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Contract breach with overconfident expectations: Experimental evidence on reference-dependent preferences

Sabine Fischer [a], Kerstin Grosch [b,*]

[a] Deggendorf Institute of Technology, Dieter-Görlitz-Platz 2, 94469 Deggendorf, Germany
[b] WU Vienna University of Economics and Business, Welthandelsplatz 1, 1020 Vienna, Austria

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ABSTRACT

This study examines the effect of agents' overconfident expectations in their production on their contract breach. Drawing on a reference-dependent framework, we theoretically deduce propositions for compliance to agreements where an agent exhibits overconfidence and loss aversion. We further conduct a lab experiment with a multiple-stage design and find that overconfident agents are more likely to breach the contract than non-overconfident agents. Moreover, overconfident agents breach more often and to a greater extent with increasing loss aversion. We also test the impact of a non-deterministic environment ("shock condition") where payoff misestimation can be masked compared to a deterministic environment ("no-shock condition"). Agents breach more often in the shock condition, but breach extent remains unaffected. Results are mostly in line with the theoretical framework. In a treatment, we manipulate agents' overconfidence exogenously and use it as an instrument to establish causality.

1. Introduction

Being overconfident about one's performance is common and translates into biased payoff expectations in various ways. Overconfident contractors, such as entrepreneurs, overestimate their performance in predicting their sales, expecting overly favorable outcomes in negotiations, or having overly optimistic expectations of successfully navigating their projects (Russo and Schoemaker, 1992; Landier and Thesmar, 2008). Biased performance estimates lead to unrealistic payoff expectations. Expecting to be more productive in the future leads to agents falling short of their payoff expectations once the contract is executed.

In this study, we examine if the deviation between expected and realized payoffs affects compliance behavior through reference payoffs. A class of theories was developed upon the assumption that agents use their payoff expectations as reference points (e.g., Bell, 1985; Loomes and Sugden, 1986; Gul, 1991; Köszegi and Rabin, 2006). These theories suggest that agents are loss averse, meaning that losses are more painful than equivalent gains are rewarding. The utility is then dependent not only on the realized payoff, but also on the payoff expectations to which the agent compares the realized payoff. When the realized payoff falls short of the expected payoff, the agent may feel a subjective loss, which may affect compliance ex-post. The contract in our setting is informal and non-enforceable, similar to an agreement or promise.

* Corresponding author.
E-mail addresses: sabine.fischer@th-deg.de (S. Fischer), kerstin.grosch@wu.ac.at (K. Grosch).

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We deduce propositions from a reference-payoff framework. Within our framework, agents weigh two conflicting motivations: (i) they can alleviate a subjective loss from falling short of the reference payoff by contract breach and (ii) contract breach is associated with moral costs. Increasing individual loss aversion results in higher subjective losses and correspondingly less utility when falling short of the reference payoff (Köszegi and Rabin, 2006). Agents can breach the contract to come closer to, or even meet their expected reference payoff. Hence, we analyze if the level of individual loss aversion moderates the effect of overconfidence on contract breach. A proposition from the framework is that agents are more likely to deviate from contractual agreements when they have overconfident expectations and are loss averse. Moreover, we examine the role of the production environment by varying if it is deterministic, meaning no shocks can affect output ("production shocks"), or non-deterministic, that is, production shocks can occur. These shocks can be positive or negative. For example, there can be technological failures slowing down the production process, health shocks (e.g., Covid, Malaria) or strikes that result in labor shortages, and high price volatility (e.g., supplier prices fall unexpectedly). Even when shocks can be observed, their overall contribution to the outcome may be disputable. Thus, independent of the overall direction of the shock, agents may attribute performance failures to external factors according to their ex-ante beliefs about their performance. This way, agents can justify their breach via the shock, while maintaining their self-image (e.g., Blanton et al., 2001; Köszegi, 2006; Dana et al., 2007; Grossman and Owens, 2012). Consequently, a non-deterministic environment may increase breaches compared to a deterministic environment.

We conduct a laboratory experiment where participants assume the roles of buyer (principal) and seller (agent) in a contract scenario. For theoretical discussion and general conclusions, we use "principal" and "agent" in line with the well-established principal-agent model in economics. When describing the experimental design and results, we refer to "buyer" and "seller" for consistency with the experiment's framing. In the experiment, participants are randomly matched into dyads as either buyer or seller. The buyer invests in the seller's production to enhance the value of the seller's goods, and the seller can reciprocate by selling value-added output to the buyer rather than to a more lucrative outside market. The payoff-structure resembles an investment game with the buyer as the trustor and the seller as the trustee. The sequence of actions in the experiment is as follows. Sellers commit to selling a specific quantity of goods, produced through a real-effort task, to buyers at a predetermined price in a non-enforceable contract. The contract is based on the seller's performance estimate, allowing for biased expectations. Buyers invest in the seller's production if they accept the offer, increasing the seller's unit price for the produced goods. In the final stage, we hypothesize that sellers compare their expected (reference) payoff with their actual payoff, experiencing a subjective loss when they are overconfident. They then decide how much of their output they sell to the buyer. Any goods not sold to the buyer are sold on a more lucrative alternative market, represented by the experimenter. Hence, overconfident sellers can make up for their potential subjective loss by breaching the contract and selling to the alternative market. In this one-shot game, sellers maximize profit by making attractive offers and breaching the contract. However, behavioral economics has shown that people value contracts and consider fairness and others' welfare when they make decisions. Our study examines differences in overconfidence and loss aversion, with the experiment designed to analyze these factors.

Sellers might breach the contract on purpose ("deliberate breach") or unintentionally by promising more goods than they produced ("mechanical breach"). We are interested in agents' opportunistic behavior with varying reference payoffs, focusing on "deliberate breach." We define our outcome variable accordingly.

To identify whether there is a causal effect from overconfidence on contract breach, we inflate expectations in an experimental group by making use of the anchoring bias (Tversky and Kahneman, 1975). The anchoring bias induces individuals to focus on certain (otherwise irrelevant) numbers and they anchor on these for subsequent estimations. In line with vast existing experimental evidence, we confirm that people are susceptible to the anchoring bias independent of individual characteristics/performance from analyses on individual-level data (e.g. Oechssler et al., 2009; Furnham and Boo, 2011). For our main analysis, this instrument fulfills the needed requirements and, thus, is a valid treatment to provide evidence for a cause-and-effect relationship.

We establish the following results. In our sample, overconfident agents are more likely to breach the contract than non-overconfident agents. As expected, the effect is even more pronounced for agents who are overconfident *and* loss averse. When focusing on the violated contracts, the data also support our proposition that loss aversion increases the *extent* of breach for overconfident agents. Moreover, we find that contract deviation increases with higher payoff expectations (i.e., under-/overestimation). This result remains significant once under-/overestimation is instrumented by the anchor treatment, which provides evidence that the effect from under-/overestimation is causal.[1] Moreover, we present several indications that agents, in fact, use their payoff expectations as a reference point, in line with the conceptual framework. Results further suggest that a non-deterministic environment makes breaching more likely than a deterministic environment.

We test our propositions in a lab experiment with students in Ghana, a developing country with a high level of young entrepreneurs between 18 and 34 years of age (41.4%) who often lack funds and access to formal credit markets (Kew et al., 2013). These young entrepreneurs try to raise funds from investors prior to production and in return promise goods or money at a future date. Investors face high risks since entrepreneurs may renege on their obligations and deliver lower quality, demand higher prices, or sell to a more lucrative alternative market. Since external enforcement mechanisms do not function properly in many developing countries (Fafchamps, 1996; Dixit, 2003; Chemin, 2012), our subject pool is particularly interesting for studying opportunistic behavior in this context.[2] The study is also relevant for rich countries in which informal contracts are commonly used to address agency problems in organizational contexts (Malhotra and Murnighan, 2002).

[1] This approach is comparable to Hill et al. (2012) who examine whether observing peers alters the decision to reciprocate in a trust game. By using a treatment, they instrument their explanatory variable of interest and justify therewith that their reported effect is indeed causal.

[2] Furthermore, Henrich et al. (2010) presents a persuasive argument supported by cognitive, anthropological, and behavioral research. It highlights the distinctiveness between WEIRD (an acronym for Western, Educated, Industrialized, Rich, and Democratic countries) and non-WEIRD societies in aspects such as perceptions

The remainder of the paper is organized as follows. We relate our study to the existing literature and highlight our contributions in Section 2. Next, our theoretical framework and its implications are presented in Section 3. The study design is described in Section 4, followed by the presentation of results in Section 5. We discuss the findings in Section 6, and finally, Section 7 provides a summary of the results and discusses potential policy implications.

2. Related literature

A large body of literature investigated the effects of reference-dependent behavior and loss aversion on economic behavior and decision-making. For example, research has demonstrated that customers adjust their consumption behavior (Huang and Liu, 2019), workers decrease their effort level (Abeler et al., 2011), traders reduce their valuation on endowed goods (Marzilli Ericson and Fuster, 2011), golf players invest more focus when going for par (Pope and Schweitzer, 2011), and gamblers gear their lottery choices (Kahneman and Tversky, 1979) to mitigate anticipated losses. These studies primarily emphasize ex-ante behavioral adjustments driven by the anticipation of losses. Limited attention has been given to ex-post behavioral changes that occur after individuals have experienced subjective losses. This aspect of loss aversion, particularly within the context of contract literature, remains relatively unexplored (Köszegi, 2014). Our study makes a contribution to this body of research by investigating the impact of subjective losses on ex-post decision-making.

Numerous other studies investigate whether individuals exhibit more unethical behavior, or more precisely, opportunistic or antisocial behavior, to evade losses. Experimental findings yield mixed results. Some studies show increased engagement in unethical behavior such as cheating, dishonesty, corruption, or criminal conduct in response to loss frames compared to gain frames (e.g., Kern and Chugh, 2009; Grolleau et al., 2016; Baumann et al., 2019; Garbarino et al., 2019; Huynh, 2020; Czibor et al., 2022; Steinel et al., 2022). We contribute to this body of literature by investigating whether an individual's overconfidence bias leads to perceived subjective losses[3] and, consequently, to increased unethical behavior such as breaching contracts to mitigate these losses.

