Can strategic delegation solve the hold-up problem?*

Yadi Yang

March 15, 2022

Abstract

This paper investigates the potential of strategic delegation to mitigate the hold-up problem. In transactions with an investment stage followed by a bilateral bargaining stage, the lack of commitment induces underinvestment. Strategic delegation can work as a commitment device if a principal sets an appropriate incentive scheme for an agent. This paper conducts a laboratory experiment in which a player can delegate the allocation decision in the bargaining stage to an agent. The payoff of the agent can be linked with bargaining results via the incentive scheme. This enables the investor to make a credible threat to reject opportunistic offers, or the non-investor to make a credible promise to limit exploitation. The experiment finds more frequent investments and fewer opportunistic behaviors when the principals properly incentivize their agents.

JEL code: L00, L14, D22, D23

Keywords: Strategic delegation, Hold-up problem, Commitment, Ultimatum bargaining

*I am grateful for valuable comments received from Jan Potters, Cédric Argenton, Alex Possajennikov, Randolph Sloof, Sigrid Suetens, Wieland Müller, Reyer Gerlagh, Rachel Kranton, Madina Kurmangaliyeva, Astri Muren, as well as from seminar participants at Tilburg University, Stocholm University, participants of NCBEE in Odense, Experimental Economics Workshop in Xiamen, Spring School in Behavioral Economics in San Diego, M-BEES in Maastricht, Tiber Symposium in Tilburg, ESA meeting in Dijon.

1 Introduction

Underinvestment in relationship-specific assets is a prevalent problem in bilateral transactions with incomplete contracts. Due to unverifiable efforts or stochastic uncertainty, the allocation of investment returns cannot be contracted upon before the investment decision, and can only be determined through *ex post* bargaining. This gives rise to possible opportunistic behaviors to appropriate investment returns. For fear of not being able to extract a sufficient share of gains to cover sunk investment, investors[1] refrain from choosing the efficient investment level. This underinvestment is often referred to as the "hold-up problem" (Klein, 1998). The hold-up problem is prevalent in vertical relationships such as manufacturer-retailer relationships (Klein et al., 1978). When a manufacturer builds customized prototypes or develops product innovations for a specific retailer, the profitability of the prototype or the technology is affected by *ex post* stochasticity and thus cannot be contracted upon when the manufacturer makes the investment decision. Fearing that the retailer may offer a low price, the manufacturer refrains from making efficient investments.[2]

One of the essential elements that give rise to the hold-up problem is *ex post* opportunistic behavior due to the lack of commitment (Klein, 1998). Existing studies on remedies for the hold-up problem highlight the use of various methods to increase the cost for opportunism and restore commitment (Miller, 2011). The current paper studies whether such commitment can be achieved by delegation in a setting with the hold-up problem. Strategic delegation can serve as a commitment device in some strategic environments under appropriate conditions (Schelling, 1960, 2006). A player can delegate the decision to an agent with known behavioral traits or setting an observable incentive scheme in advance. In this way, the principal commits to a strategy, which alters the opposing player's beliefs and responding strategies. It has been theoretically proved that principals can gain strategic advantages by credible commitment in the form of strategic delegation in oligopolistic competitions (Vickers, 1985; Fershtman and Judd, 1987; Sklivas, 1987) and various bargaining situations (Jones, 1989; Burtraw, 1992). The current paper implements strategic delegation in a hold-up game in the laboratory and

[1]The current paper considers the hold-up problem with a one-sided investment decision. The player who makes the investment decision is referred to as the investor, and the other player the non-investor. This is equivalent to the "seller-buyer" notation in other studies of the hold-up problem in vertical transactions.

[2]The hold-up problem occurs also in many other circumstances with incomplete contracts and *ex post* renegotiation, *e.g.* in firm-employee relationships with specific skills investment (MacLeod and Malcomson, 1993; Malcomson, 1997), standard-essential technology licensing (Farrell et al., 2007; Ganglmair et al., 2012; Li and Shuai, 2019), international climate agreements (Harstad, 2012, 2016), the market for academic journals (McCabe and Snyder, 2018), and international trade (Carnegie, 2014).

presents experimental evidence for how delegating the allocation decision in the bargaining stage to an agent with appropriate incentive schemes can help constrain opportunism and improve investment decisions.

The set-up in this paper is similar to the canonical model (see Che and Sákovics (2008) for a stripped-down version of the model). It is a two-player game consisting of an investor and a non-investor. The game consists of two stages: a unilateral investment stage where the investor faces a binary decision of whether or not to make a costly investment, and a subsequent bargaining stage where both players divide the gains from investment. The allocation of the investment gains cannot be contracted before the investor makes the investment decision. In the bargaining stage, the non-investor has the incentive to opportunistically extract a large share of the surplus, thus leaving an amount insufficient to cover the investment cost to the investor. Anticipating this, the investor refrains from investing in the first stage, thus creating the hold-up problem. In this paper, the bargaining stage is modeled as an ultimatum game where the non-investor makes a take-it-or-leave-it offer to divide the surplus and the investor decides whether to accept or reject.

This paper considers a baseline scenario without delegation and two delegation scenarios. In the baseline scenario, the investor and the non-investor play the basic hold-up game and make all decisions by themselves. In one delegation scenario, an agent makes the decision in the bargaining stage on behalf of the investor. The investor sets the incentive scheme for the agent prior to the investment stage of the hold-up game by setting the agent's payoff conditional on the principal's payoffs. In the other delegation scenario, the agent makes the offer on behalf of the non-investor in the bargaining stage. The non-investor sets the incentive scheme for the agent for the agent in a similar way before the investment stage. Strategic delegation allows the principal to effectively commit to strategies that later place them in an advantageous position in bargaining by setting an appropriate incentive scheme. In the investor-delegation scenario, the investor can induce the agent to reject any offer below the investment cost, thus making a credible threat to not settle for any exploitative offers. In the non-investor-delegation scenario, the non-investor can induce the agent to offer at least as much as the investment cost, thus making a credible promise to not exploit the investor so as to convince him to invest. In each of the two delegation scenarios, by giving the agent incentives which differ from the principal's own preferences, the principal are able to establish commitments that would otherwise not be credible if the strategies were to be chosen by herself[3]. With such commitments, there will be less hold-up risk and an improvement in investment decisions compared to the no-delegation baseline.

[3]For ease of distinction, this paper adopts the arbitrary convention of using feminine pronouns for the principal, and masculine pronouns for the agent.

This paper shows theoretically how strategic delegation can mitigate the hold-up problem and provides an experimental test of this potential in the laboratory. Empirical evidence on strategic delegation in bargaining is scarce. Laboratory experiments can complement the lack of empirical data with the important advantage of exogenously implementing the different institutional environments with strict control, thus the difference in investment can be compared without noise. This paper conducts an experiment with three treatments, corresponding to the baseline no-delegation scenario and the two delegation scenarios respectively.

The severity of the hold-up problem is captured by the frequency of investment, which reflects the investor's concern for potential hold-up risk, and the ultimatum offer of the non-investor (or the agent), which measures the degree of opportunism. The experimental results provide evidence for the hold-up problem. Investment decisions in all three treatments are nowhere near the efficient level. There is no significant variation in investment rates across treatments. However, conditional on investment taking place, the non-investor-delegation treatment exhibit significantly less severe hold-up behaviors compared with the other two treatments. Offers no less than the investment cost are observed significantly more frequently than the other two treatments. There is also a substantial amount of offers above the investment cost in this treatment, resulting in an average ultimatum offer significantly higher than the other two treatments. In the two delegation treatments, the investment decisions and the ultimatum offers are affected by the incentive scheme of the agent. In the investor-delegation treatment, the average investor induces the agent to reject opportunistic offers in a little more than half of the cases. Those cases are associated with more frequent investments and higher ultimatum offers than when the incentive schemes take other forms. In the non-investor-delegation treatment, the non-investor induces the agent to a sufficient amount to cover the investment cost in almost half of the cases. Those cases are also associated with fewer opportunistic offers, compared to cases with other incentive schemes. Therefore, the null result about investment rates reflects a composition effect: when the principals set the appropriate incentive schemes, investment happens more often and opportunism is hindered; when the principals do not manage efficaciously to use delegation, investment happens even less often than in the Control treatment. Strategic delegation can mitigate the hold-up problem, but in this experiment, this only applies to the subset of contracting pairs with the appropriate incentive schemes.

This paper builds its theoretical foundation upon the notion of using strategic delegation as a commitment device in bargaining (Schelling, 1960). By implementing delegation in a hold-up game setting, this paper provides evidence that the principal can gain strategic advantages by setting the incentives of the agent to differ from the principal's own payoffs. This paper contributes to the literature exploring remedies for the hold-up problem. It is in line with the growing strand of literature that investigates remedies which do not require strict institutional changes. The hold-up problem is mitigated by establishing commitment via an incentive scheme that makes the investment cost relevant for the agent. Yoon (2018) discusses the theoretical possibility of solving the hold-up problem through strategic delegation by the investor. In his paper, this is possible by making the investment cost relevant for the agent via the stock options, which raises the threat point of the agent in bargaining and can result in a higher share allocated to the investor. The scenario with delegation by the investor in the current paper has a similar mechanism. By inducing the agent to reject offers below the investment cost, the investor incorporates the sunk investment cost to the payoffs of the agent and induces the agent to be in a stronger position in the bargaining stage. This paper is also related to the few experimental studies on the trust game with a third party making the allocation decisions (Fershtman, 2007; Eisenkopf and Nüesch, 2016, 2017). These studies differ from the current paper since the agent receives a fixed payment and the principal cannot effectively commit to making or accepting certain offers. In the current paper, the principal sets an incentive scheme for the agent that links the agent's payoff to the payoff of the principal in the bargaining stage. If the agent responds to such incentives, this enables *ex ante* commitment to strategies in the bargaining stage.

The rest of the paper is organized as follows. Section 2 summarizes related literature. Section 3 explains the model for the delegated hold-up game and the SPE predictions. Section 4 describes the experiment procedure and Section 5 presents the experimental results. Section 6 takes a closer look at the incentive schemes set by the principals for the agents and their key role in mitigating the hole-up problem. Section 7 concludes the paper.

2 Related literature

This paper is related to two major strands on literature: the theoretical foundation is built upon studies of strategic delegation as a commitment device; it contributes to the literature on remedies for the hold-up problem. In particular, it is related to prior literature which examines the role of a third player to solve the hold-up problem.

2.1 Strategic delegation

Schelling (1960, 2006) proposes the idea that strategic delegation can work as a commitment device. "The delegation of part or all of one's interest, or part or all of one's initiative for decision, to some agent who becomes...another player in the game" (Schelling, 1960, p. 142) allows the principal to commit to certain strategies, which affects the opponents' beliefs and thus decisions. If chosen appropriately, strategic delegation can help the principal gain an advantageous position in subsequent transactions.[4] By setting the incentives of the agent in a different direction of herself, the principal can induce the agent to choose strategies that would not be possible if the decisions were to be made by herself.

