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Short-term vs. Long-term Contracting: Empirical Assessment of the Ratchet Effect in Supply Chain Interaction

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In laboratory experiments, we compare the performance of short-term and long-term contracts in a two-period supplier–buyer dyad with asymmetric cost information. We find that buyers tend to reject offers if the payoff inequality increases from one period to the next. We coin this dynamic form of inequity aversion as “ratcheting aversion.” We show that under short-term contracting, the buyer’s ratcheting aversion limits the supplier’s leeway to exploit information revelation in earlier periods because suppliers fear contract rejections in later periods. As a result, the suppliers’ empirical benefit of offering long-term contracts over short-term contracts is significantly larger than theory predicts. Furthermore, long-term contracts enable supply chain partners to achieve less volatile supply chain performance than short-term contracts because the buyers’ ratcheting aversion leads to more contract rejections under short-term contracting. While normative theory predicts that suppliers should include all future informational rents of the buyers in the first-period offer, thereby creating large payoff differences between periods, we show that it can be behaviorally optimal for the supplier to make offers that lead to more equitable payoffs between periods.

Key words: multi-period interaction; supply chain coordination; behavioral operations management; asymmetric information; menu of contracts

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1. Introduction

The selection of a supply contract is a critical decision faced by firms in a variety of industries. One crucial contracting parameter is the contract term structure. Both short-term and long-term contracts are frequently applied in practice. For instance, General Motors and Alcan have signed a 10-year long-term contract for aluminum supply (Shi and Feng 2016). On the other hand, Hewlett and Packard spent 15% of their purchase expenses for commodities by using short-term contracts on spot markets in 2001 (Carbone 2001). The problem has generally been discussed in terms of a tradeoff between the flexibility offered by short-term contracts and the price uncertainty

reduction achievable by using long-term contracts (Cohen and Agrawal 1999). In this study, we look at the term structure decision from a different angle. We focus on the negotiation and asymmetric information aspects of short-term and long-term contracting.

Negotiation breakdowns are commonly observed in practice and are a serious source of inefficiency in supply chain management with asymmetric information. For example, citing Kaufland’s decreased costs and increased margins, the German retailer Kaufland banished approximately 500 Unilever products from its shelves when Unilever tried to push through drastically higher wholesale prices (Handelsblatt 2018). Repeatedly renegotiated contracts are a case in point for short-term contracting in the field, even if the supply chain partners often prefer to talk about long-term relationships in their official communication. As in the previously mentioned case, volatility and asymmetric information on costs and profit margins drive

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contract adjustments. If supply chain partners prefer to reduce performance volatility at the cost of contractual flexibility, they may commit to long-term contracts (e.g., via contractual penalties). Hence, the negotiation and asymmetric information aspects of supply chain contracting that are the focus of our study constitute one of the numerous reasons why the contract term structure is a prime concern of supply chain managers.

We consider the popular context of a dominant supplier (e.g., a manufacturer) who attempts to coordinate his distribution channel but lacks information on the buyer's cost structure, for example, the retailer's variable processing or handling costs (Corbett and Groote 2000, Corbett et al. 2004, Ha 2001). We assume that the supplier-buyer relationship encompasses a repeated interaction over two consecutive periods. The buyer's privately known cost structure can be either low or high. The supplier utilizes a quantity discount contract to reduce informational rents and efficiency losses from double marginalization. Quantity discounts are among the most widely used contract forms in practice (Munson and Rosenblatt 1998). They are known to increase channel efficiency, allowing self-selected price discrimination and eliminating inefficiencies due to information asymmetry (Burnetas et al. 2007, Corbett and Groote 2000, Jeuland and Shugan 1983). Munson and Rosenblatt (1998) show that quantity discounts are utilized in various industries and usually consist of less than five price breaks in the discount schedules. Optimized quantity discounts provide a menu of contracts with different prices and quantities. The price and quantity levels in the schedules are constructed in a manner that incentivizes buyers to reveal their true types by voluntarily sorting into the corresponding categories. In multi-period settings such as ours, however, buyers with low cost have an incentive not to reveal their type early on if the cost of obfuscation in the early stages is smaller than the benefit of receiving the unadjusted contract in later stages.

In such multi-period settings, the current state-of-the-art recommendation for suppliers is to offer long-term instead of short-term contracts (Laffont and Tirole 1993). While long-term contracts are inefficient ("second best") from the supply chain perspective, they protect suppliers against the low-cost buyer's strategic cover-up strategy ("imitation"). With short-term contracts, a low-cost buyer may try to cover up her true cost by imitating the high-cost signal in period 1 to receive a more profitable contract in period 2. If she does not imitate, a low-cost buyer is susceptible to the "ratchet effect," that is, increasingly disadvantageous contract offers by the seller. Hence, the earlier the buyer releases information on her true cost, the earlier the "ratchet" tightens, leaving no option for

the buyer to return to a profitable short-term contract (i.e., to release the "ratchet" again). Thus, with a short-term contract, a low-cost buyer may have an incentive to conceal her true cost in the early stages, while with a long-term contract, she can reveal her type without fearing later disadvantages from the ratchet effect.

Although long-term contracts protect the suppliers from the buyers' strategic imitation and protect the buyers from the ratchet effect, they have the disadvantage of being theoretically inefficient for the supply chain as a whole. Normative theory predicts that supply chain inefficiency is reduced under short-term contracting because "renegotiations" after an early information revelation stage enable supply chain parties to adjust to an efficient contract. The contract adjustment, however, skews the profit distribution toward the contract offering supply chain party (e.g., the supplier), leaving the other party (e.g., the retailer) worse off than before. Hence, there is a trade-off in choosing the contract term structure. On the one hand, compared to long-term contracts, short-term contracts with information revelation enhance supply chain performance. On the other hand, they increase the skewness of the payoff distribution (i.e., the inequality of profit shares).

From a behavioral perspective, the inequity and volatility of payoffs have often been shown to impede the optimal outcomes predicted by normative theory. To date, there is little research on the behavior of supply chain partners in multi-period settings with asymmetric information, but there is a considerable amount of research on behavior in single-period supply chains. In these static settings, human behavior often departs from the game theoretic prediction. Suppliers usually do not leverage the full benefits of more complex incentive schemes, such as a menu of contracts (Kalkanci et al. 2011, 2014). Furthermore, when confronted with an incentive scheme, buyers often refuse to choose the profit-maximizing contract alternative (Ho and Zhang 2008, Inderfurth et al. 2013, Johnsen et al. 2017***, Lim and Ho 2007). A number of studies show that the buyers' choice behavior is affected by fairness preferences (Loch and Wu 2008, Katok and Pavlov 2013, Kartok et al. 2014, Hartwig et al. 2015***). Inequity averse buyers frequently do not respond as predicted to the mechanism design incentives given by a menu of contracts. These incentives are usually too small to overcome the buyer's aversion toward the differential treatment that is inherent in a menu of contracts (Johnsen et al. 2019). Additionally, short-term contracting with renegotiations requires a high degree of strategic planning, especially if fairness concerns increase the complexity of the contract choices. Previous laboratory experiments with dynamic interaction, however,

show that only very few subjects can be described as forward looking, for example, 5% of the subjects in the experiments of Bostian et al. (2012) and 11.9% in Wu and Chen (2014). If buyers are not forward looking, they may reveal their private information too early and may prefer fairness in myopic or backward looking profit sharing arrangements more than forward looking, non-linear, multiple-period profit sharing arrangements. If sellers are not forward looking, they may be reluctant to offer contracts that provide enough long-term incentives.

We use laboratory experiments to test whether the normative predictions and behavioral conjectures concerning long-term and short-term contracts are sustained in an environment with human decision makers (students). Laboratory experiments allow us to control all the assumptions of the game theoretic models (e.g., price setting, channel structure, outside options), while also enabling us to relax assumptions on the rationality of the supply chain parties and their unique objective to maximize monetary payoffs.

Our results show that suppliers effectively screen buyer types in both short-term and long-term contracting modes. In our experiments, the suppliers' chances of meeting a low-cost or a high-cost type are equally split. Belief elicitation shows that after period 1, suppliers know a buyer's type in 86% and 84% of the cases in long-term and short-term contracting, respectively. While the suppliers leverage this information gain by offering adjusted and efficient contracts in period 2, they largely refrain from offering the exploitive contracts proposed by standard normative theory. Instead, the suppliers tend to offer contracts that allow for substantial profit sharing with low-cost buyers in both periods. They do so mainly to avoid contract rejections by buyers who clearly exhibit ratcheting aversion, that is, a disutility from an increasingly disadvantageous inequity in profits from one period to the next. In a series of detailed estimations, we show that neither classical period-by-period inequity aversion (see, e.g., Bolton and Ockenfels 2000, Fehr and Schmidt 1999) nor aggregated payoff inequity aversion (see, e.g., Oechssler 2013) explain our observations as well as our new model incorporating ratcheting aversion. Our behavioral model with ratcheting aversion also explains why short-term contracting with information revelation in period 1 does not induce the efficient supply chain performance as predicted by normative theory. Although buyers are less forward looking and more likely to reveal their private information in period 1, contrary to the predictions of normative theory, their ratcheting averse preferences lead to inefficiencies due to contract rejections in period 2. These rejections impair supply chain performance and increase the volatility of profits. Hence, in a world with ratcheting aversion, suppliers

are significantly better off with long-term contracts than theoretically predicted, while the buyers' payoffs do not significantly differ between the contract formats.

The study is organized as follows. In section 2, we review the related literature. In section 3, we outline the models for the long-term and short-term contracting modes. We detail our experimental design and research hypotheses in section 4. In section 5, we present the results of our experimental study that compares short-term and long-term contracting. We present our behavioral models and their estimations in section 6 and discuss our results in section 7. Finally, we conclude the article and our results in section 8.

2. Literature Review

There is extant literature discussing the advantages and disadvantages of short-term and long-term contracts. Short-term contracts are usually associated with higher flexibility to respond to the dynamics of the markets, while long-term contracts offer improvement opportunities in product quality and price certainty (Cohen and Agrawal 1999). Several studies investigate the tradeoffs between short-term and long-term contracting modes (Cohen and Agrawal 1999, Kleindorfer and Wu 2003, Li et al. 2009, Peleg et al. 2002, Serel et al. 2001, Talluri and Lee 2010, Xu et al. 2015). In contrast to our study, these models do not consider private information and the resulting strategic effects. The supplier's selling price is usually exogenously given by the market and not a bargaining outcome, as in our game theoretic model.

