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# *Relational Contract and Endogenous Contractual Incompleteness. Experimental Evidence.*

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# Relational Contract and Endogenous Contractual Incompleteness. Experimental Evidence.

*Preliminary version*

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**Abstract**

This paper empirically investigates the interaction between relational contracting and endogenous contractual incompleteness. To account for contractual relationships with perspective of future interactions, we design an infinitely repeated games experiment between identifiable players. In this experiment, the probability of continuation and the level of shared information vary over the treatments. The level of contractual completeness is decided by participants at each period. Our results show that past interactions are a stronger determinant of the level of investment in contractual completeness than the perspective of future business.

*Keywords: Contractual Incompleteness, Relational Contract, Reputation, Repeated Games, Experiment.*

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# 1 Introduction

Many contracts are "deliberately" incomplete in the sense that parties decline to condition performance on available, verifiable measures that could be specified in the contract. Such contractual incompleteness can be explained by a trade-off : the *ex ante* costs of crafting more complete agreements is compared to the *ex post* inefficiencies associated with less exhaustive arrangements. In this paper, we would like to investigate what happens to this trade-off when parties trade repeatedly: Does the perspectives of future repeated interactions diminish the fears of hold up in renegotiations, making a less complete (and a less costly) agreement more attractive? According to the relational contract theory, cooperative behavior can be generated by concerns for future relationships and reputation (Bull [1987], Klein [1988] and Baker et al. [2008]). As a consequence, one could expect that relational contract sustained by the value of future transactions will make useless to spend *ex ante* costs to write as complete a formal contract as possible. Nevertheless, there is no empirical work (to our knowledge) that investigates the link between relational contract and contractual incompleteness. In this paper, we propose to fill this gap by analyzing the interplay between relational contracts and the dynamics of endogenous contractual incompleteness.

To study whether parties are willing to sign more incomplete contracts when relational contracts are sustainable, we implement an experimental design of infinitely repeated games between identifiable players. In our setting, buyers have to determine the level of contractual completeness they want at the beginning of each period (contractual completeness is determined by a level of *ex ante* investment) while sellers have to decide to cooperate or to hold-up in case of incomplete contract. At the end of each round, players can decide if they want to stop or pursue their relationships and/or to look for new partners in the lab. This game is played under four different treatments in which two determinants of relational contracting vary: the potential duration of the game and the nature of information. Our results show that past interactions are a stronger determinant of the level of investment in contractual completeness than the perspective of future business.

Our paper can be related to the literature on endogenous contractual incompleteness. Many theoretical papers have tried to explain why contractual incompleteness can be endogenous (Shavell [1984], Anderlini and Felli [1999], Spier [1992]), however few of them have investigated the links between contractual incompleteness and relational contracting. Bernheim and Whinston [1998] regard contractual incompleteness as a cause of relational contract, since punishment strategies allowing a relational contract to be sustainable can be more easily elaborated when contracts are incomplete. Our contribution is to empirically explore the reverse causality: instead of thinking contractual incompleteness as a way to allow for relational contract; relational agreements could be the reason for accepting incomplete contract. This implies that relational contract would be a cause and not a consequence of contractual incompleteness. Such an intuition is given in the theoretical model of Tirole [2009] (p.283).

The evolution of contractual incompleteness over time has drawn some attention in the empirical literature. Empirical studies provide various answer about how contractual incompleteness evolves over time. For instance, Corts and Singh [2004] find that oil and gas companies are less likely to write complete agreements as the frequency of their interactions with a driller increases; while Crocker and Reynolds [1993], in their study of air force engine industry, report that contracts become more and more complete over time. Those empirical results (among others) seem

to suggest that the degree of contractual incompleteness evolves over time when two partners trade repeatedly, but there is no general rule, as parties may turn to more complete or incomplete agreements. Our methodology based on experimental economics proved to be particularly relevant to study the evolution of contractual incompleteness. This allows us to overcome several limitations of empirical papers testing contractual incompleteness. Compared to the study of Crocker and Reynolds [1993], the experimental approach allows us to observe the entire story of relationships. History between parties start at the first period and the observed behavior cannot be related to unobservable past events. Moreover, the empirical works as that of Crocker and Reynolds [1993] focus on relationships between one buyer and one or two sellers; while, in lab, we can create an environment where buyers and sellers are numerous and identically distributed in the population.

Compared to experimental studies, our paper is closed to Fehr et al. [2000] and Brown et al. [2004]. In their paper, Fehr et al. [2000] study the impact of reciprocity on contractual choices. In their experiment, contractual incompleteness is endogenous since principals have the choice between an explicit contract (incentive contract) and an implicit, less complete, contract (bonus contract). They find that the bonus contract, relying on reciprocal fairness as an enforcement device, is more often chosen by principals and leads to higher levels of agents' performances. Nevertheless, at each period, players are matched randomly and anonymously so all matches are one shot. As a consequence, Fehr et al. [2000] do not analyze the impact of relational contracting on contractual incompleteness. As for Brown et al. [2004], they examine how the absence of third party enforcement affects the formation of relational contract and market interactions. In their finitely repeated game experiment, they show that, in the absence of third party enforcement, fixed identities allow the emergence of cooperative long-term relationships through contingent contract renewal (i.e. relational contract). Our results are consistent with theirs but we also introduce an additional disciplinary device through the sharing of information about all the sellers' behavior under some treatments. Moreover, we depart from them in our definition of contractual incompleteness. In their study, the presence of third party enforcement corresponds to the complete contract situation and, conversely, the absence of third party enforcement corresponds to the incomplete contract situation. As the presence of this third party depends on the treatment, contractual incompleteness is exogenously determined in their paper. In our study, contractual incompleteness corresponds to the risk to face a situation where the seller will decide the sharing of the surplus on his own, with a possibility to hold-up the buyer. Furthermore, this risk is defined by the level of investment decided by the buyer. As a consequence, our experimental design is the first attempt to study the impact of relational contract on endogenous choice of incomplete contract.

The rest of the paper is organized as follows. Next section provides a very simple theoretical framework to support our view of relational contracts as a factor of endogenous contractual incompleteness. Section 3 describes our experimental design, and section 4 describes the different treatments we study to put our propositions to the test. Section 5 comments our results and section 6 concludes.

# 2 The theoretical framework

In this section, we propose a very simple model to provide some structure on *(i)* why agents decide to cooperate in a relational contract, and (*ii*) how investments in contractual completeness evolve over time in such a situation.[1] We intend this framework to be source of testable implications that we will take to our experimental data in the following sections.

## 2.1 Basic assumptions

Let us consider a repeated and open-ended bilateral contractual relationship between two agents, a buyer (B, whom we refer as "he") and a seller (S, whom we refer as "she"). The buyer wishes a project or a service, and asks the seller to perform the work according to his specifications, *i.e.* according to the contractual design. An illustration could be the public procurement sector, where the buyer (a public authority) asks a contractor to build an infrastructure, following some contractual specifications. As in Bajari and Tadelis [2001], we focus here on problems of *ex post* adaptations in a context where the level of contractual incompleteness is endogenously determined. We consider that both parties share uncertainty about contingencies that may arise once the contract is signed, and the production begins.[2]

When all contingencies are foreseen in the contract, the buyer gets a value $U^+$ of the project. However, some *ex post* unforeseen contingencies may also occur, in which case the contractual design is inappropriate. Before the beginning of each new period, the buyer can make an *ex ante* non-observable investment, say $I \in [0,1]$, to determine the level of contractual completeness of the agreement he signs with the seller. The more complete the design is, the lower the probability that unforeseen contingencies occur. Then, with probability $\rho(I) \in [0,1]$ ($\rho' > 0, \rho'' < 0$), the contract foresees all the contingencies, and delivers a value $U^+$ for the buyer. Yet, with probability $1-\rho(I)$, some unforeseen contingencies occur. In this case, contractual incompleteness opens room for opportunistic behavior and the seller has to decide whether to cooperate or not. If she cooperates, the buyer still gets a value $U^+$ from the project, but if she decides not to cooperate and to act in her self-interest, the buyer only gets a utility $U^D < U^+$. At the end of each period, the buyer decides to continue the relationship with the seller, or to stop and to use his outside option. We denote $U^P$ the gain of the buyer when he uses his outside option, with $U^+ > U^P > U^D$. In other words, the buyer has always interest that the seller cooperates in the relationship but prefers to stop than to be cheated. In such a context, the relational contract is the threat of the buyer not to renew the seller if she decides not to cooperate in case of unforeseen contingencies.

The payoff of the seller is $C$ when all contingencies have been foreseen, and when she cooperates under unforeseen contingencies. If she deviates, she gains $D$.[3] Her expected payoff when she does not trade with the buyer (her outside option) is $P$, with $D > C > P$.[4]

[1] This model is a simplified version of Desrieux and Beuve [2011]

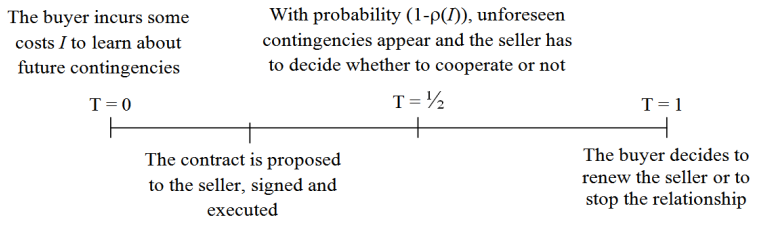
[2] To justify and illustrate this theoretical concern on *ex post* adaptations, the paper of Bajari and Tadelis [2001] (p.388) provides useful information about the public procurement, and show why the procurement problem is mainly about *ex post* adaptations rather than *ex ante* screening.

[3] The decision of the seller we describe is inspired from Gibbons [1997].