Strategic delegation was first formally modeled in settings with oligopolistic competition as a two-stage game: in the first stage, firm owners set compensation schemes of the managers; in the second stage, managers select quantities or prices (Vickers, 1985; Fershtman and Judd, 1987; Sklivas, 1987; Miller and Pazgal, 2001, 2002). Firm owners can set the managers' compensation as a weighted average of profit and revenues, sales, or relative profits, which gives the original Cournot or Bertrand game features of a Stackelberg game, where the delegating firm is placed in a pseudo-Stackelberg leader position. Firm owners set aggressive compensations (a higher weight on revenues, sales, or the firm owners' own profit) in quantity competitions and induce the managers to set higher quantities than in cases without delegation; firm owners set cooperative compensations (a lower weight on revenues and sales, or a higher weight on the rival firm's profit) in price competitions and induce the managers to choose higher prices than in cases without delegation. A few experimental studies (Huck et al., 2004; Barreda-Tarrazona et al., 2016) implement strategic delegation in a Cournot oligopoly setting. While Barreda-Tarrazona et al. (2016) find confirming evidence for principals setting the incentives for agents to deviate from strict profit maximization, Huck et al. (2004) find that principals rarely choose the aggressive contracts with sales bonus. Potters and Yang (2021) examine delegation with strategic complements and strategic substitutes respectively. While they find supporting evidence for competitive delegation incentives with strategic substitutes, they do not find sufficient evidence for cooperative incentives in delegation with strategic complements.

A different strand of literature investigates commitment by delegation in bargaining situations over the division of a sum of money (Jones, 1989; Burtraw, 1992, 1993) or the provision of public goods (Segendorff, 1998). Like delegation games with oligopolistic competition, these delegation games with bargaining also consist

[4]Sengul et al. (2012) provides a review of strategic delegation from the perspective of strategic management and organization theory and compares different incentive schemes. Kopel and Riegler (2008) summarize strategic delegation in oligopolistic competition.

of two stages. In the first stage, the principal writes an incentive contract for the agent. The incentive contract maps the agent's payoffs to second-stage bargaining outcomes. The principal can thus induce the agent to commit to advantageous bargaining strategies via the contract. In the second stage, the agent bargains with the opponent on behalf of the principal via Nash bargaining. A common finding of these papers is the existence of a non-cooperative Nash equilibrium where the principals set the agents' incentive contracts in directions different from the principals' own preferences to gain an advantageous bargaining position. The setting of the incentive contract can also be regarded as selecting agents with certain types of preferences (Lammers, 2010). A growing experimental economics literature implements this kind of delegation in ultimatum bargaining (Fershtman and Gneezy, 2001) and face-to-face bargaining (Schotter et al., 2000). Fershtman and Gneezy (2001) find confirming evidence for strategic delegation: when the decision of the responder in the ultimatum game is made by an agent, the responder induces the agent to be tough by setting incentives such that the agent only receives the highest level of compensation if he accepts offers that are sufficiently high.

Other experiments of delegated bargaining focus on a different advantage of delegation from commitment. The principal can "shift the blame" by delegating unfavorable decisions to an agent, which allows the principal to extract a larger share of the surplus in ultimatum bargaining (Fershtman and Gneezy, 2001) and dictator games (Hamman et al., 2010). Unlike the current paper, in these experiments, delegation does not serve as a commitment device, but as a "scapegoat" who is less likely to be held responsible for unkind actions. Coffman (2011), Bartling and Fischbacher (2011), and Oexl and Grossman (2013) show that unkind offers made by an agent in dictator games are punished less often than if the unkind offers were made by the principals themselves, providing supporting evidence for the "blame-shifting" conjecture.

2.2 The hold-up problem

The hold-up problem is a classical example of problems associated with incomplete contracts. Klein et al. (1978) introduce the hold-up problem as the underinvestment in exclusive dealership contracts caused by post-contractual opportunism. It is featured with specific investments, incomplete contracts, and renegotiation (Klein, 1998). The hold-up problem in inter-firm transactions is formally modeled in the setting with procurement transactions by Tirole (1986),[5] while Grout (1984) models the hold-up problem with a firm-employee setting.[6] Che

[5]See Schmitz (2001) for a review of the hold-up problem with the incomplete contracts approach. See Coase (2006) for an overview of the hold-up problem with exclusive dealership.

[6]See Malcomson (1997) for a review of the hold-up problem in the labor market.

and Sákovics (2008) summarize a stripped-down version of the canonical model of the hold-up problem with bilateral trade of a buyer and a seller. The seller makes a binary costly investment decision that is unverifiable and thus cannot be contracted upon. The investment generates a surplus to be divided through Nash bargaining between the seller and the buyer, which yields an equal split of the surplus in equilibrium. If half the surplus is insufficient to cover the investment cost, the seller refrains from making the investment decision, hence the hold-up problem. Empirical evidence of hold-up can be found in various inter-firm transactions (*e.g.* procurement contracts and supply chains)[7] and intra-firm transactions (*e.g.* employer-employee relationships)[8].

Remedies to mitigate the inefficiency in investment caused by the hold-up problem are examined both empirically and experimentally.[9] Early investigations of remedies for the hold-up problem implement changes in the institutional environment. Miller (2011) summarizes this type of remedies as remedies using formal controls. Che and Sákovics (2008) classifies these remedies into organizational remedies which change ownership rights via vertical integration or joint venture (Grossman and Hart, 1986; Hart, 1995), and contractual remedies which rely on contract enforcement (Rogerson, 1992; Nöldeke and Schmidt, 1995; Malcomson, 1997; Maskin and Moore, 1999). Shelanski and Klein (1995) review some early empirical evidence of how hold-up threat due to asset specificity can lead to organizational and contractual changes. Both empirical and experimental studies have examined the effectiveness of these two types of remedies. Experimental evidence has exhibited improvement in investment efficiency from joint ownership (Fehr et al., 2008) and option contracts (Hoppe and Schmitz, 2011). Vertical integration and joint ventures are shown to be associated with more healthcare services (Ciliberto, 2006) and higher patent investment (Geng et al., 2016). Stronger contract enforcement is found to lead to higher investment in golf courses (Cookson, 2018). (Dubois and Vukina, 2016) show how switching from short-term to long-term con-

[7]See Rindfleisch and Heide (1997) for a review of some early empirical investigations of how asset specificity, environmental and behavioral uncertainty affect investment decisions and opportunism. Evidence for the hold-up problem can be found in various industries, *e.g.* the aerospace industry (Masten, 1984), the franchise markets (Beales III and Muris, 1995), the broiler industry (Vukina and Leegomonchai, 2006), textiles and opium exporting in colonial India (Kranton and Swamy, 2008), Kenyan rose exporting (Macchiavello and Morjaria, 2015), standard-essential patents (Galetovic et al., 2015), and various US manufacturing industries (Martin and Otto, 2017).

[8]Card et al. (2014) provide evidence for hold-up in wage bargaining using matched employer-employee data in Italy. Other empirical studies on hold-up in the labor markets focus on the effect of unionization on firm-specific investments. There has been mixed effects, with Addison et al. (2007) find no impact of work councils or unions, Hirsch (1991), Cavanaugh (1998), and Cardullo et al. (2015) find evidence for a negative impact.

[9]See Miller (2011) for a general of survey of various forms of remedy for the hold-up problem. See Yang (2021) for a review of experimental studies on the hold-up problem.

tracts results in an increase in effort and faster adoption of productivity-enhancing technologies in the broiler industry.

Miller (2011) classifies an additional group of remedies as informal substitutes when strict institutional changes are not possible. Most of this type of studies involve behavioral devices such as the observability of investment decisions (Hackett, 1994; Sloof et al., 2007), the size of the outside option (Dufwenberg and Gneezy, 2000; Oosterbeek et al., 2003; Sloof et al., 2004), information asymmetry (Drake and Haka, 2008; Miller, 2007; Nguyen and Tan, 2019), the opportunity to punish (Hackett, 1994; Dufwenberg et al., 2013), group identity (Morita and Servátka, 2013, 2018), and reputation (Haruvy et al., 2019), *etc*, and provides evidence via laboratory experiments. In particular, a small strand of literature studies the effect of strengthening commitment via pre-game communication. Similar to the current paper, these studies also adopts the design of the hold-up game with a preceding stage that allows the investor or the non-investor to make commitments regarding decisions in the bargaining stage. While in the current paper this is done by setting the incentive schemes for an agent, these papers establish commitment by allowing the non-investor to make a promise (Ellingsen and Johannesson, 2004a,b; Charness and Dufwenberg, 2006, 2010) or the investor to make a threat (Ellingsen and Johannesson, 2004a,b). They provide evidence of communication mitigating the hold-up problem. Specifically, Ellingsen and Johannesson (2004b) investigate promises and threats in a similar setting to the current paper with unilateral investment and ultimatum bargaining. They find that both threats and promises strengthen credibility, but promises are more credible. This result corresponds to the finding in the current paper since investors inducing agents to reject low offers and only accept sufficiently high offers have similar effects of a threat, and non-investors inducing agents to not exploit have similar effects of a promise.

2.3 Third player in the hold-up problem

Using strategic delegation to mitigate the hold-up problem involves a third player. Some studies have also explored the possibility of employing a third party to mitigate the hold-up problem. Baliga and Sjöström (2009) theoretically discuss how introducing a third party as a "budget breaker" (Holmstrom, 1982) can mitigate the hold-up problem. Fines paid to the third party can restore incentives for investment and reach the first-best outcome. Arya et al. (2015) show that linear cost-based contracts can be implemented via a third party as the middleman to coordinate between a manufacturer and a retailer. In these papers, the third party works as an intermediary. The investor and the non-investor have no control over the third party except for making transfer. This is essentially different from strategic delegation which links the agent's payoffs to the payoffs of the principal.

Consisting of a unilateral investing stage and a subsequent stage where the non-investor allocates the gain from investment via a dictator game, the trust game by Berg et al. (1995) has similar structures as the hold-up game. The investor faces potential hold-up risk of the non-investor not offering sufficient amount and thus may refrain from investing. It can be regarded as a special form of hold-up game. Fershtman (2007), Eisenkopf and Nüesch (2016, 2017) conduct delegated trust game experiments which introduce a third party to allocate the gain from investment. In these experiments, the third party can be implemented as a neutral intermediary, as well as exgenously appointed or endogenously selected on behalf of one of the two transacting parties. Fershtman (2007) finds no improvement in investment level when the third party is exogenously appointed and labeled as a neutral intermediary, representative of the investor, or representative of the non-investor. On the contrary, Eisenkopf and Nüesch (2016, 2017) find that only when the third party is neutral is there an improvement in investment. When the agent is selected by the non-investor competition between potential agents (Eisenkopf and Nüesch, 2016) and one-sided reputation (Eisenkopf and Nüesch, 2017), investment level is even lower than when the third party is absent. In these cases, the agent decides the allocation by himself without intervention from the principal. In other words, the principal cannot commit to certain strategies in the later stage to alter the belief of the counterpart. The results in these papers indicate that giving the allocation right to a third party alone without commitment is not sufficient to restore trust from the investor. The current paper differs from these studies by allowing the principal to have some control over the agent's decision in the bargaining stage via the incentive scheme. The difference implies that the improvement in investment is mainly due to the commitment effect.

One paper that discusses the possibility of solving the hold-up problem through strategic delegation is Yoon (2018). This is possible when the manager of the investor is compensated with stock options which make the sunk investment cost relevant from the managers' perspective. The relevant sunk cost raises the threat point of the manager in the bargaining stage, and thus leads to higher share allocated to the investor, which may induce the first-best investment level. In the current paper, the incentive scheme that maps the payoff of the agent to the payoff of the principal essentially also has the effect of relating the sunk investment cost to the agent. The current paper measures the incentive schemes from a general perspective. In addition, the current paper also explores the additional scenario when the delegation is on the non-investor's side.