The literature on supply chain contracting under asymmetric information is extensive. The fields of application range from asymmetric demand information (Cachon and Lariviere 2001, Cai and Di Singham 2018, Desiraju and Moorthy 1997, Özer and Wei 2006) to asymmetric cost information (Baron and Besanko 1984, Çakanyıldırım et al. 2012, Corbett and Groote 2000, Corbett et al. 2004, Davis and Hyndman 2018, Ha 2001, Schöndube-Pirchegger and Schöndube 2012). Chen (2003) provides an excellent survey of this literature. These papers frame interaction in a principal agent model (Fudenberg and Tirole 1991), in which the principal offers a menu of contracts to induce the agents to reveal their private information. However, most of the studies mentioned above consider a static, one-period interaction, which seems reasonable for supply chains that interact infrequently.

The literature on multi-period interactions in supply chains with asymmetric information is still emerging. We can distinguish two streams of literature: one stream considers short-term contracting (Shamir 2013,

Zhang et al. 2010), and another considers long-term contracting (Amornpetchkul et al. 2015, Lobel and Xiao 2017, Ren et al. 2010, Zhang and Zenios, 2007). The methodology and results under short-term and long-term contracting can be drastically different (Zhang et al. 2010). In long-term contracting, it is assumed that the contract-offering supplier can commit himself *ex ante* to the terms of contracts in future periods. In short-term contracting, this assumption is relaxed, which leads to the main result of the short-term literature: the ratchet effect. The ratchet effect describes increasingly disadvantageous contract offers because the supplier can exploit the information revealed to him during previous periods.

Zhang et al. (2010) consider short-term contracts in a multi-period inventory model in which the buyer's inventory level is her private information. Since the buyer's current actions affect the supplier's contract offers in consecutive periods, a buyer may be reluctant to reveal her true inventory levels early on. Using a menu of contracts, Zhang et al. (2010) derive the optimal short-term contracts and demonstrate that in a two-period model, these contracts have significant value over simpler wholesale price contracts. Shamir (2013) considers the supplier's capacity planning under short-term contracts with a manufacturer, who has a private demand forecast that is either high (efficient) or low (inefficient) in all periods of the game. They derive the optimal capacity reservation contracts under two-period short-term contracting. The game theoretical predictions of their model are similar to those in our model, as a supplier exploits the revealed demand information from the buyer's contract choice in period 1 to offer an efficient contract and reap all supply chain profits in period 2. The buyer may be willing to reveal her type if she obtains a high discount in period 1. The supplier prefers long-term contracts that preclude the buyer's imitation strategies, even though these contracts lead to inferior supply chain performance compared to that of a series of short-term contracts. Hence, we believe that the results of our experimental study may additionally provide valuable insight for applications of capacity planning models.

More recently, researchers tested game theoretic (adverse selection) models in laboratory experiments (Inderfurth et al. 2013, Johnsen et al. 2019, Johnsen et al. 2020, Kalkanci et al. 2011, Sadrieh and Voigt 2017). The main insight from this research is that the game theoretic models overstate the supplier's benefits from introducing complex contracting schemes, such as a menu of contracts. One reason for this finding is that the agents frequently refuse to choose the profit-maximizing option from the menu of contracts (Inderfurth et al. 2013). Johnsen et al. (2019) and Kalkanci et al. (2011, 2014) show that a buyer's

fairness preferences can explain this observation. Sadrieh and Voigt (2017) find that subjects have preferences for the simpler contract compared to a more complex menu of contracts because they anticipate the risk of these non-profit-maximizing contract choices. Furthermore, Johnsen et al. (2020) find that subjects who increase the agent's payoff differences between the contract alternatives effectively increase the frequency of the agent's profit-maximizing contract choices. Another reason that game theoretic models may overstate the supplier's benefits is found by Kalkanci et al. (2011, 2014), who let subjects design a menu of contracts. In contrast to the theoretical prediction, they observe that a supplier often does not benefit from contracts that are more complex because subjects have difficulties setting the optimal price breaks. The main point of difference between our experiments and the above-mentioned studies is that we consider a two-period model, while the above-mentioned studies are single-period static models, in which information revelation is not relevant for future periods.

In the behavioral economics literature, only a few researchers have investigated the ratchet effect. Charness et al. (2011) consider a labor market with two types of workers, namely a high-talent type and a low-talent type. In line with the game theory predictions, in their laboratory experiments, they observe a substantial number of high-talent workers, who mimic the low-talent worker type to conceal their type and to avoid increasingly disadvantageous offers in subsequent periods. In contrast, Cooper et al. (1999) find little empirical evidence of the ratchet effect. They consider a two-period interaction between a central planner and a firm manager. Contrary to the game theoretic prediction, they observe that many managers revealed their type in the early stages of the game. They conclude that the incentive schemes that are theoretically susceptible to the ratchet effect empirically work very well in the initial rounds because inefficient imitation emerges only gradually over time. Brahm and Poblete (2017) investigate the behavior of salespersons who face a ratchet effect in a situation in which the better they perform, the more their targets are increased. In a field experiment, they observe that the strategic behavior of salespersons is highly heterogeneous. In particular, salespersons in their first year on the job showed no sign of strategic imitation behavior.

While the focus of these two studies was whether agents anticipate and respond strategically to the ratchet effect, we provide insights into how principals (i.e., the suppliers), knowing that the agents may be imitating to avoid the ratchet effect, adapt their first-period contract offer. Since Cooper et al. (1999) find

that the participants are more sensitive to the strategic implications of the game if it is presented in a business context (e.g., in the context of firm managers and planners) than if it is presented in a generic form, we expect that the supply chain environment in our experiment will enhance strategic play.

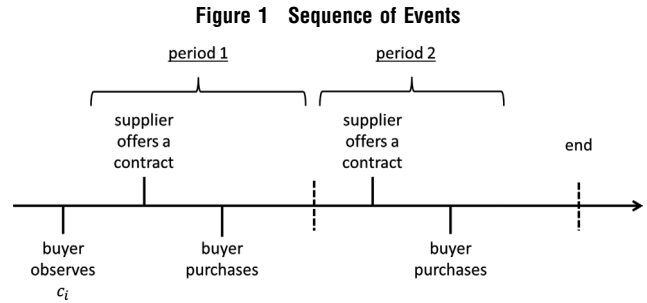
3. Outline of the Model

We consider a two-period distribution channel consisting of a single supplier (denoted by male pronouns) and a single buyer (denoted by female pronouns). At the beginning of each period t , the buyer orders q_t units of a product from the supplier. The supplier produces the product for cost s and sells the product to his buyer for price w_t . The buyer has a unit cost c and sells the products to the customers for a selling price p_t . The costs c and s are assumed to be constant over time. In both periods, customer demand is assumed to be a constant price-sensitive function given by $q(p_t) = d \times p_t^{-2k}$, where $d > 0$ is the scale and $k \geq 1$ is the price elasticity parameter (Weng 1995). We assume $k = 1$. This parameterization ensures that the supplier is willing to trade with the inefficient type, which is central to our research question concerning the dynamic effects of information revelation.¹ The buyer privately observes her costs c . We assume that c can be either low or high, $c \in (c_l, c_h)$. The supplier only has the following prior information: $prob(c = c_l) = \theta_l$, and $prob(c = c_h) = (1 - \theta_l)$. We assume all other parameters to be common knowledge. The supplier is the first mover and offers quantity-price bundles for each period. He can either offer a menu of two bundles, $(q_h, w_h), (q_l, w_l)$, that is, make an offer under asymmetric information, or a single bundle (q, w) , that is, make an offer under full information. If the buyer chooses bundle (q_h, w_h) in period t , it follows that $q_t = q_h$ and $w_t = w_h$. The buyer's profit B_i with cost c_i accepting the bundle (q, w) and the supplier's profit S in each period are given by the following:

$$B_i(q, w) = (p(q) - w - c_i)q \tag{1}$$

$$S(q, w) = (w - s)q \tag{2}$$

Figure 1 summarizes the sequence of events. (a) The buyer observes her private cost information. Her costs do not change during the term of contracting (i.e., over the two periods). (b) The supplier offers a contract in the first selling period. (c) The buyer chooses the quantity and sells the products to her customers. (d) The supplier offers a second contract for the second selling period. Note that as we will describe below, depending on the contracting mode, the supplier's second-period offer may or may not be the same as the first-period offer. (e) The buyer chooses a quantity from the second contract offer and



sells the products to the customers. (f) The relationship ends.

3.1. One-Period Game

We first consider the one-period game, which provides a foundation for the two-period model. We consider both the case of full information and that of asymmetric information.

3.2. Full Information. First—Best Contracts

Under full information, the supplier offers a single quantity-price bundle (q, w) , which the buyer can either accept or reject. The optimal contract offer for a buyer type c_i is the outcome of the following program:

$$\max_{w,q} (w - s)q \tag{3}$$

$$(p(q) - w - c_i)q \geq 0 \tag{4}$$

Constraint (4) ensures the buyer's participation. The solution (q_i^*, w_i^*) maximizes the overall supply chain profits and appropriates all surplus to the supplier. During the course of this study, we denote the supplier's optimal contract bundles (q_l^*, w_l^*) and (q_h^*, w_h^*) as the *fb-low* and *fb-high* contracts, respectively (see Tables 2 and 3 for an example). We summarize the analytical results for this and all following models in Table 17 in Appendix A1.

3.3. Asymmetric Information

To determine the supplier's optimal menu of contracts under asymmetric information, we can restrict our attention to a set of two contracts: (q_h, w_h) and (q_l, w_l) .² The supplier's optimal menu of contracts is obtained by solving the following program:

$$\max_{w_l, w_h, q_l, q_h} \theta_l(w_l - s)q_l + (1 - \theta_l)(w_h - s)q_h \tag{5}$$

$$(p(q_l) - w_l - c_l)q_l \geq (p(q_h) - w_h - c_l)q_h \tag{6}$$

$$(p(q_i) - w_i - c_i)q_i \geq 0 \quad i \in (l, h) \tag{7}$$

The participation constraints (7) ensure that the buyer is willing to accept the contract. The incentive

constraint (6) ensures that the buyer with costs c_i chooses contract (q_l, w_l) and thereby reveals her type. We denote the optimal menu of contracts by (q_l^s, w_l^s) and (q_h^s, w_h^s) . It is well known that only the incentive constraint of the low-cost buyer and the participation constraint of the high-type buyer bind. Thus, the supplier extracts all surplus from the high type, while providing the low-cost buyer with informational rents. Compared to the solution in the full information case, the solution in the asymmetric information case is usually denoted as *second-best* because the quantity q_h^s is downward distorted; that is, $q_h^s < q_h^*$, while q_l^s is efficient and $q_l^s = q_l^*$. Throughout this study, we denote the menu of contracts based on (w_h^s, q_h^s) and (w_l^s, q_l^s) as the *classical* menu of contracts (see Table 4 for an example).