[4] In other words, when unforeseen contingencies occur, the situation is similar to a prisoneer's dilemma. In a static framework, by backward induction, the buyer anticipates that the seller will deviate, and there is no trade, since the buyer prefers his outside option $U^P$ rather than $U^D$.

Last, we consider an infinitely repeated game. The buyer discounts his payoffs at rate $\delta_B \in [0,1]$, while the discount rate of the seller is $\delta_S \in [0,1]$. For analytical simplicity, we will consider trigger strategy in this infinitely repeated game: if the seller does not cooperate at any time, then the buyer stops the relationship forever. The timing of the game for one contractual period is presented in Figure 1.

Figure 1: Timing of the game for one contractual period




We propose to solve the model by backward induction: we determine whether the seller respects or not her informal commitment, and then analyze the level of investment in contractual completeness made by the buyer at the beginning of each period.

## 2.2 The seller's decision to cooperate

When unforeseen contingencies occur at date $T = \frac{1}{2}$, the seller has to choose whether to cooperate or not. We determine here the self-enforcement condition of the seller. She cooperates whenever her discounted payoff stream from cooperation is higher than that of deviation, *i.e.* :

$$\frac{C}{1-\delta_S} > D + \frac{P\delta_S}{1-\delta_S} \qquad \text{(SEC)}$$

$$\Leftrightarrow \delta_S > \frac{D-C}{D-P}$$

As traditional in the literature on relational contracting, cooperation is all the more likely to occur than:

**Result 1.** The outside option ($P$) is all the lower (*ceteris paribus*).

**Result 2.** The discount rate of the seller ($\delta_S$) is high (*ceteris paribus*).

## 2.3 The buyer's investment in contractual incompleteness

At the beginning of each new period, in $T = 0$, the buyer chooses his investment in contractual completeness so as to maximize his own payoff. Under symmetric information, the buyer knows whether (SEC) is respected or not, *i.e.* he knows whether the seller will cooperate or not in case of unforeseen events.

- If the seller cooperates, then the buyer expects a gain $U^+$ in case of *ex post* adaptations. Then, his expected per-period payoff is

$$\rho(I)U^+ + (1-\rho(I))U^+ - I = U^+ - I$$

Then, the payoff of the buyer is maximized when $I = 0$, which means that the buyer does not invest in contractual completeness. He prefers to leave the contract intentionally incomplete, because the relational contract is sustainable and the seller always cooperates.

- If the seller deviates, then the buyer expects a gain $U^D$ in case of unforeseen events. His payoff becomes:

$$U^+\rho(I) + (1-\rho(I))U^D - I$$

The buyer chooses the investment level that maximizes his own payoff, *i.e.*:

$$I^B = \arg\max\{U^+\rho(I) + (1-\rho(I))U^D - I\} \Leftrightarrow \rho'(I^B)(U^+ - U^D) = 1$$

This means that the buyer invests in contractual completeness until the marginal benefit of the investment equals its marginal cost.

In other words, the contract is left intentionally incomplete when the buyer knows that the relational contract is sustainable. Otherwise, the buyer prefers to invest *ex ante* to make a contract more complete, in order to avoid the occurrence of *ex post* adaptations that will lead to the deviation of the seller. While relational contracts are traditionally considered as a solution to contractual completeness, we show here that they can also be viewed as a factor explaining endogenous contractual incompleteness.[5]

**Result 3.** The contract is left intentionally incomplete when the buyer knows that the relational contract is sustainable.

## 2.4 Testable implications

This short model above contains several testable predictions. On the one hand, parties are all the more likely to respect a relational contract than the rate at which they discount their future payoffs is high *ceteris paribus* (*Result 1*) and than their outside option is low *ceteris paribus* (*Result 2*). On the other hand, the contract is left intentionally incomplete when parties anticipate that the relational contract governing unforeseen contingencies is sustainable (*Result 3*). To give these results some empirical content, we discuss below each of them.

### 2.4.1 The discount rate

As recalled by Fudenberg and Tirole [1991], there are two interpretations of the discount rate: it represents both the rate of time preference and the probability of continuation of the game.[6]

[5] This result can be related to that of Crocker and Reynolds [1993]: the buyer compares the *ex ante* costs of contractual completeness to *ex post* risk of opportunism. However, we show here that such a risk depends on the sustainability of relational contracts.

[6] More formally, $\delta = e^{-r\Delta}$ where r is the rate of time preference and $\Delta$ is the length of the period. However, if we add a probability $\mu$ of continuation from one period to the next, then with probability $(1-\mu)$ there is no

As a consequence, when parties anticipate that the duration of the game is longer, they discount future payoff at a higher rate, all other things being equal. Then, (SEC) is all the more likely to be satisfied, *i.e.* the relational contract is all the more sustainable. Then, we obtain our first testable implication:

***Proposition 1.*** *Cooperation is more sustainable when the duration of the game is longer.*

### 2.4.2 The outside option

In our model, the incentives of the seller to cooperate are all the higher than P (her gain outside the relationship) is low. Several determinants of the outside option can be established. Among them, the level of asset specificity included in the relationship makes the outside option all the lower, because those assets have no more value outside the relationship, and the partner supporting such investments may prefer to stay (even if he has been cheated) than to stop the relationship and to loose his specific investments. In the same way, the market structure is not neutral, since it determines whether alternative partners (outside the initial relationship) may be found in the market or not.
Last, in a context of multilateral relationship, public information also determines the value of the outside option. Greif [2006] and Bernstein [1992] show that the punishment of a cheater is effective only if it can be applied by all the members of a community, so that the outside option of the cheater becomes low. One of the many difficulties of a collective punishment is that the information and communication channels need to be very efficient so that everyone may identify a cheater (Li [2003]; Dixit [2004, 2009]), and may apply the punishment. Then, public information would allow to identify the cheater more easily, and makes the punishment more efficient in case of deviation. As a consequence, the outside option of the cheater in case of reneging is all the lower than the information about his behavior is public. With a different approach, Tadelis [2008] and Frestre and Garrouste [2011] also suggest that individuals are more willing to cooperate when they know that others observe their behavior (*i.e.* in case of public information) because of the player's aversion to being thought of as acting in an inadequate way. In our paper, the goal is not to discriminate between these different explanations but to verify whether public information leads to more cooperation or not.
Then, for a given level of asset specificity and in a given market structure, we propose here to focus on the impact of public information on the willingness to cooperate in a relational contract. When information is public, the level of the outside option should be all the lower because other potential partners are aware of the non-cooperative behavior of the agent. This would make cooperation all the more sustainable, since the alternative payoff (*i.e.* the outside option) is low:

***Proposition 2.*** *Cooperation is more sustainable when information about the behavior of the participants is public rather than private.*

gain, and with probability $\mu$, the gain is discounted at rate $\delta = e^{-r\Delta}$. Then, the expected discounted value of the gain is $\delta' = \mu\delta = \mu e^{-r\Delta}$. Thus, the situation is the same as if $\mu = 1$ and $r' = r - \frac{ln(\Delta)}{\mu}$, hence the dual interpretation of the discount rate.

### 2.4.3 Endogenous contractual incompleteness

Our model shows that parties voluntarily sign incomplete contracts when they know that a relational contract governing unforeseen contingencies is sustainable (*Result 3*). By anticipating the cooperative behavior of the seller, the buyer decide to invest less *ex ante* and to draft a less complete contract. Then, we have the following proposition:

***Proposition 3.*** *Contracts are more incomplete when the relational contract is sustainable.*

As emphasized in previous subsection, the sustainability of the relational contract depend on the incentives of the seller to cooperate in case of unanticipated contingencies. A relational contract is all the more sustainable than the duration of the game is long and information is public. By transitivity, we should observe less investment in contractual completeness in these two situations. Thus, we can break our proposition 3 down into the two following testable implications:

***Proposition 3a.*** *Contracts are more incomplete when the duration of the game is longer.*
***Proposition 3b.*** *Contracts are more incomplete when information about the behavior of the participants is public rather than private.*

# 3 Experimental design

The experiment is designed to study the interplay between relational contract and contractual incompleteness. It corresponds to a buyer-seller game where gains will be determined by the decisions of players. In the instructions and during the experiment, we only refer to players A (*i.e.* buyers) and players B (*i.e.* sellers) in order to obtain as a neutral context as possible. Nevertheless, for a better understanding of the results, we will refer in the paper to buyers and sellers.

## 3.1 Subjects

The experiment was conducted in the Experimental Economic Laboratory of Paris at University of Sorbonne. One hundred and ninety-two subjects, predominantly undergraduate students of various fields, participated in the experiment. For each of the next described treatments we conducted four separate sessions, each with one group of twelve different students (every subject only participated in one session). Subjects were randomly assigned to a workstation and received written instructions. Those instructions have also been exposed in lab and subjects answered a control questionnaire before the start of the experiments to ensure they had a complete understanding of the rules.[7] Finally, all payoffs in the game were in ECUs and at the end of each session, the ECUs earned by each subject were converted into Euros (at the exchange rate of 1 ECU = 0,025 Euros) and paid privately in cash. This exchange rate between ECUs

[7] An example of game instructions is provided in appendix 2. The results of the control questionnaire give a mean mark of 9,2/10 for a standard deviation equal to 1,1.

and euros ensured that subjects had significant incentives to try to maximize their earnings.[8]

### 3.2 Matching procedure and identifiable players

In each session, subjects are divided into two groups: six buyers and six players sellers. At the beginning of each session, players receive a fixed identification number (from $A_1$ to $A_6$ for buyers and from $B_1$ to $B_6$ for sellers) for the whole duration of the experiment. As a result, all relationships take place between players that could be identified during all stages. Under these conditions, players are able to engage in long term relationships and buyers are able to condition their choices on the seller's past behavior, so that reputation effects can emerge endogenously (Fehr et al. [2009]).
Furthermore, the matching between players is not random but autonomous. Technically, buyers can propose relationships to any seller and sellers can decide to accept or reject those offers. In the repeated game framework described after, buyers can decide to stop or to propose to pursue their relationships with current partners and to propose new relationship to other sellers at the end of each round. As for sellers, they can decide to accept or reject offers of relationships' renewal and offers of new relationships. Finally, to maintain a minimum level of competitive pressure and allow the threat of relationship termination to be effective, all players are limited to three different relationships per period.

