Economic Experiments and Environmental Policy

Noussair, Charles; van Soest, Daan

No. 2014-001

ECONOMIC EXPERIMENTS AND ENVIRONMENTAL POLICY: A REVIEW

By

Charles N. Noussair, Daan P. van Soest

07 January, 2014

ISSN 0924-7815
ISSN 2213-9532

Economic experiments and environmental policy: A review*

Charles N. Noussair[1] and Daan P. van Soest[1,2]

[1] Tilburg University, Department of Economics and CentER, Tilburg, the Netherlands
[2] Tilburg Sustainability Center, Tilburg, the Netherlands

Abstract:
We summarize and review the literature on two types of economic experiments. First we discuss the use of experimental laboratories to testbed market solutions to issues in environmental policy. We concentrate on experiments with one and two-sided markets, and applications in the domain of water allocation, food safety, and tradable permit systems. Second, we explore the consequences for environmental policies of the vast body of literature refuting the assumption that humans are only concerned with their own private welfare. We review the literature addressing whether government intervention is always necessary to protect the environment, and also whether it is always effective in doing so.

Keywords: Survey, experiment, environment, social dilemma

JEL Classification Codes: C92, Q20, Q30, Q50

1. Introduction

In this article, we discuss some of the laboratory methods that have been employed in environmental and natural resource economics, and selectively survey some of the relevant laboratory experimental

* When citing this paper, please use the following: Noussair CN, van Soest DP. 2014. Economic Experiments and Environmental Policy: A Review, *Annual Reviews of Resource Economics*, 6, submitted. Doi: 10.1146/annurev-resource-091912-151833 Daan van Soest gratefully acknowledges financial support by the European Commission, as part of the ENTRE'ACTE program. We thank Eline van der Heijden for comments and suggestions on an earlier version of this paper.

studies.[1] The first part of the paper focuses on studies of market mechanisms for achieving environmental objectives. The laboratory has been used to testbed new policies for resource allocation or trade, and for extracting information about preferences for use in demand estimation and welfare calculations. These are centralized approaches in the sense that, while they typically use market mechanisms, they presume that the market engineer or authority can impose and enforce contracts and property rights. We describe some of the methods that have been applied, and point out that they provide insights that are impressive but mostly highly focused on very specific questions. The main shortcoming of this literature is that the policy instruments studied typically only address narrow aspects of the issues that must be considered when formulating policy. To provide a taste of what has been done in the area, we consider three applications of experimental methods in some detail. The first is water allocation, in which markets are designed to allocate water efficiently. The second is food safety, which some view as placed in jeopardy by the introduction of genetically modified organisms into the food supply. The third is the design of markets to assign and exchange pollution permits. For each of the three applications, we describe a few representative studies that illustrate what can be done and learned from laboratory research. For excellent, detailed discussions of these and related topics, see Normann and Riccuti (2009) and Friesen and Gangadharan (2013).

Section three describes experimental research on social dilemmas. There are many environmental problems that have the structure of social dilemmas. Individuals who act selfishly cause greater degradation of the environment than is socially optimal. Absent centralized government regulation, environmentally friendly behavior is either voluntary or enforced by peers via systems of shared norms. Standard economic theory is skeptical about humans voluntarily addressing environmental problems. The costs associated with such activities are incurred by the agent undertaking them, while he/she only receives a small share of the total societal benefits. Yet observation of the world suggests that humans do care about more than just their own private welfare. This raises two important questions. Firstly, what are the consequences of the government imposing environmental regulations, if some or maybe many stakeholders would take voluntary action themselves to protect the environment even in the absence of regulation? Does state intervention strengthen individuals' propensity to protect the environment, or does it reduce it? Secondly, does this propensity to voluntarily take care of the environment imply that top-down government intervention is not always necessary, because self-regulation is possible? Section three considers laboratory experiments addressing these issues. Section 4 concludes.

[1] We restrict our attention to laboratory experiments, which in this article is defined as those conducted in the confines of a controlled laboratory facility. For a discussion of field experiments that relate to environmental and resource economics, see List and Price (2013).

2. Market approaches

A rich experimental literature has yielded important insights about how to design markets to help address policy challenges. One application has been the design of market-based mechanisms to manage natural resources and the environment. In this section, we describe and discuss three types of applications of experimental economics to such issues. These are (1) the use of experimental methods to design, award, or revoke property rights over the use or extraction of natural resources, (2) the extraction of privately-held information about valuation of individuals for particular goods or attributes, and (3) the design of markets to exchange property rights over use of natural resources among users. The first two applications involve the use of one-sided auctions, in which participants either bid to purchase or to sell to an authority. The third application employs two-sided markets to allocate rights to extract, degrade, or pollute a resource. The last part of the section is devoted to a brief survey of experimental results for three applications, water markets, elicitation of valuations for genetically modified foods, and allocating the right to pollute.

2.1. Designing systems to efficiently award or purchase? property rights

A body of auction theory, beginning with the work of Vickrey (1961, 1962), has considered three important questions. The first is which auction mechanisms allocate resources efficiently, in that they award or extract units in such a way as to maximize welfare. When bidding to purchase a good, an efficient allocation results when the bidder(s) with the highest value(s) of the goods receive them. A second and related issue is what rules might induce sophisticated bidders to truthfully reveal their demand or supply functions. This is an especially useful property because in such a process, the mechanism designer can read off the actual valuations of bidders from their bids and use these values for welfare calculations. An incentive to truthfully reveal willingness-to-pay also makes it simpler for bidders to formulate good strategies, since all that is required is for them to determine what their value for obtaining a unit might be.

