Essays in Contract Design under Incomplete Enforcement:
Theory and Experiments

Dissertation

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By

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Abstract

This dissertation applies relational contract theory to study the optimal incentive provision in situations when formal enforcement is too costly. Essay one considers a theoretical redistribution of bargaining power among business partners who trade repeatedly and that traditionally hold asymmetric power to negotiate contract terms. I included a bargaining process in a relational contracts model to analyze the economic consequences of shifting bargaining power under different enforcement regimes. The model predicts that as the agent’s bargaining power increases, her incentive payments decrease even though her total compensation increases. Thus, efficiency wage contracts are more likely to be observed than contingent performance contracts in markets where agents have bargaining power. In contexts where enforcement is weak, a transfer of bargaining power can erode market efficiency in a dynamic relational contracting environment. If principals lose power coupled with the absence of enforcement, they may find the short-term gains of reneging on contractual promises more attractive than long-term benefits of faithfully executing a contract where they hold less power. As a consequence trade is more likely to break down. In this case, the agent is better off exercising less bargaining power than she has. Nonetheless, the model also predicts that such a collapse in good-faith execution of contracts in the light of such a power shift may not occur if some minimum payment for contract participation is enforced. Essay two provides experimental evidence on the theoretical
predictions from essay one. I implement an experimental design that adjusts the bargaining power of sellers (agents) and the enforceability of the contract. I find that the vast majority of contracts take the form of efficiency wage contracts instead of contingent performance contracts when enforcement is partially incomplete and sellers have more bargaining power than buyers. The total contracted and actual compensation increase with the bargaining power of the sellers. However, sellers’ profits are found to increase only if a part of the total payment is third-party enforceable. In this case, observed surplus and efficiency are lower than predictions. When no part of a contract is third-party enforceable, more cooperative relationships emerge, exhibiting higher quality provision resulting in higher surplus and efficiency while rent sharing is lower. The result is explained by the stronger buyer’s deviation, confirming predictions from essay one. Essay three considers the application of relational contracts as a mechanism for the reduction of carbon emissions from deforestation and forest degradation (REDD). I compared the structure of the optimal relational contract in the presence of purely self-interested participants to the optimal structure when participants are motivated by other preferences including altruism, spite, inequality aversion or warm-glow concerns. I find that the optimal contract structure only differs from the benchmark case of self-interested agents when seller preferences are different than only profit-maximizing preferences or if either party is inequality averse. Moreover, I also show that the presence of other regarding preferences increases or decreases the likelihood of cooperation in the long-term relationship relative to the case of self-interested participants.
This dissertation is dedicated to my parents, Dyalá and Carlos Alberto, my sister, María José, and my brothers, Carlos Alberto and Roberto, who always supported me. Particularly to my persistent Dad and loving Mom whose braveness and tireless effort have inspired me through all these years. I also want to dedicate this work to my loving fiancé, Kevin, who has shared all these many years of research, sacrifice and dedication, and to Tita Alice who always dreamed about having a professional career. Finally, I want to thank God to bless me so much and hold my hand every step of the way. Los amo.
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# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Dedication</td>
<td>iv</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>v</td>
</tr>
<tr>
<td>Vita</td>
<td>vii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>x</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xii</td>
</tr>
<tr>
<td>1. The Role of Bargaining Power in Relational Contracts</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.2 The Model</td>
<td>7</td>
</tr>
<tr>
<td>1.3 The Bargaining Game</td>
<td>12</td>
</tr>
<tr>
<td>1.4 The Benchmark: Bargaining and Complete Enforcement</td>
<td>16</td>
</tr>
<tr>
<td>1.5 Bargaining and Incomplete Enforcement</td>
<td>18</td>
</tr>
<tr>
<td>1.5.1 Characterization of Self-enforcing Contracts</td>
<td>21</td>
</tr>
<tr>
<td>1.5.2 Incentive Provision and Bargaining</td>
<td>24</td>
</tr>
<tr>
<td>1.5.3 Sustainability of Self-enforcing Contracts and Bargaining</td>
<td>26</td>
</tr>
<tr>
<td>1.6 Conclusions</td>
<td>31</td>
</tr>
<tr>
<td>2. Bargaining Power in Relational Contracts: An Experimental Study</td>
<td>34</td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>34</td>
</tr>
<tr>
<td>2.2 Experimental Design</td>
<td>35</td>
</tr>
<tr>
<td>2.3 Theoretical Predictions and Hypothesis</td>
<td>44</td>
</tr>
<tr>
<td>2.3.1 Predictions for the NN Treatment</td>
<td>45</td>
</tr>
<tr>
<td>2.3.2 Predictions for the NB Treatment</td>
<td>46</td>
</tr>
</tbody>
</table>

viii
# List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Experimental sessions</td>
<td>51</td>
</tr>
<tr>
<td>2.2 Average number of periods per match</td>
<td>52</td>
</tr>
<tr>
<td>2.3 Mean values per game across treatments</td>
<td>53</td>
</tr>
<tr>
<td>2.4 Summary data</td>
<td>58</td>
</tr>
<tr>
<td>2.5 Hypothesis test for treatment effects</td>
<td>59</td>
</tr>
<tr>
<td>2.6 Quality deviation summary statistics</td>
<td>65</td>
</tr>
<tr>
<td>2.7 Social and private surplus summary statistics</td>
<td>66</td>
</tr>
<tr>
<td>2.8 Results partitioned by initial cooperation</td>
<td>76</td>
</tr>
<tr>
<td>2.9 Exchange by deviation and cooperation in the same period</td>
<td>79</td>
</tr>
<tr>
<td>2.10 Test for enforcement effects</td>
<td>92</td>
</tr>
<tr>
<td>2.11 Bargaining effect in all offers</td>
<td>93</td>
</tr>
<tr>
<td>2.12 Actual quality estimates</td>
<td>105</td>
</tr>
<tr>
<td>2.13 Actual quality, social surplus and private surplus estimates</td>
<td>106</td>
</tr>
<tr>
<td>2.14 Actual quality, social surplus and private surplus estimates (all offers)</td>
<td>107</td>
</tr>
<tr>
<td>2.15 Determinants of contract acceptance and counteroffer use</td>
<td>108</td>
</tr>
</tbody>
</table>
2.16 Bargaining effect in payments ........................................ 109
2.17 Distributional outcomes ............................................... 110
3.1 Summary results ......................................................... 155
3.2 Models ................................................................. 159
# List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>9</td>
</tr>
<tr>
<td>1.2</td>
<td>18</td>
</tr>
<tr>
<td>1.3</td>
<td>33</td>
</tr>
<tr>
<td>2.1</td>
<td>38</td>
</tr>
<tr>
<td>2.2</td>
<td>40</td>
</tr>
<tr>
<td>2.3</td>
<td>54</td>
</tr>
<tr>
<td>2.4</td>
<td>67</td>
</tr>
<tr>
<td>2.5</td>
<td>68</td>
</tr>
<tr>
<td>2.6</td>
<td>102</td>
</tr>
<tr>
<td>2.7</td>
<td>103</td>
</tr>
</tbody>
</table>
Chapter 1: The Role of Bargaining Power in Relational Contracts

1.1 Introduction

Objective measures of individual performance are difficult to verify in many economic relationships. Thus, even when institutions are strong, contract enforcement is often imperfect. As a result, parties find it impractical to write complete contracts and frequently rely on informal incentives, cooperation and good faith to self-enforce agreements, i.e. relational contracts. For example, in labor markets, many job promotions and compensation considerations rely on subjective evaluations of the employee’s performance by a supervisor or co-workers. The evaluations are based on qualitative aspects such as leadership or team collaboration that are often difficult for a third-party to verify. Furthermore, in supply contracts, some dimensions of performance such as timing of delivery, contract renewal policies or quality characteristics that are not measurable until the product is processed or consumed, are not explicitly included in contracts. Therefore informal incentives are commonly used. Other settings where relational contracting is widely used include political campaign finance and international agreements among countries.
In all of the examples described, it is reasonable to assume that the parties wield some degree of bargaining power when negotiating the terms of the agreements. For example, government representatives participate in several negotiation rounds to establish the terms of trade agreements and in some labor relationships, the prospective employee and his employer may go back and forth, negotiating over the employee’s compensation and benefits package. The final terms of the contract and the distribution of rent determined by the contract will depend on the relative bargaining power among parties.

The purpose of this essay is to show the effects bargaining power has on relational contracting. I characterize the optimal contract when a principal and an agent bargain over contract terms under different enforcement regimes. I show that a higher bargaining power of the agent affects incentive provision, efficiency, and the distribution of the surplus. I also show how the distribution of bargaining power impacts the sustainability of self-enforcement and cooperation in a market where trade takes place repeatedly. The model predicts that shifting bargaining power from the principal to the agent alters the form of incentive provision in the optimal contract. It also provides insight into the diverse effects the different contract enforcement regimens have on cooperation and efficiency.

I consider a principal/agent model where the principal purchases one unit of a good from the agent. Rather than assuming that the principal makes take-it-or-leave-it offers, as is standard in principal-agent models, parties negotiate the terms of the contract through an asymmetric Nash bargaining process (ANB) with outside
options.\(^1\) The contract includes a payment scheme that combines a base price and a contingent payment to induce the desired quality. After jointly determining how to split the surplus in a contract in the first phase of the game parties independently decide to adhere to or renge on the terms of the contract in the second phase. I analyze whether the division of the surplus resulting from the bargaining process affects the parties’ ability to self-enforce contracts under three different enforcement regimes: perfect, partial and fully imperfect third-party enforceability.

The first enforcement regimen represents the benchmark case of perfect contract enforceability in which a third-party enforces all terms of the contract. With perfect contract enforcement parties can structure a contract that redistributes surplus proportionate to each party’s bargaining power and achieves full efficiency.

The other two enforcement regimens present increasing levels of incomplete enforceability of the contract. In the partial enforcement regime, quality is not third-party verifiable but the base price is perfectly enforced. This regime has been used extensively in the literature to analyze labor markets. In the fully unenforceable regime, neither the product characteristics nor payment rules are formally enforceable. This scenario applies to contracts in which ex post reductions in payments are acceptable such as occurs with supply contracts. Partially and fully unenforceable contracts are found to have the same total compensation, which is increasing in the bargaining power of the agent. Thus, the agent’s total payment is weakly increasing.

\(^1\)The bargaining process has also been analyzed using the non cooperative approach of the alternating bargaining game with outside options for which the results of the asymmetric Nash bargaining game hold. The results are equivalent because the alternating bargaining game approaches the asymmetric Nash bargaining solution when the motivation to reach an agreement is made negligible [Binmore et al., 1986]. Proofs can be obtained from the author upon request.
in her bargaining power. Additionally, the contracts are characterized by the presence of smaller contingent payments and larger base payments than the case when bargaining does not exist. As the contingent payment is decreasing with the agent’s bargaining power, the principal loses the ability to induce high quality. However, the smaller contingent payments do not unravel the efficiency of the outcome as the agent becomes residual claimant of the trade surplus.

Furthermore, I show that in markets characterized by some bargaining power from the agent, the optimal incentive provision takes a form closer to the efficiency wages model of Shapiro and Stiglitz [1984] than to contingent performance payments. When the agent’s return to the relationship net of the outside opportunity is equal to or higher than the cost differential of producing the high quality, there is no need to provide additional incentives to perform and the contingent payment is zero. Thus, if the agent’s bargaining power exceeds a specific cutoff level the principal uses efficiency wages exclusively. When there is a contingent payment, it is positive as long as the agent’s future net gains from the relationship are less than the additional cost of producing high quality.

The model also predicts that the parties cooperate for all distributions of bargaining power when contracts are partially enforceable and the parties hold sufficiently high discount factors. As a result the outcome is always optimal and long-term relationships are sustained, reaffirming past findings from the relational contracting literature. More interestingly, the model predicts that when none of the contract terms are enforceable and when the agent is endowed with more bargaining power than the principal, she may reap too much of the surplus and the cooperating equilibrium does not exist for discount factors less than one. If the agent’s bargaining
power is too high trade cannot be sustained because the incentives for the principal to renege on the promise to pay both the base and contingent payments become too strong. His short-term gains exceed the long-term benefits of the relationship because his bargaining power is too weak to secure much of the gains from trade. Hence, cooperation breaks down and efficiency is not achieved. This result implies that the problems of efficiency and distribution of welfare can no longer be separated if the agent fully exercises bargaining power and enforcement is fully incomplete. Because trade cannot be sustained if the agent has significantly more bargaining power, she is better off exercising her power only up to the limit at which the principal is indifferent between cooperating and reneging. In this way she gets higher profits by reaping the highest possible surplus while trading in the long-term instead of just getting the short-term gains and reservation payoff thereafter.

This essay is of interest for several reasons. First, contracts are normally studied in a setting where the principal chooses the terms of the contract by making take-it-or-leave-it-offers.\(^2\) In most cases, the principal’s optimal offer yields the agent no additional gains over her alternative production opportunity and the principal reaps all of the gains from cooperation. However, in many cases it is more reasonable to assume that contract terms result from a bargaining process in which the outcome depends on the parties’ relative bargaining power. The model here captures some realistic aspects of the terms of trade used in certain markets where parties engage in negotiations over contract terms. Second, the existence of asymmetric bargaining power among parties has generated some controversies and raised concerns among policy makers about the relative ability of one party to exert influence over contract

\(^2\)See for example Bull [1987], Levin [2003], MacLeod and Malcomson [1989, 1998].
terms, and therefore to extract a higher relative return from the relationship. This is especially true in the agricultural sector where political pressure has emerged to support the redistribution of bargaining power in favor of growers [the Democratic Staff, 2004]. Furthermore, concerns about bargaining power exist in other sectors. For instance, there is debate about the leverage that small businesses and consumers have to bargain for premiums with health care insurers and providers [Lee, 2002]. Third, contracts are unenforceable in many markets, due to unverifiable product characteristics and the frequent reliance upon informal incentives, a situation that opens the door for opportunistic behavior from the party who has market power. This is especially true in developing countries in which producers face weaker institutions to enforce contracts and in addition, they often sell their products to multinational traders who have increased their market power by bargaining for trade agreements and gathering extensive information about markets and prices [Grow et al., 2003]. Therefore, this essay contributes to the understanding of the effect of bargaining power on the formation of contract terms and its role in welfare outcomes. It also provides insight into the economic consequences of policies that attempt to redistribute bargaining power among parties that trade under self-enforcing contracts.

In the existing literature, many authors have studied relational contracts in different environments. In contrast with this article, previous relational contract models have focused on the case where the principal holds all bargaining power and makes take-it-or-leave-it offers. For instance, Bull [1987], MacLeod and Malcomson [1989, 1998] and Levin [2003] use this assumption. Other authors have looked at contract design and bargaining under incomplete information. Inderst [2002] focuses on contract design that brings the agent to reveal his type when he can offer a contract
afterwards. Inderst [2003], Wang [1998] and Sen [2000] explore bargaining over two-items contracts when one party has private information. In these cases, all contract terms are fully enforceable. Wu and Roe [2007a,b] look at relational contracting under different enforcement regimes; however, they assume that the principal holds all bargaining power. Finally, another set of articles look at contract renegotiation and bargaining. Examples of this literature include Fernandez and Glazer [1991] and Macleod and Malcomson [1995] who examine renegotiation for wage-contracts and contracts over a flow of goods and services respectively.

The structure of the essay is as follows. Section one develops the model. Section two describes the equilibrium of the bargaining game. Section three presents the results of the benchmark case. Section four analyzes the consequences of bargaining under the two incomplete regimes, and finally, section five presents some conclusions.

1.2 The Model

Consider two risk-neutral parties, a principal and an agent, who have the opportunity to trade at dates \( t = 0, 1, 2, 3 \ldots \), and that bargain over the terms of a contract that will be used for trading one unit of a good.\(^3\) A contract, \( y_t = \langle p_t, D_t(q_t) \rangle \), specifies a compensation scheme that the agent is entitled to when delivering the good of quality \( q_t \in Q = [\underline{q}, \overline{q}] \) in period \( t \). Quality is observable by both parties but may not be enforceable because quality may not be verifiable by a neutral third-party. Consequently, the desired quality, \( q^* \), may differ from the delivered quality, \( q_t \). The total compensation is defined as \( P_t(q_t) = p_t + D_t(q_t) \) and consists of a base payment, \( p_t \), and a contingent payment rule \( D_t(q_t) \).

\(^3\)The quantity of the good is normalized to 1 for simplicity but can be thought analogously to any quantity parties want to specify in the contract.
The base payment, $p_t$, is paid at the end of period $t$ and may not be enforceable in contrast to the conventional assumption of enforceable base payments.\textsuperscript{4} This assumption captures contracts in which complete payments are made ex post and are subject to final inspection of the quality of the product, a feature common to supply contracts.\textsuperscript{5} The contingent payment is a mapping from outcome to payment, $D_t : Q \rightarrow \mathbb{R}$ and its existence depends on the contract enforcement regime. When $D_t = b(q_t)$ is positive, it is referred to as a bonus and is used to reward high quality. When $D_t = d(q_t)$ is negative, it is referred to as a deduction and is used as a punishment or for deviations from the principal when $p_t$ is not enforceable. Since the contingency payment depends on unverifiable quality, it is not a legally binding obligation.

The contractual relationship includes two phases. At the beginning of each period $t$, there is an interaction phase in which the principal and the agent are both aware of the enforcement regime and engage in a Nash bargaining process over a profit-sharing rule included in the contract. Once parties agree on the terms of the contract in the bargaining phase of the game, a trading phase begins and, depending on the level of contract enforcement, parties make independent decisions about quality and payments. This sequence of events repeats in each period $t$.

Figure 1.1 illustrates a single stage of the repeated game through an extensive form of the stage game. The first node corresponds to the joint decision phase that represents an abbreviated description of the negotiation process between the principal and the agent. As parties jointly determine the terms of the contract, the bargaining

\textsuperscript{4}See for example MacLeod and Malcomson [1989, 1998] and Levin [2003]

\textsuperscript{5}For instance, in the tobacco industry, nearly all contracts specify that payment is made after delivery and that if a buyer detects that the tobacco does not meet requirements of the contract, the grower must repay the company [Dimitri, 2008].
Payments depend on choices made in trading phase and contract enforcement.

Stage Game (Single period $t$)

Choices depend on contract enforcement regime.

No trade

**Figure 1.1: Game tree: the contract game with a joint decision node**

node represents a joint decision, indicated by the double circle and labeled with both $P$ and $A$. All other decision nodes represent strategic, non-cooperative decisions made by $P$ and $A$.

If a contract $y_t$ is accepted by both parties in the bargaining phase the parties move into the trading phase. The agent chooses the quality $q_t \in Q$ to deliver and incurs a cost $c_t(q_t)$ where $c'(.) > 0$, $c''(.) \geq 0$, and $c(q) = 0$. The agent’s profit per trading round is $U_t = P_t(q_t) - c_t(q_t)$. Upon delivery, the agent’s quality provision generates a direct benefit for the principal, $R_t(q_t)$, where $R'(.) > 0$, $R''(.) \leq 0$, and $R(q) = 0$. The principal chooses whether or not to pay $b_t(q_t)$, and in the fully incomplete enforcement regime, $p_t$. The principal’s profit for the trading round is given by $\pi_t = R_t(q_t) - P_t(q_t)$. It is also assumed that $R'(.) > c'(.) \forall q \in Q$, so that it is socially efficient and Pareto optimal to trade $q = \bar{q}$, since $\bar{q}$ maximizes the total surplus defined by $S(q_t) = R(q_t) - c(q_t)$. 

9
If parties do not reach an agreement before the end of period $t$ trade does not occur, and both parties receive fixed payoffs: $\bar{u}$ for the agent and $\bar{\pi}$ for the principal, representing the second-best market opportunity. If either party decides to opt out of the bargaining process trade does not occur, the game ends and both parties receive the second-best opportunity thereafter. These outside opportunities are assumed to be less attractive than trading, and any breakdown in trade represents a socially inefficient outcome. The sum of the fixed payoffs, $\bar{s} = \bar{u} + \bar{\pi}$, is the social value of the outside options. The net social surplus is given by $S(q_t) - \bar{s}$, where $S(q_t) - \bar{s} > 0 \forall q \in (\underline{q}, \bar{q}]$, and $S(\bar{q}) > S(q) \geq 0$. The net social surplus is the difference between the return to the relationship and the second-best market opportunity. Furthermore, the surplus represents the pie over which the principal and the agent bargain, and each party’s share must be greater than each party’s outside option for trading to take place.

The two phases repeat in each period $t$, and the parties interact repeatedly following the assumptions of the theory of repeated games [Watson, 2002]. Specifically I assume that: (i) the principal and the agent know only the past actions of the trading partners with whom they have traded allowing for the creation of relationships in which cooperation is an important characteristic; (ii) the parties care about the sum of a stream of discounted future payoffs, where the common discount factor is $\delta \in (0, 1]$; and (iii) the ongoing interaction sustains the equilibrium by allowing the parties to support future terms of trade contingent on the satisfactory performance of present trade. The parties cooperate if the history of play in all periods has been cooperation, where cooperation is defined as both parties fulfilling the contract. The
parties break-off trade forever if any deviation is observed. This allows for self-enforcing contracts — relational contracts — since it contains a complete plan for the relationship that describes behavior on and off the equilibrium path.

Following Levin [2003], parties cannot renegotiate the trading decision after quality is observed. The reason for this is that, if a self-enforcing contract is optimal given any history, then the contract is strongly optimal. A strongly optimal contract has the property that parties cannot jointly gain from renegotiating a new self-enforcing contract even off the equilibrium path. Additionally, each period is played following a Nash equilibrium and parties use a stationary contract, in which the principal always offers the same payment scheme, the agent always takes the same action, and the rents to the relationship are attractive enough for parties to self-enforce the contract and stay in the relationship [Baker et al., 1994, MacLeod, 2006, MacLeod and Malcomson, 1989, 1998]. Moreover, repetition allows players to maintain a Subgame Perfect Nash Equilibrium (SPNE) where parties honor the contract and maintain long-term relationships, which creates social surplus that is split between trading partners. Finally, because the principal’s behavior is perfectly observable, a stationary contract delivers the optimal surplus.

Each party’s objective is to maximize the future stream of payments, which depends on the contracting enforcement level and the bargaining process. Specifically, the objective of the agent is to maximize her present discounted utility, given as

$$\sum_{t=0}^{\infty} \delta^t \{d_t(P_t(q_t) - c(q_t)) + (1 - d_t)\pi\}, \quad (1.1)$$

As in Levin [2003] there is no loss of assuming that deviation causes the parties to break-off trade forever because this outcome never happens in equilibrium. Furthermore, it can be assumed that parties behave as in one-time interactions in which the principal offers a contract in which there are no performance incentives and the agent responds by providing the lowest quality.
and the principal’s objective is to maximize his present discounted profit

\[ \sum_{t=0}^{\infty} \delta^t \left\{ d_t (R(q_t) - P(q_t)) + (1 - d_t)\pi \right\}, \quad (1.2) \]

where \( d_t = 1 \) if the parties reach an agreement in the bargaining process and trade occurs in period \( t \), and \( d_t = 0 \) if the parties end the period with no agreement or any party opts out and no trade occurs. Once any of the parties opts out of the bargaining process, \( d_t = 0 \) thereafter.

### 1.3 The Bargaining Game

A bargaining phase is included in the model to characterize the outcome of a bargaining process. The bargaining power is distributed between the two parties in contrast to the assumption of the conventional theory that the principal has all of the bargaining power.\(^7\) Because the focus of the essay is on how different levels of the parties’ bargaining power affect their strategic interaction in relational contracting and not on the bargaining process itself, the bargaining game is included as an abbreviated model of negotiation in which parties make joint decisions [Watson, 2002, 2006].

The mechanism governing contract bargaining is an application of the asymmetric Nash bargaining solution (ANBS) with outside options. The ANBS, an axiomatically derived solution to the bargaining problem, captures the essence of the bargaining power and its influence on the proportional division of the trading surplus, while the focus of the analysis remains on the strategic aspects of self-enforcing contracting [Watson, 2002]. Moreover, joint decisions highlight the moment in the game when

\(^7\)See for example Bull [1987], MacLeod and Malcomson [1989, 1998], Levin [2003] and Wu and Roe [2007a,b].
contracting takes place, while individual decisions reflect the non-cooperative interaction in which each party takes strategic actions under the contract.\textsuperscript{8,9,10}

Parties interact and jointly determine whether to contract and under what terms. The decision node characterizes the outcome of the negotiation process which is consistent with certain bargaining weights that each player is able to exercise. Parties do not receive any payoffs while bargaining is taking place, therefore, the disagreement point is $(0, 0)$. If players do not contract and opt out, they do not trade and take the outside option, $(\pi, \pi)$, thereafter. If players contract they move ahead to the trading phase and get payoffs of $(U_t, \pi_t)$ respectively.

Maximization of the asymmetric Nash product (ANP) of the parties’ objective functions establishes how the principal and agent split the surplus from trade. The

\textsuperscript{8}The focus of the essay allows me to reconcile the use of the axiomatic approach with the strategic contract game as one in which parties make joint decisions as in Watson [2002, 2006].

\textsuperscript{9}The regime results in a bargaining equilibrium because the joint decision specification is consistent with the ANBS and the individual decision nodes are consistent with individual rationality of the parties.

\textsuperscript{10}The axiomatic bargaining problem can be mapped to the strategic framework developed by Rubinstein [1982]. For that, I identify the source of bargaining power in this context as each party’s individual cost of haggling which is arbitrarily close to zero. Recalling the findings of Binmore et al. [1986], the unique sub-game perfect equilibrium (SPE) of a non cooperative game defined by the use of an alternating offer procedure with outside options and discounting, converges to the asymmetric Nash bargaining solution when the friction in the bargaining process is positive but arbitrarily small for both parties. Therefore, in the limit, when the friction in the bargaining process (cost of haggling) is arbitrarily small, the SPE outcome of the non-cooperative model with outside options is equivalent to the Nash bargaining solution outcome, in which the disagreement point $(0, 0)$ is mapped to the impasse payoffs of the strategic game and the outside option does not affect the disagreement point [Muthoo, 1999]. The use of the non-cooperative bargaining game leads to the same results as the ANBS. I use in this essay the ANBS for a simpler exposition. Proofs can be obtained from the author upon request.
ANP optimization program is

\[
\max_{P(q), q} (P(q) - c(q))^\beta (R(q) - P(q))^{1-\beta}
\]

subject to  

\[
P(q) - c(q) \geq \bar{\pi},
\]

\[
R(q) - P(q) \geq \bar{\pi},
\]

\[
q \in [\underline{q}, \overline{q}],
\]

where the first and second terms are the objective functions of the agent and principal, and the parameter \(\beta\) represents the bargaining power of the agent. \(\beta = 0\) represents the conventional case in which the principal holds all the bargaining power. \(\beta = 1\) represents the case in which the agent holds all the bargaining power, and, \(\beta \in (0, 1)\) represents the case in which both parties hold some bargaining power. Finally, the constraints require that the surplus shares derived from the Nash bargaining solution are at least as high as each players’ outside option. Proposition 1 reports the bargaining outcomes derived from the asymmetric Nash bargaining process.

**Proposition 1.** The Nash equilibrium of the bargaining game yields profits

\[
U_i(y^*) = \begin{cases} 
\bar{\pi} & \text{if } \beta < \frac{\bar{\pi}}{S(\overline{q})} \\
\beta S(\overline{q}) & \text{if } \frac{S(\overline{q}) - \bar{\pi}}{S(\overline{q})} \geq \beta \geq \frac{\bar{\pi}}{S(\overline{q})} \\
S(\overline{q}) - \bar{\pi} & \text{if } \beta > \frac{S(\overline{q}) - \bar{\pi}}{S(\overline{q})}
\end{cases}
\]  

(1.3)

\[
\pi_i(y^*) = \begin{cases} 
\bar{\pi} - \bar{\pi} & \text{if } \beta < \frac{\bar{\pi}}{S(\overline{q})} \\
(1 - \beta) S(\overline{q}) & \text{if } \frac{S(\overline{q}) - \bar{\pi}}{S(\overline{q})} \geq \beta \geq \frac{\bar{\pi}}{S(\overline{q})} \\
\pi & \text{if } \beta > \frac{S(\overline{q}) - \bar{\pi}}{S(\overline{q})}
\end{cases}
\]  

(1.4)

where \(y^*\) is the equilibrium contract and \(\beta \in (0, 1]\).

**Proof.** See Appendix A.

Equations (1.3) and (1.4) report the bargaining outcomes for the agent and the principal respectively. These outcomes identify how the surplus is split and are dependent on the bargaining power that each party exercises in the bargaining process.
When $\frac{S(q) - \pi}{S(q)} \geq \beta \geq \frac{\pi}{S(q)}$, each player’s outside option is less than or equal to the share of the surplus they receive from the bargaining process. Then, they receive a share of the surplus depending on the value of $\beta$ and accordingly to (1.3) and (1.4). If $\beta < \frac{\pi}{S(q)}$ and $\beta > \frac{S(q) - \pi}{S(q)}$, the players have to offer a surplus share equal to the other party’s outside option to ensure participation as shown in (1.3) and (1.4). This occurs because when $\beta < \frac{\pi}{S(q)}$, the agent’s outside option strictly exceeds her surplus share resulting from the bargaining process. Therefore, the agent opts out, takes her outside option and the game ends. Similarly, when $\beta > \frac{S(q) - \pi}{S(q)}$, the principal’s outside option strictly exceeds the share of the surplus received from the relationship. If this is the case, the principal opts out, takes his outside option and the game ends. Corollary 1 reports this result and summarizes the bargaining outcomes.

**Corollary 1.** When $\beta \in [0, \frac{\pi}{S(q)}]$ the principal offers a share equal to $\bar{\pi}$ to ensure participation of the agent. When $\beta \in [\frac{S(q) - \pi}{S(q)}, 1]$ the agent offers a share equal to $\bar{\pi}$ to ensure participation of the principal. The bargaining outcomes yield contracts $y_i^*$, $i \in (p,a)$ such that

$$U_t(y_p^*) = \beta S(q), \text{ and}$$

$$\pi_t(y_a^*) = (1 - \beta) S(q).$$

(1.5)

(1.6)

where $\beta S(q) \geq \bar{\pi}$ and $(1 - \beta) S(q) \geq \bar{\pi}$ respectively.

The gains from trade must exceed the players’ outside options and the higher each party’s outside option, the higher the surplus share must be to ensure participation. Equation (1.5) is the summarized bargaining outcome for the agent (BOA) and equation (1.6) is the summarized bargaining outcome for the principal (BOP). The
contract must offer profits reflecting each party’s bargaining power and the surplus share must meet at least the value of the each party’s outside option.

An important note is that both players’ outside options can not exceed their respective surplus shares resulting from the bargaining process at the same time because by assumption $S(q_t) > \bar{s} \forall q \in (\underline{q}, \bar{q}]$. If $S(q_t) - \bar{s} \leq 0$ there will not be gains from trade, which contradicts the assumption that there are gains from trade to be exploited if the parties engage in a productive relationship.

1.4 The Benchmark: Bargaining and Complete Enforcement

As a benchmark, consider without loss of generality a Nash bargaining game where the principal offers the equilibrium contract and contracts are perfectly enforceable. In this regime, the quality is third-party verifiable and can be explicitly included in the contract. Therefore, the contract $y_p$ is defined as $y_p = \langle p_p, q_p \rangle$. Given the results described in Corollary 1, the principal proposes a contract $y^*_p$ maximizing his stream of future payoffs subject to the bargaining outcome established by equality (1.5).

**Proposition 2.** If contracts are perfectly enforceable and parties bargain over the terms of the contract, for any distribution of bargaining power, $\beta \in (0, 1]$, full efficiency is reached, $q_t = q^* = \bar{q}$, and the gains from trade are distributed according to the relative bargaining power of the parties, which characterize their profit functions:

$$U^* = \begin{cases} \frac{\pi}{1-\delta} \frac{\beta S(q)}{S(q) - \pi} & \text{if } 0 \leq \beta \leq \frac{\pi}{S(q)} - 1 \\ \frac{\pi}{1-\delta} \frac{\beta S(q)}{S(q) - \pi} & \text{if } \frac{\pi}{S(q)} - 1 \leq \beta \leq \frac{\pi}{S(q)} \\ \frac{\pi}{1-\delta} \frac{(1-\beta)S(q)}{S(q) - \pi} & \text{if } \frac{\pi}{S(q)} < \beta \leq 1 \end{cases} \quad (1.7)$$

$$\pi^* = \begin{cases} \frac{\pi}{1-\delta} \frac{S(q) - \pi}{(1-\beta)S(q)} & \text{if } 0 \leq \beta \leq \frac{\pi}{S(q)} - 1 \\ \frac{\pi}{1-\delta} \frac{S(q) - \pi}{(1-\beta)S(q)} & \text{if } \frac{\pi}{S(q)} - 1 \leq \beta \leq \frac{\pi}{S(q)} \\ \frac{\pi}{1-\delta} \frac{(1-\beta)S(q)}{S(q) - \pi} & \text{if } \frac{\pi}{S(q)} < \beta \leq 1 \end{cases} \quad (1.8)$$

**Proof.** See Appendix A \qed
Proposition 2 reports the results for efficiency and distribution under verifiable quality, complete contract enforcement and bargaining. In this setting both players agree to trade with any distribution of bargaining power because each party receives at least the reservation payoff given that contracts are fully third-party enforceable. This follows because the parties can structure a contract that redistributes surplus and achieves full efficiency.

Equations (1.7) and (1.8) characterize the distribution of surplus for all future trades which depends on the value of $\beta$ and $(1 - \beta)$. When the agent has bargaining power $\beta$, then she gets a proportion $\beta$ of the surplus as derived in Proposition 2. Therefore, when contracts are fully enforceable and the agent is able to bargain over contract terms, with $\beta > \frac{\pi}{S(q)}$, the surplus is more equally distributed among partners relative to the case where a take-it-or-leave-it offer is always made by the principal (when the principal holds all bargaining power). The new set of possible welfare distributions is compatible with the achievement of full efficiency. In other words, the redistribution of the bargaining power only affects the distribution of the welfare while parties keep trading the socially optimal quality.

Figure 2.5 shows the distribution of surplus for different values of $\beta$. At point I parties do not trade and receive fixed payments. Parties generate additional social surplus when they decide to trade with each other, and the surplus is represented by the shaded area where trading the optimal level of quality $\overline{q}$ represents the maximum surplus achievable. The distribution of the surplus can be at any point along the frontier from II to III. In the case when the principal has high bargaining power, including when he always gets to make take-it-or-leave-it offers to the agent, $\beta \in [0, \frac{\pi}{S(\overline{q})}]$, the distribution of surplus is given by II. The agent gets the value of her
outside option and the principal obtains all surplus. Similarly, when the agent holds a high bargaining power, including when she has all bargaining power and makes a take-it-or-leave-it-offer, \( \beta \in \left[ \frac{S(q) - \pi}{S(q)}, 1 \right] \), she gets all surplus while the principal only gets the value of his outside option. Point III in the figure illustrates this case. All other points on the Pareto frontier represent when \( \beta \in \left( \frac{\pi}{S(q)}, \frac{S(q) - \pi}{S(q)} \right) \).

### 1.5 Bargaining and Incomplete Enforcement

In this section I analyze the cases of partial and fully incomplete enforcement. In the former case, the base price, \( p_t \), is enforceable but the quality is not, a conventional assumption used in the literature. In the latter case, none of the terms of the contract are enforceable, including the base price. In these two cases, parties decide in the bargaining phase what level of surplus is created and how it is divided among them.
As the quality is not verifiable by a third-party, in both cases, the principal must offer a contract \( y_p = \langle p_t, D_t(q_t) \rangle \) through which he provides additional incentives to the base payment for the agent to deliver the desired quality. Therefore, the total compensation derived from the bargaining process is divided into the base payment and the discretionary payment following the constraints from relational contracting.

In the partial enforcement case, the contract consists of \( y_t = \langle p_t, b_t(q_t) \rangle \), in which \( p_t \) is a base payment that the principal pays regardless of what the agent’s performance is, and the contingent payment takes the form of a bonus that the principal promises to pay as long as the agent does not shirk. The assumptions of a partial enforcement regime have been conventionally used in the literature to analyze contracts in labor markets. Examples of this include MacLeod and Malcomson [1989, 1998] and Levin [2003] in which contingent payments cannot be formally enforced but a fixed (base) wage is enforceable by a third-party regardless of the final outcome. The presence of minimum wage or salary laws and, furthermore, the presence of labor expectations on minimum payments constrain the payment schemes. The use of additional bonuses, commissions or promotions to reward superior performance tend to be the norm in labor contracts as discretionary deductions are perceived as a socially incorrect practice and a cause of self-enforcement break down.

In contrast, in the fully incomplete enforcement case, an ex post negative adjustment on the base price is possible as it is not third-party enforceable either. A bonus, \( b_t(q_t) \), is used as a reward for providing \( q_t \geq q^* \) and a negative discretionary payment, \( d_t(q_t) \), is used to punish for low quality, \( q_t < q^* \). Because none of the terms of the contract are enforceable, the ex post total compensation can be zero. In this case the
principal does not have the means to enforce quality and the agent cannot obtain any payment from the principal through formal mechanisms.\textsuperscript{11}

The fully incomplete enforcement regime allows me to address cases such as common supply contracts in which ex post reductions as a response to a low quality product delivery are acceptable [Wu and Roe, 2007b]. For instance, Banerjee and Duflo [2000] show evidence from the Indian software industry in which firms ameliorate own errors by paying part of the overrun with the objective of maintaining a good reputation. Additionally, I examine cases in which all payments are made ex post and the costs of enforcement are extremely high. In such circumstances, the principal has the latitude to make a deduction to the base payment in addition to not paying the bonus. Because there is a high cost to going to court or a high opportunity cost of losing business, the agent takes the deduction and decides whether or not to stay in the relationship. This possibility is consistent with many aspects of contracting. For instance Hamilton [2001] points out that in the agricultural sector some contractors make ex post payment adjustments unilaterally. Moreover, in both the developed and the developing world it is a common practice to delay payments up to 60 days after delivery with no upfront payment as a way to ensure quality [Brown and Sander, 2007]. This clearly creates an opportunity for principals to withhold payments altogether.

