The Role of Cooperation and Reciprocity in Structuring Carbon Sequestration Contracts in Developing Countries

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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. However, the structure of the contracts may vary depending on the presence of selfish and altruistic agents.

This paper studies 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. We examine if the optimal structure of self-enforcing contracts differs if the

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reciprocity and cooperation are the result of the optimizing actions of purely selfish agents (so called instrumental reciprocity) or if they are the result of the presence of fair-minded agents who act according to altruistic reciprocity.

If cooperation and reciprocity are the result of instrumental reciprocity, i.e. optimization actions of selfish agents, then the relationship must be 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 Levin (2003) and MacLeod and Malcomson (1989).

If instead, cooperation and reciprocity are the result of the presence of fair-minded agents who act according to altruistic reciprocity, 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 fair-minded actors have been developed and fit via experimental methods by Brown, Falk, and Fehr (2004), Fehr and Schmidt (2007) and Roe and Wu (2009), but have not been derived in general, infinite-horizon settings as is done in this paper.

To examine if self-enforcing contracts are structured differently in the presence of non-selfish agents we consider a principal who acts according to other regarding preferences and an agent who remains purely self-interested. More specifically, we assume that the principal's objective function depends not only on his own payoff but also on the agent's payoff. Furthermore, the principal acts according to altruistic reciprocity. This assumption implies that the principal's utility increases with the well being of the agent. That is the principal's utility function is monotonically increasing with respect to the agent's payoff.

We find that when the principal acts according to altruistic reciprocity the structure of the optimal self-enforcing contract is identical to the optimal contract in the presence of a selfish principal. 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 principal interested in long-term carbon sequestration must offer the same contract structure regardless of his own preferences. This result implies 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 seeking to earn credits to satisfy compliance markets will offer.

More importantly, we find that the presence of an altruistic reciprocal principal increases the likelihood of cooperation in the long-term relationship relative to the case of a selfish principal. The minimum discount factor that sustains cooperation is inversely related to the coefficient of altruism representing the principal's sympathy for the agent's utility. In practical terms, this result implies 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 remainder of the paper is organized as follows. First, we briefly present the relational contracting model and we include the possibility that the principal acts according to altruistic reciprocity. Second, we characterize the optimal self-enforcing contract in the presence of selfish agents who act according to instrumental reciprocity. Third, we consider the presence of an altruistic principal and a selfish agent. We characterize the optimal contract under these circumstances and compare the contract structure and its sustainability with the case of pure instrumental reciprocity. We finalize with some concluding remarks.

The Model

Consider the relational contract model in which two risk-neutral parties, a principal and an agent, have the opportunity to trade carbon emissions offsets at dates $t = 0, 1, 2, 3 \ldots$. The agent possesses forest 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 principal is interested in reducing greenhouse gas emissions from deforestation and degradation. Thus, he is willing to pay the agent 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 long enough period of time, date t is the period of time that the principal wants the agent to keep the current land use. Furthermore, the principal may also be concerned about the payoff the agent receives, and therefore he may have social preferences because his utility may be affected by variations in the agent's payoff. 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 may have objectives that include economic development and therefore are an increasing function of agent payments. On the other hand a purely selfish principal, perhaps representing private companies engaged in emissions abatement, may only care about internal profit maximization.

The principal offers the agent a contract to achieve additionality and permanence of carbon offsets. At the beginning of period t, the principal and the agent agree on an initial baseline of carbon stocked in the forest land owned by the agent. Once the initial carbon stock baseline is established, the principal proposes to compensate the agent if she does not change the land-use and delivers the quantity of carbon initially agreed upon, q^*. Compensation consists of a fixed payment p_t and a contingent payment $b_t : Q \rightarrow \Re$, where Q is the observed tones of carbon. Carbon stocks are observable by both parties but they are not verifiable and therefore cannot be enforced by a neutral third-party. Consequently, the desired tones of carbon, q^*, may differ from the delivered quantity, q_t. Let $q_t \in Q = [\underline{q}, \overline{q}]$ denote the carbon delivered in period t, where $\overline{q}$ represents the carbon sequestered at the beginning of the period given the initial land use. $\underline{q}$ represents the quantity sequestered when the land use is changed completely to a non-forest activity.