3.4. Two-Period Game

The repeated interaction setting can be distinguished between at least two well-established contracting modes: *long-term contracts* (long-term) and *short-term contracts* (short-term). Under long-term contracts, the supplier and buyer cannot breach or renegotiate the first-period offer. Thus, the supplier offers the same contract in period 2 as that in period 1. The short-term contracts apply to only one period. Thus, the supplier and buyer sign a new contract in every period.

3.5. Short-Term Contracting

We derive the perfect Bayesian equilibrium for the supplier's optimal short-term contract, as in Laffont and Tirole (1987, 1993). The solution concept assumes that (a) in each period, the supplier's contract maximizes his expected profit given his current belief about the buyer's type and (b) the buyer's contract choice maximizes her expected profit, taking into account both her direct profits from the current contract and how her current decision changes the contract to be offered in the future period.

We can distinguish two types of perfect Bayesian equilibria.³ In the revelation equilibrium, the supplier would like to learn the buyer's cost and offer a menu of contracts, (q_h, w_h) , (q_l, w_l) , that induces the buyer to reveal her type. In the imitation equilibrium, the supplier offers only one contract that is accepted by both buyer types and reveals no information on their types. In the following, we present the separating equilibrium. We refer to Appendix Section A2 for the complete outline of our approach.

3.5.1. Second-Period Contract. At the beginning of the second period, the supplier updates his belief about the buyer's type. The supplier's updated belief that the buyer is of type c_l at the beginning of period 2 is denoted by θ_{l2} . A separating equilibrium implies that each buyer type chooses a distinct contract from

the menu of contracts in the first period. The update at the beginning of period 2 is given by the following:

$$\theta_{l2} = \begin{cases} 1 & \text{if the buyer has chosen } (q_l, w_l) \\ 0 & \text{if the buyer has chosen } (q_h, w_h) \end{cases} \quad (8)$$

When the supplier observes the buyer choosing contract (q_h, w_h) in the first period, he concludes that the buyer has high costs. The second-period problem then reduces to the full information scenario, and the supplier offers the efficient *fb-high* contract (q_h^*, w_h^*) . The same line of argumentation follows if the supplier observes the buyer choosing contract (q_l, w_l) . Note that if the low type is offered contract (q_h^*, w_h^*) , she earns an informational rent of $(p_h^* - w_h^* - c_l)q_h^* = \frac{d(c_h - c_l)}{4(c_h + s)^2}$ in the second period (see Appendix A1). If the high-cost buyer is offered contract (q_l^*, w_l^*) , then she incurs a loss in period 2.

3.5.2 First-Period Contract. The supplier's first-period menu of contracts must ensure that both buyer types are willing to reveal their types. As outlined above, only the low type earns a positive informational rent in the second period if she mimics the high type by choosing (q_h, w_h) in the first period. Thus, the supplier needs to include all future informational rents in the first-period offer. Since this makes the contract designed for the low type relatively more attractive, the supplier also needs to set the contract parameters such that the high type does not mimic the low type (Salanié 2005). The first-period contract scheme can be derived from the following program:

$$\max_{w_l, w_h, q_l, q_h} \theta_l(w_l - s)q_l + (1 - \theta_l)(w_h - s)q_h \quad (9)$$

$$(p(q_l) - w_l - c_l)q_l \geq (p(q_h) - w_h - c_l)q_h + \frac{d(c_h - c_l)}{4(c_h + s)^2} \quad (10)$$

$$(p(q_h) - w_h - c_h)q_h > (p(q_l) - w_l - c_h)q_l \quad (11)$$

$$(p(q_i) - w_i - c_i)q_i \geq 0 \quad i \in \{l, h\} \quad (12)$$

The participation constraints (12) ensure that the buyer accepts the scheme regardless of her type. The incentive constraint in (10) ensures that the low type reveals her information in the first period. As shown above, the term $\frac{d(c_h - c_l)}{4(c_h + s)^2}$ describes the low type's second-period profit if she imitates the high type during period 1. Equation (11) is the high-cost buyer's first-period incentive constraint that ensures that the high type chooses contract (q_h, w_h) . We denote the resulting optimal menu of contracts, (q_h^d, w_h^d) , (q_l^d, w_l^d) , as the *dynamic* contract (see Table 5 for an example). Referring

to the solution of the one-period game, the optimal menu is characterized by $q_h^d = q_h^s$, $q_l^d = q_l^s$, $w_h^d = w_h^s$, and $w_l^d < w_l^s$.

3.6. Long-Term Contracting

Salanié (2005) shows that long-term contracting reduces to the static problem of a one-period model. Because the contract is never reconsidered, it is as if the two parties interact only once. The result is intuitive because in such a stationary model, there is no reason to offer a contract that itself is not stationary. Hence, the supplier’s optimal offer resembles the optimal one-period offer, that is, the offer in which (q_h^s, w_h^s) and (q_l^s, w_l^s) are denoted as the classical contract (see Table 4 for an example).

3.7. Comparison between Short-Term and Long-Term Contracts

Table 1 compares the supplier’s, the buyer’s and the supply chain’s profit between short-term and long-term contracting. The main insights are that (a) the supply chain profit increases under short-term contracts, because the renegotiation at the beginning of the second period allows the elimination of the inefficiency generated under the classical menu of contracts. (b) The supplier benefits from a long-term contract because he saves informational rents. (c) The buyer’s informational rents increase under short-term contracting. (d) These additional informational rents appear in the low type’s payoff difference between the two contract alternatives in the first period. This payoff difference is substantial in the short-term contract but marginal under the long-term contract. Throughout this study, given a menu of contracts (q_h, w_h) , (q_l, w_l) , we denote the low type’s payoff difference between these two contract alternatives by $\delta = B_l(q_l, w_l) - B_l(q_h, w_h)$.

3.8. Example

In the following, we present the theoretical solutions based on the parameter values used in our experiments: see section 4. Table 4 presents the normative solution of long-term contracting; that is, it shows the

supplier’s theoretical optimal menu of contracts in the long-term contracting mode. Throughout the study, we denote this menu of contracts proposal as the classical contract. Table 5 shows the theoretically optimal menu of contracts for the first period under short-term contracting. We denote this menu of contracts as the *dynamic* contract. As outlined above, normative theory predicts information revelation in period 1, and thus, the supplier will switch to the first-best contract according to the buyer’s contract choice. The first-best contract for a high-type buyer is presented in Table 2, and the corresponding first-best contract for a low-type buyer is given in Table 3. We designate these contracts as the *normative fb-high* and *normative fb-low* contracts, respectively. Note the following for all contracts: in the case in which the participation or incentive constraint binds, we include a marginal incentive of 0.1 into the constraint. This additional incentive ensures that a rational and profit-maximizing buyer is not indifferent and that the expectation about her choices is not ambiguous. In Tables 4 and 5, we highlight the low type’s *revelation* contract choice with a gray shade. The dotted boxes indicate the low type’s *imitation* contract choice. For example, in the game-theoretic equilibrium of short-term contracting, the low-cost buyer earns $18.3 + 0.1 = 18.4$ units under a revelation strategy and $5.7 + 12.6 = 18.3$ units under an imitation strategy.

4. Experimental Design

Our experiments were conducted during June 2017 at the University of Hamburg, Germany. The subjects were recruited by using the hroot software program (Bock et al. 2014). At the beginning, each subject was randomly assigned a private cubicle in the lab. Written instructions (see Appendix A7) were provided for each subject. The instructions were read aloud, and the subjects had the opportunity to ask questions that were answered privately. The instructions included a numerical example and screenshots of the game stages with detailed descriptions. Every subject was required to pass a comprehension quiz before the experiment began. At the beginning of the game, subjects learned their role. Every subject kept the role throughout the whole experiment.

Table 1 Comparison between Long-Term and Short-Term Contracts

Profit	Comparison between long-term and short-term contracting
Supplier	$\pi_{short}^s = \pi_{long}^s - \frac{\theta_l^2 d(c_h - c_l)^2}{4(c_h + s)^2(c_h + s - \theta_l(c_l + s))}$
Buyer	$\pi_{short}^b = \pi_{long}^b + \frac{\theta_l^2 d(c_h - c_l)^2((1 - \theta_l)(c_h + 2s) + c_h - \theta_l c_l)}{4(c_h + s)^2(c_h + s - \theta_l(c_l - \theta_l s))^2}$
Supply chain	$\pi_{short}^{sc} = \pi_{long}^{sc} + \frac{\theta_l^2 d(c_h - c_l)^2(1 - \theta_l)}{4(c_h + s)(c_h + s - \theta_l(c_l - s))^2}$

Notes: The results are based on the assumption that the supplier is willing to separate the buyer types. Further, it needs to be checked that the incentive constraint (11) is satisfied. See Table 17 in Appendix A1 for the analytical results.

Table 2 Normative fb-high Contract Denoting the Supplier’s Theoretically Optimal Wholesale Price Contract for a Buyer with High Cost

q_h^*	w_h^*	Buyer		Supplier
		c_h	c_l	
5.0	5.0	0.1	12.6	24.9

Table 3 Normative *fb-low* Contract Denoting the Supplier's Theoretically Optimal Wholesale Price Contract for a Buyer with Low Cost

q_i^*	w_i^*	Buyer		Supplier
		c_h	c_l	
20.0	2.5	-44.9	0.1	49.9

Table 4 Classical Contract Denoting the Optimal Menu of Contracts for the Long-Term Contracting Mode

Contract	q_i^s	w_i^s	δ	Buyer's profit		Supplier's profit
				High cost	Low cost	
(q_h^s, w_h^s)	2.22	9.96		0.1	5.7	22.1
(q_l^s, w_l^s)	20.0	2.22	0.1	-44.31	5.8	44.3

Table 5 Dynamic Contract Denoting the Optimal Menu of Contracts for the First Period in the Short-Term Contracting Mode

Contract	q_i^d	w_i^d	δ	Buyer's profit		Supplier's profit
				High cost	Low cost	
(q_h^d, w_h^d)	2.22	9.96		0.1	5.7	22.1
(q_l^d, w_l^d)	20.0	1.59	12.6	-44.31	18.3	31.7

4.1. Sequence-of-Events

The game consists of 20 rounds, and each round consists of the following sequence of events (see Figure 1 in Section 3 for a summary).

In Stage 1, the buyer learns her private information. In Stage 2, the supplier's task consists of proposing a contract to the buyer. The supplier can choose to propose either a menu of contracts with (q_l, w) and (q_h, w_h) or a single first-best contract (q, w) . For the sake of complexity reduction, the supplier only decides about the prices of the proposal, while all quantities are fixed to the theoretical optimal values (i.e., in the menu of contracts, the quantities $q_l = q_l^s = q_l^d$ and $q_h = q_h^s = q_h^d$). In proposing a single contract, the supplier can choose a contract either with $q = q_h^*$, representing an offer designated for a buyer with high cost, or with $q = q_l^*$, representing an offer designated for a buyer with low cost. We denote the single first-best contract based on $q = q_h^*$ as *fb-high* and the single first-best contract based on $q = q_l^*$ as *fb-low*. In the short-term mode, the proposed contracts apply only to the first period. In the long-term mode, the proposal applies to both the first and the second period. In all experiments, we set the default values of the wholesale prices to zero. We allow the wholesale prices to range between 0 and 13. For a wholesale price of 13, regardless of her type and contract choice, the buyer's profit would be strictly negative.