\textsuperscript{11}In this case, the principal has the latitude of making potential adjustments upward or downward to the price. He can offer a contract with a promised base payment and later he can renge on paying it; or he can offer only a contingent payment. In both cases, the principal can adjust the total payment to zero. In this essay I adopt the former case, which allows me to compare the partial and the fully incomplete regimens in a clearer manner.
1.5.1 Characterization of Self-enforcing Contracts

Under the partial and fully incomplete regimes, the agent bargains for the terms of the contract with the principal. The expected compensation for both parties under cooperation is given by the bargaining outcomes reported in Corollary 1. The game is the same as shown in figure 1.1 and as applied in the complete enforcement regime, however, because enforcement is now imperfect, after the agent accepts a contract $y_p^*$, the parties may renege without a formal penalty. The agent decides on what quality to supply, $q_t$, and it may differ from the principal’s desired quality, $q^*$. The principal, after observing the quality delivered, may cooperate by paying $P_t(q_t) = p_t + b_t(q_t)$. Or he may renege on the contract by choosing the most profitable deviation, which is reneging on the payment of the bonus, ($b(q) = 0$) in the partial enforcement regime or setting the complete payment to zero, ($P_t(q_t) = 0$), in the fully incomplete enforcement case.

To characterize the set of contracts for each regime, I solve for the SPNE by using backward induction to derive a dynamic incentive compatibility constraint (DICC) for each party according to the assumptions of each case. The DICC is necessary to reach the optimal contract because it insures that the parties prefer to honor the contract instead of reneging. When the the contract is partially enforceable the agent’s and the principal’s DICC are given by (1.9) and (1.10), respectively. That is, an agent cooperates if and only if

$$\frac{p + b(q) - c(q)}{1 - \delta} \geq p - c(q) + \frac{\delta}{1 - \delta} \pi. \quad (1.9)$$

The left hand side of (1.9) is the payoff to the agent for cooperating and supplying $q_t \geq q^*$, and the right hand side represents the payoff if she shirks. Note that the
most profitable deviation for the agent is to supply \( q \), but in this case the principal after observing the quality, will not pay the bonus.

On the other hand, (1.10) represents the DICC for the principal. A principal cooperates if and only if

\[
\frac{R(q) - p - b(q)}{1 - \delta} \geq R(q) - p + \frac{\delta}{1 - \delta} \bar{\pi}.
\]

(1.10)

The left hand side of (1.10) is the principal’s payments if he cooperates and the right hand side is the payment if he deviates. Since both parties can deviate from the contract the contingent payment must be sufficient to ensure mutual benefit. It follows that the compensation scheme is bounded by the future gains of the relationship and the optimal stationary contract is defined in Proposition 3.

**Proposition 3.** If contracts are partially enforceable, the agent has bargaining power \( \beta \), and for delta sufficiently high\(^{12}\), an optimal stationary contract \( \langle p^*, b^*(q^*) \rangle \) that implements the optimal level of quality, \( \bar{q} \), must satisfy (1.5),(1.6), (1.9), and (1.10), where (1.5) holds and (1.10) binds, and the compensation scheme is characterized by:

\[
\begin{align*}
    b(q) &= c(q) - c(q_\overline{q}) - \frac{\delta}{1 - \delta} (\beta S(q) - \bar{u}) , \text{ and} \\
    p + b(q) &= c(q) + \delta S(q) .
\end{align*}
\]

(1.11)\(1.12\)

where \( \beta S(q) \geq \bar{u} \).

**Proof.** See Appendix A \( \square \)

Equality (1.11) gives the size of the bonus that the principal includes to induce a desired quality. Equality (1.12) identifies the total compensation that the principal offers the agent in the contract.

\(^{12}\)The cutoff for \( \delta \) given by \( \hat{\delta} \) is defined in Proposition 5.
The optimal contract for the fully unenforceable regime can be derived in the same way. In this regime neither the quality nor the base price \( p_t \) are enforceable, therefore the agent’s and the principal’s DICC are different with respect to the DICC from the partial enforcement regime. The DICC under the full enforcement regime are given by (1.13) and (1.14) respectively.

\[
\frac{p + b(q) - c(q)}{1 - \delta} \geq p + d(q_t) - c(q) + \frac{\delta}{1 - \delta} \pi, \quad \text{and} \\
\frac{R(q) - p - b(q)}{1 - \delta} \geq R(q) - p - d(q) + \frac{\delta}{1 - \delta} \pi. \tag{1.14}
\]

Note that the most profitable deviation for the agent is to supply \( q \), but in this case the principal after observing quality delivered, sets the total payment to zero by imposing \( d_t(q_t) = -p_t \). By the same token, the most profitable deviation for the principal is to pay nothing. Similar to the partial enforcement regime, the compensation scheme is bounded by the future gains of the relationship. Proposition 4 reports the optimal stationary contract in this case.

**Proposition 4.** Under fully incomplete contract enforcement, the agent has bargaining power \( \beta \), and for delta sufficiently high\(^{13} \), the optimal stationary contract \( \langle p^*, D^*(q^*) \rangle \) that implements \( \pi \), must satisfy (1.5), (1.6), (1.13), and (1.14), where (1.5) and (1.14) bind, and the total compensation package is characterized by:

\[
\begin{align*}
   b(q) - d(q) & \geq c(q) - c(q) - \frac{\delta}{1 - \delta} (\beta S(q) - \bar{u}), \quad \text{and} \\
   p + b(q) & = c(q) + \beta S(q). 
\end{align*} \tag{1.15}\tag{1.16}
\]

where \( \beta S(q) \geq \bar{u} \).

\(^{13}\)The cutoff for \( \delta \) given by \( \hat{\delta} \) is defined in the appendix.
Proof. See Appendix A

Equality (1.15) reports the size of the contingent payment for quality that the principal offers while equality (1.16) identifies the total compensation offered in the contract.

It is easy to see that the equilibrium contract under both regimes yields the same total compensation, which is also equal to the total compensation under the perfect enforceability regime. The total compensation reflects the division of surplus derived from the bargaining process. Yet, the payment structure in the contracts differ among the complete and incomplete regimes because when contract enforcement is lacking, the contracts need to provide incentives for the parties to perform. Furthermore, depending on the degree of incompleteness, the contracts differ in the contingent payment because when contracts are fully unenforceable there may also be a deduction in the base payment. Nevertheless, in both imperfect regimes the contingent payment has the same characteristics. The following corollary relates the total compensation of the agent to her bargaining power.

Corollary 2. The total compensation is weakly increasing and the contingent payment is decreasing with the bargaining power of the agent.

1.5.2 Incentive Provision and Bargaining

As shown in the previous section, when contracts are partially or fully unenforceable, the total compensation is increasing in the bargaining power of the agent. Furthermore, Propositions 3 and 4 report that the contingent payment is decreasing with the bargaining power of the agent. The first two terms on the RHS of equalities
(1.11) and (1.15) are the difference in the cost of providing the optimal level of quality and of providing the minimum level of quality. This difference is what must be paid to induce the optimal level of quality when the principal holds bargaining power 

$$(1 - \beta) \in \left[ \frac{S(q) - \bar{u}}{S(q)}, 1 \right].$$

This case includes when $\bar{u} - \beta S(q) > 0$ as $\beta S(q) \geq \bar{u}$ to ensure the agent’s participation. However, when the agent holds some bargaining power, such as $\beta S(q) > \bar{u}$, the range of contingent payments decreases by the third term in (1.11) and (1.15), which represents the present value of the share of the surplus net of her outside option that the agent gets by exercising her bargaining power.

A smaller conditional payment restrains the ability of the principal to induce high quality. This is intuitive because the total compensation and, therefore, the contingent payment, is limited by the proportion of surplus that the principal can extract given his bargaining power. When the principal negotiates with an agent who has some bargaining power, he must offer a higher payment, which is increasing in her bargaining power $dp/d\beta > 0$ as equalities A-17 and A-23 from the appendix show. Therefore, the size of the contingent part of the compensation scheme decreases and the contract is characterized by small explicit contingent payments.

However, the small size of the contingent payment does not unravel the optimal level of quality as the agent becomes residual claimant of the trade surplus. Since her payment depends on a $\beta$-proportion of the total surplus, it is in her interest to supply the quality which maximizes the total surplus. Consequently, the higher the agent’s bargaining power, the higher the quality she is willing to supply. In fact, by totally differentiating (1.11) and (1.15) it can be seen that in both incomplete regimens the contingent payment is decreasing with the bargaining power and the total surplus,

$$db(q)/d\beta < 0, dD(q)/d\beta < 0, db(q)/dS(q) < 0, \text{ and } dD(q)/dS(q) < 0.$$
the conditional payment is positive as long as the agent’s share of the future gains of the relationship net of the outside option is less than the difference in the cost of producing high versus low quality. When the agent’s net return to the relationship is equal to or higher than the cost differential, there is no need to provide additional incentive to the agent and the contingent payment is zero. In this way, the profit that the agent receives is increasing and the principal’s profit is decreasing with the agent’s bargaining power, even though there is no need to provide additional incentive to the agent when quality is not third-party verifiable. This result is consistent with the efficiency wages model of Shapiro and Stiglitz [1984]. In their model wages that exceed market-clearing wages in combination with the threat of dismissal are sufficient to motivate employees in labor contracts. Furthermore, MacLeod and Malcomson [1989, 1993] show that, given the self-enforcing constraints of the firm and worker, and if there exist enough rents from employment, firms may choose to use either efficiency wages or payments contingent on performance to motivate employees. The results here show that when the agent has some bargaining power, as this power increases, the principal’s choice changes generally towards using efficiency wages and not contingent performance payments to induce participation of the agent. It follows that in markets featuring agents with some bargaining power, compensation will be closer to an efficiency wage contract than a contingent performance contract.

1.5.3 Sustainability of Self-enforcing Contracts and Bargaining

A contract is self-enforceable if the parties find cooperation to be the optimal strategy. For instance, in supply contracts, the long-term returns from the current relationship have to be at least as good as the present value of the returns from the
spot market for the product involved so that the agent remains trading with the same principal, and vice versa.

In the partial enforcement regime, in which the base price \( p_t \) is enforceable but the quality is not, cooperation is the best strategy and self-enforceable contracts are maintained under the parameters presented in the next Proposition.

**Proposition 5.** In the presence of bargaining and repeated interaction, when contracts are partially enforceable, the optimal contract achieves efficiency and cooperation and self-enforcing contracts are sustainable over time if the parties have a discount factor \( \delta > \hat{\delta} \equiv \frac{c(q)-c(q)}{R(q)-c(q)+\pi} \).

**Proof.** See Appendix A

Recalling \( c(q) = 0 \), \( \hat{\delta} \equiv \frac{c(q)}{R(q)-c(q)+\pi} \), which represents the ratio of the cost of providing any level of quality such as \( q > q \) over the net surplus generated by such quality. As a consequence, for any distribution of the bargaining power, the optimal contract in a partial enforcement regime delivers the same efficiency and distribution as contracts that are completely enforceable if the parties value the future sufficiently. This implies that the sustainability of self-enforcement is independent of the distribution of the bargaining power under the partial enforcement regime. In contrast, in the fully incomplete contract enforcement regime, cooperation depends on the agent’s bargaining power and is sustainable for a smaller set of parameters given by Proposition 6.

**Proposition 6.** When contracts are fully unenforceable, if parties repeatedly trade and bargain over contract terms, cooperation and relational contracts are unraveled when \( \beta > \hat{\beta} \equiv \frac{\delta R(q)-\delta \pi-c(q)}{S(q)} \). At the limit when \( \beta = 1 \), then \( \delta > 1 \).
Proof. See Appendix A

Proposition 6 states that, as agents’ bargaining power increases, the set of discount factors that sustain cooperation and relational contracts decreases resulting in an unsustainable relationship when $\beta > \hat{\beta}$, since it requires a discount factor, $\delta$, greater than one. That is self-enforcing agreements are not sustainable when the bargaining power of agents is greater than $\hat{\beta}$. This result reflects that each party has a discount factor that mirrors how much they value the future relative to the present, and that as the agent’s bargaining power increases, the discount factor needed to sustain cooperation and keep trading with the same partner rises. A higher discount factor increases the value of the discounted surplus, and therefore the value of the relationship. Therefore, only parties who hold high discount factors, so that the total discounted surplus remains sufficiently attractive for them, sustain cooperation. Thus, in a completely unenforceable contract environment, if the agent has bargaining power, $\beta > \hat{\beta}$, then cooperation cannot be sustained for any $\delta < 1$. As a consequence, social efficiency is potentially offset by the fact that a cooperative equilibrium is harder to sustain since opportunistic behavior takes over the relationship.

The unsustainability of the relationship can be explained by the ability of the principal to withhold payments. The principal can behave opportunistically by choosing to pay any price, including a zero transfer to the agent, and earn the short-term gains. This ability of withholding payments also protects the principal from the delivery of low quality; therefore, the principal is more willing to discontinue the relationship with an agent [Wu and Roe, 2007b]. Accordingly, sustainability requires that both parties have sufficiently high discount factors to prevent the principal from shirking on payment and to continue cooperation.
These results contrast with the previous literature in which efficiency and the distribution of surplus in relational contracts can be separated. In the current case shifting the distribution of surplus can alter efficiency. If the agent demands a greater share of the gains from trade through exercising a high bargaining power, \( \beta > \hat{\beta} \), efficiency may be harmed and trade diminishes by the lack of cooperation and the presence of shorter relationships since the principal has a stronger incentive for opportunistic behavior when his proportion of the available surplus shrinks. This result is consistent with Oczkowski [2006]'s findings in agricultural bargaining. When growers hold all of the bargaining power via a bargaining co-operative no trade occurs because, if a processor chooses to participate in trade, then he will incur a loss. Thus, it can be stated that the problem of efficiency can no longer be separated from the distribution of the surplus when contracts are fully unenforceable. Accordingly, the change in bargaining power in this regime results in the next Proposition.

**Proposition 7.** When none of the terms of the contract are third-party enforceable, if the agent has bargaining power \( \beta > \hat{\beta} \), she is better off by exercising only \( \hat{\beta} \) and continuing the relationship.

**Proof.** See Appendix A

If the agent exercises bargaining power \( \beta > \hat{\beta} \) the principal gets a higher payoff by deviating and taking short-term gains, and future trade breaks down. If instead the agent exercises \( \hat{\beta} \) and takes a smaller share of the surplus in the short-term, then the principal will not deviate and continues trading with the agent. In this way she gets higher profit by trading in the long-term. Under this regime, exercising bargaining power equivalent to \( \hat{\beta} \) is the best an agent can do even if she has greater bargaining
power. This result is an alternative explanation for what Hueth and Ligon [2002] and Hueth and Marcoul [2002, 2003] observed in some agricultural sub sectors. They find little evidence for bargaining groups that increase prices for growers, supporting the prediction of the model that bargaining groups cannot exercise strong bargaining power without losing the long-term relationship.\footnote{However, these observations may also reflect the existence of poor legislation that support collective bargaining or differences between members that belong to the group and weak cohesion of the coalition may have a negative effect on the ability of the group to exercise any bargaining power.}

The model predicts that the agent can do better if contracts are at least partially enforceable as Proposition 5 reports. In the partial enforcement regime the surplus can be redistributed according to the relative bargaining power and optimal trade is sustainable whereas in the fully incomplete enforcement regime a shift in bargaining power raises the minimum discount factor needed for self-enforcement.

Figure 1.3 identifies the set of feasible contracts under the fully incomplete and partial enforcement regimens. Recalling that parties have to offer the value of the outside option when $\beta \in [0, \frac{\pi_S}{S(q)}]$ and $\beta \in [\frac{S(q) - \pi_S}{S(q)}, 1]$ respectively, the values of $\beta$ illustrated in figure 1.3 describe the outcome for any bargaining power in these ranges accordingly. Figure 1.3 (a) shows that the parties’ minimum valuation of the future required to maintain cooperation remains constant for all distributions of the bargaining power. In contrast, figure 1.3 (b) shows that the minimum discount factor is increasing in the agent’s bargaining power. Finally, figures 1.3 (a) and (b) show the set of parameters that sustain efficiency and self-enforcing contracts is greater when the base payment is enforceable.
1.6 Conclusions

Informal incentives and good faith are crucial elements to self-enforcing contracts when formal enforcement is too costly or incomplete. Previous research on relational contracting assumes that the principal holds all bargaining power and makes a take-it-or-leave-it offer to the agent. However, this may not be a realistic assumption since in many relationships, the parties bargain over the terms of the contracts. I have characterized the optimal contract when parties bargain on contract terms under three different enforcement regimes. I have shown how the bargaining power of the agent affects incentive provision, the distribution of the surplus, and the sustainability of self-enforcement and cooperation in each regime.

In the benchmark case, where contracts are fully enforced by a formal court, I have shown that parties trade regardless of the distribution of bargaining power. The contract establishes the distribution of the surplus reflecting each parties’ bargaining position and the Pareto optimal outcome is achieved for all the distributions of the bargaining power.

More interestingly, the model predicts that efficiency wage contracts are more likely to be observed than contingent performance contracts in markets where bargaining is a common characteristic and contract enforcement is incomplete, i.e., when contracts are partially, or fully unenforceable. This is because when the agent has higher bargaining power, lower contingent payments are optimal. Moreover, because higher bargaining power increases total compensation, the higher the bargaining power the higher the base compensation. Furthermore, I have shown that while, for any distribution of bargaining power, a self-enforcing contract is sustainable when contracts are partially enforceable and parties have a high valuation of the relationship, good faith
agreements collapse if the agent holds all the bargaining power when contracts are too costly to enforce or not enforceable at all. Higher bargaining power of the agent requires higher minimum discount factors for sustainable self-enforcement. Higher bargaining power of the agent triggers opportunistic behavior by the principal, who finds larger gains by reneging on the contract and taking short-term gains. In this case, the agent is better off exercising a lower bargaining power, that is leaving more surplus with the principal to encourage him to not deviate and remain in the relationship.

As a consequence, the surplus is distributed in a more effective way through the redistribution of bargaining power when partial enforcement is in place as the set of parameters that sustain efficiency and self-enforcing contracts is greater when the base payment is third-party enforceable. From a policy perspective, when governments are interested in redistributing surplus through a reallocation of bargaining power then they should evaluate the contract enforcement regime in which parties interact. When contract enforcement is lacking completely or enforcement costs are too high, shifting the power too much may have significant costs in social efficiency by breaking down the trading relationship. A government will more effectively achieve its goals if it makes contracts more complete through enforcement. Therefore, legislation that makes the base payment enforceable or encourages up-front payments are more desirable when supporting redistribution of bargaining power between parties.
Figure 1.3: Set of discount factors that sustain relational contracts when the agent holds different levels of bargaining power
Chapter 2: Bargaining Power in Relational Contracts: An Experimental Study

2.1 Introduction

Essay one suggests that, depending on the enforcement regime, a shift in bargaining power may not achieve better economic results for the weaker party (agents) because the stronger counterparty (principals) may no longer want to continue contracting. A principal who has lost power may find the short-term benefits of reneging on contractual promises larger than the long-term benefits of faithfully executing a contract where he holds less power. However, such a collapse in good-faith execution of contracts in the light of such a power shift may not occur if other changes take place, such as the enforcement of some minimum payment for contract participation. This essay explores these theoretical predictions in a context of buyer-seller (principal-agent) interactions by using experimental economics.

As the goal of this research is to study the impact of shifting bargaining power on efficiency, surplus distribution and relational contracts, I focus on bargaining under incomplete contract enforcement (partially and fully incomplete). The benchmark scenario is one in which contract enforcement is fully incomplete and buyers hold
all bargaining power relative to sellers (No enforcement, No bargaining, NN, treatment). I compare the outcomes of the NN treatment to the outcomes derived from three treatments in which changes in the allocation of bargaining power or /and the formal enforcement level take place. First I compare it to a treatment where sellers hold bargaining power but formal enforcement is still fully lacking (No enforcement, Bargaining, (NB), treatment); in the second treatment, what varies is the level of enforcement: buyers hold all bargaining power and formal partial enforcement is in place (Partial enforcement, No bargaining, PN, treatment); finally in the third treatment, both changes take place: sellers have bargaining power and formal partial enforcement is in place (Partial enforcement, Bargaining, PB, treatment).

2.2 Experimental Design

Each treatment involves a repeated game of indefinite duration that mimics the infinitely-repeated game in the theoretical model developed in Essay One. The experiments were programmed using the Z-TREE software [Fischbacher, 1999] and took place on networked computers.

The treatments differ in the parts of the contract (i.e. fixed component of payment, discretionary payment and quality) that are exogenously enforced by the experimenter or the bargaining power that subjects are able to exercise. The continuation probability and matching protocol were identical across treatments and the efficient outcome can be supported as an equilibrium in all treatments. The subjects were exogenously matched into pairs that then interacted anonymously through the computer network. There was no possibility of contagion effects across treatments because subjects play
one single game with different partners. A commonly known probability of continuation controlled for subjects’ belief about the possibility of future interaction. The subjects earned a show-up fee plus additional earnings that were proportional to the points earned during the experiment. The exchange rate was 50 experimental points per $1 which ensured that subjects had incentives to increase their points earnings.

*The supergame:* The basic experimental platform is based on the design of Brown et al. [2004] and Wu and Roe [2007a,b] and each treatment implements a particular specification of the theoretical model in Essay One. The supergame consists of an infinite market interaction between sellers and buyers achieved by the implementation of a random continuation rule. Buyers and sellers use contracts to establish the terms of trade for one unit of a good of quality $Q$ that is exchanged for a total payment that may include a base price, $p$, and a discretionary payment (bonus) that depends on the quality delivered, $b(Q)$. Buyers’ earnings are increasing in quality and decreasing in the total payment; the opposite occurs to sellers’ earnings. In each trading period, subjects can only trade one unit of a good. The price and quality of the good traded determine how much money each party makes during a trading period.

*Matching procedure:* Subjects were matched into pairs by using a rotation matching scheme. In each session, subjects were randomly divided into two groups: buyers and sellers. In each match, every buyer was paired with a seller and subjects were not paired with each other more than once. Moreover, the pairing was done in such a way that the decisions made by one subject in one match could not affect them in any future match interactions. These features were explained to the participants. Because subjects were matched with each other only once, the total number of possible matches per session is $N/2$, where $N$ is the number of subjects attending a session.
Infinitely repeated games: In each treatment, a random termination rule was used to induce infinitely repeated games. The probability of continuation used was $\delta = 4/5$, which was the same for all treatments. In each trading period the supergame is expected to go on for 5 additional periods.\textsuperscript{15} This was done at the end of each trading period by having the computer draw a number between 0 and 1, using a uniform distribution. The supergame terminated if the computer draw was 0.81 or higher. This randomization mechanism generates an infinitely repeated game because there is always a possibility of interacting with the same subject in the next round. The probability of continuation allows us to control for the subjects’ beliefs regarding the probability of continuation as subjects played a game with an uncertain number of trading periods. Because of the random termination rule, each supergame may have a different number of periods but all supergames have the same expected duration of five rounds. Then, each experimental session may be formed of one long-duration supergame or various short-duration supergames of the same treatment with different partners depending on the random termination rule. The number drawn by the computer serves as a public randomization device as in all sessions all participants observe the same drawn number.

Implementation of the bargaining: To implement the difference in bargaining power in the experiment, the design included two different conditions. In the first condition the buyer made a take-it-or-leave-it offer to the seller who could only accept or reject – in essence an ultimatum game. In the second condition, the seller was able to make a counteroffer if he or she rejected the buyer’s offer – an alternating offer game with two offers and an asymmetric cost for delaying trade for each party.

\textsuperscript{15}The expected number of periods of a game with a continuation probability of $\delta$ is equal to $T = \frac{1}{1-\delta}$. Therefore, with $\delta = 4/5$ the expected number of periods each pair interacts equals 5.
Treatments: I implemented two enforcement conditions and two bargaining conditions in a 2 x 2 design. The first condition, which I call no contract enforcement with no bargaining (NN), implements an ultimatum game in which the buyer makes take-it-or-leave it offers to the seller and the seller, upon acceptance, may choose any feasible quality irrespective of the contractually agreed upon level. The buyer could also choose any feasible level of price and bonus, therefore the buyer has the latitude to adjust the total payment to zero. That is, the total payment is discretionary and contingent on quality delivered. The second condition, which I call no contract enforcement with bargaining (NB), implements an alternating offer game with two offers in which the seller is able to counteroffer the buyer one time after he has made the first offer. The buyer could also adjust the total payment to zero. The third and fourth conditions, which I call the partial contract enforcement condition with no bargaining (PN) and the partial contract enforcement condition with bargaining (PB), implement the ultimatum game and the alternating offer game from the NN and NB conditions respectively, but in these two treatments the price is exogenously enforced by the experimenter while all other variables in the contract are not enforced. Then, the buyer could also choose any feasible (non-negative) level of bonus.

<table>
<thead>
<tr>
<th>Treatment Variable</th>
<th>PN</th>
<th>PB</th>
<th>NN</th>
<th>NB</th>
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</thead>
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<td>Bargaining</td>
<td>Take-it-or-leave-it offers</td>
<td>Counteroffers</td>
<td>Take-it-or-leave-it offers</td>
<td>Counteroffers</td>
</tr>
<tr>
<td>Enforced terms</td>
<td>Price</td>
<td>Price</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Figure 2.1: Summary of treatment conditions
*Stage game:* The stage game in all treatments has two phases: a negotiation phase and a trading phase. In the negotiation phase parties negotiate to reach an agreement about the terms of the contract including a desired quality of the good, $Q$; a price for the good, $P$, and a bonus, i.e. a payment potentially contingent on quality delivered $b(Q)$. The set of feasible quality levels is given by \{1, 2, \ldots, 10\} and prices and bonus can be in the set given by \{0, 1, 2, 3, \ldots, 100\}. In the trading phase parties make choices about some or all contract terms after bargaining is complete and the choices may differ from the contract terms previously agreed depending on the contract enforcement treatment.

In the negotiation phase of the treatments with no bargaining, buyers have all bargaining power and each buyer makes a take-it-or-leave-it-offer to his matched seller. The seller decides to accept or reject the contract. If the seller accepts, the pair moves to the trading phase. If the seller rejects, the pair does not trade in that period. In contrast, in the treatments with bargaining, if the seller rejects the offer, she can offer a contract (counteroffer) to the matched buyer. In this case, the buyer gets to accept or reject. If the buyer accepts, the pair moves to the trading phase where the good is traded at a lower value to reflect losses due to bargaining. If the buyer rejects, the pair does not trade in that period.

The trading phase is divided in two additional sub phases: quality determination and payment determination. Quality is discretionary in all treatments; therefore the quality determination phase is the same for all treatments and sellers can choose any quality from 1 to 10. The payment determination phase differs from the partial enforcement (PE) to the no enforcement (NE) treatments. In the PE treatments, price, $P$, is binding and the computer ensures that the price specified in the contract
is paid, which ranges between 0 and 100. In the NE treatments the computer does not enforce \( P \); however, in both treatments buyers can choose any bonus ranging from 0 to 100 after observing the quality. Therefore, a buyer in the NE treatments can adjust the total payment to zero while in the PE treatments a buyer has to pay the contracted price. Once all decisions are made, payments are made and each party receives payoffs. Figure 2.2 summarizes the sequence of the stage game.

Figure 2.2: Stage game by phases for all treatments

*Stage game payoffs:* The stage game payoffs differ among bargaining and no bargaining treatments. In the bargaining treatments, I include in the payoff functions the parameter \( \beta \) from the model in Essay One. The parameter reflects the bargaining power which in the traditional alternating offer game is the cost of delaying trade. In the experiments it serves as a way to transfer bargaining power between players by not only giving the opportunity to the seller to counteroffer but also by inflicting an asymmetric cost of delay for parties. I consider the following stage game payoff functions for the no bargaining treatments (PN and NN).
Buyer’s payoffs:

\[ \pi_B = \begin{cases} 
10Q - p - b(Q) & \text{if contract was concluded} \\
0 & \text{if contract was not concluded}
\end{cases} \]

Seller’s payoffs:

\[ \pi_S = \begin{cases} 
p + b(Q) - 5Q & \text{if contract was concluded} \\
5 & \text{if contract was not concluded}
\end{cases} \]

In the bargaining treatments (PB and NB), payoff functions include a \( \beta = 0.9 \), which is equivalent to the discount factor in the alternating offer game with two potential offers (original offer and one counteroffer), and it reflects the level of impatience or cost of delay for the player who makes a counteroffer (seller). If a buyer gets a counteroffer, he can accept but he only receives the profits multiplied by 0.1. However, he can reject this counteroffer and receive the outside payoff of zero. The payoffs are given by:

Buyer’s payoffs:

\[ \pi_B = \begin{cases} 
10Q - p - b(Q) & \text{if contract was concluded when first offered} \\
0.1(10Q - p - b(Q)) & \text{if contract was concluded under a counteroffer} \\
0 & \text{if contract was not concluded}
\end{cases} \]

Seller’s payoffs:

\[ \pi_S = \begin{cases} 
p + b(Q) - 5Q & \text{if contract was concluded when first offered} \\
0.9(p + b(Q) - 5Q) & \text{if contract was concluded under a counteroffer} \\
5 & \text{if contract was not concluded}
\end{cases} \]

The outside option of a seller who does not trade is 5 while for the buyer it is zero. The cost schedule for all sellers is given by 5Q. All buyers and sellers in the same treatments face the same payoff parameters in all experimental sessions.

Payoff functions, the cost schedule and the termination rule were common knowledge. However, only the pair of traders involved in each transaction were informed.
about the actual payoffs and quality level delivered. Therefore, parties could only build a reputation with the partner with whom they were trading.

At the end of each trading period, each participant is informed about the contract \((p, b(q), q)\) he had concluded, the actual quality delivered, \(q\), the payment made, his own payment, as well as about his trading partner’s payoff and ID number.

*Subjects’ total earnings:* All payoffs were in points. At the end of each session, the points earned by each subject were converted into dollars at the exchange rate of 50 points= $1. Subjects were paid privately the equivalent of points earned plus the money resulting from a pre-experimental gamble that the subjects had the option to play by using their show-up fee of $8. Note the resolution of this gamble did not occur until the end of the session.

*Order of treatments:* Subjects could participate in only one session and each subject played only a single treatment. Therefore, there was no possibility of spillover effects from one treatment to another.

*Sessions and procedures:* At the beginning of each session participants were randomly assigned to the role of either a buyer or a seller. These roles were fixed for the duration of the session. Each buyer was paired randomly with a seller. Each pair played an uncertain number of trading games. Then I could observe \(R = T \times N/2\) trades per game, where \(N\) is the number of subjects participating in the session and \(T\) is the number of periods played in each game.

The experiment consisted of sessions with one single treatment run per session and different groups of subjects participating in each session. Each treatment was run in four sessions except the PB treatment, which was run in five sessions. Each session consisted of a trial unpaid game, two surveys, a control questionnaire and
the paid treatment. The treatment was run one to six times, where the number of times depended on the results of the random termination rule and the time left after each termination. Each match consisted of as many rounds as the continuation rule indicated. All sessions lasted between one and half and two hours depending on the random termination rule.

At check in subjects were assigned a random ID number to preserve anonymity. Each subject was randomly assigned to a networked computer and was told that they will participate in a computerized trading experiment.

Throughout the pre-experimental activities subjects neither received feedback about their decisions nor information about other subjects’ decisions. They were not informed about their own payoffs until the end of the experiment. Subjects were informed about these procedures, and they were also aware that their decisions in the pre-experimental activities were completely independent of the trading game.

After the pre-experimental activities, instructions for the main treatment were read aloud for both buyers and sellers and each subject was given a printed copy for reference. When instructions were read, subjects did not know whether they had been assigned to be buyers or sellers. In addition, subjects answered a computerized control questionnaire formulated to test understanding of the treatment. In order to help the subjects to understand the game structure, the questionnaire contained hypothetical situations in the game from the perspective of both roles, buyers and sellers, and the correct answers were provided afterwards. The trading game did not start until all subjects understood the game.

To further ensure that all subjects understood the game, after completing the control questionnaire, subjects were assigned randomly to be sellers or buyers, and
participated in two practice rounds. The practice rounds were identical to normal rounds with the exception that no money was earned. Practice rounds had the purpose of familiarizing subjects with the computer controls and screens. Subjects were not able to see actual choices or payments in order to avoid possible deception.

Once the practice periods were over, the real periods of the game started. Each subject received a $5 balance in their account (250 experimental points). Because of the random termination rule, some experiments were longer than others and if the experiment ended prior to the allotted time for the evening’s session, then additional games were played until the allotted time expired. For each new game, subjects were matched with a different partner.

Each subject had an identification number for the role (IDR), e.g. buyer 1, seller 5 which was fixed during each contracting game allowing subjects to keep track of trading partners. In this way, participants could observe that they traded with a different partner after termination and rematching. This information was available only in the main treatment and not in the practice rounds.

Once all games were over, subjects were asked to complete an exit survey while experimenters determined payouts. Finally, subjects were paid privately.

2.3 Theoretical Predictions and Hypothesis

The theoretical predictions are derived from the incomplete enforcement cases in the model developed in Essay One. The analysis is based on the assumption that market participants are self-interested, risk-neutral utility maximizers and that this is common knowledge.
In all conditions, the probability of trading for one more period with the same partner is 80 per cent ($\delta = 4/5$). Given the parameters chosen, the socially efficient level of quality is $Q = 10$ because marginal revenue (10) is greater than marginal cost (5) for all quality levels. Finally, I define cooperation as both parties fulfilling the contract, the seller supplying the contracted quality and the buyer paying the contracted payment. The degree of cooperation in each treatment is defined as the proportion of pairs that cooperated.

### 2.3.1 Predictions for the NN Treatment

In the one-shot game of the NN treatment, a buyer cannot promise any payment to the seller. As a consequence, for any quality the seller supplies, the buyer maximizes payoffs by choosing a total payment equal to zero. The seller anticipates this action and realizes that for any quality she supplies, she earns $U = P(Q) - 5Q = 0 - 5Q < 5$. Therefore the seller would not accept any contract and trade does not occur.

In the repeated game, the ongoing interaction sustains the efficient outcome for discount factors equal to or greater than $\delta = 11/20 = 0.55$. Given the probability of continuation in the experiments of $\delta = 4/5$ and the parameters used, cooperation is sustainable and efficiency is reached in every period. The predictions are summarized as follows.

**Prediction 1.** In the NN treatments, the buyer offers a contract where the total payment equals 55 and the requested quality equals 10.

**Prediction 2.** In each period, the efficient outcome is sustained through cooperative actions. The actual quality equals 10 and the maximum surplus of 50 is achieved. The
buyer receives a stage payoff of 45 while the sellers’ stage payoff equals the outside option of 5.

**Prediction 3.** Cooperation is observed in every period.

### 2.3.2 Predictions for the NB Treatment

In the NB treatment, a seller can exercise bargaining power by using counteroffers while none of the terms of the contract are enforced by the experimenter. In the single-stage game there is no trade following the same intuition as in the stage game of the NN treatment.

Given the parameters used in the experiment, cooperation sustains the efficient outcome if \( \delta \geq 19/20 \). Therefore, the continuation probability of \( \delta = 4/5 \) implemented in the NB treatment does not sustain cooperation if the sellers exercise all their bargaining power, in which case, the buyer’s dynamic incentive compatibility constraint reduces to \( \frac{10Q - 0.5Q}{0.2} \geq 10Q + 0 \Rightarrow 0.5Q \geq 2Q \), which is not possible. Then, for any given quality, the buyer gets a higher payoff from deviating.

If sellers do not exercise all bargaining power, cooperation can be sustained by increasing the buyer’s stage payoff from cooperating. Increasing the buyer’s payoff from cooperation can be done by the seller accepting a lower price which is equivalent to exercising less bargaining power. That is the seller claims less of the surplus than he could. Based on the parameters used and the buyer’s DICC from the model in Essay One, if the seller only exercises a bargaining power equivalent to 0.6 cooperation is sustained and the efficient outcome is achievable.
Prediction 4. In the NB treatment, if the sellers exercise all available bargaining power the efficient outcome is not sustained. The buyers take short term profits and deviation is observed in every period.

Prediction 5. If sellers exercise bargaining power of 0.6 or less (by accepting lower prices), the efficient outcome is sustainable. The seller accepts a contract where the total payment equals 80 and the requested quality equals 10. The efficient outcome is sustained through cooperative actions, the actual quality equals 10, and the maximum surplus of 50 is achieved. The buyer receives a stage payoff of 20 while the sellers’ stage payoff equals 30.

Prediction 6. Cooperation is observed in every period when sellers exercise a bargaining power of \( \beta \leq 0.6 \).

2.3.3 Predictions for the PN Treatment

In the one-shot game of the PN treatment, the buyer can only guarantee the seller will receive the price. As a consequence the seller only supplies the minimum quality, \( q = 1 \) and the buyer pays a price just high enough to induce seller’s participation: \( p = 10 \). In this equilibrium the joint surplus created is 5, where the buyer earns 0 and the seller earns 5.

In the repeated game, given the parameters used, a discount factor equal to 1/2 or higher sustains cooperation under this regime. Therefore, the efficient outcome can be sustained as a sequential equilibrium in the PN treatment given the continuation probability implemented in the experiments, \((\delta = 4/5 > 1/2)\). The predictions are summarized as follows.
Prediction 7. *In the PN treatment, the buyer offers a contract including a quality of 10, a price of 10 and a bonus of 45 with a total payment of 55.*

Prediction 8. *In each period, the efficient outcome is sustained through cooperative actions. The actual quality equals 10 and the maximum surplus of 50 is achieved. The buyer receives a payoff of 45 while the sellers’ payoff equals the outside option of 5.*

Prediction 9. *Cooperation is observed in every period.*

### 2.3.4 Prediction for the PB Treatment

In the one-shot game of the PB treatment, the buyer can only promise the price but because for any price the seller maximizes her income by providing the lowest quality, $q = 1$, the buyer offers only a contract for the minimum quality and pays a price just enough to induce seller’s participation. Because of bargaining, the buyer offers a price of 9.5 in exchange for a quality of 1, which gives the seller a payoff of 4.5 which is lower than the seller’s outside option of 5. Therefore, exchange does not take place in the one-shot game.

In the repeated game, cooperation is sustainable for discount factors greater than or equal to 1/2. Therefore, the efficient outcome is sustained in the PB treatment given the continuation probability of 4/5 implemented in the experiments. The predictions are summarized as follow.

