Trust and Reciprocity in the Market-Based Provision of Public Goods: Experimental Evidence and Applications to Conservation Tenders

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Of all the environmental crises threatening the long-run prospects for the human species, the loss of biodiversity is the most irreversible. – Gowdy & McDaniel (1995), p.181.

Introduction

In 2000, a working group was initiated by United Nations Secretary-General Kofi Annan with the objective of assessing the consequences of ecosystem change and to create the "scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems" (Millennium Ecosystem Assessment [MA] 2005, p. 3). It was one of the main findings of the Millennium Ecosystem Assessment that gains in human well-being never before had been achieved at such high cost in terms of degradation of ecosystems.

Human well-being and ecosystem degradation are connected by the concept of ecosystem services, which are "the benefits people obtain from ecosystems" (MA 2005, p. 40). These include provisioning services such as food, water, timber, fuel, fibre, and medicinal resources; regulating services, for instance, air and water purification, pollination, erosion prevention, and pest and disease control; cultural services that provide aesthetic, recreational, educational, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling (Engel et al. 2008, MA 2005). As the report points out, the supply and resilience of ecosystem services are severely affected by the on-going loss and degradation of biodiversity[1] (MA 2005, p. 46). Few substitutes exist for biological species once they are extinct.

From an economic point of view, biodiversity loss is the result of a dysfunctional market, which trades the environment as an asset although its price has been incompletely specified. In the absence of an appropriate valuation system (cf. Costanza 1997; Gowdy and McDaniel 1995), the provision and use of ecosystem services is often subject to market failure because of imperfect property rights, the presence of external effects, uncertainty about future use or cost, and their public good nature (Tietenberg and Lewis 2009). However, whilst these characteristics have made conservation an area of government intervention and regulation in the past, the Millennium Ecosystem Assessment and institutional stakeholders (IUCN 2009, OECD 2010) have promoted "Payments for ecosystem services" as an additional and novel market-based instrument for securing conservation and sustainable use of ecosystem services.

[1] As set out in Article 2 of the United Nations Convention on Biological Diversity, "[b]iological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (UNTS 1993).

The voluntary, private provision of conservation activities is the core idea of the payments for ecosystem services (PES) approach. According to the theory of public goods, markets provide insufficient levels of environmental quality since its non-exclusiveness does not offer enough provision incentives for individuals (cf. Tietenberg and Lewis 2009, pp. 76). However, public goods can be provided on a private basis[2], relying on a binding agreement and combined with a direct payment compensating opportunity cost (Ferraro and Kiss 2002; Gerowitt et al. 2003). Accordingly, payments for ecosystem services can be broadly defined as a voluntary transaction where an ecosystem service or a specific land use to maintain that service is purchased by a service buyer from a service provider (Wunder 2005). In this way, PES address the price-setting problem by providing a "mechanism to translate external, non-market values of the environment into real financial incentives for local actors to provide such services" (Engel et al. 2008, p. 664). Incorporating a wide range of activities, such as land set-aside, reforestation, clearance of invasive species, or adoption of agricultural practices that favour regionally endangered species, PES are increasingly used in developing and developed countries (See Wunder et al. [2008] for an overview.).

Unlike other market-based instruments, such as tradable pollution or planning permits or taxes, all of which embrace a "Polluter pays approach", conservation programmes based on payments for ecosystems services implement a "Beneficiary pays principle". The rationale behind is the compensation of foregone profit due to voluntarily changed production methods or land management practices. Hence, PES are not substitutes but complement non-market-based environmental instruments. They establish a level of environmental quality that exceeds the minimum secured by environmental legislation, introduce more flexibility and permit dynamic efficiency in the provision of environmental goods and services (Bizer 1997, pp. 52). In addition to inter-temporal efficiency considerations, payments for ecosystem services are also statically cost-effective if they are competitively allocated to those most capable of using them.

Competitive tenders for allocating payments for ecosystem services have become increasingly popular in practice and have produced and inspired a rich scientific literature in different disciplines like ecology, environmental policy, agricultural economics, and economics. In an inverse (or reverse) auction-based PES scheme potential sellers of environmental goods compete for contracts with each other by submitting bids on their cost of providing the environmental good or service specified in the PES contract. The purchasing institution ranks bids according to an auction metric based on economic and ecological criteria and allocates contracts to the best-ranked bidders. If the financial budget is limited and the number of bidders sufficiently high, sellers are incentivised to bid close to their opportunity cost. Downward-bidding competition exploits heterogeneity in opportunity costs of potential providers, permitting a more cost-effective use of available conservation funds compared to

[2] See Bliss and Nalebuff (1984) and Hirshleifer (1983) for earlier discussions and applied cases of the private production of public goods (Avichai Snir is thanked for these references).

fixed-rate payments (e.g. Cason and Gangadharan 2004; Ferraro 2008; Groth and Freese 2006; Latacz-Lohmann and van der Hamsvoort 1997).

Notwithstanding the advantages of PES, and auction-based programmes in particular, the effectiveness of a conservation scheme crucially hinges on the enforcement of the contract, and its efficiency depends on the reliability of the stated cost. Contractual relationships involving payments for ecosystem services are characterised by information asymmetries. Often, buyers of environmental services (governmental agencies, non-governmental organisations or private-sector actors) neither have sufficient knowledge about the “true cost” of programme participation, nor do they have the capacities to appropriately monitor progress and sanction non-compliance. [3] Moreover, the provision of an ecosystem service might not be directly observable or measurable in output units. The providing sellers (landholders) have better knowledge on their opportunity cost and can also flexibly adapt to changing environmental conditions. Sellers therefore have a strategic advantage and may use their private information to exploit information rents from the buyers (Ferraro 2008; Latacz-Lohmann and van der Hamsvoort 1998), with potentially adverse effects on programme efficiency and effectiveness.

From a contract-theoretical perspective, the agreement between a seller and a buyer of an environmental good or ecosystem service constitutes a principal-agent relationship with one informed party (the seller/agent), whose information is relevant for the social welfare, and the uninformed party (the principal/buyer), proposing the contract (Salanié 2005). Since both parties have different objectives[4], their constellation drives problems of adverse selection and moral hazard that are particularly relevant in the context of competitive allocation procedures for PES contracts. If the buyer is imperfectly informed of the characteristics of the seller (hidden information), he might choose sellers who are providers at lowest cost but least effective in terms of conservation benefit (See Arnold et al. [2013] for a formal adverse selection model.). If the buyer is imperfectly informed of the actions of the seller (hidden action), the seller has an incentive to deviate to her individually rational level of compliance and the buyer cannot force the seller to implement the Pareto-optimal outcome (See Wu and Babcock [1996] for a formal moral hazard model.).

Targeting adverse selection is complex as conservation schemes must be tailored in a way that makes it difficult for sellers to misrepresent their environmental characteristics. A menu of contracts from which sellers self-select an individually incentive-compatible contract would be a theory-driven solution but the practical implementation of a menu approach is challenging and involves high transaction costs (Ferraro 2008). Moral hazard can be addressed by making the seller’s payment contingent on contract compliance and results

[3] According to Wunder et al. (2008, pp. 843) especially small-scale programmes do not dedicate enough funding to monitoring activities, and also large agri-environmental programmes implement annual site inspection rates of only five per cent. Moreover, sanctioning mechanisms are poorly developed.

[4] While a rational agent seeks to maximise the contract payment and minimise the cost of compliance, the principal’s goal is the complete enforcement of the contract under minimisation of payments.

instead of remunerating programme participation based on inputs. A results-oriented or outcome-based approach has the advantage of setting a direct incentive to provide the environmental good. However, a results-oriented payment shifts the risk of loss to the seller, making voluntary participation in the programmes unattractive. Another drawback of this remuneration method is the difficulty of finding appropriate indicators for measuring conservation outcomes (cf. Matzdorf et al. 2008), and taking into account the distorting influence of stochastic environmental parameters, such as changing weather conditions or market price fluctuations (Derissen and Quaas 2013; Zabel and Roe 2009).

These concerns raise the more general question on whether contracts for the provision of environmental goods should be understood as complete, i.e. fully contingent on all possible states of nature, or whether the characteristics of this type of agreement fit better within the strand of incomplete contracts. A contractual agreement between a buyer and a seller is regarded as incomplete if some aspects of it are unobservable or unverifiable, unforeseen or indescribable in advance, or if writing them into a contract is too costly (Maskin 2002). Building on the foundations set by Ronald H. Coase (1960) and Oliver E. Williamson (1985), an incomplete contract approach recognises the bounded rationality of economic agents, the existence of transaction costs and the role of relation-specific investments in economic relationships. All these aspects are of practical relevance in environmental markets and more specifically in the contractual relations between buyers and sellers of environmental goods.

Since the complete contract approach has been predominating in the scientific discourse to PES contracts, the range of solutions offered to moral hazard and adverse selection problems is driven by general or partial equilibrium theory. However, conservation neither takes place in a social vacuum nor does it involve completely rational decision-makers. On the contrary, conservation programmes create social externalities (cf. Greiner and Stanley 2013) and their effectiveness is strongly correlated to the individually shaped beliefs and preferences towards the environment (Jones 2010) and to the social capital inherent to a society (Pretty and Ward 2001). Social capital as the "ability of people to work together for common purposes in groups or organizations" (Fukuyama 1995, p.10) recognises relations of trust, common rules, norms and sanctions, and networks as important facilitators of coordinated action (Putnam 1993, p. 167). Hence, perceiving a PES contract as an incomplete contract and acknowledging the relevance of social capital for conservation paves the way for a different economic approach to payments for ecosystem services that advocates the relevance of trust and reciprocity of trust for overcoming asymmetric information problems.

In an incomplete contract, the interpersonal relations between the contracting parties and their social embeddedness need to compensate for the lack of formal institutions, e.g. insufficient third-party enforceability (Bohnet et al. 2001). For example, an investment specific to an economic relationship, i.e. with no or little value outside that relationship like in a PES contract, is risky and prone to opportunism by the other party (Williamson 1985). Taking such an investment requires trust – otherwise the relationship will suffer from socially inferior underinvestment in the environment. Trust thus acts as a stabilising mechanism and reduces uncertainty and transaction cost (cf. Ostrom and Walker 2003). Trust in the seller by the buyer should be regarded as the first prerequisite to mutually beneficial cooperation in PES contracts and all other agreements involving natural resource management (Reeson et al. 2008; Reeson 2011a).

However, trust itself is a risky endeavour and does not pay off unless the trusted party reciprocates the trust, making the seller's trustworthiness the second prerequisite for successful cooperation in PES contracts. Trustworthiness can be based on the social norm of reciprocity (Chaudhuri and Gangadharan 2007). Positive reciprocity, i.e. the act of returning a favour, is activated by a generous action, triggering what has been coined a "gift exchange" between principal and agent (Fehr et al. 1998; Fehr and Gächter 2000). Moreover, reciprocated trust creates a reputation of trustworthiness that can become a valuable asset and incentivise sellers to forego short-term rents for long-term cooperation (Ostrom and Walker 2003).

Acknowledging trust and reciprocity as prerequisites for cooperation provides a starting point for a different approach towards enhancing efficiency and effectiveness in conservation schemes. The activation of trust and reciprocity norms and the creation of incentives to build a reputation of trustworthiness are remedies to the exposed problems of asymmetric information that have yet to be addressed in the context of payments for ecosystem services. Against this background, it is the aim of this book to explore, analyse and provide empirical evidence on the role of trust and reciprocity as a means to overcoming asymmetric information in contracts for payments for ecosystem services.

The leitmotiv of all three essays compiled in this thesis relates to the gains from cooperation that are achieved when individuals are able to develop and reciprocate trust. Particular emphasis is put on the interdependency of trust and reciprocity of trust with applied market principles such as competitive contract allocation and discriminatory pricing rules, as typically used in inverse auction-based PES schemes. In this context, the performance-enhancing effect of trust and reciprocity of trust on contract-enforcement might be disturbed for three reasons:

- Competitive bidding for contracts and payments triggers a "market instinct"[5] in sellers and buyers of environmental goods that could become counterproductive to building and reciprocating trust, and prevents long-term cooperation.

- A discriminatory pricing rule as common in auction-based programmes is blind in regard to the socio-ecological linkages that are deemed to be so important for establishing successful cooperation in the governance of the environment.

[5] Reeson and Tisdell (2010) have coined this term for describing a reduced willingness to cooperate in a commons dilemma after having been confronted with and participated in a competitive tendering process.

- Reputational incentives get lost if repeated bidding is subject to the same ranking criteria as in the very first contract period.

A comprehensive analysis of these three hypotheses as well as empirical support is lacking but necessary in view of the increasing utilisation of competitive tenders to allocate payments for ecosystem services. This book aims at closing this gap and provides theoretical argumentation complemented by an empirical examination of the raised issues. The empirical parts are based on two laboratory experiments[6] in which voluntary participants made decisions in a controlled environment. Experimental economics, i.e. laboratory and field experiments, has become a useful tool for testing hypotheses related to conservation instruments, and conservation tenders, in particular (See Schilizzi [2013] for a comprehensive review of laboratory experiments in this area.).

Unlike field trials that test conservation instruments in their natural environment with real conservation activities (cf. Rolfe and Windle 2006), laboratory experiments create an artificial environment in which the variable of interest can be varied under *ceteris paribus* conditions. Experimental data may provide empirical support to hypotheses or disclose regularities, which are not well-explained by existing theories, and eventually enable refinement of the theoretical framework (Friedman and Sunder 1994). With regard to conservation instruments, experiments may also reveal innate characteristics in the population, such as the willingness to pay (or to accept as payment) for environmental goods, or act as a "test-bed" for new institutions or technical aspects before they are introduced in a field environment.

Using laboratory experiments as a test-bed for the influence of trust and reciprocity of trust in conservation tenders, the essays in this book dedicated to experimental work embrace the principles of the so-called social engineering or design economics[7] approach (cf. Santos 2011). In order to be able to derive valid insights from experiments related to existing markets, the experimental design needs to reflect the market and its inherent incentive structure, as closely as possible, without neglecting the principles of induced value theory, namely, monotonicity, salience and dominance[8] for validity of the collected data (Friedman and Sunder 1994, pp. 7). Hence, the experiments in this book have been tailored to fit the specific market characteristics of conservation tenders but have been reduced in their degree of reality if it was methodically necessary.

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[6] The experiments were mainly funded by the chair of Economic Policy and SME Research at the University of Göttingen, and to a smaller extent by a grant donated by the German Federal state of Lower Saxony.

[7] Design economics, as Ana Santos puts it, "is devoted to the (re)design of complex markets and other economic institutions to be implemented in context-specific environments, to which end the opportunistic behaviour of economic agents and their propensity to err must be taken into account. The ultimate goal is to conceive a structure of incentives such that individual actions can generate desirable social states" (2011, p. 719).

[8] The monotonicity condition requires that participants in experiments prefer more to less reward medium. Salience implies the relatedness between actions in the experiment and payments. The dominance criterion postulates that changes in the utility of participants mainly depend on changes of the payment.

Unlike prior experimental work in this area, which kept the main focus on the bidding phase (e.g. Cason and Gangadharan 2004; Reeson et al. 2011b; Schilizzi and Latacz-Lohmann, 2007), the test design developed for this book consists of an inverse auction and a contract stage, represented by an effort-level game[9]. The two-stage design permits an analysis of the interplay between behaviour in the competitive bidding phase and *ex post* contract enforcement, and is therefore well-suited to analyse information asymmetries in conservation tenders. With regard to monotonicity and dominance, a neutralisation of the subject-matter of the contract was necessary in order to level out environment-related characteristics and preferences of the participants. Therefore, the traded good has been neutrally framed as a public good, with non-exclusive and non-rival benefits for all market participants. Since most environmental goods share the characteristics of public goods, the collected experimental data on cooperation preferences as well as related analysis and interpretation has been discussed in regard to its relevance for conservation instruments.