The fixed payment, p_t, is formally enforceable and paid during the course of the trading period t; it is independent of the final outcome. The contingent payment is considered as a *bonus* and it is used to reward avoided DD. Since the contingency payment depends on an unverifiable measure, it is not a legally binding obligation.

After observing the compensation scheme, the agent decides whether to accept the principal's offer. If the agent accepts, she receives p, observes the returns of alternative land uses including non-forest activities and decides whether to adhere to the contract.

If she avoids DD, she incurs a cost for forest protection including the agent's opportunity cost of time of taking care of the forest, task difficulty and any material cost to protect the forest. The cost is given by $c(q_t)$ where $c'(.) > 0$, $c''(.) \geq 0$, and $c(\underline{q}) = 0$. The agent's utility is $U_t = P_t(q_t) - c(q_t)$, where $P_t(q_t) = p_t + b_t(q_t)$ is the total payment actually made from principal to agent.

At the end of period t and upon delivery, the agent's carbon stock generates a direct benefit for the principal, $V(q_t)$, where $V'(.) > 0$, $V''(.) \leq 0$, and $V(\underline{q}) = 0$. He also chooses whether to pay $b_t(q_t)$. The principal's utility is given by $\pi_t = V(q_t) - P_t(q_t) + a_b U_t$, where a_b is a non-negative parameter that represents the principal's utility weight on the utility of the agent.[1] If $a_b = 0$, the principal only cares about his own payoff and acts as a pure selfish agent. If $a_b > 0$ the principal acts according to altruistic reciprocity because his utility increases with the well being of the agent. Also, we assume that $V'(.) > c'(.)\ \forall\ q \in Q$, 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 $S(q_t) = V(q_t) - c(q_t)$.

If the agent rejects the contract, trade does not occur, the agent receives the value of the non-forest activity $\overline{u}$ and the principal receives $\overline{\pi}$ which is equivalent to utility gained from an 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 is $\overline{s} = \overline{u}+\overline{\pi}$, and we assume that $S(q_t)-\overline{s} > 0 \; \forall \; q \in (\underline{q}, \overline{q}]$, and $S(\overline{q}) > S(\underline{q}) \geq 0$.

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 they have traded allowing for the creation of relationships in which cooperation is an important characteristic. In addition, the agent's objective is to maximize the future discounted stream of payments and the principal's objective is to maximize the present value of his utility including material payoffs and his valuation for the agent's well-being when applicable. Moreover, parties discount their benefits by using a common discount factor given by $\delta \in (0, 1]$.

Parties rely upon informal incentives and good faith to self-enforce agreements because of the third-party unverifiability of carbon stocks. The ongoing interaction sustains the equilibrium by allowing the parties to support future terms of trade contingent on the satisfactory performance of present trade. We also assume the following. The parties cooperate if the history of play in all periods has been cooperation and break-off trade forever if any deviation is observed (Levin, 2003). Additionally, parties cannot renegotiate the trading decision after carbon sinks are observed. Also, 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, Gibbons, and Murphy, 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. Finally, because the principal's behavior is perfectly observable, a stationary contract delivers the optimal surplus and the reduction of carbon emissions from DD.

Instrumental Reciprocity in Relational REDD Contracts

When both the principal and the agent act according to instrumental reciprocity, the contract is structured in a way that satisfies the optimization actions of both selfish agents. The principal must offer a contract $y = \langle p, b(q) \rangle$ through which he provides additional incentives for the agent to avoid DD. After the agent accepts a contract y, parties may renege without a formal penalty. The agent then decides on how to use the land and it may differ from the desired use induced by the contingent payment rule in the contract. She can cooperate and choose $q_t \geq q^*$, or can shirk by choosing a non-forest activity.