Prediction 10. *In the PB treatment, the buyer offers a contract in which the requested quality equals 10, the price equals 95, the bonus equals 0 and the total payment is 95.*
Prediction 11. In each period, the efficient outcome is sustained through cooperative actions. The actual quality equals 10 and the maximum surplus of 50 is achieved. The buyer receives a payoff of 5 while the sellers’ payoff equals 45 as a result of the distribution of bargaining power.

Prediction 12. Cooperation is observed in every period.

2.3.5 Hypotheses

Given the parameters used, the model describes the efficient outcome as \( q = 10 \) and surplus equal to 50. Furthermore, in equilibrium in the no bargaining treatments sellers accept the offer and both parties cooperate while in the bargaining treatments the buyer offers the equilibrium contract of the alternating offer game such that the seller does not have an incentive to counteroffer. Then, sellers accept the first offer and cooperate unless the seller exercises bargaining power greater than 0.6 in the NB treatment.

Comparing the predictions for the previous section, I forward the following testable hypotheses with respect to efficiency, surplus distribution and cooperation.

Hypothesis 1. Actual quality chosen and social surplus should follow \( NB \geq PB \geq NN \geq PN \) if sellers only exercise the bargaining power that allows parties to trade in the NB treatment. If sellers exercise too much bargaining power actual quality and surplus in the NB is the lowest.

Hypothesis 2. Total payments follow \( PB > NB > PN \geq NN \) and the actual price is greater in \( PB \) than \( PN \) while the opposite is true for the bonus.

Hypothesis 3. There is a higher loss of private efficiency in \( PB \) than \( NB \).
**Hypothesis 4.** Seller rents are close to reservation payoffs in the no bargaining treatments and their share of the surplus is close to zero. Seller rents and the share of the surplus follow $PB \geq NB > PN \geq NN$.

**Hypothesis 5.** More cooperative outcomes are observed in PB, PN and NN treatments than in the NB treatment.

In addition, the acceptance rate, the use of counteroffers and the post-deviation actions affect the levels of efficiency and surplus distribution achieved in each treatment. Sellers are more likely to accept buyers’ offers in the no bargaining treatments because those are take-it-or-leave-it contracts. Moreover, within the bargaining treatments, sellers are able to exercise more bargaining power in the partial enforcement condition than under the no enforcement condition because the price is enforced by the experimenter so that it is secure for the seller. Finally, after any deviation, the model predicts that parties go back to play the one-shot game, in which trading the lowest quality for a minimum payment is the equilibrium for the PN treatment and no exchange is the equilibrium for all other treatments. These last hypotheses summarize these.

**Hypothesis 6.** The acceptance rate of contracts is higher in no bargaining treatments (NN and PN) than in the bargaining treatments (NB and PB).

**Hypothesis 7.** Sellers counteroffer more in the partial enforcement (PB) than in the fully incomplete (NB) condition.
Table 2.1: Experimental sessions

<table>
<thead>
<tr>
<th>Session</th>
<th>Treatment (Date)</th>
<th>Number of Subjects</th>
<th>Number of games</th>
<th>Number of pairs</th>
<th>Total number of periods</th>
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<td>3</td>
<td>9</td>
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<tr>
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<td>3</td>
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<td>1</td>
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<td>9</td>
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<td>3</td>
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<td>10</td>
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<tr>
<td>6</td>
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<td>5</td>
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<td>5</td>
<td>25</td>
<td>19</td>
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</tr>
<tr>
<td>17</td>
<td>NENBP (11 10 10)</td>
<td>14</td>
<td>4</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>168</strong></td>
<td><strong>56</strong></td>
<td><strong>297</strong></td>
<td><strong>295</strong></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>9.88</strong></td>
<td><strong>3.29</strong></td>
<td><strong>17.47</strong></td>
<td><strong>17.35</strong></td>
</tr>
</tbody>
</table>

Table 2.1: Experimental sessions

2.4 Results

Table 2.1 summarizes information about the 17 experimental sessions that have been held. Subjects were students from a variety of majors that were recruited by email and earned an average of $16.61 with a maximum $32 and a minimum of $6.

Table 2.2 presents the average number of periods per match. Mann-Whitney tests give evidence that the number of periods played per match is significantly different between some treatments. Because of this difference I control for the length of the relationship in the econometric analysis.
Tests for learning effects. Because the experiments mimic the infinite repetition of the theoretical model, the realized durations varied considerably. Because subjects may learn throughout the experiment, subjects’ behavior may be substantially different from the theoretical equilibrium in earlier periods, but, over time subjects adjust their choices and converge to the theoretical equilibrium. As a consequence potential differences across treatments may be due to learning effects, especially between those that have significantly different length.

To explore if this is an issue, I test for learning effects. First, I test learning effects by comparing subjects’ decisions across the games played in each single session across treatments. I aggregated pairs from all treatments by game number, where game number describes the order in which a specific game that included a unique pair was played\textsuperscript{16}. Table 2.3 shows the mean values per game across treatments for the most relevant variables. A Kruskal-Wallis (KW) test indicates that there is a statistically significant difference across games for at least one game for all variables in table 2.3. A Mann-Whitney (MW) test of pairwise differences identifies no significant difference among game 1 and game 2 for any of the variables. However, the same test gives

\begin{center}
\begin{tabular}{cccc}
NB & NN & PB & PN \\
3.86\textsuperscript{a} & 4.71\textsuperscript{b} & 4.88\textsuperscript{a,b} & 6.75\textsuperscript{c} \\
\end{tabular}
\end{center}

Notes: Different letter superscripts indicate that numbers are statistically distinct.

Table 2.2: Average number of periods per match

\textsuperscript{16}Because of the use of a random termination rule, one or more games were played in each session. Then, the game number represents the order in which the game was played in a session (first, second, third, etc.).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Game 1</th>
<th>Game 2</th>
<th>Game 3</th>
<th>Game 4</th>
<th>Game 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=934</td>
<td>n=252</td>
<td>n=200</td>
<td>n=246</td>
<td>n=161</td>
</tr>
<tr>
<td>Av. contracted quality</td>
<td>7.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.58&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>8.37&lt;sup&gt;c&lt;/sup&gt;</td>
<td>8.58&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>7.89&lt;sup&gt;b,c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Av. actual quality</td>
<td>6.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.53&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>6.89&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.68&lt;sup&gt;d&lt;/sup&gt;</td>
<td>6.63&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Av. contractual payment</td>
<td>58.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.05&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>63.83&lt;sup&gt;c&lt;/sup&gt;</td>
<td>63.88&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>64.43&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Av. actual payment</td>
<td>44.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40.34&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>49.75&lt;sup&gt;c&lt;/sup&gt;</td>
<td>55.21&lt;sup&gt;d&lt;/sup&gt;</td>
<td>50.84&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Av. seller’s payoffs</td>
<td>13.89&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.46&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>15.17&lt;sup&gt;a,c&lt;/sup&gt;</td>
<td>16.77&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>17.66&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Av. buyer’s payoffs</td>
<td>15.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>13.66&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>17.34&lt;sup&gt;a,c&lt;/sup&gt;</td>
<td>21.38&lt;sup&gt;d&lt;/sup&gt;</td>
<td>12.78&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cooperation rate</td>
<td>0.36&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.32&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>0.44&lt;sup&gt;a,c&lt;/sup&gt;</td>
<td>0.53&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>0.40&lt;sup&gt;b,c,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Av. Surplus</td>
<td>30.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27.63&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>34.47&lt;sup&gt;c&lt;/sup&gt;</td>
<td>38.42&lt;sup&gt;d&lt;/sup&gt;</td>
<td>33.13&lt;sup&gt;c,d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Notes: Numbers within a row with different letter superscripts are statistically distinct according to pairwise Mann-Whitney tests. Differences among games are statistically significant at 1% or 5% levels.

Table 2.3: Mean values per game across treatments

evidence of a significant difference between some of the other games (superscripts in table 2.3). This evidence suggests that subjects’ early behavior differs somewhat from later behavior. Therefore, learning and outcomes trends may be important in analyzing the data.

Table 2.3 suggests that subjects became more familiar with the incentive structure of the indefinite repetition across games in the same sessions. Figure 2.3 shows the learning trend in cooperation between games across treatments. Participants increase cooperation from the first two games to the later games. Even though cooperation is lower in game 5, it is not statistically different than cooperation in game 4. However, the difference in cooperation among games is significant at 5% level (Kruskal-Wallis test).

I also test each individual treatment for learning effects. Only the no enforcement treatments present some significant increasing differences among games for desired
quality, actual quality, desired total payment, cooperation and surplus. This evidence suggests that the small learning trend observed in the overall analysis is driven by the no enforcement treatments, especially by the NN treatment where learning trends are significant at the 1% level for almost all variables.

To test more consistently the presence of learning effects, I compare the means of the variables of interest among early and later periods across treatments and for each treatment. Because each game has a potentially different number of periods that each match plays, I define an “effective period” variable which is the number of actual periods that each subject plays in a full session across games and across partners. I analyze learning effects by comparing subjects’ earlier decisions to later decisions within a single session. For each treatment, the data was partitioned into two groups by using three different definitions of “early periods” and “late periods”. For that I
created three learning variables. The first, “learning5”, defines early periods as the first 5 periods of a session and later periods as all other periods. That is “learning5” equals 0 if period ≤ 5 and equals 1 otherwise. In the same way, “learning4”, equals 0 if period ≤ 4 and equals 1 otherwise. And finally, “leraning9” defines early periods up to the ninth period. The analysis gives evidence of learning trends in subject behavior. As in the previous analysis, the presence of learning effects is stronger in the NE treatments than in the PE treatments, especially under “learning9”. Therefore, I control for learning effects in the econometric analyses.

A final consideration is the difference in the number of periods played among games. In the NB treatment the longest game had 9 periods while in the NN, PB and PN treatments the longest game had 17, 12 and 20 periods respectively. I test for potential differences among treatments because of the presence of longer games. I created a variable called “laterperiods” that takes the value of 0 if the period played was between 1 and 9 (taking as reference the longest game in the treatment that had the shorter longest game (NB)), and 1 if the period was 10 or beyond. By using the pooled data for all treatments, I find a significant difference in the total payment (MW test p=0.0410), sellers’ profits (MW test p=0.0604) and cooperation (MW test p=0.0102). When I analyze the differences among sessions for individual treatments, I only find significant differences in the NN treatment. Therefore, I include all observations in the analysis and I control for potential differences due to longer games by including dummy variables for each period.

Summary statistics. Table 2.4 presents the summary statistics by treatment. The unit of analysis is a pair per period. There were 1493 possible interactions, of which
934 resulted in exchange. There were 1669 contracts proposed (1450 offers, 219 counteroffers). *Offer fraction* shows the proportion of possible interactions in which a buyer made an offer. *Acceptance rate fraction* shows the proportion of those offers accepted by the seller. *Counteroffer fraction* shows the proportion of all possible interactions that resulted in a counteroffer and *Counteroffer after rejection fraction* shows the proportion of rejected offers that were followed by a counteroffer. *Counteroffer acceptance rate* shows the proportion of those counteroffers accepted by buyers. *Number of pairs* shows the number of distinct subjects pairs. *Average length of the relationship* shows how many periods each pair interacted. *Pairs used offer, fraction* and *Pairs used counteroffer, fraction* show the proportion of pairs that used offers and counteroffers respectively while *Pairs contracted by offer, fraction* and *Pairs contracted by counteroffer, fraction* show the proportion of pairs that agreed on a contract by using offers or counteroffers respectively.

The remaining variables in Table 2.4 are restricted to the actual contracts that were accepted including offers and counteroffers. *Average contracted quality* and *Average contracted payment* show the averages specified in the accepted offers and counteroffers, while *Average actual quality* and *Average actual payment* show the averages actual delivered by both the seller and buyer respectively. *Average buyer payoffs* and *Average seller payoffs* and *Median seller payoffs* are the average and median seller earnings in points per period. *Overall seller share* and *Overall seller share (median)* show the mean and median proportion of the private surplus (sum of parties’ payoffs) captured by the seller including all contracts respectively, while *Seller share if offer* and *Seller share if counteroffer* show the proportion of the surplus captured by the seller when the contract was reached by an offer or counteroffer.
respectively. *Trunc. seller share* is similar to overall seller share but it truncates the ratio of payoffs to total available private surplus to the unit interval. In this case, if the payoff of either party is negative, the share is set to 0 and the other party’s share is set to one. *Payoffs relative spread* presents another way of looking at surplus distribution. It is the ratio of the spread between buyers’ and sellers’ payoffs to the total available private surplus. Finally, the *Cooperation rate* shows the overall average cooperation which is defined as pairs that act according to the contract while *Cooperation rate if offer* and *Cooperation rate if counteroffer* show the average cooperation when the contract was achieved through an offer and counteroffer respectively.

The descriptive statistics in Table 2.4 give a general idea of the overall results. The data show that buyers used almost all opportunities to make offers to their sellers. In addition, only around 32% of sellers that rejected an offer used a counteroffer in the NB treatment while close to 50% of sellers used counteroffers after rejection in the partial enforcement treatments.

Table 2.5 presents the averages by treatment for the variables of interest and the non-parametric analysis for key pair-wise treatment differences. The significance is measured by the p-values of the two-sided Mann-Whitney tests using each partnership-period as an independent observations. I examine the results in more detail by using hypothesis tests and regression analyses in the following sections and account for potential clustering of unobservables at the partnership level.

### 2.4.1 Inclusion of bargaining when formal enforcement is not available

I start the detailed analysis by comparing the outcomes in the NN treatment to the outcomes of the NB treatment. Efficiency is measured by the level of actual quality
<table>
<thead>
<tr>
<th></th>
<th>NB</th>
<th>NN</th>
<th>PB</th>
<th>PN</th>
</tr>
</thead>
<tbody>
<tr>
<td>All possible interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible interactions</td>
<td>285</td>
<td>426</td>
<td>414</td>
<td>368</td>
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<tr>
<td>Offer fraction</td>
<td>0.98</td>
<td>0.97</td>
<td>0.98</td>
<td>0.95</td>
</tr>
<tr>
<td>Acceptance rate fraction</td>
<td>0.53</td>
<td>0.60</td>
<td>0.53</td>
<td>0.69</td>
</tr>
<tr>
<td>Counteroffer fraction</td>
<td>0.24</td>
<td>na</td>
<td>0.37</td>
<td>na</td>
</tr>
<tr>
<td>Counteroffer after rejection fraction</td>
<td>0.32</td>
<td>na</td>
<td>0.50</td>
<td>na</td>
</tr>
<tr>
<td>Counteroffer acceptance rate</td>
<td>0.18</td>
<td>na</td>
<td>0.18</td>
<td>na</td>
</tr>
<tr>
<td>Number of pairs</td>
<td>70</td>
<td>87</td>
<td>84</td>
<td>56</td>
</tr>
<tr>
<td>Av. Length of relationship</td>
<td>4</td>
<td>4.7</td>
<td>4.9</td>
<td>6.75</td>
</tr>
<tr>
<td>Pairs used offer, fraction</td>
<td>1</td>
<td>0.99</td>
<td>0.94</td>
<td>1</td>
</tr>
<tr>
<td>Pairs used counteroffer, fraction</td>
<td>0.50</td>
<td>na</td>
<td>0.73</td>
<td>na</td>
</tr>
<tr>
<td>Pairs contracted by offer, fraction</td>
<td>0.80</td>
<td>0.86</td>
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<td>0.96</td>
</tr>
<tr>
<td>Pairs contracted by counteroffer, fraction</td>
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<td>0.56</td>
<td>na</td>
</tr>
<tr>
<td>Completed exchanges</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Av. contracted quality</td>
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<td>8</td>
<td>7.71</td>
<td>7.79</td>
</tr>
<tr>
<td>Av. actual quality</td>
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<td>6.41</td>
<td>6.05</td>
<td>6.33</td>
</tr>
<tr>
<td>Av. contractual payment</td>
<td>66.64</td>
<td>61.71</td>
<td>60.49</td>
<td>57.94</td>
</tr>
<tr>
<td>Av. actual payment</td>
<td>49.94</td>
<td>44.57</td>
<td>48.77</td>
<td>46.58</td>
</tr>
<tr>
<td>Av. buyer’s payoffs</td>
<td>20.90</td>
<td>19.57</td>
<td>9.63</td>
<td>16.75</td>
</tr>
<tr>
<td>Av. seller’s payoffs</td>
<td>12.39</td>
<td>12.50</td>
<td>18.15</td>
<td>14.91</td>
</tr>
<tr>
<td>Median seller’s payoffs</td>
<td>20</td>
<td>15</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Av. Surplus</td>
<td>37.53</td>
<td>32.07</td>
<td>30.26</td>
<td>31.67</td>
</tr>
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<td>Priv. surplus</td>
<td>32.29</td>
<td></td>
<td></td>
<td>27.79</td>
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<tr>
<td>Overall seller’s share</td>
<td>0.24</td>
<td>0.54</td>
<td>1.19</td>
<td>0.84</td>
</tr>
<tr>
<td>Overall seller’s share (median)</td>
<td>0.50</td>
<td>0.43</td>
<td>0.61</td>
<td>0.50</td>
</tr>
<tr>
<td>Seller’s share if offer</td>
<td>0.31</td>
<td>0.54</td>
<td>1.30</td>
<td>0.84</td>
</tr>
<tr>
<td>Seller’s share if counteroffer</td>
<td>-0.16</td>
<td>na</td>
<td>0.75</td>
<td>na</td>
</tr>
<tr>
<td>Truc. Seller’s share</td>
<td>0.43</td>
<td>0.38</td>
<td>0.64</td>
<td>0.50</td>
</tr>
<tr>
<td>Payoffs relative spread</td>
<td>0.16</td>
<td>0.30</td>
<td>-0.97</td>
<td>-0.60</td>
</tr>
<tr>
<td>Cooperation rate</td>
<td>0.49</td>
<td>0.36</td>
<td>0.38</td>
<td>0.41</td>
</tr>
<tr>
<td>Cooperation rate if offer</td>
<td>0.54</td>
<td>0.36</td>
<td>0.39</td>
<td>0.41</td>
</tr>
<tr>
<td>Cooperation rate if counteroffer</td>
<td>0.26</td>
<td>na</td>
<td>0.35</td>
<td>na</td>
</tr>
<tr>
<td>Treatment Effects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bargaining</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Enforcement</td>
<td>None</td>
<td>None</td>
<td>p</td>
<td>p</td>
</tr>
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</table>

Table 2.4: Summary data
<table>
<thead>
<tr>
<th></th>
<th>Means</th>
<th>Mann-Whitney (p-values)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NB</td>
<td>NN</td>
</tr>
<tr>
<td>Offer Acceptance rate fraction</td>
<td>0.53</td>
<td>0.60</td>
</tr>
<tr>
<td>Overall acceptance rate fraction</td>
<td>0.51</td>
<td>0.60</td>
</tr>
<tr>
<td>Av. contracted quality</td>
<td>8.57</td>
<td>8</td>
</tr>
<tr>
<td>Av. actual quality</td>
<td>7.51</td>
<td>6.41</td>
</tr>
<tr>
<td>Av. contractual payment</td>
<td>66.64</td>
<td>61.71</td>
</tr>
<tr>
<td>Av. actual payment</td>
<td>49.94</td>
<td>44.57</td>
</tr>
<tr>
<td>Av. contracted price</td>
<td>43.98</td>
<td>43.73</td>
</tr>
<tr>
<td>Av. actual price</td>
<td>34.00</td>
<td>31.79</td>
</tr>
<tr>
<td>Av. contracted bonus</td>
<td>22.66</td>
<td>17.99</td>
</tr>
<tr>
<td>Av. actual bonus</td>
<td>15.94</td>
<td>12.78</td>
</tr>
<tr>
<td>Av. buyer’s payoffs</td>
<td>20.90</td>
<td>19.57</td>
</tr>
<tr>
<td>Av. seller’s payoffs</td>
<td>12.39</td>
<td>12.50</td>
</tr>
<tr>
<td>Av. Social surplus</td>
<td>37.53</td>
<td>32.07</td>
</tr>
<tr>
<td>Av. Social surplus (all offers)</td>
<td>25.80</td>
<td>19.33</td>
</tr>
<tr>
<td>Av. Private surplus</td>
<td>33.29</td>
<td>32.07</td>
</tr>
<tr>
<td>Av. Private surplus (all offers)</td>
<td>22.80</td>
<td>19.33</td>
</tr>
<tr>
<td>Overall seller’s share</td>
<td>0.24</td>
<td>0.54</td>
</tr>
<tr>
<td>Truc. Seller’s share</td>
<td>0.43</td>
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</tr>
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<td>Payoffs relative spread</td>
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<td>0.30</td>
</tr>
<tr>
<td>Cooperation rate</td>
<td>0.49</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Notes: Median values for overall seller share and seller payoffs are in table 2.4 for reference.

Table 2.5: Hypothesis test for treatment effects
delivered, which maps directly into the surplus generated. All treatments have the same expected time horizon, therefore, parties should achieve the same surplus and quality levels in all treatments if relational contracts persist in the NB treatment.

Hypothesis 1 states that higher efficiency in the form of higher quality and social surplus is achieved in the NB treatment than in the NN treatment if sellers exercise only a bargaining power that allow parties to trade and relational contracts arise. If sellers exercise too much bargaining power actual quality and surplus in the NB is lower than in the NN treatment. The non-parametric analysis in Table 2.5 shows that the actual quality supplied and social surplus in the NB treatment are significantly higher than in the NN treatment. In fact, actual quality and social surplus in the NB treatment are significantly higher than all other treatments. These results suggests that sellers are not exercising too much bargaining power in the NB with the objective to keep trading over time as Hypothesis 1 predicts. If relational contracts arise sellers provide higher quality when bargaining is in place as they become residual claimants of the surplus (NB treatment). As a consequence, a higher level of social surplus is produced in the NB treatment relative to the NN treatment.

Table 2.12 shows results for a censored regression exploring the determinants of actual quality. The explanatory variables include all treatment effects and controls for learning effects and parties’ history. All standards errors are clustered at the pair level. A Wald test for the equality of coefficients rejects the null hypothesis that the NB coefficient equals any of the other treatment coefficients (p=0.00065 for NN, p=0.0087 for PB and p=0.0011 for PN respectively). These estimates confirm the non-parametric test results with respect to actual quality. In addition, all control variables affect significantly the actual quality delivered, suggesting that the more
the parties have previously earned in the relationship and the longer the relationship the higher the quality delivered.

Furthermore, tables 2.13 and 2.14 show the effect of the presence of bargaining and enforcement separately on the actual quality delivered. The estimations in table 2.13 include only completed contracts while in table 2.14 include all offered contracts. The estimations in the first columns in both tables are also a tobit model with actual quality level as dependent variable and the explanatory variables include the presence of bargaining (dummy taking a value of one if bargaining was in place and 0 otherwise) and enforcement (dummy takes a value of one if enforcement was in place and 0 otherwise) as well as an interaction term. Controls for the length of the relationship, buyer’s and seller’s previous earnings and period dummies are included. The constant term represents the case in which no bargaining and no enforcement are in place. That is, the NN treatment is the base line for comparison. The results confirm that inclusion of bargaining when contract enforcement is fully incomplete has a positive effect on the delivery of quality supporting the hypothesis that sellers provide a higher level of quality when bargaining is in place because they become residual claimants of the surplus.

A possible explanation of the difference in actual quality delivered between the NB and NN treatments may be that sellers shirked more in the absence of bargaining. Table 2.6 shows a summary of average contracted and actual quality as well as the percentage of trades in which actual quality fell short of the contracted quality and the average size of quality deviation across treatments. The average size of quality shortfall is smaller in the NB treatment as expected. However, a Kruskal-Wallis test cannot reject the null hypothesis that the average size of quality shortfall is the
same across treatments (p=0.1557). Therefore, quality deviation does not explain the
difference in quality provision between NN and NB treatments. This suggests that
the fact that sellers are the residual claimants of the surplus is difference.

In addition, columns two and three in tables 2.13 and 2.14 present the results of
an OLS regressions for social surplus. The estimation in column two only includes
one control for party’s history: current length of the relationship while column three
includes also parties’ previous earnings.

Regression results are consistent with the non-parametric tests for social surplus.
The inclusion of bargaining when contract enforcement is lacking has a positive and
significant effect on the social surplus, which supports the hypothesis that bargaining
power increases the level of efficiency as sellers become residual claimants.

An important note is that even though actual quality and surplus are significantly
higher in the NB treatment, there may be an important difference between the social
surplus generated and what private parties are able to collect in this treatment. The
actual quality level and the cost of providing such quality determines the total social
surplus and the sum of seller’s and buyer’s payoffs is defined as total private surplus.
In the no bargaining treatments, the sum of seller’s and buyer’s payoffs equal the
total social surplus. However, in the bargaining treatments, because of the possibility
of counteroffers, the total social surplus may differ from the total private surplus,
i.e. the value of the sum of the parties’ payoffs. If the buyer’s offer is accepted,
bargaining ends and private and social surplus are defined as above. If the buyer’s
offer is declined, the seller has the opportunity to counteroffer, but the value of
the potential payoffs for each party shrinks according to different bargaining factors,
which means that total social surplus differs from the sum of parties’ payoffs (private
surplus). Table 2.7 presents summary statistics on how the average social surplus relates to average buyer’s and seller’s payoffs and to the average private surplus for only completed contracts and for all proposed contracts. Table 2.7 also presents the average loss of private efficiency, which represents the difference between the social surplus and the private surplus. In other words, it represents the private loss that parties incur from bargaining relative to what they could achieve if they were to agree in the first offer.

The average social and private surplus are the same in the NN and PN treatments as there is no bargaining. However, in the NB and PB treatments the average private surplus is lower than the average social surplus. Although, the average private surplus in the NB treatment is consistently higher than all other treatments, it is only significantly higher than the private surplus in the PB treatment (MW $p = 0.0001$ for PB, $p = 0.1363$ for NN and $p = 0.1111$ for PN). Then, for only completed contracts the private surplus in the NB treatment is not significantly different than the private surplus in the NN treatment. However, if all contracts proposed are taken into account, the NB private surplus is significantly higher than the NN private surplus (MW $p = 0.0551$) as well as social surplus (MW $p = 0.0002$). However, private surplus in the NB treatment is not significantly different than the other treatments (MW $p = 0.4990$ for PB and $p = 0.8378$ for PN), while the social surplus is significantly higher than the PN treatment (MW $p = 0.0551$). These results suggest that when contracts were completed, the loss of efficiency due bargaining and use of counteroffers erodes social surplus such that what is left for the parties to share is not different than what is achieved in the NN treatment. But, when loss in efficiency due to contract rejection and no trade is also taken in account the average private
surplus in the NB treatment is higher than in the NN treatment. However, in either case there is no difference for buyer and seller payoffs among treatments (MW test $p = 0.1030$ and $p = 0.2292$ for seller and buyer payoffs in only complete contracts and $p = 0.2208$ and $p = 0.4884$ for all offers respectively). If the loss of efficiency due to contract rejection explains parties' payoffs among treatments, then they should be different among all contracts offered and only complete contracts. Because parties payoffs are not different among treatments in either case, then, the loss of efficiency due to bargaining may explain parties' payoffs.

Columns four and five in tables 2.13 and 2.14 present the results of an OLS regressions for private surplus. The results confirm that bargaining has a positive effect on the private surplus when contract enforcement is fully incomplete. However, it is only significant if one controls for parties’ previous earnings.

**Result 1.** *When third-party enforcement is not available, the inclusion of bargaining over contract terms increase significantly quality provision and social surplus. Parties find powerful informal incentives that allow for higher efficiency if they are able to engage in long-term relationships. However, the private surplus is only significantly higher in the presence of bargaining when efficiency loss due to contract rejection and no trade is taken in account.*

The differences in surplus between NN and NB may be driven by either the higher efficiency achieved in the NB treatment or because contract acceptance rate was lower in the NN treatment. The latter explanation contradicts hypothesis 6 which states that the acceptance rate of contracts is higher in no bargaining treatments than in the bargaining treatments.
The acceptance rate reflects the parties’ willingness to engage in a trading relationship and cooperate. Table 2.5 shows that the acceptance rate of offers in the NN treatment is higher than in the NB treatment (significant at the 10% level). Yet, by comparing the overall acceptance rate (for offers and counteroffers), the difference is more significant (5% level).

This evidence supports the idea that bargaining impacts negatively the rate of trades relative to the total number of offers made. However, a probit model estimating the probability of accepting the contract through first offers does not confirm that bargaining decreases the acceptance rate (table 2.15). Although the coefficient for the bargaining dummy is negative, it is not statistically significant, even when other determinants of the acceptance rate are included (terms of contracts in the offers). Therefore, these results do not confirm the non-parametric results.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Av. contracted quality</th>
<th>Av. actual quality</th>
<th>% of trades where $q &lt; Q$</th>
<th>Av. size of shortfall, $Q-q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB</td>
<td>8.57</td>
<td>7.51</td>
<td>0.38</td>
<td>1.06</td>
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<tr>
<td>NN</td>
<td>8</td>
<td>6.41</td>
<td>0.46</td>
<td>1.59</td>
</tr>
<tr>
<td>PB</td>
<td>7.71</td>
<td>6.05</td>
<td>0.45</td>
<td>1.66</td>
</tr>
<tr>
<td>PN</td>
<td>7.79</td>
<td>6.33</td>
<td>0.47</td>
<td>1.46</td>
</tr>
<tr>
<td>All bargaining</td>
<td>8.05</td>
<td>6.63</td>
<td>0.42</td>
<td>1.42</td>
</tr>
<tr>
<td>All no bargaining</td>
<td>7.90</td>
<td>6.37</td>
<td>0.47</td>
<td>1.52</td>
</tr>
<tr>
<td>All partial enforcement</td>
<td>7.75</td>
<td>6.19</td>
<td>0.46</td>
<td>1.56</td>
</tr>
<tr>
<td>All no enforcement</td>
<td>8.24</td>
<td>6.87</td>
<td>0.42</td>
<td>1.37</td>
</tr>
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</table>

Table 2.6: Quality deviation summary statistics

The other important issue that impacts efficiency is the use of counteroffers. Table 2.15 also presents the results of a probit model estimating the probability of the use
<table>
<thead>
<tr>
<th>Treatments</th>
<th>Av. Social Surplus</th>
<th>Av. Private Surplus</th>
<th>Loss of private efficiency due to bargaining</th>
<th>Av. Buyers’ payoffs</th>
<th>Av. Sellers’ payoffs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only completed contracts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NB</td>
<td>37.53</td>
<td>33.29</td>
<td>-0.113</td>
<td>20.90</td>
<td>12.39</td>
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<td>NN</td>
<td>32.07</td>
<td>32.07</td>
<td>0</td>
<td>19.57</td>
<td>12.50</td>
</tr>
<tr>
<td>PB</td>
<td>30.26</td>
<td>27.79</td>
<td>-0.082</td>
<td>9.63</td>
<td>18.15</td>
</tr>
<tr>
<td>PN</td>
<td>31.67</td>
<td>31.67</td>
<td>0</td>
<td>16.75</td>
<td>14.91</td>
</tr>
<tr>
<td>All contracts proposed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NB</td>
<td>25.80</td>
<td>22.80</td>
<td>-0.116</td>
<td>13.28</td>
<td>7.87</td>
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<tr>
<td>NN</td>
<td>19.33</td>
<td>19.33</td>
<td>0</td>
<td>11.80</td>
<td>7.54</td>
</tr>
<tr>
<td>PB</td>
<td>22.68</td>
<td>20.82</td>
<td>-0.082</td>
<td>6.24</td>
<td>11.75</td>
</tr>
<tr>
<td>PN</td>
<td>21.99</td>
<td>21.99</td>
<td>0</td>
<td>11.63</td>
<td>10.35</td>
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</table>

Table 2.7: Social and private surplus summary statistics

of counteroffers. This regression only includes data from bargaining treatments. The constant coefficient which represents the presence of bargaining in combination with no enforcement (NB treatment) is negative confirming that no enforcement decreases the use of counteroffers when bargaining is in place. However, the coefficient loses significance once the terms of contracts in the offers are taken in account.

One possibility is that subjects may learn throughout the experiment and move toward the equilibrium offer. In the bargaining game, the proposer makes an equilibrium offer such that it gives the receiver the same expected payoff as if the receiver were to counteroffer. One learning trajectory might be that subjects use counteroffers more often in the first periods and decrease their use as the offer approaches the equilibrium offer. Figure 2.4 shows that the percentage of pairs per period that used counteroffers decreases over time while the sellers’ potential average profits derived
from first offers\textsuperscript{17} increase over time. These trends suggest that over time buyers offered a potentially higher payoff to the seller so that she does not use the counteroffer. Because of these more attractive gains from trade, sellers used counteroffers in a decreasing fashion. This is the mechanism through which bargaining power affects the distribution of surplus.

Note that even though the use of counteroffers declines from early periods to later periods, more than 10\% of the pairs use counteroffers in all periods in both bargaining treatments. Then, bargaining is an important source of efficiency loss which is reflected in a lower private surplus.

![Figure 2.4: Number of counteroffers and potential sellers’ profits in offers](image)

\textsuperscript{17}The potential profits are scaled to a range between zero and one by dividing potential profits by 100, so that they can be plotted in the same graph as the percentage of pairs that used counteroffers.
Furthermore, the acceptance rate for offers per period is consistent with the results discussed above. Figure 2.5 shows the share of offers accepted from period one to period nine in each treatment. The acceptance ratio is not different from the earlier periods (1-5) to later periods (6-9) (MW test p-values above 0.1489). In the first three periods the acceptance rate of the no bargaining treatments is higher than the acceptance rates in the bargaining treatments (0.72 vs. 0.42, MW p< 0.0001). However, starting in period four acceptance rates decrease in the no bargaining treatments. This may be consistent with the fact that subjects knew that the expected number of periods is five; buyers may have offered less attractive contracts and sellers rejected them if either party had deviated in previous periods.

![Figure 2.5: Share of trades accepted per period](image-url)
The acceptance rate in the bargaining treatments increase slightly from period one to period five, which is consistent with the decrease in the number of counteroffers made in the same periods as shown in figure 2.4. This result may be explained by the bargaining equilibrium explained above which is also complemented with the low acceptance rate of counteroffers. The analysis above leads to the next result.

**Result 2.** The acceptance rate of contracts is higher in NN than in the NB treatment, but the econometric analysis did not support a significant difference.

In addition to exploring the difference in efficiency and surplus produced when bargaining is introduced under full absence of contract enforcement, it is important to analyze how bargaining impacts the division of the gains from trade between the buyer and the seller. The division of the available surplus is determined by the payment the buyer makes to the seller. Hypothesis 2 states that buyers’ total payments are the greatest in the bargaining treatments. Then, NB average total payment is greater than NN average total payment. Table 2.5 shows that the actual total payment is the highest in the NB treatment and the non-parametric analysis gives evidence that it is significantly higher than the total payment in the NN and PE treatments (at the 5% and 10% levels, respectively).

The econometric analysis in table 2.16 shows the effects of bargaining on actual payments. The estimations are censored models for total payment, price and bonus as dependent variables. The total payment estimation includes observations for all treatments while price and bonus estimations include only data from the partial enforcement treatments. The explanatory variables include a dummy for bargaining, a dummy for the enforcement and an interaction term for bargaining and enforcement. Controls for pairs' history and learning effects are included. The base line comparison
is the NN treatment which is captured by the constant coefficient. The results confirm that bargaining has a positive and significant effect on actual total payment. Then, the inclusion of bargaining when contract enforcement is fully lacking leads to higher total payments confirming hypothesis 2. Note that the total payment made decreases with the number of periods subjects play.

**Result 3.** *When contract enforcement is fully absent, the inclusion of bargaining increases significantly the average total payment made.*

Given the higher efficiency and higher total payments in the NB treatments, seller average payoffs should be higher in the NB than in the NN treatment. Hypothesis 4 states that in the no bargaining treatments the buyer captures the entire surplus, leaving the seller with only her reservation payoff in each period. In contrast, hypothesis 4 also states that in the bargaining treatments the seller is able to extract a higher share of surplus through bargaining.

Although, in experimental settings, it is common to see that subjects share the surplus to a greater degree than the predicted outcomes derived from a model of rational profit-maximizing agents. In the case of this experiment, buyers should get a higher proportion of the surplus in the no bargaining treatments and sellers in the bargaining treatments. Furthermore, in the NB treatment sellers should get higher rents than in the NN treatment but lower rents than in the PB treatment because if sellers exercise all bargaining power by extracting all surplus trade breaks down. Then, they are better off by getting lower rents per period but accumulating rents through trade in the long-term.

The non-parametric test in table 2.5 gives no evidence of a difference in the seller payoffs between the NB and NN treatments. Furthermore, a Wilcoxon test rejects...
the hypothesis that seller payoffs are equal to the predictions, equal to the outside option of 5 in the NN treatment \((p = 0.0000)\) and equal to 30 in the NB treatment \((p = 0.0000)\). Buyer payoffs are not different between the NB and NN treatments either. However, the hypothesis that the NB buyer payoffs are equal to the prediction of 20 is not rejected (Wilcoxon test \(p = 0.4192\)) while the NN buyer payoffs are significantly different than the prediction of 45 (Wilcoxon test \(p = 0.0000\)). Then, the inclusion of bargaining does not impact parties’ payoffs when contract enforcement is completely absent.

In addition to parties’ payoffs, each party’s share of the surplus gives an idea of the relative proportion of the available surplus that each party gets. I measure share of surplus in three ways: raw share, truncated share and payoff relative spread. Table 2.4 shows each of these for the seller. Note that the seller share of the surplus in the no bargaining treatments (Table 2.4) is also equivalent to more than the reservation payoff, which contradicts hypothesis 4. The truncated seller share censors the raw share to be in the unit interval. That is, if the payoff of either party is negative, that party’s share is set to 0 and the other party’s share is set to one. This limits the influence of outliers, which are large in some treatments. This measure of seller share suggests that sellers receive a significantly lower proportion of the surplus in the NN treatment: 38% versus 43% in the NB. However, the truncated measure loses additional information due to censoring.