Few studies analyze how subjective gains and losses affect behavior in the contract context. Theoretical (Hart and Moore, 2008) and experimental (Fehr et al., 2011; Hippel and Hoeppner, 2021) studies have demonstrated that agents breach contracts less under rigid terms, (i.e., a contract in which the price for the agent's output is fixed ex-ante) than under flexible terms (i.e., the price is not fixed ex-ante but can vary within a certain range). Under flexible contracts, agents punish the principal when the principal pays a lower price than expected – even though it is costly for the agent. We contribute to the behavioral contract literature by analyzing the effect of reference payoffs stemming from an overconfidence bias on contract breach in a situation where contracts are rigid and opportunistic behavior cannot be hidden.

Köszegi and Rabin (2006) developed a model of reference-dependent preferences based on expectations. They assume that expectation-based reference points build on rational probabilistic beliefs from prior experience which are projected to expected outcomes. Experiments examining status-quo reference points often use a framing approach (loss vs. gain), while studies examining expectation-based reference points in economic decision-making must observe or manipulate expected outcomes. To vary reference points, researchers experimentally induce varying beliefs by lotteries with altering probabilities and/or varying monetary outcomes (e.g., Abeler et al., 2011; Marzilli Ericson and Fuster, 2011; Smith, 2019; Garbarino et al., 2019). We add to this literature by investigating if reference points can form endogenously as a result of a cognitive bias, i.e., from individual overconfidence, and lead to ex-post behavioral change. Our question holds significant relevance because it remains uncertain whether monetary expectations stemming from individual cognitive biases are strong enough to serve as reference points and subsequently influence behavior. Moreover, policy measures aimed at promoting compliance may vary significantly depending on whether the reference payoffs can arise from individuals' internal misperceptions of expected payoffs.

In addition to the literature on reference-dependent behavior, we draw on the literature on performance misjudgment, especially overconfidence. Extensive empirical and experimental evidence demonstrates that people fail in assessing their performance correctly and form overconfident performance expectations (e.g., Tversky and Kahneman, 1975; Kruger and Dunning, 1999; Moore and Healy, 2008; Benoît et al., 2015). Most studies examine the implications of overconfidence for financial markets and managerial decision-making (e.g., Barber and Odean, 2001; Scheinkman and Xiong, 2003), and it has been shown that overconfidence can lead to deadweight losses in markets. Since overconfident agents are more prone to overestimating future market shares, they enter these markets excessively (Camerer and Lovallo, 1999; Koellinger et al., 2007). Overconfidence can also affect contract outcomes: Overconfident job seekers may underestimate the risks involved in certain contracts, misjudge the effort that has to be exerted, and any prospective wage that will be gained. This way, contract and incentive designs are adjusted on the employer's side, and sorting decisions and effort provision are affected on the employee's side by overconfidence, potentially leading to non-optimal outcomes (De la Rosa, 2011; Larkin and Leider, 2012; Santos-Pinto, 2012; Sautmann, 2013; Hoffman and Burks, 2020). We contribute to this literature and demonstrate that overconfidence can result in contract breach when performance misperceptions translate into reference payoffs.

of fairness and equality. These disparities arise from the diverse cultural developmental adaptations across societies. Consequently, we believe that the subject pool enhances the broader applicability of our findings, given that a majority of the global population can be categorized as non-WEIRD.

[3] Whether people consider themselves in a loss or gain domain depends on the reference point to which they compare outcomes. The emergence of reference points and their contextual variations in human cognition remain subject of ongoing controversy (O'Donoghue and Sprenger, 2018). Empirical evidence demonstrates that people adjust their reference points dynamically depending on, for example, the opponents' effort in a competitive situation (Gill and Prowse, 2012) and unfulfilled expectations (Post et al., 2008). Baillon et al. (2019) examine the share of people gravitating to different types of reference points (e.g., status quo, expectation-based). We discuss evidence for reference-dependence in our study at the end of the result section.

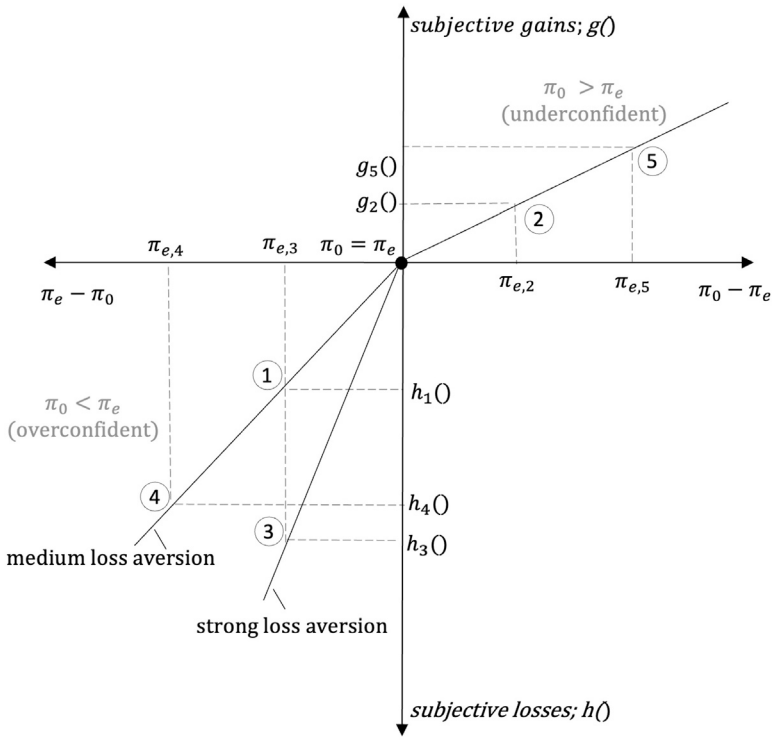

Fig. 1. Subjective losses and gains as a function of payoff expectations.

3. Conceptual framework

This section presents a conceptual framework to deduce behavioral implications for a contract situation with varying reference payoffs and without external enforcement. We use a deterministic model in which utility is reference-dependent and losses loom larger than gains (Kahneman and Tversky, 1979; Köszegi, 2006). Two parties, namely an agent (seller) and a principal (buyer), agree upon a contract determining the agent's sales to the principal. At the agreement time, the agent forms payoff expectations from the contract. Following the theory of expectations-based reference points by Köszegi (2006), we assume the contract's payoff expectation serves as a reference point, resulting in subjective losses when the agent overestimates her payoff. When faced with fulfilling the contract, the agent decides how much to sell to the principal.[4] Breaching the contract, i.e., sideselling products to a more lucrative market, allows agents with overconfident expectations to reduce their subjective losses.

This is illustrated in Fig. 1, where the y-axis represents subjective gains/losses and the x-axis reflects the disparity between the payoff according to the contract (π_0) and the payoff expectations (π_e). When the payoff according to the contract (π_0) is lower than the expected payoff (π_e), agents experience a subjective loss and they fall in the third quadrant. When the payoff according to the contract (π_0) surpasses the expected payoff (π_e), agents experience a subjective gain and fall in the first quadrant. By breaching the contract by an amount π_{br}, agents can reduce the experienced subjective loss or increase the experienced subjective gain, respectively.

We focus on breaching behavior *after* the alleged reference point has formed from the contract. Equation (1) summarizes the agent's utility based on the chosen breaching level, depicted by monetary gain from contract breach π_{br}.

$$U(\pi_{br}) = -\Omega(\pi_{br}) + \begin{cases} h(\lambda, \pi_{br}) & \text{if } \pi_{br} \leq \pi_{overest} \\ h(\lambda, \pi_{overest}) + g(\pi_{br} - \pi_{overest}) & \text{if } \pi_{br} > \pi_{overest} \end{cases} \tag{1}$$

where

[4] We also allow for the possibility to over-fulfill the contract in the experiment to avoid artificial boundaries that bias behavior. The theoretical framework could be easily extended to over-fulfillment without affecting our deduced propositions. However, we refrain from doing so since over-fulfilling contracts are a rare event in our experiment and, most likely, also in reality.

π_{br}	=	agent's payoff from breach, π_{br} can vary between 0 and a maximum amount of $\pi_{br,max}$.
$\pi_{overest}$	=	agent's overestimated payoff, whereas $\pi_{overest} = \pi_e - \pi_0$ for $\pi_e > \pi_0$ and $\pi_{overest} = 0$ for $\pi_0 \geq \pi_e$.
$\Omega()$	=	function for the moral costs from breaching the contract, which increases with the extent of breaching ($\Omega'(\pi_{br}) > 0$ and $\Omega''(\pi_{br}) > 0$) following Garbarino et al. (2019) and depends on a binary variable n which indicates whether the environment is deterministic ($n = 0$) or non-deterministic ($n = 1$). We assume that $\lvert\Omega_{n=1}\rvert < \lvert\Omega_{n=0}\rvert$.
$g()$	=	utility gain from increasing subjective gains with $g'(\pi_{br}) > 0$, $g''(\pi_{br}) = 0$, and $g(0) = 0$.
$h()$	=	utility gain from reducing a subjective loss with $h'(\pi_{br}) > 0$, $h''(\pi_{br}) = 0$, and $h(0) = 0$, while $h()$ is influenced by an individual loss aversion parameter λ so that $h'(\pi_{br}) > g'(\pi_{br})$ for $\lambda > 1$. For agents who are not loss averse, that is when $0 \leq \lambda \leq 1$, $h'(\pi_{br}) = g'(\pi_{br})$.