3 The model

A typical hold-up game is with two players and consists of two stages: an investment stage which generates a joint surplus, and a bargaining stage where the two players negotiate to divide the surplus. In the current paper, the investment stage consists of a binary decision of whether to invest with a fixed cost or not. The player who makes the investment decision is referred to as the investor, and the other player the non-investor. The bargaining stage takes the form of an ultimatum bargaining game where the non-investor makes a take-it-or-leave-it offer about how to divide the gain from investment, and the investor decides whether to accept or to reject.[10] The current paper examines the effect of commitment in two delegation scenarios: (1) delegation by the investor and (2) delegation by the non-investor. In both scenarios, the principal sets an observable compensation scheme for the agent before the hold-up game starts. In order to focus on the commitment perspective of delegation without complications of additional cost-benefit analysis, delegation is assumed to be costless. The agent is compensated from an additional budget without affecting the payoff of the principal.[11]

3.1 The baseline hold-up game

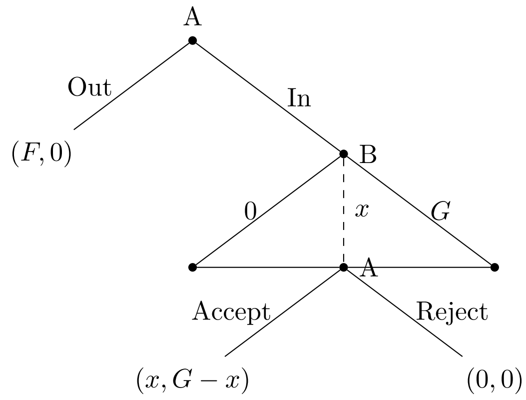
The baseline model is a two-player hold-up game. The two players in the game are denoted by Player A and Player B. π_i denotes the payoff for each player $i = A, B$. The game consists of an investment stage (henceforth Stage 1) and a subsequent ultimatum bargaining stage (henceforth Stage 2) to divide the gain from investment. In Stage 1, Player A makes an investment decision, represented by the indicator variable I, which equals 1 if Player A invests and 0 otherwise. The investment has a fixed opportunity cost of F. If $I = 0$, the game ends, and Player A keeps the investment cost F, *i.e.* $\pi_A = F$, $\pi_B = 0$. If $I = 1$, the investment generates a gain of G. Similar to other models on the hold-up problem, it is assumed that $G > F$, indicating that it is more efficient to invest since it generates a higher surplus. If $I = 1$, the game proceeds to Stage 2 where the gain from investment G is divided through ultimatum bargaining. Player B makes a proposal of $(x, G - x)$ where x is the amount to be allocated to Player A, an integer in $[0, G]$, and $G - x$ is the amount to be allocated to Player B. Player A can either accept or reject the proposal. Player A's acceptance decision is represented by $a(x) \in \{Accept, Reject\}$. If Player A accepts, the proposed

[10] The similar setting is adopted by Ellingsen and Johannesson (2004b), Hoppe and Schmitz (2011), Dufwenberg et al. (2013), Morita and Servátka (2013, 2018), and Haruvy et al. (2019).

[11] Fershtman and Gneezy (2001), Fershtman (2007), Eisenkopf and Nüesch (2016, 2017) adopt similar settings of costless delegation.

allocation is implemented, $\pi_A = x$, and $\pi_B = G - x$. If Player A rejects, both players end up with 0, $\pi_A = \pi_B = 0$. Figure 1 shows the game tree representation of the baseline hold-up game.

Figure 1: Game tree representation of the baseline hold-up game



In Stage 3, player A accepts any proposal with $x > 0$. Anticipating this, player B proposes to keep almost all of G for himself and offers $x = \epsilon$, with ϵ being a minimum positive amount. Anticipating this in Stage 1, player A does not invest in the first place. The unique subgame perfect equilibrium of the game is therefore $I = 0$, $x = \epsilon$, $a = Accept$ if $x > 0$ and $a = Reject$ if $x = 0$.[12]

Proposition 1. *Without delegation, Player A does not invest and Player B offers 0 in the ultimatum game.*

3.2 Delegation by Player A

In one delegation scenario, a third player, Player C, is included in the game to serve as an agent for Player A. Player A sets an observable incentive scheme for Player C in Stage 0 by assigning a value to $\pi_C = f(\pi_A)$ from $[0, G]$ for each possible value of π_A. Then the game follows as in the baseline game. However, if Player A chooses $I = 1$ in Stage 1 and the game continues to Stage 2, it is Player C who decides whether to accept or to reject Player B's offer on behalf of Player A. The payoffs for Player A and Player B are determined by the actions in the game in the same way as in the baseline game. The payoff for Player C is determined by the incentive scheme $\pi_C = f(\pi_A)$, which is set by Player A in Stage 0. The incentive scheme $f(\pi_A)$ is assumed to be costless. In this way, the principal's incentive setting decision is not complicated by potential trade-offs between her own payoffs and the cost of the incentives. In addition, the size of the pie to be divided between Player A and B is not affected by the cost of the incentive scheme and remains G

[12]In case of equality, it is assumed that the player takes the action on the right branch, *i.e.* $I = 1$ if $x = F$ and $a = Reject$ if $x = 0$.

whether there is delegation or not, which maintains reasonable comparability with or without delegation. Such costless delegation is also implemented by Fershtman and Gneezy (2001).

In Stage 3 Player C's best response action is $a = Accept$, if $f(x) > f(0)$; $a = Reject$, if $f(x) \leq f(0)$. In Stage 2, Player B makes the proposal $\hat{x} = argmax(G - x)$, such that $f(\hat{x}) > f(0)$. In Stage 1, Player A's decision is $I = 0$ if $\hat{x} < F$; $I = 1$ if $\hat{x} \geq F$. How Player C and Player B act in the hold up game therefore determines how Player A sets $f(x)$ in Stage 0. In order to make sure that she gets at least F if she chooses $I = 1$, $f(x)$ needs to be set such that for $x \in [0, F)$, $f(x) < f(0) < f(F)$; for $x \in [F, G]$, $f(x) \geq f(F) > f(0)$. In other words, Player A needs to induce Player C to be sufficiently tough to reject any offers below the investment cost. In this way, Player A makes sure she receives a sufficient share in the bargaining stage to cover the sunk investment cost and thus eliminates the hold-up risk.

The game has a unique subgame perfect equilibrium: for any $x \in [0, G)$, $f(x) \leq f(0) < f(G)$; $I = 1$, $x = G$, $a = Accept$ if $f(x) > f(0)$; $a = Reject$ if $f(x) \leq f(0)$. Player A makes a pregame commitment via the incentive scheme of Player C that only offers equal the full investment gain G is accepted.

Proposition 2. *With delegation by Player A, Player A rewards Player C to reject offers below the investment cost and accept only the full surplus. Player A invests and Player B offers the full share in the ultimatum game.*

3.3 Delegation by Player B

In the other delegation scenario, a third player, Player C, is included in the game to serve as an agent for Player B. Player B sets an observable incentive scheme for Player C in Stage 0 by assigning a value to $\pi_C = f(\pi_B)$ from $[0, G]$ for each possible value of π_B. Then the game follows as in the baseline game, with the proposal $(x, G - x)$ made by player C on behalf of player B in Stage 2. The payoffs for Player A and Player B are determined by the actions in the game in the same way as in the baseline hold-up game. The payoff of Player C is determined by the incentive scheme $\pi_C = f(\pi_B)$, which is set by Player B in Stage 0. Similar as delegation by Player A, $f(\pi_B)$ is also assumed to be costless.

In Stage 3 Player A accepts any $x > 0$. In Stage 2, Player C proposes $x = \bar{x}$, such that $\bar{x} = argmax\ f(G - x)$. In Stage 1, Player A's action is $I = 0$ if $\bar{x} < F$, $I = 1$ if $\bar{x} \geq F$. In Stage 0, anticipating how Player A and Player C respond to $f(\pi_B)$, Player B needs set $f(\pi_B)$ such that $\bar{x} \geq F$ in order to convince Player A to invest. This means that $f(G - F) > f(G - x)$ for any $x < F$. In other words, Player B needs to induce Player C to be sufficiently "fair" to not offer any amount below the investment cost, which also eliminates the hold-up risk and restores Player A's investment incentive.

The game has a unique subgame perfect equilibrium: for any $x \neq F$, $f(0) < f(G-x) < f(G-F)$; $I=1$, $x=F$, $a=Accept$. Player B makes a pregame promise via the incentive scheme of Player C to offer an amount equal to the investment cost.

Proposition 3. *With delegation by Player B, Player B rewards Player C to offer the investment cost. Player A invests and Player C offers the said amount in the ultimatum game.*

4 The experiment

4.1 Experimental design and procedure

A laboratory experiment is designed to test the theoretical predictions. There are three treatments: a baseline treatment without delegation (henceforth Control treatment), and two treatments with delegation: one with delegation by Player A (henceforth Treatment A), and the other with delegation by Player B (henceforth Treatment B). In the experiment, $F=6$ and $G=10$. x in the proposal $(x, 10-x)$ made by Player B (or the agent Player C in Treatment B) is an integer number from $[0,10]$. In the two delegation treatments, Player is set the incentive scheme $f(\pi_i)$ in a similar way to the one implemented by Fershtman and Gneezy (2001). The principal fills in a form by assigning a value $f(\pi_i)$ from $[0,10]$ to each possible value of π_i from $[0,10]$.

Table 1: Incentive scheme for the agent

π_i	0	1	2	3	4	5	6	7	8	9	10
$f(\pi_i)$											

In the Control treatment, after reading the instructions, subjects are randomly assigned roles of Player A and Player B. Two players assigned with different roles are randomly matched together. The baseline hold-up game as explained in Section 3.1 is played out step-by-step. Player A first chooses between In and Out. If Player A chooses Out, the game stops and the two players end up with $(6,0)$. If Player A chooses In, the game continues. Player B makes a proposal $(x, 10-x)$ with x being an integer number from $[0,10]$. Player A decides whether to accept or to reject the proposal. If Player A accepts, the proposal is implemented. If Player A rejects, both players end up with nothing.

In the two delegation treatments, there is an additional Player C who works as the agent. Subjects are randomly assigned one of the three roles, and three players with different roles are randomly matched together. There is a stage where the principal first sets the incentive scheme for the agent. In Treatment A (B), Player A (B) first fills in the above form to set the compensation scheme for Player C. The form is then announced to all three players, so that the incentive scheme is observable. After that, Player A chooses between In and Out. If Player A chooses Out, the game stops and the two players A and B end up with the same payoff as in the Control treatment, and the agent Player C receives the payoff according to the incentive scheme set by Player A (B) previously. If Player A chooses In and the game proceeds to the ultimatum bargaining stage, the agent Player C makes the decisions on behalf of Player A (B) in this stage. Player A and Player B's payoffs are determined in the same way as in the Control treatment, while Player C's payoff is the corresponding amount that Player A (B) assigns in the incentive scheme.

In all three treatments, there is one practice round and after that, the game is played for 20 rounds. At the beginning of each round, subjects are randomly re-matched within a matching group. The minimum size of a matching group is 6 in the Control treatment and 9 in the two delegation treatments. Repeated game with random matching is implemented in this paper, taking into account the complexity of the delegated hold-up game, which is different from Fershtman and Gneezy (2001) and Ellingsen and Johannesson (2004b) who let their subjects play the game only once. Compared with the delegated ultimatum game of Fershtman and Gneezy (2001), there is an additional investment stage in the delegated holdup game. Compared with the hold-up game of Ellingsen and Johannesson (2004b), there is an additional incentive setting stage. The game is played repeatedly so that the subjects can be sufficiently familiar with the underlying payoff structure of the game, so as to reduce noise caused by confusion. To minimize reputation effects, subjects are randomly re-matched in every round. One of the 20 rounds is randomly selected at the end of the session for payment. The instructions for the three treatments are given in Appendix A.2.