The thesis is organised in three chapters: The first chapter, by Nora Vogt, Andrew F. Reeson, and Kilian Bizer, addresses the potential conflict between competitive bidding and trust and reciprocity of trust in contracts for environmental goods, and shows how non-binding communication between sellers and buyers successfully eliminates information asymmetries in their contractual relationships. Building on the established literature on conservation tenders, the authors argue that contracts involving natural resource management are usually incomplete and that this makes trust a crucial determinant for the effectiveness of inverse auction-based conservation programmes. In order to prove this hypothesis, a two-stage experimental market design, a repeated inverse auction combined with an effort-level game to provide a public good, is developed, tested, and complemented by a bilateral chatting tool as a treatment variable. Since communication has been reported as one of the most powerful tools to solve social dilemmas, a text-based and non-binding communication channel between buyers and sellers was expected to enhance trust and trustworthiness, by opening a direct interface prior to the bidding phase. Organised as a within-subject experimental test design, participants interacted in both market environments with and without the chatting tool. The authors show that communication leads to Pareto-superior market results in the short and long-run without efficiency losses. Communication even continues to have an effect on cooperation behaviour after it has been switched off in the second phase of the experiment. They also provide empirical evidence for the parallel occurrence of adverse selection and moral hazard in the experimental scenario without communication. Finally, the reported dominance of relational contracting and long-term contract relationships is another important

[9] An effort-level game is an experimental test design developed for labour market experiments in which employers and workers conclude incomplete contracts (Camerer 2003, pp. 95). Participants acting as employers set a wage level and the contracted participant acting as worker individually decides on an effort level, i.e. degree of contract enforcement. Effort incurs convexly rising cost to the worker but generates linearly increasing payoff to the employer. Under the rationality assumption, self-interested workers will exert minimal effort and, therefore, profit-maximising employers pay minimal wages (cf. footnote # 4). Experimental applications (e.g. Fehr et al. 1998; Fehr and Gächter 2000) report systematic deviations from the non-cooperative game-theoretic equilibrium since workers reciprocate non-minimal wages with non-minimal efforts. The “gift exchange” is a robust finding in one-shot games, explained with reciprocity as a social norm.

finding of the survey, impressively demonstrating the role of trust-based relationships between the auctioneering institution and the sellers.

The second chapter, by Nora Vogt, is concerned with the influence of discriminatory pricing on the performance of the market-based provision of environmental goods and its sensitivity to exogenous environmental influences. Supported by recent literature, it is argued that the effort of fulfilling a conservation contract is easily distorted by exogenous environmental influences, such as adverse climatic conditions, that are often unverifiable by the buyer but observable for the seller. These stochastic influences are beyond the seller's control; however, the seller's informational advantage gives rise to two possible response strategies: While an opportunistic seller exploits the additional information rents and undersells, a reciprocating seller interested in fulfilling the contract augments the bid to counterbalance potential distortions. The author argues that environmental risk is detrimental to the establishment of a reciprocal payment-effort relationship between sellers and buyers in the short-term and long-term, and tests this hypothesis within the two-stage experimental design for the market-based provision of public goods. Environmental risk is modelled as a probabilistic upward or downward transformation of the performance level chosen by the seller and interacted as a treatment variable with fixed and random player identities. The resulting 2x2 between-subject test design permits a thorough empirical analysis of the impact of environmental risk on reciprocity norms in an anonymous trading environment, and with identification. The results demonstrate that environmental risk exacerbates the existing information asymmetries between sellers and buyers, negatively impacts the establishment of reciprocal payment-effort relationships, and reduces the efficiency and the effectiveness of the contract. Although some sellers maintain strong social preferences even in for them unprofitable situations, buyers do not put enough trust in the sellers and break up after negative shocks. Repeated interaction is found to mitigate the influence of environmental risk but the effect is less strong than in a comparative environment without risk. Finally, Logistic regression analysis reveals that the buyer's acceptance behaviour is strongly determined by the ranking of bids, showing the potentially adverse effect of discriminatory bidding in heavily disturbed environments.

The book concludes with the third chapter, by Nora Vogt and Kilian Bizer, which integrates the core aspects of the two experimental studies and questions the long-term performance of competitive tenders with multiple sign-up rounds. Based on a transaction cost economics approach, the authors argue that a repeated auction bears the risk of a "fundamental transformation", i.e. asymmetry of bidding sellers and lock-in effects between specific sellers and the auctioneering institution, that weakens the intended bidding competition with uncertain consequences for cost-effectiveness. Based on a comprehensive literature review, the authors identify three sources of bidder asymmetry that are present in a repeated conservation auction. Learning, specific investments and the creation of social capital are hypothesised to bias the chances of winning a follow-up contract in favour of former auction winners, resulting in locked-in buyer-seller relationships. The authors compare selected data from the two laboratory experiments on conservation auctions and show under which conditions lock-in effects are likely to occur in a controlled environment. They find contract relationships to be strongly bilateralised in the experimental auction scenario with social capital formation and learning effects, showing how communication with few bidders fosters asymmetry, whereas in the second scenario with limited feedback and learning effects due to a disturbed environment, they do not detect preferences of buyers for specific sellers. The authors show that long-term contract relationships are characterised by superior performance levels, suggesting that lock-in effects do not erode the effectiveness of an auction but that relationship-specific investments establish more favourable conditions for the provision of the public good, instead. Finally, in view of the mediocre performance of the market characterised by risk, they discuss institutional elements that would save reputational incentives in repeated auctions even under adverse environmental circumstances.

Returning to the problem of asymmetric information in contracts for payments for ecosystem services posed at the beginning of this book, the lessons that can be drawn from this thesis are the following: Competitive bidding is a cost-effective allocation mechanism for payments for ecosystem services if the relationships between sellers and buyers of environmental goods are based on mutual trust and understanding, and if the provisioning environment is not overly distorted by external environmental influences. Otherwise, the competitive market structure inherent to auction-based programmes fuels opportunistic and selfish behaviour on both sides, with counterproductive effects for programme effectiveness and efficiency. Social capital has been approved as a very strong vehicle to increase efforts of contractors and to generate strong ties between them that contradict to some extent the initial idea of an auction on a level playing field. However, in view of the empirical evidence for a superior performance of long-term contract relationships compared to low-cost short-term contracting, designers of future conservation programmes should provide sufficient opportunities to build trust and form networks (e.g. regular stakeholder meetings, transparent access to information), that are essential for securing the success of conservation programmes.

Although this book provides important empirical evidence as to the relevance of trust and reciprocity of trust in conservation programmes, this work can only be considered a start, with limitations that suggest directions for further research. The line of argument relies to some extent on experimental evidence interpreted with econometric techniques, raising questions of internal as well as external validity. Therefore, a replication of the data and results reported in this book is desirable in order to validate and strengthen their argumentative power, and to explore hitherto neglected parameters, e.g. social identity. Moreover, criticism with regard to the real-world representativeness of results obtained in laboratory experiments is justified and can only be effectively rebutted by corresponding field studies. Therefore, field experiments or surveys collecting data on the short- and long-term impact of social capital in auction-based conservation programmes are strongly encouraged and necessary for further research.

It is beyond the scope of this thesis to provide and discuss field data, however, the different elements of the experimental market tested in this book relate to other strands of experimental research that are beyond an application to environmental markets. With regard to the gift exchange literature, the experiments reported in this book add to our understanding on relational contracts and long-term contract relationships, as relevant for every employment relationship. Moreover, the private provision of public goods and the dynamic interplay of competition and quality has immediate relevance not only in an environmental context but also with regard to the privatisation of educational and health services.

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1 Communication, competition and social gift exchange in an auction for public good provision

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Abstract

Reverse auctions are an established policy instrument for allocating conservation contracts. While the auction mechanism has been the subject of a number of studies, less attention has been paid to the post-bidding contract phase. As contracts involving natural resource management are usually incomplete, trust becomes crucial for the effectiveness of the programme. We test the effect of communication between auctioneer and bidders on bidding behaviour and contract fulfilment using experimental economics. We combine a repeated reverse auction with an effort-level game and use a bilateral chatting tool as treatment variable. Without communication, auctioneers tended to select the lowest-priced bidders, who invested substantially less than the socially optimal level of effort when fulfilling their contract to provide the public good. Relational contracting proved important, with effort levels and profits tending to be higher when auctioneers and bidders entered into consecutive contract relationships. In the communication treatment there was no evidence of price competition, as auctioneers were more likely to accept high-priced bids. However, an overall higher price level did not lead to efficiency losses, since contractors realised higher effort levels in return, establishing a 'social gift exchange'. Our results demonstrate the importance of trust-based relationships between the auctioneering institution and landholders.

2 Environmental risk negatively impacts trust and reciprocity in the market-based provision of environmental goods

Abstract

Conservation contracts between a landholder and an agency are characterised by information asymmetries since monitoring is incomplete and the provided outcome is often not verifiable. Their contractual relationship is complicated by environmental risk, e.g. climatic conditions, that are often observable for the landholder, only. It was tested whether environmental risk is detrimental to the establishment of a reciprocal payment-effort relationship in an experimental auction-market for a public good, in an anonymous trading environment and with re-identification of bidders. In this market, auction winning sellers either reinvest their contract payment in a public good or behave opportunistically and exploit information rents. The data show that environmental risk increases opportunistic behaviour of some sellers while others maintain strong social preferences even in for them unprofitable situations. Further, environmental risk is found to decrease contract efficiency and to disturb the formation of effective long-term contract relationships as buyers do not put enough trust in the sellers, pay minimal wages, and break up after negative shocks. Repeated interaction mitigates the influence of environmental risk by benefitting contract enforcement and increasing efficiency due to higher reinvestment shares of wages, although the effect is less strong than in a comparative environment without risk. These results suggest that in a variable environment competitive bidding might be a less suitable mechanism for allocating conservation funds.

Contents

1. Introduction

Market-based conservation instruments, such as “Payments for ecosystem services”, are increasingly used as an alternative to conventional command and control approaches. Within these instruments, landholders voluntarily agree to provide a conservation service that is ‘bought’ by a regulating agency, at a specified price (Wunder 2005). Paying landholders for the provision of environmental goods and services establishes a principal-agent relationship between the regulating agency and the individual landholder. Their relationship is characterised by strategic and environmental risk and uncertainty, creating substantial informational advantages for the landholders. While strategic uncertainty refers to information asymmetries concerning the landholders’ actual activities, environmental risk and uncertainty (such as extreme weather conditions or changing commodity prices) imply external influences that are beyond the agent’s control but can substantially affect the proper fulfilment of a conservation contract (cf. Derissen and Quaas 2013; Zabel and Roe 2009; Gangadharan and Nemes 2009; Messick et al. 1988).

Environmental risk or uncertainty exacerbates informational asymmetries in principal-agent relationships, since the principal cannot differentiate between the agent’s compliance level and environmental influences affecting the output. While this increases the potential for opportunism on the part of the agent, in case of the principal trust comes at the expense of an increased risk of loss. As a consequence, these relationships often fail to be Pareto-optimal and are prone to moral hazard or adverse selection problems (cf. Arnold et al. 2013). Without environmental risk or uncertainty, informed agents can signal information, or reciprocate cooperative with non-selfish behaviour. If both parties have the option to respond reciprocally to the other party's actions, strategic uncertainty can be overcome and cooperation sustained as equilibrium (Fehr et al. 1997). Hence, repeated market interaction attenuates the risk of moral hazard since market participants can establish a reputation of reciprocating (Brown et al. 2004, 2012; Fehr et al. 2009).

In a competitive market environment characterised by environmental risk it is questionable whether repeated interaction still leads to the formation of trust-based relationships, benefitting contract-enforcement. In combination with environmental risk, competition could become counterproductive to the maintenance of social preferences (cf. Reeson and Tisdell 2010). This question is of particular relevance for the market-based provision of environmental goods, as long-term contractual obligations and stable relationships are preferable to short-term contracting. Environmental risk (and asymmetric information about its materialisation) might become an insurmountable obstacle to reputation-building and long-term cooperation in environmental markets, thereby having a detrimental effect on the intended conservation measure and damaging cost-effectiveness.

Previous experimental studies suggest that the presence of environmental risk and uncertainty impedes the establishment of reciprocity norms especially in one-shot or anonymous interactions that require trust (Croson 1996; Rapoport et al. 1996). For instance, in a lenderborrower relationship, environmental uncertainty from the lender's point of view leads to a total break-down of credit granting if reputation-building and third-party contract enforcement are impossible (Fehr and Zehnder, in prep.). In the repeated game context with identifiable trading partners, there is experimental evidence for successful reputation building with stable and profitable contract relationships under environmental uncertainty (McAllister et al. 2011). The results of recent labour market experiments (Linardi and Camerer, in prep.; Gerhards and Heinz, in prep.) also indicate that environmental risk does not necessarily undermine reciprocal behaviour and cooperation. This paper questions if these findings for private returns also hold for the market-based provision of environmental goods, sharing characteristics of public goods.

Experimental studies with voluntary contribution mechanisms to public goods point towards a reduced willingness to cooperate in view of environmental risk and uncertainty (Dickinson 1998; Gangadharan and Nemes 2009; Keser and Montmarquette 2008; Messick et al. 1988). In view of a probabilistic and input-independent transformation of the return, participants tend to transfer their contributions to the private account that is unaffected by environmental risk or uncertainty (Gangadharan and Nemes 2009). Furthermore, contributions to the public good significantly decrease with increasing environmental risk of a probabilistic loss, with uncertainty about this risk, and also directly after a loss in the previous round (Keser and Montmarquette 2008).

In the context of the provision of (public-good type) environmental goods in conservation schemes, landholders might be induced to decrease their efforts towards contract fulfilment over time if the result is uncertain and not directly observable for the regulating agency. This raises the question of the optimal payment design. Derissen and Quaas (2013) show analytically that in presence of both environmental and strategic uncertainty a combination of action- and performance-based payments is optimal, in which the action-based fraction increases with environmental uncertainty[1]. While this model is analytically straight-forward, it cannot address the question how the presence of environmental risk and uncertainty affects reciprocity norms and, hence, contract enforcement, in the one-shot case or with repeated contracting.

Thus, it is the aim of this article to provide experimental evidence on how the (repeated) market-based provision of public goods is affected by the introduction of environmental risk on the buyer's (representing the regulator) side. In this market, combining an inverse auction with an effort-level game, payoffs for sellers (representing the landholders) consist of a performance-independent wage and an action-based income component out of the public good. Sellers decide individually on the share of the wage they want to reinvest into the

[1] While action-based (or input-based) payments apply to a pre-defined conservation measure, performance-based (or output-based) are contingent on the procurement of the environmental good. Pure performance-based payments are unfavourable with regard to environmental uncertainty, as the landholder bears the complete risk of loss. But pure action-based payments are not incentive-compatible in view of incomplete monitoring and unobservable actions (Derissen and Quaas 2013; Zabel and Roe 2009).

public good. In a previous experimental study with a similar two-stage design (Vogt et al. 2013), communication between sellers and buyers led to significantly higher wages, effort levels and more equitable profits for all market participants. Moreover, buyers tended to re-conclude contracts with the same sellers, leading to highly efficient long-term relationships.

The present experimental approach features an exogenous probabilistic effort transformation, only visible for the sellers, which substantially affects their individually rational performance level. Given the relevant empirical literature, it is questionable whether environmental risk increases self-regarding behaviour, or if sellers and buyers are more interested in establishing long-term cooperation and securing the provision of the public good for the entire market. In testing the market with a 2x2 experimental design (effort transformation x identification), it is investigated whether reciprocity norms can be established under environmental risk either in an anonymous trading environment, with identification and repeated interaction, or in none of the market scenarios.