The principal, 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, $b(q) = 0$. In this case, because the principal acts according to instrumental reciprocity ($a_b = 0$), he participates in the REDD contract if the pure monetary benefits from such contract are greater than his alternative source of carbon reduction. This is given by his individual rationality constraint (IRC_b^s) which is $V(q) - p - b(q) \geq \overline{\pi}$. In addition, the principal's offer has to meet the agent's individual rationality constraint (IRC_s^s) given by $p + b(q) - c(q) \geq \overline{u}$, i.e., the offer has to provide a credible incentive to perform en every period.

In addition, the contract is self-enforceable if the parties find cooperation to be the optimal strategy. Therefore, a dynamic incentive compatibility constraint ($DICC^s$) for each party has to be fulfilled to self-enforce the contracts. In this way, the parties prefer to behave according to the contract instead of reneging. The principal's constraint is given by $\frac{V(q)-p-b(q)}{1-\delta} \geq V(q) - p + \frac{\delta}{1-\delta}\overline{\pi}$, $(DICC_b^s)$, and the agent's constraint is given by $\frac{p+b(q)-c(q)}{1-\delta} \geq p - c(\underline{q}) + \frac{\overline{u}}{1-\delta}$, $(DICC_s^s)$.

The left hand side in $(DICC_b^s)$ and $(DICC_s^s)$ is the discounted payoff from cooperation for each party respectively and it represents the discounted gains from the relationship. In order for cooperation to occur, these gains must be greater than the payments from deviation (right-hand side). The most profitable deviation for the principal is to not pay the bonus while the agent's most profitable deviation is to change the land-use and to not incur in any cost for forest conservation. However, if the agent does not perform then the principal, after observing the carbon stocks delivered, will not pay the bonus. If either party reneges they get the benefits of the alternative options (next best carbon credit source and the alternative use of land respectively).

The principal solves for the optimal self-enforcing contract including the optimal distribution of the total compensation among the fixed payment and the performance bonus, by maximizing his long term utility: $\pi = \frac{V(q)-p-b(q)}{1-\delta}$ subject to IRC_s^s, IRC_b^s, $DICC_b^s$ and $DICC_s^s$.

Additionally, given the value of the optimal contract for each party, 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 $DICC_b^s$ and $DICC_s^s$ yields the discount factor necessary to achieve cooperation under the optimal REDD contract. The optimal stationary REDD contract and the discount factor that lead to cooperation are defined in Proposition (1).

Proposition 1. *When the principal and the agent act according to instrumental reciprocity and contract enforcement is imperfect, an optimal self-enforcing stationary REDD contract* $y^* = \langle p^*, b^*(q^*)\rangle$ *implements conservation of the forest land* $\overline{q}$, *satisfying* IRC_s^s, IRC_b^s, $DICC_b^s$ *and* $DICC_s^s$, *where* IRC_s^s *and* $DICC_b^s$ *bind, and the compensation scheme is char-*

acterized by a total payment $p + b(q) = \overline{u} + c(q)$ *which includes a fixed payment of* $p = c(\underline{q})$ *and a performance payment of* $b(q) \geq c(q) - c(\underline{q}) + \overline{u}$ *and cooperation under the optimal contract is achievable* $\forall\ \delta \in [\underline{\delta}^s, 1)$*, where* $\underline{\delta}^s = \frac{c(q)-c(\underline{q})+\overline{u}}{V(q)-c(\underline{q})-\overline{\pi}} < 1$.

Proof. See Cordero Salas (2010). □

Recalling the assumptions about the cost of forest conservation, $c(\underline{q}) = 0$, the fixed payment included in the optimal REDD is equal to zero. That means that under the optimal relational contract, when parties act according to instrumental reciprocity, the agent does not get paid anything upfront or during the time she is under the contract; all payments come at the end of period. The contingent payment includes the complete payment to the agent. The result when both parties are selfish is highlighted in the following corollary.