When considering the raw share, the seller share is significantly lower in the NB than in the NN. In the absence of any enforcement, bargaining does not increases seller share of the surplus. But the payoffs’ relative spread is significantly smaller in the NB than in the NN. The latter result suggests that bargaining does not increase
the seller share of the surplus in the NB but it does decrease the difference between seller and buyer payoffs. These observations seem contradictory as efficiency is higher in the NB treatment and therefore if the relative spread between parties’ payoffs gets smaller, then seller share of the surplus should increase. Given this contradiction, the question is how the NB causes higher social and private surplus but sellers were not able to get higher payoffs and capture a significantly greater share of the overall surplus. Perhaps sellers were more timid in using aggressive counteroffers in the NB treatment because of fear of opportunistic behavior by the buyers. Table 2.4 presents the percentage of counteroffers per treatment. Sellers use counteroffers in only in 24% and 37% of the possible interactions in the NB and PB treatments respectively, while in 51% and 79 % of the times that sellers rejected an offer, they countered offered in the NB and PB treatments respectively. This supports the idea that sellers did not exercise much of their bargaining power because formal enforcement was absent. Even more, the explanation may come from differences in the parties’ share of the surplus after cooperation and deviation under the NB. As a consequence the lack of enforcement may have an important effect on how surplus is distributed: a transfer of bargaining power to the seller when formal contract enforcement is non-existent or too costly does not achieve the objective of a greater seller share of the surplus.

To explore more in detail the impact of bargaining on distributional outcomes, table 2.17 presents the econometric results. The dependent variables are the seller payoffs, the raw seller share and the spread in payoffs. If the introduction of bargaining is improving seller payoffs and share of surplus, then the coefficient on the bargaining dummies should be positive in the payoffs and share regressions while it should be negative in the spread in payoffs estimation. I run an OLS regression for

72
each measure’s dependent variable and report robust standard errors adjusted for clustering on pair. Because this is a repeated game, parties can carry losses from one period to the next. The losses of one party become the gains of the other party, which in some cases are much greater than the mean division of the surplus. Furthermore, losses and gains can be much bigger than the surplus produced in a given period, especially when one party strongly deviates. These great losses and gains become outliers, particularly for the raw share and the payoffs spread because of the way they are calculated. This fact explains the difference in the results between the truncated and raw shares. But because the truncated share loses information about overall sharing due to censoring, I use the raw share in the econometric analysis as it captures all information including big losses and gains that are carried from one period to the other. To account for possible outliers I ran a robust regression for all dependent variables and in addition, quantile regressions for the seller share and spread in payoffs.

The results in table 2.17 for the bargaining coefficient are consistent with a positive effect of the introduction of bargaining on seller payoffs and share when contract enforcement is absent. However, the coefficient is only statistically significant in the robust regressions for all variables and in the median regression for both the seller share and spread in payoffs. The results are consistent with the idea that for sellers in pairs that cooperate (stay close to the median), bargaining significantly increases their payoffs and share of the surplus. However, if sellers are in pairs that often deviate, then bargaining does not increases significantly their distributional outcomes when contracts are not enforceable. I explore this explanation further by looking at distributional outcomes by levels of cooperation.
Hypothesis 5 states that more cooperative outcomes are observed in the NN treatment than in the NB treatment. If parties agree to trade, cooperation is defined as both parties meeting their obligations according to the agreed contract. Table 2.5 shows that cooperation is significantly higher in the NB treatment than in the other treatments. These results contradict hypothesis 5 because as sellers exercise bargaining power in the NB treatment, trade was predicted to break down more often. However, the result is consistent with the idea that if pairs use informal incentives to maintain a relationship in which parties share rents more equally, then they cooperate more and the rate of cooperation may be higher in the NB treatments than in the other treatments. This is especially true for pairs that cooperate beginning with the first period of the relationship.

An underlying assumption of the theoretical model is that when cooperation is an outcome given the parameters used in the experiments, cooperation should occur from the initial period of the partnership. Because exercising full bargaining power in the NB treatment breaks down trade, a greater number of trades relative to total offers should be observed in the NN treatment than in the NB treatment as well as more cooperative outcomes with respect to parties meeting contract terms. Furthermore, greater contract acceptance and cooperation should be observed in the no bargaining treatments than in the bargaining treatments as subjects may test the use of bargaining in the initial periods even though theoretically a counteroffer should only be observed off the equilibrium path.

To analyze this I look at initial cooperation by restricting the data to include those partnerships that exhibit cooperation in the first period. Full initial cooperation is defined as the seller accepting the buyer’s offer (does not counteroffer in the BP
treatments) followed by both parties meeting the contract obligations in the first period of the partnership (regardless of actions in later periods). Only 67 pairs out of 297 pairs in the data met this criterion. Note that this partition of data is shown in Table 2.8 and it includes counteroffers and their outcomes from period two and after.

Among initial cooperators, there is not a significant difference in contract terms and outcomes between the NN and NB treatments. Although the contract and actual quality are much higher than the averages in table 2.5, they are still lower than the theoretical prediction of 10 (a Wilcoxon test results in a significant difference at standard levels). Note that the difference between social and private surplus in the NB treatment is minimal among cooperators, suggesting that sellers who are engaged in a cooperative relationship rarely resort to the use of counteroffers. Among non-cooperators, there are significant differences in contract terms, quality provision and social surplus between the NN and NB treatments. However, there are no differences in the private surplus or parties’ payoffs.

Initial cooperators are able to achieve higher efficiency and average payoffs for sellers and buyers in both the NB and NN treatments. The difference between social and private surplus is higher among non-cooperators than among cooperators in the NB treatment, which suggests that sellers in pairs that initially did not cooperate exercised greater bargaining power than those sellers in pairs that initially cooperated. The lower average social surplus among non-cooperators reduces the average payoffs for both sellers and buyers. Although the difference in buyer and seller payoffs between cooperators and non-cooperators is significant at standard levels, sellers within the group of subjects that did not initially cooperate, present a higher drop in their average payoffs than the buyers. This result suggests that buyers in pairs that did
<table>
<thead>
<tr>
<th>Initial cooperation (N=67)</th>
<th>NB</th>
<th>NN</th>
<th>PB</th>
<th>PN</th>
<th>NB vs. NN</th>
<th>NB vs. PB</th>
<th>NN vs. PN</th>
<th>PB vs. PN</th>
<th>NN vs. PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av. contracted quality</td>
<td>9.12</td>
<td>8.96</td>
<td>8.79</td>
<td>8.37</td>
<td>0.6990</td>
<td>0.4836</td>
<td>0.0989</td>
<td>0.2462</td>
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<td>Av. actual quality</td>
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<td>7.63</td>
<td>7.92</td>
<td>0.5446</td>
<td>0.0124**</td>
<td>0.0226**</td>
<td>0.7522</td>
<td>0.0209**</td>
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<td>Av. contractual payment</td>
<td>70.14</td>
<td>67.74</td>
<td>66.58</td>
<td>62.82</td>
<td>0.6877</td>
<td>0.2123</td>
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<tr>
<td>Av. actual payment</td>
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<td>64.83</td>
<td>58.33</td>
<td>57.21</td>
<td>0.3030</td>
<td>0.0061**</td>
<td>0.0065**</td>
<td>0.9433</td>
<td>0.0170**</td>
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<tr>
<td>Av. buyer’s payoffs</td>
<td>21.42</td>
<td>22.91</td>
<td>17.52</td>
<td>21.99</td>
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<td>0.2006</td>
<td>0.2010</td>
<td>0.0087**</td>
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<td>22.01</td>
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<td>20.01</td>
<td>17.61</td>
<td>0.7067</td>
<td>0.0167**</td>
<td>0.0437**</td>
<td>0.7473</td>
<td>0.1282</td>
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<td>Av. surplus</td>
<td>45.5</td>
<td>43.87</td>
<td>38.15</td>
<td>39.6</td>
<td>0.5446</td>
<td>0.0274**</td>
<td>0.0226**</td>
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<tr>
<td>Av. private surplus</td>
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<td>43.87</td>
<td>37.53</td>
<td>39.6</td>
<td>0.3474</td>
<td>0.0291**</td>
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<tr>
<th>No initial cooperation (N=287)</th>
<th>NB</th>
<th>NN</th>
<th>PB</th>
<th>PN</th>
<th>NB vs. NN</th>
<th>NB vs. PB</th>
<th>NN vs. PN</th>
<th>PB vs. PN</th>
<th>NN vs. PB</th>
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<td>Av. contracted quality</td>
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<td>7.74</td>
<td>7.24</td>
<td>7.39</td>
<td>0.0051**</td>
<td>0.0005***</td>
<td>0.4136</td>
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<td>Av. actual quality</td>
<td>6.87</td>
<td>5.78</td>
<td>5.36</td>
<td>5.22</td>
<td>0.0012***</td>
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<td>Av. contractual payment</td>
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<td>57.83</td>
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<td>0.0011***</td>
<td>0.0002***</td>
<td>0.0163**</td>
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<td>44.59</td>
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<td>0.1563</td>
<td>0.8834</td>
<td>0.8865</td>
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<td>Av. buyer’s payoffs</td>
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<td>13.09</td>
<td>0.2449</td>
<td>&lt; 0.000***</td>
<td>0.0090***</td>
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<td>&lt; 0.000***</td>
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<td>10.21</td>
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<td>0.4744</td>
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<td>0.1005</td>
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<td>Av. surplus</td>
<td>34.37</td>
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<td>26.50</td>
<td>26.12</td>
<td>0.0012***</td>
<td>&lt; 0.000***</td>
<td>0.1020</td>
<td>0.7572</td>
<td>0.0285**</td>
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<tr>
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<td>28.88</td>
<td>23.52</td>
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<td>0.3414</td>
<td>0.0005***</td>
<td>0.1020</td>
<td>0.1281</td>
<td>0.0002***</td>
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<table>
<thead>
<tr>
<th>Initial coop vs. No initial coop within treatment</th>
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<td>Av. contracted quality</td>
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<td>Av. contractual payment</td>
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<td>Av. buyer’s payoffs</td>
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<tr>
<td>Av. seller’s payoffs</td>
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<tr>
<td>Av. surplus</td>
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<td>Av. private surplus</td>
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Table 2.8: Results partitioned by initial cooperation
not cooperate initially withheld an important proportion of the total payment that allowed them to keep a greater proportion of the available surplus. Then, absent of third-party enforcement, bargaining did not assure a higher payment for the seller. In fact, regardless of the significantly higher social efficiency in the NB, neither seller nor buyer average payoffs were different between treatments when contract enforcement was absent and when parties did not initially cooperate. This follows from the fact that private surplus is not different between NB and NN among non-cooperators. Because non-cooperators reach higher efficiency when bargaining is an option, it may be the case that non-cooperative parties are obligated to cooperate more when bargaining is an option. This analysis suggests that the loss derived from bargaining decreases the available surplus to share among the parties. Therefore, seller payoffs and share in average do not significantly increase when bargaining is introduced.

To explore this explanation further, table 2.9 shows exchange outcomes by deviation and cooperation in the same period. If the contradicting higher efficiency and lower seller payoffs were because of stronger deviation from buyers, then NB actual total payments and payment shortfall should be significantly different than in the NN treatment. Although the payment shortfall in the NB treatment is higher than in the NN (-33.71 vs. -27.12), it is not significantly different (MW \( p = 0.3552 \)); the same holds for the actual total payment (MW \( p = 0.9491 \)). In fact, only the contract terms, actual quality and social surplus are significantly different between NB and NN when parties deviate. This result suggests that buyer deviations do not explain the contradiction between the achievement of higher efficiency and lower seller payoffs. However, as the private surplus is not different between NB and NN (MW \( p = 0.8231 \)), then, the efficiency loss due to bargaining explains why seller payoffs are not higher.
in the NB than in the NN treatment. Even though higher efficiency is reached in NB, the use of bargaining power reduces the surplus available to the parties. Therefore, buyer and seller payoffs remain the same as if there was no bargaining. The following results summarize the analysis.

**Result 4.** More cooperative outcomes are observed in the NB treatment than the NN treatment. Cooperators use informal incentives and achieve higher efficiency and a more even distribution of surplus in the absence of formal enforcement. Even non-cooperators achieved greater efficiency when bargaining is present.

**Result 5.** Seller payoffs and share of the surplus are higher than the reservation payoff in the NN treatment. Bargaining decreases the difference between buyer and seller payoffs, but only increases seller payoffs and seller share for those that are engaged in a cooperative relationship.

**Result 6.** The exercise of bargaining power creates a loss of efficiency that decreases the surplus available for the parties. As a consequence, seller payoffs do not significantly increase when bargaining is introduced when formal enforcement is absent.

### 2.4.2 Improvement of formal enforcement when bargaining is absent

In this section I analyze the effects on efficiency outcomes and distribution of introducing partial enforcement without altering bargaining power. This analysis compares outcomes from the NN to the PN treatment. Hypothesis 1 states that quality and social surplus should be the same in the NN and PN treatments. However, because in the partial enforcement condition sellers secure the price, it may be the case that NN quality and surplus are higher than in the PN treatment. Note that
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</tr>
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</table>

Table 2.9: Exchange by deviation and cooperation in the same period
social and private surplus are the same in the no bargaining treatments, so the results for social surplus and private surplus are identical.

Table 2.5 supports hypothesis 1. Although quality and social surplus are higher in the NN than in the PN treatment, the difference is not significant. These results are confirmed by the censored regression in table 2.12 as the coefficients for the NN and PN are not statistically different from each other ($p = 0.5482$). Furthermore, estimations in table 2.13 also confirm hypothesis 1. Although the enforcement coefficients are negative for actual quality and social surplus, they are not significant. The negative coefficient is compatible with the hypothesis that sellers may deviate from contracts more in the presence of partial enforcement because the price is enforced by the computer. This potential behavior may also drive parties to trade at lower levels of quality even when sellers do not deviate. Table 2.6 shows that the percentage of seller shirking in the PN is no different than in the NN treatment (a Kruskal-Wallis test cannot reject the null hypothesis that the percentages of trades for which $q < Q$ is the same under all treatments ($p=0.218$)). Therefore, seller deviation is the same in the presence or absence of partial formal enforcement.

When all contracts offered are taken into account in the measure of surplus, social surplus in the PN treatment is significantly higher than in the NN treatment (MW $p = 0.0350$) as table 2.7 shows. The estimations in table 2.14 confirm that enforcement has a positive effect on social surplus but the effect is not significant at standard levels. This difference in social surplus may be the result of a difference in contract acceptance rates. This suggests that sellers rejected more contracts in the NN than in the PN treatment. The argument is supported by evidence in table 2.5. The acceptance rate of contracts was significantly higher in the PN than in the NN treatment. This is also
confirmed by the results of the probit models in table 2.15. Enforcement coefficients are positive, although only significant when controlling for terms of contracts in the offers.

**Result 7.** In the absence of seller bargaining power, the movement from no enforcement to partial enforcement does not change quality provision or social surplus. When efficiency losses from lack of trade are taken into account, surplus is significantly higher in the PN treatment. The difference is explained by the higher contract rejection rate in the NN treatment. Then, efficiency loss due to no exchange is higher in the NN than in the PN treatment.

Hypothesis 2 states that total payments should be the same in the NN and PN treatments. Moreover, hypothesis 3 states that seller rents and share of surplus should be the same and close to reservation payoffs. Tables 2.5 and 2.16 give evidence to support hypothesis 2. The MW test does not reject the hypothesis of equal total payments ($p = 0.6360$) and the coefficient for the enforcement dummy in the tobit estimation for total payment is not significant.

**Result 8.** For no bargaining treatments, actual total payments are not different when partial enforcement is implemented.

However, tables 2.5 and 2.17 give some evidence of differences in the distribution of the surplus. Non-parametric tests give evidence at a 10% level that buyer payoffs are lower and seller payoffs are higher in the PN treatment. In addition, seller shares, raw and truncated, are significantly higher in the PN treatment while the payoff relative spread is significantly higher in the NN treatment. Econometric results in table 2.17 give some evidence to support these non-parametric results. Coefficients
for enforcement dummies have the expected sign (positive on payoffs and share, and negative on payoff spread). The enforcement coefficients in the OLS regressions for seller share and spread payoffs are significant at the 5% level. However, enforcement is only significant in the seller payoffs in the robust regression. Then, enforcement impacts positively seller share and payoffs when bargaining is not in place. Furthermore, seller payoffs are also different from the prediction of 5 in the PN treatment (Wilcoxon test \( p = 0.0000 \)).

**Result 9.** *Formal enforcement improves seller payoffs and seller’s share of surplus.* *Sellers receive, on average, higher payoffs than their outside option across enforcement regimes when bargaining is not implemented.*

Hypothesis 5 states that cooperation should be the same in the PN and NN treatments. The non-parametric test in table 2.5 does not reject the hypothesis that cooperation levels were the same among these treatments (\( p = 0.2952 \)). However, among initial cooperators, PN quality, surplus and seller payoffs were significantly lower than in the NN treatment while among non-cooperators only actual total payment and buyer payoffs are significantly lower in the PN treatment. This evidence suggests that sellers achieve higher efficiency and better payments in pairs that cooperate relative to pairs that do not cooperate in the PN treatment than in the NN treatment. This result is consistent with the theory of strategic ambiguity, which suggests that more incomplete contracts are more efficient when barriers to third-party
enforcement are high.\textsuperscript{18} Even though cooperators in the PN treatment achieved better outcomes than non-cooperators, non-cooperators split the surplus evenly (13.09 for buyers and 13.03 or sellers).

Although enforcement does not improve cooperation when bargaining is absent, it does impact the outcomes when deviation occurs. Table 2.9 shows that when parties deviate, payment deviation is lower in the PN treatment, which results in higher payoffs for the sellers and lower payoffs for the buyers relative to the NN treatment (all significant, MW $p = 0.0020$ for payment shortfall, $p = 0.0070$ for the buyer payoffs and $p = 0.0004$ for seller payoffs). Then, partial enforcement serves as a mechanism to improve seller payoffs and share of the surplus because it limits the size of buyer deviations since the price is formally enforced.

\textbf{Result 10.} \textit{Formal enforcement does not change the level of cooperation. However, it limits buyer deviation opportunities and serves as a mechanism through which parties share the surplus more equally.}

\subsection*{2.4.3 Improvement of formal enforcement and inclusion of bargaining}

When partial enforcement and bargaining are both implemented, hypothesis 1 states that actual quality and social surplus should be the same as in the NN treatment. However, because sellers become residual claimants of the surplus, efficiency may be greater in the PB than in the NN treatment. At the same time, because sellers secure the base price in the partial enforcement treatments, the sellers exercise a higher bargaining power and are more willing to shirk, then average delivered quality

\textsuperscript{18}Bernheim and Whinston [1998] find that when barriers to complete contracting exist, parties may prefer more incomplete contract enforcement because they may achieve more efficient outcomes through a greater discretionary use of informal incentives.
and surplus may be lower in the PB than in the NB. Furthermore, the total social surplus differs more from the total private surplus in the PB treatment than in the NB treatment (hypothesis 3).

The non-parametric tests in table 2.5 fail to reject NN=PB for actual quality and social surplus. However, the MW test gives evidence that actual quality and surplus are significantly lower when bargaining and enforcement (PB) are introduced compared to the case in which only bargaining is introduced (NB). Furthermore, the tobit estimation in table 2.12 supports the non-parametric results and in tables 2.13 and 2.14 the joint effect of bargaining and enforcement (joint test for bargaining dummy, enforcement dummy and interaction) is not significant for the actual quality and social surplus (Wald test $p = 0.7420$ and $p = 0.611$ for table 2.13, and $p = 0.782$ and $p = 0.110$ for table 2.14). Then, implementing more enforcement and bargaining does not improve efficiency outcomes relative to NN, and in fact, increasing formal enforcement in addition to a shift in bargaining decreases efficiency significantly (NB vs. PB). This result suggests that in the absence of third-party enforceability, even under the pressure of bargaining, repeated interaction achieves an overall higher efficiency supporting again the theory of strategic ambiguity. In the case of these experiments, subjects find more powerful informal incentives when third-party enforcement is not available and when participants have the option to bargain over the terms of the contract.

In addition, actual quality and social surplus are the lowest in the PB treatment but the same econometric analysis did not provide evidence of significant differences with respect to the PN treatment either. Then, efficiency outcomes are not different
from implementing a stronger formal enforcement only or combining it with the implementation of bargaining. In fact, table 2.6 shows that sellers shirk more in the PB than in NB and practically the same as in the NN and PN, however, a KW test did not reject the hypothesis that seller deviation was the same in all treatments.

**Result 11.** Implementing bargaining jointly with partial enforcement does not improve efficiency relative to NN. When bargaining is available, partial formal enforcement is detrimental to efficiency as parties achieve higher quality and social surplus when partial enforcement is not in place and parties bargain over contract terms. Furthermore, bargaining does not improve efficiency when partial enforcement is in place.

When looking at the difference in what is available to the parties to distribute (private surplus), the PB private surplus is significantly lower than the average private surplus in all other treatments as table 2.5 shows (MW $p = 0.0001$ for NB, $p = 0.0029$ for NN and $p = 0.0070$ PN). Private surplus is not significantly different among the remaining three treatments (NB, NN and PN), which separates PB as the treatment that achieves the lowest level of private surplus for only completed contracts. However, the econometric analysis in tables 2.13 and 2.14 does not give evidence to support this difference. The joint effect of bargaining and enforcement is not significantly different from zero (Wald test $p = 0.1013$ and $p = 0.7874$ for each column respectively in table 2.13, and $p = 0.625$ and $p = 0.451$ in table 2.14). But the effect is different than only implementing bargaining when only completed contracts are taken into account (Wald test with respect to bargaining effect (NB) $p = 0.0286$ and $p = 0.0263$ respectively).
If all contracts offered are considered (table 2.7), social and private surplus are significantly higher in PB than in NN (MW test \( p = 0.0036 \) and \( p = 0.0707 \) respectively), suggesting that the loss in efficiency due to lack of trade in NN is higher than the loss of efficiency from lack of trade and bargaining combined in the PB treatment. Furthermore, social and private surplus from all contracts offered is not different among PB, PN and NB (KW test \( p = 0.1337 \) and \( p = 0.7894 \) respectively).

**Result 12.** Private surplus is lower in the PB than in the NN when only completed contracts are considered but the effect of implementing partial enforcement and bargaining is not significant. If all contracts offered are considered private surplus is significantly higher in the PB treatment than NN, suggesting that the efficiency loss in NN is higher than the efficiency loss in PB (including losses due to bargaining).

The average loss of private efficiency for completed contracts is higher under the NB treatment than in the PB treatment, reflecting that contracts for which bargaining was exercised were more often used in the NB treatment. Even though, the difference in bargaining efficiency loss is not significant (MW \( p = 0.4363 \)); private surplus is significantly lower in the PB condition relative to the NB treatment. Then, the difference in private surplus is explained by the trade of lower quality levels in the PB treatment and not because of higher loss of efficiency which contradicts hypotheses 3.

**Result 13.** Loss of private efficiency due to bargaining is the same in NB and PB. However, bargaining induces parties to trade at lower quality levels when partial enforcement is in place.
Moreover, hypothesis 6 states that the acceptance rate of contracts should be the same in the bargaining treatments and higher in the NN treatment than PB. However, sellers may counteroffer more in the partial enforcement condition than in the fully incomplete condition because of the secure price. Table 2.5 shows that the offer acceptance rates among bargaining treatments are not different from each other as well as among PB and NN treatments. Results in table 2.15 confirm these results. The joint test for the bargaining and enforcement effect on the probability of acceptance give chi square p-values of 0.1375 and 0.9115 respectively.

In addition, table 2.4 shows that 50% of sellers that rejected an offer sent a counteroffer to the buyer in the PB condition while only 32% did in the NB (MW test $p = 0.0003$) which supports hypothesis 7. Table 2.15 supports this result. Enforcement has a significantly positive effect in the use of counteroffers. The next result follows:

**Result 14.** The acceptance rate is the same in NN and PB treatments. The use of counteroffers is higher in the presence of partial enforcement. Then, enforcement supports sellers’ exercise of bargaining power.

Hypothesis 2 states that total payments should be greater in the PB treatment than in the NN treatment. Table 2.5 shows that a MW test fails to reject the null hypothesis that total prices are equal among NN and PB treatments, however, the joint effect of bargaining and enforcement in the econometric analysis in table 2.16 is positive and significant (Wald test $p = 0.010$) supporting the idea that total payments are higher when partial enforcement and bargaining are jointly implemented. Furthermore, hypothesis 2 states that PB should have a higher impact than NB and PN in total payments. However, a MW test gives no evidence for a significant difference
among PN and PB total payments, and in fact, NB total payments are significantly higher than in PB (at the 10% level). In addition, there is no difference among the bargaining and joint bargaining-enforcement coefficients in the total payment regression in table 2.16 (Wald test $p = 0.9406$), but there is a difference in the effect of only enforcement implementation and joint bargaining-enforcement implementation (Wald test $p = 0.0104$).

Result 15. *PB has a positive and significant effect on total payments relative to NN. The effect is significantly higher than the effect of implementing only enforcement but it is not different than the implementation of only bargaining.*

In addition, hypothesis 2 states that actual price is greater and the bonus is smaller in the PB than in PN. Table 2.5 gives evidence that price is significantly higher and that the bonus is significantly lower in the PB treatment than in the PN treatment. Furthermore, table 2.16 gives evidence supporting these results. Columns two and three present tobit models for price and bonus respectively. Bargaining has a significantly positive effect on actual price while it has a negative effect on the size of the bonus (although it is not significant). These results support the hypotheses that the inclusion of bargaining affects how contracts are structured. When bargaining is in place contracts are structured as efficiency wage contracts by having higher prices than bonuses, while in the absence of bargaining, contracts are structured with smaller prices an higher bonuses in the form of performance contracts.

Result 16. *Bargaining affects contract structure by increasing the size of the price and lowering the size of the bonus. Then, prices are greater in the PB condition than in the PN condition, and the opposite is true for the bonus.*
Given the positive effect of bargaining and enforcement on total payments, it is expected that sellers get higher payoffs and a greater share of the surplus in the PB than NN as hypothesis 4 suggests. The opposite is expected for buyers’ payoffs and share of surplus. Non-parametric tests in table 2.5 give evidence of significant differences. Seller payoffs are significantly higher and buyer payoffs are significantly lower in PB than in NN. Furthermore, the overall seller share and the truncated share are also significantly higher in the PB than in the NN while the payoffs’ relative spread is significantly lower in the PB than in the NN treatment. Then, the implementation of bargaining and enforcement have a positive effect on seller payoffs and share of surplus. Results in table 2.17 support these results. In the OLS regression, the joint effect of enforcement and bargaining is significantly positive for seller payoff and share, and it is significantly negative to the spread of payoffs (Wald test $p = 0.001$, $p = 0.002$ and $p = 0.002$ respectively).

When compared with only the implementation of either bargaining (NB) or partial enforcement (PN), seller share (raw and truncated) is significantly higher in the PB than in the NB and PN treatments (table 2.5). In the case of payoffs’ relative spread, it is significantly lower in the PB than in NB and PN.

Result 17. The combined implementation of bargaining and partial enforcement have a significantly positive effect on seller payoff and share, and a significantly negative effect on payoff spread. Furthermore, the impact on seller payoff and share is higher than introducing only enforcement or only bargaining.

Furthermore, the sharing amount seems to be correlated with the possibility of bargaining as the truncated sellers’ share of the surplus is significantly higher in both bargaining treatments relative to the corresponding no bargaining treatment (Table
Although seller payoffs are not significantly different between NB and PB, when considering the raw share, the truncated share and the payoffs’ relative spread are significantly more favorable to sellers in the PB condition than in the NB treatment. As a consequence the enforcement level may have an important effect on how surplus is distributed.

The enforcement level affects positively the share of the surplus that the seller is able to accrue. When compared across enforcement levels for the same bargaining level, the seller share is different among PB and NB (p < 0.0000) and among NN and PN (p < 0.0000). In the no bargaining treatments (NN and PN), it seems that the smaller payment deviation that buyers can exercise in PN may explain the difference in sellers’ share of the surplus. By the same token, the difference in the sellers’ share of surplus among NB and PB may also be explained by the availability of third-party enforcement. Furthermore, the lower seller share of surplus in the NB treatment relative to the PB treatment contrasts with the higher proportion of counteroffers that were accepted by buyers, 40% in the NB treatment and 34% in the PB treatment. In order to control for the effect of enforcement on the seller share of the surplus, I compare contracts offered by buyers (first offers) and counteroffers from sellers in the bargaining treatments that resulted in trade. The results are presented in Table 2.10.

First offers include a higher desired quality than counteroffers in both treatments, but the desired quality is only different between offers and counteroffers in the PB treatment (p = 0.0026). In addition, the desired quality level in both offers and counteroffers were higher in the NB than in the PB treatment, however, they are only
significantly different for first offers \((p = 0.0011)\). Desired total payment was significantly different among treatments in both offers and counteroffers. However, sellers included a higher total payment only in the NB, but it is not different among offers and counteroffers \((p = 0.8133)\). Meanwhile the desired total payment is significantly higher for first offers than for counteroffers in the PB treatment \((p = 0.0103)\).

Consequently, counteroffers in the NB seem to reflect a stronger exercise of bargaining power because for the same level of quality, sellers ask for a higher price relative to the PB treatment. However, the payment shortfall is much higher and significantly different in the NB than in the PB, causing bargaining power to not have much effect on sellers’ payoffs as sellers earn an average of 14.43 experimental points when the contracts were reached through a first offer relative to 1.13 experimental points when the contracts were made through counteroffers \((p = 0.0002)\). In the PB, sellers also got higher payoffs through first offers, but they are not significantly different from payoffs made through counteroffers \((p = 0.0951)\). Therefore, in the PB, the level of enforcement seems to complement the exercise of bargaining power by sellers.

In addition, in table 2.11 I examine the difference between contracts that were accepted and those that were not accepted for each treatment. I separate contracts by offers and counteroffers in the case of bargaining treatments and present the potential outcomes for sellers’ payoffs, buyers’ payoffs and social and private surplus from rejected contracts.

When comparing bargaining treatments, the average terms in the rejected first offers were significantly lower than the terms included in accepted first offers in both treatments. Although the terms in the rejected contracts would only make a difference for the potential buyer’s payoff in the PB treatment, the result gives some evidence
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<td><strong>Offers</strong>=363</td>
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<tr>
<td>Desired quality</td>
<td>7.85</td>
<td>8.81</td>
<td>0.0011***</td>
</tr>
<tr>
<td>Desired total payment</td>
<td>61.91</td>
<td>66.09</td>
<td>0.0037***</td>
</tr>
<tr>
<td>Actual quality</td>
<td>6.05</td>
<td>7.71</td>
<td>&lt; 0.0001***</td>
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<td>Actual Payment</td>
<td>48.79</td>
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<tr>
<td>Payment shortfall</td>
<td>13.12</td>
<td>13.11</td>
<td>0.0507*</td>
</tr>
<tr>
<td>Payment shortfall (median)</td>
<td>5.5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Buyer’s payoff</td>
<td>11.68</td>
<td>24.13</td>
<td>&lt; 0.0001***</td>
</tr>
<tr>
<td>Seller’s payoff</td>
<td>18.55</td>
<td>14.43</td>
<td>0.7899</td>
</tr>
<tr>
<td>Social surplus</td>
<td>30.23</td>
<td>38.56</td>
<td>&lt; 0.0001***</td>
</tr>
<tr>
<td>Private surplus</td>
<td>30.23</td>
<td>38.56</td>
<td>&lt; 0.0001***</td>
</tr>
<tr>
<td><strong>Counteroffers</strong>=79</td>
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<td></td>
</tr>
<tr>
<td>Desired quality</td>
<td>7.15</td>
<td>7.22</td>
<td>0.9369</td>
</tr>
<tr>
<td>Desired total payment</td>
<td>54.67</td>
<td>69.63</td>
<td>0.021**</td>
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<td>Actual quality</td>
<td>6.07</td>
<td>6.37</td>
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<td>Actual Payment</td>
<td>48.73</td>
<td>33.11</td>
<td>0.0224**</td>
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<td>Payment shortfall</td>
<td>5.94</td>
<td>36.52</td>
<td>0.0001***</td>
</tr>
<tr>
<td>Buyer’s payoff</td>
<td>1.20</td>
<td>3.06</td>
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<tr>
<td>Seller’s payoff</td>
<td>16.51</td>
<td>1.13</td>
<td>0.0045**</td>
</tr>
<tr>
<td>Social surplus</td>
<td>30.39</td>
<td>31.85</td>
<td>0.6423</td>
</tr>
<tr>
<td>Private surplus</td>
<td>17.72</td>
<td>4.19</td>
<td>0.0058**</td>
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Table 2.10: Test for enforcement effects
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<tr>
<th>Offers</th>
<th>PB Accepted</th>
<th>Not Accepted</th>
<th>MW (p-value)</th>
<th>NB Accepted</th>
<th>Not Accepted</th>
<th>MW (p-value)</th>
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<tbody>
<tr>
<td>Desired quality</td>
<td>7.85</td>
<td>6.54</td>
<td>0.0001***</td>
<td>8.81</td>
<td>8.33</td>
<td>0.0272**</td>
</tr>
<tr>
<td>Desired total payment</td>
<td>61.91</td>
<td>49.19</td>
<td>&lt; 0.0001***</td>
<td>66.09</td>
<td>56.72</td>
<td>0.0004***</td>
</tr>
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<td>Buyer’s payoff (Potential)</td>
<td>11.68</td>
<td>16.25</td>
<td>0.0263**</td>
<td>24.13</td>
<td>26.64</td>
<td>0.3937</td>
</tr>
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<td>Seller’s payoff (Potential)</td>
<td>18.55</td>
<td>16.479</td>
<td>0.100*</td>
<td>14.43</td>
<td>15.04</td>
<td>0.9053</td>
</tr>
<tr>
<td>Social surplus (Potential)</td>
<td>30.23</td>
<td>32.72</td>
<td>0.0871*</td>
<td>38.56</td>
<td>41.68</td>
<td>0.103</td>
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<td>Private surplus (Potential)</td>
<td>30.23</td>
<td>32.72</td>
<td></td>
<td>38.56</td>
<td>41.68</td>
<td></td>
</tr>
<tr>
<td>Counteroffers</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desired quality</td>
<td>7.15</td>
<td>6.75</td>
<td>0.4816</td>
<td>7.22</td>
<td>7.63</td>
<td>0.8051</td>
</tr>
<tr>
<td>Desired total payment</td>
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<td>58.79</td>
<td>0.1157</td>
<td>69.63</td>
<td>65.98</td>
<td>0.5553</td>
</tr>
<tr>
<td>Buyer’s payoff (Potential)</td>
<td>1.20</td>
<td>0.871</td>
<td>0.0529*</td>
<td>3.06</td>
<td>1.03</td>
<td>0.0164**</td>
</tr>
<tr>
<td>Seller’s payoff (Potential)</td>
<td>16.51</td>
<td>22.54</td>
<td>0.0003***</td>
<td>1.13</td>
<td>25.07</td>
<td>&lt; 0.000***</td>
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<tr>
<td>Social surplus (Potential)</td>
<td>30.39</td>
<td>33.75</td>
<td>0.7106</td>
<td>31.85</td>
<td>38.13</td>
<td>0.2021</td>
</tr>
<tr>
<td>Private surplus (Potential)</td>
<td>17.72</td>
<td>23.41</td>
<td>4.19</td>
<td>26.082</td>
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<tr>
<td>Offers</td>
<td>PN</td>
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<td></td>
<td>NN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desired quality</td>
<td>7.80</td>
<td>6.63</td>
<td>0.0012***</td>
<td>8.00</td>
<td>7.52</td>
<td>0.0368**</td>
</tr>
<tr>
<td>Desired total payment</td>
<td>57.94</td>
<td>49.54</td>
<td>&lt; 0.0056***</td>
<td>61.72</td>
<td>59.15</td>
<td>0.0757</td>
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<tr>
<td>Buyer’s payoff (Potential)</td>
<td>16.75</td>
<td>16.71</td>
<td>0.9225</td>
<td>19.57</td>
<td>16.09</td>
<td>0.034**</td>
</tr>
<tr>
<td>Seller’s payoff (Potential)</td>
<td>14.91</td>
<td>16.41</td>
<td>0.5341</td>
<td>12.50</td>
<td>21.53</td>
<td>&lt; 0.000***</td>
</tr>
<tr>
<td>Social surplus (Potential)</td>
<td>31.67</td>
<td>33.13</td>
<td>0.4361</td>
<td>32.07</td>
<td>37.62</td>
<td>0.0010***</td>
</tr>
</tbody>
</table>

Table 2.11: Bargaining effect in all offers
that buyers had to offer a relatively higher payment for a higher quality in order to have sellers accept the contract which may be caused by the potential threat of bargaining. The difference between the desired quality level among accepted and rejected contracts is 1.31, which would cost the seller an additional 6.55 points to supply. The difference in the desired total payment that buyers offer in the accepted contracts is 12.72 points. Then, buyers offered on average more than the cost needed to supply the additional 1.31 units of quality. The same is true for the NB treatment. The average difference in the quality level in the contract is 0.48 which would cost the sellers 2.4 additional points to supply while the buyer offered an additional 9.37 points (almost 4 times the additional cost).

When I perform the same comparison between the no bargaining treatments, I find that the quality difference in the PN treatment is 1.17, which would cost 5.85 points and that the additional payment offered is 8.4 points. In the NN treatment, the difference in the quality level is also 0.48 (cost= 2.4 points), but the difference in the total payment offered is 2.57. Then, the difference in the payments offered relative to the average quality requested is bigger in the bargaining treatments, suggesting that bargaining affects the proposed contracts from the buyer.

When contracts were proposed by the sellers (counteroffers), contract terms in the accepted counteroffers were not significantly different from the rejected counteroffers in terms of social surplus generated or the potential surplus. However, assuming that the parties would cooperate in the rejected contracts, the differences in the terms of the contracts, would lead to a significantly different distribution of surplus in which the sellers would get higher payoffs and the buyers would get lower payoffs. It is interesting to note that the difference in the potential sellers’ payoffs is much greater
in the NB treatment than in the PB treatment, suggesting that the lower sellers’ payoff may come from the opportunistic behavior of the buyers. It is easy to see that accepted counteroffers in the NB included a lower quality for a higher total payment than accepted offers but seller payoffs were higher when contracts were made through offers and not through counteroffers. An explanation for this may be that after sellers exercise their bargaining power by making a counteroffer, the buyer withholds the majority of the total payment giving him ability to adjust the total payment to zero in the NB condition. Then, the seller’s payoff is not only significantly reduced by the bargaining factor applied to the payoffs but also for the lack of payments from the buyer. In contrast, in the PB treatment buyers can only withhold part of the total payment, and as Table 2.5 shows the majority of the payment is offered as the enforceable base payment. Therefore, the enforcement of the base price insures the seller can exercise bargaining power and avoid opportunistic behavior which is not the case in the NB treatment.