### 3.3 Incomplete contract and cooperation

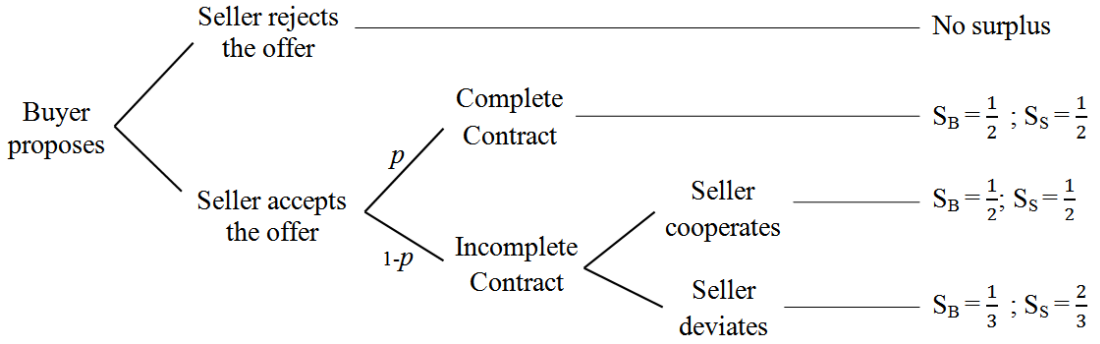
In our experimental design, the surplus of the relationship is automatically and equitably shared between parties with a probability $p$; and, with a probability $1-p$ the sharing of the surplus is decided by the seller. According to the theoretical model we provide in section 2, the first case corresponds to a complete contract where contingencies are well foreseen and there is no need for *ex post* adaptation, while the second case corresponds to an incomplete contract where unanticipated contingencies arise and parties have to find a new agreement. This incomplete contract situation opens rooms for opportunistic behavior. Hence the sellers decide if they want to cooperate (*i.e.* to maintain an equitable sharing of the surplus) or to hold-up buyers (*i.e.* to have two-thirds of the surplus and leave one-third to the buyer). Figure 2 summarizes those first elements of the experimental design.

### 3.4 Additional investment and endogenous contractual incompleteness

The experimental design considers two different types of investment associated with contracting. On the one hand, both players have to bear an initial investment at the beginning of each new relationship (*i.e.* when they first play with a new partner). This initial investment can be compared to specific investment due to the implementation of the relationship. On the other hand, the buyers can decide to periodically incur an additional investment which allows them to

[8]Earnings in ECUs : $m = 583$ , $\sigma = 182$. Earnings in Euros : $m = 14{,}6$ , $\sigma = 4{,}6$. Duration of the session : between 15 and 30 minutes depending on treatments.

Figure 2: Matching, contractual completeness and surplus sharing




($S_B = \frac{1}{2}; S_S = \frac{1}{2}$) means that the surplus is shared equally between parties, while ($S_B = \frac{1}{3}; S_S = \frac{2}{3}$) means that the buyer gets one-third and the seller gets two-thirds of the surplus. The seller makes the decision only when contracts are incomplete, so that the game becomes similar to a dictator game in this case.

minimize the risk of incomplete contract and, *de facto*, the risk to be held up. Such an additional investment could be compared to efforts to make the contract more complete. Contrary to the initial investment, those efforts can be made at the beginning of each new period (*i.e.* whether the partner is new or not).

More precisely, when they start a new relationship, a buyer and a seller both invest 6 ECUs (which is then the amount of initial investment). Thereafter, at the beginning of each round, the buyer can decide to invest 2 ECUs in order to limit the risk of incomplete contract in the current round. If the buyer does not make this additional investment, the probability $1 - p$ to face an incomplete contract is equal to 0.5. This probability falls to 0.25 when the buyer makes the additional investment.[9] Here we can notice that information about additional investment and associated probabilities are known by all players. Nevertheless, during the experiment, the sellers do not know if the buyers decide or not to make this additional investment. As a consequence, the choice of cooperation in case of incomplete contract cannot be analyzed as a reciprocal answer to the trust expressed by the buyers when they choose not to make the additional investment. The explanation of sellers' cooperation have to be found in the relational contract mechanism : cooperation might be reward by offers of relationships' renewal. In other words, the choice to not hold-up made by the seller is not due to the buyer's choice of contractual completeness (non observable) but relies on the repeated interactions (the buyer can discipline the seller by practicing a contingent renewal policy).

## 3.5 Payoffs

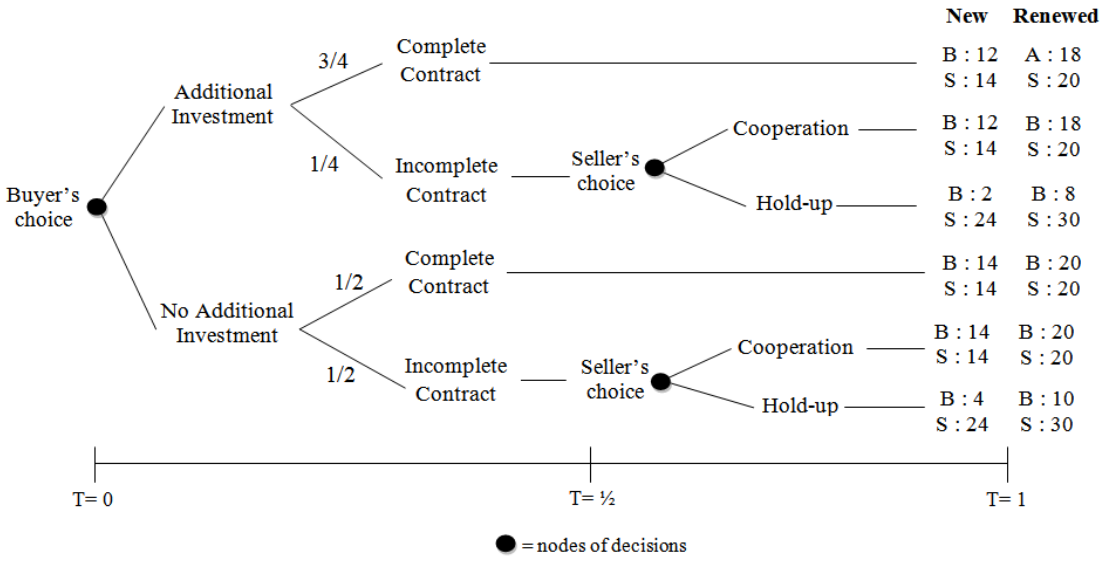
At the beginning of the experiment, all players have an initial capital of 0 ECUs. In the end, payoffs of players will be determined by the nature of the relationship (new or renewed) and their actions (additional investment or not of buyers and cooperative or opportunistic behavior of sellers). Figure 3 displays the payoffs tree (in ECUs) of players for all different situations. It is

[9] All the values assigned to the parameter of the experimental design are discretely determined by the authors. Nevertheless, values are established in order to ensure enough incentives to players and to hold specific conditions described in the subsection 3.5.

important to note that gains associated with the different actions are the same in all treatments. They were specifically designed to fulfill the following conditions:

- It is always profitable to have a relationship for players.
- In one shot-game, it is always profitable for sellers to deviate.
- In one shot-game, it is always profitable for buyers to protect themselves against risk of hold-up by making the additional investment.
- In infinitely repeated games, it is always profitable for buyers to make the additional investment if they know with certainty that sellers will deviate.
- In infinitely repeated games, it is never profitable for buyers to make the additional investment if they know with certainty that sellers will cooperate.

Figure 3: Payoffs




# 4 Treatments

In the previous section, we present the experimental design that holds for all treatments. In this section, we now focus on the parameters that will be modified between treatments in order to put to the test our propositions described in section 2.

## 4.1 The duration of the game

When they come to the lab, the players are informed that they will play two different games without knowing what those two games will be. They discover them successively.

#### 4.1.1 One shot game

The first game is a one shot game where players only interact during one period. There is only one matching procedure and no initial specific investment. According to the design, buyers decide the level of completeness they want (*i.e.* additional investment) and sellers decide to cooperate or deviate in case of incomplete contract. Afterward, gains are announced to players and the game stops. Once this first game is ended, players receive instructions for the second game.

#### 4.1.2 Infinitely repeated games

The second game is a repeated version of the one shot game. Obviously, identification numbers are redistributed among players in a manner that no information could be extracted from the first game. We run experiment in two different infinitely repeated games contexts by using a random continuation rule. In long-run repeated game (LR), players interact during at least six periods, thereafter they play successive additional periods with a probability of continuation $\delta$ = 0,8. In short-run repeated game (SR), players interact during at least six periods, thereafter they play successive additional periods with a probability of continuation $\delta = 0{,}2$.[10] In infinitely repeated games with a continuation probability $\delta$, the expected number of rounds is equal to $1/(1\text{-}\delta)$. Therefore, the expected numbers of rounds in our treatments are equal to 7 for $\delta = 0{,}2$ and 11 when $\delta = 0{,}8$.
According to our propositions 1 and 3a, we expect to observe a higher level of sellers' cooperation and a lower level of buyers' additional investment when the time horizon is longer (*i.e.* when the probability of continuation is equal to 0,8).

### 4.2 The nature of information

#### 4.2.1 Private information

When information is private, buyers can only observe the behavior of sellers they are currently associated with. They have no possibility to obtain information neither on the behavior of their partners in other relationships nor about other sellers they are not associated with.