The experiment was conducted in June and September 2018 in CentER lab at Tilburg University. The experiment was programmed using zTree (Fischbacher, 2007). There are six sessions of the baseline treatment, and five sessions in each of the two delegation treatments. The number of participants in each session ranged between 6 to 10 in the baseline treatment, and 9 to 21 in the two delegation treatments.[13] There are 168 participants in total, with 48 in the Control treatment, 60

[13]There were two matching groups of 9 in one session in Treatment A with 18 subjects in that session, and a matching group of 9 and one of 12 in one session in Treatment B with 21 subjects

in Treatment A, and 60 in Treatment B. Subjects are bachelor and master students from various disciplines at Tilburg University. A detailed summary table of the subjects' demographic characteristics is shown in the Appendix. Each session lasted around 40 minutes in the baseline treatment, and around 75 minutes in the two delegation treatments. The payment unit was in Euros. In addition to the randomly selected payoff out of the 20 rounds, subjects also received a show-up fee of 3 Euro. The average payment for each subject was 7.7 Euro, with the minimum being 3 Euro, and the maximum being 13 Euro.

4.2 Behavioral predictions

The severity of the hold-up problem can be measured by (1) the investment decisions of Player A, *i.e.* whether Player A invests when the investment is efficient; and (2) the ultimatum offer made by Player B/C in the bargaining stage, *i.e.* whether Player B/C offers enough for Player A to cover the investment cost. The current paper focuses on two related variables: the investment rate and the hold-up rate. The investment rate is defined as the frequency of Player A choosing In. "Hold-up" is defined as the case in which an ultimatum offer insufficient to cover the sunk investment cost. In this experiment, "hold-up" occurs when the ultimatum offer is lower than 6. Accordingly, the hold-up rate is defined as the proportion of ultimatum offers below 6.

Theoretical analysis in Section 3 indicates that there will be higher investment rates and lower hold-up rates in the two delegation treatments compared with the Control treatment. In Treatment A, Player A induces Player C to reject any offers below the investment cost via the incentive scheme, which creates a credible threat that hinders Player B from extracting too much surplus, and thus restores investment incentive for Player A. In Treatment B, Player B induces Player C to offer at least as much as the sunk investment cost, which creates a credible promise to not exploit Player A, and thus also encourages Player A to invest. In both delegation cases, a reduction in hold-up behaviors and an increase in investment decisions are predicted.

Hypothesis 1. *The investment rate is higher in the two delegation treatments than in the Control treatment. The investment rates in Treatment A and Treatment B are similar.*

Hypothesis 2. *The hold-up rate is lower in the two delegation treatments than in the Control treatment. The hold-up rates in Treatment A and Treatment B are similar.*

in that session. In all other sessions, each session constitutes one matching group.

The level of ultimatum offers also provides information about the hold-up behavior. A higher level of ultimatum offer is associated with a lower hold-up rate. Therefore, the ultimatum offers in the two delegation treatments are predicted to be higher than those in the Control treatment. Contrary to the investment rate and the hold-up rate, which are predicted to exhibit no difference between Treatment A and Treatment B, ultimatum offers are predicted to be higher in Treatment A than in Treatment B. In Treatment A, delegation gives Player A a pseudo "first-mover advantage" to commit to asking for as large a share as possible. SPE predicts the extreme case of Player A asking for the whole gain from investment. This will be hard to observe in the experiment, but generally, it is reasonable to predict that Player A will incentivize Player C to start accepting at an amount above the investment cost. In Treatment B, Player B has the pseudo "first-mover advantage" and can promise to offer no more than the amount just enough to convince Player A to invest, *i.e.* the same amount as the investment cost.

Hypothesis 3. *The ultimatum offer is higher in the two delegation treatments than in the Control treatment. The ultimatum offer is higher in Treatment A than in Treatment B.*

The propositions in Section 3 are derived under the assumption that the players are self-interested agents who only care about their own material payoffs. Violation of this assumption may result in possible behavioral deviations. Previous experimental studies of the baseline hold-up problem show that social preferences can mitigate the hold-up problem to some extent (Gantner et al., 2001; Ellingsen and Johannesson, 2004b,a). Non-investors rarely fully exploit and usually offer a positive amount to the investor. In some cases, an equal, 6:4, or 4:6 split of the investment gain is sometimes observed and accepted by the investor. This indicates that the hold-up problem in the baseline game may be less severe than SPE predictions with more investment decisions and higher bargaining offers to the investors. This potential concern for fairness can also affect behaviors in the two delegation treatments of the current experiment. In addition to using the investment cost as the benchmark, principals set incentive schemes for the agents according to their own interpretations of a "fair" allocation. For example, an equal split that allocates 5 each to the investor and the non-investor can also restore investment despite being lower than the sunk investment cost.

Another possible behavioral deviation may arise due to individual heterogeneity in social preferences of the players. Individuals may have different interpretations with regards to what allocation is "fair" or equitable. In the hold-up game with fixed investment cost, some individuals may regard the equal split of the investment gain as “fair”, while some may regard the equal split of the net return as “fair” (Gantner et al., 2001; Ellingsen and Johannesson, 2004a,b). The discrepancy in equity standards may intensify the hold-up problem. If Player A and Player B have different equity standards, in Treatment B, when Player B incentivizes the agent according to her own equity standard, it may be insufficient to convince Player A to invest.

Another associated issue is the trust of the rationality of the agent. In the two delegation treatments, one key assumption is that the agent is rational and follows through the incentive scheme set by the principals. In the experiment, a number of agents’ actions may deviate from what the incentive schemes induce them to do. This consequently brings about trust issues from the principal. Especially in Treatment A, adding a third-player gives rise to the risk of the agent not behaving according to the principals’ instructions, in addition to the original hold-up risk. This may prevent Player A from investing, which even intensifies the hold-up problem.

5 Results

Table 2 presents an overview of the investment rate, hold-up rate, and ultimatum offer in all three treatments. All variables are presented as the treatment average of observations from six independent matching groups. For each treatment, the first column reports data from all 20 rounds, while the second column reports data from the last four rounds.

Table 2: Summary of results across treatments

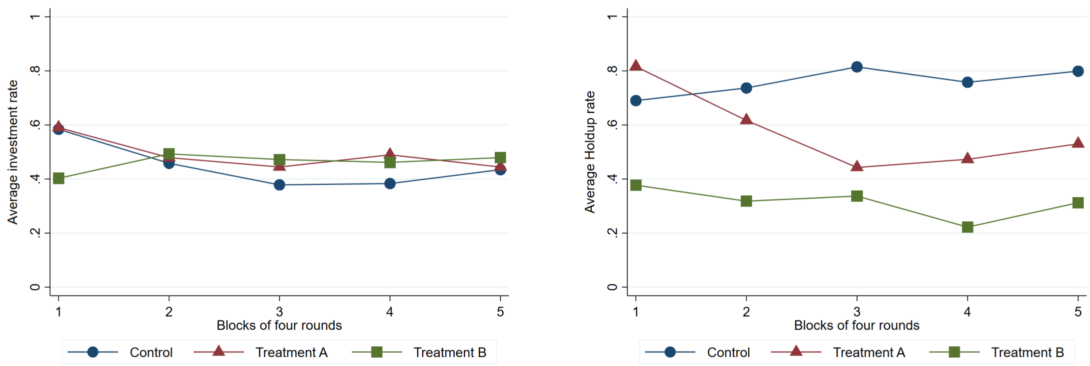
	Control		Treatment A		Treatment B	
	Overall	Last 4	Overall	Last 4	Overall	Last 4
Invest. Rate	0.45	0.43	0.49	0.44	0.46	0.49
	(0.117)	(0.126	(0.279)	(0.137)	(0.127)	(0.128)
Hold-up Rate	0.73	0.80	0.64	0.53	0.24	0.30
	(0.148)	(0.218)	(0.193)	(0.232)	(0.252)	(0.315)
Ult. Offer	4.82	4.79	4.24	5.24	6.03	6.34
	(0.433)	(0.500)	(1.468)	(1.231)	(0.617)	(0.900)
Accept. Rate	0.90	0.93	0.75	0.79	0.97	1
	(0.046)	(0.059)	(0.120)	(0.109)	(0.030)	(0)

Note: The unit of observation is one independent matching group. The table reports the treatment average (and standard deviation in parentheses) over six independent matching groups of the proportion of “In” decisions, the proportion of ultimatum offers that are below 6, the level of ultimatum offer, and the proportion of ultimatum offers that are accepted for each treatment in all 20 rounds and in the last four rounds.

Both the overall data and data from the last four rounds indicate similar levels of investment rate across all three treatments. The investment rate is a little bit below 50%. A Kruskal-Wallis test does not show any significant difference across the three treatments. In terms of (under-)investment decisions, the result does not indicate any significant treatment effect of delegation on the hold-up problem. Figure 2a divides all 20 decision rounds in five blocks of four rounds and plots the average investment rate in each treatment across the five blocks. The average investment rate remains between 0.4 and 0.6 across all five blocks in all three treatments. The difference in the pattern of the investment rate is also small across the three treatments.

Result 1. *The investment rate is similar in all three treatments*

Figure 2: Investment rate and hold-up rate across five blocks of four rounds



(a) Average investment rate

(b) Average hold-up rate

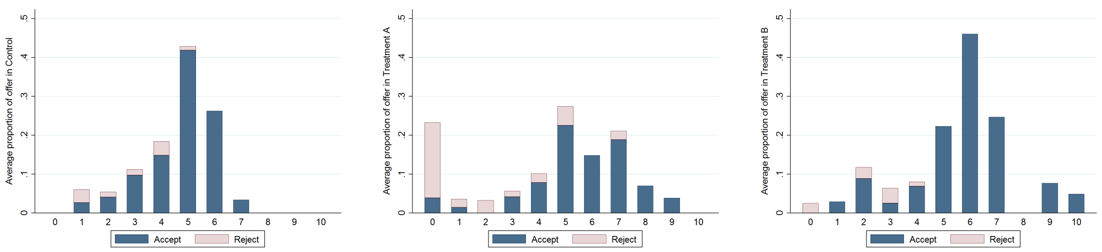
Note: The unit of observation is one independent matching group. The graph presents the development of (a) average investment rate and (b) average hold-up rate in blocks of four rounds for each treatment.

The average hold-up rate measures the actual hold-up behavior from the non-investor's side after the investor has chosen to invest. Looking at the overall data of all 20 rounds, in the Control treatment, the non-investor makes an offer below the outside option of the investor around 73% of the times when the game moves to the ultimatum stage. In Treatment A, the proportion of such offers is around 64%, slightly lower than in the Control treatment. In Treatment B, the proportion of offers below 6 is only 24%. A Kruskal-Wallis test and a Dunn's test indicate that the hold-up rate in Treatment B is significantly lower than both the Control treatment ($p < 0.01$) and Treatment A ($p < 0.05$), while the difference between the Control treatment and Treatment A is not significant. In the last four rounds, the hold-up rate is 80% in the Control treatment, 53% in Treatment A, and 30% in Treatment B. A Dunn's test following a Kruskal-Wallis test indicates a significant difference between Treatment A and the Control treatment ($p < 0.05$), as well as between Treatment B and Control ($p < 0.01$), which is also present in the overall average data. However, the difference is not significant between Treatment A and B. Figure 2b shows that the pattern of the average hold-up rate in both the Control treatment and Treatment B is fairly stable across the five blocks, with the hold-up rate remaining between 0.6 and 0.8 in the Control Treatment and between 0.2 and 0.4 in Treatment B. In Treatment A, the average hold-up rate starts at around 0.8 in the first block, and then drops to between 0.4 and 0.6 in the following four blocks. The dynamics indicate a stable significant treatment effect in Treatment B over time, while the treatment effect in Treatment A only becomes significant towards the later rounds of the experiment.