Corollary 1. *When the principal and the agent act according to instrumental reciprocity, 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.*

Furthermore, Proposition 1 reports the range of discount factors that can support a cooperative equilibrium under the optimal REDD contract in the presence of instrumental reciprocity. It predicts that parties who have a discount factor greater than or equal to the parameter $\underline{\delta}^s$ cooperate in the REDD context. A high discount factor threshold emerges when it is too costly for the agent to conserve the forest or if the returns of the non-forest activity are too high. Additionally, for any given REDD payment, when the benefit that a selfish principal accrues from the carbon sinks delivered by the contract is similar to the benefits of getting carbon credits from alternative sources, the discount factor needed for cooperation is also very high and cooperation is harder to sustain. Finally, the lower the cost of forest conservation is relative to the net returns from the carbon delivered under the contract, the smaller is the discount factor needed to self-enforce the contract.

Altruistic Reciprocity in Relational REDD Contracts

In this section we assume that the principal has some sympathy for the agent's well-being. Then, he gives some positive weight to the agent's utility such that $a_b > 0$. His utility is now given by $\pi_t = V_t(q_t) - P_t(q_t) + a_b U_t$ and his IRC_b^a is given by $V_t(q_t) - P_t(q_t) + a_b U_t \geq \overline{\pi}$.

Furthermore, the principal's $DICC_b^a$ also changes reflecting the principal's altruistic preferences. The $DICC_b^a$ for an altruistic principal is given by $\frac{V_t(q_t) - P_t(q_t) + a_b \overline{U_t}}{1-\delta} \geq V(q) - p + a_b \underline{U_t} + \frac{\delta}{1-\delta}\overline{\pi}$.

On the left hand side, the modified principal's DICC reflects his payoff if parties cooperate. In this case, the principal receives the materials payoff from the contract and his utility also increases with the payoff that the agent gets from the contract $\overline{U_t}$. On the right hand side, $DICC_b^a$ reflects the principal's utility when he deviates. In this other case, he gets the returns from the carbon offsets net of the fixed payment that is enforced and his utility is also affected by the utility that agent gets when the principal deviates, $\underline{U_t}$. $\underline{U_t}$ represents true altruism because the principal benefits from the agent's utility even if he deviates.

Consequently, a principal that acts according to altruistic reciprocity derives the optimal self-enforcing contract by maximizing his long term utility, $\pi = \frac{V_t(q_t) - P_t(q_t) + a_b U_t}{1-\delta}$, subject to IRC_s^s, $DICC_s^s$, IRC_b^a and $DICC_b^a$.

Note that the agent continues to act according to instrumental reciprocity, therefore, her individual rationality constraint and the DICC do not change. Then, a principal who acts according to altruistic reciprocity offers the optimal stationary REDD contract defined in Proposition (2).

Proposition 2. *An altruistic principal offers a optimal stationary REDD contract* $y^* = \langle p^*, b^*(q^*) \rangle$ *that implements conservation of the forest land* $\overline{q}$*, and satisfies* IRC_s^s*,* $DICC_s^s$*,* IRC_b^a *and* $DICC_b^a$*, where* IRC_s^s *and* $DICC_b^a$ *bind, and the compensation scheme is characterized by a total payment of* $p + b(q) = \overline{u} + c(q)$*, including a fixed payment of* $p = c(\underline{q})$ *and* *a performance payment of* $b(q) \geq c(q) - c(\underline{q}) + \overline{u}$.

Proof. First let's prove that IRC_s^s binds. If IRC_s^s binds, then $P(q) - c(q) = \overline{u}$. Substituting IRC_s^s in $DICC_s^s$ yields: $\frac{\overline{u}}{1-\delta} \geq \frac{\overline{u}}{1-\delta}$, which is true. Then IRC_s^s binds. If $DICC_s^s$ binds we have $\frac{p+b(q)-c(q)}{1-\delta} = p - c(\underline{q}) + \frac{\overline{u}}{1-\delta}$. Rearranging we get $b(q) = c(q) - \delta p + \overline{u}$ and 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 principal offers to an agent, where $P(Q) = p + b(Q)$. The principal maximizes profits holding IRC_s^s with equality: $P(q) = \overline{u} + c(q))$, and solving for p in both IRC_s^s ($p = \overline{u} + c(q)) - b(q)$) and $DICC_s^s$ ($p \geq c(\underline{q}) + \frac{c(q)-c(\underline{q})+\overline{u}-b(q)}{\delta}$). Substituting IRC_s^s on $DICC_s^s$ and rearranging we get $b(q) \geq c(q) - c(\underline{q}) + \overline{u}$, which holds with equality because the principal is maximizing his utility subject to the participation of the agent. 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 $p = c(\underline{q})$. Combining p and $b(q)$ the total payment is $P(q) = \overline{u} + c(q)$. Substituting $P(q)$ in the principal's objective function, solving for the first order Kuhn-Tucker conditions and since $V'(q) > c'(q) \;\; \forall \, q \in [\underline{q}, \overline{q}]$ and $q \neq \underline{q}$ 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 principal's DICC it is satisfied if $\alpha_b \geq \frac{c(q)+\overline{u}+\delta\overline{\pi}-\delta V(q)}{(1-\delta)c(q)+\overline{u}} \in (0,1)$, given $S(q) > \overline{s}$. □