#### 4.2.2 Public information

When information is public, buyers still have information about sellers they are currently associated with but also about past behavior of all sellers present in the lab. More precisely, at the end of each period, buyers learn the percentage of cooperative versus non cooperative choices of sellers in all their relationships and in all previous periods.[11] As a result, the nature of information could modify the behavior of both players.

[10] The probability of game continuation is common knowledge for all players at the beginning of the experiment.

[11] As soon as we have an incremental measure of sellers' reputation, we do not distinguish short run reputation (information about the last session) and long-run reputation (information about all sessions). See Keser (2002) for an interesting comparison between the effect of short-run reputation and long-run reputation in trust game.

According to our proposition 2 and 3b, we expect to observe more sellers' cooperation and less buyers' additional investment in treatments with public information.

### 4.3 Summary

Thus we have five different treatments of the experiment. A one shot game treatment (OSG) and four different infinitely repeated game treatments. The second and the third are treatments with a probability of continuation $\delta = 0{,}2$ after the fifth round. However, information is private in the treatment denoted SR (Short Run) and is public in the treatment denoted SRP (Short Run with Public information). The fourth and the fifth are treatments with a game discount $\delta = 0{,}8$ after the fifth round. Similarly, information is private in the treatment denoted LR (Long Run) and is public in the treatment denoted LRP (Long Run with Public information). Table 1 summarizes the different treatments.

Table 1: Treatments

| **Name** | **OSG** | **SR** | **SRP** | **LR** | **LRP** |
|---|---|---|---|---|---|
| Type of the game | One shot game | Infinitely repeated game | Infinitely repeated game | Infinitely repeated game | Infinitely repeated game |
| Probability of continuation | 0 | 0.2 | 0.2 | 0.8 | 0.8 |
| Nature of information | - | Private | Public | Private | Public |

## 5 Results

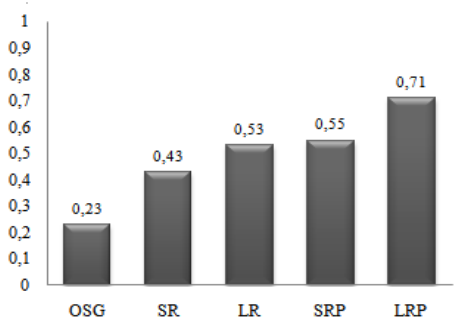
To test our four propositions described in subsection 2.4, we draw our attention on the determinants of seller's cooperation and the interaction between sustainable relational contract and contractual incompleteness. Nevertheless, before analyzing results coming from descriptive statistics and the econometrical analysis, we have to control if we can compare observations from our different treatments. Consequently, the first question is whether there is enough evidence to reject the proposition that samples of observations of our main variables (*i.e. Cooperation* and *Additional Investment*) are generated by the same stochastical process. As suggested by many studies, this is evaluated by using non parametric testing methods (Hackett 1993). The nonparametric Wilcoxon test reports are presented in Table 4 (in Appendix) where "Z" is the Wilcoxon score and "P>Z" is the significance level at which the null proposition of no difference in distribution is rejected. Most of the time, tests reject the null proposition of no difference in distribution of our variables between samples. Particularly, the null proposition is rejected at 1 percent level when we compare short run versus long run treatments on the one hand and private versus public information treatments on the other hand.

## 5.1 Descriptive Statistics

### 5.1.1 The determinants of cooperation

We begin our analysis with some statistics about the frequency of cooperative behavior of sellers[12] in case of incomplete contracts observed in the treatments described in the previous section (see Figure 4).

Figure 4: *Cooperation* of sellers (frequency by treatments)




All things being equal, we find that the duration of the game leads to higher levels of sellers' cooperation. In fact, cooperation is higher in the LR treatment than in the SR treatment (comparison under private information) and sellers also cooperate more often in the LRP than in the SRP treatment (comparison under public information). Thus, in accordance with proposition 1, a longer duration of the game enhances sellers to sustain informal cooperation. It means that the higher probability of continuation makes the cooperation strategy more chosen compared to the deviation one because the opportunity cost associated with a punishment by buyers increases with the likelihood of longer relationship.[13]

Observations are also consistent with our proposition 2 as we observe that sellers are more willing to behave cooperatively when they know that information about their past behavior is made public. Indeed, cooperation is higher in the SRP treatment than in the SR treatment (comparison under short duration) and sellers also cooperate more often in the LRP than in the LR treatment (comparison under long duration). The interpretation of this result is that the risk of deviation to be punished by non renewal becomes higher when it might be extended to all sellers' relationships.[14] It is consistent with the view that many subjects understand the logic of reputational incentives (Fehr et al. [2009]). Taking separately, longer duration and public information are real enhancing factors of cooperation. Moreover, the combination of these two factors (LRP treatment) leads to the highest level of cooperative decisions (71%).

[12]This frequency means here the percentage of cooperative behavior among all the observed behavior.

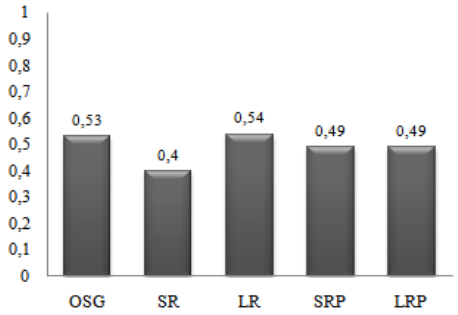
[13]Those observations are consistent with previous findings of experimental studies in different repeated games framework (Murninghan and Roth [1983], Engle-Warnick and Slonim [2006], Duffy and Ochs [2009], Dal Bo [2005]).

[14]Hereagain, this observation is consistent with previous experiments findings on the positive impact of reputational concerns on cooperative behavior (Fehr et al. [2009], Bolton et al. [2005]).

### 5.1.2 Sustainable relational contract and endogenous contractual incompleteness

We pursue our analysis with some statistics about the frequency of additional investments made by buyers[15] (see Figure 5). In our experiment, the risk of facing an unforeseen contingency (opening room for sellers' opportunism) decreases with the level of buyer's periodic efforts to complete the contract. In other words, buyers have to invest more (additional investment) in order to lower the risk of incomplete contract in which case sellers make the decision of surplus sharing.

Figure 5: *Additional Investment* of Buyers (frequency by treatments)



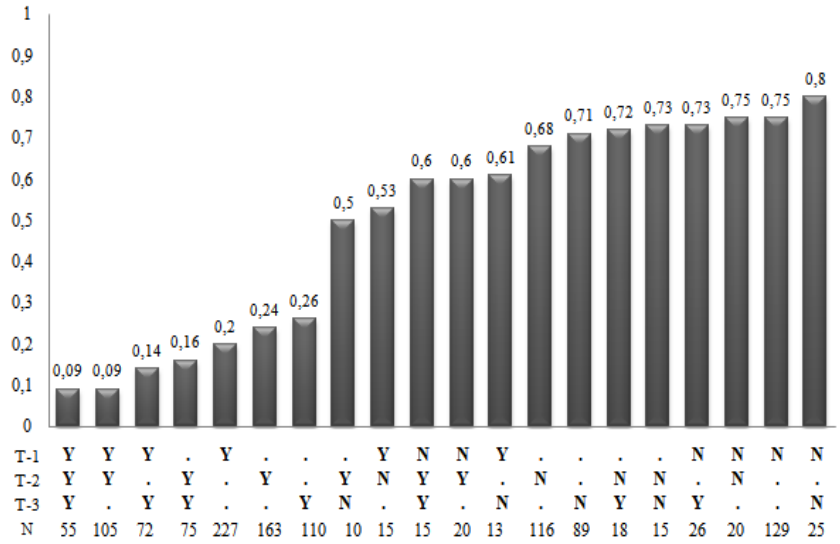

The comparison between SR and LR treatment on the one hand and SRP and LRP treatment on the other hand is not consistent with our proposition 3a. As for proposition 3b, levels of additional investment are equal between SRP and LRP treatment while buyers invest more in contractual completeness in the LR than in the SR treatment. Observations neither provide support for our proposition 3b. Actually, buyers' additional investment are higher in the SRP than in the SR treatment and buyers invest more in contractual completeness in the LR than in the LRP treatments. It indicates that neither longer duration nor public information do not lead to lower level of additional investment. This appears as surprising observations. It seems that buyers do not anticipate the higher incentives of the sellers to cooperate under public information and long game duration, and then do not react accordingly by choosing a lower level of additional investment. In other words, although reputational concerns provide incentives for sellers to behave cooperatively, buyers do not invest less in contractual completeness. As a consequence, both propositions 3a and 3b are rejected and it seems that we cannot make conclusions about the direct effect of the probability of continuation and the nature of information about behavior of sellers on the level of additional investment chosen by buyers.

If the perspective of future interactions and public information are not the determinants of endogenous contractual incompleteness, an alternative could be to investigate the link between past experimentations and subsequent choices of buyers in terms of additional investment. Here, our intuition is that the perspective of future business is not sufficient to lower the investment in contractual completeness, yet, reputation building over time could influence this decision. Following this intuition, Figure 6 shows the frequency of additional investment of buyers according to the observed behavior of sellers during the last three periods and Figure 7 shows the frequency of additional investment of buyers according to the reputation of sellers observed in

[15]This frequency means here the percentage of additional investment among all the observed behavior.