When there is a single unit to be sold, and individuals know their own value for the good before they make their bid, both the English auction and the second price auction, have a dominant strategy of truthful demand revelation. An English auction is an open ascending price auction, in which the last active bidder receives the item and pays the price at which the second-to-last active bidder left the bidding. A second price auction is a sealed bid auction, in which all players bid simultaneously, the highest bidder receives the item, and the winner pays a price equal to the second highest bid. When multiple identical units are to be sold but each buyer wishes to or is constrained to purchase only one of the units, multi-unit generalizations of these two processes exist with a uniform

price for all winners that have similar demand revelation properties.[2] Experimental work has shown that English auctions, particularly clock versions, are highly efficient, with the dominant strategy transparent even to unsophisticated individuals (McCabe et al. 1990). Demand-revealing sealed bid auctions of the second-price sealed bid auction family require a bit more training, but can also be effective in generating efficient allocations (Noussair et al. 2004b).

However, there are a number of problems with this using demand-revealing English or sealed bud auctions to elicit valuations for a good. One is that the incentives are very weak to bid truthfully when one's bid is unlikely to be close to the margin between obtaining and failing to obtain a unit (Noussair et al., 2004b). Suppose that there are numerous units to be sold and bidder *i* has a valuation that is quite likely to be one of the highest among the set of bidders. Her bid has a very low likelihood of being marginal and therefore *i* has a very low expected cost of failing to adhere to the dominant strategy of truthful bidding. Furthermore, in an auction in which there are relatively few units available for sale, an individual with a very low valuation may well bid zero or many multiples of his valuation since, again, his bid is highly unlikely to be marginal.

To combat this problem, auction formats have been proposed that preserve the incentive for truthful bidding. The random *n*th price auction (Shogren et al., 2001) is an auction, in which the supply eventually to be sold is unknown to bidders at the time of bidding. There are *n* units sold, and each of the *n* highest bidders is awarded a unit and pays the $n+1^{st}$ greatest bid. The quantity *n* is randomly generated after all bids are submitted. This evens out the marginal incentives for different valuations. However, while this auction can be effective for valuation elicitation, it is impractical for the selling off of resources or rights when the supply available is inflexible or costly to vary.

Another widely used tool for eliciting valuations is the Becker de Groot Marschak (BDM) mechanism (Becker et al., 1964). This simulates the incentives of the second price sealed bid auction in a setting in which only one individual bids. It operates in the following manner. The bidder submits a bid to obtain an item. Then a sale price is randomly drawn from a range of possible prices. If the individual's bid is greater than the sale price, she obtains a unit and pays the sale price. If the bid is lower than the sale price, she does not obtain a unit and does not pay anything. However, there are difficulties with this process as well. The structure can be confusing for some individuals and may require considerable training (Noussair et al., 2004a). A more general problem is that the incentives to

[2] When each individual wishes to purchase multiple units, different prices are required for different units to achieve demand revelation (Weber, 1982; Ausubel 2004). See Noussair (2003) for a discussion of work on complex auctions for environments in which preferences have non-convexities.

truthfully reveal demand can be very weak because of a flat payoff function (Noussair et al., 2004b), an issue that is even more severe than for the auction mechanisms described above.[3]

All of these systems, which are incentivized in the sense that individuals must pay from their endowments, are also characterized by some other problems. First, because voluntary participants in research studies must be compensated for participation, they typically receive an endowment from the researcher. This means that it is very expensive to elicit valuations for very expensive items. One approach to considering valuations for such items is to conduct hypothetical auctions. However, these auctions typically yield greater willingness-to-pay estimates than do auctions with real stakes – a phenomenon that has been dubbed "hypothetical bias" (List and Gallet, 2001; Harrison and Rutstrom, 2008). Secondly, if valuations of an attribute are very small for each individual, though they may be very large when aggregated across a large number of people, individual bids for goods differing in the attribute can become indistinguishable from each other. When the question of interest is which one of two goods is more highly valued, a separation in the value of the measure of preference between the two goods is needed. It is possible to merely ask people which one they prefer or to choose between two items, but that yields no cardinal information about the intensity of preferences. Alternatively, participants can rate goods on a Likert Scale, in which individuals rate a product on a scale from very negatively to very positively. Noussair et al. (2004c) argue that Likert scales can be very effective in settings in which values of goods are very high, or very close together.

In the laboratory, participation constraints are not an issue since the experimenter creates a situation in which there always exist potential gains from trade for every party relative to a status quo of non-participation. In field applications, however, every major stakeholder must typically be made better off from participating in a new system when it introduced. If individuals must pay for something in an auction that they have been awarded for free or for lower prices previously, there may be resistance to the adoption of an auction system. Grandfathering of rights may be necessary (Ledyard and Szakaly-Moore, 1994). Revenue-neutral auctions, in which the revenue taken in is rebated to bidders in the auction (Franciosi et al., 1993), provide a partial solution to this problem.

2.2 Designing market mechanisms to exchange property rights

Experimental methods have also been used to develop and test two-sided markets for use in environmental and natural resource management. Laboratory research establishes that competitive equilibria can be attained consistently under fairly general conditions if property rights are guaranteed

[3] This can be partially overcome by modifying with the distribution of valuations from which sale prices are drawn to put greater density near more likely valuations. See for example Irwin et al. (1998).

and the appropriate trading rules are in place. A number of different trading rules are effective, but the most comprehensively studied is the continuous double auction (Smith, 1962). The rules of the double auction market process are the following. The market is open for an interval of time, and may be subject to a fixed or random time of termination. At any time agents can submit offers to the market. These offers are posted publicly. At any time, agents may accept any outstanding offer that is currently on the market and conclude a trade at the offered price. A sealed bid auction, sometimes referred to as a call market, in which all bids are submitted simultaneously and all trades are made at the same market-clearing price, also tends to lead to competitive pricing and allocations (Cason and Friedman, 1997).