Comparing the contracts in Proposition 1 and Proposition 2, we can see that the payment scheme in the presence of only parties that act accordingly to instrumental reciprocity is equivalent to the optimal payment in the presence of an altruistic principal and a selfish agent. Therefore, regardless of the preferences the principal may have, the optimal REDD contract has the same characteristics: a fixed payment close to zero and a performance payment that contains the entire of the payment including the cost of forest conservation and the value of the alternative economic activity for the agent. In other words, no matter how sympathetic the principal is toward the agent, 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 (3) gives the discount factor necessary to achieve cooperation under the optimal REDD contract when the principal is altruistic.

Proposition 3. *Cooperation under the optimal REDD contract is achievable* $\forall\ \delta \in [\underline{\delta}^a, 1)$, *where* $\underline{\delta}^a = \frac{(c(q)-c(\underline{q})+\overline{u})(1-\alpha_b)}{V(q)-c(\underline{q})-\overline{\pi}-\alpha_b(c(q)-c(\underline{q}))}$.

Proof. Let's check the participation constraint of the principal. Substituting $P(q)$ we get: $R(\overline{q}) - c(\overline{q}) - \overline{u} + \alpha_b(c(q) + \overline{u} - c(q)) \geq \overline{\pi}$, which ends up being $S(\overline{q}) - \overline{s} + \alpha_b\overline{u} \geq 0$, which is true since $q = \overline{q}$ and, by assumption, $S(\overline{q}) - \overline{s} > 0\ \forall\ q \in [\underline{q}, \overline{q}]$ and $q \geq \underline{q}$ and $\alpha_b\overline{u} \geq 0$. For cooperation to be achievable, the DICC of both parties must hold. Then, combining equations $DICC_s^s$ and $DICC_b^a$ we get: $\underline{\delta}^a \geq \frac{(c(q)-c(\underline{q})+\overline{u})(1-\alpha_b)}{V(q)-c(\underline{q})-\overline{\pi}-\alpha_b(c(q)-c(\underline{q}))}$. Hence, cooperation takes place for all values of delta that satisfy $\underline{\delta}^a$. □

Proposition 3 reports the range of discount factors that can support a cooperative equilibrium under the optimal REDD contract when the principal is altruistic. It predicts that parties that have a discount factor greater than or equal to the parameter $\underline{\delta}^a$ cooperate in the REDD contract. Recalling $c(\underline{q}) = 0$, the term in the numerator includes the total payment the principal has to make to the agent to avoid carbon emissions net of the principal's altruistic value of the payment. The denominator represents the principal's altruistically adjusted net benefit of the carbon sinks from the contract.

Similar to when both parties are selfish, a high discount factor is needed when it is too costly for the agent to conserve the forest or if the returns of the non-forest activity are too high. However, with an altruistic principal, the discount factor is inversely related to the parameter of altruism as $\frac{\partial \delta^a}{\partial \alpha_b} < 0$. Then, the more altruistic the principal is, the wider the range of discount factor that sustain cooperation.