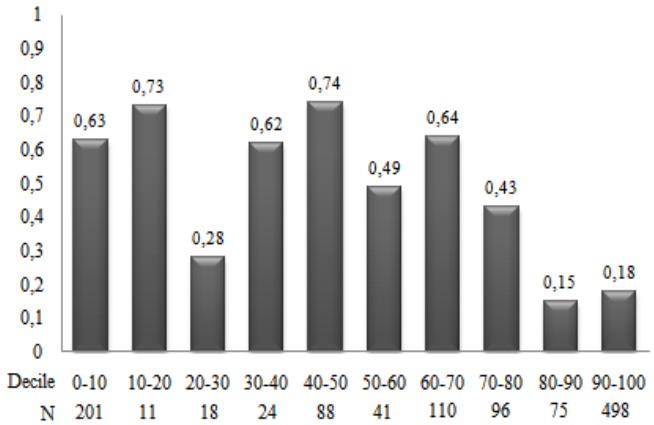
the last period (*i.e.* frequency of cooperative behavior of sellers ranked by decile) in treatments where information is public.

Figure 6: Buyer's *Additional Investment* depending on sellers' past *Cooperation*




The first column means that when the seller cooperated in the last three rounds, only 9% of the buyers make the additional investment. The fifth column means that when the seller cooperated to the previous period (T-1), but the contract was complete during the two anterior periods (T-2 and T-3), then 20% of the buyers make the additional investment.

Figure 7: Buyer's *Additional Investment* depending on sellers' *Reputation*
(in SRP and LRP treatments)




The first column means that 201 sellers cooperated in less than 10% of the cases of contractual incompleteness, and 63% of the buyers choose to make additional investments when they interact with those sellers.

Buyers are less likely to invest *ex ante* when sellers were cooperative during previous rounds. The lowest three rates of additional investment (*i.e.* 9%; 9% and 14%) correspond to situations where buyers only observe cooperative behavior during the last three rounds. On the opposite, the highest three rates (*i.e.* 75%; 75% and 80%) correspond to situations where buyers only

observe opportunistic behavior during the last three rounds. Moreover, we also observe a gap in buyers' behavior: as soon as there is at least one opportunistic behavior during the last three periods, the *Additional Investment* rate of buyers switches from 26% to 50%. Such an observation indicates that opportunistic behavior of sellers in the past make buyers more wary. This is consistent with (relational contract theory based on) trigger strategy which assume cooperative choices so long as no party has defected from the implicit agreement in past interactions.
A same effect is observed in Figure 7 when we look at the impact of sellers' reputation. We find that the lowest rate of *Additional Investment* is reached when sellers are known to be cooperative. For instance, the frequency of additional investment of buyers is equal to 18% when they observed that seller's reputation is higher than 90%. Similarly, a high rate of *Additional Investment* is reached when sellers are known to be opportunistic (the frequency of additional investment of buyers is equal to 63% when they observed that seller's reputation is lower than 10%).
in the end, those descriptive statistics reject the direct impact of reputational concerns on the level of additional investment decided by buyers. Nevertheless, they highlight a strong interaction between past cooperative behavior of sellers and choices of buyers in terms of contractual completeness.

## 5.2 Panel Data Analysis

Our experiment allows us to obtain panel data where panel variables are all the different relationships between buyers and sellers and where time variables are successive rounds. Thus we can also test econometrically our propositions.

### 5.2.1 The determinants of cooperation

Table 2 provides the results of logit estimation of sellers' *Cooperation*.[16] For each model, we look at the impact of the *Probability of Continuation* (*PC*) and *Public Information* (*PI*) on the choices of sellers to cooperate or not in case of incomplete contract. We also add a set of control variables which includes the number of previous interactions between the seller and the buyer (*Past Experiences*), the number of ongoing relationships of the seller during the round (*Ongoing Relationships*), the "level" of altruism identified in each particular session (*Altruism*)[17] and a dummy variable which indicates that relationships take place after the round 5 (*Round 6*), *i.e.* when uncertainty of playing next periods starts. Finally, to tackle the issue of potential fixed effects, we include control variables about the age (*Age*), the sex (*Sex*), the status (*Status*) and the discipline (*Discipline*) of each seller and we cluster on sellers' level.

Results of Model 1 confirm the observations coming from descriptive statistics. Coefficients associated with the variables *Probability of Continuation* (prop. 1) and *Public Information* (prop.

[16] All the variables used in the estimations, their descriptive statistics and the correlation matrix are provided in appendix.

[17] As previously said, participants first play a one shot game without knowing that they will play a repeated game after. Since there is any incentive to cooperate in the one shot game, we use the level of cooperation observed during the one shot game as a measure of the proportion of altruistic players present in the lab.

Table 2: Logit analysis of Sellers' *Cooperation*

| | Model 1<br>All sample | Model 2<br>PI = 0 | Model 3<br>PI = 1 | Model 4<br>PC = 0 | Model 5<br>PC = 1 |
|---|---|---|---|---|---|
| Probability of Continuation (PC) | 0.481** | 0.347 | 0.722** | . | . |
| | (0.170) | (0.210) | (0.268) | . | . |
| Public Information (PI) | 0.862*** | . | . | 0.648* | 0.817*** |
| | (0.167) | . | . | (0.298) | (0.211) |
| Past Experiences | 0.084** | 0.109** | 0.026 | 0.146 | 0.047 |
| | (0.030) | (0.034) | (0.051) | (0.093) | (0.035) |
| Ongoing Relationships | 0.737*** | 0.732* | 0.807** | 0.640* | 0.920*** |
| | (0.203) | (0.362) | (0.252) | (0.320) | (0.273) |
| Altruism | 0.007 | 0.011 | 0.005 | -0.007 | 0.008* |
| | (0.004) | (0.007) | (0.005) | (0.013) | (0.004) |
| Round 6 | -1.097*** | -1.295*** | -0.877* | -2.059*** | -0.537 |
| | (0.232) | (0.321) | (0.351) | (0.390) | (0.284) |
| Control Variables | yes | yes | yes | yes | yes |
| Constant | -4.112*** | -4.624*** | -2.054* | -2.916** | -5.029*** |
| | (0.745) | (1.291) | (0.954) | (1.026) | (1.271) |
| $R^2$ | 0.08 | 0.09 | 0.06 | 0.12 | 0.08 |
| Predict | 66.6 | 63.2 | 71 | 69.5 | 69.5 |
| N | 935 | 456 | 479 | 334 | 601 |

Level of significance: *:$p$<0,05 ; **:$p$<0,01 ; ***:$p$<0,001

2) are positive and significant. It means that cooperative behavior is more likely to emerge in situations where the expected length of the relationship is long and the information about cooperative or uncooperative sellers' past behavior is public.

To gain more insight on the impact of the duration of the game on sellers' cooperation, we split the sample into two subsamples : one with data from private information treatments and the other with data from public information treatments. Hence, we isolate the direct impact of our variable *Probability of Continuation* (Models 2 and 3). Results show that the duration of the game is an enhancing factor of cooperative behavior when information is public. On the contrary, the probability of continuation does not encourage cooperation when the information is private.[18] We use the same method to study the direct effect of public information. Hence, Models 4 and 5 estimate the cooperative choices of sellers in case of incomplete contract on two subsamples (one with data from short run treatment and the other with data from long run treatment). Results show that public information is always an enhancing factors of cooperation. This result is consistent with previous studies which highlight reputational concerns as a powerful amplifier of cooperative behavior (Fehr et al. [2009]). However, we can notice that this effect is of higher magnitude (and also more significant) when the duration of the game is longer. Moreover, Table 2 also show that endgame effect is reduced when we focus on treatment characterized by the higher probability of continuation. Indeed, the variable *Round 6* is not significant in Model 5 while it is always significant in all other specifications.

In the end, our findings indicate that both longer duration and public information enhance cooperation, especially when they are used in the meantime. In the following subsection, we now study the impact sustainable relational contracts have on endogenous contractual incompleteness.

[18] As we will discuss later, such a result can be explained by the existence of sellers' strategic behavior when information is private.

### 5.2.2 Sustainable relational contract and contractual incompleteness

Table 3 provides the results of logit estimation of buyers' *Additional Investment*. For each model, we look at the impact of the *Probability of Continuation* (*PC*) and *Public Information* (*PI*) on the choices of buyers to invest in contractual completeness or not at the beginning of each period. Furthermore, according to what we find with the descriptive statistics, we also introduce variables about sellers' past behavior. On the one hand, we have the variable *Lagged.Cooperation* that counts for the number of time the seller decides to cooperate in the past in case of incomplete contract in the relationship with the buyer; on the other hand, the variable *Lagged.Reputation* that counts for the number of time the seller decides to cooperate in the past in case of incomplete contract in all her relationships (information only available in SRP and LRP treatments). The set of control variables we include is the same than previously (*Past Experiences*, *Ongoing Relationships*, *Altruism*, *Round*, *Age*, *Sex*, *Status* and *Discipline*) and only differs from the addition of a new variable about the "level" of risk aversion (*Risk Prone*) identified in each particular session.[19] Here also, we cluster on buyers' level.

