2–3b, we analyse the probability of observing over-aggressive behaviour. Formally, Y_{ji} is a binary variable that takes the value one if a participant i 's response to a leader quantity j is over-aggressive ('above optimal') and is zero otherwise. We use the following econometric specification of a logistic model for our regression analysis:

$$\ln \frac{P(Y_{ji} = 1)}{1 - P(Y_{ji} = 1)} = \beta_0 + \beta_1 RPE_{ji} + \beta_3 Behind_j + \beta_4 Behind_j \times RPE_{ji} + \eta_{0i}$$

where $P(Y_{ji} = 1)$ is the probability that participant i 's response is over-aggressive ($Y_{ji} = 1$), RPE is the dummy to represent the RPE contract, and $Behind_j$ is a dichotomous variable taking the value one if the leader quantity j is above the threshold for a disadvantageous position. Our approach in establishing this threshold is similar to Lau and Leung (2010). Intuitively, if the optimal choice of the follower in response to leader quantity j results in a higher payoff for the follower, then the follower is in an advantageous position. Thus, $Behind_j$ takes the value zero for all responses to leader choices j below 27 (33) for the APE (RPE) compensation scheme and is one otherwise. We accommodate the panel structure of our data by including a

random intercept (η_{0i}) in our analysis (Gelman and Hill 2006, 301). Logistic regressions were run in R with lme4 package (Bates et al. 2015).

We report the results of the above analysis along with two reduced-form logistic regressions in Table 2 along with simple linear probability models¹⁹ (Table 2: LPM 1-3) for the convenience of the reader. The coefficients obtained from the linear probability models reflect the marginal effects on the probability of the occurrence of over-aggressive behaviour and are therefore useful to illustrate the marginal effects, although strictly speaking, they are not entirely correct (see Beck 2019).

The coefficient estimate of β_1 is positive and statistically significant at the 0.1% level ($p < 0.001$) in all of our logit models (RE Logit 1-3), indicating the RPE contract increases the log-odds ratio of observing quantities above payoff-maximising values. Thus, we can infer that the RPE environment increases the tendency to engage in overly aggressive behaviour *in general*, contrary to the prediction in Hypothesis 2. The coefficient estimate of β_2 is also positive and statistically significant ($p < 0.001$), implying that being in a disadvantageous position encourages over-aggressive behaviour under both contracts (Hypothesis 3a). The coefficient for the interaction term is not statistically significant at conventional significance levels (RE Logit 3). In fact, omitting the interaction term improves most model specifications we estimate, suggesting that we cannot confirm Hypothesis 3b that the RPE environment has a stronger effect on the likelihood of over-aggressive behaviour if a participant is in an unfavourable position. These results are confirmed by the estimates obtained from the linear probability models. The estimated marginal effects show that RPE contracts increase the likelihood of observing over-aggressive behaviour by almost ten percentage points. The marginal effect of an unfavourable position is even stronger, leading to an increase in the probability of over-aggressive behaviour by more than 25 percentage points.

TABLE 2 | Determinants of the probability of over-aggressive behaviour: logistic regressions and linear probability models.

	RE Logit 1	LPM 1	RE Logit 2	LPM 2	RE Logit 3	LPM 3
<i>RPE</i>	0.478*** (0.087)	0.069*** (0.020)	0.845*** (0.100)	0.099*** (0.020)	0.893*** (0.163)	0.080*** (0.020)
<i>Behind</i>			2.194*** (0.111)	0.269*** (0.026)	2.238*** (0.161)	0.251*** (0.028)
<i>RPE × Behind</i>					-0.078 (0.205)	0.037 (0.028)
Intercept	-1.728*** (0.145)	0.245*** (0.020)	-3.318*** (0.195)	0.095*** (0.019)	-3.347*** (0.211)	0.105*** (0.017)
Num. of Obs.	3546	3546	3546	3546	3546	3546
AIC	3491.7	4363.1	3015.8	4032.6	3017.7	4033.0
BIC	3510.3	4381.6	3040.5	4057.3	3048.5	4063.9

Note: Significance levels at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Logistic regressions (RE Logit 1–3): Coefficients are in log-odds for intercept and log-odds ratios for predictors. Linear Probability models (LPM 1–3): Dependent variable $Pr(Y_{ji} = 1)$. Coefficients are in the marginal probabilities. Cluster-robust standard errors (for LPMs) are in parentheses.

4.3 | Robustness Checks

As with any experiment, it is inevitable to make certain decisions regarding the experimental design and the type of empirical analysis of the data. Therefore, to check the robustness of our results, we perform some additional analyses. The results of these additional analyses are presented in Appendix C. Because we used a within-subjects design in which subjects had to make decisions related to both APE-based compensation and RPE-based compensation, it could matter whether they received one form of compensation first and then the other, or vice versa. In other words, there may be concerns about potential order effects. For example, Huck and Wallace (2002) provide some evidence of aspiration effects: once subjects have experienced symmetric payoffs, they are not easily forced into an unfavourable position. These aspiration effects could affect the participants who start with the APE condition. We address this issue in two ways. First, we run our previous analyses while controlling for order effects. The resulting Tables C1–C3 show that the order variable is not statistically significant and does not improve the fit of either of our models.