Result 2. *The hold-up rate is similar in the Control treatment and Treatment A, but significantly lower in Treatment B than in the other two treatments. Towards the end of the game, the hold-up rate decreases in Treatment A.*

The comparison of the hold-up rate across the three treatments indicates that delegation by the non-investor can effectively reduce the actual hold-up behavior from the non-investor's side. A similar conclusion can also be drawn from the comparison of the average ultimatum offer across treatments in the fifth and fourth rows of Table 2. When the game has progressed to the ultimatum stage, the average offer is higher in Treatment B than in the other two treatments, which is supported by a Dunn's test following a Kruskal-Wallis test ($p < 0.01$ when comparing Treatment B with either Control or Treatment A). The overall average ultimatum offers are similar in all 20 rounds as in the last four rounds. The only exception is found in Treatment A, where there is a slight increase to 5.24 in the last four rounds, but it does not affect the treatment effect.

Figure 3: Distribution of ultimatum offers and the frequency of acceptance



(a) Control (b) Treatment A (c) Treatment B

Note: The unit of observation is one single ultimatum offer decision. The graph presents the average frequency each possible value of ultimatum offer is offered and the respective frequency of acceptance and rejection decisions in (a) Control, (b) Treatment A, and (c) Treatment B.

The last two rows of Table 2 report the overall conditional acceptance rate of ultimatum offers in each treatment. The findings in all 20 rounds are similar as in the last four rounds. In the Control treatment, most ultimatum offers are accepted at a rate around 90%. In Treatment B, the (conditional) acceptance rate is close to 100%, with all offers accepted in the last four periods towards the end of the game. However, there appears to be more rejections in Treatment A. The (conditional) acceptance rate in Treatment A is lower than the other two treatments. A Dunn's test following a Kruskal-Wallis test indicate that the acceptance rate in Treatment A is significantly lower than in Control ($p < 0.05$) and in Treatment B ($p < 0.01$), and the acceptance rate in Treatment B is also significantly higher than in Control ($p < 0.05$). Figure 3 presents the distribution of ultimatum offers and the acceptance rate conditional on the level of offers in all three treatments. Higher ultimatum offers are offered more frequently in Treatment B and also accepted more often than in the other two treatments. In Treatment A, lower offers are rejected more often than in the other two treatments. In addition, a small proportion of high offers is also rejected in Treatment A, while the same level of offer has a 100% acceptance rate if offered in the other two treatments.

Result 3. *The ultimatum offer is similar in the Control treatment and Treatment A, but significantly higher in Treatment B than in the other two treatments.*

Table 3: Summary of payoffs across treatments

	Control	Treatment A	Treatment B
Overall payoff			
A's payoff	5.31	5.11	5.94
	(0.296)	(0.404)	(0.275)
B's payoff	2.02	1.64	1.81
	(0.556)	(1.056)	(0.705)
C's payoff	-	5.53	5.43
		(0.219)	(0.439)
Payoff if A chooses In			
A's payoff	4.50	3.48	5.95
	(0.438)	(1.761)	(0.580)
B's payoff	4.50	2.75	3.74
	(0.367)	(1.520)	(0.712)
C's payoff	-	8.09	5.36
		(0.973)	(0.323)

Note: The unit of observation is one independent matching group. The table reports the average payoffs (and standard deviation in parentheses) for each type of player in six independent matching groups over all 20 rounds in each treatment.

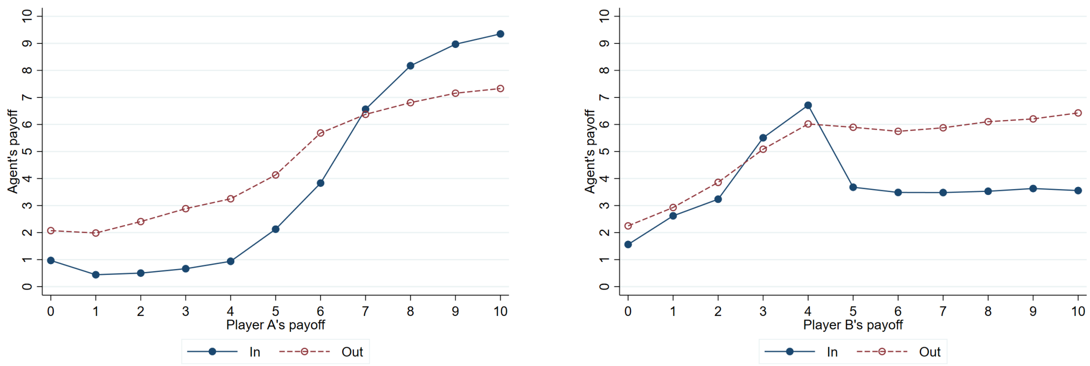
Table 3 compares the average payoffs for each player over all 20 rounds across treatments. The overall payoff for Player A is 5.94 in Treatment B, slightly higher than in other two treatments. This difference is statistically significant, supported by a Dunn's test following a Kruskal-Wallis test ($p < 0.05$ when comparing with Control, and $p < 0.01$ when comparing with Treatment A). The overall payoffs for Player B and Player C are similar across treatments. The second panel of Table 3 presents the payoffs of each player conditional on Player A choosing "In" and the game proceeding to the ultimatum stage. It can be calculated that the joint payoff of A and B in the ultimatum stage is as high as 9.02 in Control. The highest level of joint payoff is 9.69 as observed in Treatment B ($p < 0.05$ when comparing with Control and $p < 0.01$ when comparing with Treatment A in a Dunn's test following a Kruskal-Wallis test). This is consistent with the frequently proposed high offers and high acceptance rate in the treatment. Similarly, the joint payoff is lowest in Treatment A ($p < 0.05$ when comparing with Control and $p < 0.01$ when comparing with Treatment B in a Dunn's test following a Kruskal-Wallis test), being only 6.44, which is also consistent with the distribution of ultimatum offers and the relatively high rate of rejections in Treatment A.

6 Incentive Schemes

The incentive scheme set by the principal plays a key role in enabling strategic delegation to work as a commitment device. Theoretical predictions in Section 3 indicate that the principal distorts the incentives of the agent, *i.e.* incentives of the agent do not increase with the principal's own payoff for some values, in order to make a credible commitment. In Treatment A, this is represented by setting $f(\pi_A) \leq f(0) < f(6)$ for all $\pi_A \in [0, 6)$. The delegate is rewarded for rejecting any offer below the investment cost 6. In Treatment B, this is represented by setting $f(\pi_B) \leq f(4)$ for $\pi_B \in [4, 10]$. The delegate is rewarded for keeping at most 4 for Player B and thus offering at least 6 to Player A. This property of the incentive scheme is defined as *Commit*. In addition, a self-interest principal also aligns the incentives of the agent with her own payoffs for some values. In Treatment A, this is represented by setting $f(10) \geq f(\pi_A)$ for $\pi_A \in [0, 10]$, so that accepting only the whole pie is the agent's most preferred action. In Treatment B, this is represented by setting $f(\pi_B) \leq f(4)$ for $\pi_B \in [0, 4)$, so that it is in the delegate's best interest to keep at least 4 for Player B and thus to offer no more than the investment cost 6 to Player A. This property of the incentive scheme is defined as *Align*.

The average incentive schemes in each of the two delegation treatments are shown in the two panels of Figure 4 respectively. In each treatment, the average incentive schemes for those whose Player A has chosen "In" and for those whose Player A has chosen "Out" are presented separately. In both treatments, the *Align* property is represented for both types: the reward for the agent when the

Figure 4: Average incentive scheme for the delegation treatments



(a) Treatment A

(b) Treatment B

Note: The unit of observation is one independent matching group. The graph presents the average incentive for each possible value of the principal's payoff in (a) Treatment A and (b) Treatment B.

principal's payoff is 10 (4) in Treatment A (B) is higher than the reward for any amount below it. On the other hand, the *Commit* property is only represented among those whose Player A has chosen "In". In Treatment A, the reward for the agent when Player A's payoff is 0 is higher than the reward for any amount below 4. In Treatment B, the reward for the agent when Player B's payoff is 4 is higher than the reward for any amount above it. On the contrary, the incentive schemes for those whose Player A has chosen "Out" rarely exhibit any trend of the *Commit* property in both treatments.

The incentive schemes in the two delegation treatments can be classified according to the representation of these two properties. Incentive schemes that satisfy both the *Commit* property and the *Align* property are classified as *Commit & Align*; incentive schemes that satisfy only the *Commit* property but not the *Align* property are classified as *Commit Only*; incentive schemes that satisfy only the *Align* property but not the *Commit* property are classified as *Align Only*; whereas all other incentive schemes that satisfy neither of the two properties are classified as *Other*.

Table 4 shows the average investment rate, hold-up rate, and ultimatum offer for each type of incentive scheme In Treatment A. Around 38% incentive schemes as shown in Column 1 satisfy both properties. They exhibit an average investment rate of around 77% and an average hold-up rate of around 42%. The investment rate is higher than that of incentive schemes that satisfy only one or neither of the properties, and the hold-up rate is lower than that of all other incentive schemes. Compared with the overall investment rate and hold-up rate in Treatment A and the Control treatment as shown in Table 2, these *Commit & Align*

Table 4: Comparison across different incentive schemes in Treatment A

	Commit & Align	Commit Only	Align Only	Other
Share	0.38	0.15	0.37	0.10
	(0.116)	(0.184)	(0.190)	(0.057)
Investment rate	0.77	0.10	0.34	0.25
	(0.313)	(0.203)	(0.308)	(0.332)
Hold-up rate	0.42	0.67	0.94	1
	(0.308)	(0.577)	(0.100)	(0)
Ultimatum offer	4.35	3.58	4.61	4.50
	(2.175)	(2.003)	(0.266)	(0.500)

Note: The unit of observation is one independent matching group. The table reports the treatment average of all 20 rounds (and standard deviation in parentheses) for each type of incentive scheme in Treatment A.

incentive schemes also exhibit a higher average investment rate and a lower hold-up rate. This result indicates that when Player A induces the agent to reject any offers below the investment cost as well as encourages the agent to accept as high an offer as possible, Player A is more confident to invest and Player B holds up less often. Theoretical predictions indicate that the *Commit* property is essential to hinder Player B from exploiting, regardless of whether the *Align* property is present or not. However, the *Commit Only* incentive schemes as shown in Column 2 indicate otherwise. The hold-up rate is higher and the ultimatum offer is lower than that of the *Commit & Align* incentive schemes. In addition, the ultimatum offer is even lower than that in Control. On the other hand, the hold-up rate is the highest for the two types of incentive schemes that do not satisfy the *Commit* property. This indicates that inducing the agent to reject any offers below the investment cost is a necessary but not sufficient condition to hinder hold-up. Player A also needs to induce the agent to be sufficiently tough to accept only high offers.

In Treatment A, both the investment decision and the incentive setting decision are made by Player A, which generates potential endogeneity bias in explaining the difference in investment rates among different types of incentive schemes. The three types of incentive schemes that do not satisfy the two properties simultaneously are all associated with lower investment rates than that in Control. One possible explanation for this low investment rate is the lack of trust in the agent when delegation is mandatory. Because of the behavioral uncertainties associated with delegating the decision right to a third party, investors who do not trust the agent may choose to not invest and thus may not spend efforts in setting the proper incentive scheme.