In Stage 3, the buyer chooses one contract from the proposal or she rejects the offer. Note that we automated the buyer's calculation of the selling price; that is, we determined the selling price such that the chosen order quantity is optimally sold to the end customer. In Stage 4, the buyer and the supplier receive a summary of the first period. Both the supplier and the buyer see the supplier's contract proposal, the buyer's contract choice, and their own profit of the first round. Then, the game continues with the second period, during which Stages 5 (supplier's contract proposal), 6 (buyer's contract choice), and 7 (summary) are identical to Stages 2, 3, and 4, respectively. In the treatments that cover a long-term environment, Stage 5 is omitted, and in the second period, the supplier's proposal from stage 2 is offered to the buyer again.

We provide a decision support tool to the supplier in Stages 2 and 5 and to the buyer in Stage 1 (see Instructions in Appendix A7 for an illustration with an example). In Stages 2 and 5, the tool gives the supplier the opportunity to try out several wholesale prices before submitting a decision. The tool shows the profits of each buyer type and the supplier's profit under tentatively submitted wholesale prices and contract type. The tool is structured by three tables, which look similar to Table 4, Table 3, and Table 2. In each table, the cells in the second column refer to the wholesale prices and are input cells; that is, in total, there are four input cells, which allow subjects to enter and change wholesale prices in each contract type. The subjects have two buttons for each table. A gray button updates the profits in the table by using the currently entered wholesale prices. By pushing the red button, a subject submits the corresponding contract type with currently entered wholesale prices. In Stage 1, the decision support tool gives the buyer the opportunity to analyze the potential contract offers of the supplier.

4.2. Belief Elicitation

In the last four rounds, we introduced a belief elicitation at summary Stage 4. We asked the suppliers whether they believed that their buyer had low or high costs. He could answer with a response of either *high cost*, *low cost*, or *indecisive*. We asked the buyer about her second-order belief, that is, what she expects the supplier to believe about her costs. She could answer with a response of either *high cost*, *low cost*, or *indecisive*. We neither incentivize the belief elicitation nor provide the results to the answers. However, because these questions may make the players more sensitive to the strategic implications of the game, we check all statistical tests when omitting the last four rounds. All results remain significant unless stated otherwise.

4.3. Parameters and incentives

In all the treatments, the customer demand is given by $q(p) = 500p^{-2}$. The supplier's production costs are $s = 0$. The buyer's production costs are either $c_l = 2.5$ or $c_h = 5$. The respective probabilities are $\text{prob}(c = c_l) = \theta_l = 0.5$ and $\text{prob}(c = c_h) = 1 - \theta_l = 0.5$. The buyer's cost information changes randomly after each round (but not between periods).⁴ We incentivize the subjects by paying out the sum of profits over all rounds with an exchange rate of 0.02, and the participants can earn 2 EUR for 100 experimental units. The average earnings amount to 15.10 EUR. Each session lasted for approximately 75 minutes.

4.4. Statistical Analysis

To form units of independent observations, we use matching groups of three buyers and three suppliers. We told the subjects that they would be randomly and anonymously re-matched after each round, but we did not tell them that they would be re-matched only within the matching group. Our statistical analysis is based on matching-group averages. We use the non-parametric Mann–Whitney U test and present the two-sided p -values for treatment comparisons, if not stated otherwise. We omit the first five decision rounds in our analysis because we observed learning effects in the supplier's contract offers. All statistical tests remain significant when including all observations unless stated otherwise.

4.5. Pre-study

We administered a pre-study with computerized suppliers. In this study, the (human) buyer knows that the supplier is automated and follows the updating rule as described in (8). The pre-study contains three treatments manipulating either the contract offer in period 1 (the classical contract vs. the dynamic contract) or the contracting mode (short-term vs. long-term). The treatment comparisons reveal that a buyer easily finds the contract in period 1 that maximizes her total profits (sum of profits of period 1 and period 2). In doing so, they confirm a buyer sensitivity to even small payoff differences of 0.1 in total profits when choosing the contract in period 1. Overall, the buyer's contract choices in the pre-study largely support the rational model, while we note that the contract offers of the automated supplier were easily foreseeable, as the programming of the computer was public knowledge and explained before the start of the experiment (see Appendix A3 for details).

4.6. Treatments and Hypotheses

Table 6 summarizes our treatments. The numbers in parentheses describe the number of independent observations per treatment (i.e., the number of

independent matching groups with six subjects). The main manipulation in our experiment is the contracting mode: *long-term* contracting (Long-Term) and *short-term* contracting (Short-Term). In our main treatments, Long-Term and Short-Term, the supplier is unrestricted and freely chooses prices and the contract type. In the CI-Short-Term and Dy-Short-Term treatments, the supplier is restricted to choosing their offers from a set of predefined contract proposals, as detailed below.

Hypotheses 1 and 2 concern the strategic reasoning effects that normatively only play a role in the short-term contracting mode. In this treatment, the supplier should set the payoff difference (δ) between the contract alternatives in period 1 sufficiently high such that the buyer is willing to reveal her type in period 1, while forgoing informational rents in period 2. Because the supplier in the long term has no leeway to leverage information obtained in period 1 for contract offers in period 2, this payoff difference is expected to be lower.

HYPOTHESIS 1. *In the first period, the supplier chooses higher payoff differences δ in the Short-Term than in the Long-Term.*

In the Short-Term, to receive a more favorable contract in the next period, the low-cost buyer may have an incentive imitating a high-cost buyer via the contract choice if the payoff differences between the contract alternatives are too low (i.e., for $0 \leq \delta < 12.6$). In the Long-Term, however, the supplier cannot adjust the contract offer in period 2. Therefore, imitation in period 1 brings no strategic advantage for the buyer in period 2, and we therefore expect less imitation the Long-Term than in the Short-Term.

HYPOTHESIS 2. *The frequency of imitation contract choices in Period 1 is higher in the Short-Term than in the Long-Term.*

Hypotheses 3 and 4 summarize how we expect the supplier to leverage the information revealed in

Table 6 Treatment Overview

Contract offer	Contracting mode	
	Long-term	Short-term
Classical		CI-Short-Term (9)
Dynamic		Dy-Short-Term (9)
Unrestricted	Long-Term(11)	Short-Term (12)

Notes: The numbers in parentheses are the number of independent observations. One independent observation consists of three buyers, and three suppliers each were randomly re-matched in matching groups.

period 1 for use in making contract offers in period 2 in the Short-Term (compared to the Long-Term). On the one hand, the information revelation in period 1 may lead to more efficient contract offers in period 2 (Hypothesis 3) because if the supplier knows the buyer's type, the supplier has no incentive to distort the order size for the high type (q_H). Furthermore, the supplier has an incentive to exploit the information revealed in period 1 by increasing the wholesale prices up to a level at which the low-cost buyer only attains her minimum acceptable profit (Hypothesis 4). Note that such an increase in wholesale prices is not feasible by design in the Long-Term.

HYPOTHESIS 3. *In the second period, the rate of efficient contract offers is higher in the Short-Term than in the Long-Term.*

HYPOTHESIS 4. *In the Short-Term, the wholesale price w in the fb-low contract in period 2 is higher than w_1 in the menu of contracts in period 1.*

Previous research has shown that subjects often have difficulties designing incentive-compatible menus of contracts (Kalkanci et al. 2011, 2014). Therefore, we run two more treatments in which we restrict the supplier to select a contract from a predefined set of theoretically optimal and non-optimal contracts. The main goal is to assess how sensible the results in the Short-term are in light of the supplier's potentially sub-optimal contract offers in period 1. As one extreme, in the Dy-Short-Term treatment, the supplier may offer the *dynamic* menu of contracts that provides normatively ideal incentives for the low-cost buyer to reveal her type (Table 5). As another extreme, in the CI-Short-Term, the supplier may offer the theoretically non-optimal *classical* menu of contracts (Table 4) that provides no incentives at all for the low-cost buyer to reveal her type under short-term contracting.

We expect in Hypothesis 5 that the supplier will identify more easily that offering the menu of contracts is optimal when the incentives are optimally calibrated, as in the Dy-Short-Term, than when the incentives are rather obviously misaligned, as in the CL-Short-Term, or when the parameters are freely chosen, as in the Short-term.

HYPOTHESIS 5. *In the first period, the frequency of menu of contracts selections is higher in the Dy-Short-Term than in the (a) CI-Short-Term and the (b) Short-Term.*

As it is the normatively optimal strategy for the buyer to reveal her type under a menu-of-contracts in the Dy-Short-Term treatment, in this treatment, we expect to observe information revelation more often

than in the situations where incentives are clearly misaligned (as in CL-Short-Term) or potentially misaligned (as in Short-term).

HYPOTHESIS 6. *In the first period, the frequency of the low-cost buyers' revelation choices is (a) higher in the Dy-Short-Term than in the CI-Short-Term and (b) higher in the Dy-Short-Term than in the Short-Term.*

5. Experimental Results

5.1. Does the Supplier Screen the Buyer?

Table 7 summarizes the mean statistics of the supplier's contract type selection for all treatments. Comparing the Long-Term and Short-Term treatments, we find that the supplier has a strong preference for offering a menu of contracts in the first period in both treatments (i.e., 75% in the Short-Term and 82% in Long-Term, $p = 0.50$); this finding corresponds with the game theoretic prediction.

For a treatment, Table 8 compares the mean statistics of wholesale prices and payoff differences δ in the menu of contracts. The results show that wholesale prices are significantly lower than their theoretical counterparts in both the Long-Term and the Short-Term treatments ($p < 0.01$ and $p < 0.01$, respectively). In the Long-Term treatment, we observe a significantly positive payoff difference δ , $p < 0.01$. Furthermore, we observe that the payoff difference δ in the first period is significantly greater in Short-Term than in Long-Term ($p = 0.02$),⁵ and this finding supports Hypothesis 1 that strategic reasoning affects the supplier's contract design. However, the observed payoff difference δ in period 1 of the Short-Term treatment is significantly smaller than theoretically predicted ($p = 0.01$). The normative theory predicts information revelation only in the Long-Term but not in the Short-Term treatment since revelation incentives are too small in the latter.