2. Methods

2.1. Baseline scenario

The experimental design permits the investigation of the behaviour of individuals under environmental risk and asymmetric information in a competitive market for the provision of a public good (cf. Vogt et al. 2013). Reflecting key-issues of inverse auction-based conservation programmes, the two-stage market is based on four main elements (Table 1). There are two types of players: a buyer (auctioneer) and three sellers (bidders) who interact over 20 periods.[2]

Table 1: Design elements of the experimental scenario and corresponding stages in the market-based conservation programme

1. Inverse auction	Selection of sellers based on downward bidding competition	Landholders state their costs of programme participation, sealed bid discriminatory price rule ("pay-as-you-bid")
2. Incomplete contract	Execution of the contract Individual choice of effort	Provision of the ecological good or service Non-contractible quality of contract execution
3. Public good	Shared contract dividend	Non-exclusive benefit of the environmental good
4. Repetition	Reputation building	Periodical re-enrolment

At the beginning of every period, sellers submit wage offers between 100 and 250 experimental dollars. The buyer then chooses and pays one seller out of a budget that is set to 250 in every period. The contractual agreement between seller and buyer is incompletely specified (effort is non-contractible), which enables the contracting seller to freely choose a

[2] Total number of periods was not known to the subjects in advance in order to avoid end-game effects.

quality of contract execution between 0 and 100. Effort incurs costs to the contracting seller; they rise according to a convex effort-cost function in the range from 50 to 200.[3] Every contract generates a contract dividend that is split equally amongst all market participants; it rises linearly with the level of effort chosen by the respective seller.[4] The shared contract dividend represents the non-exclusive benefits of the environmental good, generated by the seller's effort. In every period, non-contracting bidders receive a share of the contract dividend and sellers also keep the remaining part of their wages. The buyer's payoff per period consists of the share of the budget not spent for wages plus the contract dividend. In the basic scenario, the buyer and the non-contracting bidders are informed on the seller's effort choice and their individual payoffs at the end of the period.

Given this payoff structure, the individually rational strategy for sellers is to maximise their individual net gain from contracting. Figure 1a shows that the net gain function for sellers (linear contract dividend minus convex effort cost function) has an interior optimum (50) that is novel compared to the zero-effort Nash-optimum in other effort level games (e.g. Brown et al. 2004) but a better representation of the specificities of a socio-ecological dilemma (cf. Vogt et al. 2013, Cardenas 2011). Since this function is common knowledge in the game, rational auctioneers should not pay any wages exceeding the corresponding cost of effort (100).[5]

Table 2: Combinations of strategies and impact on profits

Buyers / **Sellers**	**Selfish** (low wages)	**Non-selfish** (high wages)
Opportunistic (low efforts)	- , -	+ , -
Non-opportunistic (high efforts)	- , +	+ , +

Note: Signs in the matrix denote combinations of strategies and relative impact on profits (seller, buyer), grey-shaded field represents social optimum.

The social optimum, i.e. the maximum contract dividend and, hence, the highest provision level of the public good, is established only if the buyer pays wages higher than the Nash-solution, and the seller reciprocates with higher efforts (cf. Table 2). As the seller has an incentive to deviate from the social optimum to the individually rational provision level, the buyer faces a trade-off between risky earnings out of the public good and secure income resulting from paying low wages. Hence, the buyer needs to trust the seller and accept a potentially efficiency-increasing wage.

[3] Effort cost are calculated as follows $c(e) = 25 \cdot 4^{(0.5+e/100)}$, e is defined within the interval (0, 100).

[4] The individual share of the contract dividend d is calculated according to $d = mv\,(0.5 + e/100)/n$, where m is 0.5, 1.0 or 1.5 (p=0.33), v is a level parameter (set to 551), e is effort in the interval of (0, 100) and n is the number of market participants (4).

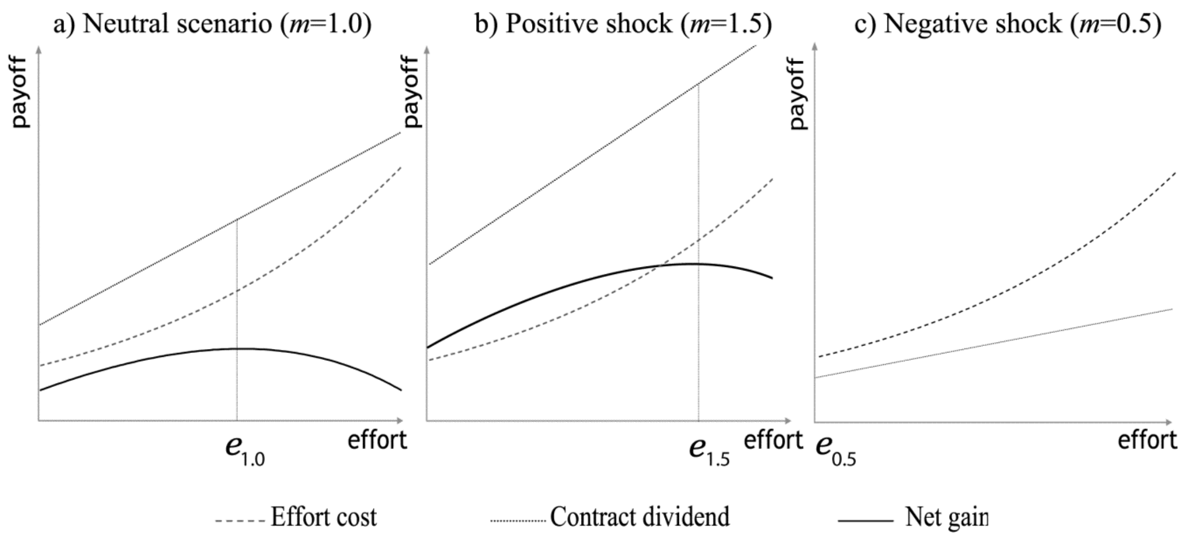
[5] The mentioned strategies relate to the one-shot case, the Folk Theorem applies with repetition.

2.2. Probabilistic effort transformation

As a source of environmental risk the public good can be subject to a probabilistic transformation, which is represented by the coefficient m in the contract dividend. The coefficient reflects environmental risk common in agricultural production and land management, such as extreme weather conditions. Information on the type of event taking place is asymmetrically distributed, as it is assumed that sellers have better information on the environmental conditions for their specific acreage than the buyers (cf. Cason and Gangadharan 2005; Derissen and Quaas 2013).

A random generator determines m in every period. There are three types of events (m = {0.5, 1.0, 1.5}) all of which are equally distributed with a probability of occurrence of 0.33 ($E(m)$ = 1). The transformation increases (or decreases) the steepness of the contract dividend and implies a reduction (or augmentation) of effort cost for the seller. A positive shock (m = 1.5) improves the respective setting, increasing potential returns from the public good and moving the interior optimum from 50 to a higher effort level of 80 (cf. Figure 1b). A period with a negative shock (m = 0.5) represents worsened conditions for the provision of the public good, changing the interior optimum to a corner solution of 0 (cf. Figure 1c). Thus, a negative shock makes it entirely unprofitable for the seller to fulfil the contract. A neutral shock (m = 1.0) represents the default scenario without transformation, as used in the baseline (cf. Figure 1a). Independently from the type of event, the contract dividend is always maximised with an effort level of 100.

Figure 1: Effort cost, contract dividend and net gain for contracting sellers under different scenarios



Only the contracting seller ever knows the coefficient that will apply to the contract dividend in that period, and learns this prior to selecting an effort level[6]. This timing represents the seller's information advantage to the buyer and the non-contracting bidders who all know the

[6] The effort decision screen entailed a calculator with the corresponding effort cost, contract dividend and individual profits.

probability distribution but not the outcome. The buyer and remaining bidders learn the contract dividend and the total profit at the end of the period, but cannot distinguish with certainty whether their payoff was affected by a transformation or not.[7]

2.3. Test design and experimental procedures

A 2 x 2 between-subject factorial design is employed to analyse if reciprocity norms can be established under environmental risk in an anonymous or non-anonymous provision environment. Thus, identification and the probabilistic effort transformation are combined as treatment variables in two levels (Table 3).

Table 3: Treatments used in the experiment

2 x 2 Factorial design	Random ID	Fixed ID
No effort transformation *m* set to 1.0	BRID	BFID
Effort transformation m={0.5, 1.0, 1.5} p=0.33	MRID	MFID

In the BRID baseline treatment, random re-matching of markets and random identification numbers (RID) in every period prevent reputation-building. MRID represents the anonymous market with environmental risk, including the effort transformation and random re-matching and IDs. In the MFID treatment, the probabilistic transformation of efforts is enabled and market participants are able to identify each other by fixed identification numbers (FID) and interact in the same constellation over 20 periods. BFID is the corresponding baseline market scenario without a probabilistic effort transformation[8] but with fixed IDs, permitting repeated interaction. This design permits testing in three dimensions: (1) the overall effect of environmental risk on the market-based provision of a public good (RISK to BASE), (2) the effect of identification in a market with environmental risk (MFID to MRID), and (3) the impact of environmental risk on the formation and characteristics of contract relationships (MFID to BFID). A between-subject design is used in order to limit learning and other interaction effects, e.g. signalling strategies in RID treatments after playing with FID.

Table 4: Session parameters

	MRID	BRID	MFID	BFID
Sessions	3	3	4	4
Markets	12	11	13	12
Participants	48	44	52	48
Periods	20	20	20	20

[7] This excludes some cases in which other market participants could draw inferences from the announced contract dividend to the random event. Contract dividends < 69 indicated a downward transformation; contract dividends > 207 indicated an upward transformation.

[8] Instructions in BRID and BFID treatments did not include any information on a potential multiplier (cf. appendix [to this chapter]).

The experimental sessions were conducted at the Goettingen Laboratory of Behavioural Economics in Germany, from October 29 to December 14, 2012. Table 4 presents the session parameters. The computerised experiment was coded with z-tree software (Fischbacher 1999). Participants were students from different disciplines who signed up and were recruited via ORSEE (Greiner 2004). All students participated in one treatment only. Upon arrival each student drew a hidden subject number referring to a PC cabin. In the cabin they were each given the same instructions for all subjects except that it was written at the top “You are an auctioneer” or “You are a bidder”. After reading the instructions, control questions on the calculation of payoffs and other rules of the games tested the participants’ understanding of the experimental setting. During the experiment communication was prevented by physical separation. Participants in the experiment earned an average of 15.30 €.[9]

3. Results

3.1. Main treatment effects

Figure 2 presents descriptive statistics of relevant market variables in all four treatment conditions MFID, MRID, BRID and BFID. The results are based on analyses of variances with two independent factor variables, producing the main treatment effects of environmental risk (BASE versus RISK) and fixed identities (RID versus FID) as well as their interaction effect. Moreover, non-parametric hypotheses tests are used for comparisons between single treatments.

3.1.1. Offers (Figure 2a)

An offer of at least 200 was necessary to realise the maximum level of the public good but the average offers in all treatments were below that threshold, even though offers in the RISK treatments were significantly elevated. Environmental risk induced sellers to make significantly higher offers regardless of whether they interacted in an anonymous or non-anonymous market ($F(1, 2819)=38.47$, $p<0.001$). Furthermore, offers were higher if sellers and buyers stayed together in the same market ($F(1, 2819)=6.15$, $p=0.013$). Thus, sellers bid highest in the non-anonymous market with risk (MFID) whereas bidding competition was most intense in the anonymous market without risk (BRID).

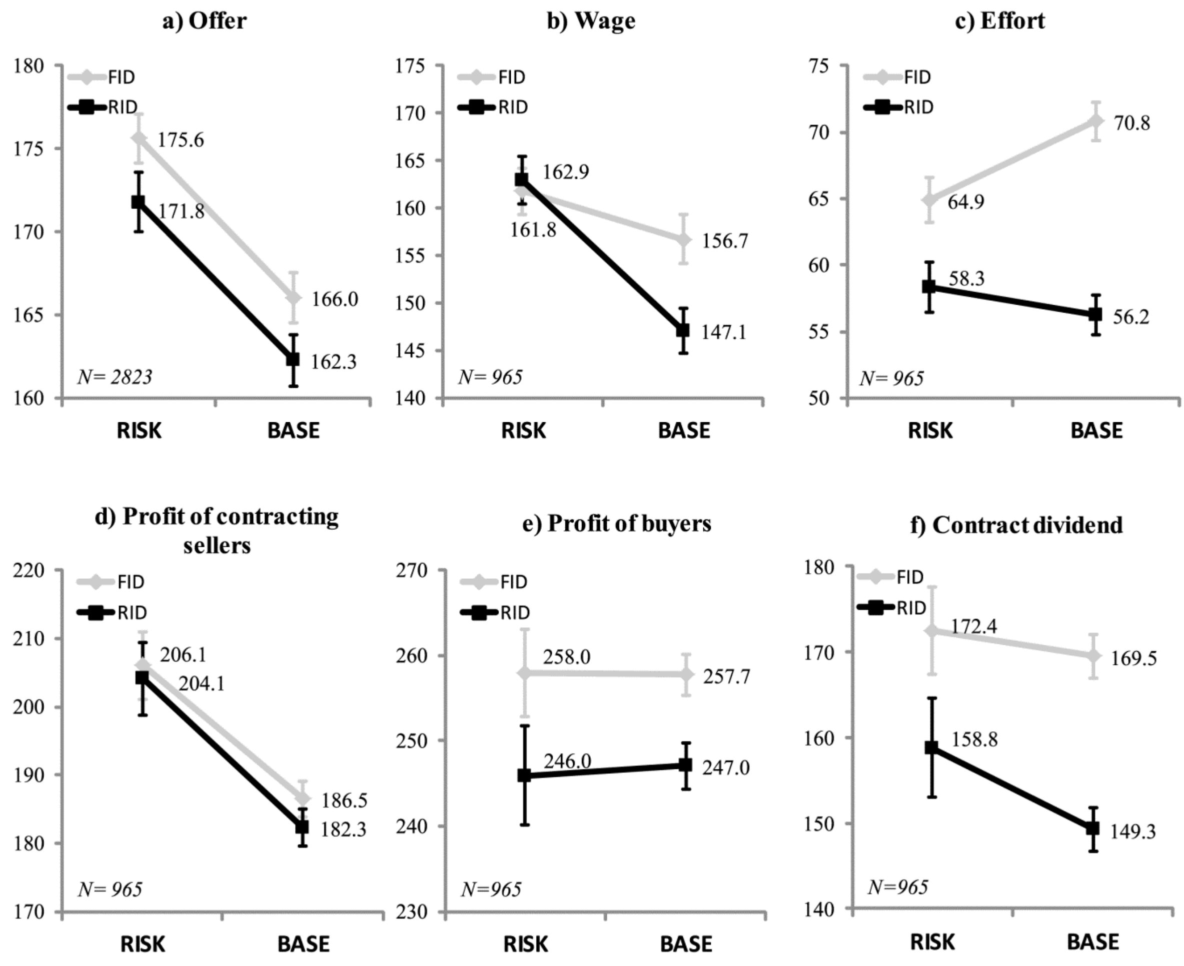
3.1.2. Wages (Figure 2b)

Corresponding to the increased level of offers, buyers paid significantly higher wages if they faced environmental risk ($F(1, 961)=17.71$, $p<0.001$). Fixed IDs did not produce an equally strong main effect on wages ($F(1, 961)=2.95$, $p=0.086$). Although wages differed significantly between BRID and BFID (Wilcoxon signed rank test: $z=2.766$, $p=0.006$), buyers facing environmental risk did not pay higher wages if they knew with whom they were repeatedly interacting. Interestingly, wages paid with fixed IDs were not statistically different between

[9] Including a show-up fee of 2.50 € and the results of a standard lottery game, data not shown.