Numerous studies have investigated the allocative properties of double auction or call markets in environments mimicking markets for tradable pollution permits or resource exploitation rights. They tend to show that markets converge to competitive equilibrium prices and allocations, though not without difficulties in some environments. However, the ability to design such markets only can aid policy so far and a number of limitations of this research must be recognized. One such limitation is that attaining competitive equilibrium is only as desirable as the resulting prices and allocations are from a social welfare point of view. If there are negative externalities imposed on other agents, the quantity of pollution or resource exploitation may still well exceed the socially optimal level. It may also be less than the social optimum since the partial equilibrium focus on the market for pollution or extraction rights ignores the social value created by the polluting or the extracting industry (though the demand in the rights market presumably takes into account some aspects of the private value or profitability of the industry). Furthermore, while the market for pollution permits tends to lead those with the lowest abatement cost to reduce their emissions, the market ignores the differing social value of reducing some sources of pollution rather than others. If entities with high abatement cost are doing the most damage because of their location near population centers, the market would not take this into account, because it allocates based only on the private values and costs of the polluters.

Another difficulty in using these institutions arises when a few individuals accumulate a high degree of market power. In this case the mechanism generates some inefficiency in allocations. Another issue is the possibility that there is no competitive equilibrium, that is, if there exists no price at which quantity demand equals quantity supplied. This could occur for example, if pollution is generated in lumpy, discrete amounts, so that individual permits to pollute have no value to a demander unless she is able to obtain a certain threshold number of them. In such an environment, double auction markets are known to perform poorly (Van Boening and Wilcox, 1996), and more complex markets must be designed.

Another potential problem with applying market institutions developed in the laboratory to the field is the lack of endowment effects (Kahneman et al., 1990) in the laboratory. The laboratory studies surveyed below all induce preferences with monetary payments. This means that the only value of the good being traded is that it can be redeemed for cash from the experimenter and the only cost of sale is a cash payment that must be paid to the experimenter at the time of sale. No emotional attachment to such goods can be expected. This is quite different from some field settings in which, for example, farmers are indicating the cash payment they would accept to take their land out of cultivation. In such circumstances, one might expect a substantial endowment effect may be present. Endowment effects would reduce the number of trades realized and may have considerable negative impact on the efficiency of market allocations (Dijk et al. 2013).

2.3 Three Applications of these methods

2.3.1 Water Allocation and Rationing

In many parts of the world, water is scarce and must be rationed. Ideally, the allocation should be accomplished in an efficient manner that also achieves target levels of water use and quality. Experimental methods have been used by researchers in several parts of the world to develop, evaluate and study market processes for rationing water.

The use of auctions for reducing agricultural runoff spilling into waterways is considered by Cason et al. (2003). They implement a sealed bid auction in which users bid to receive payments to take their land out of production. The buyer, representing a governmental authority, has a fixed budget to spend. The authors compare a setting in which individuals are informed of the environmental benefit of their project to one in which they are not. They find that the information induces landowners to behave strategically, reducing abatement and increasing seller profits

Experimental methods were used to develop an auction to promote water conservation by Cummings et al. (2004). Users bid to receive payments to forego irrigation from a fixed total available budget. The auction rules allows multiple rounds in which individuals could revise their bids. They studied both discriminative pricing, in which each winning bidder receives a payment equal to her bid, as well as uniform pricing, in which each winning bidder gets an amount equal to the highest accepted bid. The laboratory experiment was determined to be effective and led to a field test and implementation of the discriminative auction in the state of Georgia.

When it comes to water conservation, in addition to overall consumption level, ensuring water quality is critical. Duke and Gangadharan (2008) focus specifically on the high salinity of the water supply resulting from intensive agriculture, an important problem in many parts of the world. The

experiment they report evaluates a system of salinity levies in operation in Victoria, Australia, and compares its behavior against alternative policies. They compare the current salinity levy with an alternative salinity tax, and with a baseline of no regulation. The current levy is paid by buyers of water, and has the feature that it creates no incentive to make trades that reduce salinity concentrations. The experimental data show that the tax reduces the cost of salinity interception by 75%. Differences in the framing of the two policies accounts for the effect. There is no difference in water price or in the variability of outcomes between the two systems. Both systems reduce salinity relative to an unregulated setting.

Water scarcity in Australia, the driest of the world's continents, also motivates the work of Tisdell et al. (2007). They compare closed-call tenders, cap and trade regulation, and a command and control system, as means of reducing the concentrations of suspended solids in the Somerset Stanley catchment in Queensland. They study both first-price and second-price tender systems. Bidders can make offers to construct riparian buffer zones that have the effect of reducing sediment levels. The solids are a non-point source of pollution making it impossible to directly tax the polluter based on the amount that he pollutes. They find that the first-price auction is susceptible to strategic behavior on the part of sellers, reducing the quantity offered and increasing prices. This does not occur under the second-price sealed bid auction. The cap and trade system is also effective in converging toward the target level specified in the cap. Nonetheless, direct command and control regulation meets the target at the least cost.

The use of water, like all renewable resources, involves a tradeoff between current exploitation and the reservation of stocks available for future use. Intertemporal water stock management is considered by Garrido (2007). His experiment evaluates two specific water market policies that were included in the 1999 water reform law in Spain. The first policy was that junior holders of water rights were not permitted to buy water from senior right holders. The second was that the law did not define water rights over quantities that remained in reservoirs from the previous season. Garrido's results show that the restrictions on trade reduce the welfare of the senior users, while the junior users nonetheless fail to benefit. He concludes that removing trading restrictions and specifying property rights over the stocks remaining in reservoirs would increase average stocks and price stability.

The study of smart markets to allocate water was initiated by Murphy et al. (2000). A smart market is one in which allocation of the traded good is aided by algorithms. The design is based on the demand and supply configuration in California's water market. They consider a system of sealed-bid uniform price double auctions for allocating both water itself and transportation capacity. An algorithm computes an efficient allocation based on submitted bids and offers and calculates prices

and allocations at each network node. They consider treatments with conveyance links controlled by unique (no co-tenancy) and multiple (co-tenancy) parties. They find that outcomes are efficient despite rather thin markets, and that co-tenancy increases efficiency.