Second, we run the same analyses only for the subsample of observations with the first exposure to either APE or RPE (i.e., employing a strict between-subject comparison). While we lose some statistical power due to fewer observations, we still observe a significantly higher tendency to engage in overly aggressive behaviour under the RPE contract (Appendix C, Table C4).

Furthermore, in our tests for Hypotheses 2–3b, we account for the nested structure of the data by incorporating random intercepts in our models. The inclusion of subject-specific random effects in a model is generally recommended for the inferences about individual responses (Lee and Nelder 2004), which is a primary objective of our paper. As an additional robustness check, we also run generalised linear mixed models (see Rabe-Hesketh et al. 2000) with random slopes for contracts and ‘behindness’

on individual level.²⁰ While these model specifications do not change the significance or quality of the above conclusions, they slightly increase the magnitude of the predicted effect of the RPE environment. We present the results in Table C5 as part of the Appendix C (Additional tests and robustness checks).

Finally, we take into account the heterogeneity in our data by considering the slope of the individual response curves. Based on our estimates of the α_{i1} parameter for each subject, we are able to identify three groups of participants. Consistent with our theoretical considerations, we find negatively sloped response curves for 141 participants. However, there are also 39 participants with positively sloped response curves and for 17 participants, we find a random pattern (see Appendix A, Table A1 for the demographic details of each group).

Figure 4 shows the average individual response curve estimates for the groups of participants with negatively and positively sloped best-response curves. Not surprisingly, for the group of participants with negatively sloped response curves, the chosen quantities are considerably closer to the theoretical predictions than for the other group. However, even for these 141 participants, our estimates show that RPE compensation increases the probability that subjects act over-aggressively (see Table C6, Appendix C). Moreover, the estimated coefficient of the interaction term ($RPE \times Behind$) is now statistically significant ($p < 0.01$). Thus, for this group of subjects, we find empirical evidence that the RPE reward system has a stronger positive effect on the probability of over-aggressive behaviour when the subject’s company is in an unfavourable position (Hypothesis 3b).

Our estimates suggest that 20% of subjects have a positively sloped best response curve, which could be explained by a strong preference for fairness in this group of subjects. Choosing the same quantity as the Stackelberg leader in their response plans ensures that, with APE compensation, both the leader and the follower receive the same payoffs.²¹ This

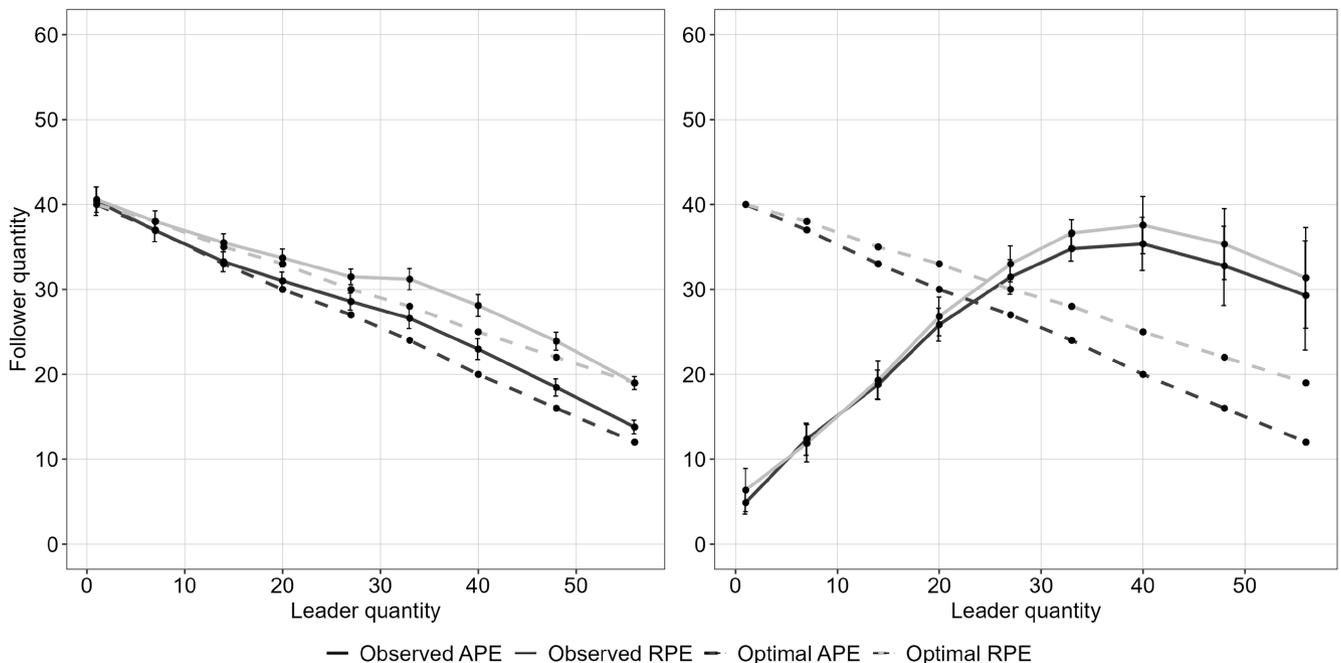


FIGURE 4 | Observed average responses for two groups of subjects with positively and negatively sloped response curves.

explanation is also supported by the fact that we find little difference between the average response curves for APE and RPE contracts in this group.