The agent's utility which is described in equation (1) is influenced by reference-dependent utility associated with gains or losses, denoted by the functions $g()$ and $h()$, respectively. Following prospect theory, we assume that $g()$ and $h()$ are asymmetric, meaning that losses are weighted more heavily than gains. The steepness of the loss function $h()$ rises with an individual's loss aversion parameter λ. Breaching the contract can reduce the utility loss $h()$, with full recovery of the subjective loss occurring when $\pi_{br} = \pi_{overest}$. The additional payoff from breaching ($\pi_{br} - \pi_{overest}$) results in utility gains determined by $g()$. For unbiased and underconfident agents ($\pi_{overest} = 0$), the utility gains are defined solely by $g()$.[5] Agents incur personal moral costs of breaching ($\Omega(\pi_{br}, n)$) which reduce the agents' utility when breaching the contract. Agents' moral costs depend on the extent of breaching (π_{br}), and the environment (n) which can be deterministic or non-deterministic.

In the following, we derive propositions from this conceptual framework. These propositions relate to agents' breach of contracts and are contingent upon the following factors.

1. Varying payoff expectations, which correspond to the type (overconfident vs. unbiased/underconfident agents) and the level of overestimation. In our experimental design, we introduce variation in overestimation with an exogenous (anchor) treatment further described in Section 4.3;
2. Different levels of individual loss aversion, which varies in intensity across people. In the experiment, we use an incentivized measure to elicit loss aversion on an individual level;
3. The type of the environment which can be deterministic or non-deterministic. In the experiment, this variable is varied in the "shock condition" and the "no-shock condition" further described in Section 4.1.

1. Varying payoff expectations. Overconfident agents suffer a subjective loss, underconfident agents experience a subjective gain, and unbiased agents experience neither. An agent breaches the contract when the utility gained from the breach exceeds the utility from not breaching. When $\lambda > 1$, overconfident agents, all else being equal, benefit more from breaching by one unit compared to unbiased or underconfident agents, as the curve in the loss domain is steeper than in the gain domain ($h'(\pi_{br}) > g'(\pi_{br})$). Hence, we expect that overconfident agents have a lower participation constraint to engage in breaching than unbiased or underconfident agents as summarized in Proposition Ia.

Focusing on the extent of breach, overconfident agents may breach their contracts to a higher extent when the gap between their expected and contractually agreed payoffs ($\Delta = \pi_e - \pi_0$) widens. The agent reaches the optimal breach level (π_{br*}) when the marginal benefits from breach offset the marginal moral costs:

$$\Omega'(\pi_{br*}) = \begin{cases} h'(\pi_{br*}) & \text{if } \pi_{br*} < \pi_{overest} \\ g'(\pi_{br*} - \pi_{overest}) & \text{if } \pi_{br*} > \pi_{overest} \end{cases} \tag{2}$$

Overconfident agents end up in the loss domain, where they can reduce their subjective loss by contract breach. Each unit of breach decreases the loss by $h'(\pi_{br})$ until π_{br} equals $\pi_{overest}$. Beyond this point, the benefit of breaching declines to a reduced marginal utility gain $g'(\pi_{br})$ from further breach.

With an increasing difference between expected and actual payoffs, i.e., an increasing level of overconfidence, agents experience higher subjective gains for contract breach. This leads to higher breach levels with increasing overconfidence.

Next, we will describe and illustrate this reasoning with an example which is depicted in Fig. 2. Consider two agents, A and B, identical except for their levels of overconfidence. Agent B's overestimation level is higher by ϵ than that of agent A and $\pi_{B,overest} = \pi_{A,overest} + \epsilon$. In Fig. 2, the marginal utility gain from breaching by reducing the loss for each unit of breach in $h'(\pi_{br})$ is illustrated by the dotted line for agent A and the solid line for agent B. Due to B's greater overconfidence, the range of $h'(\pi_{br})$ is larger for B, extending up to point 2, compared to A, where it extends only up to point 1. When the subjective losses $\pi_{A,overest}$ and $\pi_{B,overest}$ are offset by breach, the marginal utility gain from breach reduces to $g'(\pi_{br})$. The optimal level of breach is at the intersection of the marginal utility gain from breach and the marginal costs $\Omega'(\pi_{br})$ (see equation (2)). Accordingly, agent A's optimal breach level is at point 4 and lower than the optimal breach level of B which is at point 3.[6] Thus, with increasing $\pi_{overest}$ the optimal level of breach π_{br*} also increases due to higher subjective gains from breaching, summarized in Proposition Ib.

[5] Our analysis does not consider diminishing sensitivity since studies by Fehr-Duda et al. (2006) and Gächter et al. (2022) indicate that in experiments with relatively low stakes, most participants demonstrate linear value functions.

[6] This holds true as long as the optimal amount of breach for agent A is larger than her overestimation level ($\pi^A_{br*} > \pi^A_{overest}$) and the difference in overestimation between A and B (ϵ) equals or exceeds $\pi^A_{br*} - \pi^A_{overest}$.

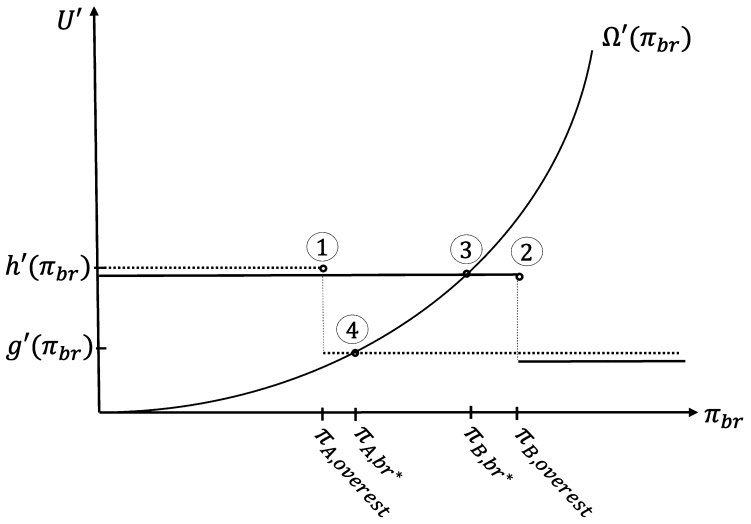

Fig. 2. Optimal level of breach depending on the extent of overestimation.

Proposition I. *a) When agents are loss averse, overconfident agents have a higher propensity to breach contracts compared to non-overconfident agents. (extensive margin) b) Overconfident agents who breach the contract, breach to a larger extent with an increasing divergence between their payoff expectations and their payoff according to the contract. (intensive margin)*

Different levels of individual loss aversion.

Next, we discuss expectations for breaching depending on the agents' individual loss aversion and their under-/overestimation. Stronger loss aversion (λ_s) steepens the loss function, so overconfident agents with similar expected payoffs experience greater subjective losses – and thus gain more from breaching – than those with medium loss aversion (λ_m): $h'_{\lambda_s}(\bar{\pi_{br}}) > h'_{\lambda_m}(\bar{\pi_{br}})$. Fig. 1 illustrates how varying degrees of loss aversion, contingent on agents' overestimation, influence subjective losses by comparing the encircled points 1 and 3. For a given expected payoff $\pi_{e,3}$, an agent with medium loss aversion incurs a loss denoted by $h_1()$, which is smaller than the loss incurred by an agent with strong loss aversion ($h_3()$). Overconfident agents with stronger loss aversion perceive greater gains from breaching, more easily offsetting moral costs. Hence, they are more likely to breach, as stated in Proposition IIa.

Focusing on the extent of breach, we expect that overconfident agents breach contracts also to a higher extent with a more pronounced loss aversion: Equation (2) shows that the optimal breach level occurs when the marginal benefits equal the marginal costs of breaching. In the loss domain, higher loss aversion is associated with higher marginal costs $h'()$. When $\pi_{br} < \pi_{overest}$, the optimal amount of breach is determined by $h'()$ which is higher for more loss averse agents than $g'()$ until $\pi_{br*} = \pi_{overest}$, all else being equal. When $\pi_{br*} > \pi_{overest}$, the parameter λ does not influence the breach level within the framework, as loss aversion does not affect the costs/benefits in the gain domain $g'()$.

Proposition II. *a) Overconfident agents have a higher propensity to breach with more pronounced individual loss aversion. (extensive margin) b) Overconfident agents who breach the contract, breach it to a higher extent with higher loss aversion, conditional on their overestimation. (intensive margin)*

The impact of a (non-)deterministic environment. The moral costs of breaching ($\Omega()$) may depend on the type of environment. A non-deterministic environment provides latitude, and agents can shift their accountability for the breaching action to the environmental conditions, avoid negative self-signals from failing to meet expectations, and do not have to update their self-concept (Sackeim and Gur, 1979; Köszegi, 2006; Dana et al., 2007). Hence, the moral costs $\Omega(\pi_{br}, n)$ may be reduced within a non-deterministic environment with an exogenous production shock compared to a deterministic environment. Therefore, we expect that agents in a non-deterministic environment will be more likely to breach the contract and will breach to a higher extent than sellers in a deterministic environment.

Proposition III. *Agents are more likely to breach in a non-deterministic environment and will breach the contract to a higher extent than agents in a deterministic environment.*

4. Study design

We conducted an experiment comprising a brief pre-survey, individual preference elicitation, the core contract experiment, and a subsequent ex-post questionnaire. The study was implemented on tablets using the software "oTree" (Chen et al., 2016). Sessions lasted approximately 120 minutes and students were paid, in total, approximately GHS 44 ($11), including a show-up fee of GHS 20.

Payments varied between GHS 22 and GHS 90. In our sample (N = 172), subjects reported an average disposable monthly income of GHS 265 (25th percentile: 100, median: 200, 75th percentile: 300). This suggests that the experimental stakes were high for most of the subjects.

In Subsection 4.1, we describe the core of the study, the contract experiment, and then demonstrate in Subsection 4.2 how performance misperception corresponds to subjective losses/gains. To test for causal inference, we use an anchor treatment described in Subsection 4.3, followed by further information on the definition of contract breach in our study (Subsection 4.4), and procedures and elicitation of preferences including loss aversion (Subsection 4.5). We conclude the section with the description of participant recruitment and the study sample (Subsection 4.6). Complete instructions can be found in section D in the Online Appendix available here.