Table 3: Logit analysis of Buyers' *Additional Investment*

| | Model 1<br>All sample | Model 2<br>PI = 0 | Model 3<br>PI = 1 | Model 4<br>PC = 0 | Model 5<br>PC = 1 | Model 6<br>PC = 0<br>PI = 1 | Model 7<br>PC = 1<br>PI = 1 |
|---|---|---|---|---|---|---|---|
| Probability of Continuation (PC) | 0.612** | 1.178*** | 0.130 | . | . | . | . |
| | (0.198) | (0.253) | (0.297) | . | . | . | . |
| Public Information (PI) | -0.356 | . | . | -0.688 | -0.541 | . | . |
| | (0.264) | . | . | (0.518) | (0.335) | . | . |
| Lagged.CumulCooperation | -0.671*** | -0.843*** | -0.636*** | -1.021*** | -0.835*** | -0.494* | -0.699*** |
| | (0.110) | (0.134) | (0.134) | (0.197) | (0.111) | (0.242) | (0.160) |
| Lagged.Reputation | -0.012*** | . | -0.019*** | . | . | -0.019*** | -0.020** |
| | (0.003) | . | (0.004) | . | . | (0.005) | (0.008) |
| Past Experiences | 0.136** | 0.177** | 0.170*** | 0.023 | 0.179** | -0.073 | 0.212*** |
| | (0.052) | (0.063) | (0.050) | (0.106) | (0.055) | (0.161) | (0.054) |
| Ongoing Relationships | 0.012 | 0.281 | -0.053 | 0.480* | -0.321 | 0.434 | -0.408 |
| | (0.172) | (0.235) | (0.262) | (0.238) | (0.200) | (0.341) | (0.329) |
| Altruism | -0.014** | -0.020* | -0.006 | -0.031* | -0.014** | -0.026 | -0.004 |
| | (0.005) | (0.009) | (0.005) | (0.016) | (0.005) | (0.019) | (0.007) |
| Risk Adversity | -0.004 | -0.016 | 0.001 | -0.015 | -0.002 | -0.013 | -0.000 |
| | (0.005) | (0.010) | (0.005) | (0.013) | (0.005) | (0.018) | (0.007) |
| Round 6 | 0.666*** | 0.427 | 0.918** | 1.151*** | 0.707** | 1.220* | 0.988** |
| | (0.183) | (0.226) | (0.280) | (0.338) | (0.229) | (0.519) | (0.383) |
| Control Variables | yes | yes | yes | yes | yes | yes | yes |
| Constant | 0.803 | 0.972 | 0.198 | 0.319 | 1.533 | 1.136 | 1.098 |
| | (0.676) | (0.941) | (1.037) | (1.155) | (1.008) | (2.307) | (1.483) |
| $R^2$ | 0.23 | 0.23 | 0.24 | 0.14 | 0.23 | 0.18 | 0.28 |
| Predict | 74.3 | 72.3 | 76.8 | 68.2 | 75.6 | 71.2 | 78.8 |
| N | 1963 | 1046 | 968 | 711 | 1384 | 340 | 628 |

Level of significance: *:$p$<0,05 ; **:$p$<0,01 ; ***:$p$<0,001

Results of Model 1 confirm the surprising results observed through descriptive statistics in the previous subsection. Actually, the coefficient associated with our variable *Probability of Continuation* is positive and significant, meaning that buyers are more prone to pay for contractual completeness when the duration of the game is longer. In the same way, we do not find any significant impact of the nature of information. Hereagain, we divided the sample in different

[19] As for the variable *Altruism*, participants first play a one shot game without knowing that they will play a repeated game after. Since there is any incentive for sellers to cooperate in the one shot game, buyers have strong incentives to protect themselves as much as they can. Thus, we use the level of no additional investments observed during the one shot game as a measure of the proportion of risk prone players present in the lab

subsamples in order to study more carefully the direct impact of the duration of the game and the nature of information on buyers' *Additional Investment*. On the one hand, the comparison between Models 4 and 5 confirm that the nature of information, whether public or private, does not directly modify the choice of buyers in terms of *Additional Investment*. On the other hand, the comparison between Models 2 and 3 highlights that a longer duration of the game make buyers more willing to invest in completeness but only when information is private.
Hence our propositions 3a and 3b, previously infirmed by descriptive statistics, are also rejected by econometric tests. However, the existence of an indirect effect through cooperative behavior of sellers is clearly observable: past cooperative behavior of sellers promotes less contractual completeness. This effect is highly significant in Model 1 but also in Models 2 to 7 where we successively isolate the impact of the *Probability of Continuation* and the *Public Information*. In all those estimations, the main factor explaining buyers' choices in terms of *Additional Investment* is our variable *Lagged.CumulCooperation*. The negative and significant coefficients associated with this variable indicates that buyers are less likely to invest in contractual completeness when they learn that they are associated with cooperative sellers. Similarly, the coefficients associated with our variable *Lagged.Reputation* are negative and significant. In spite of the fact that the nature of information does not directly influence sellers' behavior in terms of *Additional Investment* (the variable *Public Information* is not significant in Models 4 and 5), we observe that in treatments where information is public, this information is used by buyers to determine the level of contractual completeness they want. Actually, the more the seller appears as cooperative, the less the buyer is prone to invest in completeness. Furthermore, our variable *Lagged.CumulCooperation* is still significant even when we introduce our variable *Lagged.Reputation*. It means that buyers not only take into account their personal interactions with each particular seller but they also care about the behavior of the seller outside of their relationship. We interpret this result by the key role played by past reputation: sellers' reputation helps two different type of buyers in their decisions. On the one hand, it could reinforce or moderate information obtained by buyers through direct interactions; on the other hand, it could be used by buyers who do not know yet the seller as a proxy for the willingness to cooperate. In the end, our results show that less complete contracts are observed in highest cooperative past relationships and with highest reliable sellers. As a consequence, we can affirm that the sustainability of relational contracts over time encourage buyers to reduce the level of contractual completeness. A learning process is needed to determine the type of seller (*i.e.* her ability to sustain the relational contract).[20]

Concerning the surprising result of the positive and significant sign associated with the variable *Probability of Continuation* in case of private information, the explanation we propose comes from the existence of strategic behavior of sellers. Although long duration of the game facilitates cooperation, it does not imply that sellers always cooperate. As observed in the data, and as confirmed by informal discussions with participants at the end of experiments, sellers in repeated game are more willing to imagine strategies than to follow a specific behavior. In most of the cases, such strategies take two forms : cooperate most of the time and hold-up occasionally in order to increase their earnings while avoiding the risk of being punished by buyers, or always cooperate at the beginning of the game in order to build reputation of reliability and hold-up more and more frequently when the game was extended periods by periods. Consequently, buyers also have to periodically revise their beliefs and to protect themselves by investing more in

[20]Such a timing is confirmed by the results of the two stages estimation provided in Table 9 in Appendix.

contractual completeness. Since those kind of strategies are easier to implement on the long run and when such strategic behavior have lower risk to be broadly discovered, it could explain why, only when information is private, we have a positive and significant sign associated with the variable *Probability of Continuation* in the econometric analysis of *Additional Investment* (Model 2, Table 3) and why this same variable *Probability of Continuation* does not significantly impact on sellers' cooperation (Model 2, Table 2).
Finally, to check for robustness, all the results presented in this section are also analyzed without taking into account the first fifth rounds where the probability of continuation is equal to one. Figures 8 and 9 and Tables 7 and 8 provided in Appendix show highly similar results.

# 6 Conclusion

The primary purpose of this study was to examine the interplay between sustainable relational contract and endogenous contractual incompleteness. The series of experiments shed new lights on this topic. Evidence suggests that reputational concerns - through higher probability of continuation and public information - are enhancing factors of sustainable relational contract but also that the more or less cooperative behavior of sellers has a strong consequence in the subsequent choices made by buyers in terms of contractual completeness. Buyers clearly appear less prone to protect themselves (by investing more in the contractual design) when they are associated with cooperative sellers than uncooperative ones. It means that buyers adapt their investment in contractual completeness according to what they learned in previous periods and they decide themselves to incur lower costs in contractual safeguard mechanisms only when they really observe cooperative behavior. Those results are a step forward on the path to improve our understanding of the dynamics of contractual incompleteness. For instance, it might be used to explain many situations of "lock-in" effect where a firm (or a public authority) prefers to keep its actual partner (or operator) or to choose the same one for a new project despite the presence of other potential and cheaper partners. The learning process allow parties to know each other and to build contractual design accordingly, making the change of partners potentially risky and more expensive than the cost reduction proposed by the alternative option. It also highlights the importance of considering past experiences in the choice of partner and level of safeguard mechanisms foreseen by the contract.
Our study leaves many directions open for future extensions. The first concern is about the extent to which the results in this study are robust to changes in the payoffs parameters. In the experiment, the level of payoffs does not vary since we are primarily interested in the enhancing factors of cooperation and their implications on the level of contractual completeness. Nevertheless, one can expect that the level of payoffs may impact on the behavior of buyers and sellers. For instance, a case where the hold-up is high for sellers (*i.e.* possibility to grab all the surplus) and strongly dangerous for buyers (*i.e.* negative payoffs) may modify their respective behavior in terms of cooperation and investment in contractual completeness. A second concern is that we only focus in this paper on one-side opportunism (only sellers have the possibility to deviate). Obviously, in classical buyer-seller relationship, buyers can also deviate (payment default for instance) and sellers could want to learn their partner's type. Then, an interesting extension will be to enrich the experimental design in order to allow both players to choose between cooperation or deviation in the surplus sharing and to define the level of

contractual completeness they want. Such an experiment can provide us with a more satisfactory analysis of the interplay between cooperative relationships and subsequent choices in terms of contractual completeness. Our third concern is about outside option. While we remind that incentives provided by the outside option depend on the levels of competitive pressure, specific investments and information sharing, only the nature of information varies in our experiments. As a consequence, we actually observe few cases of relationships failures in our experiment (fewer than 10% of relationships are ended when buyers observe opportunistic behavior). Most of the time, the buyers prefer to increase the level of contractual completeness rather than to start a new relationship. Thus, it could be explained by the level of initial investment (*i.e.* specific investment) but also by the fact that the maximum authorized number of different relationships by rounds is established to three while there are six potential partners on the lab. It might be worthwhile to compare our actual results with sessions with different levels of initial investment and/or including more potential partners in order to observe the subsequent choices of buyers and sellers. An interesting extension has to be found in Brown et al. [2008]. In this paper, the authors study the performance of relational contract with variations in the market structure: they refer to *high-demand* market where there are fewer principals than agents and, inversely, to *low-demand* market where there are fewer principals than agents.
Finally, another extension that could be worthwhile to investigate would be to allow players to have more or less profitable relationships (or similarly to specify more or less important payoffs for different relationships). Such a design would help us to observe how the causality between relational contract and endogenous contractual incompleteness could also be influenced by the profitability of relationships. All those possible extensions are as many alleys for future researches in this exciting topic.