5 | Discussion

In this study, we conduct an online lab-in-the-field experiment to investigate how managerial behaviour is affected by RPE-based compensation compared with APE-based compensation. More specifically, we examine the causal effect of the RPE compensation scheme on followers' strategies in a Stackelberg duopoly market. Our experimental results support our first hypothesis, showing that managers under the RPE compensation scheme choose higher output levels than managers under the APE compensation scheme. According to the literature on strategic delegation, this change in managerial behaviour is the primary justification for the use of competitor-oriented incentives (Vickers 1985; Salas Fumas 1992).

However, the exploratory analysis suggests that managers overreact to these incentives. Subjects in our experiment deviate from optimal behaviour under both compensation schemes, but the RPE-based contract, in particular, has resulted in over-aggressive output levels. Thus, we conclusively reject our second hypothesis that the likelihood that managers will act over-aggressively is *lower* in an RPE-based compensation system than in an APE-based one. We also investigate if managers are more prone to over-aggressive choices when their firm is in a disadvantageous position and whether the RPE-based compensation system amplifies this effect. Our data confirms our Hypothesis 3a and shows spiteful behaviour under both contracts: when their firm's profits lag behind a rival's, participants were significantly more likely to sacrifice their own compensation to harm the competitor. This finding is in line with previous studies of experimental markets (e.g., Müller and Tan 2011; Cardella and Chiu 2012), which document spiteful behaviour under standard Stackelberg setting (i.e., APE). While we do not find evidence that RPE has a more substantial effect on over-aggression when a manager's firm is in a disadvantageous position (Hypothesis 3b), its effect on aggressive behaviour remains present.

In summary, our results suggest that RPE-based compensation drives highly aggressive market decisions, hurting both firm profits and managers' pay. Although our experiment focuses on identifying the causal effects of RPE- versus APE-based compensation schemes on managerial decision-making, our results also contribute to the literature on strategic delegation (Vickers 1985; Jansen et al. 2008) and the literature on the effects of competitor-oriented objectives on firm performance (Armstrong and Collopy 1996; Armstrong and Green 2007; Griffith and Rust 1997). According to our findings, the use of RPE-based compensation systems as a strategic instrument in oligopolistic competition could backfire, as aggressive managers could choose extreme production levels that exceed the levels expected by the owners and thereby reduce their company's profits. Aggressive managers may even perceive RPE-based compensation systems as a signal from the owner that their aggressive behaviour is desirable. In this case, business owners would essentially be adding fuel to the fire. Our results may thus

explain the observation that competitor-oriented objectives are associated with reduced profitability of firms (Armstrong and Green 2007). These conclusions, although derived in a quantity-setting duopoly context, are likely robust to other types of strategic interactions, such as heterogeneous price competition. In the latter scenario, aggressive managerial decisions would manifest as suboptimally low prices rather than excessively high quantities; however, we would expect the behavioural deviations induced by RPE-based incentives to remain broadly consistent with our results.

While our study has links to previous experimental studies in the field of strategic delegation, it differs from those studies in two respects. First, we investigate the impact of an RPE-based compensation scheme. Previous studies examined other remuneration schemes, such as a sales bonus in a Cournot duopoly (Huck et al. 2004) or a revenue bonus in a mixed duopoly (Du et al. 2013). Second, we also use a different experimental design. We focus on the effects of compensation systems on managers' decisions, whereas previous studies on strategic delegation focused on firm owners' decisions. Methodologically, this means that our results can be interpreted causally as the assignment of the subjects to the two compensation systems is exogenous (randomised). In contrast, in previous studies, subjects (firm owners) determined the compensation system for other subjects (managers).

Moreover, our study also contributes to the literature dealing with the link between executive compensation based on RPE and incentives to engage in costly sabotage Harbring and Irlenbusch (2011); Harbring et al. (2007). While most of this literature addresses RPE and sabotage *within* firms, RPE-based compensation systems can also incentivise costly sabotage against other firms. For example, Bloomfield et al. (2023)[p.2] note that 'in the context of CEO compensation, costly sabotage would likely take the form of overly aggressive product market strategies, such as sub-optimally low prices, extreme output volumes, or excessive advertising spending'. The authors argue that such actions harm the value of companies making use of RPE-based compensation schemes and may explain the 'RPE puzzle', that is, the reluctance of firm owners to use RPE as a basis for CEO compensation. Using firm-level data, Bloomfield et al. (2023) provide empirical evidence of an influence of cartel membership on the likelihood of using RPE in CEO compensation, particularly in concentrated markets. However, their findings present only indirect evidence for a relationship between RPE and interfirm sabotage.²² In addition, these results do not prove a causal link between compensation based on RPE and management decisions, as it is not possible to identify such links based on firm-level observational data. By contrast, our experimental design allows direct identification of the causal effects of RPE-based compensation and provides complete observability of management decisions, making it easier to detect cases of costly sabotage.