BASE and RISK, indicating that risk did not overly distort wages in non-anonymous repeated markets. However, wages paid with random IDs differed significantly and reached the bottom line without risk (BRID) whereas the combination of risk and anonymity (MRID) led to the highest wage level across all treatments. Since the observed wage differential cannot result from reputation effects, the significant interaction effect (F(1, 961)=4.68, p=0.031) points towards substantial efficiency losses in anonymous risk markets.

Figure 2: Influence of environmental risk on the six main market variables with fixed and random IDs reported as mean values with standard errors



Note: 2a) mean offer made by three sellers per market in each period; 2b) mean accepted offer (paid wage) in each period; 2c) mean effort realised by contracting sellers; 2d) mean profit made by contracting sellers per period; 2e) mean profit per period of buyers; 2f) mean contract dividend per period, individual share.

3.1.3. Efforts (Figure 2c)

Environmental risk did not produce a clear main effect on efforts compared to the BASE treatments (F(1, 961)=1.35, p=0.245), suggesting that sellers did not behave more opportunistically with risk. However, sellers chose significantly higher efforts if they repeatedly played in the same market (F(1, 961)=41.09, p<0.001), regardless of whether their decision would be affected by a performance shock or not. Hence, the possibility to form a reputation seemed to have had a significant effect on sellers even in a heavily disturbed environment, as shown by the significant interaction between FID and RISK ($F(1, 961)=5.98$, $p=0.015$). But it was less effective as a contract-enforcing device compared to the scenario with complete *ex post* information for buyers (BFID). Although the effect of non-anonymous competition on contract execution is significantly larger in the base market[10], the difference is still significant between the MFID and MRID market (Wilcoxon signed rank test: $z=2.229$, $p=0.026$).

3.1.4. Profits (Figures 2d - f)

With environmental risk, profits for contracting sellers but not for buyers were significantly elevated compared to the BASE scenarios. In RISK markets, contracting sellers' profits were increased by 11 % ($F(1, 961)=24.21$, $p<0.001$). This difference can be explained with generally higher wages in markets with one-sided environmental risk and also reflects information rents realised by sellers who kept higher wage shares to themselves.[11] Buyers' mean profits remained unaffected by environmental risk but show a higher variance due to the different shocks. Fixed IDs significantly increased profits for buyers ($F(1, 956)=6.74$, $p=0.010$) but insignificantly for sellers, confirming less pro-social behaviour in random markets. Accordingly, contract dividends, i.e. the produced level of the public good including potential transformations, were significantly higher with fixed IDs ($F(1, 961)=15.14$, $p<0.001$). With environmental risk, contract dividends had a larger variance but were not significantly higher compared to the BASE markets.

3.2. Responses of sellers to the three different environmental shocks

In every round, only contracting sellers were informed on the environmental shock taking place. They could decide between optimising their effort choice corresponding to the shock or maximising the contract dividend despite the environmental condition. It was noticed earlier that the main effect of environmental risk on effort choices was insignificant across treatments (BASE versus RISK). Hence, despite the probabilistic shock, effort choices corresponded on average to those in the BASE markets. Nonetheless, seller behaviour was influenced by the random shocks as the distribution of efforts in RISK treatments is statistically different from sessions without (Kolmogorov-Smirnov-Test: exact $p=0.039$).

As presented in Figure 3, sellers adjusted their effort choices with regard to the shock taking place. Corresponding to the shift of the individually rational solution (cf. Figure 1), effort levels in both markets were significantly lower in the negative shock ($m=0.5$) and higher if a positive shock ($m=1.5$) occurred. Compared to the distribution of efforts in the random market with environmental risk, efforts in the MFID treatment were higher in the neutral and

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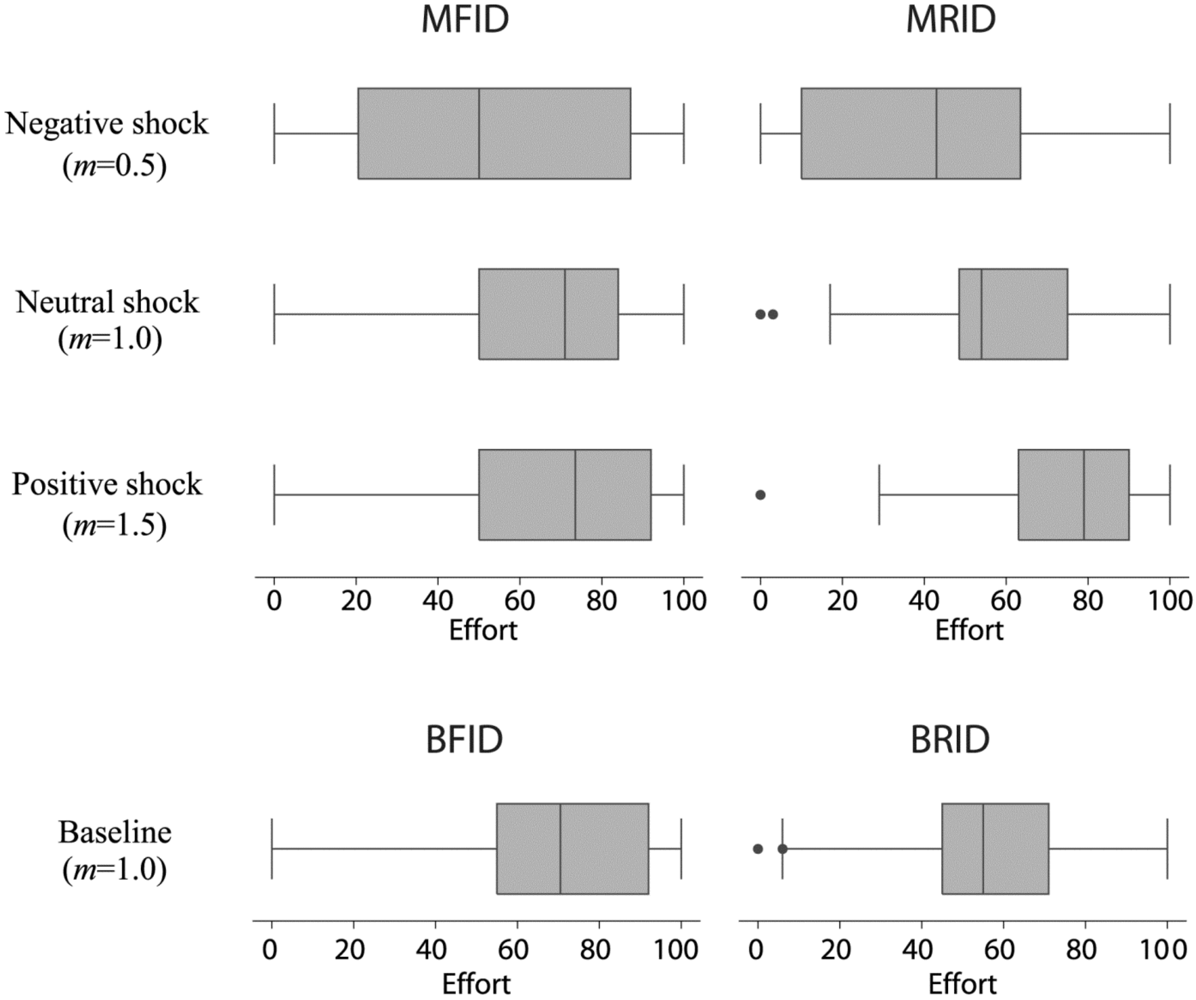
[10] Wilcoxon signed rank tests are significant for the difference between BFID and MFID ($z=2.368$, $p=0.018$) and between BFID and BRID ($z=6.792$, $p<0.001$).

[11] While sellers in the MRID treatment reinvested on average only 75 % of their wages, sellers in the MFID treatment spent 83 % for the public good. By contrast, sellers in the base market with fixed identities kept only 10 % of their wages to themselves. This share rises to 21 % in the random base market, confirming increased opportunism in an anonymous market context.

negative scenario. A nested random effects panel regression (Table 5) confirms these effects for both RISK markets, estimating a significant overall effect of fixed IDs of around 9 effort points.

Figure 3: Distribution of effort choices in periods with negative, neutral and positive shocks, and corresponding BASE markets



Note: Box-whisker plots with median, 25, and 75 percentile ranges and outliers, the vertical bars show minimum and maximum (excluding outliers).

The size of the offer had a positive and highly significant influence on efforts, however very high offers did not necessarily translate to very high effort levels (partly due to the upper bound of the effort level) as shown by the significant negative effect of the squared offer variable. Moreover, a positive shock induced sellers to increase their efforts significantly by 16 points in the random market and by 6 in the MFID treatment.[12] The negative scenario made positive efforts unprofitable for the sellers and, indeed, sellers reacted with a significant effort reduction of around 16 effort points.

[12] Coefficients presented must be interpreted with regard to the base category (neutral shock). In view of a neutral shock (*m*=1.0), RISK markets resembled BASE markets (cf. Figure 3), with efforts in the MFID treatment exceeding MRID performance significantly (Wilcoxon signed-rank test: z=2.775, p=0.006).

Nevertheless, at the individual decision level 26 % of all sellers in the non-anonymous and 13 % in the anonymous market aimed at the social optimum and realised effort levels beyond 85 effort points in periods with negative shocks. By contrast, only 19 % of the sellers in the MFID and 30 % in the MRID treatment exploited their informational advantage and chose low effort levels (<15 effort points) if they knew it would be unprofitable. While this shows that a substantial share of sellers had non-opportunistic preferences for the provision of the public good, it also demonstrates the catalytic effect of fixed identities for non-selfish performances in risky environments.

Table 5: Determinants of effort choices in markets with environmental risk

VARIABLES	Effort
Offer	0.789***
	(0.200)
Offer_squared	-0.00161**
	(0.000644)
Fixed identity (MFID)	9.366**
	(4.161)
Negative shock	-16.00***
	(3.639)
Positive shock	16.34***
	(4.751)
Negative shock x MFID	-1.744
	(6.416)
Positive shock x MFID	-10.75*
	(5.486)
Constant	-25.15*
	(14.79)
Observations	505
Number of id	75
Wald $\chi^2(7)$	187.75***

Note: Nested random effects panel regression with id-clustered, robust standard errors in parentheses. Fixed id, negative and positive shock as well as their interactions are binary variables, base category is neutral shock MRID (*m*=1.0).
*** p<0.01, ** p<0.05, * p<0.1

3.3. Acceptance strategies of buyers

In each round, buyers chose one offer out of three and paid the desired wage using their budget. Buyers and sellers knew that higher wages were necessary for socially superior contract performance. However, sellers competed for contracts and buyers had to decide between trusting and paying higher wages or distrusting and keeping more of their budgets to themselves. Environmental risk was not expected to affect decision strategies of buyers, since it could improve, maintain or degrade contract execution with the same probability.

However, markets with one-sided environmental risk were characterised by significantly higher offers and higher wages. The causality of the observed effects is unclear, permitting two possible explanations. On the one hand, buyers could have preferred higher to lower offers in order to trigger reciprocal responses, thereby increasing offers over time. On the other hand, higher wages could result from the overall higher offer level. As the individual decision spaces of buyers were confined to the menu of offers in each round, a higher wage level would thus be a direct consequence of sellers making higher offers. In line with the rationale of an inverse auction, buyers would then randomly select the lowest-priced sellers and signalling strategies of sellers were ineffective.

In order to address the causal relationship, a logistic regression (presented in Table 6) was carried out, measuring the treatment-specific odds ratios[13] for sellers to be accepted as a contractor. To begin with the marginal effect of the continuous offer variable, the table shows that for all treatments the odds of acceptance slightly declined if sellers increased their offers by one unit. Although the size of the effect is small, it indicates a general preference for lower offers, independent from risk or identification of sellers. In case their offer was the lowest available in that period, the odds of being chosen by the buyer were significantly improved for sellers in all treatments. The strongest effect was measured for the base market with random IDs, for which the odds of being selected as a contractor were 5.6 times higher if a seller's offer was the lowest available one, relative to non-minimal offers. The effect is smaller for MFID (3.6 times higher) and smallest for BFID and MRID (2.9). Hence, the relative ranking of offers was the most determining factor of the buyers' decisions as buyers favoured the lowest available offer. Therefore, the increased wage level in markets with environmental risk was a direct result of increased offers by sellers.

Under these circumstances it is questionable if fixed IDs and the probability to form a reputation really increased the chances of contract conclusion with environmental risk. And, indeed, while the chances of being re-selected as a contractor were significantly higher in the base market without risk, the effect of the lagged variable of acceptance is insignificant for MFID. Further controls reveal that contract-reacceptance in MFID rather depended on the shock in the previous period: If sellers contracted in periods with a negative shock, their odds of being re-chosen by the buyer in the next round were significantly reduced, compared to other shocks. As a result, buyer-seller relationships in MFID were also significantly shorter compared to the base market (Wilcoxon signed rank test on consecutive contract acceptance: $z=3.720$, $p<0.001$). Moreover, relationship length in BFID was positively correlated to effort (Spearman's rho: $\rho=0.1729$, $p=0.003$) whereas there was no positive correlation under environmental risk ($\rho= -0.0228$, $p=0.712$). Hence, buyers contracted rather randomly based

[13] The odds in favour of being accepted as a contractor are defined by the ratio of the probability of being accepted (p) to not being accepted (1–p). For example, in a market with three sellers (p=0.33), the odds for a seller to be chosen were 1 : 2. In a logit regression with standard output, the influence of an explanatory variable measured in odds is obtained by raising e to the power of the coefficient. Hence, a negative coefficient produces an odds ratio of a fraction smaller 1, a positive sign yields an odds ratio larger 1, and a coefficient of zero equals an odds ratio of one.

on the ranking of offers and failed to establish relationships as profitable as those in the BFID market.

Table 6: Determinants of contract acceptance

VARIABLES		Acceptance as contractor (Odds ratios)
Offer	Base market random ID	0.996***
		(0.00150)
	Base market fixed ID	0.996***
		(0.00147)
	Market with environmental risk random ID	0.998
		(0.00136)
	Market with environmental risk fixed ID	0.998*
		(0.00135)
Lowest offer (1 if lowest available offer in the specific period; 0 otherwise)	BRID	5.603***
		(1.031)
	BFID	2.938***
		(0.512)
	MRID	2.901***
		(0.503)
	MFID	3.367***
		(0.653)
Accepted in the preceding round (FID treatments only)	BFID	2.483***
		(1.247)
	MFID	1.401
		(0.369)
Negative shock (in preceding contract)	MFID	0.341***
		(0.136)
Neutral shock (in preceding contract)	MFID	0.737
		(0.240)
Constant		0.479***
		(0.119)
Observations		2,679
Wald $\chi^2(12)$		330.01***
Pseudo R^2		0.100

Note: Logistic regression, standard errors in parentheses. Offer is a continuous variable interacted with binary variables controlling for each treatment; the other variables are factorial interactions of binary treatment variables. *** p<0.01, ** p<0.05, * p<0.1.