Result 4. *With delegation by Player A, when Player A induces the agent to reject low offers and accept sufficiently high offers, there is a higher investment rate and* *a lower hold-up rate.*

Table 5: Comparison across different incentive schemes in Treatment B

	Commit & Align	Commit Only	Align Only	Other
Share	0.44	0.05	0.34	0.17
	(0.188)	(0.069)	(0.107)	(0.131)
Investment rate	0.53	0.81	0.25	0.46
	(0.232)	(0.270)	(0.189)	(0.149)
Hold-up rate	0.26	0.06	0.72	0.38
	(0.182)	(0.115)	(0.298)	(0.256)
Ultimatum offer	6.17	6.95	4.72	6.08
	(0.118)	(1.078)	(1.168)	(0.715)

Note: The unit of observation is one independent matching group. The table reports the treatment average of all 20 rounds (and standard deviation in parentheses) for each type of incentive scheme in Treatment B.

Table 5 shows the average investment rate, hold-up rate, and ultimatum offer for each type of incentive scheme In Treatment B. Around 44% incentive schemes as shown in Column 1 satisfy both properties. They are associated with an average investment rate of around 53%, an average hold-up rate of around 26% and an average ultimatum offer of 6.17, which is similar to the overall results in Treatment B as shown in Table 2. The small share (5%) of *Commit Only* incentive schemes exhibit the highest investment rate (81%), lowest hold-up rate (6%) and highest ultimatum offer (6.95) in Treatment B. Theoretical predictions indicate that the *Commit* property is essential to hinder hold-up from Player B/C and restore investment from Player A, regardless whether the *Align* property is present or not. The low hold-up rate and high ultimatum offer associated with the two types of incentive schemes that satisfy the *Commit* property is consistent with the prediction. When Player B induces the agent to offer at least as much as the investment cost, the agent indeed follows through. However, promising to offer just the investment cost is not sufficient to convince Player A to invest. An even stronger promise is needed. A mixed-effect logistic model of observations in the Control treatment and Treatment B[14] with the binary variable of investment decision being the dependent variable is estimated. The estimated coefficients are presented in Column (1) of Table 6. The *Commit* property has a positive effect on investment, while the *Align* property has a negative effect of approximately similar size. Both effects are significant.

[14]Observations from Treatment A are not included because of the endogeneity bias in the investment decision and the incentive scheme types. Since subjects are randomly re-matched within each independent matching group, therefore the random effects are clustered by each matching group.

Result 5. *With delegation by Player B, when Player B induces the agent to offer at least as much as the investment cost, there is a lower hold-up rate and a higher ultimatum offer. There is a higher investment rate only when Player B induces the agent to offer more than the investment cost.*

Table 6: Regression table dependent on incentive scheme properties

	(1) Investment	(2) Hold-up	(3) Ultimatum offer
Treatment A		20.40	-1.360***
		(783.3)	(0.482)
Treatment B	0.887*	-2.964***	1.448***
	(0.500)	(1.000)	(0.415)
A × *Commit*		-4.617***	0.109
		(0.715)	(0.253)
B × *Commit*	1.755***	-2.885***	0.970***
	(0.265)	(0.608)	(0.348)
A × *Align*		-17.79	1.141***
		(783.3)	(0.406)
B × *Align*	-1.584***	1.697**	-1.015***
	(0.329)	(0.623)	(0.366)
Constant	2.379**	2.628	3.709***
	(1.131)	(1.732)	(1.382)
Observations	880	596	596
Number of groups	12	18	18
Number of subject	25	62	62

Note: This table presents regression results using mixed-effect models. Random effects are clustered by each independent matching group. Time fixed-effects are included. Column (1) and (2) present average estimated coefficients from a mixed-effect logistic model with the binary variables of Investment and Hold-up as the dependent variable respectively. Column (3) presents coefficient estimates from a mixed-effect Tobit model with the ultimatum offer as the independent variable, left censored at 0 and right censored at 10. Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Column (2) of Table 6 shows the estimated coefficients of a mixed-effect logistic model[15] of observations from all three treatments with the binary variable of whether the ultimatum offer is considered as hold-up being the dependent variable. The results are consistent with Result 4 and Result 5. The *Commit* property significantly reduces the hold-up rate in both delegation treatments in comparison to Control. The coefficients are larger in Treatment A than in Treatment B. In

[15]Random effects are clustered by each independent matching group.

addition, in Treatment B, the *Align* property offsets the effect of *Commit* and raises the hold-up rate. Column (3) of Table 6 shows the estimated coefficients of a mixed-effect Tobit model[16] of observations from all three treatments with the level of ultimatum offer being the dependent variable. Similar to the results of the hold-up rate, *Commit* and *Align* have significant and opposites effect on the ultimatum offer in Treatment B, with the effect of *Commit* being positive, and *Align* negative. In Treatment A, *Align* increases the level of ultimatum offer. *Commit* also has a slight positive effect, but it is hardly significant.

In both regression (2) and regression (3), it is worth noting that after controlling for incentive scheme types, Treatment B exhibit significantly lower hold-up rates and higher ultimatum offers than the Control treatment. This comes from the *Other* incentive schemes as shown in Column (4) of Table 5. A closer look at these incentive schemes shows that on average the non-investor sets a high reward for the agent to offer the equal split. This fairness concern reduces opportunistic behaviors and mildly improves investment compared to the Control treatment.

The results of all observations in the three treatments pooling the incentive scheme types as shown in Section 5 seem to indicate that the only significant difference is the lower hold-up rate and higher ultimatum offer in Treatment B than the other two treatments. However, how the principals set the incentive scheme plays an important role in establishing commitment. With delegation by the investor, only when the investor induces the agent to reject potential hold-up offers and be sufficiently "tough" to accept high offers can hold-up be hindered and investment increase. With delegation by the non-investor, the non-investor inducing the agent to take into account the investment cost can reduce hold-up and encourage investment. However, when the non-investor does not induce the agent to be "fair" enough, there may be a counter-effect.

7 Conclusion

This paper examines strategic delegation as a commitment device in a hold-up game. In the baseline game with unilateral investment and subsequent bilateral bargaining, underinvestment occurs because the non-investor does not make sufficient offers for the investor to cover the sunk investment cost. Delegation is implemented in two treatments: one with the agent making decisions in the bargaining stage on behalf of the investor, and the other the non-investor. The principal has some control over the agent's decisions by first setting an observable incentive scheme that links the agent's payoff to her own payoff before the hold-up

[16]Random effects are clustered by each independent matching group. Observations are left-censored at 0 and right-censored at 10.

game starts. The effectiveness of delegation as a remedy for opportunistic hold-up largely depends on the type of incentive scheme set by the principals. With delegation by the investor, when the investor induces the agent to reject offers below the investment cost and encourages the agent to accept sufficiently high offers, the investor is more prone to invest and this also hinders opportunism from the non-investor. With delegation by the non-investor, when the non-investor induces the agent to offer more than the investment cost, the agent follows through by exploiting the investor less often and the investor is also more prone to invest; however, if the non-investor limits the agent's offer with the investment cost as the upper bound, it has an offsetting effect on both hold-up behaviors and investment decisions. Overall, delegation by the non-investor is more effective in reducing hold-up and encouraging investment.

Both the theoretical predictions and experimental results indicate that the incentive scheme set by the principal plays an essential role in establishing commitment. In order to establish commitment, the principal needs to distort the incentives of the agent. In the baseline hold-up game, the non-investor can refrain from making exploitative offers if the investor makes it credible to reject low offers in the bargaining stage; the investor will invest if the non-investor makes it credible to offer a sufficient amount. Both are not possible without effective commitment devices. With delegation, the investor can set the incentive scheme such that the agent prefers the investor getting a payoff of 0 to any positive payoff below the investment cost, or the non-investor can set the incentive scheme such that the agent prefers making an offer above the investment cost to any smaller amount. In this way, the agent decides on rejection or makes an offer on behalf of the principal. In practice, this is possible by setting instructions for the agent to act "tough" or "fair" or by employing the agent with "tough" or "fair" preferences or personality traits.

The current paper provides evidence for strategic delegation as a remedy to mitigate the hold-up problem. Most of the existing literature on contractual and organizational remedies for the hold-up problem requires the implementation of strict controls through changes in the institutional environment. This paper explores a novel remedy that establishes commitment via an already existing institution, *i.e.* the separation of ownership and management. It provides confirming evidence for the strategic advantage of observable managerial incentives that differ from the principal's payoff function. This paper sheds light on strategic delegation in bargaining, the potential advantage of which has not been explored enough in the existing literature.

The investor inducing the agent to reject offers below the investment cost is essentially similar to making a credible threat. In the same way, the non-investor inducing the agent to offer an amount above the investment cost is similar to making a credible promise, which is also related to using hostages as credible commitment as suggested by Williamson (1983). In a hold-up game similar to the baseline game in the current paper, Ellingsen and Johannesson (2004b) find stronger credibility in promises than in threats. They claim that inequity aversion makes it harder for investors to follow through threats that may generate unequal outcomes, but helps non-investors keep fair promises. In the current paper, credibility is not a concern since the incentive scheme is set before the investment decision and is not renegotiable. The comparison between delegation by the investor and by the non-investor in the current paper echos the finding of Ellingsen and Johannesson (2004b). Taking into account the fairness concerns, credible promises by the non-investor also have a larger effect than credible threats by the investor in hindering opportunism.

The focus of this paper is on the commitment effect of strategic delegation. In order to single out this effect, some real-world complications were abstracted away in the experimental design. In particular, delegation is exogenously imposed and is assumed to be costless. When the principal needs to pay the agent out of her own budget, commitment is at the cost of the principal's own payoff. The principal faces the trade-off between incentivizing the agent to increase her own payoff and to gain strategic advantages in the bargaining stage. As a result, the share of principal reluctant to distort the agent's incentives away from her own payoff may increase. This opens room for future research.

References

Addison, J. T., Schank, T., Schnabel, C., and Wagner, J. (2007). Do works councils inhibit investment? *ILR Review*, 60(2):187–203.

Arya, A., Löffler, C., Mittendorf, B., and Pfeiffer, T. (2015). The middleman as a panacea for supply chain coordination problems. *European Journal of Operational Research*, 240(2):393–400.

Baliga, S. and Sjöström, T. (2009). Contracting with third parties. *American Economic Journal: Microeconomics*, 1(1):75–100.

Barreda-Tarrazona, I., Georgantzís, N., Manasakis, C., Mitrokostas, E., and Petrakis, E. (2016). Endogenous managerial compensation contracts in experimental quantity-setting duopolies. *Economic Modelling*, 54:205–217.

Bartling, B. and Fischbacher, U. (2011). Shifting the blame: On delegation and responsibility. *The Review of Economic Studies*, 79(1):1–21.

Beales III, J. H. and Muris, T. J. (1995). The foundations of franchise regulation: Issues and evidence. *Journal of Corporate Finance*, 2(1-2):157–197.

Berg, J., Dickhaut, J., and McCabe, K. (1995). Trust, reciprocity, and social history. *Games and Economic Behavior*, 10(1):122–142.

Burtraw, D. (1992). Strategic delegation in bargaining. *Economics Letters*, 38(2):181–185.

Burtraw, D. (1993). Bargaining with noisy delegation. *The RAND Journal of Economics*, 24(1):40–57.

Card, D., Devicienti, N. F., Revelli-CCA, L., and Maida, A. (2014). Rent-sharing, hold-up, and wages: Evidence from matched panel data. *The Review of Economic Studies*, 81:84–111.

Cardullo, G., Conti, M., and Sulis, G. (2015). Sunk capital, unions and the hold-up problem: Theory and evidence from cross-country sectoral data. *European Economic Review*, 76:253–274.

Carnegie, A. (2014). States held hostage: Political hold-up problems and the effects of international institutions. *American Political Science Review*, 108(1):54–70.

Cavanaugh, J. K. (1998). Asset-specific investment and unionized labor. *Industrial Relations*, 37(1):35–50.