Our findings are most relevant to practitioners as they highlight the unintended side effects of RPE-based compensation systems. Such schemes can amplify managers' tendency towards over-aggressive behaviour—already observed without competitor-oriented incentives (Armstrong and Collopy 1996)—leading to larger deviations from

profit-maximising decisions. Recent theoretical models that explore RPE in different market settings (e.g., Tanaka 2014; Hamamura 2020; Hamamura and Ramani 2022; Xu et al. 2024) are based on the crucial assumption that managers are agents who maximise their compensation and that firm owners can perfectly predict their response to the RPE bonus. Our experimental results challenge this, as they show that the observed deviations from the assumption of compensation maximisation are not random and occur in particular when compensation is based on RPE contracts. RPE bonus payments lead to overly aggressive quantity decisions and, thus, lower firm profits. Business owners should, therefore, consider the potential adverse effects before adopting RPE-based executive pay. However, our findings also imply that introducing RPE-based compensation schemes improves allocative efficiency. In oligopoly markets, managers' over-aggressive (i.e., more competitive) market choices would lead to falling prices and, thus, higher consumer surplus. In this respect, antitrust authorities might be sympathetic to the introduction of such compensation schemes. Furthermore, it could be conjectured that RPE-based contracts could also impact the likelihood of collusive behaviour. However, more research is needed to investigate this.

As with all experimental studies, there are some potentially critical issues with our methodology. We use a specific framework of a game with sequential moves. An alternative approach would be to study managerial decisions in a simultaneous game. A repeated game with simultaneous moves would provide better opportunities for subjects to punish other subjects for their choices. As pointed out by Brandts and Charness (2011), the extent of punishment could be substantially lower in the strategy method. However, assuming that RPE-based compensation systems influence punishment behaviour, our measurement of the effects of RPE-based compensation tends to represent the lower bound of what one can expect in games with simultaneous moves. In other words, if the strategy method has a 'cooling' effect and makes over-aggressive behaviour less likely, our experimental design provides a more conservative test of our research hypotheses. Moreover, games with simultaneous moves provide further difficulties in eliciting entire strategies and categorising the managers' responses (Müller and Tan 2011). We, thus, believe that the strategy method is particularly well suited for experimental analyses of the effects of compensation systems on strategic management decisions.

Another potential criticism of our approach is the use of the 'lab-in-the-field' method in the form of an online experiment. While online experiments offer new research opportunities and are becoming increasingly popular, they also carry the risk of reduced control and pose methodological challenges, especially in interactive designs.²³ When conducting online experiments with the general population, it is absolutely crucial that all subjects fully understand the consequences of their decisions, that is, the link between actions and monetary rewards. For this reason, we added a *learning phase* with mandatory comprehension checks before the actual experiment and attention tests during the experiment. Moreover, Arechar et al. (2018) report that behavioural patterns of cooperation and punishment in the laboratory are replicable online. Thus, we are convinced that our online experiment provides valid results.

Finally, the question arises of whether it is possible to learn something about the behaviour of managers in the real world from the behaviour of the subjects in our online experiment. One may question whether our experimental environment is the appropriate testing ground for our hypotheses. We claim that it is, because subjects in our market experiment act as managers who are paid based on their decisions. Beyond that, following the idea of a modified experimental claim by (Bardsley et al. 2010, p. 66), we argue that our experimental environment is in the test domain of the theory unless there is a difference between our experimental environment and the intended domain that can reasonably be expected to make behaviour in the intended domain significantly more consistent with the theory. The question arises whether the subjects in our sample are suitable to test our hypotheses regarding the decision-making of managers incentivised by different types of compensation schemes. Unlike most market experiments, whose participants are students, we employ a general population sample. Although our sample selection addresses the usual criticism of using students as subjects, we still need to consider the possibility that the behaviour of managers in the real world may differ from the behaviour of subjects in our general population sample. In other words, managers in the real world might exhibit less aggressive behaviour, that is, they would tend to choose lower quantities. Armstrong and Collopy (1996), however, show that the tendency to engage in aggressive behaviour is increasing with management education. In addition, recent studies suggest that more competitive individuals are more likely to move into high-level professional or managerial positions (Buser et al. 2024; Urbig et al. 2019). Lastly, reports of the behavioural evaluations of upper management point out the prevalence of narcissistic traits among CEOs that are associated with more antagonistic behaviour (Cragun et al. 2019). In conclusion, existing evidence suggests that real-world managers tend to be more aggressive rather than less aggressive compared with the general population.

6 | Conclusion

The increasing use of RPE-based compensation systems as the basis for executive compensation by organisations, such as the S&P 500 companies, stands in stark contrast to the knowledge of the potential impact of this type of compensation on the behaviour of managers. Although previous research provides some empirical evidence of possible negative effects on the profits of companies that use RPE-based compensation schemes, it has not yet been proven whether this is due to the causal effects of these compensation schemes on executive behaviour.