Moreover, the negative effect that bargaining power has in the NB on the sellers’ share of the surplus occurs for two reasons. First, buyers may behave more opportunistically after accepting a counteroffer because of the absence of enforcement which gives them opportunity to withhold the full payment. Second, sellers may also be reneging and after observing this deviation, buyers punish the sellers by withholding the full payment. In contrast, buyers have less incentive to withhold payment in the PB, because the buyer can only punish by withholding the bonus, which decreases the buyer’s potential gains from deviation. Then, the enforcement level complements the seller’s bargaining power and allows the seller to get a higher share of the surplus.
The experimental results give evidence that parties share rents in all treatments, contradicting the hypothesis that in the no bargaining treatments buyers claim all surplus and sellers only get reservation payoffs. Furthermore, the combination of bargaining and partial enforcement results in higher seller payoffs and share of surplus while only bargaining does not increase significantly seller payoffs. However, bargaining decreases the difference in payoffs between buyers and sellers when enforcement is fully absent. These results are summarized as follows.

**Result 18.** *The implementation of bargaining and enforcement together has a significant effect on seller payoffs and share of the surplus. In general, bargaining decreases the spread of payoffs but only when coupled with greater enforcement bargaining does increase seller payoffs and share of surplus.*

Cooperation should be the same in the PB and NN treatments as Hypothesis 5 states. However, because the price is guaranteed in PB, sellers may deviate more. Table 2.5 confirms that there is no differences in the level of cooperation between PB and NN. However, there are important differences in the outcomes achieved by both initial cooperators and non-cooperators between NN and PB. Efficiency outcomes and buyer payoffs are significantly higher in NN than PB (including private surplus) for both cooperators and non-cooperators. However, seller payoffs are significantly lower in the NN among non-cooperators while there is no difference among cooperators’ seller payoffs. Even though cooperation levels are not different between PB and NN, in pairs that deviate sellers get higher payoffs. This result gives additional evidence that enforcement limits buyers’ deviation opportunities resulting in higher payoffs for sellers. Furthermore, evidence from table 2.9 supports this result. When parties cooperate, efficiency outcomes are significantly higher in NN than PB (MW test $p =$
0.0739 for actual quality and social surplus and \( p = 0.0007 \) for private surplus), and the distribution of this higher available surplus results in significantly higher payoffs for both buyers and sellers (MW \( p = 0.0050 \) and \( p = 0.0859 \) respectively). These results support the idea that when parties cooperate, the use of informal incentives lead parties to achieve higher efficiency when contract enforcement is absent (theory of strategic ambiguity).

When parties deviate, efficiency outcomes are not different between NN and PB (MW \( p = 0.1246 \) for actual quality and social surplus), but the available surplus is significantly higher in NN than PB (MW \( p = 0.0068 \)). Even though there is a lower private surplus, sellers get significantly higher payoffs in PB than NN. The explanation is that buyers are able to withhold significantly more of the payment in the NN than in PB (MW \( p = 0.0013 \) for payment shortfall), which again supports the idea that enforcement complements the exercise of bargaining power on the sellers’ side.

**Result 19.** Cooperation does not change when partial enforcement and bargaining are implemented together. Cooperators are able to achieve higher efficiency and higher payoffs when contract enforcement is absent. But among non-cooperators, even with a lower private surplus sellers achieve higher payoffs when bargaining and enforcement are in place. Then, enforcement complements the sellers’ exercise of bargaining power.

Compared to the case in which only bargaining is implemented, the difference in efficiency between cooperators and non-cooperators is reflected in much lower seller payoffs (table 2.11). In contrast, in the presence of bargaining and partial enforcement, a higher proportion of the efficiency loss translates into a greater drop in buyer payoffs. Among non-cooperators bargaining insures sellers against a higher drop in
payoffs relative to buyers, through achieving a safer payment structure with a higher base payment which is third party enforceable (the average contracted price was 37.48 and the average contracted bonus was 20.35). Then, the seller receives a lower punishment from the buyer if he defects or a lower impact from the buyer deviation because the buyer was only able to withhold the bonus.

Table 2.9 presents consistent patterns with respect to the observations made above. Among cooperators, there is no significant difference in efficiency outcomes between NB and PB (MW test $p = 0.1004$ for quality and social surplus), but private surplus is significantly higher in NB (MW $p = 0.0124$). This evidence reflects the higher use of counteroffers in the PB treatments. This higher private surplus results in higher seller payoffs and the same buyer payoffs. Then, when parties cooperate the lower loss of efficiency due to bargaining in the NB treatment translates to higher payoffs for the sellers, achieving the same share of surplus as in the PB treatment.

Among non-cooperators, efficiency is significantly higher in NB than PB (MW test $p = 0.0002$ for quality and social surplus). This evidence supports the idea that even among cooperators informal incentives when enforcement is absent results in higher efficiency than when partial enforcement is in place which is consistent when we compare PN and NN.

However, even though social and private surplus are significantly higher in the NB treatment than the PB treatment, the distribution of the private surplus is quite different. Among non-cooperators, bargaining affects the distribution of the surplus as buyers get significantly higher payoffs when enforcement is totally absent (MW $p = 0.0000$) and sellers get significantly higher payoffs when partial enforcement is in place (MW, $p = 0.0091$). Again, this evidence supports the explanation that
among non-cooperators bargaining triggers more opportunistic behavior and buyers are able to defect more when enforcement is absent. Furthermore, sellers get higher payoffs than buyers when partial enforcement is in place because, in addition, sellers are able to renege and suffer a lower possible punishment. The PB actual total payment is significantly higher than PN. This again results from the structure of the contract in which the bulk of the payment is allocated to the enforceable base payment. Then, among non-cooperators when bargaining is present, the enforcement level reinforces the opportunities for deviation or punishment, for buyers in the no enforcement treatment and for sellers in the partial enforcement treatment. Then, the contrast of higher levels of efficiency and lower payments for the seller in NB are explained by the deviation behavior when bargaining is exercised in NB.

To explore this further I compare payment shortfalls among offers and counteroffers within and across NB and PB (table 2.9). When parties cooperate, buyers tend to pay more than what was in the contract. The difference in payment is not different between offers and counteroffers in the NB treatment (MW $p = 0.4769$) while the difference is significantly higher for counteroffers than first offers in PB. Furthermore, payment differences are the same in PB and NB when comparing first offers and counteroffers (MW, $p = 0.4031$ for first offers and $p = 0.3793$ for counteroffers). When parties deviate, payment shortfall is significantly higher for counteroffers than first offers in NB (MW $p = 0.0053$) while the opposite is true in the PB treatment (MW $p = 0.0009$). More importantly payment shortfall is higher in NB than PB for both first offers and counteroffers. Although, only payment shortfall is significantly higher for counteroffers (MW, $p = 0.3326$ for offers and $p = 0.0000$ counteroffers), the absolute payment shortfall is much greater in the NB treatment. These results support
the argument that among non-cooperators when sellers exercise bargaining power through counteroffers buyers withhold a high proportion of the total payment which explains the low seller payoffs. Then, the exercise of bargaining triggers stronger deviation from buyers in NB which explains why sellers do not achieve higher payoffs even though average efficiency levels were higher.

In contrast with PN non-cooperators achieve the same level of efficiency and a more even distribution of surplus relative to PB, but sellers achieve a higher share of the surplus when bargaining is in place (MW, \( p = 0.0451 \)). Finally, among non-cooperators in treatments with no enforcement (NN and PN), parties only reach higher efficiency when bargaining is an option. Among no bargaining treatments, there is no difference in efficiency across enforcement regimes. A possible explanation is that non-cooperative parties are obligated to cooperate more when bargaining is an option. Therefore, among non-cooperating parties, the theory of strategic ambiguity holds when bargaining puts pressure on the relationship.

**Result 20.** Seller payoffs and share of the surplus are higher than the reservation payoff in the no bargaining treatments. Bargaining decreases the difference between buyer and seller payoffs. Greater enforcement increases sellers’ rents and share of the surplus, and bargaining increases both if enforcement is in place. Seller payoffs and share of the surplus are the highest when both bargaining and partial enforcement are implemented.

**Result 21.** Among non-cooperators when bargaining is present, the enforcement level reinforces the opportunities for deviation or punishment, for buyers in the no enforcement treatment and for sellers in the partial enforcement treatment. Then, bargaining affects the distribution of the surplus such that buyers get significantly higher payoffs.
when enforcement is totally absent and sellers get significantly higher payoffs when partial enforcement is in place.

2.5 Summary results and conclusion

In this essay I use experiments to study how bargaining affects the formation of self-enforcing agreements and parties’ reciprocal actions in the marketplace. I implemented four treatments in which subjects played a game with an uncertain number of periods and the parts of the contract (i.e. price, bonus and quality) that were exogenously enforced by the experimenter or the bargaining power that subjects were able to exercise differed.

The observed behavior in the experiments supports many hypothesis derived from Essay One while it also presents results that contrast with the predictions of that model. Figure 2.6 summarizes predictions and mean results for efficiency outcomes and distribution of surplus for all exchanges that resulted in trade (circles) and all pairs including non-trades (triangles). Figure 2.7 shows the same results in terms of medians. The axis correspond to seller (horizontal) and buyer (vertical) payoffs respectively. The solid line represents the efficient frontier which contains all possible combinations of surplus when full efficiency is achieved (q=10 and surplus=50) while the dotted line is a 45 degree line indicating an equal share of surplus for different levels of efficiency. Note that the flat portion of the frontier from point (5, 45) to point (0, 45) corresponds to the outside option of the seller. The diamond-shaped markers represent the predictions by treatment ((45, 5) for PB, (30, 20) for NB and (5, 45) for PN and NN). The circles represent outcomes for only completed contracts and the triangles for all offers. Then, the former includes only efficiency losses due
to bargaining while the latter also includes efficiency losses due to no trade. Arrows show the NN treatment outcomes, which is the benchmark treatment.

Figure 2.6: Social surplus by treatment: Predictions and observed outcomes (means)

When looking at mean outcomes (figure 2.6), subjects achieved a lower level of efficiency in all treatments than what was predicted by the model in essay 1. However, the results give an idea of what would be the result from implementing bargaining and enforcement measures when none of them exist in the first place. If only the efficiency loss due to bargaining is taken in account, implementing bargaining and partial enforcement (PB) improves significantly efficiency and gives the seller higher
absolute payments. If only bargaining is implemented (NB), efficiency is not improved and the distribution shifts in the buyer’s favor, the opposite of the objective of shifting the bargaining power in the seller’s favor. When only enforcement is implemented (PN), there is no improvement on efficiency but parties share available surplus more equally. If efficiency loss due to no trade is taken into account either measure improves efficiency relative to NN and distribution outcomes follow the same path as when only the losses from bargaining are accounted for.
When considering the median outcomes (figure 2.7) and only the efficiency loss from bargaining, subjects achieved higher efficiency and equal distribution of surplus with only the introduction of bargaining (NB), while introducing both bargaining and enforcement reduced efficiency (PB). The introduction of bargaining alone does not change efficiency levels nor the surplus distribution. If I consider also the efficiency loss due to no trade, the introduction of only bargaining reduced efficiency while seller median payoffs remain at zero. The implementation of either enforcement or the enforcement-bargaining combination results in higher efficiency, however it is greater if only enforcement is introduced. In fact, sellers get exactly the same payoffs with either PB or PN but buyers get higher payoffs when only enforcement is implemented (PN). Then, the introduction of only enforcement results in a Pareto improvement with respect to all other treatments.

Consequently, if a social planner’s objective is to improve efficiency (social surplus) when contract enforcement is incomplete, the results give evidence that implementing bargaining increases efficiency if contract enforcement is lacking. However, social surplus differs from private surplus. If the social planner’s goal is to improve the bargaining position of the weaker party so that she achieves a higher share of the surplus, then shifting bargaining power needs to be complemented by the implementation of formal enforcement of at least the base price. However, the social planner can achieve a more egalitarian distribution of the surplus and minimize the efficiency loss from bargaining and no trade by only implementing more formal enforcement.
<table>
<thead>
<tr>
<th>Regressors</th>
<th>Actual Quality Coefficients/Std Error</th>
</tr>
</thead>
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<tr>
<td>NN dummy</td>
<td>2.9624*** (0.7975)</td>
</tr>
<tr>
<td>NB dummy</td>
<td>5.1737*** (0.8173)</td>
</tr>
<tr>
<td>PB dummy</td>
<td>3.1439*** (0.8238)</td>
</tr>
<tr>
<td>PN dummy</td>
<td>2.4196*** (0.8542)</td>
</tr>
<tr>
<td>Length of relationship</td>
<td>0.3344** (0.1484)</td>
</tr>
<tr>
<td>Buyer’s previous earnings</td>
<td>0.1286*** (0.0198)</td>
</tr>
<tr>
<td>Seller’s previous earnings</td>
<td>0.1474*** (0.0215)</td>
</tr>
<tr>
<td>Sigma</td>
<td>4.5066*** (0.2963)</td>
</tr>
<tr>
<td>F(1, 721) statistic for equality of NB and NN coefficients</td>
<td>7.46*** p=0.0065</td>
</tr>
<tr>
<td>F(1, 721) statistic for equality of NN and PB coefficients</td>
<td>0.05 p=0.8195</td>
</tr>
<tr>
<td>F(1, 721) statistic for equality of NN and PN coefficients</td>
<td>0.36 p=0.5482</td>
</tr>
<tr>
<td>F(1, 721) statistic for equality of NB and PB coefficients</td>
<td>6.93** p=0.0087</td>
</tr>
<tr>
<td>F(1, 721) statistic for equality of NB and PN coefficients</td>
<td>10.75** p=0.0011</td>
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<tr>
<td>F(1, 721) statistic for equality of PB and PN coefficients</td>
<td>0.82 p=0.3656</td>
</tr>
<tr>
<td>Observations</td>
<td>735</td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>-1495.5747</td>
</tr>
</tbody>
</table>

Notes: The estimation for actual quality is a tobit model. Asterisks indicate the significance level of the estimate: * at 10% level, ** at 5% level and *** at 1% level. Standard errors reported are robust and adjusted for clustering on buyer-seller pairs. There were 126 left-censored observations at 1 and 246 right censored observations at 10. Additional controls included dummies for each period.

Table 2.12: Actual quality estimates
<table>
<thead>
<tr>
<th>Regressors</th>
<th>Actual Quality</th>
<th>Social Surplus</th>
<th>Social Surplus</th>
<th>Private Surplus</th>
<th>Private Surplus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff./Std Error</td>
<td>Coeff./Std Error</td>
<td>Coeff./Std Error</td>
<td>Coeff./Std Error</td>
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</tr>
<tr>
<td>Constant</td>
<td>3.8011***</td>
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<td>21.0795***</td>
<td>29.6088***</td>
<td>19.4325***</td>
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<tr>
<td></td>
<td>(0.5008)</td>
<td>(2.0628)</td>
<td>(2.2033)</td>
<td>(2.1003)</td>
<td>(2.2297)</td>
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<td>Bargaining dummy</td>
<td>1.5606***</td>
<td>5.6109**</td>
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<td>1.3165</td>
<td>4.2003*</td>
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<td>(2.9034)</td>
<td>(2.2735)</td>
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<td>(0.5557)</td>
<td>(3.2396)</td>
<td>(2.5482)</td>
<td>(3.2292)</td>
<td>(2.4725)</td>
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<td>Bargaining*enforcement</td>
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</tr>
<tr>
<td></td>
<td>(0.7466)</td>
<td>(4.0226)</td>
<td>(3.3553)</td>
<td>(4.1235)</td>
<td>(3.2503)</td>
</tr>
<tr>
<td>Length of relationship</td>
<td>0.1776***</td>
<td>1.3554***</td>
<td>0.8269***</td>
<td>1.2720***</td>
<td>0.7252***</td>
</tr>
<tr>
<td></td>
<td>(0.0530)</td>
<td>(0.4286)</td>
<td>(0.2483)</td>
<td>(0.4289)</td>
<td>(0.2403)</td>
</tr>
<tr>
<td>Buyer's previous earnings</td>
<td>0.0841***</td>
<td>0.3766***</td>
<td>0.4041***</td>
<td>0.4041***</td>
<td>0.4041***</td>
</tr>
<tr>
<td></td>
<td>(0.0117)</td>
<td>(0.0517)</td>
<td>(0.0509)</td>
<td>(0.0509)</td>
<td>(0.0507)</td>
</tr>
<tr>
<td>Seller's previous earnings</td>
<td>0.0903***</td>
<td>0.4066***</td>
<td>0.4402***</td>
<td>0.4402***</td>
<td>0.4402***</td>
</tr>
<tr>
<td></td>
<td>(0.0116)</td>
<td>(0.0509)</td>
<td>(0.0504)</td>
<td>(0.0504)</td>
<td>(0.0504)</td>
</tr>
<tr>
<td>Sigma</td>
<td>3.2534***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.1500)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>735</td>
<td>934</td>
<td>735</td>
<td>934</td>
<td>735</td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>-1442.6996</td>
<td>0.0441</td>
<td>0.2444</td>
<td>0.0338</td>
<td>0.2543</td>
</tr>
<tr>
<td>R-squared</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The estimation for actual quality is a tobit model. There were 108 left-censored observations at 1. Estimations for social and private surplus are OLS with additional controls for party’s history in columns three and five, which use data restricted to interactions after period one. Asterisks indicate the significance level of the estimate: * at 10% level, ** at 5% level and *** at 1% level. Additional controls included dummy variables for each period. Standard errors reported are robust and adjusted for clustering on buyer-seller pairs. All regressions include only completed contracts.

Table 2.13: Actual quality, social surplus and private surplus estimates
<table>
<thead>
<tr>
<th>Regressors</th>
<th>Actual Quality Coeff./Std Error</th>
<th>Social Surplus Coeff./Std Error</th>
<th>Social Surplus Coeff./Std Error</th>
<th>Private Surplus Coeff./Std Error</th>
<th>Private Surplus Coeff./Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.4092 (0.6319)</td>
<td>19.6965*** (2.1707)</td>
<td>7.0123*** (1.9703)</td>
<td>18.7516*** (2.1732)</td>
<td>6.4473*** (2.0093)</td>
</tr>
<tr>
<td>Bargaining dummy</td>
<td>1.1958* (0.6103)</td>
<td>6.0339* (3.1040)</td>
<td>6.2712*** (1.9673)</td>
<td>3.0847 (3.1574)</td>
<td>4.3015** (1.9695)</td>
</tr>
<tr>
<td>Enforcement dummy</td>
<td>0.4956 (0.6285)</td>
<td>2.0969 (3.5924)</td>
<td>0.4190 (2.0096)</td>
<td>2.0718 (3.5921)</td>
<td>0.4264 (2.0461)</td>
</tr>
<tr>
<td>Bargaining*enforcement</td>
<td>-1.4053* (0.8336)</td>
<td>-5.0782 (4.6018)</td>
<td>-3.9021 (2.7850)</td>
<td>-3.9399 (4.5948)</td>
<td>-3.4930 (2.7386)</td>
</tr>
<tr>
<td>Length of relationship</td>
<td>0.1207 (0.1516)</td>
<td>1.0184 (0.8052)</td>
<td>0.5041 (0.4243)</td>
<td>0.9583 (0.8024)</td>
<td>0.4682 (0.4282)</td>
</tr>
<tr>
<td>Buyer’s previous earnings</td>
<td>0.1270*** (0.0138)</td>
<td>0.4941*** (0.0498)</td>
<td>0.4811*** (0.0500)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seller’s previous earnings</td>
<td>0.1880*** (0.0162)</td>
<td>0.7304*** (0.0621)</td>
<td>0.7236*** (0.0650)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sigma</td>
<td>4.9206*** (0.2113)</td>
<td>1375</td>
<td>1059</td>
<td>1375</td>
<td>1059</td>
</tr>
<tr>
<td>Observations</td>
<td>1159</td>
<td>1375</td>
<td>1095</td>
<td>1375</td>
<td>1095</td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>-2560.664</td>
<td>0.0303</td>
<td>0.3154</td>
<td>0.0197</td>
<td>0.3006</td>
</tr>
</tbody>
</table>

Notes: The estimation for actual quality is a tobit model. There were 424 left-censored observations at 0. Estimations for social and private surplus are OLS with additional controls for party’s history in columns three and five, which use data restricted to interactions after period one. Asterisks indicate the significance level of the estimate: * at 10% level, ** at 5% level and *** at 1% level. Additional controls included dummy variables for each period. Standard errors reported are robust and adjusted for clustering on buyer-seller pairs. All regressions include all contracts offered.

Table 2.14: Actual quality, social surplus and private surplus estimates (all offers)
<table>
<thead>
<tr>
<th>Regressors</th>
<th>Probability of acceptance Coeff./Std Error</th>
<th>Probability of acceptance Coeff./Std Error</th>
<th>Probability of counteroffer Coeff./Std Error</th>
<th>Probability of counteroffer Coeff./Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.0952 (0.1604)</td>
<td>-0.7365*** (0.2174)</td>
<td>-0.8564** (0.4046)</td>
<td>-0.0475 (0.5031)</td>
</tr>
<tr>
<td>Bargaining dummy</td>
<td>-0.1254 (0.1452)</td>
<td>-0.0808 (0.1568)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enforcement dummy</td>
<td>0.2265 (0.1568)</td>
<td>0.4870*** (0.1584)</td>
<td>0.4090** (0.1761)</td>
<td>0.3370* (0.1832)</td>
</tr>
<tr>
<td>Bargaining*enforcement</td>
<td>-0.2953 (0.2031)</td>
<td>-0.4215** (0.2141)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contracted quality</td>
<td>0.0072 (0.0278)</td>
<td></td>
<td>0.0557 (0.0493)</td>
<td></td>
</tr>
<tr>
<td>Contracted price</td>
<td>0.0140*** (0.0043)</td>
<td></td>
<td>-0.0266*** (0.0069)</td>
<td></td>
</tr>
<tr>
<td>Contracted bonus</td>
<td>0.0019 (0.0044)</td>
<td></td>
<td>-0.0124** (0.0063)</td>
<td></td>
</tr>
<tr>
<td>Length of relationship</td>
<td>-0.0088 (0.0421)</td>
<td>-0.0026 (0.0417)</td>
<td>0.1946 (0.1871)</td>
<td>0.1364 (0.2214)</td>
</tr>
<tr>
<td>Buyer’s previous earnings</td>
<td>0.0177*** (0.0032)</td>
<td>0.0136*** (0.0034)</td>
<td>-0.0113** (0.0047)</td>
<td>-0.0046 (0.0049)</td>
</tr>
<tr>
<td>Seller’s previous earnings</td>
<td>0.0292*** (0.0042)</td>
<td>0.0251*** (0.0044)</td>
<td>-0.0093* (0.0051)</td>
<td>-0.0029 (0.0052)</td>
</tr>
<tr>
<td>Observations</td>
<td>1156</td>
<td>1156</td>
<td>534</td>
<td>534</td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>-713.99146</td>
<td>-693.40854</td>
<td>-318.71962</td>
<td>-299.74677</td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.0888</td>
<td>0.1150</td>
<td>0.0481</td>
<td>0.1048</td>
</tr>
</tbody>
</table>

Notes: Estimation are probit models with a dummy that takes value of 1 if the contract was accepted or counteroffer was used respectively and zero otherwise as dependent variables respectively. Asterisks indicate the significance level of the estimate: * at 10% level, ** at 5% level and *** at 1% level. Additional controls are current length of the relationship, buyer’s and seller’s payoffs and dummies for each period. Standard errors reported are robust and adjusted for clustering on buyer-seller pairs. Both estimations use subdata for only offers made by buyers. Data excludes observations for first period interactions. In addition, estimation for probability of counteroffers limits data to bargaining treatments.

Table 2.15: Determinants of contract acceptance and counteroffer use
<table>
<thead>
<tr>
<th>Regressors</th>
<th>Total payment Coeff./Std Error</th>
<th>Price Coeff./Std Error</th>
<th>Bonus Coeff./Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>24.6634***</td>
<td>24.8533***</td>
<td>1.3186</td>
</tr>
<tr>
<td></td>
<td>(3.7520)</td>
<td>(2.9196)</td>
<td>(3.6497)</td>
</tr>
<tr>
<td>Bargaining dummy</td>
<td>9.4269**</td>
<td>10.2931***</td>
<td>-4.0900</td>
</tr>
<tr>
<td></td>
<td>(4.3521)</td>
<td>(2.8731)</td>
<td>(3.5686)</td>
</tr>
<tr>
<td>Enforcement dummy</td>
<td>1.4745</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.7649)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bargaining*enforcement</td>
<td>-1.1804</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.3853)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of relationship</td>
<td>1.0218**</td>
<td>1.1579*</td>
<td>0.1746</td>
</tr>
<tr>
<td></td>
<td>(0.4155)</td>
<td>(0.5950)</td>
<td>(0.6466)</td>
</tr>
<tr>
<td>Buyer previous earnings</td>
<td>0.4892***</td>
<td>0.2307**</td>
<td>0.4591***</td>
</tr>
<tr>
<td></td>
<td>(0.0854)</td>
<td>(0.0903)</td>
<td>(0.1349)</td>
</tr>
<tr>
<td>Seller previous earnings</td>
<td>0.8717***</td>
<td>0.3740***</td>
<td>0.3248***</td>
</tr>
<tr>
<td></td>
<td>(0.1012)</td>
<td>(0.1048)</td>
<td>(0.1239)</td>
</tr>
<tr>
<td>p3</td>
<td>-2.5365</td>
<td>-6.8210***</td>
<td>-0.9315</td>
</tr>
<tr>
<td></td>
<td>(2.4148)</td>
<td>(2.0966)</td>
<td>(2.9068)</td>
</tr>
<tr>
<td>p4</td>
<td>-3.4121</td>
<td>-6.5769***</td>
<td>-1.0035</td>
</tr>
<tr>
<td></td>
<td>(2.5749)</td>
<td>(2.4940)</td>
<td>(2.9148)</td>
</tr>
<tr>
<td>p5</td>
<td>-5.8881*</td>
<td>-6.3447*</td>
<td>-2.0598</td>
</tr>
<tr>
<td></td>
<td>(3.4230)</td>
<td>(3.6656)</td>
<td>(4.0867)</td>
</tr>
<tr>
<td>p6</td>
<td>-10.3953**</td>
<td>-15.1703***</td>
<td>-7.1378</td>
</tr>
<tr>
<td></td>
<td>(4.4203)</td>
<td>(3.7461)</td>
<td>(4.8519)</td>
</tr>
<tr>
<td>p7</td>
<td>-10.7013**</td>
<td>-13.4672**</td>
<td>-0.7246</td>
</tr>
<tr>
<td></td>
<td>(4.5391)</td>
<td>(5.4322)</td>
<td>(5.6905)</td>
</tr>
<tr>
<td>p8</td>
<td>-9.4057*</td>
<td>-18.7800***</td>
<td>-4.5912</td>
</tr>
<tr>
<td></td>
<td>(4.7955)</td>
<td>(6.1096)</td>
<td>(7.5364)</td>
</tr>
<tr>
<td>pl</td>
<td>-8.4115*</td>
<td>-16.3411**</td>
<td>-3.7638</td>
</tr>
<tr>
<td></td>
<td>(4.4910)</td>
<td>(6.6756)</td>
<td>(8.2166)</td>
</tr>
<tr>
<td>Sigma</td>
<td>22.6719***</td>
<td>17.2426***</td>
<td>18.9888***</td>
</tr>
<tr>
<td></td>
<td>(0.8155)</td>
<td>(0.8636)</td>
<td>(2.1278)</td>
</tr>
</tbody>
</table>

Observations: 735  411  411
Log pseudolikelihood: -3225.0957 -1744.4882 -1256.6361
Pseudo R2: 0.0326  0.0203  0.0269

Notes: The estimations are tobit models and used observations from period 2 and above. Total payment regression used data from all treatments and had 34 left-censored observations at 0; price and bonus regressions used data only from partial enforcement treatments and have 3 and 149 left-censored observations at 0 respectively. Asterisks indicate the significance level of the estimate: * at 10% level, ** at 5% level and *** at 1% level. Standard errors reported are robust and adjusted for clustering on buyer-seller pairs. Additional controls include period dummies in which pl is a dummy for period 9 and above.

Table 2.16: Bargaining effect in payments
<table>
<thead>
<tr>
<th>Regressors</th>
<th>OLS Coeff. / Std Error</th>
<th>Robust reg. Coeff. / Std Error</th>
<th>OLS Coeff. / Std Error</th>
<th>Robust reg. Coeff. / Std Error</th>
<th>Quantile (50) Coeff. / Std Error</th>
<th>Quantile (90) Coeff. / Std Error</th>
<th>OLS Coeff. / Std Error</th>
<th>Robust reg. Coeff. / Std Error</th>
<th>Quantile (50) Coeff. / Std Error</th>
<th>Quantile (90) Coeff. / Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.2943 (2.6694)</td>
<td>-3.1721*** (3.365)</td>
<td>1.3907*** (0.3365)</td>
<td>-0.4666*** (0.0376)</td>
<td>0.5420*** (0.0234)</td>
<td>4.2014*** (0.0709)</td>
<td>-2.0347*** (0.6687)</td>
<td>0.0312 (0.0759)</td>
<td>-0.2063*** (0.0294)</td>
<td>3.0419*** (0.2027)</td>
</tr>
<tr>
<td>Bargaining dummy</td>
<td>1.1232 (3.4866***</td>
<td>0.0014 (1.5424)</td>
<td>0.0387*** (0.1422)</td>
<td>0.0133 (0.1422)</td>
<td>-0.3213 (0.1422)</td>
<td>-0.3070*** (0.1422)</td>
<td>-0.1352*** (0.1352)</td>
<td>-0.2368 (0.1352)</td>
<td>-0.1352*** (0.1352)</td>
<td>-0.2368 (0.1352)</td>
</tr>
<tr>
<td>Enforcement dummy</td>
<td>2.1148 (3.7823)</td>
<td>0.1803 (0.0317)</td>
<td>0.0140 (0.0194)</td>
<td>0.0532 (0.0532)</td>
<td>0.3465 (0.0532)</td>
<td>0.0640 (0.0532)</td>
<td>-0.2063*** (0.1693)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bargaining*enforcement</td>
<td>1.6653 (0.6846)</td>
<td>0.1677 (0.0278)</td>
<td>0.0170 (0.0502)</td>
<td>0.3413 (0.0502)</td>
<td>-0.1352*** (0.1352)</td>
<td>-1.2664*** (0.1352)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual quality</td>
<td>0.6810*** (0.0870)</td>
<td>-0.1718*** (0.0314)</td>
<td>-0.0145*** (0.0035)</td>
<td>-0.0022*** (0.0022)</td>
<td>-0.0074*** (0.0022)</td>
<td>-0.0064 (0.0022)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buyer previous earnings</td>
<td>0.0573 (0.0182)</td>
<td>-0.0092 (0.0049)</td>
<td>0.0002 (0.0009)</td>
<td>-0.0002 (0.0009)</td>
<td>0.0002 (0.0009)</td>
<td>-0.0004 (0.0009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seller previous earnings</td>
<td>0.3708*** (0.0238)</td>
<td>0.0217*** (0.0062)</td>
<td>0.0008 (0.0005)</td>
<td>0.0018 (0.0005)</td>
<td>0.0012 (0.0005)</td>
<td>0.0006 (0.0005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of relationship</td>
<td>0.0612 (0.0311)</td>
<td>-0.0710 (0.0212)</td>
<td>0.0004 (0.0006)</td>
<td>-0.0029 (0.0006)</td>
<td>-0.0051 (0.0006)</td>
<td>0.0000 (0.0006)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>7.35</td>
<td>7.35</td>
<td>7.35</td>
<td>7.35</td>
<td>7.35</td>
<td>7.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.1659</td>
<td>0.1544</td>
<td>0.0223</td>
<td>0.2543</td>
<td>0.1603</td>
<td>0.0317</td>
<td></td>
<td></td>
<td>0.1757</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Columns one, three and seven are OLS estimations with seller’s payoff, seller’s share and payoff spread as dependent variables respectively. Columns two, four and eight are robust regressions for the same dependent variables. Columns five, six, nine and ten are median and 90 percentile regressions respectively. Asterisks indicate the significance level of the estimate: * at 10% level, ** at 5% level and *** at 1% level. Additional controls are quality level delivered, the current length of the relationship, buyer and seller payoffs and dummies for each period (not included in output). Standard errors reported are robust and adjusted for clustering on buyer-seller pairs for the OLS estimations.

Table 2.17: Distributional outcomes
3.1 Introduction

The reduction of emissions from deforestation and forest degradation (REDD) presents a key opportunity for developing countries to mitigate global warming and to help meet long-term global climate objectives. However, the success of a REDD strategy in a post-Kyoto protocol regime depends primarily on the design and implementation of a financial mechanism that is feasible and effective in providing the right incentives to land-holders to manage forests in a sustainable manner that contributes to climate goals.

Optimal REDD contracts must not only properly reward agents who reduce emissions from deforestation and degradation (DD) but also account for technical issues such as permanence and additionality of carbon offsets. In many countries, national authorities may not have the institutional capacity and the proper technology for measuring the delivery of carbon offsets. Furthermore, contract enforcement becomes complex because the effort and outcomes described in such contracts are difficult for a third-party to monitor and verify. Therefore, contracts need to provide sufficient
incentives to all parties to participate and perform in the long-term, i.e., to be self-enforcing.

Contracts may be structured in a way where contractual performance (forest conservation) maximizes material payoffs and economic returns for the participants. This contract gives incentives to parties to choose forest conservation assuming that material self-interest is the sole motivation in their optimization program. However, many economists, including Smith [1759], Becker [1974] and Arrow [1981], have pointed out that people are often concerned for the well-being of others and not only for their own material payoffs. Furthermore, Andreoni [1989], Andreoni [1990] and Videras and Owen [2006] posit that people experience a private benefit from contributing to public goods including environmental protection. Moreover, there is large body of experimental evidence that indicates that some people are strongly motivated by fairness and reciprocity concerns as well as by warm-glow giving. Examples of this include Roe and Wu [2009], Fehr and Schmidt [2007], Wu and Roe [2007a], Brown et al. [2004], Andreoni and Miller [2002], Andreoni [1990] and Andreoni [1989]. As a consequence, the structure of the optimal REDD contracts may vary depending on the preferences participants have.

This paper studies three different theoretical models that include preferences that go beyond material self-interest to explore the role of cooperation and reciprocity on the structure of carbon sequestration contracts in the context of developing countries where legal enforcement may be impractical. I examine if the optimal structure of self-enforcing contracts differs if the reciprocity and cooperation are the result of the optimizing actions of purely self interested agents (so called instrumental reciprocity)
or if they are the result of the presence of participants who act according to social or egoistic (impure altruistic) preferences.

When parties behave according to purely instrumental reciprocity, i.e. the optimization actions of self-interested agents, then the relationship is structured in way where contractual performance (forest conservation) is in each party’s personal best interest and agents reciprocate in order to sustain a profitable long-term relationship. This is the baseline assumption in the relational contracting literature and underlies models of self-enforcing contracts such as those by MacLeod and Malcomson [1989], Baker et al. [1994], Baker et al. [2002] and Levin [2003].

If instead, cooperation and reciprocity are the result of agents who act according to social or “warm glow” preferences, then the optimal contract may involve a different structure that leverages the non-selfish motivations of individual actors. Models of dynamic contracting relationships in the presence of social and warm glow preferences have been developed and fit via experimental methods by Roe and Wu [2009], Fehr and Schmidt [2007], Brown et al. [2004], Andreoni and Miller [2002], Andreoni [1990] and Andreoni [1989], but have not been derived in general infinite-horizon settings or applied to the carbon sequestration context as is done in this paper.

To examine how self-enforcing contracts are structured in the presence of agents that derive utility from reasons other than only individual material payoffs, I consider different cases in which one or both parties act according to altruism, spite, inequality aversion or warm-glow concerns and both parties perfectly know each other’s preferences. First, I derive the case in which a buyer (principal) and a seller (agent) only care about personal material payoffs and act as purely self-interested profit-maximizing agents. Second, I analyze the case in which the buyer’s or the seller’s
objective function depends not only on his / her own payoff but also on the material resources that the other party receives. I first assume that the buyer acts according to altruistic reciprocity or spitefulness while the seller remains purely self-interested. Next I assume that it is the buyer who remains purely self-interested and the seller who acts according to such social preferences. In either case the utility function of the party with social preferences increases or decreases with the well being of the other party. In other words the utility function is monotonically increasing or decreasing with respect to the other party’s payoff. Third, I analyze the case in which one or both parties are inequality averse. Inequality-averse parties derive disutility if the allocation of material payoffs becomes more inequitable, regardless of the direction of inequality. Finally, I assume that the principal and the agent get warm-glow from the act of contributing to climate change goals. I derive and compare the optimal relational contract and the parameters under which cooperation is achievable for all these cases.

I find that when the buyer acts according to altruistic reciprocity or spite the structure of the optimal self-enforcing contract is identical to the one in the presence of a self-interested buyer. The fixed payment is set close to zero while the performance payment includes the value of the cost differential of forest conservation and carbon sequestration and the value of the alternative use of land. Therefore, a buyer interested in long-term carbon sequestration must offer the same contract structure regardless of his own preferences. However, if the buyer is averse to inequality he pays compensation that allocates half of the surplus to the seller. In this case, the total compensation package includes a positive fixed payment and a bonus that is no
greater than the bonus paid when the buyer is self-interested. Therefore, the difference in the total payment is allocated to the fixed payment. These results imply that agencies or organizations that are not only concerned about carbon sequestration but also have objectives related to the economic development of the small land holders should offer the same optimal contract that a profit-maximizing firm offers unless they have preferences about inequality in the allocation of material payoffs.

If the seller is altruistic or experiences a warm-glow from participating in carbon sequestration activities, I find that the optimal contract offers a lower total payment than the one necessary to motivate the seller when she is a purely profit-maximizing agent. The fixed payment is zero while the bonus includes the value of the cost differential of forest conservation and the value of the alternative use of land less an altruistic or warm-glow value that the seller obtains. That is, the seller is willing to accept a lower payment because she is compensated in her payoffs by an altruistic or warm-glow value derived from participating in the contract. If instead, the seller feels spite towards the buyer, the optimal contract provides a higher total payment than when the seller is purely self-interested. The larger payment has to compensate for the disutility the seller gets from the spite towards the buyer’s material payoff. Furthermore, if the seller is averse to inequality, the optimal contracts contain the same payment as when the buyer is averse to inequality.