One technique for water management is to encourage traders who are motivated by environmental considerations to purchase water without the intent of consuming. Murphy et al. (2009) study a smart market in which one large trader has such motivation. They study three different property right schemes to manage instream flows. The first is the imposition of minimum instream flow constraints. Consumptive users are free to trade but there is a minimum instream flow that is required. The second is to subsidize downstream consumption through having the environmentally motivated user contributing to the cost of supplying upstream water. The third is to accord private property rights on instream water flows to the environmental user. The results show that all three systems generate high levels of efficiency, though the participation of the non-consumptive user does induce a slight reduction in efficiency.

2.3.2. Genetically Modified Organisms in the Food Supply

An important policy issue in recent years, especially in Europe, has been the appropriate policy response to the introduction of genetically modified organisms (GMOs) into the food supply. Because strict segregation between GM and non-GM varieties of the same crop is very costly, the introduction of GM plants threatens to perturb the ecosystem. Surveys and polls show great apprehension about the appearance of GM foods. Experimental methods have been used to inform this debate by studying the value that individuals place on genetically modified, compared to conventional products.

Noussair et al. (2004) consider the extent to which consumers drawn from the French population prefer products that are guaranteed to be free of genetic modification to those that are not. They find that about 35% of individuals refuse to pay any positive amount of money for a GM product, 23% are indifferent between GM and GM-free products, 5% prefer genetically modified products, and the remaining 47% are willing to buy GM-products if they receive a sufficiently large price discount. The willingness of consumers to purchase these products contrasts sharply with the results from prior hypothetical surveys of the same population, in which 89% of respondents indicate that they would never buy a genetically modified food product. In related research, Noussair et al. (2002) find that consumers' relatively high revealed willingness to purchase GM products is largely due to the fact that they tend not to read labeling information.

Lusk et al. (2001) consider the relationship between measures gathered under two different auction institutions eliciting willingness-to-pay and a specially designed survey. The first-price and second-price sealed-bid auctions are considered. In the experiment, participants could bid to pay to

exchange a bag of GM corn chips for one that was free of genetic modification. They found that 20% of their student participants were willing to pay at least 25 cents for the exchange, and also that the survey was a good predictor of bidding behavior. They found no strong differences between the two auction types.

Rousu et al. (2007) and Huffman et al. (2007) study the impact and value of third-party information about GM content on the willingness to pay for a guarantee of no genetic modification with a representative sample of midwestern American consumers. This third-party information distinct from second party information from interested parties, such as the sellers of GM seeds, the food industry, or environmental activists. Third party information refers to information that is independent and verifiable. Rousu et al. studied three goods; vegetable oil, tortilla chips, and Russet potatoes. They use a random *n*th price auction. Between bidding periods, participants received one of six different pieces of information. These varied in whether it had a pro- or anti-GM viewpoint and in whether or not it came from a third party. Pro- and anti-biotech information shifts willingness-to-pay in the intended direction, even when it comes from interested parties. Verifiable information pushes behavior in similar directions as information with the same content from interested parties.

2.3.3 Pollution Permits

Experimental markets have been used in the development of systems for organizing distribution and trade of the right to pollute. Cason (1995) uses an experiment to demonstrate the incentive properties of an auction used by the American Environmental Protection Agency to sell sulfur dioxide emission allowances. The rules of this auction specify that the sellers with the lowest asking prices receive the highest payments from among the accepted offers. He studies an inverted version of this auction, in which the buyers submit the bids. He finds that, as theory predicts, buyers tend to make bids greater than their valuations, and this results in some inefficiency. Players bid closer to the risk-neutral Nash equilibrium level when facing robot buyers using Nash strategies, suggesting that some of the deviation from equilibrium bidding is due to beliefs that other players will also submit out-of-equilibrium bids. Cason and Plott (1996) report a series of experiments that show that a more standard uniform-price call auction generates greater efficiency, leads to prices closer to competitive levels, and exhibits greater responsiveness to changes in market conditions than the EPA auction.

One-sided auctions of the right to pollute have been studied by Porter et al. (2009). They design and test three auction mechanisms for the sale of nitrous oxide emission allowances for the state of Virginia. The three mechanisms considered are a combinatorial sealed bid auction (in which individuals can bid for packages of units, see Noussair 2003 for a discussion), a sequential English clock auction, and a combinatorial English clock auction. They find that the sequential and

combinatorial English clock mechanisms generate greater efficiency than the sealed-bid process when demand is relatively elastic. The systems behave similarly when demand is inelastic.

Ledyard and Szakaly-Moore (1994) use experiments to design and create an institution that realizes gains from exchange after the initial allocation is made, but is politically viable to implement in that it does not leave any stakeholders worse off in expectation. They study a revenue neutral sealed bid auction, where the revenue the auctioneer takes in is rebated to bidders, as well as a double auction market with grandfathered initial allocations. The double auction market generates greater efficiency than the revenue neutral auction in a competitive environment, though there is no difference in an environment where there is monopoly power over initial permit holdings. A revenue neutral auction was also studied by Franciosi et al. (1993), who compared its performance to that of a uniform-price sealed bid auction with no rebate. They found that efficiency and prices were similar under the two systems, so that rebating revenue did not greatly distort the allocation resulting from the auction. Goeree et al. (2010) also compare auctioning versus grandfathering initial allocations in pollution permit markets. When the permits are grandfathered, there is a phase of spot market trade which, in principle, should remove any inefficiency from the initial allocation. In contrast, however, they find that high emitters exercise market power so that grandfathering rights distorts the operation of the market. When permits are auctioned, on the other hand, low bidders tend to receive a larger proportion of the initial allocation. Compared to grandfathering, the auction leads to greater consumer surplus and lower prices on average.