4.1. Contract experiment

The experimental setup depicts a contract situation with voluntary agreements. Our applied procedure of allowing subjects to choose their preferred contract (if any), is common practice when studying behavior after contract conclusion (e.g., Fehr et al., 2011; Bartling and Schmidt, 2015). Moreover, voluntary agreements largely rule out a confound from agents' breaching due to potentially perceived unfairness of contracts. We ensured that the contract conditions were attractive across different groups and we do not find selection bias (Section A in the Online Appendix). We framed the experiment, e.g., by calling the agent "seller" and the principal "buyer", to increase understanding (Alekseev et al., 2017). All subjects were informed about the sequence of actions in advance. We explain the experiment's sequence of actions step by step in the following.

1. Real-effort task and performance estimate. Sellers work on 25 puzzles with four possible answers each. We explain to them that correctly solved puzzles correspond to produced goods. In the experimental instructions, the produced goods are labeled as "low-value goods" and worth GHS 0.20. We opted for a difficult task, as studies indicate that difficult tasks generate higher individual overestimation (e.g., Larrick et al., 2007; Moore and Healy, 2008). Time is limited to 15 seconds per task and the first answer is always logged in as a default to avoid the opportunity of strategically-acting participants who skip all tasks enabling them to perfectly assess their performance post hoc. Afterward, sellers estimate their performance, that is, the number of correctly solved puzzles, and earn an additional GHS 5 if their estimate is correct.[7]

2. Contract offer. After estimating their performance, sellers can make an offer to the buyer and, if so, decide on how *many* goods they want to offer. The upper limit for the offer is their estimated performance/production. Only if the buyer accepts the seller's offer and invests in her production the value of the goods is enhanced, i.e. low-value goods are transformed into high-value goods. Sellers earn GHS 1 per high-value good sold to the buyer or GHS 2.50 by selling to the alternative market. Without buyer investment, high-value goods are not produced. Low-value goods can only be sold to the alternative market at GHS 0.20 each.[8] We provide sellers with a calculation table to facilitate payoff calculations and to ensure that sellers make informed decisions.

3. Contract acceptance. Buyers, on the other hand, receive an endowment of GHS 4. They can decide to invest it in the seller's production to enhance the production value or to keep the endowment. In the rare event of a seller not offering a contract (5% of sellers), the buyer keeps the endowment, the buyer and the seller are informed about their payoffs, and the contract experiment ends. The value of the seller's production cannot be "enhanced" and goods are only worth GHS 0.20 at the alternative market.

Buyers learn about sellers' performance in the "trial phase" of the real-effort task to make an informed decision.[9] They also learn about the number of goods the seller offers to them. If a buyer accepts the contract, GHS 4 is invested in the seller's production. The buyer receives GHS 1 for each good sold from the seller.

4. Information about total output and occurrence of a production shock. After contract conclusion, both sellers and buyers are informed about the actual total output and whether a production shock occurred. The total output corresponds to the real performance in the real-effort task unless a shock has affected production. A shock affects the production with a 50% chance and output is either topped up by two goods or reduced by two goods (each case is equally likely). The two parties learn whether a shock has occurred ("shock condition") or not ("no-shock condition") and the resulting total output is displayed. In the shock condition, subjects are not informed about the real performance or the direction of the shock (positive or negative) but only about the resulting total output to allow for performance misperception. The shock and no-shock conditions had identical instructions, with all subjects aware of the probability that a shock could affect their production.

5. Selling of goods. To remind parties of the details of the agreed-upon contract, the contract is summarized and displayed. Thereafter,

[7] Other studies on overconfidence with different research focuses (e.g., belief updating) often elicit guesses before the task. We chose to elicit performance estimates after the task to maintain control over the reference point. Specifically, subjects' initial expectations (ex-ante estimates) may align with their actual experience during the task, but for others, their perception may shift – feeling better or worse than expected. If estimates were given ex-ante, some might mentally adjust them during the task, creating an unobservable reference point. Eliciting ex-post estimates ensures consistency and control.

[8] We made the contract with the buyer very attractive deliberately since the only reason for an experimental design with voluntary contract agreements is to mitigate confounds based on unfair/unwanted contracts. 95% of sellers made a voluntary offer demonstrating that this approach was successful.
The price structure was a design decision that allows us to observe sellers' opportunistic behavior but may also reflect real-life incentives. The price in the alternative market is higher than the price that the buyer pays for a good once a contract is concluded. In real life, when buyers invest in the seller's production, buyers pay lower prices to redeem the investment compared to prices offered at the spot market. This creates a moral hazard situation and sellers can be tempted to sell to the alternative market.

[9] The design of the trial phase is similar to the actual contract stage. The style of the puzzles is similar as well as the payment, which is GHS 0.20 per solved puzzle. Participants had not learnt about the contract experiment in this trial phase, yet. Therefore, we do not consider it strictly as an element of the core experimental design.

sellers can decide on the number of goods they ultimately want to sell to the buyer. We provide sellers (again) with a calculation table though this time the payoff expectation and the realized payoff when complying with the contract are displayed at the top of the screen to make the alleged reference point salient. Sellers then decide how many goods of their total output they want to sell to the buyer and the alternative market.

4.2. Under-/overestimation as a proxy for subjective losses/gains

In the previous section, we derived propositions for the effect of different levels of expected payoffs (π_e) on contract compliance. In our design, expected payoffs result from the sellers' performance estimate (P_{exp}):

$$\pi_e = Q_{offered} * GHS1 + (P_{exp} - Q_{offered}) * GHS2.5, \tag{3}$$

where π_e is the expected payoff, $Q_{offered}$ is the seller's offered number of goods, and P_{exp} is the performance estimate. The agent's payoff according to the agreed-upon contract is

$$\pi_0 = Q_{offered} * GHS1 + (P_i - Q_{offered}) * GHS2.5, \tag{4}$$

where P_i is the sellers' real performance. We can derive the experienced subjective loss ($\pi_e - \pi_0 > 0$) or the subjective gain ($\pi_e - \pi_0 < 0$), by subtracting the right-hand sides from Equations (3) and (4), respectively. Doing so shows that the subjective gain/loss corresponds with the deviation of the performance estimate from the real performance ($P_{exp} - P_i$), that is a measure under-/overestimation (Moore and Healy, 2008), while offered goods cancel out of the equation. Thus, under-/overestimation ($P_{exp} - P_i$) is an adequate proxy for subjective losses and gains.

4.3. Manipulation of overestimation (anchor treatment)

To exogenously manipulate performance estimates, we use an anchor as an experimental treatment. In the treatment design, we avoided introducing suggestive attributes. Instead, we implement a simple non-incentivized question that was quickly and intuitively replied to by the subjects. In the treatment condition (but not in the control condition), we pose the yes-or-no question "Do you think you have produced more than 20 goods?" just before subjects estimate their performance (step 1 in the contract experiment). The number of 20 goods in the question can serve as an "anchor" that people use for their subsequent judgments, a cognitive bias first theorized by Tversky and Kahneman (1975). This means that participants use the number 20 to make their subsequent performance estimate and start iterating downwards until they reach their final estimate. This way, estimates get biased towards 20 (Tversky and Kahneman, 1975). Recall that sellers worked on 25 puzzles in total. Less than 1% of participants reached a total performance of over 20 goods. We chose the number 20 because we wanted to implement a substantially high anchor to raise performance estimates. Moreover, it is an even focal number that mitigated skepticism and avoided that participants question the purpose of the question. In Subsection 5.2, we demonstrate that the anchor is a valid instrument for under-/overestimation.

4.4. Contract breach

We define contract breach (*breach*) as sellers' deliberate action to shorten the buyer's due by selling the withheld part to the alternative market for a higher profit. Therefore the amount of breach Q_{br} equals the difference between the buyer's due (Q_0) and the amount sold to the buyer (Q_{sold}), so that $Q_{br} = Q_0 - Q_{sold}$. The buyer's due depends on the seller's promised number of goods ($Q_{offered}$) and the seller's total number of produced goods (Q_{total}). Since the actual production may be less than the offered goods, we differentiate two cases:

1. $Q_{offered} \leq Q_{total}$: When sellers can fulfill their promise, that is, the total produced output exceeds the number of promised goods to the buyer, the buyer's due is equal to the number of promised goods ($Q_0 = Q_{offered}$).
2. $Q_{offered} > Q_{total}$: When sellers are unable to fulfill their promise, that is, the number of offered goods to the buyer outnumbers the total produced output, the buyer's due is equal to the total number of produced goods ($Q_0 = Q_{total}$). This definition follows the experimental instructions (slide 157) suggesting that contract compliance requires selling the entire output to the buyer in this case£.

With this definition, we focus on deliberate contract breach as opposed to mechanical breach due to production shortage. Accordingly, we consider sellers as complying with the contract (*compliance*) when they sell the buyer's due, as defined above, to the buyer. Sellers can also sell more goods to the buyer than initially promised, allowing for flexibility in their decision-making. We refer to this incident as *over-fulfillment*.

4.5. General procedures, elicitation of preferences, and ex-post survey

Before starting a lab session, we ensured that the number of participants in the session was even to guarantee one-to-one interactions in the contract experiment. Subjects were fully informed about the entire course of action before they made their decisions. We explained the experiment twice; first with a descriptive text of each step and, second, using mainly pictures. We asked several

Table 1
Estimation types and compliance.