More importantly, I find that the discount factor needed for self-enforcement does not change if parties are fair-minded and averse to inequality when I compare it to the case of self-interested parties. However, I find that the presence of an altruistic reciprocal party (either buyer or seller) increases the likelihood of cooperation in the long-term relationship relative to the case of selfish parties. The minimum discount
factor that sustains cooperation is inversely related to the coefficient of altruism representing one party’s sympathy for the other’s utility. This result is also true for the case in which either party receives a warm-glow from participating in carbon sequestration activities. The minimum discount factor needed for self-enforcement is also inversely related to the warm-glow coefficient. In practical terms, these results imply that a relationship established for the delivery of carbon offsets between a small land holder and an organization that is concerned about the small land holder’s well-being is more likely to deliver cooperation in the long run than a relationship between the same small land holder and an organization that cares only about its own material payoff. The same is true if the small land holder cares about the firm’s objectives rather than only being self-interested. Finally, if either party gets additional utility from carbon sequestration per se (warm-glow) then cooperation is also a more likely outcome than if they only receive utility from material payoffs.

In contrast, I find that the presence of a spiteful party decreases the likelihood of cooperation relative to the case of purely profit-maximizing parties. When a party feels spite towards the other party, he gets disutility from any payoffs that the other party gets. As a consequence, the discount factor needs to be higher to compensate for the decrease of utility because of spite so the value of cooperation is greater than the gains from deviation. Then, the range of discount factors that support self-enforcement is smaller. For example, if the buyer of carbon credits is a corrupt government, the seller may feel spite towards the buyer, and therefore cooperation is less likely to occur. By the same token, if the seller is a corrupt government that favors elite groups, the valuation of the future needs to be high enough so that it compensates the buyer as his utility decreases if he trades with this kind of seller.
The remainder of the essay is organized as follows. First, I briefly present the relational contracting model and I characterize the optimal self-enforcing contract in the presence of selfish agents who act according to instrumental reciprocity. Second, I include the possibility that the buyer or the seller act according to altruistic reciprocity or spite. I characterize the optimal contract in these cases and find the parameters under which cooperation is achievable. Third, I consider the presence of inequality-averse parties and I characterize the optimal contract under these circumstances as well as the cooperation parameters. Fourth, I analyze the case in which parties get warm-glow from participating in carbon sequestration activities. Finally, I compare the contract structures and their sustainability with the case of pure instrumental reciprocity and finish with some final comments.

3.2 The Model

Consider the relational contract model in which two purely profit-maximizing risk-neutral parties, a buyer and a seller, have the opportunity to trade carbon emissions offsets at dates \( t = 0, 1, 2, 3, \ldots \). Trading can be on an international or on a national level. If trading is on an international level the buyer may be attempting to comply with obligations to reduce green house gas (GHG) emissions, e.g., governments of industrialized countries or an international agency such as the Forest Carbon Partnership Facility of the World Bank acting as an intermediary. The seller may be governments of developing countries, local governments, project developers or non-governmental organizations (NGOs) interested in reducing carbon emissions. If trading is on a national level the buyer may be the government of the recipient country, a local government, a project developer or an NGO. The seller could be an
individual land-owner, farmer or local community who has the possibility of maintaining carbon stocks for specific periods of time.

The seller possesses the exploitation rights for forested land and is interested in adopting land use and management practices that maximize her economic returns. She has the option to conserve the forest and maintain the carbon stocks or she can change the land use to a non-forest activity such as farming and timber harvesting, which would result in carbon emissions.

The buyer is interested in reducing greenhouse gas emissions from deforestation and degradation. Thus, he is willing to pay the seller to avoid changing the current land use and to maintain the carbon stock captured in the forest for a given period of time. Because carbon stocks only have value if they stay for a sufficient period of time, date $t$ is the period of time that the buyer wants the seller to keep the current land use.

The buyer is interested in the additionality and permanence of carbon offsets to comply with REDD objectives, thus he offers a seller a contract to achieve these objectives. At the beginning of period $t$, the buyer and the seller agree on an initial baseline of tonnes of carbon stocked in the forested land exploited by the seller. Once the initial carbon stock baseline is established, the buyer proposes a compensation scheme that the seller receives if she does not change the land use and delivers the quantity of carbon initially agreed, $q^*$. Compensation consists of a fixed payment $p_t$ and a contingent payment $b_t : Q ightarrow \mathbb{R}$, where $Q$ is the observed tonnes of carbon. Carbon stocks are observable by both parties but they are not enforceable because carbon stocks are not verifiable by a neutral third-party either because a formal court does not have the technology and means for verification or because it is too costly to
verify. Consequently, the desired carbon, $q^*$, may differ from the delivered quantity, $q_t$. Let $q_t \in Q = [\underbar{q}, \overbar{q}]$ denote the set of tonnes of carbon delivered in period $t$, where $\overbar{q}$ represents the tonnes of carbon dioxide sequestered at the beginning of the period given the initial land use. $\underbar{q}$ represents the quantity of carbon sequestered when the land use is completely changed to a profit-maximizing non-forest activity.

The fixed payment, $p_t$, is paid independently of the final outcome and it is paid during the course of the trading period $t$. Because $p_t$ is formally enforced, when it is paid becomes less important. However, having a fixed payment at the beginning of or during the period may more attractive for sellers who depend on the contract compensation to relieve cash flow constraints as period $t$ may last for long durations. The contingent payment is considered as a performance payment or bonus and it is used to reward compliance with the baseline carbon level and avoidance of deforestation and forest degradation. Since the contingency payment depends on an unverifiable measure, it is not a legally binding obligation.

After observing the compensation scheme, the seller decides whether or not to accept the buyer’s offer and her decision set is given by $d_t \in \{0, 1\}$, where 0 denotes rejection and 1 denotes acceptance. If the seller accepts, she receives $p$, observes the returns of alternative land uses including non-forest activities and decides to adhere to the contract or to change the land use and breach the contract.

If the seller decides to avoid deforestation and forest degradation, she performs under the contract and incurs a cost for forest protection. The cost includes aspects of maintaining the initial state of the forest land such as the seller’s opportunity cost of time of taking care of the forest, the cost of materials, e.g. to build a fence around the property, or task difficulty which includes making sure other people do
not exploit the forest. The cost is given by $c_t(q_t)$ where $c'(.) > 0$, $c''(.) \geq 0$, and $c(q) = 0^{19}$. The seller’s profit is $U_{st}^m = P_t(q_t) - c_t(q_t)$, where $P_t(q_t) = p_t + b_t(q_t)$ is the total payment actually made from the buyer to the seller. At the end of period $t$ and upon delivery, the sellers’s carbon stock generates a direct benefit for the buyer, $V_t(q_t)$, where $V'(.) > 0$, $V''(.) \leq 0$, and $V(q) = 0$. The buyer also chooses whether or not to pay $b_t(q_t)$. The buyer’s material utility is given by $U_{bt}^m = V_t(q_t) - P_t(q_t)$. Also, $V'(.) > c'(.) \forall q \in Q$, so it is socially efficient and Pareto optimal to maintain the forest land and trade $q = \overline{q}$, since $\overline{q}$ maximizes the total joint surplus defined by $S(q_t) = V(q_t) - c(q_t)$. Note that the superscript $m$ in the objective functions denotes the profit-maximizing preferences which are perfectly known by each party.

If the seller rejects the contract, trade does not occur, the seller receives a fixed payoff from the non-forest activity$^{20} \overline{u}$ and the buyer receives $\overline{\pi}$ which is equivalent to a fixed payoff from the alternative source of carbon credits. These options are assumed to be less attractive than trading, but are desirable to the parties if there are insufficient incentives for the parties to trade. The sum of the fixed payoffs, $\overline{s} = \overline{u} + \overline{\pi}$, is the value of the outside opportunities. The net social surplus is given by $S(q_t) - \overline{s}$, where $S(q_t) - \overline{s} \geq 0 \forall q \in (\underline{q}, \overline{q}]$, and $S(\overline{q}) > S(q) \geq 0$. The net social surplus is the difference between the return to the relationship and the second-best market opportunity for both parties.

This sequence of events repeats in each period $t$, and over the course of repeated interactions the parties know only the past actions of the trading partners with whom

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19I assume that the fixed costs of harvest and transition are netted out of the returns to the non-forest activity.

20I assume that the net returns of the non-forest activity are always more attractive than sustaining the forest without a payments for forest conservation. Then, forest is harvested in the absence of a contract.
they have traded allowing for the creation of relationships in which cooperation is an important characteristic. In addition, each party’s objective is to maximize the future discounted utility, where the common discount factor is $\delta \in (0, 1]$. The common discount factor captures the time value of money and the probability that the parties will meet again after the current period. If today’s interaction is likely to be the last, any dollar to be received in the next period if parties were to interact is not worth as much as if it is received today. Then, the discount factor reflects both time preference and the exogenous uncertainty about the realization of future production opportunities.

Specifically, the objective of a purely self-interested seller is to maximize her present discounted utility, given as

$$\sum_{t=0}^{\infty} \delta^t \{d_t(U^m_{st}) + (1 - d_t)\bar{u}\}$$

and a self-interested buyer’s objective is to maximize his present discounted utility

$$\sum_{t=0}^{\infty} \delta^t \{d_t(U^m_{bt}) + (1 - d_t)\bar{\pi}\}$$

where $d_t = 1$ if the seller accepts the contract and trade occurs in period $t$, and $d_t = 0$ if the seller rejects and no trade occurs.

The nature of carbon stocks suggests that they are observable by the parties involved in a contract but not verifiable by a neutral third-party. In this case, parties must rely on informal incentives and good faith to self-enforce agreements. However, the contingent payments are just a promise, therefore parties have the temptation to deviate from the contract as they do not incur a formal third-party penalty for reneging the original agreement.
If parties were to interact just one time, the buyer can only make the fixed payment credible as it is assumed to be enforceable and paid during the trading period. Because this payment does not include any additional incentives to the seller to continue to sequester the carbon, avoiding carbon emissions from reducing deforestation and forest degradation cannot occur in a static equilibrium. Consequently, trade does not occur and both parties receive their outside options.

In contrast, the ongoing interaction sustains the equilibrium by allowing the parties to support future terms of trade contingent on the satisfactory performance of present trade. The parties cooperate if the history of play in all periods has been cooperation, where cooperation is defined as both parties fulfilling the contract. The parties break-off trade forever if any deviation is observed. There is no loss in assuming that deviation causes the parties to break-off trade forever because this outcome never happens in equilibrium [Levin, 2003]. Furthermore, it can be assumed that after any deviation parties behave as they would in one-time interactions in which the buyer offers a contract in which there is no performance incentives and the seller responds by changing the land use. In this setting, this assumption reflects the fact that it takes a long period of time to recuperate the forested land if the seller deviates via deforestation. Therefore the buyer will not be interested in trading with such a seller anymore as she does not have carbon sinks to offer. On the other hand, if the buyer deviates, the seller looses trust in the buyer and responds by changing the land use to a non-forest activity. Again, carbon sinks are destroyed along with the opportunity for future trade.

Additionally, parties cannot renegotiate the trading decision after carbon sinks are observed. The reason for this is that if a self-enforcing contract is optimal given
any history, then the contract is strongly optimal. A strongly optimal contract has the property that parties cannot jointly gain from renegotiating a new self-enforcing contract even off the equilibrium path. Following the same argument as before, if either party deviates, carbon sinks are destroyed and with them the social surplus. Therefore there is no gain from renegotiation.

Finally, each period is played following a Nash equilibrium and parties use a stationary contract, in which the buyer always offers the same payment scheme, the seller always takes the same action, and the rents to the relationship are attractive enough for parties to self-enforce the contract and stay in the relationship [Baker et al., 1994, MacLeod, 2006, MacLeod and Malcomson, 1989, 1998]. Moreover, repetition allows players to maintain a Sub-game Perfect Nash Equilibrium (SPNE) where parties honor the contract and maintain long-term relationships. Lastly, because the buyer’s behavior is perfectly observable, a stationary contract delivers the optimal surplus and the reduction of carbon emissions from deforestation and forest degradation.

These assumptions allow for self-enforcing contracts — relational contracts — since they contain a complete plan for the relationship that describes behavior on and off the equilibrium path. On the equilibrium path, both parties fulfill the contract, the seller avoids deforestation and forest degradation and incurs the cost of forest conservation by spending the necessary time (effort) and making sure the forest remains intact to deliver the same carbon stocks from the baseline. If she decides to provide the carbon stock, at the delivery date, since the quantity is not verifiable by a third party, then the buyer has to decide to fulfill the initial agreement or to shirk. If the buyer honors the agreement he pays full payment $P_t(q_t) = p_t + b_t(q_t)$, gets the benefits of the carbon stocks and trade continues in the next period. If he
decides to shirk then he can argue that the carbon sinks delivered are different from
the baseline they agree on, and therefore pay \( b_t(q_t) = 0 \). If the seller breaches the
contract, she does not incur in the cost of forest conservation and changes the land-
use to a non-forest activity. Then, she receives \( p \) and the returns of the non-forest
activity \( \bar{u} \) and the buyer receives nothing. Lastly, if either party shirks, the parties
break off trade forever.

3.2.1 Characterization of Self-enforcing Contracts

Because third-party enforcement is imperfect, the buyer must offer a contract
\( y^* = \langle p, b(q) \rangle \) through which he provides additional incentives for the seller to avoid
deforestation and forest degradation. The buyer pays \( p \) as a fixed payment regardless
of what the seller’s performance is, and the contingent payment takes the form of a
bonus that the buyer promises to pay as long as the seller does not shirk. Because
enforcement is imperfect after the seller accepts a contract \( y^* \), parties may renege
without a formal penalty. The seller decides on how to use the land and it may differ
from the buyer’s desired use set forth in the contract. She can cooperate and choose
\( q_t \geq q^* \), or can shirk by choosing a non-forest activity.

The buyer, after observing the carbon delivered, may cooperate by paying \( P_t(q_t) = p_t + b_t(q_t) \), or he may renege by choosing the most profitable deviation, i.e., not pay
the bonus, \( b(q) = 0 \). The buyer participates in the REDD contract if the benefits
from such contract are greater than his alternative source of carbon reduction. This
is given by

\[
U_{bd}^m = V(q_t) - p_t - b(q_t) \geq \bar{\pi} \ (IRC_b^m) \tag{3.3}
\]
In addition, the buyer’s offer has to meet the seller’s individual rationality constraint, i.e., the offer has to provide a credible incentive to perform in each single period. This is given by

\[ U_{st}^m = P(q_t) - c(q_t) \geq \bar{u} \ (IRC_{s}^m) \]  

(3.4)

Because of the imperfect enforcement a dynamic incentive compatibility constraint (DICC) for each party has to be fulfilled to self-enforce the contracts. The DICC is necessary to reach the optimal contract because it requires the parties to prefer to behave according to the contract instead of reneging. The seller’s and the buyer’s DICC are given by (3.5) and (3.6) respectively.

\[ \frac{p + b(q) - c(q)}{1 - \delta} \geq p - c(q) + \frac{\pi}{1-\delta} \ (DICC_{s}^m) \]  

(3.5)

\[ \frac{V(q) - p - b(q)}{1 - \delta} \geq V(q) - p + \frac{\delta}{1-\delta} \pi \ (DICC_{b}^m) \]  

(3.6)

A seller cooperates if and only if (3.5) is satisfied. The left hand side of (3.5) is the discounted payoff of the seller for cooperating and maintaining the carbon stock \( q_t \geq q^* \) at the end of each date \( t \). It represents the discounted gains from the relationship for the seller. She receives \( p \) during period \( t \) and the contingent payment \( b(q) \) after delivering the carbon stocks established in the contract and she incurs the forest conservation costs. The right hand side represents the payoff if she shirks. Note that the most profitable deviation for the seller is to change the land-use and to not incur in any cost for forest conservation but in this case the principal, after observing
the carbon stocks delivered, does not pay the bonus. If the seller does so, she incurs $c(q)$, receives the $p$ and changes the land use to an alternative activity. Therefore, she collects the benefits from the alternative activity starting in period $t = 0$ and therefore, receives the present value of the returns from the non-forest activity for all periods.

Additionally, participation for the buyer in the long-term relationship is optimal if his DICC given by (3.6) is satisfied. A buyer cooperates if and only if the left hand side payments from cooperation are greater than the right hand side payments from deviation. If he cooperates he gets the long-term benefits of the carbon stocks delivered net of the payments he makes. If he deviates he gets the benefits of the carbon storage minus what he paid upfront. Then in all future periods, he guarantees himself the benefits of the alternative options for carbon credits.

Since both parties can deviate from the contract, the contingent payment must be sufficient to ensure a self-enforcing contract. It follows that the compensation scheme is bounded by the future gains of the relationship.

The buyer’s optimization program is given by

$$
\max_{p, b(q), q} \left( \frac{V(q) - p - b(q)}{1 - \delta} \right)
$$

subject to

$$
P(q) - c(q) \geq \pi, \quad (3.7)
$$

$$
\frac{p + b(q) - c(q)}{1 - \delta} \geq p - c(q) + \frac{\pi}{1 - \delta},
$$

$$
\frac{V(q) - p - b(q)}{1 - \delta} \geq V(q) - p + \frac{\delta}{1 - \delta} \pi,
$$

and

$$
q \in [\underline{q}, \overline{q}].
$$
The seller’s IRC can be rearranged as (3.8) and because a profit maximizing buyer pays only as much as is needed to induce the seller to participate, then the $IRC^m_s$ binds:

$$p = \overline{\pi} + c(q) - b(q)$$  \hspace{1cm} (3.8)

and expression (3.5) can be restated as,

$$p \geq c(q) + \frac{c(q) - c(q) + \overline{\pi} - b(q)}{\delta}$$  \hspace{1cm} (3.9)

which gives the lower bound on the fixed payment, $p$, for inducing long-term seller cooperation. The presence of the performance payment allows the buyer to offer a lower fixed payment. By substituting (3.8) in (3.9), the optimal distribution of the total compensation among the fixed payment and the performance bonus is established.

The optimal stationary REDD contract is defined in Proposition (8).

**Proposition 8.** If parties are purely profit-maximizing agents that trade repeatedly and contract enforcement is imperfect, assuming $\delta$ high enough, an optimal stationary REDD contract $\langle p^*, b^*(q^*) \rangle$ that implements conservation of the forest land $\overline{q}$, satisfies $IRC^m_s$, $IRC^m_b$, $DICC^m_s$ and $DICC^m_b$, where $IRC^m_s$ and $DICC^m_b$ bind, and the compensation scheme is characterized by:

$$b(q) = c(q) + \overline{\pi} ,$$ \hspace{1cm} (3.10)

$$p = 0 , \text{ and}$$ \hspace{1cm} (3.11)

$$P(q) = \overline{\pi} + c(q) .$$ \hspace{1cm} (3.12)

**Proof.** See Appendix B  \hspace{1cm} \square
Equality (3.12) identifies the total compensation that the buyer offers the seller in the contract. Equality (3.11) gives the fixed payment that the seller receives during date $t$ and equality (3.10) gives the size of the bonus that the buyer promises to pay at the end of the period to induce the seller to not change the land-use.

Recalling the assumptions about the cost of forest conservation, $c(q) = 0$, the fixed payment included in the optimal REDD contract equals zero. That means that under the optimal relational contract the seller does not get paid anything upfront or during the time she is under the contract until the end of the period. The contingent payment includes the complete payment to the seller. It includes the cost of providing optimal forest conservation and the opportunity cost of the alternative land use. This is intuitive because the seller knows that if she deviates from the contract and changes the use of land, the buyer does not pay the performance payment and furthermore he does not do business again with her. As a consequence she cannot get any future benefits from the relationship. This happens even with the smallest change in the land use as the carbon sinks differ from the baseline established at the beginning of the period and renegotiation is not possible under the assumptions of the optimal relational contract. Therefore, if the seller deviates from the contract she chooses the most profitable actions which include not incurring any cost for forest conservation and converting all land to agricultural or timber activities. Because an up-front fixed payment does not give incentives to the seller to remain in the relationship as it is not conditioned on performance, the buyer needs to provide enough additional incentives to the seller to perform under imperfect verifiability of carbon sinks. Moreover, because the contingent payments are limited by the future gains from the relationship and because the buyer’s utility decreases when the fixed payment is positive, then
all compensation is shifted to the contingent payment so that the seller has enough incentives to perform.

The result is highlighted in the following corollary.

**Corollary 3.** For imperfect enforcement regimes when parties are purely profit maximizers, all compensation is paid as a performance payment upon delivery of the carbon sinks, and the payment is weakly increasing in the returns of alternative activities and the full cost of forest conservation.

The total compensation is weakly increasing in the returns of non-forest activities and the cost of forest conservation because the contingent payment is limited by the gains from the relationship. If the returns from other activities or the cost of conserving the land are too high, then the future gains from the relationship may not be enough to provide enough incentives to the parties to perform and self-enforce the contract. Furthermore, the payment in the contract represents the cost of forest conservation under a REDD contract.

### 3.2.2 Sustainability of Self-enforcing Contracts

Self-enforcing contracts are sustainable if parties find that the optimal strategy is to cooperate in every period. The cooperation decision depends on each party’s discounted payoff stream from the contract. The discounted payoff stream represents the value of the relationship and depends on how much each party values the future relative to the present (discount factor). If parties hold a very low discount factor, \( \delta \) near to zero, the value of the relationship shrinks and it becomes less attractive to comply with the obligations of the contract. Therefore, it is more difficult to sustain
cooperation and enforce contracts privately. As a consequence, social efficiency is potentially offset by the lack of formal enforcement.

In the case of the optimal REDD contract described in Proposition 8, parties find cooperation (self enforcement) to be the best strategy if they value the future relationship enough. The valuation is given by each party’s dynamic incentive compatibility constraints. Combining the dynamic constraints for both parties given by (3.5) and (3.6) yields the discount factor necessary to achieve cooperation under the optimal REDD contract.

**Proposition 9.** Let $\delta^m > 0$. Cooperation under the optimal REDD contract is achievable $\forall \delta \in [\delta^m, 1)$, where $\delta^m = \frac{c(q) - c(q) + \pi}{V(q) - c(q) - \pi}$.

Proposition 9 reports the range of discount factors that can support a cooperative equilibrium under the optimal REDD contract when parties are purely self-centered. It predicts that parties that have a discount factor greater or equal to the parameter $\delta^m$ will cooperate in the REDD context.

Recalling again the assumption that $c(q) = 0$, the parameter $\delta^m$ can be rewritten as

$$\delta^m = \frac{c(q) + \bar{u}}{V(q) - \pi}. \quad (3.13)$$

The term in the numerator includes the total payment the buyer has to make to the seller to avoid carbon emissions from deforestation and forest degradation. The payment represents the full cost of forest conservation under a REDD contract. The denominator represents the value of the carbon sinks from the contract. That is, the value of the carbon sinks under contract for the buyer net of the outside option to get
carbon credits from an alternative source. Then, $\delta^m$ is the ratio of the total cost of forest conservation to the net value of the carbon sinks derived from the same forest conservation.

The higher the total payment is relative to the net value of the carbon sinks in the contract the closer to one is the discount factor needed to maintain cooperation. As a consequence, only parties who value the future nearly as much as the present find cooperation to be the optimal strategy.

A high discount factor threshold emerges when it is too costly for the seller to conserve the forest or if the returns of the non-forest activity are too high. The latter implies a higher opportunity cost for the land use which also relates to the seller’s cost of forest conservation. This happens because the land becomes more attractive to other parties who will try to get the returns of the non-forest activity. Therefore, it will be more costly for the seller to make sure the forest land is not deforested or degraded by other parties.

On the other hand, for any given REDD payment, when the benefit that the buyer accrues from the carbon sinks delivered by the contract is similar to the benefits of getting carbon credits from other alternative sources, the discount factor needed for cooperation is also very high and cooperation is harder to sustain. Accordingly, contract sustainability requires that both parties have sufficiently high discount factors to prevent any party from shirking on contract obligations and to continue cooperation.

In contrast, the lower the cost of forest conservation is relative to the difference of returns from the carbon delivered under the contract and the alternative source of carbon credits, the smaller is the discount factor needed for contract self-enforcement. In these situations, REDD contracts are more likely to achieve their objective.
If parties have a discount factor such as $\delta > \delta^m$, they repeatedly trade. The buyer gets the discounted value of the net social surplus (3.14) while the seller gets the discounted value of her outside opportunity (3.15).

\[
U_b = \frac{V(q) - c(q) - \pi}{(1-\delta)} , \quad (3.14)
\]

\[
U_s = \frac{\pi}{(1-\delta)} . \quad (3.15)
\]

3.3 Social Preferences, Warm-Glow and Relational REDD Contracts

In this section I assume that parties are not only motivated by material self interest. The participants’ utility function does not only depend on their own material payoff, but parties may also be concerned about the material resources the trading partner receives or may have some preferences for forest conservation. I assume that each party has perfect knowledge of the other’s party’s utility function so that there are no issues related to asymmetric information about parties’ types. Given these alternative preferences, the buyer and the seller are assumed to behave rationally. I use three models applied in the literature to analyze social preferences and taste for conservation in the context of REDD relational contracts.

The first model includes social preferences by allowing the parties’ utility functions to be either monotonically increasing or decreasing in the well-being of the other party, i.e. altruism and spite [Andreoni, 1989, Andreoni and Miller, 2002, Charness and Rabin, 2002, Cox et al., 2001, Levine, 1998]. The second model also includes social preferences by assuming that parties are averse to inequality [Bolton and Ockenfels, 2000, Charness and Rabin, 2002, Fehr and Schmidt, 1999]. In the third model parties
are assumed to get a “warm-glow” from participating in activities related to climate goals achievement [Andreoni, 1989, 1990, 1993, Andreoni and Miller, 2002, Videras and Owen, 2006]. In the next sections, I analyze when either party or both parties act according these preference models.

### 3.3.1 Altruism, Spite and Relational REDD Contracts

In this section I assume that the either or both agents are altruistic or spiteful towards the other agent by having their utility strictly increasing or decreasing with the well being of the other party. For example some agencies such as the Forest Carbon Partnership Facility of the World Bank and The United Nations Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries have objectives that include economic development of the participants in developing countries and therefore their utility functions are an increasing function of sellers’ payments. In contrast purely selfish buyers, perhaps representing private companies engaged in emissions abatement, may only care about internal profit maximization. In addition, the buyer may value the material payoff of the seller negatively (spite). An example of this may be the case in which the seller is a corrupted government or a strong elite that owns the forested land and the buyer may dislike doing business with them.

On the other hand, the seller may have some sympathy for the objectives that a NGO such as Conservation International may have about conservation, and therefore the NGO’s payoff has some positive weight into the seller’s utility. Or, the agent may get disutility from the benefits a corrupted government may have from carbon sequestration contracts.
I assume that the buyer’s utility is given by
\[ U_{bt} = V(q_t) - P_t(q_t) + a_b U_{st}^m, \]
where \( a_b \) is a parameter that represents the buyer’s utility weight on the utility of the seller.\(^{21}\) If \( a_b = 0 \), the buyer only cares about his own payoff and acts as a purely self-interested agent as in the previous section. If \( a_b > 0 \) the buyer acts according to altruistic reciprocity because his utility increases with the well being of the seller. Finally, if \( a_b < 0 \), the buyer’s utility function decreases with the well-being of the seller. By the same token, the seller’s utility is given by
\[ U_{st} = P_t(q_t) - c(q_t) + a_s U_{bt}^m, \]
where \( a_s \) represents the seller’s utility weight on the utility of the buyer and has the same effect that \( a_b \) has on the buyer’s utility function.

**Case 1: Altruistic buyer and self-interested seller**

If the buyer acts altruistically and the agent continues to be self-interested, then \( a_s = 0 \) and the seller’s \( IRS_s^m \) and \( DICC_s^m \) remain the same while the buyer’s \( IRC \) is now given by
\[
U_{bt}^a = V(q_t) - P_t(q_t) + a_b U_{st} \geq \pi \ (IRC_{bt}^a). \tag{3.16}
\]
Furthermore, the buyer’s \( DICC \) also changes reflecting the buyer’s altruistic preferences and it is given by
\[
\frac{V_t(q_t) - P_t(q_t) + a_b U_{st}^m}{1 - \delta} \geq V(q) - p + a_b U_{st}^m + \frac{\delta}{1 - \delta} \pi \ (DICC_{bt}^a). \tag{3.17}
\]
On the left hand side, the modified buyer’s \( DICC \) reflects his payoff if parties cooperate. In this case, the buyer receives the material payoff from the contract and

\(^{21}\)This expression was first used by Edgeworth [1881] who referred to it as a co-efficient of sympathy. It has been used by various authors to include altruism and spite in public goods models, other-regarding preference models and interdependent preference models. Examples of this are Anderson et al. [1998], Andreoni and Miller [2002], and Levine [1998].
additional utility derived from the seller’s payoff under the contract $U_{st}^m$. On the right hand side, the $DICC_a^b$ reflects the buyer’s utility when he deviates, in which case, he gets the returns from the carbon offsets net of the enforced payment and his utility is also affected by the utility that the seller gets when the buyer deviates, $U_{st}^m$. $U_{st}^m$ represents true altruism because the buyer benefits from the seller’s utility even if he deviates.

Consequently, a buyer that acts according to altruistic reciprocity derives the optimal self-enforcing contract by maximizing his long term utility:

$$\max_{p,b(q),q} \left( \frac{V_t(q_t) - P_t(q_t) + a_b U_{st}^m}{1 - \delta} \right)$$

subject to

$$P(q) - c(q) \geq \pi,$$  \hspace{1cm} (3.18)

$$\frac{p + b(q) - c(q)}{1 - \delta} \geq p - c(q) + \frac{\pi}{1 - \delta},$$

$$\frac{V_t(q) - P_t(q) + a_b U_{st}^m}{1 - \delta} \geq V(q) - p + a_b U_{st}^m + \frac{\delta}{1 - \delta} \pi,$$

and

$$q \in [\underline{q}, \overline{q}].$$

Following the same steps as in section 2.1, I solve for the optimal contract in the presence of an altruistic buyer and a self-interested seller. Then, a buyer who acts according to altruistic reciprocity offers the optimal stationary REDD contract defined in Proposition (10).

**Proposition 10.** An altruistic principal offers a optimal stationary REDD contract

$$y^* = (p^*, b^*(q^*))$$

that implements conservation of the forest land $\overline{q}$, and satisfies
$IRC^m_s$, $DICC^m_s$, $IRC^a_b$ and $DICC^a_b$, where $IRC^m_s$ and $DICC^a_b$ bind. The compensation scheme is characterized by

\[ b(q) \geq c(q) + \bar{\pi}, \quad (3.19) \]

\[ p = 0, \quad \text{and} \quad (3.20) \]

\[ P(q) = \bar{\pi} + c(q). \quad (3.21) \]

**Proof.** See Appendix B \hfill \Box

As expected, the contract is structured in the same way as in the presence of purely profit-maximizing parties because the seller’s preferences have not changed. Then, she needs the same incentive structure to perform. As a consequence, regardless of the preferences the buyer may have (self-interested or altruistic), the optimal REDD contract has the same characteristics: a fixed payment close to zero and a performance payment that contains the entire payment including the cost of forest conservation and the value of the alternative economic activity for the seller. In other words, no matter how sympathetic the buyer is toward the seller, it never results in an upfront payment or a larger bonus.

Once again, the contract is self-enforcing if parties find cooperation to be the best strategy. Proposition (11) addresses the conditions for self-enforcement.

**Proposition 11.** Let $\delta^{ab} > 0$. Cooperation among an altruistic buyer and a self-interested seller under the optimal REDD contract is achievable $\forall \delta \in \left[ \delta^{ab}, 1 \right)$, where $\delta^{ab} = \frac{(c(q)-c(q)+\pi)(1-a_b)}{V(q)-c(q)-\bar{\pi}-a_b(c(q)-c(q))}$.

Proposition 11 reports the range of discount factors that can support a cooperative equilibrium under the optimal REDD contract when the buyer is altruistic. It predicts
that parties that have a discount factor greater than or equal to the parameter $\delta^{a^b}$ will cooperate in the REDD contract. Recalling $c(q) = 0$, $\delta^{a^b}$ can be rewritten as

$$\delta^{a^b} = \frac{(c(q) + \pi)(1 - a_b)}{V(q) - \pi - a_b c(q)}.$$ (3.22)

The term in the numerator includes the total payment the buyer has to make to the seller to avoid carbon emissions net of the buyer’s altruistic value of the payment. The denominator represents the buyer’s altruistically adjusted net benefit of the carbon sinks from the contract.

Similar to when both parties are purely self-interested, a high discount factor is needed when it is too costly for the seller to conserve the forest or if the returns of the non-forest activity are too high. However, with an altruistic buyer, the discount factor is inversely related to the parameter of altruism as $\partial \delta^{a^b}/\partial a_b < 0$. The overall result is that the more altruistic the buyer is, the wider the range of discount factors that sustains cooperation because the threshold for cooperation is lower. Table 3.1 summarizes the results and compares them to the purely self-interested agent case.

The wider range of discount factors reflects the increase in the per period payoff from altruism that an altruistic buyer gets with respect to the per period payoff of a self-interested buyer. An altruistic buyer gets the altruistic value of the seller’s payoff in addition to the payoff of a purely self-interested buyer. Then, the more altruistic the buyer is, the higher the overall per period payoff he gets. Therefore, even with a lower discount factor, the discounted stream of benefits from cooperation is more attractive than the benefits from deviation. That is, the increase in the per period payoff overcomes a lower valuation of the future, reflected in a lower discount factor, and therefore cooperation can be sustained for a wider range of discount factors. If
cooperation is the case, parties repeatedly trade. The seller gets the discounted value of her outside opportunity (3.23) while the buyer gets the discounted value of the net social surplus adjusted for his altruism (3.24). The buyer’s altruism gives him higher utility than if he were only to value material payoffs.

\[ U_s = \frac{\pi}{(1-\delta)} \], \hspace{1cm} (3.23)

\[ U_b = \frac{V(q) - c(q) - \pi(1-a_b)}{(1-\delta)}. \] \hspace{1cm} (3.24)

**Case 2: Spiteful buyer and self-interested seller**

Now assume that the buyer gets disutility from the seller’s payoffs, \((a_b < 0)\), which reflects a spiteful buyer. The buyer’s IRC and DICC remain the same but now \(a_b\) is negative. For instance, this can reflect the case in which either the contracts are implemented or the contracted land rights belong to a corrupted government, therefore the buyer dislikes the profits the seller gets. As the seller’s IRC and DICC have not changed, the payments are going to be the same as in the case of an altruistic buyer, however, the spitefulness is going to be reflected in the long term cooperation opportunities.

**Proposition 12.** Let \(\delta^{s^b} > 0\). Cooperation among a spiteful buyer and a self-interested seller under the optimal REDD contract is achievable \(\forall \delta \in \left[\delta^{s^b}, 1\right]\), where \(\delta^{s} = \frac{(c(q)-c(q)+\pi)(1+a_b)}{V(q) - c(q) - \pi + a_b(c(q) - c(q))}\).

Recalling the assumption of \(c(q) = 0\), \(\delta^{s^b}\) reduces to

\[ \delta^{s^b} = \frac{(c(q) + \pi)(1 + a_b)}{V(q) - \pi + a_b c(q)}. \] \hspace{1cm} (3.25)
The term in the numerator includes the total payment to the seller for avoiding carbon emissions adjusted by the buyer’s spite towards the seller’s material payoffs. The denominator represents the spite-adjusted net benefit of the carbon sink from the contract. It is easy to see that with an spiteful buyer, the discount factor is directly related to the parameter of spite as $\partial \delta^b / \partial a_b > 0$. Then, the more spiteful the buyer is, the narrower the range of discount factors that sustains cooperation because the threshold for cooperation is higher. The explanation for this is that a spiteful buyer gets a lower per period payoff compared to a purely self-interested buyer. The more spite the buyer feels, the lower the per period utility he gets, therefore he needs a higher discount factor so that the value of the long-term benefits from cooperation remain higher than the benefits from deviation. As a consequence, cooperation is more difficult to maintain. Nevertheless, if parties cooperate, the seller gets the discounted value of her outside opportunity (3.26) while the buyer gets the discounted value of the net social surplus adjusted for his spite (3.27). The buyer receives the same material payoff but his spite towards the seller gives him lower utility than if he were only to value material payoffs.

$$U_s = \frac{\pi}{(1-\delta)}.$$ (3.26)

$$U_b = \frac{V(q) - c(q) - \pi(1+a_b)}{(1-\delta)}.$$ (3.27)

**Case 3: Altruistic seller and self-interested buyer**

Consider the case in which only the seller acts altruistically and the buyer continues to be self-interested, then, $a_s > 0$, $a_b = 0$ and the buyer’s IRS and DICC
remain the same $IRS_b^m$ and $DICC_b^m$, while the seller’s $IRC$ is given by

$$U_{st}^a = P_t(q_t) - c(q_t) + a_s U_{bt}^m \geq \bar{\pi} \ (IRC_s^a). \ (3.28)$$

Furthermore, the seller’s $DICC_s^a$ also changes reflecting the seller’s altruistic preferences and it is given by

$$\frac{P_t(q_t) - c(q_t) + a_s U_{bt}^m}{1 - \delta} \geq p - c(q) + a_s U_{bt}^m + \frac{\bar{\pi}}{1 - \delta} \ (DICC_s^a). \ (3.29)$$

An example of this may be the case in which the seller is sympathetic to the buyer’s objectives such as conservation objectives that a NGO such as Conservation International may have. Then, the self-interested buyer solves the following maximization program:

$$\max_{p,b(q),q} \left( \frac{V_t(q_t) - P_t(q_t)}{1 - \delta} \right)$$

subject to

$$P_t(q_t) - c(q_t) + a_s U_{bt}^m \geq \bar{\pi}, \ (3.30)$$

$$\frac{P_t(q_t) - c(q_t) + a_s U_{bt}^m}{1 - \delta} \geq p - c(q) + a_s U_{bt}^m + \frac{\bar{\pi}}{1 - \delta},$$

$$\frac{V_t(q_t) - P_t(q_t)}{1 - \delta} \geq V(q) - p + \frac{\delta}{1 - \delta} \bar{\pi},$$

and

$$q \in [q, \bar{q}].$$

Because a profit-maximizing buyer only offers a payment that ensures the acceptance of the seller, the seller’s $IRC_s^a$ can be rearranged as

$$p = \frac{\bar{\pi} + c(q) - a_s V(q_t) - b(q)(1 - a_s)}{1 - a_s} \quad (3.31)$$

and expression $DICC_s^a$ can be restated as,
\[ p \geq \frac{c(q) + \bar{u} - (1 - a_s)b(q) - a_sV(q) + (1 - \delta)(a_sV(q) - c(q))}{\delta(1 - a_s)} \]  

(3.32)

which gives the lower bound on the fixed payment, \( p \), for inducing long-term seller cooperation. By substituting (3.31) in (3.32), the optimal distribution of the total compensation among the fixed payment and the performance bonus is established.