As indicated earlier, much interest has centered on the use of continuous double auctions in tradable permit markets. Muller et al. (2002) study the ability of the double auction market to discipline monopolists and monopsonists in emissions trading markets. They find that considerable market power can be exercised within the double auction institution. Furthermore, Cason and Gangadharan (1998) find that an Electronic Bulletin Board institution, in which individuals post terms for trade that serve as the basis for bilateral negotiation, performs as well as the double auction. Ben-David et al. (1999) find that greater heterogeneity in abatement costs reduces market volume and efficiency of outcomes.

The question of what sort of polluters are unlikely to comply with the allocation they receive under a tradable quota system is taken up in Murphy and Stranlund (2007), building on Murphy and Stranlund (2006). They find that while violations are independent of the benefits from non-compliance, they do depend on the initial allocation of permits. Those who are predicted to purchase permits in equilibrium during trading were more likely to commit violations than those who would be equilibrium sellers. Under fixed emissions standards, compliance behavior is different than under an emission trading program. Those with a higher marginal benefit from non-compliance have a greater

tendency to commit violations. Targeted monitoring and enforcement has no additional benefit over random monitoring in the presence of a permit market.

Saving permits for use at future dates can in principle increase efficiency by allowing intertemporal substitution of polluting activities Godby et al. (1997) consider the behavior of emissions trading markets when permits can be banked. This banking is a feature of most emission trading programs currently in existence. Godby et al. also study the effect of trading rights to emit in the future. They find that banking reduces price variability, but reduces efficiency of the market. Trading entitlements to future permits increases efficiency and leads to more stable prices. Cason and Gangadharan (2006) consider the effect of banking permits in a setting in which traders experience random shocks to their emission levels after they make production and emission control decisions. Subjects can trade permits after the shock occurs. They then report their emissions to the regulator. Banking of permits increases price stability, though it increases noncompliance and emissions. Stranlund et al. (2011) also consider the value of allowing banking of emissions permits, focusing on the link between emission reporting, permit enforcement, and compliance. They design a setting in which imperfect monitoring could give rise to quota violations or untruthful emission reporting. The result suggests that it is very difficult to induce truthful self-reporting of emissions, even with severe permit violation penalties.

3. Decentralized approaches to solving environmental social dilemmas

The market approaches discussed in section 2 are the result of formal government intervention, but a large part of the experimental research also speaks to the question whether self-regulation is possible too in the environmental domain. By definition, selfish individuals will not incur additional costs to protect the environment, but then it is also true that a large body of literature indicates that only a relatively small share of the human population is "homo economicus". For example, using a preference elicitation game, Fischbacher et al. (2001) find that about one third of the subjects displayed behavior consistent with 'homo economicus', while about half of them acted 'conditionally cooperatively', reciprocating social-welfare maximizing actions of others. More generally, experimental research has documented that individuals do not invariably choose the action that maximizes their private payoffs. About 20% of the subjects participating in essentially one-shot Prisoner Dilemma games choose "cooperation" (Roth and Murnigham 1978). When given the opportunity to divide an amount of money between oneself and another anonymous participant (as in the Dictator game), many decision makers give a substantial portion to the other person (see for example Henrich et al. 2001). If the amount offered is too small, many recipients reject the offer when giving the opportunity to do so (as in the Ultimatum game), even if this results in neither of the participant receiving any money (Güth et al. 1982). And if any money sent by the proposer is tripled

by the experimenter, after which the recipient is free to split the sum received between herself and the proposer, proposers do invest positive amounts, and the recipient returns a fair share of the moneys received (Berg et al. 1995). These results suggest that not all humans simply try to maximize their own material welfare, but that some also value distributional fairness, dislike inequity, care about social welfare, and reciprocate kind and unkind actions; cf. Rabin (1993), Bolton and Ockenfels (1998), Charness and Rabin (2002), Fehr and Schmidt (1999), and Andreoni and Samuelson (2006); for an overview, see Meier (2007).

Many researchers have explored to what extent these social preferences are salient in multi-person social dilemmas, of which environmental preservation is an example. The dominant multi-person social dilemma paradigm in experimental economics is the Public Goods game (also known as the Voluntary Contribution Mechanism). In this game, each subject can invest in a public account that benefits all other subjects in her group, but she can also invest money in a private account. Any moneys invested in the private account are hers to keep; any funds invested in the public account are multiplied by a number larger than 1, and are subsequently shared equally among all members of a group. Because the investments in the public account are increased by the experimenter, group payoffs are maximized if all subjects invest their entire endowment in the public account. But the parameters are typically chosen so that a subject's investments in the public account increases her payoff by less than 1 unit – any point invested in the private account thus yields a higher return to the decision maker than investing in the public account. In spite of this prediction, subjects invest on average between 40 and 60% of their endowment in the public account in the first period of the interaction (cf. Ledyard 1995, Chaudhuri 2010). Contributions decline over time but typically remain substantial (Isaac and Walker, 1988a; Gächter et al. 2008).

Many subjects thus behave more cooperatively in these multiperson social dilemma games than is predicted by standard economic theory (but see Andreoni 1995a). This insight gives rise to two potentially important implications for policy. First, it seems that, at least under some circumstances, humans are able to overcome the "collective action problem" of taking care of the environment on their own, at least for a short period of time. If so, governments may have a larger set of policies instruments at their disposal than standard economic theory suggests. Perhaps policies aimed at stimulating "cooperation at the grass roots level" can also be an effective means to address environmental problems. If so, the question arises about how communities should be involved in the policy making process, and whether these participatory approaches are not only effective in the short run, but also in the long run (Bouma et al. 2007, 2008). Second, the fact that people are not just own-welfare maximizing automata, may imply that government interventions are not always welfare enhancing – and maybe not even effective in mitigating environmental problems (Deci 1971, Frey and Jegen 2001 – for an overview see Richter and van Soest 2012). Extrinsic incentives like

environmental taxes or tradable permits may not always result in increased provision of public goods because it may "crowd out" an individual's intrinsic motivation "to do good". This may be because of moral considerations (Ayala, 2010) or out of of a sense of fulfillment from having contributed to something constructive (Ariely et al. 2008). We discuss each of the two broader implications in more detail in the next two subsections.