	Non-overconf. [correct[a]]	Overconfident	Total
Compliance	30 (53.57%) [7]	52 (44.83%)	82 (47.67%)
Breach	12 (21.43%) [7]	63 (54.31%)	75 (43.60%)
Over-fulfillment	14 (25.00%) [0]	1 (0.01%)	15 (8.72%)
Total	56 (32.56%) [14]	116 (67.44%)	172 (100.00%)
Test statistic[b] (χ^2 Value)	35.2026		
P-value (χ^2)	< 0.001		

Notes: The sample consists of 172 dyads in total. *Compliance* indicates that sellers sell exactly the buyer's due (see definition in Section 4.4) to the buyer, *breach* that sellers sell less, and *over-fulfillment* that sellers sell more to the buyer than the buyer's due. Out of 172 contracts, 132 have $Q_{offered} < Q_{total}$, indicating that these contracts can be fulfilled, while 40 contracts have $Q_{offered} > Q_{total}$ and sellers cannot meet the contract terms due to lower production. As outlined in section 4.4, we focus on deliberate breach. The column "Non-overconfident" encompasses underconfident and correct estimators. [a]Number of correct estimators. [b]The test statistics compare the two columns for non-overconfident and overconfident sellers.

control questions to make sure that participants understood the experimental sequence.
Before the contract experiment, we elicited (social) preferences to capture the moral costs of breaching (Ω). More precisely, we measured social value orientation (Murphy et al., 2011), risk preferences (Eckel and Grossman, 2002), inequality aversion à la Blanco et al. (2011), and loss aversion à la Gächter et al. (2007, 2022), all in an incentivized way.[10] We use these preferences to confirm that our main variable of interest, *under-/overestimation*, varies with the anchor treatment independent of individual characteristics and as controls in the analysis. Moreover, the measure of loss aversion (λ) allows us to test whether loss aversion amplifies the effect of overestimation at the individual level.[11]
The ex-post questionnaire starts with questions about the experiment such as payoff satisfaction and the sellers' feelings when learning about the realized payoff from the contract. We use this survey data to scrutinize the reference-payoff hypothesis. We also collected data on guilt aversion (Cohen et al., 2011), experience in participating in experiments, and how many other persons the participants knew in the room. At the very end, we asked participants about their socio-demographic background, such as education and income.

4.6. Recruitment and sample

The sample consists of students recruited from the two largest cities in Ghana, the capital Accra and the university city Kumasi. Our study was publicly announced without any reference to the content of the study and students could register for a particular session in advance. To attract participants, we announced a show-up fee of GHS 20 and used non-monetary incentives such as certificates for participation and a free drink for each participant. Overall, the majority of participants were male (approximately 70% men and 30% women). On average, participants were 21 years old and reported a disposable monthly income of GHS 200 (approximately US $40). 51% of the students participated in a lab experiment for the first time.
The data were collected in November and December 2016. In total, we conducted 52 sessions over five weeks at the aforementioned two locations. The sessions comprised between 16 to 24 participants each. We randomized treatments within sessions.[12] In these two conditions, 484 participants took part, that is, 242 sellers and 242 buyers. In total, 186 contracts were concluded. Due to power outages in the field, we lost variables for 14 observations resulting in 172 observations for analysis. Observation numbers in different stages and experimental groups are shown in Table III in section B in the Online Appendix. There are 99 observations in the shock condition and 73 in the no-shock condition. We received ethical approval for this study from the ethical board of Social Sciences at the University of Goettingen (Germany).

5. Data and results

5.1. Descriptive statistics

Table 1 reports compliance decisions across two estimation types: non-overconfident and overconfident sellers. *Overconfident* sellers overestimated their performance, while *non-overconfident* sellers either underestimated or accurately assessed it.

[10] To ensure an independent assessment, we elicited individual preference measures, such as SVO and loss aversion, before the contract experiment. Since this phase was brief and the focus was on the contract experiment, we find it unlikely that it influenced reference points later on.

[11] We acknowledge that the elicitation of loss aversion following the procedure by Gächter et al. (2007) and Gächter et al. (2022) has been debated in the experimental community. However, we selected this approach because it is simple to explain and implement, making it well-suited for our diverse subject pool, which includes participants from various study fields with limited experience in lab experiments. To mitigate concerns about potential biases, we employed a carefully controlled design and avoided framing effects. Notably, this measure has also been used in other studies, such as Koudstaal et al. (2016), reinforcing its relevance.

[12] We implemented four different treatments in total. We analyze data from two treatments in this paper, the control treatment and the anchor treatment. The other two treatments employed exact and noisy performance feedback and are part of a separate study on feedback's impact on performance misjudgment and effort (Fischer et al., 2025). In another companion study, we analyzed gender differences in overconfidence using pre-treatment decisions from the full dataset (N = 1084) of the first stage (trial round), including relative performance estimates, which are not used in the current paper (Grosch and Fischer, 2024).

Table 2
Test of independence for under-/overestimation.

	age	income	share offered	loss aversion	risk seeking	SVO angle	female	econ student
Under-/overest.	-0.026	7.736	-0.009	0.001	-0.001	0.288	0.009	0.000
	(0.033)	(4.106)	(0.017)	(0.033)	(0.029)	(0.258)	(0.007)	(0.007)
Constant	21.387	245.070	3.784	3.857	3.125	26.510	0.280	0.279
	(0.174)	(22.066)	(0.917)	(0.177)	(0.157)	(1.386)	(0.040)	(0.039)
Observations	172	172	172	172	172	172	172	172

Notes: This table reports regression coefficients for under-/overestimation (*under-/overest.*) on the variables age (years), income (in GHS per month), share offered in ultimatum game à la Blanco et al. (2011) (scale from 0 to 8), loss aversion à la Gächter et al. (2007) (scale from 1 to 8), risk seeking by Eckel and Grossman (2002) (scale from 1 to 6), SVO angle by Murphy et al. (2011), female (dummy = 1 if respondent is female), econ student (dummy = 1 if respondent is enrolled in an econ program). The coefficients were estimated in separate OLS regressions. Standard errors are reported in parentheses.

The majority of sellers in the sample (N = 172), 67.44%, overestimate their performance in the real-effort task whereas 32.56% of sellers correctly estimate or underestimate their performance. A histogram of under-/overestimation can be found in Figure I in Section C in the Online Appendix. Overall, we see that 47.67% of sellers comply with their contracts, whereas 43.60% breach the contract, and 8.72% over-fulfill the contract.

In the following, we check whether individual under-/overestimation is independent of individual characteristics and preferences. In Table 2, we present results of OLS regressions from individual characteristics on *under-/overestimation*. The variable *under-/overestimation* is a continuous measure and is calculated by the difference between performance estimation and real performance. The variable is zero for sellers who correctly estimated their performance, positive for overconfident, and negative for underconfident sellers. We see that none of the coefficients are significant, implying that different levels of *under-/overestimation* are independent of social preferences such as Social Value Orientation (*SVO angle*) or inequality aversion (*share offered* in an ultimatum game). The literature suggests that men might be more overconfident than women (e.g., Barber and Odean, 2001). We do not find gender differences in *under-/overestimation* in our sample (Mann-Whitney test, $p = 0.237$).[13] Moreover, students enrolled in an economics program are similar to students enrolled in other programs with regard to *under-/overestimation* (Mann-Whitney test, $p = 0.963$).

The distributions of the sellers' number of offered and sold goods are presented in Figure II in section C in the Online Appendix. The number of offered goods is correlated with the expected output by design (Spearman's Rho = 0.6069, p<0.001). Thus, we will check if our results are robust by controlling for offered goods in upcoming regressions testing our propositions.

5.2. The anchor's validity as an instrument

In the following, we summarize results that prove that the anchor treatment is a valid instrument for under-/overestimation. On average, sellers' estimates are approximately three units higher in the anchor compared to the control group.

In Fig. 3, we show the cumulative distribution functions of under-/overestimation for subjects by experimental group. Although subjects in the anchor group demonstrate higher levels of under-/overestimation (Kolmogorov-Smirnov test, $p = 0.002$), the anchor did not alter the distribution of overestimation. To test that, we reduce individual under-/overestimation in the anchor group by the mean difference to under-/overestimation of the control group (3.092 goods). When comparing the adjusted anchor distribution with the distribution of under-/overestimation in the control, there is no significant difference (Kolmogorov-Smirnov test, $p = 0.311$). Experimental evidence demonstrates that the susceptibility of anchors is independent of various individual characteristics (e.g. Oechssler et al., 2009; Furnham and Boo, 2011). We can confirm that the anchor alters under-/overestimation independent of participants' varying characteristics, preferences, and skills. We tested for heterogeneous effects from the anchor on under-/overestimation for the various covariates that we elicited with a standard OLS model. The covariates include cognitive ability measured by performance in the incentivized trial phase of the production task, SVO angle, share offered in the ultimatum game, loss aversion, and risk-seeking behavior. These characteristics are all insignificant at the 10 percent level. Statistical analyses are available from the authors upon request. We obtain similar results with the causal machine learning approach "double lasso" (Chernozhukov et al., 2018) where we test if the covariates have heterogeneous effects on under-/overestimation. The double lasso drops all covariates confirming that they do not confound the anchor effect on under-/overestimation. As expected, the estimate of the anchor is similar to the descriptive results before. The estimate is 3.092 under the anchor compared to the control which is significant at a 1-percent-level (standard error = 0.6774, $p < 0.001$). Moreover, we do not find differences in contract-related behavior such as selection into contracts across the two experimental groups (see Table I in the Online Appendix). Most importantly, the anchor is a strong instrument for under-/overestimation, as shown by various indicators in Table 3's IV estimations with further explanations in the upcoming subsection.

[13] In the companion study Grosch and Fischer (2024), we conduct an in-depth analysis of gender differences in various forms of overconfidence using the entire dataset, including all treatments.