The optimal stationary REDD contract in this case is defined in Proposition 13.

**Proposition 13.** If contract enforcement is imperfect and the seller is altruistic, and assuming \( \delta \) high enough, a self-interested principal offers an optimal stationary REDD contract \( \langle p^*, b^*(q^*) \rangle \) that implements conservation of the forest land \( q^* \), that satisfy \( IRS_s^a, IRS_b^s, DICC_s^a \), and \( DICC_b^m \), where \( IRS_s^a \) and \( DICC_b^m \) bind, and the compensation scheme is characterized by:

\[
\begin{align*}
 b(q) & \geq \frac{c(q) + \bar{u} - a_s(V(q))}{1 - a_s}, \\
p & = 0, \text{ and} \\
P(q) & = \frac{\bar{u} + c(q) - a_sV(q)}{1 - a_s}
\end{align*}
\]

(3.33)

(3.34)

(3.35)

**Proof.** See Appendix B

Equality (3.35) identifies the total compensation that a buyer has to offer to an altruistic seller in the contract. Equality (3.34) gives the base payment that the seller receives during date \( t \) and equality (3.33) gives the size of the bonus that the buyer promises to pay at the end of the period to induce the seller to not change the land-use.

The total payment and both the base and performance payments are decreasing in the seller’s coefficient of altruism. Recalling the assumptions about the cost of
forest conservation, $c(q) = 0$ and the carbon benefits from changing the land use, $V(q) = 0$, the base payment included in the optimal REDD contract for an altruistic seller also equals zero. That means that regardless of the the seller’s preferences, under the optimal relational contract the seller does not get paid anything upfront or during the time she is under the contract until the end of the period. The contingent payment includes the complete payment to the seller. It includes the cost of providing optimal forest conservation and the opportunity cost of the alternative land use.

In the case of the optimal REDD contract in the presence of an altruistic seller, parties find cooperation (self enforcement) to be the best strategy if they value the future relationship at least as much as the discount factor described in Proposition 14.

**Proposition 14.** Let $\delta^a > 0$. Cooperation under the optimal REDD contract is achievable $\forall \delta \in [\delta^a, 1)$, where

$$\delta^a = \frac{c(q) - c(q) + \pi - a_s(V(q) - V(q))}{V(q) - c(q) - \pi - a_s(V(q) - V(q) - \pi)}.$$

Proposition 14 reports the range of discount factors that can support a cooperative equilibrium under the optimal REDD contract when an altruistic seller and a self-interested buyer trade.

Recalling again the assumption that $c(q) = 0$ and $V(q) = 0$, the parameter $\delta^a$ can be rewritten as

$$\delta^a = \frac{c(q) + \pi - a_sV(q)}{(1 - a_s)(V(q) - \pi)}.$$  \hspace{1cm} (3.36)

The term in the numerator includes the total payment the buyer has to make to the seller to avoid carbon emissions net of the seller’s altruistic value for the buyer’s benefits. The denominator represents the buyer’s net benefit of the carbon sinks from
the contract adjusted by the seller’s altruistic parameter. With an altruistic seller, the discount factor is also inversely related to the parameter of altruism as $\partial \delta^a_s / \partial a_s < 0$. The overall result is analogous to the case with an altruistic buyer; the more altruistic the seller is, the wider the range of discount factors that sustains cooperation because the threshold for cooperation is lower.

As with an altruistic buyer, the wider range of discount factors reflects the increase in the per period payoff from altruism that an altruistic seller gets with respect to the per period payoff of a self-interested seller. Then, the more altruistic the seller is, the lower the payment she is willing to accept. The lower payment increases the buyer’s monetary payoff, resulting in a lower discount factor needed for cooperation. Even with a lower discount factor, the discounted stream of benefits from cooperation is more attractive than the benefits from deviation. That is, the increase in the per-period payoff overcomes a lower valuation of the future, reflected in a lower discount factor, and therefore cooperation can be sustained for a wider range of discount factors.

If parties cooperate, the seller gets a lower material payoff than if she were purely self-interested. However, the seller receives the discounted value of her outside opportunity (3.37) because the utility derived from altruism compensates for the lower payment. The buyer gets the discounted value of the net social surplus adjusted for the seller’s altruism (3.38). The buyer receives a higher material payoff than if the seller were self-interested because he is able to pay less.

$$U_s = \frac{\pi}{(1-\delta)} , \quad (3.37)$$

$$U_b = \frac{V(q) - c(q) - \pi}{(1-a_b)(1-\delta)} . \quad (3.38)$$
Case 4: Spiteful seller and self-interested buyer

Let’s assume that the seller gets disutility from the payoffs that the buyer gets, then \( a_s < 0 \), which reflects a spiteful seller. For instance, this can reflect the case in which the buyer is a corrupted government that traditionally has given rents to an elite group. Therefore, the seller dislikes the profits the buyer makes from carbon sequestration. The maximization program is the same as (26) but now \( a_s \) is negative.

The next proposition states the optimal contract in the presence of a spiteful seller and a self-interested buyer.

Proposition 15. If contract enforcement is incomplete and the seller is spiteful, assuming \( \delta \geq \frac{\delta^{ss}}{\delta} \), a self-interested buyer offers an optimal stationary REDD contract \((p^*, b^*(q^*))\) that implements conservation of the forest land \( q \), which satisfies IRC\(_s\), DICC\(_s\), IRS\(_b\), and DICC\(_b\), where IRS\(_s\) and DICC\(_b\) bind, and the compensation scheme is characterized by:

\[
\begin{align*}
    b(q) &\geq \frac{c(q) + \pi + a_u V(q)}{1 + a_u}, \quad \text{(3.39)} \\
p & = 0, \quad \text{and} \\
P(q) & = \frac{\pi + c(q) + a_u V(q)}{1 + a_u} \quad \text{(3.41)}
\end{align*}
\]

and cooperation is achievable \( \forall \delta \in [\delta^{ss}, 1) \), where \( \delta^{ss} = \frac{c(q) - c(q) + \pi + a_u (V(q) - V(q))}{V(q) - c(q) - \pi + a_u (V(q) - V(q) - \pi)} \).

Proof. See Appendix B

Proposition 15 presents the total payment and its structure given a spiteful seller and a self-interested buyer. It is easy to see that all payments are increasing in the seller’s spite coefficient. That is the more spite the seller feels towards the buyer, the higher the total compensation needs to be for the seller to participate and engage
in a long-term relationship. Although the fixed payment is also increasing in the spite coefficient, giving the assumptions of the model, it equals zero while the bonus contains all payments.

Additionally the seller’s spite is also reflected in the long-term cooperation opportunities. Recalling again \( c(q) = 0 \) and \( V(q) = 0 \), \( \delta^* \) can be rewritten as:

\[
\delta^* = \frac{c(q) + \bar{u} + a_s V(q)}{(1 + a_s)(V(q) - \pi)}
\]

(3.42)

It is easy to see that with a spiteful seller, the discount factor is directly related to the parameter representing spite as \( \partial \delta^*/\partial a_s > 0 \). Then, the more spiteful the agent is, the narrower the range of discount factors that sustains cooperation because the threshold for cooperation is higher. The intuition in this case is similar to the case of a spiteful buyer. An spiteful seller gets a lower per-period payoff when compared to payoffs derived only from material resources. Therefore, she needs a higher payment to compensate the utility loss she gets from the buyer’s material gains. Therefore, the buyer gets lower payoffs from the relationship and as a consequence a higher discount factor is needed.

If parties cooperate, the seller gets a higher material payoff than if she were purely self-interested. However, the seller receives the same discounted value of her outside opportunity because of the disutility derived from spite. The buyer gets the discounted value of the net social surplus adjusted for the seller’s spite. The buyer receives lower material payoff than if the seller were self-interested because he has to pay a higher compensation to induce a spiteful seller to participate.
\begin{align*}
U_s &= \frac{\pi}{(1-\delta)}, \quad (3.43) \\
U_b &= \frac{V(q) - c(q) - \pi}{(1+\alpha_b)(1-\delta)}. \quad (3.44)
\end{align*}

### 3.3.2 Inequality Aversion and Relational REDD Contracts

Fehr and Schmidt [1999] developed a theory of fairness in which they assume that a fair participant is altruistic towards other participants if his or her material payoffs are less than equal, but the fair participant also feels envy when the other participants’ material payoffs is greater than half. In this section, I analyze the cases in which the buyer and / or the seller are characterized by such a dislike of advantage or disadvantage. I assume for simplicity that the reference agent for each party is the agent with whom they contract. In this case, the reference agent for the seller is the buyer and vice versa. To capture this idea, I consider the following utility functions for the buyer and seller respectively.

\begin{align*}
U^{IA}_b(x_s, x_b) &= V(q) - P(q) - \alpha_b \max\{x_s - x_b, 0\} - \beta_b \max\{x_b - x_s, 0\} \quad (3.45) \\
U^{IA}_s(x_s, x_b) &= P(q) - c(q) - \alpha_s \max\{x_b - x_s, 0\} - \beta_s \max\{x_s - x_b, 0\} \quad (3.46)
\end{align*}

where \(\beta_i \leq \alpha_i\) and \(0 \leq \beta_i \leq 1\). The parameter \(\alpha_i\) weights the utility loss from inequality to \(i\)'s disadvantage, while the parameter \(\beta_i\) weights the loss in utility from advantaged inequality. \(x_s\) and \(x_b\) represent the material payoffs for the seller and the buyer respectively, where \(x_s = U^m_s = P(q) - c(q)\) and \(x_b = U^m_b = V(q) - P(q)\) and \(P(q)\) determines the share of the total surplus, \(S(q) = V(q) - c(q)\), that each party gets. In addition, \(x_b - x_s = V(q) + c(q) - 2P(q)\) and \(x_s - x_b = 2P(q) - V(q) - c(q)\).
For any given payment, the fair party prefers a quality level that equalizes the material payoffs for both parties. That means to maximize either function, for a fair buyer or a fair seller or both, the material payoff for the seller should be equal to the buyer’s material payoffs. Then, when maximizing a fair minded party’s function $x_b = x_s$ holds. Solving for the total payment and differentiating with respect to $q$, we get:

\[
\begin{align*}
    x_b &= x_s \\
    U_b &= U_s \\
    V(q) - P(q) &= P(q) - c(q) \\
    P(q) &= \frac{V(q) + c(q)}{2} \quad (3.47) \\
    \frac{\partial P(q)}{\partial q} &= \frac{\frac{\partial V(q)}{\partial q} + \frac{\partial c(q)}{\partial q}}{2}. \quad (3.48)
\end{align*}
\]

Rearranging $\frac{\partial P(q)}{\partial q}$ I obtain how the quality level changes with respect to the change in the total compensation: $\frac{\partial q}{\partial P(q)} = \frac{2}{V'(q) + c'(q)}$. This implies that higher the total payment, the higher the quality provision.

If the buyer is of a fair type, he offers a compensation that equals $P(q) = \frac{V(q) + c(q)}{2}$. If the seller is of a self-interested type, she accepts the contract if the compensation, $P(q) = \frac{V(q) + c(q)}{2}$, gives her a payoff such that $U^m_s \geq \bar{u}$. If the seller is the one that is of a fair type and the buyer is self-interested, the buyer has to offer a contract that gives the seller a payoff at least as great as $\bar{u}$ and provides a quality level that equalizes the each party’s material payoffs. Therefore, if at least one of the parties is of the fair type, the compensation has to reflect equal material payoffs for the parties. Additionally, for both types to cooperate in the long-term relationship, the gains from
cooperation need to be greater than the gains from deviation. In this case, the DICCs are the same as $DICC_s^m$ and $DICC_b^m$.

If either party is of a fair type the buyer solves the following maximization problem:

$$\max_{p,b(q),q} \left( \frac{V(q) - P(q)}{1 - \delta} \right)$$

subject to

$$P_t(q_t) = \frac{V(q_t) + c(q_t)}{2},$$

$$P_t(q_t) - c(q_t) \geq \bar{u},$$

$$\frac{P_t(q_t) - c(q_t)}{1 - \delta} \geq p - c(q) + \frac{\pi}{1 - \delta},$$

$$\frac{V_t(q_t) - P_t(q_t)}{1 - \delta} \geq V(q) - p + \frac{\delta}{1 - \delta} \pi,$$

and

$$q \in [\underline{q}, \overline{q}].$$

If $P(q) = \frac{V(q) + c(q)}{2}$, then $\frac{V(q) + c(q)}{2} - c(q) \geq \bar{u}$ needs to be true for the seller to participate. This implies that $\frac{V(q) - c(q)}{2} \geq \bar{u}$ needs to be true. In other words, the total surplus needs to be high enough so that $V(q) - c(q) \geq 2\bar{u}$.

Now, solving the $DICC_s^m$ for $p$, we get the same lower bound for the base payment as the case with self-interested parties. By substituting $p = \frac{V(q) + c(q)}{2} - b(q)$, the structure of the total compensation of the optimal stationary REDD contract is derived and it is given in the next Proposition.

**Proposition 16.** The optimal REDD contract, $(p^*, b^*(q^*))$, when the buyer and / or the seller are fair-type, implements conservation of the forest land $\overline{q}$ if $\delta$ is high enough, $S(q) \geq 2\pi, S(q) \geq 2\pi$, the $IRC_s^m, IRC_b^m, DICC_s^m, DICC_b^m$ and 3.47 are
satisfied. The contract is characterized by:

\[ b(q) = \frac{c(q) + \pi}{1 - \delta} - \frac{\delta(V(q) + c(q))}{2(1 - \delta)}, \quad (3.50) \]

\[ p = \frac{V(q) - c(q) - 2\pi}{2(1 - \delta)}, \quad \text{and} \]

\[ P(q) = \frac{V(q) + c(q)}{2}. \quad (3.52) \]

**Proof.** See Appendix B.

When the total surplus is such that \( S(q) \geq \pi \), the total payment in the presence of fair parties is higher than the total payment in the presence of purely selfish parties. By using this total payment, the buyer and the seller share equally the surplus. Recalling the assumptions about the cost of forest conservation, \( c(q) = 0 \), the base payment included in the optimal REDD contract, in the presence of fair parties, is greater than zero, which contrasts with the base payment in the case of purely selfish agents. In the presence of a fair buyer and / or a fair seller, the optimal relational contract pays the seller a positive upfront payment. In addition, the contingent payment that the buyer promises to pay is also higher than the case of purely self-interested agents. The result is highlighted in the following corollary.

**Corollary 4.** For imperfect enforcement regimes in the presence of a fair minded buyer and / or seller, the total compensation is higher than the case of purely selfish agents. Both the performance payment and the base payment are also higher. The payment is weakly increasing in the returns to carbon credits and the cost of forest conservation.

Even more, parties find cooperation (self enforcement) to be the best strategy if they value the future relationship as much as the threshold discount factor \( \delta^{IA} \) given in the next Proposition.
Proposition 17. Let $\delta^{IA} > 0$. Cooperation under the optimal REDD contract when parties are fair minded is achievable $\forall \delta \in \left[\delta^{IA}, 1\right)$, where $\delta^{IA} = \frac{c(q_{-q})+\pi}{V(q_{-q})-c(q_{-q})-\pi}$.

Recalling again the assumption that $c(q) = 0$, the parameter $\delta^{IA}$ can be rewritten as $\delta^{IA} = \frac{c(q_{-q})}{V(q_{-q})-\pi}$. It is easy to see that $\delta^{IA}$ is the same as the threshold for the discount factor for the case when both parties are selfish, or that $\delta^{IA} = \delta^{m}$.

In conclusion, the presence of fair-minded agents only changes the distribution of surplus but not the range of discount factors for which the long-term relationship is sustained. The results are the same if only one party is fair-minded and the other one is selfish, or if both parties are fair-minded. In all cases, the long-term payoff for both parties are given by

\[ U_s = \frac{V(q_{-q})-c(q_{-q})}{2(1-\delta)}, \quad (3.53) \]
\[ U_b = \frac{V(q_{-q})-c(q_{-q})}{2(1-\delta)}. \quad (3.54) \]

3.3.3 Warm-Glow and Relational REDD Contracts

So far, I have assumed that parties act according to purely selfish motives, altruism towards the trading partner’s payoff or inequality aversion preferences. However, when parties decide to participate in activities related to carbon sequestration provision there are many factors influencing their decisions. In fact, parties may argue they care about climate change goals or environmental conservation as an altruistic motive, which implies that they receive utility from the value society gets from carbon sequestration. However, agents may behave according to “impurely altruistic” motives. As in the literature on contributions for privately provided public goods,
agents may increase their utility by simply contributing to the achievement of environmental goals because of the prestige, friendship or respect that can be earned from the action.

In the context of charitable giving, Andreoni [1989, 1990] shows that agents have two motives for giving. First, each individual’s utility is increasing in the level of provision of a public good. Therefore he demands and contributes more to the provision of the public good, a motivation known in the public goods literature as “altruism” [Becker, 1974]. Second, agents experience an increase in their utility from giving per se, which is called a “warm-glow”. Warm-glow giving is identified as a selfish motive, therefore, a model of charitable giving that also includes warm-glow is considered as an impure altruistic model. In the case of carbon sequestration, parties may also experience warm-glow giving from participating in carbon sinks provision. In this section, I derive a the optimal relational contract when one or both parties have such preferences.

I assume that the parties care about their own monetary payoff derived from participating in carbon sequestration contracts, but they also receive a warm glow from contributing to climate change goals. Further I assume the warm glow is increasing in the amount of carbon sequestered. The new utility functions for the seller and the buyer are given by (55) and (56) respectively and they reflect what Andreoni [1989, 1990] calls “purely egoistic” preferences.

\[
\begin{align*}
U_{s}^{WG} &= P(q_t) - c(q_t) + g_{s}q_t, \quad (IRC_{s}^{WG}) \\
U_{b}^{WG} &= V(q_t) - P(q_t) + g_{b}q_t, \quad (IRC_{b}^{WG})
\end{align*}
\]

151
where $g_s$ and $g_b$ are the parameters of warm glow for the seller and buyer. If $g_i = 0$ the buyer and the seller only get utility from the material payoff derived from the conservation of carbon sinks. If $g_i > 0$, warm glow adds to each party’s utility function a term $g_i$ times the amount of carbon sinks provided. For simplicity, I assume that the value $q$ equals zero. Furthermore, the self-enforcing constraints are given now by

$$\frac{P_t(q_t)-c(q_t)+g_sq_t}{1-\delta} \geq p - c(q) + g_sq + \frac{\pi}{1-\delta}, \quad (DICCs^W) \quad (3.57)$$

$$\frac{V_t(q_t)-P_t(q_t)+g_q}{1-\delta} \geq V(q_t) - p + g_bq_t + \frac{\delta}{1-\delta} \pi. \quad (DICCb^W) \quad (3.58)$$

In this case, the buyer solves the following program to obtain the optimal contract under a warm-glow assumption:

$$\max_{p,b(q),q} \left( \frac{V(q) - P(q) + g_bq}{1 - \delta} \right)$$

subject to

$$P_t(q_t) - c(q) + g_sq \geq \bar{u}, \quad (3.59)$$

$$\frac{P_t(q_t)-c(q)+g_sq}{1-\delta} \geq p - c(q) + g_sq + \frac{\pi}{1-\delta},$$

$$\frac{V_t(q_t)-P_t(q_t)+g_q}{1-\delta} \geq V(q_t) - p + g_bq_t + \frac{\delta}{1-\delta} \pi;$$

and $q \in [\underline{q}, \bar{q}]$.

The lower bound of the base payment is obtained by rearranging $DICCs^W$: $p \geq \frac{c(q_t)-g_sq_t-c(q)+g_sq+\pi-b(q)}{1-\delta} + c(q) - g_sq$. Because the buyer only pays as much as necessary to ensure seller participation, the $IRS^W$ binds and rearranging for $p$ it becomes: $p = c(q) + \bar{u} - g_sq_t - b(q)$. Now substituting one in the other, the structure of the optimal contract is identical to that given in the next Proposition.
Proposition 18. The optimal REDD contract, \( (p^*, b^*(q^*)) \), when the buyer and the seller have warm glow preferences, implements conservation of the forest land \( \bar{q} \) if \( \delta \geq \delta^{WG} \) and satisfies \( IRS_s^{WG}, IRS_b^{WG}, DICC_s^{WG} \) and \( DICC_b^{WG} \). The contract is characterized by:

\[
\begin{align*}
    b(q) & \geq c(q) - g_s q + \pi, \\
p & = 0, \text{ and} \\
P(q) & = c(q) + \pi - g_s q.
\end{align*}
\]

\[
\text{and } \delta^{WG} = \frac{c(q) - c(q) + \pi - g_s q - q}{V(q) - c(q) - \pi + g_s q + g_b q}.
\]

Proof. See Appendix B

Proposition 18 presents the total payment and payment structure under warm-glow preferences. The payment is independent of the buyer’s warm glow coefficient, \( g_b \), but it relates inversely to the seller’s warm glow coefficient, \( g_s \). The larger the carbon sink maintained, the lower the payment the seller accepts to participate and cooperate. This happens because the warm glow that the seller receives from an additional unit of carbon sequestered compensates the loss in utility she gets from a lower payment. By the same token, the more satisfaction a unit carbon sink gives the seller the lower the payment per unit of carbon she accepts as it compensates for the lower payment with warm glow.

From the first order conditions we get \( V'(q) + g_b = c'(q) - g_s \) and by assumption we know that \( V'(.) > c'(.) \forall q \in Q \), therefore, the highest level of forest conservation is always achieved in the presence of warm glow. Furthermore, parties cooperate if \( \delta \geq \delta^{WG} \), and they get \( U_s = \pi \) and \( U_b = V(q) - c(q) - \pi + q(g_s + g_b) \).
3.4 Final Analysis and Comments

Designing contracts to reduce emissions from deforestation and forest degradation is key for the success of global climate change mitigation strategies. The use of self-enforcing contracts may provide enough incentives for parties to perform given the institutional differences among the countries in which the contracts will be implemented. However, the structure and the sustainability of these contracts may vary depending on the objectives and preferences of the parties participating. In this essay, I have compared the structure of the optimal relational contract in the presence of purely self-interested participants to the optimal structure when participants are motivated by other preferences in addition to own material payoffs. Table 3.2 summarizes the models analyzed, each party’s objective function, the individual rationality constraints and the dynamic enforcement constraints in each case for the buyer and seller respectively.

The benchmark case includes purely self-interested parties who only care about own material payoffs. The parties’ objective functions change relative to the benchmark case to reflect altruism and spite by placing positive and negative weights upon the material payoffs gained by the other party while the other party remains purely self-interested. In the second case, the objective function changes relative to the benchmark to reflect inequality aversion by the parties. Then, parties maximize utility if parties receive equitable material payoffs from the relationship. Lastly, the objective functions also change by including utility gains from the warm glow of contributing to climate change goals. The individual rationality constraints and self-enforcement constraints also changed to reflect the new preferences with exception of
<table>
<thead>
<tr>
<th>B-S Function</th>
<th>Payment</th>
<th>Discount factor</th>
<th>Monetary payoffs (per period)</th>
<th>Total Utility (per period)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U^m_b, U^m_s$</td>
<td>$P(q) = c(q) + \pi$</td>
<td>$\delta \geq \delta^m = \frac{c(q) + \pi}{V(q)}$</td>
<td>$U^m_b = V(q) - c(q) - \pi$</td>
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<td>$U^m_b = V(q) - c(q) - \pi$</td>
<td>$U^m_s = \pi$</td>
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Table 3.1: Summary results
the inequality aversion case in which in addition to the IRC and DICC the contract satisfies a equitable distribution of surplus.

Table 3.1 summarizes the results for each case. I find that when the buyer acts according to altruistic reciprocity or spite the optimal contracts offer identical incentives to the seller as in the benchmark case of self-interested parties - a payment scheme in which all remuneration for carbon sequestration is provided at the end of the contracting period as a bonus payment and no upfront payment is provided. However, if the buyer is inequality averse he compensates the seller such that she gets half of the surplus and the payment includes a positive fixed payment and a bonus no greater than the bonus paid when the buyer is self-interested. This latter result holds when the seller is averse to inequality or if both parties hold such preferences.

If the seller is altruistic or holds warm-glow preferences, the optimal contract offers a lower total payment than the one necessary to motivate the seller when she is a purely profit maximizing agent. The fixed payment is zero while the bonus includes the value of the cost differential of forest conservation and the value of the alternative use of land less the altruistic or warm-glow value that the seller obtains. In these cases, the seller is willing to accept a lower payment because she is compensated in her payoffs by an altruistic or warm-glow value derived from participating in the contract. If instead, the seller feels spite towards the buyer, the optimal contract provides a higher total payment relative to the benchmark. The higher payment compensates for the disutility the seller gets from the spite towards the buyer.

More importantly, the presence of other preferences can impact the terms of trade in the carbon market. If parties are inequality averse, the discount factor needed for self-enforcement does not change relative to the benchmark case of self-interested
parties. However, if either party is altruistic, the buyer and the seller are less likely to engage in opportunistic behavior that would lead to a break down in trade, i.e., cooperation is more likely. This happens because the lowest discount factor that sustains cooperation and long-run trade is negatively related to the altruism parameter. This result is also true for the case in which either party receives a warm-glow from participating in carbon sequestration activities.

In contrast, the presence of a spiteful party increases the chances that the parties will engage in opportunistic behavior and trade will break down compared to the case of purely profit-maximizing parties. When a party feels spite towards the other party, he gets a lower per period utility than if he would not care about the other participant’s material gains, therefore he needs a higher discount factor to maintain the value of the discounted stream of benefits higher than the benefits from deviation. As a consequence, cooperation is more difficult to maintain.

Finally, the per period monetary payoffs equal the per period total utility the buyer and the seller get respectively when both parties are self-interested and when either party is inequality averse. This is also true for the buyer when parties get warm-glow from carbon sequestration or when the buyer is self-interested but the seller is altruistic or spiteful. In the case of the seller, her monetary payoffs also equal the per period total utility when the buyer is altruistic or spiteful while the seller gets higher and lower monetary payoff than total utility respectively. In contrast, the seller gets higher monetary payoffs than total utility when he is spiteful and the opposite is true when she is altruistic.
Furthermore, the buyer gets higher monetary payoffs while the seller gets lower monetary payments than the benchmark when the seller is altruistic or holds warm-glow preferences. By the same token, the buyer receives lower monetary payments when the seller is spiteful or either party is averse to inequality while the seller gets a higher monetary payoff than in the benchmark. When the buyer is altruistic or spiteful the monetary payments for each party are the same as the self-interested case. Lastly, only in the presence of inequality aversion preferences, the buyer and the seller share equally the surplus and get the same monetary payoffs and total utility.

The results outlined here show that if parties care about the material payoffs of the other party or care about carbon sequestration per se, they may be more or less willing to cooperate and sustain the relationship over time than when they only care about own monetary payoffs. These results have interesting implications for the design of self-enforcing REDD contracts. When contracts are offered by an organization that has objectives in addition to profit maximization, long-term achievement of climate goals are more likely to occur. The results suggest that cooperation in carbon sequestration may be more sustainable with real world examples of buyers that have a history of concern about stakeholders or observable objectives in line with more altruistic goals. For example, REDD contracts offered by organizations such as Conservation International as well as governments with a history of strong commitments to environmental protection such as Costa Rica could be examples of altruistic buyers that could trigger greater cooperation.

In addition, buyers could express altruism in other ways. For instance, national and local governments that offer better social safety nets or less corrupt governance
<table>
<thead>
<tr>
<th>Preferences</th>
<th>Buyer function</th>
<th>Seller function</th>
<th>Individual rational constraint/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-interest</td>
<td>$U^b_b = V(q) - P(q)$</td>
<td>$U^m_s = P(q) - c(q)$</td>
<td>$\frac{U^m_s = V(q) - P(q) - \frac{\pi}{\gamma}}{V(q) - P(q) + \frac{c(q)}{\gamma}} \geq 1 - \beta_{\max}$</td>
</tr>
<tr>
<td>Altruism</td>
<td>$U^\alpha_b = V(q) - P(q) + a_b U^m_s$</td>
<td>$U^\alpha_s = P(q) - c(q) + a_b U^m_s$</td>
<td>$\frac{V(q) - P(q) + a_b U^m_s}{V(q) - P(q) + \frac{c(q)}{\gamma}} \geq 1 - \beta_{\max}$</td>
</tr>
<tr>
<td>Spite</td>
<td>$U^s_b = V(q) - P(q) - a_b U^m_s$</td>
<td>$U^s_s = P(q) - c(q) - a_b U^m_s$</td>
<td>$\frac{V(q) - P(q) - a_b U^m_s}{V(q) - P(q) + \frac{c(q)}{\gamma}} \geq 1 - \beta_{\max}$</td>
</tr>
<tr>
<td>Inequality Aversion</td>
<td>$U^{LA}_b(x_b, x_b) = V(q) - P(q)$</td>
<td>$U^{LA}_s(x_b, x_b) = P(q) - c(q)$</td>
<td>$\frac{V(q) - P(q)}{V(q) - P(q) + \frac{c(q)}{\gamma}} \geq 1 - \beta_{\max}$</td>
</tr>
<tr>
<td>Warm-Glow</td>
<td>$U^{WG}_b = V(q) - P(q) + g_b q$</td>
<td>$U^{WG}_s = P(q) - c(q) + g_b q$</td>
<td>$\frac{V(q) - P(q) + g_b q}{V(q) - P(q) + \frac{c(q)}{\gamma}} \geq 1 - \beta_{\max}$</td>
</tr>
</tbody>
</table>

Table 3.2: Models
may also be an example of an altruistic buyer. Such governments could present a great opportunity for engaging in successful carbon sequestration while providing additional economic benefits to REDD participants in their countries.

In contrast, the results also suggest that a more self-interested party including profit maximizing firms such as electric companies or nations with a past history of rent seeking and corruption would be less likely to achieve cooperation in REDD contracts. For example, in countries where lands have been historically used for generating rents directed to the elite groups instead of for broader public needs, greater public ownership or control of forest lands might lead to more spite and less cooperation.

These results open an interesting avenue for additional research as it leads to testable hypotheses and stimulates questions about how different forms of non-self-interested preferences (e.g., maximin preferences or preferences for equality) might impact optimal relational contracts. However, the models in this essay assumed that each party has perfect knowledge of the other party’s preference type, ignoring any issues that may arise with the existence of hidden information. For the empirical implementation of carbon sequestration contracts participants’ ability of distinguishing preference types may be crucial for long-term success. Carbon sellers may be able to observe buyers’ objectives more easily and distinguish buyer type. For example, it would be easy to distinguish the pure profit-maximizing type of an electrical company in contrast with more altruistic objectives of the United Nations Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries. Yet individual sellers’ preferences would more difficult to identify. The difficulties derived from the inability to distinguish preference type is something
to consider for future research and the implementation of carbon sequestration con-
tracts.
PROOF OF PROPOSITION 1

Let $\beta \in (0, 1]$ be the bargaining power \(^{22}\) of the agent, $(0, 0)$ the Nash disagreement point and $(\bar{u}, \bar{\pi})$ is the outside option point. There are two possible ways in which players fail to reach an agreement: if parties perpetually disagree but remain negotiating, they get payoffs equal to the disagreement point. If either player opts out, the game ends and players get payoffs equal to the outside option point. The agent’s profit function is given by $U = P(q) - c(q)$ and given the agent’s outside option profits must be such as $U = P(q) - c(q) \geq \bar{u}$. Similarly, the principal’s profit function is $\pi = R(q) - P(q)$, and given his outside option, his profits must be such as $\pi = R(q) - P(q) \geq \bar{\pi}$.

Assuming that both parties seek to maximize own profits, the Asymmetric Nash Bargaining maximization problem is:

\(^{22}\)Here I assume that $\beta > 0$ because the agent has to have some bargaining power in order for this proposition to be relevant, and $\beta \geq \frac{\pi}{\pi_U}$ so that the agent participates.
\[
\max_{P(q)} (P(q) - c(q))^\beta (R(q) - P(q))^{1-\beta}
\]
subject to \( P(q) - c(q) \geq \bar{u}, \quad R(q) - P(q) \geq \bar{\pi}, \)
\[ q \in [\underline{q}, \bar{q}]. \]

The Lagrangian is given by:

\[
L = (P(q) - c(q))^\beta (R(q) - P(q))^{1-\beta} + \lambda (P(q) - c(q) - \bar{u}) + \phi (R(q) - P(q) - \bar{\pi})
\]

where \( \lambda \) and \( \phi \) are the Lagrangian multipliers. From the FOC we have the following cases:

Case 1
\[
\lambda = 0 \quad \text{and} \quad P(q) - c(q) - \bar{u} > 0 \quad \text{and} \quad R(q) - P(q) - \bar{\pi} > 0
\]
In this case we obtain the Nash bargaining outcome (BOA) for the agent:

\[
P(q) - c(q) = \beta S(q)
\]

This condition can be rewritten as:

\[
U_1(y^*) = \beta S(q)
\]  \quad (A-1)

where \( y^* \) is the equilibrium contract. Rearranging equation A-1 and adding the profit function of the principal we can obtain the bargaining outcome for the principal:

\[
P(q) - c(q) + R(q) - P(q) = \beta (R(q) - c(q)) + R(q) - P(q). \quad \text{Then,} \quad R(q) - c(q) = \beta (R(q) - c(q)) + R(q) - P(q). \quad \text{Finally rearranging we get:} \quad R(q) - P(q) = (1 - \beta)S(q).
\]
This inequality can be rewritten as the bargaining outcome for the principal (BOP):
\[ \pi_t(y^*) = (1 - \beta)S(q) \]  

(A-2)

Substituting A-1 in the Kuhn Tucker conditions we get \( \beta S(q) - \bar{u} > 0 \) and \( (1 - \beta)S(q) - \pi > 0 \). Rearranging we get:

\[
\begin{align*}
\beta & > \frac{\bar{u}}{S(q)} \\
\beta & < \frac{S(q) - \pi}{S(q)}
\end{align*}
\]  

(A-3)  

(A-4)

**Case 2**

\( \lambda = 0 \) and \( P(q) - c(q) - \bar{u} > 0 \)

\( \phi > 0 \) and \( R(q) - P(q) - \pi = 0 \)

From the Kuhn Tucker conditions we get that \( R(q) - \pi = P(q) \). Substituting in \( P(q) - c(q) - \bar{u} > 0 \), we get \( R(q) - c(q) - \pi - \bar{u} > 0 \) which is true because by assumption \( S(q) - \bar{s} > 0 \) \( \forall q \in [q, \bar{q}] \) and \( q \neq \bar{q} \). Substituting in each player’s objective function we get:

\[
\begin{align*}
U_t(y^*) & = S(q) - \pi \\
\pi_t(y^*) & = \pi
\end{align*}
\]  

(A-5)  

(A-6)

**Case 3**

\( \lambda > 0 \) and \( P(q) - c(q) - \bar{u} = 0 \)

\( \phi = 0 \) and \( R(q) - P(q) - \pi > 0 \)

From the Kuhn Tucker conditions we get that \( P(q) = c(q) + \bar{u} \). Substituting in \( R(q) - P(q) - \pi > 0 \), we get \( R(q) - c(q) - \bar{u} - \pi > 0 \) which is true because by assumption \( S(q) - \bar{s} > 0 \) \( \forall q \in [q, \bar{q}] \) and \( q \neq \bar{q} \). Substituting in each player’s objective function we get:
\[ U_t(y^*) = \pi \quad \text{(A-7)} \]
\[ \pi_t(y^*) = S(q) - \overline{\pi} \quad \text{(A-8)} \]

**Case 4**
\[ \lambda > 0 \quad \text{and} \quad P(q) - c(q) - \overline{\pi} = 0 \]
\[ \phi > 0 \quad \text{and} \quad R(q) - P(q) - \pi = 0 \]

From the Kuhn Tucker conditions we get that \( P(q) = c(q) + \overline{\pi} \) and \( R(q) - \overline{\pi} = P(q) \).

Substituting \( P(q) = c(q) + \overline{\pi} \) in \( R(q) - P(q) - \pi > 0 \), we get \( R(q) - c(q) - \overline{\pi} - \pi = 0 \) which is not true because by assumption \( S(q) - \overline{s} > 0 \forall q \in [q, \overline{q}] \) and \( q \neq q \). Then, case 4 is not possible.

Now let’s show when the agent’s Individual rationality constraint (IRC) binds. That is \( P(q) - c(q) = \overline{\pi} \). Substituting IRC into the bargaining outcome for the agent, A-1, and rearranging gives \( \frac{\overline{\pi}}{S(q)} = \beta \). This is the result in case 3, in which the agent’s bargaining outcome is \( U_t(y^*) = \overline{\pi} \). Because for any \( \beta < \frac{\overline{\pi}}{S(q)} \), \( \beta S(q) < \overline{\pi} \), then when \( \beta \in [0, \frac{\overline{\pi}}{S(q)}] \), the bargaining outcome for the agent is equal to \( \overline{\pi} \) and for the principal \( S(q) - \overline{\pi} \). Now let’s show when the principal’s Individual rationality constraint (IRC) binds. That is \( R(q) - P(q) = \overline{\pi} \). Substituting IRC into the bargaining outcome for the principal, A-2, and rearranging gives \( \frac{S(q) - \pi}{S(q)} = \beta \). This is the result in case 2, in which the principal’s bargaining outcome is \( \pi_t(y^*) = \overline{\pi} \). Because for any \( \beta > \frac{S(q) - \pi}{S(q)} \), \( (1 - \beta)S(q) < \overline{\pi} \), then when \( \beta \in [\frac{S(q) - \pi}{S(q)}, 1] \), the bargaining outcome for the principal is equal to \( \overline{\pi} \) and for the agent \( S(q) - \overline{\pi} \). As a consequence the bargaining outcomes for the parties can be summarized in:

\[ U_t(y^*_p) = \beta S(\overline{q}) \quad \text{and} \]
\[ \pi_t(y^*_a) = (1 - \beta)S(\overline{q}). \quad \text{(A-9)} \]

\[ (1 - \beta)S(\overline{q}), \quad \text{(A-10)} \]
where $\beta S(\bar{q}) \geq \bar{u}$ and $(1 - \beta)S(\bar{q}) \geq \bar{\pi}$ respectively.