Charness, G. and Dufwenberg, M. (2006). Promises and partnership. *Econometrica*, 74(6):1579–1601.

Charness, G. and Dufwenberg, M. (2010). Bare promises: An experiment. *Economics Letters*, 107(2):281–283.

Che, Y.-K. and Sákovics, J. (2008). Hold-up problem. In Durlauf, S. N. and Blume, L. E., editors, *The New Palgrave Dictionary of Economics*. Palgrave Macmillan, Basingstoke.

Ciliberto, F. (2006). Does organizational form affect investment decisions? *The Journal of Industrial Economics*, 54(1):63–93.

Coase, R. (2006). The conduct of economics: The example of fisher body and general motors. *Journal of Economics & Management Strategy*, 15(2):255–278.

Coffman, L. C. (2011). Intermediation reduces punishment (and reward). *American Economic Journal: Microeconomics*, 3(4):77–106.

Cookson, J. A. (2018). Does contract enforcement mitigate holdup? *Review of Corporate Finance Studies*, 7(2):245–275.

Drake, A. R. and Haka, S. F. (2008). Does abc information exacerbate hold-up problems in buyer-supplier negotiations? *The Accounting Review*, 83(1):29–60.

Dubois, P. and Vukina, T. (2016). Incentives to invest in short-term vs long-term contracts: Theory and evidence. *The BE Journal of Economic Analysis & Policy*, 16(3):1239–1272.

Dufwenberg, M. and Gneezy, U. (2000). Measuring beliefs in an experimental lost wallet game. *Games and Economic Behavior*, 30(2):163–182.

Dufwenberg, M., Smith, A., and Van Essen, M. (2013). Hold-up: With a vengeance. *Economic Inquiry*, 51(1):896–908.

Eisenkopf, G. and Nüesch, S. (2016). Third parties and specific investments. *Schmalenbach Business Review*, 17(2):151–172.

Eisenkopf, G. and Nüesch, S. (2017). Trust in third parties. *Journal of Economic Behavior & Organization*, 137:410–427.

Ellingsen, T. and Johannesson, M. (2004a). Is there a hold-up problem? *The Scandinavian Journal of Economics*, 106(3):475–494.

Ellingsen, T. and Johannesson, M. (2004b). Promises, threats and fairness. *The Economic Journal*, 114(495):397–420.

Farrell, J., Hayes, J., Shapiro, C., and Sullivan, T. (2007). Standard setting, patents, and hold-up. *Antitrust Law Journal*, 74(3):603–670.

Fehr, E., Klein, A., and Schmidt, K. M. (2008). Fairness and contract design. *Econometrica*, 75(1):121–154.

Fershtman, C. (2007). Delegated trust: The role of agency in trust relationship. Discussion paper no. 3-2007, Pinhas Sapir Center for Development.

Fershtman, C. and Gneezy, U. (2001). Strategic delegation: An experiment. *The RAND Journal of Economics*, 32(2):352–368.

Fershtman, C. and Judd, K. L. (1987). Equilibrium incentives in oligopoly. *The American Economic Review*, 77(5):927–940.

Fischbacher, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 10(2):171–178.

Galetovic, A., Haber, S., and Levine, R. (2015). An empirical examination of patent holdup. *Journal of Competition Law & Economics*, 11(3):549–578.

Ganglmair, B., Froeb, L. M., and Werden, G. J. (2012). Patent hold-up and antitrust: How a well-intentioned rule could retard innovation. *The Journal of Industrial Economics*, 60(2):249–273.

Gantner, A., Güth, W., and Königstein, M. (2001). Equitable choices in bargaining games with joint production. *Journal of Economic Behavior & Organization*, 46(2):209–225.

Geng, H., Hau, H., and Lai, S. (2016). Technological progress and ownership structure. Discussion paper no. dp11064, CEPR.

Grossman, S. J. and Hart, O. D. (1986). The costs and benefits of ownership: A theory of vertical and lateral integration. *The Journal of Political Economy*, 94(4):691–719.

Grout, P. A. (1984). Investment and wages in the absence of binding contracts: A nash bargaining approach. *Econometrica: Journal of the Econometric Society*, pages 449–460.

Hackett, S. C. (1994). Is relational exchange possible in the absence of reputations and repeated contact? *Journal of Law, Economics, & Organization*, 10(2):360–389.

Hamman, J. R., Loewenstein, G., and Weber, R. A. (2010). Self-interest through delegation: An additional rationale for the principal-agent relationship. *The American Economic Review*, 100(4):1826–1846.

Harstad, B. (2012). Climate contracts: A game of emissions, investments, negotiations, and renegotiations. *The Review of Economic Studies*, 79(4):1527–1557.

Harstad, B. (2016). The dynamics of climate agreements. *Journal of the European Economic Association*, 14(3):719–752.

Hart, O. (1995). *Firms, contracts, and financial structure*. Oxford university press.

Haruvy, E., Katok, E., Ma, Z., and Sethi, S. (2019). Relationship-specific investment and hold-up problems in supply chains: Theory and experiments. *Business Research*, 12(1):45–74.

Hirsch, B. T. (1991). Union coverage and profitability among us firms. *The Review of Economics and Statistics*, 73(1):69–77.

Holmstrom, B. (1982). Moral hazard in teams. *The Bell Journal of Economics*, 13(2):324–340.

Hoppe, E. I. and Schmitz, P. W. (2011). Can contracts solve the hold-up problem? experimental evidence. *Games and Economic Behavior*, 73(1):186–199.

Huck, S., Müller, W., and Normann, H.-T. (2004). Strategic delegation in experimental markets. *International Journal of Industrial Organization*, 22(4):561–574.

Jones, S. R. (1989). Have your lawyer call my lawyer: Bilateral delegation in bargaining situations. *Journal of Economic Behavior & Organization*, 11(2):159–174.

Klein, B. (1998). The hold-up problem. In Newman, P., editor, *The New Palgrave Dictionary of Economics and the Law*. Palgrave Macmillan UK, London.

Klein, B., Crawford, R. G., and Alchian, A. A. (1978). Vertical integration, appropriable rents, and the competitive contracting process. *The journal of Law and Economics*, 21(2):297–326.

Kopel, M. and Riegler, C. (2008). Delegation in an r&d game with spillovers. *Contributions to Economic Analysis*, 286:177–213.

Kranton, R. and Swamy, A. V. (2008). Contracts, hold-up, and exports: Textiles and opium in colonial india. *The American Economic Review*, 98(3):967–89.

Lammers, F. (2010). Fairness in delegated bargaining. *Journal of economics & management strategy*, 19(1):169–183.

Li, Y. and Shuai, J. (2019). Licensing essential patents: The non-discriminatory commitment and hold-up. *The Journal of Industrial Economics*, 67(1):37–55.

Macchiavello, R. and Morjaria, A. (2015). The value of relationships: Evidence from a supply shock to kenyan rose exports. *The American Economic Review*, 105(9):2911–45.

MacLeod, W. B. and Malcomson, J. M. (1993). Investments, holdup, and the form of market contracts. *The American Economic Review*, 83(4):811–837.

Malcomson, J. M. (1997). Contracts, hold-up, and labor markets. *Journal of economic literature*, 35(4):1916–1957.

Martin, T. and Otto, C. A. (2017). The effect of hold-up problems on corporate investment: Evidence from import tariff reductions. Research paper no. fin-2017-1208, HEC Paris.

Maskin, E. and Moore, J. (1999). Implementation and renegotiation. *The Review of Economic studies*, 66(1):39–56.

Masten, S. E. (1984). The organization of production: Evidence from the aerospace industry. *The Journal of Law and Economics*, 27(2):403–417.

McCabe, M. J. and Snyder, C. M. (2018). Open access as a crude solution to a hold-up problem in the two-sided market for academic journals. *The Journal of Industrial Economics*, 66(2):301–349.

Miller, F. (2007). Information aggregation, strategy, and investment decision in buyer-supplier relationships. *SSRN Working Paper*.

Miller, F. (2011). Using formal and informal controls to limit opportunism: Review and classification of remedies to hold-ups. *Journal of Accounting Literature*, 30:1–39.

Miller, N. and Pazgal, A. (2002). Relative performance as a strategic commitment mechanism. *Managerial and Decision Economics*, 23(2):51–68.

Miller, N. H. and Pazgal, A. I. (2001). The equivalence of price and quantity competition with delegation. *The RAND Journal of Economics*, 32(2):284–301.

Morita, H. and Servátka, M. (2013). Group identity and relation-specific investment: An experimental investigation. *European Economic Review*, 58:95–109.

Morita, H. and Servátka, M. (2018). Investment in outside options as opportunistic behavior: An experimental investigation. *Southern Economic Journal*, 85(2):457–484.

Nguyen, A. and Tan, T. Y. (2019). Information control in the hold-up problem. *The RAND Journal of Economics*, 50(4):768–786.

Nöldeke, G. and Schmidt, K. M. (1995). Option contracts and renegotiation: A solution to the hold-up problem. *The RAND Journal of Economics*, 26(2):163–179.

Oexl, R. and Grossman, Z. J. (2013). Shifting the blame to a powerless intermediary. *Experimental Economics*, 16(3):306–312.

Oosterbeek, H., Sonnemans, J., and Van Velzen, S. (2003). The need for marriage contracts: An experimental study. *Journal of Population Economics*, 16(3):431–453.

Potters, J. and Yang, Y. (2021). Delegation with strategic complements and substitutes. *Working Paper*.

Rindfleisch, A. and Heide, J. B. (1997). Transaction cost analysis: Past, present, and future applications. *Journal of Marketing*, 61(4):30–54.

Rogerson, W. P. (1992). Contractual solutions to the hold-up problem. *The Review of Economic Studies*, 59(4):777–793.

Schelling, T. C. (1960). *The strategy of conflict*. Harvard university press.

Schelling, T. C. (2006). *Strategies of commitment and other essays*. Harvard University Press.

Schmitz, P. W. (2001). The hold-up problem and incomplete contracts: A survey of recent topics in contract theory. *Bulletin of economic research*, 53(1):1–17.

Schotter, A., Zheng, W., and Snyder, B. (2000). Bargaining through agents: An experimental study of delegation and commitment. *Games and Economic Behavior*, 30(2):248–292.

Segendorff, B. (1998). Delegation and threat in bargaining. *Games and Economic Behavior*, 23(2):266–283.

Sengul, M., Gimeno, J., and Dial, J. (2012). Strategic delegation: A review, theoretical integration, and research agenda. *Journal of Management*, 38(1):375–414.

Shelanski, H. A. and Klein, P. G. (1995). Empirical research in transaction cost economics: A review and assessment. *Journal of Law, Economics, & Organization*, 11(2):335–361.

Sklivas, S. D. (1987). The strategic choice of managerial incentives. *The RAND Journal of Economics*, 18(3):452–458.

Sloof, R., Oosterbeek, H., and Sonnemans, J. (2007). Does making specific investments unobservable boost investment incentives? *Journal of Economics & Management Strategy*, 16(4):911–942.

Sloof, R., Sonnemans, J., and Oosterbeek, H. (2004). Specific investments, holdup, and the outside option principle. *European Economic Review*, 48(6):1399–1410.

Tirole, J. (1986). Procurement and renegotiation. *The Journal of Political Economy*, 94(2):235–259.

Vickers, J. (1985). Delegation and the theory of the firm. *Economic Journal*, 95(380a):138–47.

Vukina, T. and Leegomonchai, P. (2006). Oligopsony power, asset specificity, and hold-up: Evidence from the broiler industry. *American Journal of Agricultural Economics*, 88(3):589–605.