The results of our experiment show a causal effect of RPE-based compensation schemes on executive behaviour. While the results of our market experiment are consistent with the theoretical predictions based on payoff maximisation, that is, the RPE-based compensation scheme results in higher quantities than the APE-based compensation scheme in quantity competition, we also find evidence that subjects are more likely to sacrifice their own compensation to reduce a competitor's profits, particularly in an RPE-based compensation system. Our results suggest that business owners deciding whether to implement RPE-based compensation systems in their organisations should also consider their potentially undesirable effects on managerial behaviour.

We see our experiment as a solid starting point for future research on the causal effects of RPE-based compensation schemes on managers' decision-making behaviour. One obvious avenue for further research is to analyse data obtained in the context of repeated Cournot competition, which may reveal dynamic strategic patterns or learning effects not observable in one-shot interactions. Another promising direction is to investigate other types of oligopoly markets where the nature of competition differs, for example, price competition or asymmetric strategic settings. While our theoretical framework and results suggest that the core behavioural mechanisms we identify are robust to such changes, experimental validation in these alternative contexts would further strengthen the external validity of our findings. Furthermore, future work could examine whether the over-aggressive behaviour observed in our study is systematically related to unobserved individual characteristics, such as social preferences or competitive orientation.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Endnotes

- ¹ The primary reason for using RPE stems from the 'informativeness principle' (Holmstrom 1979): if agents' efforts are unobservable, all informative signals about agent effort should be included in an optimal contract. See Edmans et al. (2017), Chapter 3.4.1 for the overview of theoretical studies.
- ² See strategic delegation literature, for example, Vickers (1985); Miller and Pazgal (2002); Jansen et al. (2008).
- ³ Note that being 'irrational' takes a different connotation in behavioural economics literature. Economic agents may not choose compensation-maximising actions as they maximise some (potentially unknown) objective function, thus being 'rational' from their own perspective but 'irrational' from a compensation-maximising perspective.
- ⁴ For example, see studies by Armstrong and Collopy (1996), Armstrong and Green (2007).
- ⁵ See Huck et al. (2004); Georgantzis et al. (2008); Du et al. (2013).
- ⁶ Peer groups often include direct competitors, for example, De Angelis and Grinstein (2020) show that 40% of peer firms belong to the same 4-digit Standard Industrial Classification code.
- ⁷ This formulation is also standard in both empirical studies (e.g., Vrettos 2013) and theoretical models of delegation (e.g., Jansen et al. 2008).
- ⁸ We restrict our focus only on cases where $\gamma > 0$, similar to empirical works on RPE, for example, Aggarwal and Samwick (1999a); Vrettos (2013). However, there is some evidence of negative γ (i.e., the RPE bonus is tied *positively* to the profits of the competing firm), which is likely to increase collusive tendencies (Joh 1999).
- ⁹ A strategic delegation model by Miller and Pazgal (2002) assumes managers to have an intrinsic objective function similar to the one in Equation (1). According to this approach, owners choose a certain

type of manager rather than providing explicit monetary incentives for aggressive behaviour.

- ¹⁰ Fehr and Gächter (1998) refer to this phenomenon as behindness aversion (aversion to negative payoff inequality).
- ¹¹ For the comparison between Stackelberg and Cournot games, see Huck et al. (2001).
- ¹² See (Edmans et al. 2017), who report that fixed salaries account for approximately 13% of total CEO compensation.
- ¹³ For higher values of γ , for example, $\gamma = 1$, some of the follower responses would result in negative compensation.
- ¹⁴ The exact best response is $\frac{2660}{83} \approx 32$, but due to discretised action set, the closest is 33.
- ¹⁵ For examples, see Müller and Tan (2011), or Du et al. (2013).
- ¹⁶ For example, Du et al. (2013) also use a calculator, and Requate and Waichman (2011) demonstrate that experimental results in duopoly market games are not significantly different between payoff calculator and payoff table.
- ¹⁷ Sixty-three subjects have not completed the experiment, 67 subjects have failed the attention checks, and three subjects made choices outside the allowed strategy space.
- ¹⁸ Further indirect evidence for the sabotage hypothesis is provided by Feichter et al. (2022) and Bloomfield et al. (2023).
- ¹⁹ Throughout the chapter, linear probability models are estimated with OLS regression. Reported errors are cluster-robust. See Pustejovsky and Tipton (2017) for methodology.
- ²⁰ Following the advice by Sommet and Morselli (2017).
- ²¹ Initially, we have assumed that choosing the same quantity could be the least mentally taxing strategy for participants. Although this conjecture may still be true for some subjects, several participants voluntarily messaged us to describe their strategy as *specifically* based on fairness.
- ²² Further indirect evidence for the sabotage hypothesis is provided by Feichter et al. (2022) and Bloomfield et al. (2023).
- ²³ We discuss various challenges associated with conducting an online experiment and discuss their implications for our experimental design in Appendix B.
- ²⁴ For example, Arechar et al. (2018) find that behavioural patterns of cooperation and punishment are replicable online, which is the main interest of the proposed design.