4. Discussion

It was the aim of this article to address the question if the market-based provision of public goods is negatively affected by external environmental influences not observable for the buyer. Previous studies point towards an increased relevance of trust-based relationships in markets with asymmetric information (McAllister et al. 2011; Reeson et al. 2011; Vogt et al. 2013) but also emphasise how environmental risk and uncertainty become obstacles to mutually beneficial cooperation (Fehr and Zehnder, in prep.; Gangadharan and Nemes 2009). This experiment was designed to examine the effect of one-sided environmental risk in a competitive market for a public good in a random market context and with repeated interaction with fixed IDs. The market-based provision of public goods relies on trust as a prerequisite for a socially optimal outcome but the fulfilment of the conservation contract is often not easily verifiable and might become affected by exogenous environmental influences. Thus, environmental risk could be detrimental to the establishment of a reciprocal wage-effort relation, and hence, leads to inefficient provision levels.

The data analysis showed that environmental risk led to less efficient contracts, resulting from significantly elevated offers and wages but volatile effort levels, especially in the random ID markets. However, environmental risk increased opportunistic behaviour of some sellers while others maintained strong social preferences even in for them unprofitable situations. Repeated interaction with fixed IDs mitigated the influence of environmental risk by benefitting contract enforcement and increasing efficiency due to higher reinvestment shares of wages, although the effect was less strong than in a comparative environment without risk. Further, environmental risk was found to disturb the formation of effective long-term contract relationships as buyers did not put enough trust in the sellers and broke-up after negative shocks. Attempts by sellers to build a reputation were mostly ineffective since buyers showed distinctive preferences for the lowest-priced offers and followed rather random contracting strategies in the fixed ID scenario with environmental risk. As a consequence, contract relationships were less stable and also less profitable compared to the non-risk environment.

In this experiment, the sellers' contributions to the public good were positively correlated with the environmental risk multiplier, contrasting studies on public goods that reported significantly reduced provision levels in an uncertain environment (Dickinson 1998; Gangadharan and Nemes 2009; Keser and Montmarquette 2008; Messick et al. 1988). Although the public good in this market was provided by only one seller, it generated a non-exclusive payoff, creating a trade-off for the seller between the individual and social optimum, similar to the common public good dilemma. This trade-off was minimised in the positive shock scenario and sellers significantly increased their effort levels, benefitting from the favourable environment. In times of a negative shock, sellers significantly reduced their contributions to the public good although a substantial share of sellers realised effort levels to the benefit of the whole market. Repeated interaction doubled the ratio of sellers who chose socially optimal effort levels even if the environmental circumstances made it unprofitable for them.

Reputational incentives are very powerful in bilateral relationships characterised by asymmetric information (e.g. Fehr et al. 2009), but environmental risk combined with competition seems to undermine relationship-building. In this experiment, sellers chose significantly higher efforts if they were repeatedly interacting within the same market although they were not able to credibly build a reputation due to the changing environmental conditions. However, buyers did not respond with more trusting behaviour as shown by their lowest-bid acceptance strategy. Instead of observing a strong bilateralisation of buyer-seller relationships in repeated games (Brown et al. 2004, 2012; Vogt et al. 2013), buyers swapped sellers significantly more often if they were confronted with environmental risk. While shorter duration of employment relationships due to external shocks is supported by Linardi and Camerer (in prep.), it stands in contrast to the observed stable relationships in a non-competitive, variable environment reported in McAllister et al. (2011), suggesting that the bidding competition induced buyers to terminate relationships earlier. Without knowing whether the observable contract outcome was subject to a transformation or not, buyers were less inclined to bear the risk of initiating a long-term reciprocal relationship and sooner tried alternative sellers. Moreover, the environmental shock made it more difficult and costly for sellers to maintain such relationships.

The establishment of profitable long-term contract relationships mainly failed because buyers systematically favoured low offers to higher priced offers instead of a particular seller. Moreover, buyers tended to break up contracts after negative shocks. Overly selfish buyer behaviour in view of environmental risk contrasts with Gerhards and Heinz (in prep.) who report more cooperative behaviour by employers in experimental labour markets affected by probabilistic shocks. Environmental risk induced employers to pay higher wages to counterbalance potential productivity losses of workers. Against this background, it is interesting that sellers in this experiment also increased offers and pushed through higher wages in risk markets compared to the baseline scenarios. This finding could imply that in a risky environment higher wage premiums are needed to stimulate reciprocal behaviour, whereas in a setting with full information sellers are more concerned about their reputations and are motivated with less generous payments. In this way, these results could provide empirical support to Derissen and Quaas's analytically driven argument to increase the action-based share of payments under environmental risk (2013).

5. Concluding remarks

The results presented here suggest that environmental risk is an obstacle to establishing cooperation in the market-based provision of environmental goods. But it is surmountable given some sellers maintain non-opportunistic, social preferences even in adverse circumstances. Nevertheless, environmental risk leads to efficiency losses and disturbs the formation of effective long-term contract relationships as buyers do not put enough trust in the sellers. These insights are relevant in view of the increasing usage of market-based mechanisms for the allocation of conservation funds to landholders. In the context of natural resources management, environmental risk and uncertainty will play an ever increasing role, and can substantially impact the socially desired effect of conservation measures. In addressing environmental risk in the principal-agent relationship between the regulating agency and the landholder, this study adds to our understanding on the functioning and performance of environmental markets especially in view of the challenges posed by climate change. The results suggest that reciprocity is of increased importance in a variable environment, potentially making competitive bidding a less suitable mechanism for allocating conservation funds in the future.

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Appendix

A1: Instructions for auctioneers and bidders for the RISK treatments (MRID, MFID)

A2: Instructions for auctioneers and bidders for the BASE treatments (BRID, BFID)

Note: The instructions were originally provided in German language and are reprinted in an English translation. Italics are used to distinguish those parts that were depending on whether the random identity (RID) or fixed identity condition (FID) was played.

A1: Instructions

You are participating in an economic experiment. You have already earned 2,50 € for having arrived well on time. During the experiment you have the possibility to earn more money. Please read the following instructions carefully as they include all relevant information. In case you have trouble understanding some parts of it, please indicate and your questions will be answered in your cabin.

The experiment takes place in several rounds. In every round, you are asked to make decisions that you need to enter into the PC. During the experiment any form communication is not allowed. Moreover, you are only allowed to use the PC as necessary for running the experiment. Communication and fooling around with the PC leads to exclusion form the experiment. We are happy to answer your questions.

In the experiment, you earn further monetary units (MU) which will be converted to € at the end of the experiment at a conversion rate of 100 MU = 25 eurocent.

→ Overview

- **In this game there are two types of players:**
    - **One auctioneer [→ *You are the auctioneer*]**
    - **Three bidders [→ *You are a bidder*]**
- In every round, bidders have the possibility to conclude a contract with the auctioneers.
- The auctioneer selects one bidder and pays a wage.
- The bidder needs to use the wage to fulfill the contract.
- Every contract generates a dividend that is split equally amongst all three bidders and the auctioneer (=contract dividend).
- The more the bidder reinvests of the wage (=effort), the higher rises the contract dividend.
- The bidder keeps the share of the wage that has not been reinvested.
- In every round, the effort chosen by the bidder can be transformed by a random mechanism, which may halve the effort, keep it constant or double the contract dividend by half as much again.
- The contracting bidder is informed on the event taking place, before choosing an effort. The other bidders and the auctioneer are only informed on the resulting contract dividend.
- If a bidder does not conclude a contract, that bidder only receives a share of the contract dividend.
- The game is played over several rounds [Fixed Identity Treatment Condition: *and you play with the same players in every round*].

→ Schedule of one round

1. Every bidder submits a wage offer to the auctioneer.

2. The auctioneer chooses one bidder and pays the wage.

3. This bidder is informed which random event takes place.

4. This bidder chooses an effort that determines the contract dividend.

5. Every player receives the results.

➔ **The single steps in more detail:**

1. Every bidder submits a wage offer to the auctioneer.

- Wage offers are allowed within the range of 100 und 250 MU.
- Only the auctioneer sees all the bids.
- [Fixed Identity Treatment Condition:] *In every round, the same bidders play with the same auctioneer. The auctioneer can clearly identify every bidder according to a number.*
- [Random Identity Treatment Condition:] *The composition of group is shuffled in every round, and bidders and auctioneers cannot re-identify themselves. You play with other players in every round!*

2. The auctioneer chooses one bidder and pays the wage.

- The auctioneer sees all bids and chooses one bidder.
- The auctioneer is endowed with a budget of 250 GE to pay the wage.
- Unused budget is added to the auctioneer's profit.

3. This bidder is informed about which random event takes place.

- There are three different events, each of which can occur with a probability of 33,3% :

  a) The effort is kept as it was (no transformation)

  b) The effort is halved.

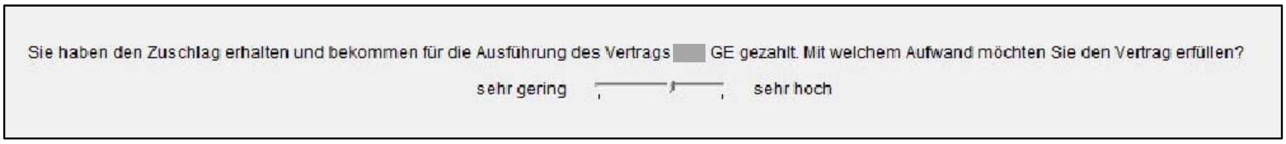
  c) The effort is increased by half the original amount.
- Before choosing an effort, the bidder is informed which event a), b) or c) takes place in that round.
- Depending on the type of event, the effort chosen by the bidder generates the same contract dividend (a), half of the original contract dividend (b), or half as much of the contract dividend again (c).
- The auctioneer only sees the resulting contract dividend, without knowing the type of random event that took place.

4. This bidder chooses an effort that determines the contract dividend.

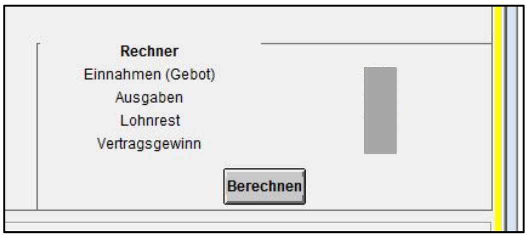
- The bidder needs to decide how to fulfil the contract. By using a slider (See picture on the next page), the bidder can choose every value between 0% and 100%.
- The contract dividend rises linearly with effort. In other words, the higher the effort gets, the higher rises the contract dividend. The maximum contract dividend is 100%.

- All market participants (the auctioneer and the three bidders) receive the same contract dividend.
- Cost of effort is deducted from the contracting bidder's wage. Effort cost cannot exceed the given wage, and the bidder can only choose effort levels that are financially feasible. The bidder cannot incur losses.
- Every effort level is associated with distinct effort cost, cost of effort rises with increasing effort.
- The bidder can check the cost of effort, the remaining wage and share of the contract dividend with a calculator (See picture on the next page), or use the contract table handed out to every participant.
- Independent from the random event taking place, the contract dividend is always maximised with 100% effort.

The slider for choosing a level of effort:



The calculator:



5. Every player receives the results.

- At the end of one round, this rounds results are summarised (total revenue, revenue of this round, and components):

Revenue as a contractor	**=**	**Retained wage**	**+**	**Contract dividend**
Revenue without a contract	**=**	**0**	**+**	**Contract dividend**
Revenue as auctioneer	**=**	**Retained budget**	**+**	**Contract dividend**

- Then a new round begins, the experiment ends after a pre-determined number of rounds.

We ask you now to answer a few control questions on the screen. The game starts, once you have answered these correctly.

Quality of contract fulfilment	Effort in %	Cost of effort in MU	Contract dividend (min* - normal - max**)		
minimal contract fulfilment	**0%**	**50**	**34**	**69**	**103**
	5%	54	**38**	**76**	**114**
	10%	57	**41**	**83**	**124**
	15%	62	**45**	**90**	**134**
	20%	66	**48**	**96**	**145**
	25%	71	**52**	**103**	**155**
	30%	76	**55**	**110**	**165**
	35%	81	**59**	**117**	**176**
	40%	87	**62**	**124**	**186**
	45%	93	**65**	**131**	**196**
	50%	100	**69**	**138**	**207**
	55%	107	**72**	**145**	**217**
	60%	115	**76**	**152**	**227**
	65%	123	**79**	**158**	**238**
	70%	132	**83**	**165**	**248**
	75%	141	**86**	**172**	**258**
	80%	152	**90**	**179**	**269**
	85%	162	**93**	**186**	**279**
	90%	174	**96**	**193**	**289**
	95%	187	**100**	**200**	**300**
maximal contract fulfilment	**100%**	**200**	**103**	**207**	**310**

In the contract table only 5 % increments are shown.
With the in-game slider between-values can be chosen as well.

** if halved*
*** if doubled by half of the original effort*

A2: Instructions

You are participating in an economic experiment. You have already earned 2,50 € for having arrived well on time. During the experiment you have the possibility to earn more money. Please read the following instructions carefully as they include all relevant information. In case you have trouble understanding some parts of it, please indicate and your questions will be answered in your cabin.

The experiment takes place in several rounds. In every round, you are asked to make decisions that you need to enter into the PC. During the experiment any form communication is not allowed. Moreover, you are only allowed to use the PC as necessary for running the experiment. Communication and fooling around with the PC leads to exclusion form the experiment. We are happy to answer your questions.

In the experiment, you earn further monetary units (MU) which will be converted to € at the end of the experiment at a conversion rate of 100 MU = 25 eurocent.

→ Overview

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- The bidder needs to use the wage to fulfill the contract.
- Every contract generates a dividend that is split equally amongst all three bidders and the auctioneer (=contract dividend).
- The more the bidder reinvests of the wage (=effort), the higher rises the contract dividend.
- The bidder keeps the share of the wage that has not been reinvested.
- If a bidder does not conclude a contract, that bidder only receives a share of the contract dividend.
- The game is played over several rounds [Fixed Identity Treatment Condition: *and you play with the same players in every round*].

→ Schedule of one round

1. Every bidder submits a wage offer to the auctioneer.

2. The auctioneer chooses one bidder and pays the wage.

3. This bidder chooses an effort that determines the contract dividend.

4. Every player receives the results.

➔ **The single steps in more detail:**

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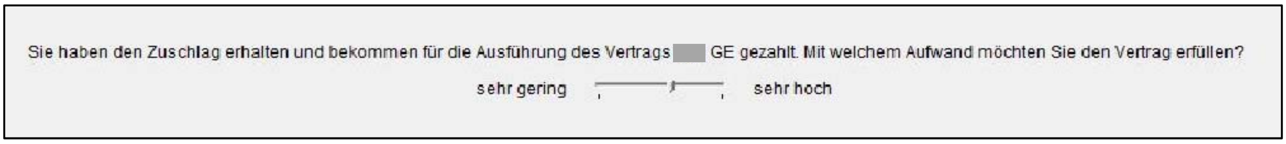
2. The auctioneer chooses one bidder and pays the wage.

- The auctioneer sees all bids and chooses one bidder.
- The auctioneer is endowed with a budget of 250 GE to pay the wage.
- Unused budget is added to the auctioneer's profit.

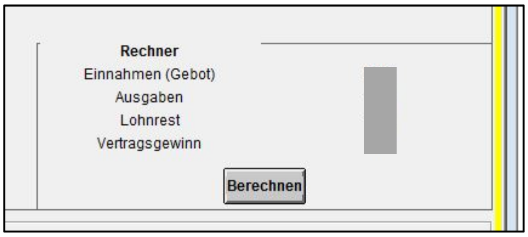
3. This bidder chooses an effort that determines the contract dividend.

- The bidder needs to decide how to fulfil the contract. By using a slider (See picture on the next page), the bidder can choose every value between 0% and 100%.
- The contract dividend rises linearly with effort. In other words, the higher the effort gets, the higher rises the contract dividend. The maximum contract dividend is 100%.
- The contract dividend is maximised with 100% effort.
- All market participants (the auctioneer and the three bidders) receive the same contract dividend.
- Cost of effort is deducted from the contracting bidder's wage. Effort cost cannot exceed the given wage, and the bidder can only choose effort levels that are financially feasible. The bidder cannot incur losses.
- Every effort level is associated with distinct effort cost, cost of effort rises with increasing effort.
- The bidder can check the cost of effort, the remaining wage and share of the contract dividend with a calculator (See picture on the next page), or use the contract table handed out to every participant.
- In every round, the auctioneer is informed about the contract fulfilment.