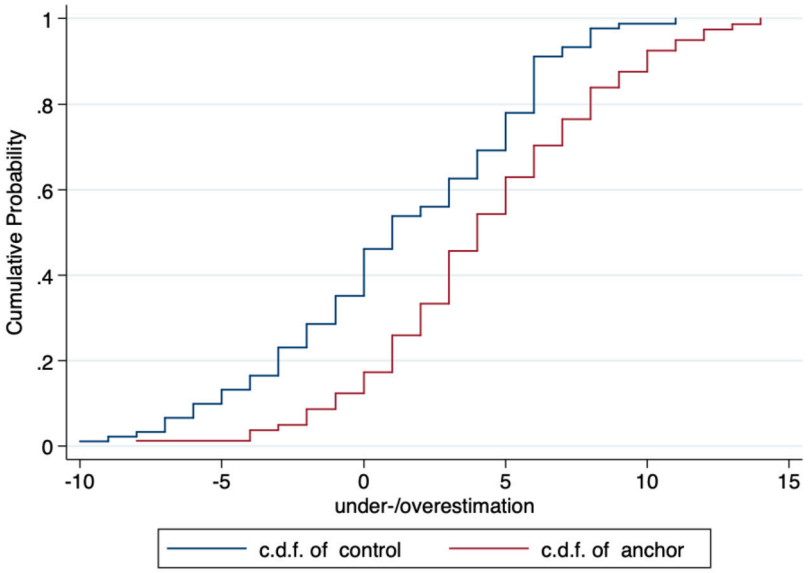

Fig. 3. Cumulative distribution functions of under-/overestimation by experimental groups (N = 172). (For interpretation of the colors in the figure(s), the reader is referred to the web version of this article.)

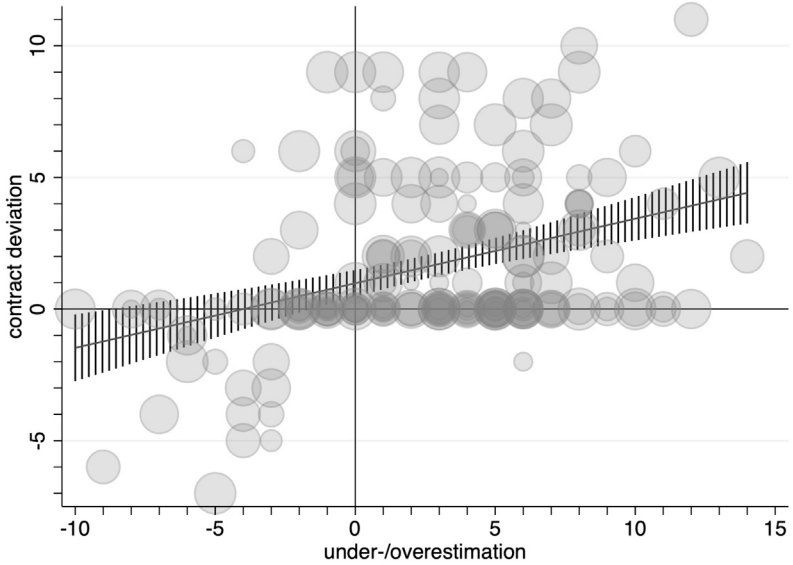

Fig. 4. Association of under-/overestimation and contract deviation with a fitted line and 95% confidence interval (N = 172).

5.3. Estimation results

Does under-/overestimation affect contract deviation?

In Fig. 4, we graphically resume the relationship between under-/overestimation and *contract deviation*. *Contract deviation* combines compliance decisions of *breach* and *over-fulfillment* as defined in Section 4.4, and is positive in cases of *breach* and negative in cases of *over-fulfillment*. Underconfident sellers are positioned to the left of 0 on the x-axis, while overconfident sellers are to the right. Sellers with accurate estimates are plotted on the y-axis. The upward trend of the fitted line suggests that with rising under-/overestimation, contract deviation increases. In the following, we use regression analyses to corroborate the descriptive result.

In Table 3, we present the results from different specifications where the dependent variable is *contract deviation* as defined previously; it is *0* when sellers comply, takes on positive values when sellers breach, and negative values when sellers over-fulfill the contract. Independent variables are the level of *under-/overestimation*, *shock* is an indicator variable that is *1* when a shock affected sellers' output and *0* otherwise, and *performance* is sellers' number of correct tasks. Performance and under-/overestimation are

Table 3
Effect of under-/overestimation on contract deviation.

	(1) OLS	(2) IV	(3) OLS	(4) IV
Under-/overestimation	0.291***	0.433***	0.294***	0.377***
	(0.049)	(0.166)	(0.051)	(0.142)
Shock	0.560	0.575	0.606	0.620
	(0.453)	(0.462)	(0.471)	(0.456)
Performance	0.199***	0.261***	0.165**	0.207**
	(0.061)	(0.086)	(0.072)	(0.088)
Constant	-1.819**	-2.937**	-2.999	-3.687
	(0.809)	(1.411)	(2.978)	(3.186)
Observations	172	172	172	172
Adjusted R-squared	0.165	0.124	0.193	0.179
Fstat		16.51		18.57
WuHausman		0.374		0.576
Covariates[a]	No	No	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Notes: This table presents estimates of OLS regressions in models (1) and (3). Models (2) and (4) present estimates of IV regressions using the anchor treatment as an instrument for under-/overestimation. Coefficients are estimated without (models (1) and (2)) and with covariates (models (3) and (4)). *Under-/overestimation* reflects sellers' performance misperception and ranges from -12 to 19 (negative numbers indicate underestimation, positive numbers overestimation), *Shock* is a dummy variable (1 = shock treatment), and sellers' *performance* in the real-effort task is a continuous variable ranging from 0 to 25
[a] Covariates are described in the notes of Table 2.

moderately correlated (Spearman's rho = −0.3170, $p < 0.001$).[14] We assess multicollinearity using the variance inflation factor (VIF) in the OLS regressions. The VIF for performance is 1.13 in model (1) and 1.34 in model (3), both well below the standard threshold of 5, indicating no collinearity concerns. Models (1) and (3) present OLS regressions where model (1) does not control for covariates but model (3) does. Covariates encompass socio-demographics and (social) preferences (see Table 2). We re-estimated these models with the IV approach in models (2) and (4) where model (2) does not control for covariates but model (4) does. Results from all models demonstrate that with rising *under-/overestimation* contract deviation increases, significant on a 1-percent level. The coefficients vary from 0.291 (model (1)) to 0.433 (model (2)), while model (4) shows, that an increase of one unit in under-/overestimation is associated with a 0.377 unit higher contract deviation. We run an additional robustness check by excluding performance as a regressor, with results presented in Tables V (second-stage) and VI (first-stage) in the Online Appendix. The results remain stable in both significance and magnitude, confirming the robustness of our findings. The instrumental variable (IV) approach uses the anchor treatment as an instrument for under-/overestimation to test whether our measure of under-/overestimation is exogenous. Focusing on the IV regressions, results from the first-stage regression in Table IV in the Online Appendix demonstrate significant effects from the anchor on *under-/overestimation*. To assess the strength of an instrument, it is common practice to check if the F-Statistic is above ten (Staiger and Stock, 1997). Also widely used is the Stock-Yogo weak ID test (Stock and Yogo, 2002), which suggests a minimal possible bias of maximal 10% with an F-Statistic above 16.38. Our data passes both requirements with F-Statistics of 16.51 (model (2)) and 18.57 (model (4)), respectively. The Wu-Hausman test reveals that we cannot reject the hypothesis that the variable *under-/overestimation* is exogenous ($p > 0.374$, models (2) and (4)). Therefore, we conclude that the reported effect from under-/overestimation is causal and exclude omitted variable bias. When variables are exogenous as the results suggest, OLS and probit estimators are preferred over IV estimators and are, thus, the preferred model specifications hereafter.

Result I. *With increasing under-/overestimation, sellers deviate from the contract to a higher extent. Our analysis implies that the relationship between under-/overestimation and contract deviation is causal.*

Performance has a statistically significant positive effect. One reason for the significant link between performance and contract breach could be the rising opportunity costs associated with compliance as performance increases: Evidence has shown that people may cheat more with increasing incentives (e.g. Freeman and Gelber, 2010; Kajackaite and Gneezy, 2017). Therefore, sellers with a relatively high performance/output might be more prone to breach the contract to secure a relatively high payoff from selling more goods to the lucrative alternative market compared to sellers with a relatively low performance/output.
Models (3) and (4) control for covariates. The only covariates that are significant at a 5%-level are *location*, that is, subjects from the university in Kumasi breach less than subjects from the university in Accra (model (4), $p = 0.022$), and the female dummy which is

[14] We include performance as a control in all regressions, as sellers with higher performance levels are less likely to overestimate themselves compared to those with lower performance levels.

Table 4
Probit regressions models on the propensity to breach.

	Contract Breach					
	(1)	(2)	(3)	(4)	(5)	(6)
Overconf. Dummy	0.749***	0.618**	-0.418	0.749***	0.633**	-0.315
	(0.245)	(0.286)	(0.486)	(0.245)	(0.284)	(0.540)
Loss Dummy		0.103	-0.987**			
		(0.262)	(0.492)			
Overconf. Dummy × Loss Dummy			1.532***			
			(0.576)			
Loss Aversion					-0.000	-0.179*
					(0.057)	(0.107)
Overconf. Dummy × Loss Aversion						0.254**
						(0.125)
Performance	0.034	0.002	-0.002	0.034	0.005	0.006
	(0.030)	(0.036)	(0.036)	(0.030)	(0.036)	(0.036)
Shock	0.397*	0.404*	0.449**	0.397*	0.393*	0.429*
	(0.209)	(0.223)	(0.228)	(0.209)	(0.223)	(0.227)
Offered Goods		0.067*	0.064*		0.065*	0.059*
		(0.035)	(0.036)		(0.035)	(0.035)
Constant	-1.240***	-2.344	-1.540	-1.240**	-2.234	-1.326
	(0.479)	(1.569)	(1.581)	(0.479)	(1.595)	(1.643)
Observations	157	157	157	157	157	157
Covariates[a]	No	Yes	Yes	No	Yes	Yes
Pseudo R-squared	0.061	0.138	0.171	0.061	0.137	0.157

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Notes. [a]Covariates are described in the notes of Table 2. Loss aversion is only included in the regression models when explicitly reported in the table.
The dependent variable is 1 if subjects breached the contract according to the definition in Subsection 4.4 and 0 otherwise.

also negative indicating that women breach less than men (model (4), $p = 0.045$). Effects from under-/overestimation remain similar across models with and without controlling for covariates.

Who breaches the contract?