With regard to the restricted treatment variants, we find that the *classical* menu of contracts (CI-Short-Term) is selected significantly less often than the *dynamic* menu of contracts (Dy-Short-Term); this result is in line with Hypothesis 5a, with $p < 0.01$. In the CI-Short-Term treatment, the suppliers partly prefer to offer the normative fb-high contract in the first period. However, there is still a significant number of menu of contracts selections (57%) that normative theory does not predict. We refer to section 5.2 for an explanation. Moreover, the frequency of menu of contracts selections is slightly higher in the Dy-Short-Term than in Short-Term but the difference is not significant $p = 0.48$ (Hypothesis 5b). This shows that suppliers identify that offering the menu of contracts is optimal in short-term contracting even if contracts are not pre-set at their normatively optimal level.

Table 7 Supplier’s Contract Type Selection

Treatment	Period 1			Period 2		
	Menu of contracts	fb-low	fb-high	Menu of contracts	fb-low	fb-high
Long-Term	0.78 (0.22)	0.03 (0.09)	0.19 (0.22)	0.78 (0.22)	0.03 (0.09)	0.19 (0.22)
Short-Term	0.75 (0.15)	0.09 (0.13)	0.16 (0.15)	0.30 (0.17)	0.29 (0.19)	0.41 (0.14)
Cl-Short-Term	0.57 (0.19)	0.02 (0.02)	0.42 (0.18)	0.30 (0.12)	0.04 (0.03)	0.66 (0.12)
Dy-Short-Term	0.82 (0.17)	0.01 (0.01)	0.18 (0.16)	0.42 (0.16)	0.09 (0.13)	0.49 (0.12)
<i>Equilibrium prediction</i>						
Long-Term	1.00	0.00	0.00	1.00	0.00	0.00
Short-Term	1.00	0.00	0.00	0.50*		0.50
Cl-Short-Term	0.00	0.00	1.00	1.00	0.00	0.00
Dy-Short-Term	1.00	0.00	0.00	0.50*		0.50

Notes: The numbers in the upper four rows present the average rates of contract selections across treatments. The numbers in parentheses are the standard deviations. *Cells are merged since both contracts are efficient.

Table 8 Supplier’s Wholesale Prices

Treatment	Period 1					Period 2				
	Menu			fb-high	fb-low	Menu			fb-high	fb-low
	w_h	w_l	δ	w	w	w_h	w_l	δ	w	w
Long-term	6.90 (0.98)	1.60 (0.20)	5.51 (2.14)	4.26 (0.36)	1.28 (0.0)	Same as period 1				
Short-term	6.32 (0.62)	1.43 (0.25)	7.75 (4.05)	4.73 (2.04)	1.71 (0.60)	6.84 (0.86)	1.72 (0.93)	2.86 (6.55)	3.52 (0.73)	1.71 (0.39)
<i>Equilibrium prediction</i>										
Long-term	9.96	2.22	0.1			Same as period 1				
Short-term	9.96	1.59	12.6						5.0	2.50

5.2. Does the Low-Cost Buyer Reveal Private Information in Period 1?

Table 9 summarizes the low-type buyer’s contract choices. We observe a relatively high frequency of revelation choices in both the Long-Term (95%) and the Short-Term (88%) treatments. The results contradict Hypothesis 2, as under the menus of contracts with $0.1 \leq \delta < 12.6$, we do not observe significantly higher imitation rates in the Short-Term than in the Long-Term ($p = 0.30$). In particular, in this subset, in the Short-Term, buyers choose the imitation contract in only 8% of the cases, which is significantly lower than the theoretical benchmark (100%, $p < 0.01$). This observation is in line with the supplier choosing too low payoff differences δ in the Short-Term, as described above. Comparing revelation frequencies in the Short-Term with those in the Dy-Short-Term (where the payoff difference is higher and exogenous), we see that this frequency significantly increases from 88% in the Short-Term to 95% ($p = 0.03$) in the Dy-Short-Term, supporting Hypothesis 6b. Furthermore, the revelation rates are significantly higher in the Dy-Short-Term than in the Cl-Short-Term, supporting Hypothesis 6a, $p < 0.01$. However, given that the values of δ are theoretically too small for revelation, it is somewhat puzzling that we do not observe more imitation in the Short-Term. To shed light on the low imitation frequency, we

analyze the low-cost buyer’s average empirical advantage from revealing her type rather than imitating the high-cost buyer. The empirical profits are a relevant measure because they factor in, on an aggregate level, how the supplier actually sets the contract parameters and thereby allocates profits.

We calculated the low-cost buyer’s empirical payoff difference per period between acting as a low-type (revelation) and acting as high-type (imitation) buyer (see Table 10). Under the menu of contracts, this difference is given by the average payoff difference δ between the contract alternatives. Under the first-best (fb) contracts scenario, we calculated the low type’s observed average profit per period under the fb-low contract minus her average observed profit under the fb-high contract. As such, a positive value indicates that revelation is myopically beneficial (i.e., in the respective period). Finally, we computed the sum of the observed profits over the two periods to analyze whether revelation turns out to be empirically beneficial (see the column “revelation benefit” in Table 10; for a comparison to the theoretical values, see the last two rows of that table). Positive values indicate that revealing low-type buyers made higher profits than those who imitated in the first period.

In the game-theoretic benchmark, the buyer earns 0.1 (0.2) more under a revelation strategy than under an imitation strategy in the short-term (long-term)

Table 9 Low-cost Buyer’s Contract Choices under a Menu of Contracts

Treatment	Period 1			Period 2		
	Revelation	Imitation	Rejection	Revelation	Imitation	Rejection
Long-Term	0.95 (0.06)	0.04 (0.06)	0.01 (0.03)	0.95 (0.06)	0.04 (0.06)	0.01 (0.01)
Short-Term	0.88 (0.12)	0.11 (0.12)	0.01 (0.02)	0.84 (0.16)	0.06 (0.09)	0.10 (0.18)
CI-Short-Term	0.30 (0.25)	0.53 (0.15)	0.17 (0.2)	0.37 (0.35)	0.51 (0.31)	0.12 (0.16)
Dy-Short-Term	0.98 (0.04)	0.01 (0.03)	0.01 (0.02)	0.98 (0.07)	0.01 (0.02)	0.02 (0.05)

contracting mode (see last two rows in Table 10) over both periods. Interestingly, it turns out that a revelation strategy is empirically even more beneficial. In the Long-Term, the buyer earns on average $5.51 + 5.51 = 11.02$ more under the revelation strategy than under the imitation strategy (compared to 0.2 in the game-theoretic prediction). In the Short-Term, the average buyer earned $7.75 + 1.49 = 9.24$ more under the revelation strategy than under the imitation strategy (compared to 0.1 in the game-theoretic prediction). This may explain why the buyer reveals her information in the Short-Term, although the δ in period 1 is lower than the game-theoretic benchmark.

With regard to the CI-Short-Term treatment, we observe a significant number of revelation choices (30%) in period 1, and the number is substantially more than that predicted by theory. Analyzing the data in more detail, we can distinguish three groups of low-cost buyers: (a) 23% of the buyers (6 out of 26) always choose the revelation contract from the menu of contracts in period 1, (b) 15% of the buyers (4 out of 26) almost always reject the menu of contracts in period 1, and (c) 62% of the buyers mainly choose the imitation contract. The heterogeneity in the buyers’ contract choice behavior may explain the large number of menu of contracts proposals in period 1 (57%). It seems that hoping for a myopic buyer who chooses the revelation contract, some suppliers offer a menu of contracts.

Finally, the belief elicitation shows that at the beginning of the second period, the supplier’s beliefs about the buyer’s type were correct in 86% and 84% of the cases in the Long-Term and the Short-Term treatments, respectively. Thus, the menus of contracts work as an information transmission device even if incentives are set too low (compared to a game-theoretic benchmark based on rational and profit maximizing parties).

5.3. Does the Supplier Offer More Efficient Contracts in Period 2?

The game theoretic prediction is that the supplier replaces the inefficient menu of contracts in period 1 with an efficient first-best contract in period 2. Figure 2 illustrates the supplier’s second period contract offer as a function of the buyer’s contract choice under a menu of contracts in period 1. The supplier most frequently offers the fb-high contract after the buyer has chosen the imitation contract from the menu in period 1. After a buyer’s revelation contract choice, the supplier offers the fb-low contract in most cases. However, in more than 15% of the cases, the supplier also offers a menu of contracts in period 2 if the buyer reveals that she is a low-cost type. Note that in theory, offering the menu of contracts to a low-cost buyer is as efficient as offering an fb-low contract.

Table 11 compares the fractions of efficient contract offers across treatments and periods. We find that supporting Hypothesis 3, the fraction of efficient contract offers in the second period is significantly higher in the Short-Term than in the Long-Term (73% vs. 52%, $p < 0.01$). In comparison, the rate of efficient contract offers in the second period is significantly higher in the Dy-Short-Term than in the CI-Short-Term (77% vs. 51%, $p < 0.01$), highlighting that sufficiently large payoff differences δ are a prerequisite for renegotiations having a positive impact on the efficiency of the supplier’s contract offers in later periods.

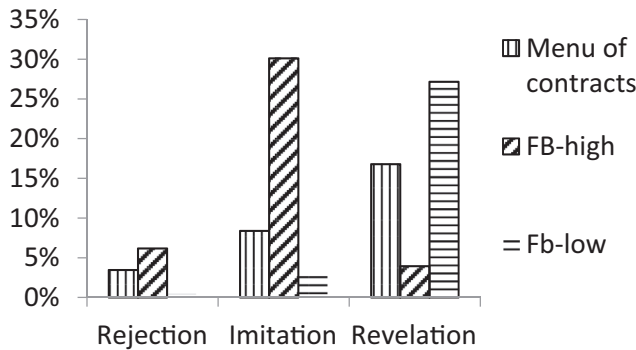
5.4. Does the Supplier Ratchet the Low-Cost Buyer in Period 2?

Ratcheting describes the supplier’s behavior of making unfavorable offers in later periods based on private information that is revealed in earlier periods. Figure 3 compares the supplier’s wholesale price w_1 in the menu of contracts proposal in period 1 with the

Table 10 Average Payoff Differences between Revelation and Imitation Strategies

Treatment	Period 1	Period 2		Total Revelation benefit
	Menu of contracts	Menu of contracts	First-best contracts	
Long-Term	+5.51 (2.14)	+5.51 (2.14)		+11.02
Short-Term	+7.75 (4.05)		+1.49 (5.11)	+9.24
<i>Equilibrium prediction</i>				
Long-Term	+0.1	+0.1		+0.2
Short-Term	+12.6		-12.5	+0.1

Figure 2 Short-Term Treatment with Supplier Contract Selection in Period 2 as a Function of the Buyer's Contract Choice under a Menu of Contracts in Period 1



wholesale price w under the fb-low contract in period 2 in the Short-Term treatment. In line with Hypothesis 4, we find that the supplier significantly increases wholesale prices by 20% from an average of 1.43 in period 1 to 1.71 in period 2 (see also Table 8, $p < 0.01$, Wilcoxon matched-pairs signed-rank test). However, wholesale prices are significantly lower than predicted by theory (1.71 vs. 2.5, $p < 0.01$). We note that suppliers may ratchet either with a menu of contracts or with *fb-low* contracts. To this end, we observe no significant difference between w_i in the menu of contracts and w in the fb-low contract ($p = 0.17$, Wilcoxon matched-pairs signed-ranks test) in period 2. Thus, the supplier's ratcheting of a low-cost buyer occurs under both contract formats.