The slider for choosing a level of effort:



The calculator:



4. Every player receives the results.

- At the end of one round, this round's results are summarised (total revenue, revenue of this round, and components):

Revenue as a contractor	**=**	**Retained wage**	**+**	**Contract dividend**
Revenue without a contract	**=**	**0**	**+**	**Contract dividend**
Revenue as auctioneer	**=**	**Retained budget**	**+**	**Contract dividend**

- Then a new round begins, the experiment ends after a pre-determined number of rounds.

We ask you now to answer a few control questions on the screen. The game starts, once you have answered these correctly.

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	20%	66	**96**
	25%	71	**103**
	30%	76	**110**
	35%	81	**117**
	40%	87	**124**
	45%	93	**131**
	50%	100	**138**
	55%	107	**145**
	60%	115	**152**
	65%	123	**158**
	70%	132	**165**
	75%	141	**172**
	80%	152	**179**
	85%	162	**186**
	90%	174	**193**
	95%	187	**200**
maximal contract fulfilment	**100%**	**200**	**207**

In the contract table only 5 % increments are shown.
With the in-game slider between-values can be chosen as well.

3 Lock-in effects in competitive bidding schemes for payments for ecosystem services – Revisiting the fundamental transformation

with Kilian Bizer

Abstract

Competitive bidding is considered to be a cost-effective allocation mechanism for payments for ecosystem services. We argue in this article that competition is not a necessary condition for sustaining cost-effectiveness in the long run. In a repeated conservation auction, learning, specific investments and the creation of social capital bias the chances of winning a follow-up contract in favour of former auction winners. Applying the concept of fundamental transformation (Williamson 1985), we argue that this asymmetry weakens competition and leads to lock-in effects between the auctioning agency and a stable pool of sellers with uncertain consequences for cost-effectiveness. We compare data from two laboratory experiments on auction-based conservation programmes and show under which conditions lock-in effects are likely to occur in a controlled environment. Our findings demonstrate lock-in effects do not erode the effectiveness of an auction but change the rules of the game towards more favourable conditions for the provision of the targeted good or service. In view of the empirical evidence for a superior performance of long-term contract relationships compared to low-cost short-term contracting, we discuss directions for follow-up empirical work.

Contents

1. Introduction

The creation of monetary incentives for the provision of environmental services and formation of competitive structures among the recipients of payments are drivers of cost-effective conservation of biological diversity in developing and developed countries (Engel et al. 2008, IUCN 2009, OECD 2010). Following Wunder et al. (2005, p. 3), we define payments for ecosystem services as "(a) a voluntary transaction where (b) a well-defined environmental service [..] or a land use likely to secure that service (c) is being 'bought' by a (minimum one) service buyer (d) from a (minimum one) service provider (e) if and only if the service provider secures service provision (conditionality)." Since the financial resources dedicated to conservation issues are mostly limited, cost-effectiveness becomes a crucial criterion for buyers of environmental goods and services, e.g. environmental agencies.

Cost-effectiveness implies that the available funds are allocated to the sellers who generate the highest conservation outcome per currency unit spent. Payment differentiation is one means of achieving cost-effectiveness as it takes into account that heterogeneous sellers can have different opportunity costs (Ferraro et al. 2008; Wunder et al. 2008). These costs can be revealed to the buyer with a sealed, competitive bidding mechanism, i.e. similar to a procurement auction. The economic rationale for the use of competitive bidding is that they create incentives for sellers to offer bids close to their true opportunity costs of programme participation. This enables buyers to select the cheapest sellers. Moreover, sellers face a trade-off between a higher net-gain from a higher bid and decreased competitiveness (e.g. Latacz-Lohmann and van der Hamsvoort 1997, 2005). The present article discusses shortcomings of this logic and shows that, in the long run, competition is not a necessary condition for sustaining cost-effectiveness.

Conservation auctions, i.e. payments for ecosystem services allocated on the basis of competitive bidding, are an established and well-researched policy instrument. They are being or were operated on a large-scale in the United States (USDA Conservation Reserve Program, running since 1985), Australia (e.g. BushTender, EcoTender and ALR – Auction for Landscape Recovery), and on smaller-scale projects around the globe (e.g. Challenge Funds in Scotland, Northeimer Modell in Germany, Southern Rivers Bush Incentives in New South Wales Australia). Moreover, the experience with auction-based conservation programmes is increasing in developing countries (e.g. Jindal et al. 2013). Some of these conservation auctions have been run over several contract periods, i.e. contracts were auctioned regularly amongst varying groups of sellers (for instance annually as in the USDA Conservation Reserve Program). From a conservation point of view, a long and stable contract relationship is preferential to the one-shot case (IUCN 2009). However, the economic consequences and inherent dynamics of repeated auctioning and contracting in long-term conservation programmes have not been sufficiently addressed.

Field and experimental studies have focused on auction metrics (Reeson et al. 2011a; Rolfe et al. 2009), examined bidding behaviour in conservation auctions (Cason and Gangadharan

2004; Schilizzi and Latacz-Lohmann 2007) and also highlighted their social dimension (Greiner and Stanley 2013; Jindal et al. 2013; Lockie 2013; Reeson et al. 2011b; Vogt et al. 2013; Zammit 2013). A research focus on repeated bidding and contracting poses some challenges to the underlying theoretical framework because the one-shot auction format (mostly treated in the literature) converts to a repeated auction scenario, i.e. an indefinite sequence of separate auctions.[1] Assuming rational behaviour and symmetry of bidders, game-theoretic auction models (Latacz-Lohmann and van der Hamsvoort 1997; Milgrom 2004) are suitable for one-shot auctions, but do not yield tractable results in a repeated auction context (Hailu and Schilizzi 2004; Reeson et al. 2012; Rolfe et al. 2009). Repeated interaction brings about learning effects, reputation effects and intertemporal competition concerns which can hardly be captured in an analytical model but require a more holistic approach. Therefore, we use transaction cost economics, complemented by the dimension of social capital, to offer a comprehensive explanatory approach to the effects of repeated auctioning of conservation contracts.

Taking into account laboratory and field data, we identify learning effects, social capital and asset specificity as the three dimensions in which repeated conservations auctions differ from the one-shot case. We discuss how these aspects create asymmetry amongst successful and non-successful bidders over time. Applying the concept of the fundamental transformation (Williamson 1985), we argue that repeated conservation auctions bear the risk of reduced competition and lock-in effects between the auctioning agency and a stable pool of bidders. Finally, we compare data from two laboratory experiments on auction-based conservation programmes and show under which conditions lock-in effects are likely to occur in a controlled environment. In view of the empirical evidence for a superior performance of long-term contract relationships compared to short-term contracting, we discuss directions for follow-up empirical work.

2. Sources of bidder asymmetry in repeated auction-based conservation programmes

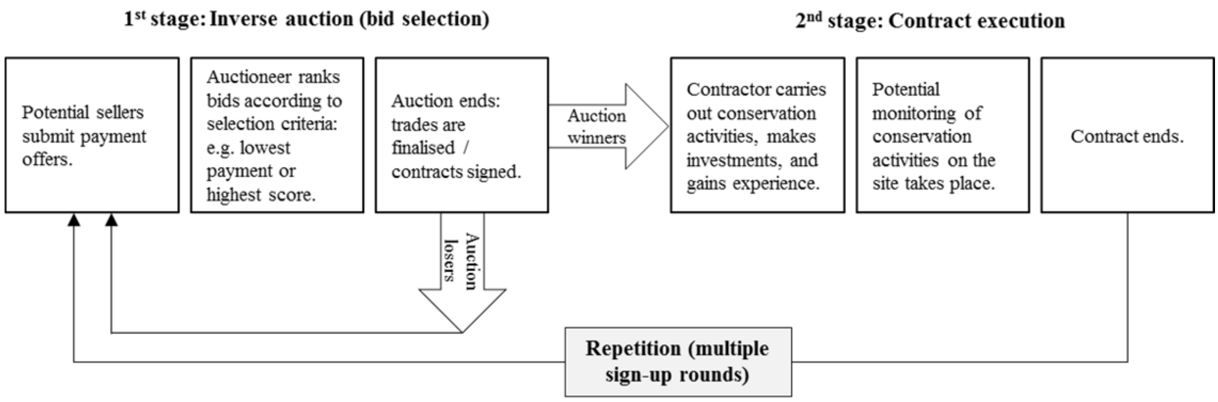
Consider a simple, hypothetical government programme that targets the conservation of biological diversity on arable land by paying landholders for the provision of clearly defined conservation services for a limited time period. Due to budget constraints, there is an upper limit to the available number of contracts and the environmental agency must apply a selection mechanism that identifies some farmers as being preferential to others. Thus, the agency decides to differentiate payments by holding an inverse auction.

As can be seen from Figure 1, there are two main stages of a conservation auction. The first stage is the inverse auction that serves to identify the optimal contractors according to a

[1] This format needs to be distinguished from a sequential auction where bidders play several bidding rounds until the auction ends.

ranking rule. Interested landholders are invited to submit their individual bid proposals, i.e. the amount necessary to cover their cost of programme participation. Then, the conservation agency selects the most cost-effective bids and enters into a contractual relationship with these sellers who are paid their bids (discriminatory auction format). Secondly, the ecological goods and services are provided by the contractors at the specified price in the contract stage. Complete monitoring is too costly to implement and it takes place with a small probability. Contract duration is fixed to a limited time period.

Figure 1: Stages of an auction-based conservation programme



Under these circumstances, only in the first auction round bidders are symmetric as to their chances of winning a contract (notwithstanding differences in their opportunity cost or ecological value). With the agency's decision being based on only two selection criteria – an ecologic and an economic component –, bidders initially operate on parity since only cost-benefit ratios count for programme participation (Groth 2010). Once all bids are ranked and contracts are made and executed for the first time, the auction logic will lead to two groups of landholders: those accepted to carry out the conservation service and those rejected. Given a stable pool of bidders both groups can compete again for contracts in the follow-up auction rounds.

This raises two questions: Firstly, how will experienced and non-experienced bidders differ subsequently in their probability of winning a conservation contract? And secondly, which economic and ecological effects result from potential differences? We hypothesise that starting with round two of the auction bidders are increasingly asymmetric with regard to three aspects:

- Learning: with regard to actual costs, foregone profit and bid caps, enabling price adjustments,

- Social capital and reputation: reflecting the history of contracts,

- Specific assets: programme-specific investments made in a previous round, not being part of future bid calculation.

2.1. Learning

Empirical results indicate that bidders learn from previous bidding rounds and that this has a significant impact on the bid proposals (Cason and Gangadharan 2004; Hailu and Schilizzi 2004; Reeson et al. 2011a, 2012; Rolfe et al. 2009; Schilizzi and Latacz-Lohmann 2007). Experience with the USDA Conservation Reserve Program (CRP) has shown that bidders quickly learn to adjust their bids. For the 1986 CRP sign-up rounds, Reichelderfer and Boggess (1988) reported that the distribution of bids decreased over the course of the sign-up period after decisions of the CRP authorities became publicly announced. Kirwan et al. (2005) found empirical evidence for increasing premiums (net-gains) of landholders who participated in CRP sign-ups between 1997 and 2003.

The distribution of information between sellers and buyers in environmental markets plays a crucial role (Latacz-Lohmann and van der Hamsvoort 2005). If not managed correctly, leakage of information on the average winning bids, the ranking criteria or the budget ceiling can incentivise strategic bidding in a repeated auction. As a consequence, the auction loses efficiency: If sellers inflate their bids (beyond their actual cost), less conservation can be financed per dollar. On the other hand if sellers underbid, the quality of the provided conservation service might suffer. These two sides are reflected in the experimental literature: While Cason and Gangadharan (2004), Hailu and Schilizzi (2004), Schilizzi and Latacz-Lohmann (2007), and Reeson et al. (2011a) all supported the positive correlation between sharing and distributing of information and efficiency losses in a repeated auction, Reeson et al. (2012), Rolfe et al. (2009) and Vogt et al. (2013) reported that learning led to improved auction outcomes.

The main reason for potential efficiency gains in repeated bidding rounds is the possibility for sellers to better understand and gain experience with the calculation of their opportunity costs. Depending on the conservation service aimed at in the programme, landholders may be more or less familiar with the required management activities and related cost. For instance, up to 50% of all participants of the Southern Rivers Bush Incentives Programme (Australia) stated in follow up interviews that they had difficulties in calculating and estimating their cost. Overbidding can be reduced by multiple bidding rounds that enable sellers to learn the payments structure and to improve (reduce) their bids (Rolfe et al. 2009). But also inefficient underbidding can be reduced by the dissemination of information resulting from communication between auctioneer and each individual bidder (Vogt et al. 2013).

Competitive advantages caused by information spill-over are in three ways different for the two groups of landholders (those rejected and those participating). Who benefits most depends on the flow of information inside and outside the auction. In very closed-off auction schemes, where the administrative agencies do not announce average winning bids or other criteria of the selection procedure ex-post, only the auction winners have information rents. This advantage vanishes with the amount of information publicly available (cf. Latacz-Lohmann and van der Hamsvoort 2005). However, auction winners have a second competitive advantage to non-winners since they gain experience in providing the conservation service. This enables them to improve their skills and to mirror their bid calculation to their actual cost. Auction losers do not have the possibility to learn about their potential costs of contract execution. A third disadvantage for outsiders is the lacking possibility to build social capital with the agency and other participating landholders.

2.2. Trust, reputation and social capital

Social capital is crucial for the successful management of natural resources and also a significant parameter for the effectiveness of market-based instruments (Jones 2010; Ostrom 2003; Zammit 2013). As a multidimensional concept, social capital comprises social and institutional trust, norms of reciprocity, and embeddedness in groups, networks or institutions (Jones 2010; Pretty and Ward 2001). Social capital positively influences the willingness to engage for conservation activities, increases cooperation, and reduces uncertainty. More precisely, it addresses adverse selection and opportunism, which is of particular relevance in the context of an auction-based conservation programme.

Although the definition of payment for ecosystem services (PES) requires the environmental service to be "well-defined", in practice contracts on natural resources management are in many cases incomplete[2], making trust between contractors a necessary component for cooperation. In conservation contracts, often neither the exact quantity nor quality of the targeted ecological good can be defined in specified terms. Moreover, conservation outcomes are difficult to measure and monitor, creating uncertainty and a potential for opportunistic behaviour. Consequently, for the agency high-priced bids are risky if they cannot rely on their contractors' performance.[3] This can easily lead to a "market for lemons" outcome with suboptimal conservation effort (Arnold et al. 2013; Vogt et al. 2013). Such an inferior auction result can be overcome if the agency puts enough trust in the participating landholders and if they reciprocate with non-opportunistic behaviour.

Trust can be understood as an investment decision that leads to a positive return if the trustee reciprocates the trust placed on him (Ostrom and Walker 2003). Trust is reciprocated because of incentives or social norms (Hardin 2003). If the trustee's preferences are encapsulated in the ones of the trustor, the trustee has an interest to reciprocate and continue the relationship. If not, the trustee may still feel morally obligated to honour the trust bestowed on him. Moreover, embeddedness in networks or groups can create social pressure for compliance (Jindal et al. 2013). In either way, reciprocity of trust increases connectedness between the stakeholders, self-enforces cooperation and leads to additional positive conservation outcomes (Pretty and Ward 2001; Zammit 2013).