In the following, we analyze the impact of varying payoff expectations and individual loss aversion on the *propensity* to breach the contract compared to complying with the contract (proposition Ia and IIa). Our Proposition Ia compares overconfident and non-overconfident sellers. The *Overconfidence Dummy* in the following regression is 0 for unbiased or underconfident sellers and 1 for overconfident sellers. Overconfident sellers breach the contract significantly *more often* than sellers with underconfident/correct expectations ($\chi^2(1) = 35.624$, $p < 0.001$) in line with Proposition Ia. To corroborate the result, we run regressions. Table 4 presents results of probit model specifications. We do not analyze the effect of underestimation and overestimation on *over-fulfillment* due to only 15 sellers over-fulfilling, implying low statistical power and a high false discovery rate. Models (1) and (2) confirm the overconfidence effect: overconfident individuals are more prone to breach contracts, observed in both models without covariates (model 1) and with covariates (model 2). Hypothesis Ia is expected to hold true for sellers exhibiting loss aversion. Thus, we use our incentivized measurement for loss aversion measured ex-ante the core experiment and categorize sellers into loss averse (loss dummy=1) and sellers who are loss seeking/not loss averse (loss dummy=0) sellers.[15] The interaction effect in model (3) corroborates that overconfident sellers conditional on being loss averse are more likely to breach the contract than overconfident sellers who are not loss averse and/or sellers who are not overconfident.

Result II. *Overconfident sellers have a higher propensity to breach the contract than non-overconfident sellers. This effect is particularly pronounced for sellers who are overconfident and loss averse.*

Next, we evaluate Proposition IIa, positing that greater loss aversion among overconfident sellers increases the likelihood of breaching the contract. Models (4) and (5) show regressions with both the overconfidence dummy and the continuous measure of loss aversion without (model 4) and with covariates (model 5), affirming that overconfident sellers are more prone to breach. In model (6), we observe that increasing levels of loss aversion correspond to an increased likelihood of breach among overconfident sellers, confirming Proposition IIa.

[15] Participants who accepted all or six out of the seven lotteries are categorized as not loss averse or loss seeking, respectively, and assigned a loss dummy value of 0. In lottery seven, the potential gain is 9 GHS and the potential loss is 10.5 GHS, while in lottery six, participants could gain or lose 9 GHS when accepted. Detailed instructions for the lotteries are in the Online Appendix D as well as a histogram of the distribution of loss aversion in Figure IV. According to this categorization, 115 sellers in the regression are loss averse whereas 42 are not.

Table 5
OLS regression models on contract breach.

	Contract Breach					
	(1)	(2)	(3)	(4)	(5)	(6)
Overestimation	0.146	-0.091	-0.222	0.146	-0.241	-0.373*
	(0.096)	(0.170)	(0.190)	(0.096)	(0.186)	(0.199)
Loss Dummy		-0.899	-0.487			
		(1.005)	(1.062)			
Overestimation × Loss Dummy		0.312	0.321			
		(0.190)	(0.205)			
Loss aversion					-0.220	-0.133
					(0.233)	(0.243)
Overestimation × Loss Aversion					0.092**	0.095**
					(0.040)	(0.042)
Underestimation	0.032	-0.038	0.078	0.032	0.038	0.064
	(0.475)	(0.483)	(0.534)	(0.475)	(0.461)	(0.497)
Performance	0.291***	0.281***	0.177	0.291***	0.271***	0.175
	(0.094)	(0.094)	(0.114)	(0.094)	(0.091)	(0.108)
Shock	-0.010	-0.049	-0.428	-0.010	0.076	-0.395
	(0.631)	(0.657)	(0.740)	(0.631)	(0.632)	(0.700)
Offered Goods			0.231**			0.204*
			(0.114)			(0.111)
Constant	0.303	1.035	-4.952	0.303	1.327	-5.032
	(1.503)	(1.654)	(4.368)	(1.503)	(1.733)	(3.803)
Observations	75	75	75	75	75	75
R-squared	0.128	0.163	0.258	0.128	0.201	0.303
Covariates[a]	No	No	Yes	No	No	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Notes. [a]Covariates are described in the notes of Table 2. Loss aversion is included in the regression models only when explicitly reported in the table.
The dependent variable is continuous and follows the definition in Subsection 4.4. The presented regressions focus on subjects who breached the contract (N = 75).

Result III. *Overconfident sellers have a higher propensity to breach the contract with increasing levels of loss aversion corresponding to a higher subjective loss.*

Do higher levels of loss aversion and payoff expectations increase the extent of contract breach?

We analyze whether increasing overestimation and increasing loss aversion affects the extent of contract breach (proposition Ib and IIb) in the following by estimating an OLS model. Thus, the dependent variable is *breach* as defined in subsection 4.4 but we focus on the subjects who breached the contract (N = 75) to match the requirements of the tested proposition. Since we are interested in the effect of the extent of overestimation we introduce the variables *Overestimation* and *Underestimation*. The variable *Overestimation* is 0 for subjects underestimating or correctly estimating their performance and increases continuously with the level of overestimation. Similarly, the variable *Underestimation* is 0 for subjects overestimating or correctly estimating their performance and increases continuously with the level of underestimation. All other independent variables are as defined previously. We expect that overconfident sellers with a pronounced individual loss aversion breach contracts to a higher extent than less overconfident sellers with a less pronounced individual loss aversion.

Results are reported in Table 5. We control for the sellers' offers in models (3) and (6) to account for variation in offers across estimation levels. When we focus on increasing payoff expectations only (Proposition Ib), we do not find an effect (model 1). Being loss averse is also insignificant indicating that loss averse sellers do not breach to a higher extent (model 2). Moreover, the interaction of being loss averse and increasing payoff expectations is insignificant indicating that the extent of breaching is not more pronounced with increasing subjective losses (models 2 and 3), rejecting Hypothesis Ib. However, it is important to avoid overstating the significance of the null result, considering the limited statistical power.

Result IV. *Our results indicate that with increasing payoff expectations, sellers who breach do not breach to a higher extent.*

To test Proposition IIb, we include an interaction term between loss aversion and overestimation (models 5 and 6). We see that the interaction between *overestimation* and *loss aversion* is positive and significant at a 5%-level (model 6).[16] The interaction effect in the OLS regressions demonstrates that in line with Proposition IIb of our conceptual framework, sellers with relatively high subjective

[16] While high individual loss aversion might lead to a decrease in the alleged reference point when people make lower offers to reduce potential losses, our data does not support this line of reasoning. That is, correlations between loss aversion and (i) absolute offers (Spearman's $\rho = 0.0947$, $p = 0.216$), (ii) offers as a percentage of the total performance (Spearman's $\rho = 0.0294$, $p = 0.702$), and (iii) under-/overestimation (Spearman's $\rho = -0.0043$, $p = 0.956$) are all insignificant.

losses induced by inflated payoff expectations and a relatively pronounced loss aversion, breach to a larger extent compared to overconfident people with relatively low subjective losses.

Result V. *With increasing subjective losses (increasing interaction of individual loss aversion and overestimation), overconfident sellers breach the contract to a higher extent. We find no evidence that varying payoff expectations affect the breach extent in the absence of loss aversion.*

Does the occurrence of shocks facilitate contract breach?

We investigate how the occurrence of a shock affects contract breach (Proposition III) in the following. We have argued that the shock condition increases breaching by offering an opportunity to justify unethical actions. In general, when focusing on the frequency of breach, 65.33% of the sellers breach the contract in the shock condition (non-deterministic environment) whereas only 34.67% of sellers breach in the no-shock condition (deterministic environment). This indicates that being in the shock treatment increases the likelihood for breaching the contract which is confirmed by regression analyses as seen in Table 4. However, the effect of the shock is only significant at a 10%-level in the majority of model specifications except model (3). The dummy variable for the shock condition for the sellers who breach (Table 5) is not significant which demonstrates that the shock does not affect the *extent* of breach. Overall, our data suggests that the shock increases the propensity of breach but not the extent of breach, thereby partially confirming Proposition III.

Result VI. *Our data suggests that the occurrence of a production shock increases the likelihood of breaching. However, it does not affect the extent of contract breach.*

Robustness analysis of the contract breach variable

We define contract compliance for sellers unable to fulfill the contract ($Q_{offered} > Q_{total}$) as selling all their goods to the buyer (see Subsection 4.4). We examine whether these sellers differ from those who can fulfill the contract to test the robustness of our contract breach definition.

Among sellers unable to fulfill the contract (N = 40), 45.00% (N = 18) comply by selling all their goods, similar to those who can fulfill it (N = 132, 48.48% compliance). Excluding over-fulfillment (which was not possible for sellers with lower total output than offered), we find no significant difference between sellers who can fulfill and sellers who cannot fulfill the contract ($\chi^2(1) = 1.124,\ p = 0.289$). This suggests that sellers unable to fully honor their contract perceive their total production as the intended output for the buyer.

To test the robustness of our contract definition, we examine whether sellers unable to fulfill the contract breach it differently from those who can by including a dummy variable for fulfillable/non-fulfillable contracts. If our definition was inadequate and should instead be based on a lower threshold than the offered quantity, we would expect higher and/or more frequent breaches among sellers unable to fulfill the contract.

Robustness checks for the preceding tables, presented in Section B (Tables VII – X) of the Online Appendix, show that the dummy variable *Fulfillable Contract* is not significant in any main regression. This indicates that sellers unable to fulfill the contract do not breach more frequently or severely than those who can, based on our definition. As expected, the dummy is only significant in the first stage of the IV regression, reflecting that overconfident sellers are more likely to breach their initial contract.

5.4. Evidence of reference-dependent behavior

Next, we discuss evidence of expectation-based, reference-dependent preferences in our experiment. For this purpose, we first recall the results presented in the previous section. Second, we examine data on sellers' emotions from the ex-post questionnaire. More precisely, we investigate the impact of a subjective loss on their satisfaction with their payoff and their stated disappointment.