Moreover, in the Dy-Short-Term treatment, the supplier is limited to either tighten the ratchet completely (i.e., offer the normative fb-low contract) or to keep it released (i.e., offer a menu of contracts). We see that almost no supplier is willing to tighten the ratchet completely, as the normative fb-low contract is hardly offered (i.e., 9% in period 2). Regarding the high-cost buyer, we also observe ratcheting, but this effect is less severe.⁶

5.5. Does Ratcheting Affect Buyer's Contract Choices?

Turning back to Table 8, in the second period, we observe that the low-cost buyer has a significantly

higher rate of contract rejections under short-term contracting than under long-term contracting ($p < 0.05$). We analyzed the contract rejections in more detail and present an analysis based on the CI-Short-Term treatment, since the predefined contract proposal produces a very clear assessment of the underlying effects, and it results in a considerable number of rejections.

Under the classical menu of contracts in period 2, Table 12 details the low-cost buyer's contract choices as a function of the contract proposal in period 1. The data reveal that the low-cost buyer's contract choices under a menu of contracts in period 2 strongly correlate with the contract proposal in period 1. If a menu of contracts was offered in period 1 and period 2, then the contract is only rejected in 1% of these cases in period 2. In contrast, if the *fb-high* contract was offered in period 1, the menu of contract is rejected in 50% of the cases in period 2. It seems that the low-cost buyer's contract rejections in period 2 are triggered by the supplier moving from a relatively generous offer in period 1, that is, a *fb-high* contract yielding a surplus of 12.5 to the low-cost buyer (see Table 2), to a more stingy offer, that is, a classical menu of contracts yielding a surplus of 5.7 to the low-cost buyer (see Table 4). Note that this may also explain the relatively low rate of menu of contracts selections in period 2 in the CI-Short-Term (see Table 7). In section 6, we show that this behavior is in line with an aversion against ratcheting, that is, against increasing the payoff differences from period 1 to period 2. This aversion, in turn, limits the supplier's leeway to make less favorable offers in period 2, since tighter ratchets increase rejections.

5.6. Profit Allocations and Supply Chain Performance

Table 13 compares between treatments the profit of the supply chain, the supplier, and the buyer. In line with the normative prediction, we observe that the supplier benefits from a commitment to long-term contracts, as the supplier's total profits are significantly higher in the Long-Term than in the Short-Term ($p = 0.02$). In comparison with the normative prediction on the increased benefits of long-term

Table 11 Efficient Contract Offers

Treatment	Period 1				Period 2			
	Menu of contracts	fb-high	fb-low	Total	Menu of contracts	fb-high	fb-low	Total
Long-Term	0.53 (0.01)	0.52 (0.18)	0.50 (0.0)	0.52 (0.02)	0.53 (0.01)	0.52 (0.18)	0.50 (0.0)	0.52 (0.02)
Short-Term	0.54 (0.01)	0.52 (0.16)	0.33 (0.25)	0.53 (0.03)	0.53 (0.21)	0.76 (0.15)	0.89 (0.12)	0.73 (0.09)
CI-Short-Term	0.52 (0.05)	0.46 (0.03)	0.60 (0.55)	0.50 (0.03)	0.59 (0.08)	0.48 (0.03)	0.38 (0.39)	0.51 (0.04)
Dy-Short-Term	0.52 (0.02)	0.36 (0.23)	1.0 (0.0)	0.50 (0.04)	0.77 (0.11)	0.77 (0.14)	0.81 (0.35)	0.77 (0.11)

Figure 3 Supplier's Ratcheting of Low-Cost Buyers

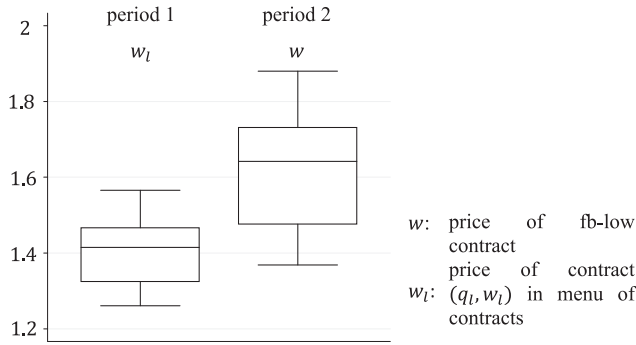


Table 12 CI-Short-Term Treatment with the Low-Cost Buyer's Contract Choices under a Classical Menu of Contracts in Period 2 as a Function of the Contract Offer in Period 1

Period 1 offer	Period 2		
	Revelation	Imitation	Rejection
Menu of contracts	0.46 (0.39)	0.53 (0.39)	0.01 (0.03)
fb-high	0.04 (0.08)	0.46 (0.42)	0.50 (0.41)
fb-low	0.5 (0.71)	0.50 (0.71)	0 (0)

contracting over those of short-term contracting, the supplier's long-term contracting benefits relative to those of short-term contracting are even greater than expected. In particular, the supplier's total profits increase by 15% on average (i.e., from 36.53 in the Short-Term to 41.90 in the Long-Term), while theory predicts an increase of merely 3.7% (i.e., from 65.45 in the Short-Term to 67.99 in the Long-Term). The main reason for this larger than expected increase in profits is that suppliers offer contracts that are more equitable in period 2 than the extreme contracts postulated by theory.

Concerning the buyer's profits, we observe a slight and non-significant disadvantage of long-term contracting over short-term contracting ($p = 0.12$). In comparison with normative theory, which predicts that the buyer's profits will decrease by 36.6% (from 9.91 in the Short-Term to 6.28 in the Long-Term), we

observe a decrease of 13.8% (from 26.81 in the Long-Term to 23.09 in the Short-Term). For supply chain performance, on average, we observe no significant difference between the Long-Term and the Short-Term ($p = 0.90$). Thus, our results contradict the game theoretic prediction that the supply chain benefits from a series of short-term contracts. Moreover, comparing the standard deviations across treatments, we find that supply chains may benefit from the lower variance in performance with long-term contracting than with short-term contracting ($p = 0.01$, F -test of equality of variances).

Concerning the restricted treatment variants, we find that in comparison to those in the Short-Term, the supply chains' profits are significantly lower in the CI-Short-Term ($p < 0.01$) and not significantly different in the Dy-Short-Term ($p = 0.32$). Thus, even if we provide subjects with theoretically optimal contracts, we do not observe a positive effect of short-term contracting on supply chain performance.

In sum, our results support the normative recommendation that as the contract offering party, the supplier should prefer long-term contracts over short-term contracts. Notably, the suppliers' benefits from long-term contracts are even greater than predicted by normative theory because normative theory overestimates the supplier's ability to ratchet up wholesale prices in short-term contracting. From the supply chain perspective, we do not observe the positive effect of short-term contracting, as predicted by normative theory. In contrast, there may even be a positive effect of long-term contracts, as these contracts involve less variance in supply chain performance.

6. Behavioral Explanation

We have established that low-cost buyers reveal more information about their type in period 1 than normative theory predicts. In this section, we investigate the behavioral motives that drive the buyers' revelation and rejection behavior and influence the contract offers by suppliers. We begin the analysis with period 2 and afterwards consider period 1.

Table 13 Summary Statistics of the Average Profit for the Supply Chain, Suppliers and Buyers

Treatment	Period 1			Period 2			Total		
	Supply chain	Supplier	Buyer	Supply chain	Supplier	Buyer	Supply chain	Supplier	Buyer
Long-Term	32.26 (1.6)	20.83 (2.22)	11.43 (2.59)	32.73 (1.46)	21.06 (2.85)	11.66 (2.37)	64.99 (2.92)	41.90 (5.15)	23.09 (4.95)
Short-Term	30.92 (3.27)	17.18 (1.64)	13.74 (2.72)	32.41 (3.90)	19.35 (2.55)	13.06 (2.40)	63.33 (6.89)	36.53 (3.98)	26.81 (4.89)
CI-Short-Term	25.67 (4.30)	21.45 (4.19)	4.22 (0.74)	26.20 (3.99)	21.19 (3.94)	5.01 (0.60)	51.87 (7.34)	42.64 (7.54)	9.34 (0.95)
Dy-Short-Term	30.91 (4.43)	22.33 (3.84)	8.58 (0.87)	29.18 (4.88)	21.75 (3.71)	7.42 (2.17)	60.09 (8.87)	44.08 (7.15)	16.00 (2.87)
<i>Equilibrium prediction</i>									
Long-Term	37.03	33.94	3.14	37.03	33.94	3.14	74.06	67.88	6.28
Short-Term	37.03	27.22	9.81	38.33	38.23	0.1	75.36	65.45	9.91

6.1. Buyer's Contract Choices in Period 2

The idea of inequity aversion is that participants care not only about their own profit but also about how profits are allocated among each other (Bolton and Ockenfels 2000, Fehr and Schmidt 1999). An aversion to inequality in income allocation implies that participants incur psychological costs both from earning less than the opponent (disadvantageous inequality) and from earning more than the opponent (advantageous inequality). Since a buyer earns less than a supplier in our experiments, we focus on the disadvantageous part of inequity aversion.

Little is known so far about the way individuals with fairness preferences evaluate a sequence of payoffs in a repeated interaction. The conventional approach is to assume that payoffs are compared period by period as the interaction unfolds. Another approach is to assume that individuals with fairness preferences aggregate the period-by-period payoffs and compare the aggregated payoffs of the players over the entire interaction. The reasoning for the non-aggregated approach is that individuals with fairness preferences seek to have an equitable outcome at any stage of the game, especially if the uncertainty about future payoffs and positions is high. The reasoning for the aggregation approach is that transient inequity from one period to the next is acceptable, especially if payoff distributions across periods are easily controlled and payoffs are perfect substitutes across periods (Oechssler 2013).

Inequity aversion based on current profits (Model 1). The utility function of a buyer who compares her profits to the supplier's profits period by period is as follows (Fehr and Schmidt 1999):

$$U_2^b(b_2, s_2, \beta) = b_2 - \beta(s_2 - b_2)^+ \quad (13)$$

where b_2 and s_2 are the buyer's and supplier's second-period profits, respectively, and $\beta \geq 0$ corresponds to the buyer's perceived disutility from having lower profits than the supplier in the second period. This utility function omits the earnings from the first period.