PROOF OF PROPOSITION 2 Let $y_p^*$ be the equilibrium contract that a principal offers to the agent. A rational principal that maximizes profits offers a price that ensures the acceptance of the agent. Then, when $\beta S(q) \geq \bar{u}$ the bargaining outcome binds, it yields to:

$$P = c(Q) + \beta S(Q) \quad (A-11)$$

and $\beta S(Q) \geq \bar{u}$.

Substituting equation (A-11) into the objective function of the principal and solving for the First Order Kuhn-Tucker conditions:

$$R'(q) \begin{cases} < \frac{c'(q)}{\delta} & \text{if } q^* = \bar{q} \\ = \frac{c'(q)}{\delta} & \text{if } q < q^* < \bar{q} \\ > \frac{c'(q)}{\delta} & \text{if } q^* = Q \end{cases}$$

since $R'(.) > c'(.)$ by assumption, the principal sets $q^* = \bar{q}$. Since the contract is completely enforceable, if the agent accepts, then she has to supply $q = \bar{q}$. This results in:

$$P^* = \begin{cases} c(\bar{q}) + \bar{u} & \text{if } 0 \leq \beta < \frac{\bar{\pi}}{S(\bar{q})} \\ c(\bar{q}) + \beta S(\bar{q}) & \text{if } \frac{\bar{\pi}}{S(\bar{q})} \leq \beta \leq \frac{S(\bar{q}) - \bar{\pi}}{S(\bar{q})} \\ R(\bar{q}) - \bar{\pi} & \text{if } \frac{S(\bar{q}) - \bar{\pi}}{S(\bar{q})} < \beta \leq 1 \end{cases} \quad (A-12)$$

$$U^* = \begin{cases} \frac{\bar{\pi}}{1 - \delta} & \text{if } 0 \leq \beta < \frac{\bar{\pi}}{S(\bar{q})} \\ \frac{\bar{\pi}}{1 - \delta} & \text{if } \frac{\bar{\pi}}{S(\bar{q})} \leq \beta \leq \frac{S(\bar{q}) - \bar{\pi}}{S(\bar{q})} \\ \frac{S(\bar{q}) - \bar{\pi}}{1 - \delta} & \text{if } \frac{S(\bar{q}) - \bar{\pi}}{S(\bar{q})} < \beta \leq 1 \end{cases} \quad (A-13)$$

$$\pi^* = \begin{cases} \frac{\bar{\pi}}{1 - \delta} & \text{if } 0 \leq \beta < \frac{\bar{\pi}}{S(\bar{q})} \\ \frac{\bar{\pi}}{1 - \delta} & \text{if } \frac{\bar{\pi}}{S(\bar{q})} \leq \beta \leq \frac{S(\bar{q}) - \bar{\pi}}{S(\bar{q})} \\ \frac{S(\bar{q}) - \bar{\pi}}{1 - \delta} & \text{if } \frac{S(\bar{q}) - \bar{\pi}}{S(\bar{q})} < \beta \leq 1 \end{cases} \quad (A-14)$$

where $A-12$ is the payment schedule, $A-13$ is the profits for the agent, and $A-14$ is the profits for the principal. Now we check the bargaining condition of the principal (BOP): $\pi = R(q) - P \geq (1 - \beta)S(q)$. Substituting $A-12$ into it, we get
\[ R(\bar{q}) - c(\bar{q}) - \bar{u} \geq (1 - \beta)S(\bar{q}), \] that results in \( \beta S(\bar{q}) \geq \bar{u} \), which is true. Also, \[ R(\bar{q}) - c(\bar{q}) - \beta S(\bar{q}) \geq (1 - \beta)S(\bar{q}), \] that results in \( 0 \geq 0 \), which is also true. Finally, \[ R(\bar{q}) - R(\bar{q}) + \bar{\pi} \geq (1 - \beta)S(\bar{q}), \] that results in \( \beta \geq \frac{S(\bar{q}) - \bar{\pi}}{S(\bar{q})} \), which is true because \( (1 - \beta)S(\bar{q}) \geq \bar{\pi} \). Now we check the IRC\(_p\): \[ R(q) - c(q) - \bar{u} \geq \pi \] which is true. Also, \[ R(q) - c(q) - \beta S(q) \geq \pi \] and \[ R(q) - R(q) + \bar{\pi} \geq \bar{\pi} \] which are also true.

Now let’s prove that the results hold for any distribution of power. When \( \beta \in [0, \frac{\bar{\pi}}{S(\bar{q})}] \) the agent has very little or none bargaining power. This case is the benchmark in which cooperation is sustainable. In this case, equation 1.5 becomes \( P = c(q) + \bar{\pi} \). The BOA becomes \( c(q) + \bar{\pi} - c(q) = \bar{u} \), which satisfies the IRC\(_a\). When \( \beta \in [\frac{S(\bar{q}) - \bar{\pi}}{S(\bar{q})}, 1] \), equation 1.5 becomes \( P = R(\bar{q}) - \bar{\pi} \). Now profits are given by \( \pi = \frac{\bar{\pi}}{1 - \delta} \) and \( U = \frac{R(\bar{q}) - c(q) - \bar{\pi}}{1 - \delta} \) respectively. The IRC\(_p\) reduces to: \( R(q) - R(q) + \bar{\pi} \geq \bar{\pi} \), and both sides reduce to \( \bar{\pi} \), so the condition is satisfied: \( \pi \geq \bar{\pi} \).

PROOF OF PROPOSITION 3 Let \( y_p^* \) the equilibrium contract that a principal offers to an agent, where \( P(Q) = p + b(Q) \). The contract has to satisfy equation 1.5. The principal maximizes profits holding equation 1.5 with equality, and solving for \( p \) in both the 1.5 and the DICC given by equation 3.5:

\[
p \geq \bar{u} + c(q) + \frac{c(q) - c(q) - b(q)}{\delta} \quad \text{(A-15)}
\]

Substituting the price, \( p = c(q) + \beta S(q) - b(q) \) on A-15 and rearranging we get:

\[
b(q) \geq c(q) - c(q) + \frac{\delta}{1 - \delta} (\bar{u} - \beta S(q)) \quad \text{(A-16)}
\]

Since the principal is maximizing profits, he will only offer a \( b(q) \) large enough to induce quality, so inequality A-16 holds with equality. Substituting back in \( p = c(q) + \beta S(q) - b(q) \) and rearranging it leads to:

\[
p = c(q) + \frac{\beta S(q) - \delta \bar{u}}{1 - \delta} \quad \text{(A-17)}
\]
Now to solve for the entire compensation package, adding A-16 and A-17 we get:

\[ P(q) = p + b(q) = c(Q) + \beta S(q) \]  \hspace{1cm} (A-18)

Then, the principal solves the following maximization problem when offering a contract:

\[
\max_{P(q), q} \left( \frac{R(q) - P(q)}{1 - \delta} \right)
\]

subject to \[ P(q) = c(q) + \beta S(q) \] \hspace{1cm} (A-19)

and \[ q \in [q, \bar{q}] \].

Recalling \[ S(q) = R(q) - c(q) \], substituting \[ P(q) \] in principal’s objective function, and solving for the First Order Kuhn-Tucker conditions results in:

\[
R'(q) \begin{cases} 
< c'(q) & \text{if } q^* = \bar{q} \\
= c'(q) & \text{if } q < \bar{q} < \bar{q} \\
> c'(q) & \text{if } q^* = q 
\end{cases}
\]

and since \[ R'(q) > c'(q) \ \forall \ q \in [q, \bar{q}] \] and \[ q \neq \bar{q} \] by assumption then the principal requests \[ q^* = \bar{q} \]. Therefore, \[ P(\bar{q}) = p + b(\bar{q}) = c(\bar{q}) + \beta S(\bar{q}) \], where \[ \beta S(Q) \geq \bar{u} \].

**Proof of Proposition 4** First let’s prove that 1.5 and 1.14 bind. If BOA binds, then \[ p(q) - c(q) = \beta S(q) \]. From the agent’s DICC and since \[ d(q) = -p \] and \[ b(q) = 0 \] on the RHS, then we have: \[ \frac{p + b(q) - c(q)}{1 - \delta} \geq -c(q) + \frac{\delta}{1 - \delta} \bar{u} \]. Substituting 1.5 in the agent’s DICC it yields to: \[ \frac{\beta S(q)}{1 - \delta} \geq -c(q) + \frac{\delta}{1 - \delta} \bar{u} \]. Following: \[ \beta S(q) \geq -c(q) + \delta c(q) + \delta \bar{u} \], which is true since \[ \beta S(Q) \geq \bar{u} \geq \delta \bar{u} \]. Then the BOA binds.

Let’s check if principal’s bargaining outcome (BOP) binds. That is \[ R(q) - P(q) = (1 - \beta)S(q) \]. Substituting in the principal’s DICC we get \[ \frac{(1 - \beta)S(q)}{1 - \delta} \geq R(q) + \frac{\delta}{1 - \delta} \bar{u} \]. This leads to \[ \delta(R(q) - \bar{u}) \geq \beta S(q) + c(q) \], which is only true of \[ \delta = 1 \] for any \[ q > \bar{q} \]. Then the principal’s BOP does not bind.

168
Lets check the DICC for both agent and principal. If the agent’s DICC binds then: \[ \frac{p+b(q)-c(q)}{1-\delta} = p + d(q) - c(q) + \frac{\delta}{1-\delta} \bar{u}. \] Given that \( d(q) = -p \), this results in \( p + b(q) = -c(q) + \delta c(q) + \delta \bar{u} + c(q). \) Substituting this in the BOA and we get: \[ -c(q) + \delta c(q) + \delta \bar{u} + c(q) \geq c(q) + \beta S(q). \] Since \( c(q) = 0 \), this leads to \( \delta \bar{u} \geq \beta S(q) \), which is not true for \( \delta \in (0, 1) \) and \( \beta S(q) \geq \bar{u} \). Then the DICC of the agent does not bind.

If the principal’s DICC binds, then \[ \frac{R(q)-p-b(q)}{1-\delta} = R(q) - p - d(q) + \frac{\delta}{1-\delta} \bar{u}. \] It follows that \( b(q) = \delta R(q) - \delta \bar{u} - p \), given that \( d(q) = -p \). Given the principal’s BOP \( R(q) - p - b(q) \geq (1 - \beta)S(q) \) and substituting the DICC we get \( c(q) + \beta S(q) \geq -\delta(\bar{u} - R(q)) \), which is true for \( \delta \in (0, 1) \) and \( \beta \leq \frac{S(q)-\bar{u}}{S(q)} \). Then the principal’s DICC binds.

Now let \( y_p^* \) the equilibrium contract that a principal offers to an agent, where \( P(q_t) = p_t + b_t(q_t) \). The contract has to satisfy the BOA. He wants to maximize profits thus he holds 1.5 with equality and solve for \( p \):

\[ p = c(q) + \beta S(q) - b(q) \quad (A-20) \]

Since he wants to induce a desired quality of \( q^* \) he also solves for \( p \) in the DICC for the agent given by: \[ \frac{p+b(q)-c(q)}{1-\delta} \geq p + d(q) - c(q) + \frac{\delta}{1-\delta} \bar{u} \] we get:

\[ p \geq \bar{u} + c(q) - d(q) + \frac{d(q) - b(q) - c(q) + c(Q)}{\delta} \quad (A-21) \]

Substituting A-20 on A-21 and rearranging we get:

\[ b(q) - d(q) \geq c(Q) - c(q) + \frac{\delta}{1-\delta}(\bar{u} - \beta S(Q)) \quad (A-22) \]

Thus, we can define \( b(q) \geq c(Q) - c(q) + d(q) + \frac{\delta}{1-\delta}(\bar{u} - \beta S(Q)) \). Since the principal is maximizing profits, he will only offer a \( b(q) \) large enough to induce quality, so he
sets the equation with equality and substitute it in A-20 and rearranging it leads to:

\[ p = c(q) - d(q) + \frac{\beta S(Q) - \delta \bar{u}}{1 - \delta} \]  

(A-23)

which represents how the base payment is related to \( \beta \).

Now to solve for the entire compensation package, from A-22 we get:

\[-d(q) \geq c(Q) - c(q) - b(q) + \frac{\delta}{1 - \delta} (\bar{u} - \beta S(Q)) \]

setting it equal because maximizing behavior and substituting this in A-23 we get:

\[ P(q) = p + b(q) = c(Q) + \beta S(Q) \]  

(A-24)

Then, the principal solves the following maximization problem when offering a contract:

\[
\max_{P(q), q} \left( \frac{R(q) - P(q)}{1 - \delta} \right)
\]

subject to \( P(q) = c(q) + \beta S(q) \),

and \( q \in [q, \bar{q}] \).

Recalling \( S(q) = R(q) - c(q) \), substituting \( P(q) \) in principal’s objective function, and solving for the First Order Kuhn-Tucker conditions results in:

\[
R'(q) \begin{cases} 
< c'(q) & \text{if } q^* = \bar{q} \\
= c'(q) & \text{if } q < q^* < \bar{q} \\
> c'(q) & \text{if } q^* = \bar{q} 
\end{cases}
\]

and since \( R'(q) > c'(q) \ \forall \ q \in [q, \bar{q}] \) and \( q \neq \bar{q} \) by assumption then the principal requests \( q^* = \bar{q} \). Therefore, \( P(\bar{q}) = p + b(\bar{q}) = c(\bar{q}) + \beta S(\bar{q}) \) and \( \beta S(\bar{q}) \geq \bar{u} \). Now let’s check the bargaining condition of the principal. Substituting \( P(\bar{q}) \) we get: \( R(\bar{q}) - c(\bar{q}) - \beta S(\bar{q}) \geq (1 - \beta) S(\bar{q}) \), that ends being \( S(\bar{q}) \geq S(q) \), which is true, and \( IRC_p \) holds \( R(Q) - c(Q) - \beta S(Q) \geq \bar{\pi} \) which reduces to \( (1 - \beta) S(Q) \geq \bar{\pi} \).
PROOF OF PROPOSITION 5  For cooperation to be achievable, the DICC of both parties must hold. Then, combining equations 3.5 and 3.6 we get:

\[ \hat{\delta} \geq \frac{c(q) - c(q)}{R(q) - c(q) - \bar{u} - \bar{\pi}} \]  

(A-25)

Hence, cooperation takes place for all values of delta that satisfy A-25.

PROOF OF PROPOSITION 6 First check the participation constraint for the principal when \( \beta = \frac{S(q) - \bar{\pi}}{S(q)} \), e.g. the agent has a high bargaining power: \( R(\bar{q}) - c(\bar{q}) - S(\bar{q}) + \bar{\pi} \geq \bar{\pi} \), which leads to \( \bar{\pi} \geq \bar{\pi} \). For cooperation to be achievable, it must be the case that the DICC of both parties hold. In the case of the agent, she cooperates if and only if equation 1.13 is satisfied. If the agent deviates, the principal will choose the most profitable deviation that is given \( d(q) = -p \), and substituting it in 1.13: \( \frac{\beta S(q)}{1-\delta} \geq -c(q + \frac{\delta}{1-\delta} \bar{u} \). We know by substituting the price \( \beta S(q) \geq \bar{u}, \bar{u} \geq \delta \bar{u} \) and \( \beta S(q) \geq \frac{\bar{\pi}}{1-\delta} \). Then, given that \( c(q) = 0 \), \( \beta S(q) \geq -c(q + \frac{\delta}{1-\delta} \bar{u} \). Therefore, DICC for the agent does not bind. Turning to the principal’s DICC, given \( d(q) = -p \), and substituting it into equation 1.14:

\[ \frac{R(q) - p - b(q)}{1-\delta} \geq R(q) + \frac{\delta}{1-\delta} \bar{\pi} \]. Given \( P = p + b(q) = c(q) + \beta S(q) \), then:

\[ \frac{R(q) - c(q) - \beta S(q)}{1-\delta} \geq R(q) + \frac{\delta}{1-\delta} \bar{\pi} \]  

(A-26)

Solving for \( \delta \), we get:

\[ \delta \geq \frac{c(q) + \beta S(q)}{R(q) - \bar{\pi}} \]  

(A-27)

When \( \beta = 1 \), then \( \delta > 1 \).

Now, to find the threshold for \( \beta \), go back to the DICC of the principal given by \( \frac{R(q) - p - b(q)}{1-\delta} \geq R(q) - p - d(q) + \frac{\delta}{1-\delta} \bar{\pi} \), and given \( d(q) = -p \), solve for \( \beta \) to get:

\[ \hat{\beta} \leq \frac{\delta R(q) - \delta \bar{\pi} - c(q)}{S(q)} \]  

(A-28)
where \( \hat{\beta} \) represent the higher value of the bargaining power of the agent under which cooperation and relational contracts are sustainable.

PROOF OF PROPOSITION 7 Recalling the agent’s profits under no contract enforcement regime: 
\[
U = \frac{\beta S(q)}{1-\delta},
\]
which are increasing in \( \beta \) as \( \frac{dU}{d\beta} \geq 0 \ \forall \ q \in [q, \overline{q}] \) and \( q \neq \overline{q} \). If the agent exercises \( \hat{\beta} \), then the principal does not deviate because

\[
\frac{R(q) - c(q) - \beta S(\overline{q})}{1-\delta} \geq R(q) + \frac{\delta}{1-\delta} \pi
\]  
(A-29)

Substituting: \( \hat{\beta} = \frac{\delta R(q) - \delta \pi - c(q)}{S(q)} \), we get that the DICC for the principal is met:

\[
\frac{R(q) - \delta R(q) + \delta \pi}{1-\delta} \geq R(q) + \frac{\delta}{1-\delta} \pi
\]
(A-30)

Then the principal does not deviate and the agent gets a profit of:

\[
U^{\hat{\beta}} = \frac{\delta R(q) - \delta \pi - c(q)}{1-\delta}
\]  
(A-31)

If the agent exercises a bargaining power \( \beta > \hat{\beta} \), the principal deviates because he will get higher payoff by deviating. For instance if \( \beta = 1 \), the DICC of the principal results in :

\[
0 \geq R(q) + \frac{\delta}{1-\delta} \pi
\]
(A-32)

Clearly, the principal is better off by deviating. His most profitable deviation is to set the total payment to zero. Then, the agent gets profits of:

\[
U^{\beta > \hat{\beta}} = -c(q) + \frac{\delta \pi}{1-\delta}
\]  
(A-33)

Then, the agent is better off by only exercising \( \hat{\beta} \) as \( U^{\hat{\beta}} > U^{\beta > \hat{\beta}} \)

\[
\frac{\delta R(q) - \delta \pi - c(q)}{1-\delta} > -c(q) + \frac{\delta \pi}{1-\delta}
\]
(A-34)
Appendix B: Chapter 3 Proofs

PROOF OF PROPOSITION 8 First let’s prove that \( IRC^m_s \) binds. If \( IRC^m_s \) binds, then \( P(q) - c(q) = \bar{u} \). Substituting \( IRC^m_s \) in \( DICC^m_s \) yields: \( \frac{\pi}{1-\delta} \geq \frac{\pi}{1-\delta} \), which is true. Then \( IRC^m_s \) binds. If \( DICC^m_s \) binds we have \( \frac{p + b(q) - c(q)}{1-\delta} = p - c(q) + \frac{\pi}{1-\delta} \). Rearranging we get \( b(q) = c(q) - \delta p + \bar{u} \) and by substituting in \( IRC^m_s \) we get \( p > 0 \) which is not true as, by assumption, the fixed payment can be zero. Now let \( y^* \) be the equilibrium contract that a buyer offers to a seller, where \( P(Q) = p + b(Q) \). The buyer maximizes profits holding \( IRC^m_s \) with equality: \( P(q) = \bar{u} + c(q) \), and solving for \( p \) in both \( IRC^m_s \) (\( p = \bar{u} + c(q) - b(q) \)) and \( DICC^m_s \) (\( p \geq c(q) + \frac{c(q) - c(q) + \pi - b(q)}{\delta} \)). Substituting \( IRC^m_s \) in \( DICC^m_s \) and rearranging we get \( b(q) \geq c(q) - c(q) + \bar{u} \), which holds with equality because the buyer is maximizing his utility subject to the participation of the seller. He will only offer a \( b(q) \) large enough to induce quality and participation. Substituting back into the \( IRC^m_s \) and rearranging leads to \( p = c(q) \), which is zero because by assumption \( c(q) = 0 \). Combining \( p \) and \( b(q) \) the total payment is \( P(q) = \bar{u} + c(q) \). Substituting \( P(q) \) in the buyer’s objective function, solving for the first order Kuhn-Tucker conditions yields:

\[
V'(q) = \begin{cases} 
<c'(q) & \text{if } q^* = \frac{q}{\bar{q}} \\
= c'(q) & \text{if } \frac{q}{\bar{q}} < q^* < \frac{\bar{q}}{q} \\
> c'(q) & \text{if } q^* = \frac{\bar{q}}{q}.
\end{cases}
\]
Since $V'(q) > c'(q) \ \forall \ q \in [q, \bar{q}]$ and $q \neq \bar{q}$ by assumption, then the buyer requests $q^* = \bar{q}$. Therefore, $P(\bar{q}) = p + b(\bar{q}) = c(\bar{q}) + \bar{u}$. Let’s check the participation constraint of the buyer. Substituting $P(q)$ we get: $V(\bar{q}) - c(\bar{q}) - \bar{u} \geq \pi$, which ends up being $S(\bar{q}) - \bar{s} \geq 0$, which is true since $\bar{q} = \bar{q}$ and, by assumption, $S(\bar{q}) - \bar{s} \geq 0 \ \forall \ q \in [q, \bar{q}]$ and $q \geq q$. For cooperation to be achievable, the DICC of both parties must hold. Then, combining equations $DICC^m_s$ and $DICC^a_b$ we get: $\delta^m_s \geq \frac{c(q) - c(q) + \pi}{V(q) - c(q) - \bar{u}}$. Hence, cooperation takes place for all values of delta that satisfy $\delta^m_s$.

PROOF OF PROPOSITION 10 First let’s prove that $IRC^m_s$ binds. If $IRC^m_s$ binds, then $P(q) + c(q) = \bar{u}$. Substituting $IRC^m_s$ in $DICC^m_s$ yields: $\frac{\pi}{1 - \delta} \geq \frac{\pi}{1 - \delta}$, which is true. Then $IRC^m_s$ binds. If $DICC^m_s$ binds we have $p + b(q) - c(q) = p - c(q) + \frac{\pi}{1 - \delta}$. Rearranging we get $b(q) = c(q) - \delta p + \bar{u}$ and by substituting in $IRC^m_s$ we get $p > 0$ which is not true as by assumption the fixed payment can be zero. Now let $y^*$ be the equilibrium contract that a buyer offers to an agent, where $P(Q) = p + b(Q)$. The buyer maximizes profits holding $IRC^m_s$ with equality: $P(q) = \pi + c(q)$, and solving for $p$ in both $IRC^m_s$ $(p = \bar{u} + c(q)) - b(q))$ and $DICC^m_s$ $(p \geq c(q) + \frac{c(q) - c(q) + \pi - b(q)}{\bar{s}})$. Substituting $IRC^m_s$ in $DICC^m_s$ and rearranging we get $b(q) \geq c(q) - c(q) + \bar{u}$, which holds with equality because the buyer is maximizing his utility subject to the participation of the seller. He will only offer a $b(q)$ large enough to induce quality and participation. Substituting back into the $IRC^m_s$ and rearranging leads to $p = c(q)$. Combining $p$ and $b(q)$ the total payment is $P(q) = \pi + c(q)$. Substituting $P(q)$ in the buyer’s objective function, solving for the first order Kuhn-Tucker conditions and since

\[
V'(q) = \begin{cases} 
< c'(q) & \text{if } q^* = \bar{q} \\
= c'(q) & \text{if } q < q^* < \bar{q} \\
> c'(q) & \text{if } q^* = \bar{q}.
\end{cases}
\]

174
by assumption, then the principal requests $q^* = \overline{q}$. Therefore, $P(\overline{q}) = p + b(\overline{q}) = c(\overline{q}) + \overline{u}$. Finally, checking the buyer’s DICC it is satisfied for $a_b \geq \frac{c(q) + \overline{u} + \delta \overline{V}(q)}{(1 - \delta) c(q) + \overline{u}} \in (0,1)$, given $S(q) > \overline{s}$. Let’s check the participation constraint of the buyer. Substituting $P(q)$ we get: $V(\overline{q}) - c(\overline{q}) - \overline{u} + a_b (c(q) + \overline{u} - c(q)) \geq \overline{\pi}$, which ends up being $S(\overline{q}) - \overline{s} + a_b \overline{u} \geq 0$, which is true since $q = \overline{q}$ and, by assumption, $S(\overline{q}) - \overline{s} \geq 0 \forall q \in [\underline{q}, \overline{q}]$ and $q \geq q$ and $a_b \overline{u} \geq 0$. For cooperation to be achievable, the DICC of both parties must hold. Then, combining equations $DICC_s$ and $DICC_b$ we get: $\delta^a \geq \frac{(c(q) - c(q) + \overline{u})(1 - a_s)}{V(q) - c(q)} - \frac{a_b (c(q) - c(q))}{\overline{\pi} - a_b (c(q) - c(q))}$. Hence, cooperation takes place for all values of delta that satisfy $\delta^a$.

PROOF OF PROPOSITION 13 First let’s prove that $IRC_s$ binds. If $IRC_s$ binds, then $P(q) - c(q) + a_s U_{bt}^m = \overline{u}$. Substituting $IRC_s$ in $DICC_s$, yields: $\frac{\overline{u}}{1 - \delta} \geq \frac{\overline{s}}{1 - \delta}$, which is true. Then $IRC_s$ binds. If $DICC_s$ holds we have $\frac{p + b(q) - c(q) + a_s U_{bt}^m}{1 - \delta} = p - c(q) + a_s U_{bt}^m + \frac{\overline{u}}{1 - \delta}$. Rearranging we get $b(q) = c(q) - a_s U_b - \delta p + a_s (1 - \delta) U_{bt} + \overline{u}$ and by substituting in $IRC_s$ we get $p > 0$ which is not true as by assumption the fixed payment can be zero. Now let $y^*$ be the equilibrium contract that a buyer offers to a seller, where $P(Q) = p + b(Q)$. The buyer maximizes profits holding $IRC_s$ with equality:

$P(q) = \overline{u} + c(q)$, and solving for $p$ in both $IRC_s$ ($p = \overline{u} + c(q) - b(q) - a_s U_{bt}^m$) and $DICC_s$ ($p \geq \frac{c(q) + \overline{u} - (1 - a_s) b(q) - a_s V(q) + (1 - \delta) (a_s V(q) - c(q))}{\delta (1 - a_s)}$). Substituting $IRC_s$ on $DICC_s$ and rearranging we get $b(q) = \frac{c(q) - c(q) + \overline{u} - a_s V(q)) - V(q)}{1 - a_s}$, which holds with equality because the buyer is maximizing his utility subject to the participation of the seller.

He will only offer a $b(q)$ large enough to induce quality and participation. Substituting back into the $IRC_s$ and rearranging leads to $p = \frac{c(q) - a_s V(q)}{1 - a_s}$, which is zero because by assumption $c(q) = 0$. Combining $p$ and $b(q)$ the total payment is $P(q) = \frac{\overline{u} + c(q) - a_s V(q)}{1 - a_s}$.
Substituting $P(q)$ in the buyer’s objective function, solving for the first order Kuhn-Tucker conditions:

$$V'(q) \begin{cases} < c'(q) & \text{if } q^* = q \\ = c'(q) & \text{if } q < q^* < \overline{q} \\ > c'(q) & \text{if } q^* = \overline{q}. \end{cases}$$

Since $V'(q) > c'(q) \forall q \in [q, \overline{q}]$ and $q \neq \overline{q}$ by assumption, then the buyer requests $q^* = \overline{q}$. Therefore, $P(\overline{q}) = p + b(\overline{q}) = \frac{\pi + c(\overline{q}) - a_s V(\overline{q})}{1-a_s}$. Let’s check the participation constraint of the buyer. Substituting $P(q)$ we get: $V(\overline{q}) - \frac{\pi + c(\overline{q}) - a_s V(\overline{q})}{1-a_s} \geq \pi$, which ends up being $\frac{S(\overline{q}) - \pi}{1-a_s} \geq \pi$, which is true for any $a_b \geq 0$ since $q = \overline{q}$ and, by assumption, $S(\overline{q}) - \pi \geq 0 \forall q \in [q, \overline{q}]$ and $q \geq q$. For cooperation to be achievable, the DICC of both parties must hold. Then, combining equations $DICC_s^a$ and $DICC_b^m$ we get:

$$\frac{\pi^a}{\pi^q} \geq \frac{c(q) - c(q) + \pi - a_s V(q) - V(q)}{V(q) - c(q) - \pi + a_s V(q) - V(q) - \pi}. $$

Hence, cooperation takes place for all values of delta that satisfy $\delta^a$.

PROOF OF PROPOSITION 15 First let’s prove that $IRC_s^s$ binds. If $IRC_s^s$ binds, then $P(q) - c(q) - a_s U_{m_b} = \pi$. Substituting $IRC_s^s$ in $DICC_s^s$ yields: $\frac{\pi}{1-\delta} \geq \frac{\pi}{1-\delta}$, which is true. Then $IRC_s^s$ binds. If $DICC_s^s$ binds we have $\frac{\pi + b(q) - c(q) - a_s U_{m_b}}{1-\delta} = p - c(q) - a_s U_{m_b} + \frac{\pi}{1-\delta}$. Rearranging we get $b(q) = c(q) + a_s U_{m_b} - \delta p - a_s (1 - \delta) U_{m_b} + \pi$. By substituting in $IRC_s^s$ we get $p > 0$ which is not true as by assumption the fixed payment can be zero. Now let $y^*$ be the equilibrium contract that a buyer offers to a seller, where $P(Q) = p + b(Q)$. The buyer maximizes profits holding $IRC_s^s$ with equality: $P(q) = \pi + c(q) + a_s U_{m_b}$, and solving for $p$ in both $IRC_s^s$ ($p = \pi + c(q) - b(q) + a_s U_{m_b}$) and $DICC_a^a$ ($p \geq \frac{c(q) + \frac{c(q) + a_s V(q) + (1-\delta)(a_s V(q) - c(q))}{1+a_s}}{\delta(1+a_s)}$).

Substituting $IRC_s^s$ on $DICC_s^s$ and rearranging we get $b(q) = \frac{c(q) - c(q) + \pi + a_s V(q) - V(q)}{1+a_s}$, which holds with equality because the buyer is maximizing his utility subject to the participation of the seller. He will only offer a $b(q)$ large enough to induce quality and participation. Substituting back into the $IRC_s^s$ and rearranging leads to $p = 176$.
$c(q) + a_s V(q)$, which is zero because by assumption $c(q) = 0$ and $v(q)$. Combining $p$ and $b(q)$ the total payment is $P(q) = \frac{\pi + c(q) + a_s V(q)}{1 + a_s}$. Substituting $P(q)$ in the buyer’s objective function, solving for the first order Kuhn-Tucker conditions:

$$V'(q) \begin{cases} 
< c'(q) & \text{if } q^* = q \\
= c'(q) & \text{if } q < q^* < q \overline{q} \\
> c'(q) & \text{if } q^* = \overline{q}.
\end{cases}$$

Since $V'(q) > c'(q)$ $\forall q \in [q, \overline{q}]$ and $q \neq q^*$ by assumption, then the buyer requests $q^* = \overline{q}$. Therefore, $P(\overline{q}) = p + b(\overline{q}) = \frac{\pi + c(q) + a_s V(q)}{1 + a_s}$. Let’s check the participation constraint of the buyer. Substituting $P(q)$ we get: $V(\overline{q}) - \frac{\pi + c(q) + a_s V(q)}{1 + a_s} \geq \pi$, which ends up being $S(\overline{q}) - \overline{s} \geq a_s \pi$, which is true as long as $a_b \leq \frac{S(q) - \pi}{\pi}$ for $q = \overline{q}$ and, by assumption, $S(\overline{q}) - \pi \geq 0 \forall q \in [q, \overline{q}]$ and $q \geq q$. For cooperation to be achievable, the DICC of both parties must hold. Then, combining equations $DICC^s_b$ and $DICC^m_s$ we get: $\delta^{ss} = \frac{c(q) - c(q) + \pi + a_s (V(q) - V(q))}{V(q) - c(q) - \pi + a_s (V(q) - V(q))}$. Hence, cooperation takes place for all values of delta that satisfy $\delta^{ss}$.

PROOF OF PROPOSITION 16 To maximize the fair-type’s objective function $P_s(q_t) = \frac{V(q) + c(q)}{2}$. Substituting in the $IRC^m_s$, the following inequality must be true for a seller to accept the contract: $V(q) - c(q) \geq 2\pi$. Let $y^*$ be the equilibrium contract that a buyer offers to a seller, where $P_s(q_t) = \frac{V(q) + c(q)}{2}$. Solving for $p$, $p = \frac{V(q) + c(q)}{2} - b(q)$.

Also, solving for $p$ in the $DICC^s_m$ ($p \geq c(q) + \frac{c(q) - c(q) + \pi - b(q)}{\delta}$ and substituting $p$ on $DICC^m_s$ and rearranging we get $b(q) = \frac{c(q) + \pi}{1 - \delta} - \frac{\delta (V(q) + c(q))}{2(1 - \delta)} - c(q)$, which holds with equality because the buyer is maximizing his utility given his preferences. Substituting into the $IRC^m_s$ and rearranging leads to $p = \frac{V(q) - c(q) - 2\pi}{2(1 - \delta)} + c(q)$, which is $p = \frac{V(q) - c(q) - 2\pi}{2(1 - \delta)}$ because by assumption $c(q) = 0$. Combining $p$ and $b(q)$ the total payment is $P(q) = \frac{V(q) + c(q)}{2}$. Substituting $P(q)$ in the buyer’s objective function,
solving for the first order Kuhn-Tucker conditions:

\[ V'(q) \begin{cases} < c'(q) & \text{if } q^* = \bar{q} \\ = c'(q) & \text{if } q < q^* < \bar{q} \\ > c'(q) & \text{if } q^* = \bar{q}. \end{cases} \]

Since \( V'(q) > c'(q) \) \( \forall q \in [\underline{q}, \bar{q}] \) and \( q \neq \bar{q} \) by assumption, then the buyer requests \( q^* = \bar{q} \). Therefore, \( P(\bar{q}) = p + b(\bar{q}) = \frac{V(\bar{q}) + c(\bar{q})}{2} \). Let’s check the participation constraint of the buyer. Substituting \( P(q) \) we get: \( V(\bar{q}) - \frac{V(\bar{q}) + c(\bar{q})}{2} \geq \pi \), which holds if \( \frac{S(\bar{q})}{2} \geq \pi \). For cooperation to be achievable, the DICC of both parties must hold. Then, combining equations \( DICC^m_s \) and \( DICC^m_b \) we get: \( \delta^{IA} = \frac{c(q) - c(q) + \pi}{V(q) - c(q) - \pi} \). Hence, cooperation takes place for all values of delta that satisfy \( \delta^{IA} \).

**PROOF OF PROPOSITION 18** The buyer maximizes profits holding \( IRC^{WG}_s \) with equality: \( P_i(q_i) - c(q) + g_s q = \bar{u} \), and solving for \( p \) in both \( IRC^{WG}_s \) \( (p = c(q) - g_s q + \bar{u} - b(q)) \) and \( DICC^{WG}_s \) \( (p \geq \frac{c(q) - g_s q + \bar{u} - b(q)}{2} + c(q) - g_s q) \). Substituting \( IRC^{WG}_s \) on \( DICC^{WG}_s \) and rearranging we get \( b(q) = c(q) − c(q) − g_s(q − \bar{q}) + \bar{u} \), which holds with equality because the buyer is maximizing his utility subject to the participation of the seller. He will only offer a \( b(q) \) large enough to induce quality and participation. Substituting back into the \( IRC^{WG}_s \) and rearranging leads to \( p = c(q) - g_s q \), which is zero because by assumption \( c(q) = 0 \) and \( g_s q = 0 \). Combining \( p \) and \( b(q) \) the total payment is \( P(q) = c(q) + \bar{u} - g_s q \). Substituting \( P(q) \) in the buyer’s objective function, solving for the first order Kuhn-Tucker conditions yields:

\[ V'(q) + g_s \begin{cases} < c'(q) & \text{if } q^* = \bar{q} \\ = c'(q) & \text{if } q < q^* < \bar{q} \\ > c'(q) & \text{if } q^* = \bar{q}. \end{cases} \]

Since \( V'(q) > c'(q) \) \( \forall q \in [\underline{q}, \bar{q}] \) and \( q \neq \bar{q} \) by assumption, then the buyer requests \( q^* = \bar{q} \). Therefore, \( P(\bar{q}) = p + b(\bar{q}) = P(q) = c(\bar{q}) + \bar{u} - g_s \bar{q} \).

Let’s check the participation constraint of the buyer. Substituting \( P(q) \) we get:

\( V(\bar{q}) - c(q) - \bar{u} + g_s \bar{q} \geq \pi \), which ends up being \( S(\bar{q}) - \bar{s} + g_s \bar{q} \geq 0 \), which is true as
by assumption, $S(q) - \bar{s} \geq 0 \forall q \in [\underline{q}, \overline{q}]$ and $q \geq \underline{q}$. For cooperation to be achievable, the DICC of both parties must hold. Then, combining equations $DICC^W G_s$ and $DICC^W G_b$ we get: 

$$\delta_{WG} = c(q) - c(q) + \pi - g_s(q - \underline{q})$$

$$V(q) - c(q) - \pi + g_b q + g_s \underline{q}.$$ 

Hence, cooperation takes place for all values of delta that satisfy $\delta_{WG}$. 

179
Bibliography