3.1 The impact of top-down policy instruments on behavior: the possibility of "crowding out"

Dating back to Titmuss's famous example about whether paying people to donate blood would increase or decrease donorship (see Titmuss 1970, Mellström and Johannesson 2008), a substantial amount of (sometimes anecdotal) evidence has been gathered that formal interventions to increase pro-social behavior may turn out to be counterproductive. People may actually decrease their contribution to voluntary work if a fee for non–participation is introduced (Brekke et al. 2003), and "not in my backyard" (NIMBY) opposition to projects may increase when monetary compensation is offered to the local community (Frey and Oberholzer-Gee 1997, Frey et al. 1996).

Multiple reasons may exist for such crowding out effects, including that formal interventions may reduce the 'warm glow' of voluntary action (Andreoni 1993), take away the opportunity to signal one's cooperative attitude (Gintis et al. 2001, Ariely et al. 2009), undermine moral sentiments (Bowles 2008), or induce agents to update their beliefs about the value of the actions provided (Gneezy and Rusticchini 2000, Bénabou and Tirole 2003). Formal interventions may also be counterproductive if they are interpreted as signaling a lack of trust on the part of the regulator (Fehr and Fischbacher 2005). Detecting crowding out in the real world is quite difficult – the effects are likely to be subtle, and this mechanism may just be one among many factors that affect policy outcomes. For these reasons economic experiments are particularly useful because the presence of crowding out can be detected by having one group of subjects play a multi-person social dilemma game with "formal regulation" in place and another group without. If crowding out takes place in context-free laboratory settings, it may be even more important in the world outside the laboratory.

Andreoni (1993) tests whether complete crowding out occurs in a public goods game that was modified to generate an interior Nash equilibrium. In one treatment subjects could invest non-negative amounts, in the other the minimum permissible contribution level was two tokens. The minimum contribution level of two is similar to a lump-sum tax, and this tax rate was set below the symmetric interior Nash equilibrium contribution level. – average voluntary contributions in the positive minimum contribution level treatment should thus be two tokens lower than in the zero minimum contribution treatment. Yet Andreoni finds that total contributions (the minimum plus the voluntary contribution) were 0.57 tokens higher in the "tax" treatment than in the "no-tax" treatment. This difference is significant, but it also means that the lump-sum tax of two tokens reduced voluntary

contributions by 1.43 tokens – implying a crowding out rate of more than 70%. Hence, Andreoni concludes that government intervention may indeed be less effective than predicted by standard game theory.

These experiments employed student subjects and provided no decision context (see also Khadjavi and Lange 2013 for similar results). One may wonder whether the same effects are found if the games are played by people with experience solving public good provision problems in the field. Cárdenas et al. (2000) ran experiments in a region in rural Colombia where excessive firewood extraction negatively impacts water availability. Using villagers from this region as subjects in a contextualized pen-and-paper experiment mimicking the region's environmental situation, they find that the excessive extraction of firewood falls when a small (probabilistic) fine is introduced. But they also find that the longer-run consequences of introducing the institution were negative -- in the later periods extraction was even more aggressive than without a fine. These results echo Gneezy and Rusticchini's (2000) adagium "fine enough, or don't fine at all" (see also Nyborg and Brekke 2003). In a similar vein, Vollan (2008) tested crowding theory among livestock owners in different regions in southern Africa, and finds that fines increase efficiency in regions where trust was low (as measured by a Trust game), but crowds out voluntary actions in high-trust environments. In sum, crowding out may be a concern in the real world, although the exact circumstances under which it may materialize, are still uncertain (but see Frey and Jegen 2001).

3.2 Can humans overcome collective action problems without centralized enforcement?

Another consequence of human prosociality is that the government's environmental policy tool box may be larger than just top-down instruments such as environmental taxes, subsidies, tradable permits, and technical requirements. Maybe the government should not focus on imposing rules and regulations, but rather invest in strengthening local institutions that can support cooperation. Two such institutions have received most attention in experimental research; (1) communication, and (2) the use of peer-to-peer enforcement mechanisms (punishments and rewards).

First, communication between peers has been found to be a very effective mechanism for fostering cooperation. Even if communication is just cheap talk (not affecting the game's strategy space or payoffs), group payoffs are much greater in experimental settings when subjects have the possibility to communicate with other group members, than when they cannot (Ostrom et al. 1992, Ledyard 1995, Masclet et al. 2003, Noussair and Tucker 2005; Chaudhuri 2010). Communication increases efficiency in social dilemma experiments because it substantially postpones (or even prevents) the decay in cooperation that is typically observed absent communication possibilities – and more so if communication is face-to-face (Isaac and Walker 1988b) – probably because of two

reasons: communication can coordinate actions and improve subjects' understanding of the optimal group strategy.

Second, giving subjects the opportunity to impose punishments and/or rewards, at positive cost to the decision maker, also substantially increases cooperation in Public Goods games (Fehr and Gächter 2000, Carpenter 2004, Rand et al. 2009, Vyrastekova and van Soest 2008). However, there are limitations to the robustness of this result. The impact of punishments on efficiency is culturally dependent (Herrmann et al. 2008). Furthermore, the effectiveness of these decentralized enforcement instruments also depends on the specifics of how the game is implemented. The typical setup is the following. Each period consists of a social dilemma stage followed by one stage in which punishments or rewards can be meted out. Group composition is kept constant throughout the interaction. Subjects' identity labels also remain constant within periods, but are randomly changed between periods. These features have been found to substantially increase the effectiveness of decentralized enforcement institutions, as a single enforcement stage combined with randomly reassigned identity labels between periods implies that punishing and rewarding cannot become a game in itself.