[2] A contract is considered incomplete if it is not as fully contingent on all states of the world as the contracting parties would like it to be (Maskin 2002).

[3] In this context, neo-classical theory predicts selfish behaviour due to the lack of credible commitments. However, a well-established branch of experimental literature provides empirical evidence on trust and reciprocity of trust in incomplete contractual agreements (e.g. Fehr et al. 1997).

Contrary to a one-shot auction where trust can be betrayed without future consequences, a repeated auction works in a different time frame, allowing sanctioning and reputation-building. Auction winners can build a reputation of trustworthiness based on past activities, demonstrated motivation and capabilities, permitting credible expectations about their future behaviour. Hence, for the agency it pays off to re-conclude contracts with trustworthy bidders, who are intrinsically motivated, have a great sense of environmental responsibility or receive private benefits from the conservation service (Lockie 2013). However, the rationale of an auction still requires selecting the most competitive candidates, who might not be identical to those with the highest reputation. It is thus questionable whether a highly competitive selection mechanism jeopardises these benefits of social capital or if the existence of trust erodes the effectiveness of the auction.

2.3. Asset specificity

Depending on the targeted conservation outcome, contract execution may require monetary or non-monetary investments during the contract period. These investments (or assets) constitute a third source of bidder asymmetry if they are specifically dedicated to the conservation programme. Asset specificity is a concept to describe the extent to which an investment is specialised to a particular contractual agreement. An asset is considered to be highly specific if changing from the originally intended usage to alternative applications leads to high losses in asset value.[4]

In the context of agri-environmental programmes with uniform payments, asset specificity negatively influences contract adoption (Ducos and Dupraz 2007; Rørstad et al. 2007). Often required for more targeted policy measures, specific assets increase on-farm transaction costs (Rørstad et al. 2007). Since participation in a conservation programme is usually voluntary, high asset specificity bears the risk of low participation rates. However, a farmer's willingness to participate in a programme associated with highly specific assets depends on the amount of (institutional) trust in the environmental agency or other administrative stakeholders (Ducos and Dupraz 2007).

In contrast to a one-shot conservation scheme with uniform payments where specific assets reduce the gains from participation, repeated competitive bidding enables bidders to endogenise the cost of specific assets. This creates ex-post advantages for auction winners against losers if they compete for contracts in another auction round (Groth 2010). Since winners had already invested in specific assets and factored them into their bid calculation in the previous auction and contract period, *ceteris paribus*, their bids become more competitive against other bidders in the next round.

[4] The difference in values is called transaction-specific quasi-rent. Quasi-rents rise with increasing specificity of assets.

Williamson (1983) lists four dimension of asset specificity that can be adapted to conservation programmes. We add reputational aspects as a fifth dimension[5]:

- Human asset specificity: Highly specialised skills that arise from learning, practical experience or professional training,
- Physical asset specificity: Special machines or tools, which cannot be used for other purposes,
- Dedicated assets: Discrete investments in generalised production capacity only made for the purposes of the transaction (e.g. specific changes in production methods),
- Site specificity: the distinct value of land for conservation purposes,
- Relational specificity[6]: The degree of successful interaction of contractors in the past, incorporating the reputation of trustworthiness. Relationship-specific assets are created through social interaction, and their degree of specificity is determined by the length and mutually assessed value of that interaction.

2.3.1. Specific assets of sellers (landholders)

Participation in a conservation auction requires a good understanding of the administrative procedure, and interested landholders might be unfamiliar with the payment mechanism (cf. Rolfe et al. 2009). Therefore, often preparatory meetings, mock-auctions or on-site assessments are held before the first auction takes place. For landholders these meetings cost time and effort and have only limited use in a non-auction related context. However, understanding the auction procedure is an initial investment in human capital and related transaction costs are no longer incurred in subsequent sign-up periods (cf. McCann et al. 2005). Information meetings or on-site assessments actively support the formation of social capital. Landholders interested in a long-term contract relationship need to signal commitment to the agency and make relationship-specific investments. The more often buyers and sellers of conservation services interact, the more specific their relationship gets, providing opportunities to observe each other's actions, motivation and capabilities.

The level of physical asset specificity highly depends on the conservation measure and the local context (Mettepenningen et al. 2009). While the USDA CRP is based on land set-aside, some conservation programmes require the one-time purchase of specific equipment, for instance a mechanical weeder, or specific plants, e.g. for the re-vegetation of bush land as in the EcoTender (cf. Eigenraam et al. 2006). Besides potential physical investment, farmers need to dedicate assets in terms of changed production cycles or work assignment (e.g.

[5] As Williamson points out (1985, p. 62), additional transaction-specific savings can form at the interface between transaction partners as regards economies through familiarity, institutional and personal trust.

[6] The terms "relationship-specific investments", "relational assets", "R-assets" or "relational capital" have been used interchangeably mainly in a management-related context, describing "the level [and value] of mutual trust, respect, and friendship that arises out of close interaction at the individual level between alliance partners" (cf. Kale et al. 2000, p. 218).

postponed mowing of grassland). Narrow conservation targets reduce options for establishing standardised routines; this implies increased asset specificity on the farm level (Rørstad et al. 2007).

In order to provide the targeted ecological good or service, landholders need to dedicate land. If it can be put under conservation measure depends on the requirements of the programme, e.g. the presence of certain species, or location in a catchment area. More targeted programmes require specific areas (Mettepenningen 2011). However, there are other dimensions how land can become specific to the conservation programme. Often, the conservation value of a site rises with the time being under protection (Kleijn et al. 2006), thus re-enrolment could be preferable to starting from scratch on another patch. Moreover, connectivity between sites increases the contribution of individual conservation actions (Reeson et al. 2011a).

Whether specific patches of land generate competitive advantages within the auction largely depends on the auction metric and its capacity to differentiate between land types. Some conservation auctions rank bids on the basis of a multi-criteria index (e.g. the Environmental Benefit Index in the CRP or the Biodiversity Benefits Index used in the BushTender), others are based on site-assessments and individual management plans (e.g. Southern Rivers Bush Incentives Programme, New South Wales Australia) to find a better balance between ecological and economic ranking.

2.3.2. Specific assets of the buyers (environmental agency)

The agency in charge of executing the auction must dedicate financial and personal resources to the conceptualisation, administration, processing, and monitoring of the programme. Moreover, advertising is necessary to attract a large pool of bidders. Some practitioners argue that the running of an inverse auction and related cost-effectiveness gains are set off by increased transaction and human resources costs. These cost rise with the complexity of the environmental policy measure (Mettepenningen et al. 2011) and with individualised procedures, e.g. on-site assessments or information meetings. However, these meetings provide opportunities to build social capital with the participating landholders, which can induce better compliance in the contract phase.

From the agency's perspective, concluding a contract with a seller also implies a site-specific investment. Given the positive correlation between duration of a conservation contract and its ecological benefits, the site value increases with the time enrolled in a programme. Contract expiration and termination of payments often results in farmers returning to their previous practices (IUCN 2009; OECD 2010; Sullivan et al. 2004). Consequently, losing a seller can lead to ecological costs for the agency.

3. The fundamental transformation, lock-in effects and the role of social capital

A repeated conservation auction establishes bidder asymmetry: A previous contracting history leads to competitive advantages due to programme-relevant experience, reputation as a contractor, and specific assets already factored into bids in earlier bidding rounds. As a consequence, we argue that there is a risk for conservation auctions to degenerate into a rather symbolic act involving only the "usual suspects" in the long-run. Reeson et al. (2012) report that strong heterogeneity in environmental values can lead to the dominance of "a small number of bidders" over time. Groth (2010) also sees potential for gradually reduced competition in repeated auction-based conservation schemes, contradicting the rationale of an inverse auction.

According to Oliver Williamson's conclusions on the subject of contractual relationships between sellers and buyers (1985), competition transforms into a bilateral monopoly for transactions involving specific assets (known as the "fundamental transformation"). Williamson notes that "such investments are [..] risky, in that specialised assets cannot be redeployed without sacrifice of productive value if contracts should be interrupted or prematurely terminated" (1985, p. 54). As a consequence, contractors can be locked-in in the sense that the potential benefit of continuing the transaction relationship is higher than terminating and switching to other partners.

We argue that participation in a conservation programme involves specific assets on the sellers' side, including the dedication of acreage, adaptation of managerial practices and acquisition of specific knowledge. Once enrolled in a programme, landholders become more competitive in subsequent auctions compared to previously unsuccessful bidders but incur losses through quasi-rents if the contract is not renewed. As a consequence, landholders interested in a long-term contract relationship have clear incentives to make relationship-specific investments and reciprocate with non-opportunistic behaviour.

As to the agency acting as buyer, we argue that the building of social capital and institutional trust is crucial for the conservation outcome. While there is an initial need to identify cost-effective bidders, periodic re-enrolment is valued by the agency since it creates trust and reduces uncertainty about the quality of the provided conservation service. In order to achieve effective results, the agency becomes likewise dependent on the programme participants and on their specific acreage.

Hence, with the beginning of the second competitive sign-up for conservation contracts, bidders are asymmetric with regard to specific assets, learning experience, and reputation. Inequality amongst bidders is maintained and consolidated in subsequent rounds, leading to increasingly asymmetric chances of winning the contract and the dominance of some bidders. Moreover, the agency has a twofold interest in maintaining long-term contract relationships: increasing social capital (reducing opportunism) and avoiding ecological costs, which would be incurred with programme withdrawal. As a consequence, neither agency nor contracting landholders should face incentives to terminate an on-going contract relationship, which results in the establishment of long-term contract relationships.

3.1. Expected impact of lock-in effects on auction performance

Whether lock-in effects constitute challenges or opportunities depends on their effect on the conservation output (ecological effectiveness), on the competition amongst bidders, and on the cost-effectiveness criterion (Table 1). The existing empirical evidence points towards the fact that learning effects, specific investments and strong social capital, benefit the ecological effectiveness of conservation measures. However, they all bear the risk of reduced competition as they create advantages for insiders against outsiders. Learning effects can decrease the auction's cost-effectiveness if they imply strategic bidding and inflated bids, but can also increase cost-effectiveness if they reflect an improved understanding of procedures and costs. Once they are sunk, specific investments in physical assets, human capital and changed management practices increase the cost-benefit ratio but their initial costs are high.

Still, the effect of social capital is unclear. Bidders with high reputation might not be the lowest-priced suppliers and, consequently, the auction could set perverse incentives and destroy relationship-specific assets. Hence, social capital leads to improved cost-effectiveness only if landholders in long-term contract relationships are incentivised to refrain from opportunism.

Table 1: Typology of influential variables for the performance of conservation programmes

Impact factor	Learning	Specific assets	Social capital
Ecological effectiveness	+	+	+
Competition	- /+	-	-
Cost-effectiveness	- /+	+	?

(-) negative; (+) positive; (-/+) both directions possible; (?) uncertain

3.2. Empirical evidence for lock-in effects in laboratory auctions

In the following section, data from two laboratory experiments (Vogt et al. 2013; Vogt, in preparation) provide empirical evidence on the conditions under which lock-in effects in repeated conservation auctions are likely to occur. Both experiments have a different research focus from the question scrutinised here, however, their unique experimental market design enables us to draw conclusions in the context of repeated auctioning. Both experiments are based on an inverse auction market for the provision of a public good that is produced in an effort-level game (cf. Fehr et al. 1997), and represent key features of auction-based conservation programmes.

In both experiments, one round of the game consists of a bid selection and a contract stage. In the bid selection stage, a fixed number of bidders compete for contracts with an auctioneer who chooses bidders on the basis of their sealed offers. There is no formalised auction metric, though, the auctioneer is endowed with a budget and keeps the residual amount. In the contract stage, the successful bidder individually decides on a performance level, which determines the part of the received payment the bidder will re-invest to fulfil the contract. In this way, the contracting bidder's investment generates a public good that is split amongst all participants of the market. The more the bidder invests, the higher the share of the public good for everyone. The inherent moral hazard problem requires the auctioneer to put trust in the bidder's offer signal and the bidder to reciprocate and perform non-selfishly, otherwise the level of the public good is socially suboptimal. In Vogt et al. (2013; hereafter COM), text-based bilateral communication prior to the bidding phase allows for cheap talk between bidders and auctioneers; while in Vogt (in preparation; hereafter RISK), contract performance can be affected by a probabilistic effort transformation that is known *ex ante* to the contracting bidder but unverifiable *ex post* by the auctioneer.[7] Table 2 summarises the two experimental treatments.

Table 2: Overview of the experimental treatments

	Market-based provision of public goods with	
	Communication (Vogt et al. 2013)	**Environmental Risk (Vogt, in prep.)**
Participants (subset)	66	52
Sessions (subset)	4	4
Number of markets	11	13
Market size	6 (1 buyer, 5 bidders)	4 (1 buyer, 3 bidders)
Contracts allocated per period	2	1
Random chance of contracting	40 %	33,3 %
Periods played*	12	20
Feedback	Incomplete	Incomplete
Fixed player types	Yes	Yes
Fixed IDs	Yes	Yes
Test design	Within-subject**	Between-subject
Time of experimentation	February 2012	November-December 2012

Note: Only subsets of data are reported as relevant here, data in the second column corresponds to the communication in the first phase of market interaction (C1) treatment of Vogt et al. (2013), data in the third column corresponds to the fixed identities and effort multiplier (MFID) treatment of Vogt, in prep. Both computerised experiments were conducted in the Goettingen Laboratory of Behavioural Economics, based on z-tree software, participants were mostly students with different academic backgrounds. *The total number of periods was not announced to avoid end-game effects. ** First treatment phase reported here.

Both experiments employ treatments with repetition and fixed identities, enabling us to compare repeated bidding and the iterative selection of contractors over several periods. A locked-in contract relationship is measured by its consecutive (uninterrupted) length given the random chance of concluding a contract. Favouring the same bidder over more than two periods implies that an auctioneer does not want to trade the established payment-profit ratio

[7] The risk parameter {0.5, 1.0, 1.5} models environmental risk common in land management and agricultural production, it was evenly distributed and had an expected value of {1}. Hence, auctioneers should not alter their strategies.

of the on-going relationship for a risky alternative. Measured by the random chance of winning a contract per period, both markets are similarly competitive in terms of rivalry amongst bidders. [8] However, they differ in their possibility to learn and build social capital.

Learning has been identified as one substantial cause of bidder asymmetry since successful bidders are able to re-adjust their bids in subsequent rounds based on previous contracting experience. In both experimental auction markets, the cost associated to different performance levels is common knowledge and identical for every bidder in both experiments, but the feedback mechanism to the auctioneer and non-contracting bidders is incomplete[9]. Hence, only bidders who enter the contract stage gain experience with the interplay of performance and payment structure and can adjust their bids subsequently. These benefits of learning are reduced in the RISK market, as the random multiplier introduces cost uncertainty that applies to every bidder in the bidding stage. Hence, only in the COM market learning takes place effectively (Hypothesis 1).

Social capital and its components trust, reputation and networking have been identified as a second source of bidder asymmetry provoking lock-in effects. In the RISK market, fixed identities allow the re-identification of market participants over time while other forms of direct interaction amongst players are unavailable. In contrast, the COM market with its bilateral chatting tool offers substantial opportunities for bidders to interact with the auctioneer, and *vice versa*. Every bidder is granted the same access to the auctioneer but the total chatting time is limited to three minutes per period, inducing potential variation in the amount of communication with the single bidders. Although non-binding and text-based, communication simplifies the creation of trust amongst players and improves the formation of reputation despite the incomplete feedback mechanism. Hence, the COM market is characterised by longer-lasting contract-relationships than the RISK market (Hypothesis 2).