Estimation results. We find an effect of overconfidence on contract breach conditional on loss aversion. This effect is robust when controlling for sellers' offers. The perception of a loss only eventuates when sellers compare their status quo with the reference payoff. Thus, this result demonstrates that a negative deviation from payoff expectations, the alleged reference point, is perceived as a loss indicating reference-dependent behavior.

Payoff satisfaction. If sellers compare their realized payoff with the alleged reference payoff, they should be less satisfied with their realized payoff when they fail to reach their reference payoff. In other words, greater subjective losses reduce sellers' satisfaction with the status quo payoff.

In the following, we test the effect of subjective losses/overestimation on payoff satisfaction. We asked sellers "How satisfied are you with your final payoff from the production phase?" in the ex-post questionnaire. They answered on a scale from 1 to 10 where 1 indicated very low satisfaction and 10 very high satisfaction. The distribution of the variable is illustrated in Figure IV the Online Appendix. Results are presented in Table 6. The variable *payoff* entails the final payoff from the contract stage. Model (1) shows that increasing overestimation is associated with decreasing payoff satisfaction. To examine whether overestimation reduces payoff satisfaction for a given payoff level, we include an interaction term of *overestimation* and *payoff*. The interaction effect is negative and statistically significant at a 5% level (models 2 – 4). This suggests that overconfident sellers are indeed less satisfied with their payoff with increasing subjective losses as captured by the variable *overestimation* (see also Subsection 4.2) which is another indication of reference-dependent utility. The results are robust when we include an interaction term of *underestimation* and *payoff* in the models (3) and (4). Moreover, the reported effects are robust when controlling for *contract deviation*, and this variable does not seem to

Table 6
Seller's payoff satisfaction.

	Payoff satisfaction			
	(1)	(2)	(3)	(4)
Overestimation	-0.103**	0.112	0.146	0.146
	(0.050)	(0.106)	(0.115)	(0.115)
Underestimation	-0.076	-0.093	0.163	0.160
	(0.050)	(0.106)	(0.115)	(0.115)
Payoff	-0.013	0.026	0.036	0.037
	(0.027)	(0.031)	(0.034)	(0.038)
Overestimation × *Payoff*		-0.012**	-0.014**	-0.014**
		(0.005)	(0.006)	(0.006)
Underestimation × *Payoff*			-0.011	-0.011
			(0.014)	(0.014)
Performance	0.069	0.052	0.054	0.052
	(0.069)	(0.069)	(0.069)	(0.074)
Shock	-0.015	0.079	0.089	0.089
	(0.298)	(0.296)	(0.297)	(0.298)
Contract deviation				-0.003
				(0.066)
Constant	3.261	2.888	2.676	2.678
	(2.024)	(2.004)	(2.025)	(2.031)
Observations	172	172	172	172
R-squared	0.140	0.168	0.171	0.171
Covariates[a]	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Notes: The table reports estimates of OLS regression models on the sellers' level of payoff satisfaction; a variable from the ex-post questionnaire ranging from 1 to 10. *Payoff* is the final payoff from the contract experiment. *Contract deviation* is defined in Subsection 4.4. All other independent variables are described in the notes of Tables 3 and 4.
[a]Covariates are described in the notes of Table 2.

affect payoff satisfaction (model (4)). In all models, we control for covariates. Generally, economics students are significantly less satisfied with their payoff from the contract stage, and guilt aversion is weakly positively correlated with payoff satisfaction. The other covariates, not presented in the table, are not significant.

Disappointment. In the ex-post questionnaire, we asked sellers how they felt after they learned how much they produced. They could choose between the four answers "I felt disappointed," "I felt joyful," "I was surprised," and "something else." We expected that overconfident sellers would feel more disappointed than sellers who were underconfident or correctly estimated their performance if they indeed used their payoff expectations as a reference payoff, and this is exactly what we find. From 116 overconfident sellers, 43.1% stated that they were disappointed, 28.45% were surprised and 12.93% joyful. In contrast, only four subjects (7.14%) of the 56 non-overconfident sellers felt disappointed, 41.04% were surprised, and 33.93% were joyful. Overall, approximately 16% stated that they felt "something else" than our preset answers. The distribution of stated feelings is significantly different between non-overconfident and overconfident sellers ($\chi^2(1) = 25.955,\ p < 0.001$).
Disappointed sellers also shortchange, on average, 1.5 goods more compared to non-disappointed sellers. This difference is significant using a Mann-Whitney test ($p = 0.002$).[17] This result could be a correlation between people who state that they are disappointed and breach the contract rather than a causal relationship between biased expectations and contract breach. It may also, in fact, indicate that sellers compare their realized payoff with their expected payoff and discharge feelings of disappointment arising from the comparison by breaching (à la Loewenstein and Lerner, 2003).

6. Discussion

Various factors influence when and why individuals respond to reference payoffs. Payoff expectations might simply serve as a goal that agents want to achieve (Oettinger, 1999; Fehr and Goette, 2007). In contract situations, it has been found that agents' feelings of entitlement to a reference payoff affect compliance. When principals withdraw part of the agent's reference payoff, agents feel betrayed and, consequently, breach the contract (Fehr et al., 2011). This does not play a dominant role in our study because *agents* make the contract offer and have the opportunity to betray the principal and not the other way around. Another reason for responding to a reference payoff may be negative emotions such as disappointment or dissatisfaction (e.g. Bell, 1985; Loomes and Sugden, 1986). For this, we find indications in our study as presented in the preceding subsection. Breaching the contract might serve

[17] To test whether disappointed sellers breach more, we created a dummy variable that takes the value 1 if sellers stated that they were disappointed and takes the value *0* if sellers stated "joyful," "surprised," or "something else." We tested whether the means of the absolute breach were different between the two groups with a Mann-Whitney test.

as an "emotion-relieving action" that can counteract the source of disappointment (Loewenstein and Lerner, 2003).
The discussed motives for responding to reference payoffs may be intertwined. Depending on the context of the situation and individual characteristics and preferences one or the other motive may play a more prominent role. Our results, particularly those of Section 5.4, support that emotions such as disappointment and dissatisfaction may explain at least part of behaving non-compliantly. Furthermore, emotions such as elation à la Bell (1985) and Loomes and Sugden (1986) may explain (partly) why underconfident sellers are less likely to breach contracts or even over-fulfill contracts.
It is noticeable that although we investigate a situation where contracts are not enforceable and money-maximizing agents should always breach contracts to a full extent, a rather high share of agents honors their contract. This is in line with findings that people have a general preference for keeping their promises (Vanberg, 2008) and can be interpreted as evidence for contractual agreements to serve as reference points themselves (e.g., Herweg and Schmidt, 2015). This could also explain the missing effects from overestimation/varying payoff expectations on the *extent* of breach. Another reason why the effects of overestimation on contract breach are not pronounced could be explained by the limited internalization of reference points in an experimental setting (Heffetz, 2021). However, our post-experimental survey shows that around 85% of sellers answered yes to the question of whether they compared their realized payoff to their expected payoff before making their final decision.

7. Conclusion

An agent's performance estimate can create a reference point in contract situations. In our lab experiment, we show evidence that agent's overconfidence results in higher reference points by inflating their payoff expectations. This illustrates how reference points can form endogenously through overconfidence. Our study thus contributes to the broader debate in economics on the nature and formation of reference points – whether they can reflect the status quo, expectations, or aspirations (O'Donoghue and Sprenger, 2018). Our results are in line with the theoretical idea that unmet expectations lead to disappointment and a utility loss with increasing individual loss aversion (e.g., Bell, 1985; Loomes and Sugden, 1986; Gul, 1991; Köszegi and Rabin, 2006). Moreover, we find that individual loss aversion increases contract breach when the realized payoff falls short of the reference payoff. Making use of the anchoring bias to manipulate expectations, we show that the effect of over-/underestimation is causal. Multiple indicators support the role of reference-dependent preferences: (i) contract breaches increase with loss aversion among overconfident agents; (ii) overconfident participants report greater disappointment upon learning their actual payoff; and (iii) payoff satisfaction declines with the degree of overestimation. Results for the exogenous production shock are partially consistent with the theory: while breach frequency rises under uncertainty, breach magnitude does not, at least in our data.

Overall, our work contributes to the economic literature trying to better understand the consequences of overconfidence which has been described as "the most significant of the cognitive biases" (Kahneman, 2011). Specifically, our study addresses a gap in the literature by examining the implications of the overconfidence bias. Particularly contract compliance is an important domain to study its consequences since it is a prerequisite for economic growth. We utilize a theoretical and an experimental approach to study the relationship between overconfidence and contract compliance which is novel and contributes to the research domains of contract research, reference-dependent preferences, loss aversion, and unethical behavior.
Our results suggest that contract breach can be reduced by taking the overconfidence bias into account at the time when the principal and agent negotiate the contract, that is, *before* a principal agrees upon a contract with an agent. Principals should not raise unrealistic expectations to avoid spurring agents' overconfidence and high payoff expectations. This may even be more cost-effective than attempts to enforce contracts ex-post. Policies could try to rein in biased beliefs and support people in judging their abilities correctly. Reducing overconfidence not only encourages contract compliance by influencing reference points but also prevents unintended breaches by failing to meet the promised output. In some instances, however, being overconfident may even affect outcomes positively and increase real performance by reducing emotions such as anxiety of failure or by taking precautionary actions to avoid an anticipated loss (Compte and Postlewaite, 2004). Our study design does not allow the investigation of these effects. We leave that open for future research.

Declaration of competing interest

The authors declare that they have no relevant or material financial interests that relate to the research described in this paper. We have received ethical approval from the University of Goettingen for our data collection.

Acknowledgments and Availability of Data & Code

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All data and code required to replicate the results of this study are publicly available on the Open Science Framework (see this link). The replication package includes the dataset, analysis code, experimental instructions, and a comprehensive codebook.

Appendix A. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.geb.2025.05.012.

Data availability

A replication package is available on the Open Science Framework (OSF) under this link: https://osf.io/8tgzj/?view_only=588248d0653b48f4bff4be22c509590b

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