Nikiforakis (2008) explored what happens if the experimental setting allows for "counterpunishment" by having the social dilemma stage being followed by two punishment stages rather than just one. The consequences are quite dramatic – the threat of retaliation implies that hardly any punishments are imposed at all, and efficiency in the social dilemma stage is equally low as absent the option to impose punishments (see also Denant-Boemont et al. 2007). Similar results have been found with rewards. As soon as subjects can positively reciprocate to rewards received (either because the social dilemma stage is followed by two reward stages per period rather than just one, or because identity labels are kept constant between periods), the reward institution loses its effectiveness (Stoop et al. 2013). In contrast to the case of punishment, this is not due to the fact that subjects give fewer rewards than when the experimental design does not allow for reciprocity in rewarding. Those who acted cooperatively in the social dilemma stage tend to give rewards to those who were also cooperative. But the free-riders in the social dilemma stage also exchange reward tokens with other free-riders; they use the option to reward to establish a mutually profitable bilateral exchange relationship.

The work discussed above gives mixed support for the idea that local stakeholders can overcome collective action problems. There are settings in which humans are able to support high levels of cooperation if they have the opportunity to communicate with their peers in a sufficiently rich manner. On the other hand, self-regulation by means of punishments and rewards seems to be effective in some circumstances, but not in all. But there may be another reason why humans are not

able to overcome the Tragedy of the Commons without centralized intervention. This is because the Public Goods paradigm has an important feature that helps maintain cooperation which is not present in all environmental problems. This feature is that in the Public Good paradigm, agents may fail to contribute, but they cannot decrease the balance in the public account. This is important for two reasons.

First, even if the action space is the same in terms of net contributions to the public good, ultimate contributions tend to be higher if subjects can only give, than if they can only take. Extending the strategy space in a Dictator game from just being able to give to the anonymous other participant to also being able to take from her endowment makes subjects much less prosocial than if they can only give (Bardsley 2008, List 2007). In this setting, giving zero can be viewed as a generous act. Andreoni (1995b) explored whether emphasizing the social benefits of investing in the public account yields the same contributions as emphasizing the social costs of *not* investing in the public account (but in one's private account instead). This pure framing effect caused a substantial reduction in contributions. Average contributions were 16.2% when the social costs of investing in one's private account were emphasized, while they were 34.5% when the social benefits of investing in the public account were emphasized.

Khadjavi and Lange (2013) build on this work by comparing play in the standard VCM game to the amount of public good provision observed if subjects can only take from the public account, as well as if they can either give to or take from the public account. The starting point is that some, all, or none of a subject's endowment has already been put into the public account, and then subjects have the possibility of adjusting the allocation before the public good is actually created. In all treatments the dominant strategy is to not contribute to the public good – invest nothing in the public account, or take out everything that was allocated to the account on one's behalf. They find that if subjects can only take, net contributions are significantly below those if subjects can only give (the standard VCM game), while net contributions are somewhere in the middle if the experimental design allows for both giving and taking (see also Bosman and van Winden 2002, and Cubitt et al. 2010). If environmental problems are caused by extractive activities, this literature suggests that establishing cooperation is more difficult than when public goods need to be created via positive investments.

The second reason why play in the standard Public Goods game may depict an overly optimistic image of human ability to cooperate in the real world, is that in many environmental problems the contributions by some can be undone by others. This is the case in virtually all renewable resource problems (Brown 2000). If some resource users decide to reduce their harvesting, the resource stock increases. This makes harvesting for others even more attractive because larger stocks reduce search costs and hence increase profitability – harvesting activities are thus strategic

substitutes (cf. Hoel 1991). But it also holds for many pollution problems, maybe not directly in the form of "technical" externalities as in renewable resources, but indirectly via the markets. Mitigating climate change has been labeled "the greatest public good of all" (cf. Stern 2007), but the climate change game does not have a dominant strategy of "zero abatement" as in the standard Public Goods game. The more some countries invest in improving their energy efficiency or in utilizing renewable energy sources, the lower the price of fossil fuels on the world markets, and this makes it more attractive for other countries to actually increase their fossil fuel consumption. The global net effect may even be an actual increase in total emissions, giving rise to the so-called "Green Paradox"; cf. Sinn (2008), Gerlagh (2010), and van der Ploeg and Withagen (2012). Similar "leakage effects" play a role in many other environmental problems – if not in all.

So what happens in economic laboratory experiments if some can undo the good works of others? Van Soest et al. (2013) developed a modified version of the standard Public Goods game in which subjects can invest in the public account, but where they can also take from that account – thus reducing the size of the public good that is being provided by others. They find that contributions fall even more than already documented by Khadjavi and Lange (2013) – net contributions are effectively zero from the first period onwards. These results echo the findings obtained using a related experimental paradigm, the Common Pool resource game. While this game differs from the standard Public Goods game in many respects, it shares the characteristic explored by van Soest et al. (2013) that contributions (or extractions) are strategic substitutes. The more cooperatively some people act, the more profitable it becomes for others to act non-cooperatively. And the results are similar – absent any institutions to support cooperation, there is, on average, no cooperation (Ostrom et al. 1992, Vyrastekova and van Soest 2003, 2008). These results suggest that despite the fact that a substantial share of humanity is prosocial, the strategic environment can make all subjects behave as is if they only care about their own private payoffs – a result that echos Milton Friedman's methodological instrumentalism (Friedman 1953).