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Appendix A

Tables

TABLE A1 | Demographics: Overall sample and subsamples.^a

Characteristic	Overall N = 197	Downward slope N = 141	Random slope N = 17	Upward slope N = 39
Gender				
Female	121 (61%)	80 (57%)	11 (65%)	30 (77%)
Male	75 (38%)	61 (43%)	5 (29%)	9 (23%)
No data	1 (0.5%)	0 (0%)	1 (5.9%)	0 (0%)
Country				
Ireland	14 (7.1%)	9 (6.4%)	1 (5.9%)	4 (10%)
United Kingdom	171 (87%)	125 (89%)	14 (82%)	32 (82%)
United States	12 (6.1%)	7 (5.0%)	2 (12%)	3 (7.7%)
Level of education				
Doctorate degree	4 (2.0%)	3 (2.1%)	0 (0%)	1 (2.6%)
Graduate degree	34 (17%)	25 (18%)	4 (24%)	5 (13%)
High school diploma	30 (15%)	21 (15%)	4 (24%)	5 (13%)
No data	32 (16%)	24 (17%)	2 (12%)	6 (15%)
Technical college	15 (7.6%)	10 (7.1%)	2 (12%)	3 (7.7%)
Undergraduate degree	82 (42%)	58 (41%)	5 (29%)	19 (49%)
Student				
No	115 (58%)	80 (57%)	13 (76%)	22 (56%)
No data	34 (17%)	25 (18%)	2 (12%)	7 (18%)
Yes	48 (24%)	36 (26%)	2 (12%)	10 (26%)
Age	31 (25, 41)	31 (24, 41)	33 (24, 42)	31 (28, 37)
Employment status				
Due to start a new job	2 (1.0%)	1 (0.7%)	0 (0%)	1 (2.6%)
Full-time	76 (39%)	52 (37%)	10 (59%)	14 (36%)
No data	34 (17%)	27 (19%)	1 (5.9%)	6 (15%)
Not in paid work	20 (10%)	14 (9.9%)	1 (5.9%)	5 (13%)
Other	13 (6.6%)	11 (7.8%)	0 (0%)	2 (5.1%)
Part-time	30 (15%)	21 (15%)	2 (12%)	7 (18%)
Unemployed (and job seeking)	22 (11%)	15 (11%)	3 (18%)	4 (10%)
Time taken	25 (17, 34)	27 (18, 35)	24 (15, 34)	20 (16, 28)
Bonus	7.00 (4.99, 8.13)	7.00 (4.99, 8.29)	7.21 (5.34, 7.62)	7.00 (4.22, 7.85)

^a n (%); median (IQR).

Appendix B

Challenges of Running Online Experiment

The interface has been programmed using LIONESS platform (Giamattei et al. 2020) along with standard tools for website design (HTML, CSS and JavaScript). The participants were recruited via Prolific.ac (Palan and Schitter 2018). Although online experiments are becoming more acceptable in experimental economics²⁴ and seem inevitable during the COVID-19 restrictions, they also pose considerable challenges from a methodological perspective. This subsection

briefly describes these challenges and explores their implications for the experimental design.

The largest challenge is data quality. While some platforms, such as MTurk, have been criticised for a high incidence of inattentive respondents and automated responses (Webb and Tangney 2022), recent comparative studies find that Prolific performs significantly better in this regard (Peer et al. 2017, 2021). In particular, Douglas et al. (2023) show that Prolific participants are more likely to pass attention checks, provide meaningful responses, follow instructions, and avoid suspicious behaviour (e.g., duplicate IPs or unusually fast

completion times). Nevertheless, concerns about inattentive or automated participation remain. To mitigate these risks, we implemented several checks. First, we included comprehension questions that assessed participants' understanding of the market conditions and the interactive profit calculator. Participants could only proceed if they answered all questions correctly (see Appendix D), ensuring that fully automated responses were not possible. Second, we embedded attention checks during the decision stages, in line with Prolific's guidelines. Third, we utilised Prolific's feature to flag exceptionally fast completions (more than three standard deviations below the mean). Combined, these measures reduced the number of usable observations from 330 to 197, but gave us a high degree of confidence in the quality and reliability of the resulting data.

The second challenge is time constraints. Long experiments and surveys have detrimental effects on response quality (Savage and Waldman 2008) and may be too boring for the participants (Ambler et al. 2021). Additionally, due to Prolific's policy of linking guaranteed payment to median completion time, there was also a cost incentive to decrease the average time for finishing the experiment. We have attempted to do it in two ways. First, we have reduced the strategy space of the leaders to the nine choices indicated in Section 3.1 (compared with 12 choices in Müller and Tan (2011) and Huck et al. (2001)). Second, we have implemented a 'delayed matching' protocol. Suppose a participant finishes the decision stages with no available opponents to match with her. In that case, her responses are stored until the next participant also completes all stages. Thus, she does not have to wait to be matched. These measures decreased the average completion time to 25 minutes and allowed new participants to join the experiment at different times.