Inequity aversion based on total profits (Model 2). In this model, the buyer evaluates the profit sequence based on total profits. She first aggregates her profits over both periods and subsequently compares it with the supplier's aggregated profits. The buyer's utility function is given by the following (Oechssler 2013):

$$U_2^b(b_1, s_1, b_2, s_2, \beta^{tp}) = b_1 + b_2 - \beta^{tp}(s_1 + s_2 - b_1 - b_2)^+ \quad (14)$$

where b_1 and s_1 are the buyer's and supplier's first-period profits, respectively. The parameter $\beta^{tp} \geq 0$ corresponds to the buyer's disutility from having lower total profits than her supplier.

Ratcheting aversion (Model 3). Ratcheting aversion is defined as a disutility from an increase in disadvantageous inequality of profits from one period to the next. Hence, when the term $((s_2 - b_2)^+ - (s_1 - b_1)^+)$ is positive, that is, when the inequality between the supplier's and the buyer's profit increases from period 1 to period 2, a buyer with ratcheting aversion experiences a disutility. We model the disutility associated with ratcheting aversion by the parameter $\gamma \geq 0$. In model 3, we define the following utility function, which entails inequity aversion based on current profits and ratcheting aversion:

$$U_2^b(b_1, s_1, b_2, s_2, \beta, \gamma) = b_1 + b_2 - \beta(s_2 - b_2)^+ - \gamma((s_2 - b_2)^+ - (s_1 - b_1)^+)^+ \quad (15)$$

To estimate models, we add a random error term e_{it} to all utility functions and assume that it is i.i.d. and has an extreme value distribution. In this multi-nominal logit specification, the parameter λ captures the degree of randomness in the buyer's choices, and this degree ranges from full randomness ($\lambda = 0$) to no errors ($\lambda \rightarrow \infty$).

The results of all estimations are presented in Table 14. Model 0 is a restricted variant that only assumes randomness in choices but does not add any of the behavioral aspects. The two models that include inequity aversion, model 1 and model 2, provide similar results with almost equivalent log-likelihood values. Both models explain the data significantly better than the restricted model 0, which only assumes random errors. Model 3 with *ratcheting aversion*, which captures the disutility from increased inequity over time, provides a significantly better fit to the data than models 1 and 2. It shows a significant and strong effect of ratcheting aversion on the buyer's contract choices $\gamma = 0.27$. Furthermore, model 3 produces no significant effect of classical inequity aversion on the buyer's contract choices. Thus, we conclude that in period 2, it is not inequity aversion that drives the buyer's behavior but ratcheting aversion that surfaces when the supplier tries to exploit the information gained through the buyer's revelation in period 1. It seems that the buyer uses contract rejections in period 2 to discourage the supplier from ratcheting. We finally note that we estimated a model that incorporates mental accounting by weighing incomes from periods 1 and 2 differently. The fit of this model is not better than that of Model 1 or 2, and for details, we refer to Appendix A5.

6.2. Buyer's Contract Choices in Period 1

Normative theory assumes that the buyer is fully forward-looking and anticipates the evaluated expected profits in period 2. In the next set of models, we

assume that subjects are to some extent forward-looking. We model the values associated with period 2 by using the parameter σ , where $\sigma = 0$ indicates that buyers only care about the profits in the current round and $\sigma = 1$ implies that buyers care about the profits in period 2 to the same extent as they care about the profits in period 1. We define the buyer’s utility function as follows:

$$U_1^b(b_1, s_1, \bar{b}_2, \bar{s}_2, \beta, \hat{\gamma}) = b_1 - \beta(s_1 - b_1)^+ + \sigma \left(\bar{b}_2 - \hat{\gamma} \left((\bar{s}_2 - \bar{b}_2)^+ - (s_1 - b_1)^+ \right) \right)^+ \quad (16)$$

where the first two terms correspond to period 1 and the third term corresponds to the expected utility in period 2. While in period 1 the profits of period 2 are not known, it seems reasonable to assume that the buyer forms an empirical expectation about the supplier’s ratcheting behavior and, thus, about the supplier’s contract offer in period 2. To estimate the model, we assume that period 2 profits, \bar{b}_2 and \bar{s}_2 , equal the empirical averages observed in the experiment; that is, the supplier’s contract proposals are based on the wholesale prices in Table 8. We set $\hat{\gamma} = 0.27$, as estimated in model 3. The results are shown in Table 15. Model 4 corresponds to the restricted model, where $\beta = \sigma = 0$. In model 5, we constrain $\sigma = 0$, and model 6 presents the full model. The results indicate that the buyer’s inequity aversion has its merits in explaining her contract choices in period 1. In model 6, the parameter σ is not significantly different from zero, which indicates that the buyer is not forward looking. She mainly considers the current profits when making the decision in period 1. This result mirrors the observation that the empirical payoff difference in period 2 between acting as a low-type (revelation) and acting as a high-type (imitation) buyer turned out to be negligible (see Table 10). The empirically small negative payoff consequences explain the high rate of the buyers’ revelation choices in period 1. They also reflect the suppliers’ restrained information exploitation via ratcheting,

Table 14 Multi-Nominal Logit Estimation

Parameter	Model 0	Model 1	Model 2	Model 3
Randomness λ	3.85** (0.30)	3.18** (0.22)	3.25** (0.30)	3.25** (0.32)
Inequity cp β	—	0.14** (0.03)		0.00 (0.08)
Inequity tp β^{tp}	—		0.14** (0.04)	
Ratcheting γ				0.27* (0.10)
Log-likelihood	-132.44	-125.98	-126.72	-118.09
LL-ratio test p		<0.01 vs. model 0	<0.01 vs. model 0	<0.01 vs. Model 1

Notes: tp: total profits; cp: current profits.

* $p < 0.05$;

** $p < 0.01$.

Table 15 Multi-Nominal Logit Estimation in Period 1

Parameter	Model 4	Model 5	Model 6
Error λ	3.83** (0.28)	3.04** (0.33)	3.04** (0.33)
Inequity β	—	0.22** (0.04)	0.22** (0.04)
Forward looking σ	—	—	0.00 (0.09)
Log-likelihood	-171.35	-158.50	-158.50
LL-ratio test (p)		<0.01 vs. model 4	1.0 vs. model 5

Notes: ** $p < 0.01$.

which in turn is due to their fear of rejections by buyers with ratcheting aversion.

6.3. Supplier’s Contract Design

We have established that in most cases, the supplier’s menu of contracts proposals involve payoff differences δ that are too low to induce revelation. Furthermore, the wholesale prices are generally lower than theoretically expected. In the following, we assume a rational supplier and calculate his behaviorally optimal contract proposals for a buyer with contract choice behavior as identified above. We rely on the random utility model to describe the buyer’s contract choices in period 1 and period 2. In this framework, the buyer with cost c_j accepts contract fb (q_i^*, w_i^*) in period 2 with a probability:

$$p_2(q_i^*, w_i^* | c_j, q_1, w_1, \hat{\gamma}) = \frac{e^{\lambda U^b(q_i^*, w_i^* | c_j, q_1, w_1, \hat{\gamma})}}{\sum_{s \in \{0, i\}} e^{\lambda U^b(q_s^*, w_s^* | c_j, q_1, w_1, \hat{\gamma})}} \quad (17)$$

where $s = 0$ refers to the buyer’s outside option, that is, contract rejection, and the buyer’s utility function is defined according to (15). λ describes the randomness in the buyer’s choices. The buyer’s contract choice under a menu of contracts in period 1 is described by assuming utility function (13); see Appendix A6 for details.

Given that, we have described the buyers’ contract choice behavior; we can calculate the probabilities for revelation, imitation and rejection choices in period 1 and subsequently the probabilities for acceptance of the *fb-low* and *fb-high* contracts in period 2. Under the assumption that the supplier follows the rule in

Table 16 Supplier's Optimal Contract Parameters

Treatment	Period 1			Period 2	
	Menu of contracts			fb-high	fb-low
	w_h	w_l	δ	w_h^*	w_l^*
Short-Term	6.32 (0.62)	1.43 (0.25)	7.75 (4.05)	3.52 (0.73)	1.71 (0.60)
Behavioral optimal	7.10	1.48	8.37	3.66	1.86
Normative optimal	9.96	1.59	12.6	5.0	2.5

equation (8), that is, assuming that the *fb-high* contract follows the imitation contract choice and that the *fb-low* contract follows a revelation contract choice, we can maximize the supplier's expected profit under the contract terms w_l and w_h corresponding to the menu of contracts in period 1 and under the contract terms w_l^* and w_h^* corresponding to *fb-high* and *fb-low* contracts in period 2. We assume $\hat{\lambda} = 3.25$, $\hat{\beta} = 0.23$, $\hat{\gamma} = 0.27$. See Appendix A6 for details.

Table 16 compares the results with the empirical observations and the normative predictions. Behaviorally optimal wholesale prices are close to those observed in the Short-Term treatment. In particular, we find that the behavioral optimal payoff difference δ is lower than the normative value (i.e., 12.6 vs. 8.37). The behavioral value of 8.37 is not significantly different from the empirical observation of 7.75 ($p = 0.58$).⁷ Furthermore, we find no significant differences between the behaviorally optimal w_h^* and w_l^* and the corresponding empirical observations ($p = 0.14$, $p = 0.09$). The behavioral optimal price w_l is not different from the empirical observations ($p = 0.12$), while w_h is significantly higher in the Short-Term treatment ($p < 0.01$). Thus, the supplier in our experiments makes slightly more generous offers in period 1 than predicted by our behavioral optimization model and makes these offers more so to the high-cost buyer than to the low-cost buyer.⁸ Overall, the results show that it can be optimal from the supplier's perspective to offer in the menu of contracts payoff differences δ lower than those in the normative prediction.

7. Discussion and Limitations

We next discuss how our results fit within the literature. Our experiments provide three significantly new implications. First, we have established that the buyers' contract choice behavior in period 2 is driven by ratcheting aversion, as the buyers rejected contract offers more often if the inequity between the buyers' and the suppliers' profits increased from period 1 to period 2. Wu (2013) investigates a repetitive contractual relationship between a supplier and a buyer under full information. In the author's experiment,

the subjects repeatedly negotiate with the same partner over a series of 100 rounds. They observe that when the supplier attempts to adjust the contract parameters to increase his own expected profit, the buyer more likely rejects the offer. Wu (2013) concludes that the buyer's rejections are used as an enforcement tool to build up reputation and achieve long-run economic benefits. In our experiments, the buyer's contract rejections in period 2 cannot be motivated by long-run economic benefits since the supplier's and the buyer's contractual relationships end after period 2 and are randomly re-matched afterwards. The behavioral motivation of ratcheting aversion is very different from long-run economic benefits, as the former is backward looking and the latter is forward looking. Moreover, the idea of ratcheting aversion relates to the concept of *contracts as reference points* (Hart and Moore 2008). The authors claim that a signed contract provides a reference point for the parties' trading relationship by affecting their feelings of entitlement. If a party is shortchanged, that is, does not receive what he feels entitled to, he may shade on performance. Their approach also yields a trade-off between contractual rigidity (i.e., long-term) and flexibility (i.e., short-term). While a flexible contract allows adjustment to the state of nature, it has the disadvantage that it can involve much shading. Fehr et al. (2011) test the theory in laboratory experiments and, similarly, find that flexible short-term contracts cause a significant amount of shading, which hampers their expected dominance over rigid contracts under standard assumptions.