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# 7 Appendix

## 7.1 Experimental instructions

*The following instructions were handed out to the participants in the* ***LRP treatment***

### Instructions

You participate in an economic experiment which takes place in a computer room. We inform you that during this experiment it is purely forbidden to have talks. If you follow carefully the instructions, you will make gains and you will be paid in cash at the end of the experiment.
Please note that the following guidelines are applicable to all candidates.
The currency used during the experiment is the ECU (Experimental Currency Unit), and all the transactions will only be denominated in ecus. At the end of this session, your gains will be paid in euro according to the following exchange rate: 40 ecus for 1 EURO.

**Parts of the experiment**
The participants of the experiment are assigned to two different groups:

- Group A: 6 participants: from $A_1$ to $A_6$.
- Group B: 6 participants: from $B_1$ to $B_6$.

The participants have to assume the role of their group (A or B) and number (from 1 to 6) until the end of the experiment. This way, you can identify the other participants with who you are going to interact throughout the experiment. You start the experiment with 0 ecus.
The experiment is composed of an undetermined number of periods.

**The relationship**
In order to improve your decision-making and to optimize your understanding of the decisions made by the other participants, there is some information about the relationships' functioning.
During this experiment, you are going to make other participants your partners in. These partnerships allow your partner and you to make some profits.
Players A will suggest partnerships to Players B. Players B will have the choice to accept or refuse the partnerships' suggestions made by Players A.
You will be able to make at the most three different partnerships per periods. It is also possible that according to the other participants' choices you will have 0 partnerships sometimes.

**Investment**
When you create a partnership for the first time, both of the participants (A and B) will have to invest 6 ecus. This investment has to be made only once. This way, if you repeat the partnership during the following period, the two participants will not have to invest 6 ecus again. Yet, if two participants who were already in a partnership before decide to get into a partnership again, both of them will have to invest again 6 ecus because they did not repeat the partnership during the following period.

**"Situations" and "choices"**
When a partnership is created, two types of situations can happen (according to the probabilities given between parentheses) :

- Situation 1 (probability : 50%) : the partnership yields 40 ecus which are automatically spitted up into two equals part. A and B both receive 20 ecus.
- Situation 2 (probability : 50%) : the partnership yields 40 ecus but in this case, the distribution of the profits depends of the choice of the B participant. B will choose between:
  - Choice 1 : A receives 20 ecus and B receives 20 ecus.
  - Choice 2 : A receives 10 ecus and B receives 30 ecus.

**Additional Investment**

At the beginning of each period, players A can decide to make an additional investment of 2 ecus in order to change the probabilities assigned to the situations 1 and 2. This additional investment allows players A to obtain the situation 1 with a probability of 75% and the situation 2 with a probability of 25% (to compare with the 50%-50% probability when there is not additional investment) for the current period and the concerned partnership.

**Information**

At the end of each period, players A are informed about the choices made by all players B during the past periods. This way, players A can notice the distribution (in percentage) of the choices made by players B between the choice 1 and the 2 during all the past periods.

**The sequence of one period**

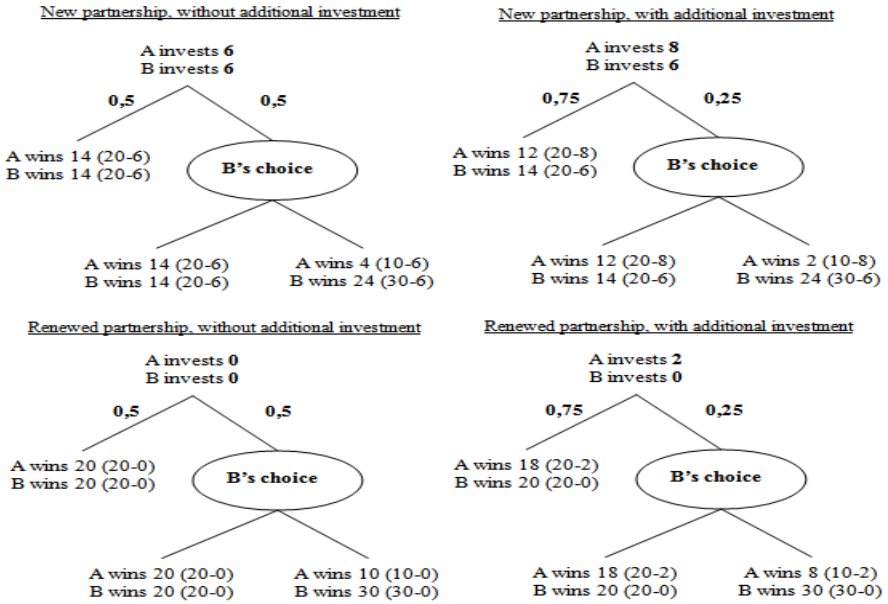
- Step 1. Players A suggest partnerships to players B. (At most 6 propositions)
- Step 2. Players B accept or reject partnership offers from players A. (At most 3 accepted partnerships)
- Step 3. Players A choose at most 3 players B among positive answers.
- Step 4. Players A choose the level of their investment. (Players B do not know the investment level chose by players A)
- Step 5. All participants learn the repartition of their partnerships between situations 1 and 2.
- Step 6. Players B choose surplus sharing in case of situations 2.
- Step 7. All participants learn their gains for the current period, then their cumulative gains for the whole experiment.
- Step 8. Players A learn the choice made by all players B in their partnerships since the beginning of the experiment.
- Step 9. Players A can decide to stop some of their partnerships (or all of them) or to suggest to players B to pursue some of their partnerships (or all of them).
- Step 10. Players B accept or reject partnership's renewals' offers from players A.
- Step 11. Players A can suggest partnerships to players B with who they were not associated within the current period.
- $\rightarrow$ Go back to Step 2.

**Length of the experiment**

The experiment entails at least 6 periods. After which, the experiment continues period by period with a probability 0.8. In other words, at the end of the sixth period, there are 8 in 10 chances to play an extra seventh period. At the end of this seventh period, there are 8 in 10 chances to play an extra eighth. And so on ...

**Payoffs**

The figure below summarizes gains associated with different situations and actions of players.




## 7.2 Tables and Figures

Table 4: Samples, non-parametric test results (Wilcoxon scores)

| Variables | Samples | Z | Probability >Z |
|---|---|---|---|
| **Cooperation** | SR vs SRP | -2.187 | 0.0287 |
| | SR vs LR | -0.963 | 0.3358 |
| | SR vs LRP | -5.555 | 0.0000 |
| | SRP vs LR | 1.309 | 0.1905 |
| | SRP vs LRP | -3.301 | 0.0010 |
| | LR vs LRP | -5.555 | 0.0000 |
| | **Short Run vs Long Run** | **-3.046** | **0.0023** |
| | **Private vs Public information** | **-5.021** | **0.0000** |
| **Additional Investment** | SR vs SRP | -0.085 | 0.9321 |
| | SR vs LR | -4.562 | 0.0000 |
| | SR vs LRP | 0.530 | 0.5959 |
| | SRP vs LR | -4.565 | 0.0000 |
| | SRP vs LRP | 0.630 | 0.5287 |
| | LR vs LRP | 0.530 | 0.5959 |
| | **Short Run vs Long Run** | **-2.870** | **0.0041** |
| | **Private vs Public information** | **3.966** | **0.0001** |

Table 5: List of variables and summary statistics

| **Variable** | **Description** | **Obs.** | **Mean** | **St. Dev.** | **Min.** | **Max.** |
|---|---|---|---|---|---|---|
| Cooperation | Dummy variables indicating whether the seller decide to cooperate (1) or not (0). | 935 | 0.58 | 0.49 | 0 | 1 |
| Additional Investment | Dummy variables indicating whether the buyer decide to make an additional investment at the beginning of the round (1) or not (0). | 2450 | 0.44 | 0.50 | 0 | 1 |
| Probability of continuation | Dummy variables indicating whether the probability of continuation is high (1) or low (0). | 5400 | 0.63 | 0.48 | 0 | 1 |
| Public Information | Dummy variables indicating whether the information about sellers' past behavior is public (1) or not (0). | 5400 | 0.51 | 0.50 | 0 | 1 |
| Past Experiences | Number of past interactions between the seller and the buyer during previous rounds. | 5400 | 7.2 | 3.6 | 0 | 19 |
| Ongoing Relationships (Buyer) | Number of ongoing relationships of the buyer in the current round. | 5400 | 2.72 | 0.57 | 0 | 3 |
| Ongoing Relationships (Seller) | Number of ongoing relationships of the seller in the current round. | 5400 | 2.72 | 0.58 | 0 | 3 |
| Reputation | Percentage of cooperative decisions made by each seller in all the previous periods and in all its relationships. | 2308 | 56.75 | 42.77 | 0 | 100 |
| CumulCooperation | Percentage of cooperative behavior of seller in all the previous periods of their relationship. | 2322 | 0.53 | 0.45 | 0 | 1 |
| Altruism | Percentage of "altruistic players" identified during the one shot game. | 16 | 21.81 | 20.94 | 0 | 66.6 |
| Risk Prone | Percentage of "risk prone players" identified during the one shot game. | 16 | 56.94 | 28.18 | 0 | 100 |