Williamson, O. E. (1983). Credible commitments: Using hostages to support exchange. *The American Economic Review*, 73(4):519–540.

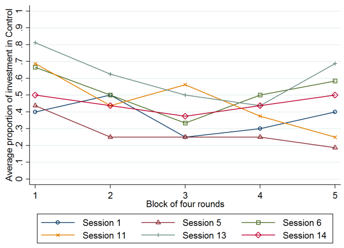
Yang, Y. (2021). A survey of the hold-up problem in the experimental economics literature. *Journal of Economic Surveys*, 35(1):227–249.

Yoon, D.-H. (2018). Strategic delegation, stock options, and investment hold-up problems. *Accounting, Organizations and Society*, 71:1–14.

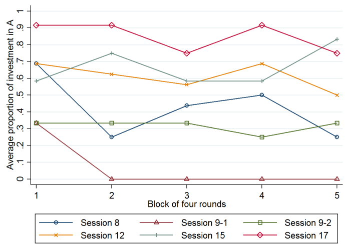
A Appendix

A.1 Average investment rate and ultimatum offer over time

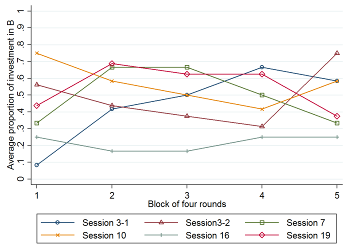
Figure 5: Development of average investment rate over time



(a) Control

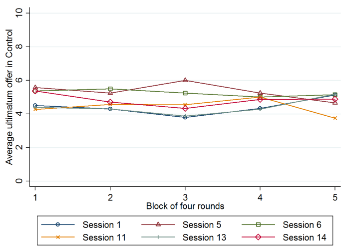


(b) Treatment A

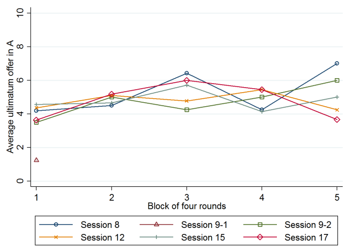


(c) Treatment B

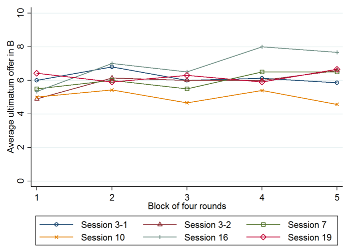
Figure 6: Development of average ultimatum offer over time



(a) Control



(b) Treatment A



(c) Treatment B

A.2 Instructions

A.2.1 Instructions in Treatment A

Welcome to the experiment. We will first go over the instructions together. After that, you will be given some time to read the instructions at your own pace and ask questions. Please do not write on the instructions. If you need to take notes, you can use the extra blank paper.

During the experiment, you will interact with other participants in this room and make some decisions. The decisions are anonymous and will not be linked to your identity. Your payment from the experiment depends on your decisions, the decisions of other participants, and chance. In addition, there is a participation fee of **3 Euro**. You will receive your final payment at the end of the experiment in cash.

Please be quiet during the experiment and do not talk with any other participants. If you have a question, please raise your hand and an experimenter will come to you.

The task

In the experiment, there are three types of roles, Player A, Player B and Player C. You will be randomly assigned as one of the roles with equal chances. Your role will be fixed throughout the experiment.

The game

This experiment consists of a basic game where the decisions of Player A and Player B determines the payment of each other. The details of the basic game is as follows.

Step 1: Player A chooses between **In** and **Out**.

If Player A chooses **Out**, then Player A gets 6, Player B gets 0, and thats the end of the game.

If Player A chooses **In**, the game continues to Step 2.

Step 2: After Player A has chosen **In**, Player B makes a proposal to divide 10 euro between Player A and Player B.

Player B can make a proposal to give X to Player A, and keep 10-X for himself.

Step 3: Player A decides whether to **accept** or to **reject** Player B's proposal.

If Player A **accepts**, Player A gets X, Player B gets 10-X.

If Player A **rejects**, both Player A and B gets 0.

Player A and Player C

However, in this experiment, Player A **CANNOT** make the decision by himself in Step 3. Instead, Player A must hire a Player C to decide whether to accept or to reject Player B's proposal on his behalf. Before Step 1, there is a Step 0 in which Player A will set a payment scheme determining how Player C will be paid

(The details of how Player A should set the payment scheme is explained below). The payment scheme is announced to all three players. Player A will then choose between **In** and **Out**. If Player A chooses **In**, Player B makes a proposal to divide 10 between Player A and Player B. Then Player C decides on behalf of Player A whether to **accept** or **reject** the proposal.

Step 0: Player A sets the payment scheme for Player C by filling in the following form on the screen. In each column, Player A must fill in a value from 0 to

If you get	0	1	2	3	4	5	6	7	8	9	10
Player C gets											

10 of how much to pay Player C if in the end Player C gets for Player A the corresponding amount. For example, in the grid below 0, Player A must fill in how much he wants Player C to get if Player C gets for him 0 in the game, etc.

The money used to pay Player C comes from an extra budget of 10 euro. It shall only be used to pay Player C. If Player A fills in less than 10 in the form, the unused amount is lost. How much Player A fills in the form will not affect Player As own payment.

The payment scheme is announced to Player A, Player B, and Player C after it is set.

Procedure

There will be one practice round and 20 rounds that count towards your final payment. As the experiment begins, you will be randomly assigned one of the three roles. Your role will be kept fixed throughout the experiment. At the beginning of each round, you will be randomly matched with two other players to play the game step by step. At the end of each round, you will be informed of the other players' decisions and your payment in that round. After all 20 rounds, you will fill in a questionnaire.

Payment

At the end of the experiment, one of the 20 rounds will be randomly selected for your payment. In addition, you will receive a participation fee of **3 Euro**. The payments will be made in cash to you at the end of the experiment.

Summary

- There are one practice round and 20 rounds that count towards your payment.
- You will be randomly assigned a role of Player A, Player B, or Player C. The role is kept fixed throughout the experiment
- You will be randomly matched with two other players at the beginning of each round.

- In each round, Player A first sets a payment scheme for Player C. The payment scheme is announced to all three players.
- Player A chooses between In and Out
- If Player A chooses Out, Player A gets 6, Player B gets 0, and Player C gets the corresponding amount for if Player A gets 6 according to the payment scheme. The game ends for that round.
- If Player A chooses In, the game continues. Player B makes a proposal to divide 10 between Player A and himself.
- Player C decides whether to accept or to reject the proposal.
- If Player C accepts, Player A and Player B each get according to the proposal by Player B, and Player C gets the corresponding amount for Player A's actual payment according to the payment scheme.
- If Player C rejects, both Player A and Player B get 0, and Player C gets the corresponding amount for if Player A gets 0 according to the payment scheme.
- You will learn other players' decisions and your payment in that round at the end of each round.
- At the end of the experiment, one of the 20 rounds is randomly selected for payment.

You can now go over the instructions on your own and ask clarifying questions (if any). Please raise a hand if you have a question.
Please be reminded that you are not allowed to communicate with other participants throughout the experiment.

A.2.2 Instruction for Treatment B

Welcome to the experiment. We will first go over the instructions together. After that, you will be given some time to read the instructions at your own pace and ask questions. Please do not write on the instructions. If you need to take notes, you can use the extra blank paper.
During the experiment, you will interact with other participants in this room and make some decisions. The decisions are anonymous and will not be linked to your identity. Your payment from the experiment depends on your decisions, the decisions of other participants, and chance. In addition, there is a participation fee of **3 Euro**. You will receive your final payment at the end of the experiment in cash.
Please be quiet during the experiment and do not talk with any other participants. If you have a question, please raise your hand and an experimenter will come to you.

The task

In the experiment, there are three types of roles, Player A, Player B and Player C. You will be randomly assigned as one of the roles with equal chances. Your role will be fixed throughout the experiment.

The game

"This experiment consists of a basic game where the decisions of Player A and Player B determines the payment of each other. The details of the basic game is as follows.

Step 1: Player A chooses between In and Out.

If Player A chooses Out, then Player A gets 6, Player B gets 0, and thats the end of the game.

If Player A chooses In, the game continues to Step 2.

Step 2: After Player A has chosen In, Player B makes a proposal to divide 10 euro between Player A and Player B.

Player B can make a proposal to give X to Player A, and keep 10-X for himself.

Step 3: Player A decides whether to accept or to reject Player Bs proposal.

If Player A accepts, Player A gets X, Player B gets 10-X.

If Player A rejects, both Player A and B gets 0.

Player B and Player C

However, in this experiment, Player B **CANNOT** make the decisions himself. Instead, Player B must hire a Player C to make all the decisions on his behalf. Before Step 1, there is a Step 0 in which Player B will set a payment scheme determining how Player C will be paid (The details of how Player B should set the payment scheme is explained below). The payment scheme is announced to all three players. Player A will then choose between **In** and **Out**. If Player A chooses **In**, Player C makes a proposal to divide 10 between Player A and Player B on behalf of Player B. Then Player A decides whether to **accept** or **reject** the proposal.

Step 0: Player B sets the payment scheme for Player C by filling in the following form on the screen. In each column, Player B must fill in a value from 0 to 10 of

If you get	0	1	2	3	4	5	6	7	8	9	10
Player C gets											

Table 7: Incentive scheme for the agent

how much to pay Player C if in the end Player C gets for Player B the corresponding amount. For example, in the grid below 0, Player B must fill in how much he wants Player C to get if the Player C gets for him 0 in the game, etc.

The money used to pay Player C comes from an extra budget of 10 euro. It shall

only be used to pay Player C. If Player B fills in less than 10 in the form, the unused amount is lost. How much Player B fills in the form will not affect Player Bs own payment.
The payment scheme is announced to Player A, Player B, and Player C after it is set.

Procedure
There will be one practice round and 20 rounds that count towards your final payment. As the experiment begins, you will be randomly assigned one of the three roles. Your role will be kept fixed throughout the experiment. At the beginning of each round, you will be randomly matched with two other players to play the game step by step. At the end of each round, you will be informed of the other players' decisions and your payment in that round. After all 20 rounds, you will fill in a questionnaire.
Payment
At the end of the experiment, one of the 20 rounds will be randomly selected for your payment. In addition, you will receive a participation fee of **3 Euro**. The payments will be made in cash to you at the end of the experiment.
Summary

- There are one practice round and 20 rounds that count towards your payment.
- You will be randomly assigned a role of Player A, Player B, or Player C. The role is kept fixed throughout the experiment
- You will be randomly matched with two other players at the beginning of each round.
- In each round, Player B first sets a payment scheme for Player C. The payment scheme is announced to all three players.
- Player A chooses between In and Out
- If Player A chooses Out, Player A gets 6, Player B gets 0, and Player C gets the corresponding amount for if Player B gets 0 according to the payment scheme. The game ends for that round.
- If Player A chooses In, the game continues. Player C makes a proposal to divide 10 between Player A and Player B on behalf of Player B.
- Player A decides whether to accept or to reject the proposal.
- If Player A accepts, Player A and Player B each get according to the proposal by Player C, and Player C gets the corresponding amount for Player B's actual payment according to the payment scheme.
- If Player A rejects, both Player A and Player B get 0, and Player C gets

the corresponding amount for if Player B gets 0 according to the payment scheme.

- You will learn other players' decisions and your payment in that round at the end of each round.
- At the end of the experiment, one of the 20 rounds is randomly selected for payment.

You can now go over the instructions on your own and ask clarifying questions (if any). Please raise a hand if you have a question.
Please be reminded that you are not allowed to communicate with other participants throughout the experiment.