Appendix C

Additional Analyses

In our experimental setting, some of the participants started with APE, and some with RPE. 'Order' takes the value 1 for the responses under the initial contract and 0 for the responses for the subsequent contract.

Additional model specifications: We check the robustness of our results with regard to changes in econometric specification. In the main body of the chapter, we have presented the simplest generalised linear mixed model with random intercepts on the individual level. As a robustness check, we also run GLMMs with random coefficients for contracts (η_{1i}) and behindness (η_{2i}). Thus, the complete model could be summarised as

TABLE C1 | Estimated linear response functions of followers (including order effects).

	Model 1	Model 2
Intercept	33.594*** (1.012)	34.379*** (0.968)
Q_L (Leader quantity)	-0.232*** (0.032)	-0.253*** (0.031)
<i>RPE</i>	1.617* (0.777)	
$RPE \times Q_L$ (Leader quantity)	0.060** (0.021)	0.102*** (0.010)
<i>Order</i>	-0.334 (0.388)	-0.288 (0.382)
Num. of Obs.	3546	3546
R^2	0.119	0.117

Note: Significance levels at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Cluster-robust standard errors are in parentheses.

$$\text{Logit}(\text{Pr}(Y_{ij} = 1)) = \beta_{00} + (\beta_{10} + \eta_{1i})RPE_{ij} + (\beta_{20} + \eta_{2i})\text{Behind}_j + \beta_3(RPE_{ij} \times \text{Behind}_j) + \eta_{0i}$$

$$\begin{pmatrix} \beta_{0i} \\ \beta_{1i} \\ \beta_{2i} \end{pmatrix} \sim N \left(\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{\beta_{0i}}^2 & \rho_{\beta_{0i}\beta_{1i}} & \rho_{\beta_{0i}\beta_{2i}} \\ \rho_{\beta_{1i}\beta_{0i}} & \sigma_{\beta_{1i}}^2 & \rho_{\beta_{1i}\beta_{2i}} \\ \rho_{\beta_{2i}\beta_{0i}} & \rho_{\beta_{2i}\beta_{1i}} & \sigma_{\beta_{2i}}^2 \end{pmatrix} \right), \text{ for subject } i = 1..n$$

Table C5 presents this model as well as its variations (i.e., including/excluding the slopes and/or the interaction term ($RPE \times \text{Behind}$)). Our conclusions from Section 4 remain valid under any model specification.

TABLE C2 | Estimated linear response functions of followers (between-subject comparison).

	Model 1	Model 2
Intercept	31.984*** (1.439)	33.185*** (1.041)
Q_L (Leader quantity)	-0.184*** (0.049)	-0.215*** (0.038)
<i>RPE</i>	2.190 (2.066)	
$RPE \times Q_L$ (Leader quantity)	0.036 (0.065)	0.092*** (0.026)
Num. of Obs.	1773	1773
R^2	0.080	0.077

Note: Significance levels at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Cluster-robust standard errors are in parentheses.

TABLE C3 | Determinants of the probability of over-aggressive behaviour: logistic regressions and linear probability models (including order effects).

	RE Logit 1	LPM 1	RE Logit 2	LPM 2
<i>RPE</i>	0.833*** (0.100)	0.097*** (0.020)	0.877*** (0.164)	0.079*** (0.020)
<i>Behind</i>	2.198*** (0.111)	0.269*** (0.026)	2.238*** (0.161)	0.251*** (0.028)
$RPE \times \text{Behind}$			-0.071 (0.205)	0.037 (0.028)
<i>Order</i>	0.178 (0.097)	0.019 (0.020)	0.178 (0.097)	0.019 (0.020)
Intercept	-3.405*** (0.201)	0.086*** (0.021)	-3.432*** (0.217)	0.097*** (0.020)
Num. of Obs.	3546	3546	3546	3546
AIC	3014.5	4032.8	3016.4	4033.2
BIC	3045.4	4063.6	3053.5	4070.2

Note: Significance levels at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Logistic regressions (RE Logit 1–2): Dependent variable $\text{Logit}(\text{Pr}(Y_{ij} = 1))$. Coefficients are in log-odds for intercept and log-odds ratios for predictors. Linear probability models (LPM 1–3): Dependent variable $\text{Pr}(Y_{ij} = 1)$. Coefficients are in the marginal probabilities. Cluster-robust standard errors (for LPMs) are in parentheses.

TABLE C4 | Determinants of the probability of over-aggressive behaviour: logistic regressions and linear probability models (between-subject comparison).