Table 6: Correlations

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| (1) Cooperation | 1.0000 | | | | | |
| (2) Additional Investment | -0.2331 | 1.0000 | | | | |
| (3) Probability of Continuation | 0.1244 | 0.0672 | 1.0000 | | | |
| (4) Public Information | 0.1597 | -0.1089 | 0.0139 | 1.0000 | | |
| (5) CumulCooperation | 0.4800 | -0.2549 | 0.2550 | 0.0767 | 1.0000 | |
| (6) Reputation | 0.7647 | -0.2879 | 0.1084 | 0.2161 | 0.5270 | 1.0000 |
| (7) Past Experiences | 0.0500 | 0.0400 | 0.3156 | -0.0711 | 0.6484 | 0.1204 |
| (8) Ongoing Relationships (Buyers) | 0.0632 | -0.0271 | 0.0290 | -0.0329 | 0.1029 | 0.0805 |
| (9) Ongoing Relationships (Sellers) | 0.1172 | -0.0519 | 0.0744 | -0.0391 | 0.2188 | 0.2612 |
| (10) Altruism | 0.0890 | -0.0529 | 0.2685 | -0.1822 | 0.2638 | 0.1111 |
| (11) Risk Prone | 0.0810 | -0.0892 | -0.3365 | 0.6716 | 0.0005 | 0.1537 |

| | (7) | (8) | (9) | (10) | (11) | |
|---|---|---|---|---|---|---|
| (7) Past Experiences | 1.0000 | | | | | |
| (8) Ongoing Relationships (Buyers) | 0.1470 | 1.0000 | | | | |
| (9) Ongoing Relationships (Sellers) | 0.2211 | 0.0935 | 1.0000 | | | |
| (10) Altruism | 0.3974 | 0.1195 | 0.1236 | 1.0000 | | |
| (11) Risk Prone | -0.1806 | -0.0171 | -0.0591 | -0.2945 | 1.0000 | |

Figure 8: Sellers' *Cooperation* (*left*) and buyers' *Additional Investment* (*right*)

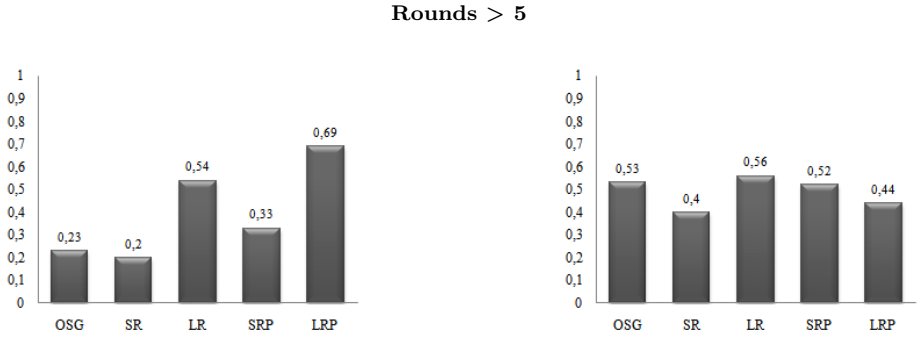



Figure 9: Buyer's *Additional Investment* depending on sellers' past *Cooperation* (*left*) and depending on sellers' *Reputation* (in SRP and LRP treatments) (*right*)

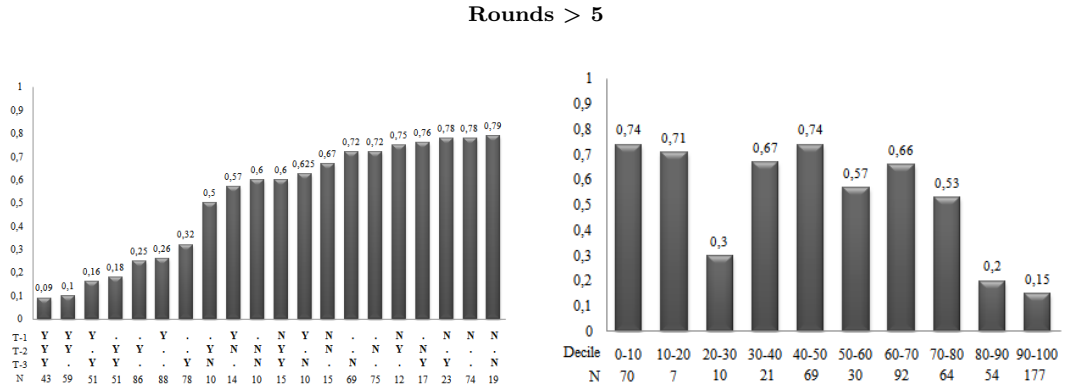



Table 7: Logit analysis of Sellers' *Cooperation* - Rounds > 5

| | Model 1<br>All sample | Model 2<br>PI = 0 | Model 3<br>PI = 1 | Model 4<br>PC = 0 | Model 5<br>PC = 1 |
|---|---|---|---|---|---|
| Probability of Continuation (PC) | 1.281*** | 2.100* | 0.911* | . | . |
| | (0.389) | (0.960) | (0.448) | . | . |
| Public Information (PI) | 0.919*** | . | . | 0.865* | 0.633* |
| | (0.241) | . | . | (0.397) | (0.285) |
| Past Experiences | 0.066 | 0.080* | 0.029 | 0.241 | 0.057 |
| | (0.034) | (0.037) | (0.062) | (0.174) | (0.038) |
| Ongoing Relationships | 1.438* | 3.213 | 1.116* | -0.599 | 2.603* |
| | (0.559) | (2.389) | (0.494) | (1.006) | (1.175) |
| Altruism | 0.007 | 0.001 | 0.009 | 0.002 | 0.006 |
| | (0.004) | (0.007) | (0.005) | (0.025) | (0.004) |
| Control Variables | yes | yes | yes | yes | yes |
| Constant | -9.434*** | -15.862 | -7.865*** | -2.396 | -14.137*** |
| | (2.086) | (8.522) | (2.153) | (3.052) | (3.510) |
| $R^2$ | 0.17 | 0.21 | 0.13 | 0.06 | 0.18 |
| Predict | 73.4 | 77.6 | 71.3 | 71.7 | 74.4 |
| N | 447 | 210 | 237 | 99 | 348 |

Level of significance: *:$p$<0,05 ; **:$p$<0,01 ; ***:$p$<0,001

Table 8: Logit analysis of Buyers' *Additional Investment* - Rounds > 5

| | Model 1<br>All sample | Model 2<br>PI = 0 | Model 3<br>PI = 1 | Model 4<br>PC = 0 | Model 5<br>PC = 1 | Model 6<br>PC = 0<br>PI = 1 | Model 7<br>PC = 1<br>PI = 1 |
|---|---|---|---|---|---|---|---|
| Probability of Continuation (PC) | 0.649* | 1.504*** | 0.354 | . | . | . | . |
| | (0.273) | (0.371) | (0.406) | . | . | . | . |
| Public Information (PI) | -0.203 | . | . | -1.406* | -0.339 | . | . |
| | (0.388) | . | . | (0.679) | (0.505) | . | . |
| Lagged.CumulCooperation | -0.658*** | -0.725*** | -0.706*** | -0.838** | -0.799*** | -0.872* | -0.699*** |
| | (0.114) | (0.127) | (0.146) | (0.264) | (0.108) | (0.440) | (0.168) |
| Lagged.Reputation | -0.011* | . | -0.013* | . | . | -0.010* | -0.023* |
| | (0.005) | . | (0.006) | . | . | (0.004) | (0.011) |
| Past Experiences | 0.138** | 0.168** | 0.147** | -0.043 | 0.167*** | -0.293 | 0.184** |
| | (0.048) | (0.061) | (0.053) | (0.167) | (0.050) | (0.207) | (0.057) |
| Ongoing Relationships | -0.074 | 0.002 | -0.029 | 0.749* | -0.390 | 1.222** | -0.499 |
| | (0.266) | (0.540) | (0.327) | (0.358) | (0.333) | (0.449) | (0.374) |
| Altruism | -0.011 | -0.017 | -0.006 | -0.064** | -0.011 | -0.065** | -0.000 |
| | (0.006) | (0.012) | (0.007) | (0.020) | (0.007) | (0.021) | (0.008) |
| Risk Prone | -0.007 | -0.029* | -0.002 | -0.036* | -0.006 | -0.037 | -0.004 |
| | (0.007) | (0.013) | (0.008) | (0.015) | (0.009) | (0.019) | (0.010) |
| Control Variables | yes | yes | yes | yes | yes | yes | yes |
| Constant | 1.707 | 3.350 | 0.429 | 2.955 | 2.931* | 2.512 | 2.783 |
| | (0.998) | (1.879) | (1.460) | (1.617) | (1.320) | (2.941) | (2.563) |
| $R^2$ | 0.24 | 0.3 | 0.22 | 0.19 | 0.26 | 0.2 | 0.28 |
| Predict | 75.2 | 77.4 | 73.7 | 69.4 | 76.8 | 68.8 | 78.5 |
| N | 1144 | 579 | 570 | 258 | 906 | 141 | 429 |

Level of significance: *:$p$<0,05 ; **:$p$<0,01 ; ***:$p$<0,001

Table 9: Two Stage Analysis

| | **First Stage**<br>*Cooperation* | **Second Stage**<br>*Additional Investment* |
|---|---|---|
| Cooperation | | -0.619* |
| | | (0.309) |
| Probability of Continuation | 0.339** | 0.116* |
| | (0.103) | (0.051) |
| Public Information | 0.974*** | -0.012 |
| | (0.195) | (0.072) |
| Lagged.Past Experiences | 0.088** | -0.016* |
| | (0.034) | (0.008) |
| Lagged.Ongoing Relationships | 1.216*** | -0.032 |
| | (0.283) | (0.042) |
| Lagged.ROUND | -1.292*** | 0.096 |
| | (0.271) | (0.090) |
| Altruism | 0.005 | -0.000 |
| | (0.004) | (0.001) |
| Risk Prone | | 0.000 |
| | | (0.001) |
| Control Variables | yes | yes |
| Constant | -5.753*** | 0.893*** |
| | (1.112) | (0.141) |
| $R^2$ | 0.10 | 0.22 |
| N | 749 | 749 |

Level of significance: *:$p$<0,05 ; **:$p$<0,01 ; ***:$p$<0,001