Second, our results show that suppliers exploit information disclosure to ratchet up prices and to align in period 2, contracts to the buyer's cost type, that is, to make more efficient contract proposals. Wu (2013) observes in the suppliers' contracts a slight time trend in the opposite direction; that is, the suppliers' contracts become slightly more generous over time. However, these experiments do not involve the revelation of private information.

Third, we find that the supplier's benefits from long-term contracts are larger than those that normative theory predicts. While we are not aware of any experimental work comparing the suppliers' profits

under long-term and short-term contracts, a number of studies investigate the benefits of more complex contracts over simpler contracts. A general finding in this stream of literature is that suppliers do not leverage the benefits of more complex contracts, for example, quantity discount contracts with more price breaks, to the extent predicted by theory. Short-term contracting can also be seen as a more complex contracting situation than long-term contracting because short-term contracting involves renegotiations, strategic imitation choices, and more inequitable profit allocations across periods. Thus, it seems that the complexity in the contracting environment also hampers the performance of the involved contracting schemes.

Consistent with Cooper et al. (1999) and Brahm and Poblete (2017), we find that buyers reveal more information in period 1 than normative theory predicts. We explain this observation by the subjects' limited forward-looking approach. In newsvendor experiments, Wu and Chen (2014) and Bostian et al. (2012) investigate the subjects' forward-looking perspective. Both studies find that only very few subjects can be described as forward looking, that is, 5% in the experiments of Bostian et al. (2012) and 12% in Wu and Chen (2014).

Our experiments replicate a series of observations from former laboratory experiments on supply chain contracting under asymmetric information. Our results resemble Kalkanci et al.'s (2014) and Johnsen et al.'s (2019) findings that fairness preferences and bounded rationality often affect buying behavior. Additionally, we also find that the self-selection mechanism presumed by normative theory for menus of contracts is empirically fragile (Inderfurth et al. 2013) when the payoff difference between contract alternatives is marginal. Sadrieh and Voigt (2017) observe that suppliers have an aversion against offering menus of contracts, and the authors identify the risk of buyers not choosing revelation contracts as the most plausible explanation for this. In contrast, suppliers in our experiments prefer to offer menus of contracts instead of simpler contracts. A potential explanation for the different observations is that the suppliers in our experiments are unrestricted in choosing wholesale prices, while in the previous experiments, they are restricted to the normative optimal values. Moreover, we observe a large number of low-cost buyers who reject the menu of contracts in period 1 in the CI-Short-Term; see Table 9. This observation appears to be consistent with the observation of Wu (2013), in which buyers reject offers due to future economic interests and reputation building.

While our supply chain setup accounts for the central aspects of a repeated supply chain interaction, there are some bounds and limitations on the

generalizability of our results for encouraging future research.

First, we use a student subject pool for our experiments. It is possible that managers in practice are more experienced with the situation and more open-minded to strategic considerations. However, the laboratory experiments from Cooper et al. (1999) contradict this expectation, as they found that younger students exhibit stronger strategic play than do older managers.

Second, we assume that the interaction between the supplier and the buyer covers two selling periods. A real-world interaction usually exceeds this time horizon. However, we conjecture that an extension of the time horizon strengthens the result that suppliers prefer long-term contracts to short-term contracts. The suppliers' cost for separating the buyer types increases with the length of the time horizon because suppliers must pay all expected future rents to the buyers in the first period to get the buyers to reveal their type. Therefore, when the time horizon increases, we expect more imitation behavior early on. Hence, we expect that the benefits of long-term contracts increase with the time horizon.

Third, we assume customer demand to be deterministic. A menu of contracts is also effectively used to coordinate supply chains with asymmetric information and stochastic demand (Burnetas et al. 2007). Since our setup with deterministic demand makes it easier for the subjects to trace the payoff consequences of their strategies, we believe that we can assess strategic behavior in this set-up more reliably than in a setup with stochastic demand. It is an interesting direction for future research, however, to examine how subjects consider the strategic effects under stochastic demand.

8. Conclusion

This study reports an experimental test of the performance of short-term and long-term contracting in repeated supply chain interactions. We consider a two-period interaction of a supplier-buyer dyad with pre-contractual information asymmetry. The standard game theoretic prediction is that the supplier that makes the contract offers in the game prefers long-term contracting to short-term contracting, while the supply chain is better off under a series of short-term contracts. Short-term contracting, however, involves the "ratchet effect," that is, the supplier exploits the buyer's information disclosure in period 1 ("revelation contract") to ratchet up prices and reap supply chain profits in period 2. Under the (theoretically) suboptimal short-term contract, the low-cost buyer imitates the high-cost buyer to receive more profitable contracts in later periods; that is, to signal high cost,

the low-cost buyer sacrifices some of her current profits, choosing the contract the high-cost buyer would choose (“imitation contract”).

The main insights of our experiments are as follows. (a) The buyers’ contract choices are driven by ratcheting aversion and a limited forward-looking perspective. In this study, we introduce ratcheting aversion as a dynamic version of fairness preferences. It captures the disutility of individuals from an increase in payoff inequality from one period to the next. We find that neither the classical period-by-period inequity aversion (see, e.g., Fehr and Schmidt 1999) nor an extended form of inequity aversion that compares aggregate profits over all periods (see, e.g., Oechssler 2013) can explain the observed behavior of buyers in our experiment as well as ratcheting aversion can. We establish statistical support for a behavioral model with ratcheting aversion by showing that it explains our data significantly better than models with the previously proposed fairness preferences. (b) The suppliers exploit information disclosure to ratchet up prices. However, they increase period 2 prices less than predicted by normative theory because they fear contract rejections by the ratcheting of averse buyers. (c) The suppliers’ benefits from long-term contracts are larger than those normative theory predicts and greater than those observed with short-term contracts. (d) Long-term contracts enable supply chain partners to achieve less volatile supply chain performance than short-term contracts, especially because the buyers’ ratcheting aversion (i.e., their dynamic inequity aversion) leads to more contract rejections. From the contract design perspective, normative theory predicts that suppliers should include all future informational rents of buyers in the first period offer. Our analysis shows that it can be behaviorally optimal to lower the informational rents offered to buyers in the first period if the buyers are limited in their forward-looking abilities and are ratcheting averse, that is, likely to reject contracts with increased profit differences in future periods.

Overall, long-term contracts seem more robust than short-term contracts because suppliers can credibly commit not to renegotiate and, thus, not to increase profit differences. This commitment induces buyers to reveal their true cost types and reduces the probability of contract rejections in period 2. The behavioral robustness of long-term contracting that we observe in our experiment may in fact be indicative of the high prevalence of long-term contracts observed in the field. While many other institutional and cost parameters may influence the choice of the contract type in the field, our study suggests that using long-term contracts can also help to avoid repeated coordination problems and fairness issues that impede the effectiveness of short-term contracts.

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Notes

¹In behavioral research, it is common to use the linear demand function $q(p) = a - bp$. In contrast to the use of a linear function, we apply a non-linear demand function because it yields larger incentives for the supplier to trade with both buyer types (instead of refusing trade with the high cost type).

²Note that if θ_i is sufficiently high, the supplier may want to exclude the c_h buyer from trade. We do not consider this case in our experiments and therefore omit it here. However, we ensured that given the parameters in our experiments, the supplier is willing to trade with both buyers.

³Note that there can also be a semi-separating equilibrium, in which the supplier offers a menu of contracts, but the offer does not entirely separate the types because at least one buyer type mixes between both contract alternatives. See Appendix A for further details.

⁴The set of cost realizations was randomly drawn prior to the experiment. We created three parameter tables with different orders of these realizations. Each buyer was randomly assigned one of these tables. We tested whether our predetermined parameters were serially independent by using a Run-Test. The test detected no serial correlation ($p = 0.33$, $p = 0.33$, and $p = 0.15$).

⁵When including the observations from all rounds, the difference is not significant ($p = 0.27$). The reason is a strong learning effect for the supplier’s contract offers during the first rounds, especially in the Short-Term treatment. In the first five rounds, the average payoff difference δ is -2.35 in the Short-Term and 5.82 in the Long-Term. In the Short-Term, as calculated by Wilcoxon matched-pairs signed-ranks test (WMS), δ is significantly smaller in rounds 1–5 than in rounds 6–20 ($p < 0.01$). Comparing rounds 5–10 with 11–20 ($p = 0.82$, WMS), we do not find a significant difference for δ . In the Long-Term, we neither observe a significant difference for δ when comparing rounds 1–5 with 6–20 ($p = 0.38$, WMS) nor when comparing rounds 6–10 with 11–20 ($p = 0.31$, WMS), indicating that learning is less distinct in the Long-Term than in the Short-Term.

⁶Note that although the wholesale price decreases from on average 6.32 in period 1 to 3.52 in period 2, the high-cost buyer’s average profit decreases only from 8.2 in period 1 to 7.4 in period 2. This is because the quantity threshold claimed under the *fb-high* contract is larger than that under the menu of contracts.

⁷Note that we also solved the model (9)–(12) for a rational buyer with disadvantageous inequity aversion. Under this

assumption, we derive the payoff difference $\delta = \frac{\beta d(c_h - c_l)}{4(c_h + s)^2}$, which is strictly larger than the normative benchmark, that is, $\frac{d(c_h - c_l)}{4(c_h + s)^2}$. Thus, mere inequity aversion cannot explain the observed small payoff differences. The buyer's low level of forward looking stimulates a small δ .

⁸Note that we run the regression model 7 separately for the low- and high-cost buyers. For the low-cost buyer, we estimated $\beta = 0.12$ (0.02), and for high-cost buyer, $\beta = 0.46$ (0.22). Changing this parameter in the optimization model yields the following for $\beta = 0.12$: $\delta = 7.61$, $w_h = 7.70$, $w_l = 1.59$, $w_l^* = 1.82$, and $w_h^* = 3.65$. For $\beta = 0.46$, it yields the following $\delta = 9.41$, $w_h = 6.44$, $w_l = 1.36$, $w_l^* = 1.72$, and $w_h^* = 3.43$.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1: Online Appendix to Short-term vs. Long-term Contracting.