	RE Logit 1	LPM 1	RE Logit 2	LPM 2	RE Logit 3	LPM 3
<i>RPE</i>	0.609* (0.294)	0.082* (0.040)	1.054** (0.378)	0.114** (0.039)	1.690*** (0.461)	0.119*** (0.035)
<i>Behind</i>			2.493*** (0.174)	0.287*** (0.031)	3.089*** (0.307)	0.293*** (0.043)
<i>RPE × Behind</i>					-0.906* (0.359)	-0.011 (0.062)
Intercept	-1.739*** (0.230)	0.247*** (0.028)	-3.624*** (0.332)	0.088*** (0.025)	-4.089*** (0.393)	0.084*** (0.020)
Num. of Obs.	1773	1773	1773	1773	1773	1773
AIC	1838.0	2229.0	1559.0	2045.4	1554.3	2047.4
BIC	1854.4	2245.4	1580.9	2067.4	1581.7	2074.8

Note: Significance levels at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Logistic regressions (RE Logit 1–3): Dependent variable $\text{Logit}(\text{Pr}(Y_{ij} = 1))$. Coefficients are in log-odds for intercept and log-odds ratios for predictors. Linear probability models (LPM 1–3): Dependent variable $\text{Pr}(Y_{ij} = 1)$. Coefficients are in the marginal probabilities. Cluster-robust standard errors (for LPMs) are in parentheses.

TABLE C5 | Determinants of the probability of over-aggressive behaviour: additional model specifications (logistic regressions).

	RE Logit 1	RE Logit 2	RE Logit 3	RE Logit 4	RE Logit 5	RE Logit 6
<i>RPE</i>	0.845*** (0.100)	0.893*** (0.163)	1.286*** (0.245)	1.837*** (0.351)	1.489*** (0.277)	1.783*** (0.369)
<i>Behind</i>	2.194*** (0.111)	2.238*** (0.161)	2.528*** (0.129)	2.913*** (0.217)	2.299*** (0.307)	2.558*** (0.374)
<i>RPE × Behind</i>		-0.078 (0.205)		-0.629* (0.270)		-0.407 (0.326)
Intercept	-3.318*** (0.195)	-3.347*** (0.211)	-4.057*** (0.294)	-4.434*** (0.354)	-4.122*** (0.318)	-4.337*** (0.373)
Num. of Obs.	3546	3546	3546	3546	3546	3546
Random effects:						
Intercept (η_{0i})	✓	✓	✓	✓	✓	✓
Contract (η_{1i})			✓	✓	✓	✓
Behindness (η_{2i})					✓	✓
AIC	3015.8	3017.7	2886.2	2882.7	2671.9	2672.4
BIC	3040.5	3048.5	2923.3	2925.9	2727.5	2734.1

Note: Significance levels at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Coefficients are in log-odds for intercepts, log-odds ratios for predictors.

TABLE C6 | Determinants of the probability of over-aggressive behaviour: logistic regressions and linear probability models (restricted sample analysis: only downward-sloping group).

	RE Logit DS 1	RE Logit DS 2	LPM DS 1	LPM DS 2
<i>RPE</i>	0.947*** (0.129)	0.687*** (0.195)	0.098*** (0.013)	0.060** (0.019)
<i>Behind</i>	1.309*** (0.132)	1.059*** (0.193)	0.136*** (0.013)	0.098*** (0.019)
<i>RPE</i> × <i>Behind</i>		0.443 (0.255)		0.076** (0.026)
Intercept	-3.467*** (0.264)	-3.316*** (0.276)	0.105*** (0.024)	0.126*** (0.025)
Num. of Obs.	2538	2538	2538	2538
AIC	1948.0	1947.0	1919.7	1918.8
BIC	1971.3	1976.2	1948.9	1953.8

Note: Significance levels at * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Logistic regressions (RE Logit DS 1–2) include random intercepts on the individual level. Coefficients are in log-odds for intercept, log-odds ratios for predictors. Linear Probability models (LPM DS 1–2): Dependent variable $Pr(Y_{ij} = 1)$. Coefficients are in the marginal probabilities.

Including the interaction component does not significantly improve the model fit in all but one model specification. The increase in conditional probabilities of observing over-aggressive behaviour under RPE contract ranges from 10% (RE Logit 1) to 13% (RE Logit 6).

Appendix D

Instructions and Screenshots

Experimental instructions are presented in the sequence they are shown to participants (except pages 5–6—as described in the main body of the chapter, the order was randomised for each participant). The content of each page can be summarised as follows:

1. Introduction to the experiment.
2. Learning phase and comprehension checks: Information about the market environment, introduction to the profit calculator and the sliders. By moving the sliders, participants change quantities and receive immediate feedback on the profits of their firm and the other firm's profits. Participants can proceed only after having answered the three control questions correctly.
3. Information about payoffs, matching and exchange rates.
4. Practice round to describe how creating the response plan works. If the information is unclear, participants have an opportunity to see the description again.
5. First payoff-relevant rounds as the follower. This page contains an attention check: 'Please write the following number in this field: 22.'
6. Second payoff-relevant rounds as the follower. This page contains an attention check: 'Please write the following number in this field: 11.'
7. Announcement of Leader Quantity rounds.
8. First payoff-relevant rounds as the leader (there were two rounds like this, but the pages are identical except for the contracts).
9. The final page if the participant has not been matched (i.e., if there were any available participants). Could be refreshed to see if they have been matched.
10. The final page (if the participant has been matched), along with a calculator to check the payoff.