Recalling the minimum value for the discount factor that sustains cooperation in the presence of two selfish agents, $\underline{\delta}^s = \frac{c(q)-c(\underline{q})+\overline{u}}{V(q)-c(\underline{q})-\overline{\pi}}$, and the assumption that $c(\underline{q}) = 0$, we can rewrite both $\underline{\delta}^s$ and $\underline{\delta}^a$ and compare the cooperation parameters.

$$\underline{\delta}^s = \frac{c(q) + \overline{u}}{V(q) - \overline{\pi}} > \frac{(c(q) + \overline{u})(1 - \alpha_b)}{V(q) - \overline{\pi} - \alpha_b c(q)} = \underline{\delta}^a$$

It is easy to see that cooperation is easier to sustain when the principal has some altruistic preferences. This leads to the following Corollary.

Corollary 2. *Cooperation is a more likely outcome in the presence of an altruistic principal than when he acts according to instrumental reciprocity. In the limit, as $\alpha_b \rightarrow 1$, $\underline{\delta}^a \rightarrow 0$, meaning that cooperation is always sustained.*

Concluding Remarks

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 paper, we have compared the structure of the optimal relational contract in the presence of purely selfish participants to the optimal structure when the principal is altruistic and places positive weight upon the utility gained by the agent but the agent remains purely selfish. We find that both optimal contracts offer identical incentives to the agent - 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, we find that the principal's altruism can impact the terms of trade in the carbon market. Specifically, the principal and agent 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 principal's altruism parameter. That means when the principal cares about the material payoffs of the agent, he is more willing to cooperate and sustain the long-term relationship than when he only cares about own monetary payoffs. These results have interesting implications for the design of self-enforcing contracts that attempt to reduce carbon emissions from deforestation and degradation. 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. These results open an interesting avenue for additional research as it leads to testable hypotheses and stimulates questions about how different forms of non-selfish preferences (e.g., maximin preferences or preferences for equality) might impact optimal relational contracts.

Notes

[1]This expression was first used by Edgeworth (1881) who referred to it as a coefficient of sympathy. It has been used by various authors to include altruism and spite in public good models and social preferences and interdependent preferences models. Examples of this are Anderson (1998), Andreoni and Miller (2002), and Levine (1998).

References

Anderson, G.J.K.H.C.A., Simon P. 1998. "A theoretical analysis of altruism and decision error in public goods games." *Journal of Public Economics* 70:297–323.

Andreoni, J., and J.H. Miller. 2002. "Giving According to GARP: An Experimental Test of the Consistency of Preference for Altruism." *Econometrica* 70(2):737–53.

Baker, G., R. Gibbons, and K. Murphy. 1994. "Subjective Performance Measures in Optimal Incentive Contracts." *The Quarterly Journal of Economics* 109:1125–1156.

Brown, M., A. Falk, and E. Fehr. 2004. "Relational Contracts and the Nature of Market Interactions." *Econometrica* 72:747–780.

Cordero Salas, P. 2010. "Designing Contracts for Reducing Emissions From Deforestation and Forest Degradation." Unpublished, Working Paper.

Edgeworth, F.Y. 1881. *Mathematical Psychics*. C. Kegan Paul and Co.

Fehr, K., and Schmidt. 2007. "Fairness and Contract Design." *Econometrica* 75(1):121–154.

Levin, J. 2003. "Relational Incentive Contracts." *American Economic Review* 93:835–847.

Levine, D. 1998. "Modeling Altruism and Spitefulness in Experiments." *Review of Economic Dynamics* 1:593–663.

MacLeod, W.B. 2006. "Reputations, Relationships and the Enforcement of Incomplete Contracts." Working paper, IZA Discussion Paper 1978, Institute for the Study of Labor (IZA).

MacLeod, W.B., and J. Malcomson. 1989. "Implicit Compatibility, and Involuntary Unemployment." *Econometrica* 57:447–480.

—. 1998. "Motivation and Markets." *American Economic Review* 88:388–441.

Roe, B., and S. Wu. 2009. "Do the Selfish Mimic Cooperators? Experimental Evidence from Finitely-Repeated Labor Markets." Working paper, IZA Discussion Paper No. 4084. Available at SSRN: http://ssrn.com/abstract=1369830.