Table 3: Time trends and means of key market variables

	COM		**RISK**	
	Mean	**Trend**	**Mean**	**Trend**
Offers made by bidders	167.9 (2.3)	⇧ (3.38)	175.6 (1.5)	⬀ (0.96)
Payments to auction winners	176.3 (2.3)	⇧ (3.38)	161.8 (2.4)	⬂ (– 0.17)
Performance of auction winners (effort levels)*	73.0 (1.8)	⇧ (4.30)	64.9 (1.7)	⬀ (0.82)

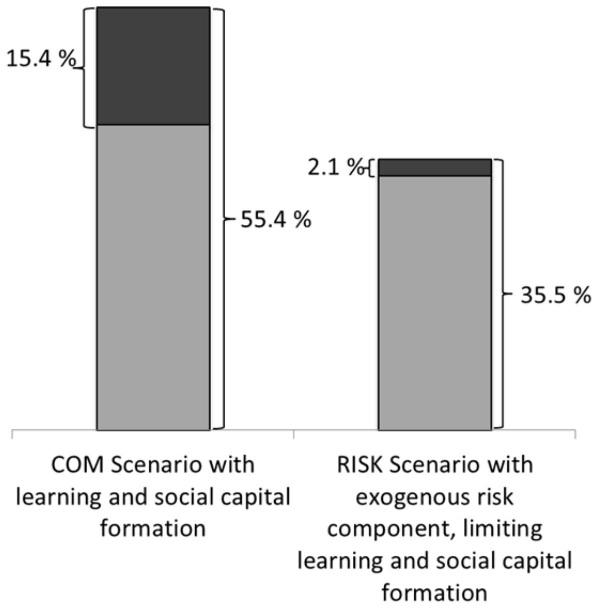
Note: Mean values are presented with standard errors in parentheses. The direction of the arrow symbolises the direction of the time trend, lopsided arrows show tendency. The t statistics of a linear regression of period on the respective variable is reported in parentheses (estimated over 12 periods for COM and 20 periods for RISK). * Untransformed effort levels are reported in the RISK scenario. Data originally published in Vogt et al. (2013), and Vogt, in prep.

[8] While in COM two contracts are allocated amongst five bidders (40 %), in the RISK treatment three bidders compete for one contract (33.3%).

[9] In COM only the sum of both contracts' effort is announced and in RISK only the contracting bidder knows which random event took place.

In both markets the social optimum is achieved if the auctioneer makes a payment of 200 and bidders reciprocate with a performance level of 100. The COM market outperforms the RISK market with regard to higher payments and performance levels, while bidders made higher offers in the RISK scenario (Table 3). It is striking that auctioneers favoured higher to lower offers if they were able to communicate with their bidders, but *vice versa*, if they were deprived of communication and moreover faced additional output uncertainty.

Figure 2: Probability of re-concluding a contract in two experimental scenarios of a repeated inverse auction



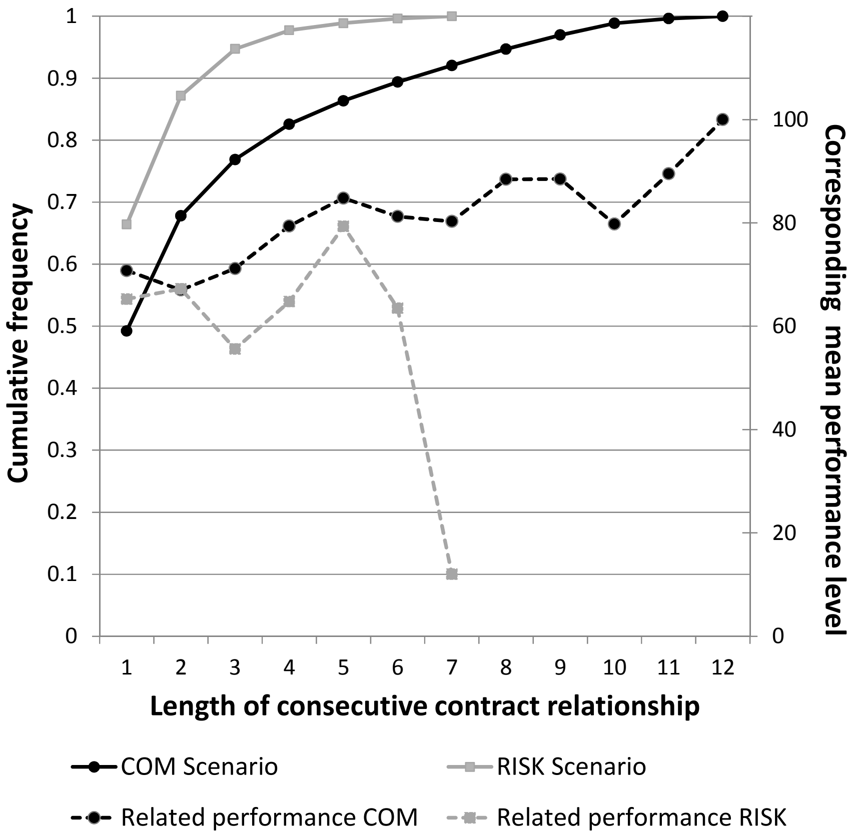
Note: The grey shaded parts denote the random probability (resulting from the number of bidders and contracts) of every bidder to conclude a contract. The darker shaded parts show the excess probability. The total percentage share gives the probability of consecutive contracting. Data originally published in Vogt et al. (2013); cf. Vogt, in preparation.

As the establishment of the social optimum is counterintuitive to the competitive logic of an inverse auction, we approximate learning effects by the time trends of the market variables: offers made by bidders, payments and performance levels of auction winners (cf. Table 3). All three key variables follow a strong positive time trend in the market with communication, while the picture is ambiguous and insignificant in the market struck by risk. This confirms our first hypothesis on the limited learning effects in the RISK scenario. Moreover, it shows the benefits associated with learning in the auction with communication. Since offers and performance increase simultaneously, learning effects do not lead to efficiency losses and strategic bidding but cause a “social gift exchange” instead (cf. Vogt et al. 2013). The establishment of such a mechanism is much more difficult if a random factor affects the output and contractors have no possibility to exchange experience with the auctioneer. The results of the RISK market show that auctioneers then rather apply market principles and choose lower-priced bidders, leading to suboptimal performance levels (cf. Vogt, in prep.).

Similar to a “market for lemons” low payments yield low re-investments by bidders since higher performance levels cannot be financed. Under these conditions, any learning experience gained by contracting bidders is ineffective, confirming Hypothesis 1.

If social capital accounts for the establishment of bidder asymmetry and relationship-specific assets generate lock-in effects, auctioneers should follow distinct selection strategies in each experimental scenario. Indeed, this is the case. Bidders in the inverse auction with social capital formation had a clearly higher probability to re-conclude a contract with the auctioneer (Figure 2). In contrast to the RISK market where contract allocation was almost entirely random, the random chance was exceeded by 15.4 percentage points in the market with communication.

Figure 3: Cumulative frequency of contract relationships of different lengths and corresponding performance levels in two experimental scenarios of a repeated inverse auction



Note: Number of observations is 264 in the COM and 265 in the RISK scenario. Potential maximum length of contract relationship is 12 in the COM and 20 in the RISK scenario. Data originally published in Vogt et al. (2013); cf. Vogt, in preparation.

Further differences across markets are shown in Figure 3 (solid lines), which illustrates the composition of consecutive contract relationships in both markets. Auctioneers facing environmental risk swapped bidders more often than they did in the scenario with communication, resulting in the termination of almost 90 % of contract relationships after not more than two consecutive contracts. Being able to communicate, auctioneers more often contracted with the same bidder, repeatedly. Hence, in the COM market roughly 30 % of all relationships exceeded two consecutive contracts. Interestingly, although every bidder had the same access to the chatting tool, the amount of conversation varied substantially[10]. Indeed, the number of chat lines sent to the auctioneer before issuing an offer had a significant positive impact on the probability of receiving a contract (cf. Vogt et al. 2013). The variation in the amount of conversation, an increased re-acceptance probability and longer contract relationships point towards a reduced bidding competition under social capital formation and bring up the question of opportunistic bidder behaviour in locked-in relationships.

But, reduced competition does not necessarily lead to poorer performance in an inverse auction for a public good. Quite the contrary is true; relationship length and performance level are positively correlated in the market scenario with social capital formation (cf. Figure 3, dashed line in black). The more locked-in a relationship between bidder and auctioneer becomes in the COM market, the higher the resulting performance. This strong relationship is not observed in the market with RISK although there is some evidence for a positive length-performance-correlation in contract relationships based on three to five consecutive contracts (cf. dashed line in grey).[11] In sum, Hypothesis 2 can be confirmed: Social capital resulting from bilateral communication favours the establishment of locked-in relationships. Moreover, long-term relationships pay off with regard to the provision of the public good.

4. Conclusion

If cost-effective conservation instruments to safeguard ecological goods are to be established with the support of the relevant stakeholders, the role of relationships between them should not be neglected. We provide conceptual-theoretical as well as initial empirical support to the discussion on the long-term performance of repeated conservation auctions using a transaction cost economics approach complemented by the dimension of social capital. We pointed out that learning, specific assets, and social capital have the potential to generate asymmetries amongst bidders who repeatedly participate in conservation auctions. We reviewed the relevant empirical literature on auction-based conservation programmes and showed where in the tendering and contracting process learning effects, social capital formation and specific assets play a role. Applying Williamson’s concept of the fundamental transformation of a competitive process into bilateral monopolies (1985), we argued that repeated conservation auctions bear the risk of lock-in effects which affect the auction’s competition, cost-effectiveness and ecological effectiveness.

[10] In the respective subsample treatment of Vogt et al. (2013) the mean number of chat lines sent per period was 1.8 for bidders (standard deviation = 2.4) and 7.1 for auctioneers (standard deviation = 4.0).

[11] Though, only based on three observations, the data shown in Figure 3 indicates that mean performance declines with longer contract relationships.

By comparing laboratory data from two experimental inverse auctions based on a contract selection and a contract execution stage, we provided initial empirical evidence for the conditions under which lock-in effects in inverse auctions occur and how they affect contract performance. In the experimental auction characterised by a constant experimental environment, learning effects fostered the gradual adjustment of key market variables towards the socially optimal performance level. Moreover, a communication channel between auctioneer and bidders actively encouraged the creation of social capital. We demonstrated that in this experimental auction relationship-specific investments significantly affected contracting behaviour of auctioneers, leading to long-term contract relationships with particular bidders. However, these locked-in relationships were characterised by superior performance levels.

Compared to the experimental auction with communication, in the second scenario without communication but with environmental risk auctioneers did not develop preferences for specific bidders. Instead of allowing direct interaction, the experimental scenario introduced additional output uncertainty for the auctioneer by means of a probabilistic effort transformation only known to the contracting bidder. We showed that this parameter destroys positive learning effects and also induces auctioneers to select bidders rather randomly. While competition could be maintained in the inverse auction, the overall performance of the market was inferior with a suboptimal provision of the public good. Hence, a lack of trust in the bidders significantly reduced the auction's cost-effectiveness.

Our findings demonstrate that lock-in effects do not erode the effectiveness of an auction but change the rules of the game towards more favourable market conditions for the provision of the public good. Thus, auctioning is not only about finding the lowest-cost supplier but also identifying those who are intrinsically motivated (cf. Lockie 2013). This is especially important in view of the second market scenario. Since environmental risk is an integral component of every conservation effort involving resource and land management, the mediocre performance of the second experimental scenario is an alarm signal. Trust-based working relations and long-term contract relationships would have been necessary to overcome the challenges posed by random performance shocks. But the market scenario did not provide opportunities for direct interaction. Therefore, the most important lesson for designers of contracts for payments for ecosystem services is the necessity to build sufficient social capital with conservation stakeholders in order to effectively deal with situations characterised by high environmental risk and uncertainty.

As the creation of social capital amongst the landholders and the environmental agency is important for effective conservation programmes, programme designers should focus more on establishing long-term contract relationships, for instance, by means of differential treatment or longer contract durations. If contract re-enrolment would be excluded from the competitive sign-up and made conditional on other criteria, social capital indicators could become an institutionalised feature of contract allocation. Differential treatment would enable the agency to safeguard attained ecological goals and keep bidding competition for new participants.

Another possibility to (implicitly) address bidder asymmetry is contract duration. A longer contract (10 to 15 years) reduces the frequency of re-enrolment and increases the time span in which land is covered under a conservation measure.

Especially, laboratory experiments are suited to pre-test new design elements as they provide the controlled environment to thoroughly differentiate between contract allocation and contract execution. Future research activity should thus be directed towards further empirical work on the distinct sources of bidder asymmetry and behavioural implications, to further improve the effectiveness of incentive-based conservation programmes.

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Synopsis

Payments for ecosystem services (PES) and their allocation via competitive tendering processes is an important and innovative instrument in the battle against on-going biodiversity loss. Based on a contractual arrangement between a service provider and a private or public entity willing to buy the conservation service, favourable land management activities or extensive agricultural practices can be stipulated. The advantage of PES is the direct monetary incentive for conservation effort, as a public good, and the potential to achieve a level of environmental protection that exceeds the bottom line drawn by environmental legislation. Its disadvantage is the profound degree of information asymmetry within the contract relationship that results from using environmental goods as an asset and from the nature of economic decision-making.

Analysing the interdependent relationship between competitiveness and compliance, and demonstrating the importance of trust and reciprocity in contracts for environmental goods, this thesis contributes to the rich and multidisciplinary literature on payments for ecosystem services, and conservation auctions in particular. During the past 25 years, practitioners, scholars and scientists have been constantly improving and expanding our understanding on the functioning of inverse auctions for allocating PES contracts. Research mainly focussed on the auction metrics and bidding behaviour, whilst the resulting contract relationships between programme managers as buyers and landholders as sellers have not been sufficiently addressed. However, as shown in this thesis, their relationship is the key to the success of a market-based conservation programme.

In this thesis, three articles set out the argument that trust and reciprocity are relevant in overcoming problems of asymmetric information inherent to competitively allocated PES contracts. A two-stage experimental test scenario, developed for this purpose, simulates the decision-making process in the inverse auction market and the subsequent contract execution in the laboratory. Using this test design in a first experiment, it is demonstrated that conservation auctions bear a profound risk of adverse selection, moral hazard and, thus, suboptimal contract results. However, market failure can be effectively overcome by means of trust-building institutions, such as communication between sellers and buyers. Personal interactions induce market participants to change their individually rational behaviour in a more socially optimal way. However, the social benefit comes at the expense of a certain degree of market bilateralisation. A second experiment illustrates how crucially necessary trust-based contract relationships become if the contracting and provisioning environments are heavily distorted by external, stochastic influences. In this case cooperation almost entirely breaks down due to the lack of trust.

Finally, comparing the results of these two experiments in a third article it becomes obvious that stable long-term contract relationships in auction-based PES programmes ought to be fostered and not be prevented. While, from a conservation point of view, stable and trust-based contract relationships are favourable to random short-term contracting, they are also shown to be more cost-effective in economic terms. This reveals a significant challenge for programme designers to provide sufficient opportunities to build social capital between contractors and maintain fair market structures.

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Eidesstattliche Erklärung

Ich versichere an Eides statt, dass ich die eingereichte Dissertation “Trust and Reciprocity in the Market-Based Provision of Public Goods: Experimental Evidence and Applications to Conservation Tenders” selbstständig und ohne unerlaubte Hilfsmittel verfasst habe. Anderer als der von mir angegebenen Hilfsmittel und Schriften habe ich mich nicht bedient. Alle wörtlich oder sinngemäß den Schriften anderer Autoren entnommenen Stellen habe ich kenntlich gemacht.