The above exploration of experimental results on the nature of human prosociality yields important insights. On the one hand, we cannot always be certain that top-down government intervention enhances welfare, if agents' intrinsic motivation to act cooperatively is crowded out. On the other hand, devolving environmental policies to local stakeholders is not always likely to increase welfare either, particularly if some can undo the good works of others. These insights are important for local or domestic environmental and resource problems, but the decision to intervene or devolve environmental policy is not really applicable to transboundary environmental problems. Sovereign countries can only be induced to voluntarily internalize the consequences of their actions on the welfare of other countries – they cannot be forced to do so. Many of the above insights about the extent to which individuals can provide (local) public goods spill over to case where countries need to

address transboundary or even global environmental problems too. For example, the Green Paradox referred to above may cause countries not to commit to reducing their greenhouse gas emissions, even though they may well be aware of the desirability, or even necessity, of doing so. But there is a particular feature that may make intergovernmental cooperation to mitigate climate change even more difficult, and that is that climate change is an inherently complex problem. The relationship between greenhouse gas concentrations and climate change impacts may be (highly) non-linear. As long as concentrations remain a certain (unknown) threshold, damages are small too. But if concentrations exceed that threshold, damages may become much larger. Examples of processes that may give rise to such positive feedbacks are the melting of the Greenland ice sheet and of the permafrost.

The experimental paradigm that captures these effects is the so-called dynamic threshold public goods game (also called step-level public good game). Here, there is a public account that can be used to prevent a specific catastrophic loss in all subjects' private accounts. The experiment lasts multiple periods. If, in the final period, cumulative contributions are larger than a specific threshold, the private accounts of all participants in the group are secure. If a group fails to reach the cumulative aggregate threshold contribution, there is a positive probability that all group members lose a share of the funds in their private accounts, potentially giving rise to a double welfare loss. Money has been invested in the public account rather than in private accounts while the disaster can still strike. And if the disaster happens, group members sustain substantial losses in their private accounts as well. The typical findings are as follows. As is the case in the standard Public Goods game, subjects are willing to cooperate by investing in the public fund to avoid the disaster, but groups typically fail to reach the threshold (cf. Walker and Gardner 1992, Milinski et al. 2008, Milinski 2013; for an overview of these games see Croson and Marks 2000). Inequality tends to worsen outcomes, while communication helps to improve them (Tavoni et al. 2011). And when given the possibility to not just invest in mitigation but in adaptation[4] as well, the probability that the threshold contribution level is achieved is even smaller (Hasson et al. 2010).

4. Conclusion

In this article we have described and reviewed some of the work using laboratory experimental methods in environmental and resource economics. The survey has been selective, by necessity. In section two we considered studies concerned with the design of market institutions to achieve better patterns of resource allocation and to estimate demand. The discussion shows that the experimental laboratory has helped to develop innovative solutions to some specific policy questions. However, in

[4] Mitigation constitutes all actions that reduce damages, while adaptation refers to shielding one's assets or economy against negative risks. In Hasson et al. (2010), mitigation refers to the investments subjects can make in the public fund that can be used to reduce the probability of disasters, while adaptation is introduced by offering subjects the opportunity to invest in shielding their own private accounts against the negative risk.

our view, reviewing the literature lays bare the fact that experimental methods can only inform a narrow slice of the task of devising resource and environmental management policies, and must operate in conjunction with other methods.

We then turned to the use of experiments to study influences on the propensity to cooperate. This is relevant because environmental preservation is essentially a social dilemma. The intrinsic tendency to cooperate is important because it influences the heavy-handedness with which formal rules must be enacted and enforced. The evidence shows that under some circumstances, peer punishment and cooperation can lead to high levels of cooperation. It also demonstrates the possibility that formal rules requiring pro-social behavior may have the effect of crowding out the intrinsic motivation to cooperate. Furthermore, the presented experimental results highlight the importance of distinguishing between environments in which the gains from pro-social behavior can be offset or undone by the behavior of others, and those in which it cannot.

References

Andreoni, J. (1993). "An Experimental Test of the Public-Goods Crowding-out Hypothesis." *American Economic Review* 83:1317-27.

Andreoni, J. (1995a). "Cooperation in Public-Goods Experiments: Kindness or Confusion?" *American Economic Review 8*5: 891-904.

Andreoni, J. (1995b). "Warm-Glow versus Cold-Prickle: The Effects of Positive and Negative Framing on Cooperation in Experiments". *Quarterly Journal of Economics* 110, 1-21.

Andreoni, J., and L. Samuelson. (2006). "Building Rational Cooperation." *Journal of Economic Theory* 127:117–54.

Ariely, D., Kamenica, E., Prelec, D. (2008). "Man's Search for Meaning: The Case of Legos". *Journal of Economic Behavior and Organization* 67, 671-677.

Ariely, D., Bracha, A. and Meier, S., (2009). "Doing Good or Doing Well? Image Motivation and Monetary Incentives in Behaving Prosocially". *American Economic Review* 99, 544-555.

Ausubel L. (2004), "An Efficient Ascending-Price Auction for Multiple Objects", *American Economic Review* 94(5), 1452 – 1475.

Ayala, F.J., (2010). "The Difference of Being Human: Morality". *Proceedings of the National Academy of Sciences* 107, 9015-9022.

Bardsley, N. (2008), "Dictator Game Giving: Altruism or Artefact?" E*xperimental Economics* 11: 122–133.

Becker, G. M., M. DeGroot and J. Marschak (1964) "Measuring Utility by a Single-Response Sequential Method", *Behavioral Science* 5(3), 226 – 232.

Bénabou, R. and Tirole, J., (2003). "Intrinsic and Extrinsic Motivation" *The Review of Economic Studies* 70, 489-520.

Ben-David, S., D. Bookshire, S. Burness, M. McKee, and C. Schmidt (1999), "Heterogeneity, Irreversible Production Choices and Efficiency in Emission Permit Markets," *Journal of Environmental Economics and Management* 38, 176 – 194.

Berg, J., J. Dickhaut and K. McCabe (1995), "Trust, Reciprocity and Social History", *Games and Economic Behavior* 10, 122–142.

Bolton, G. E., and A. Ockenfels (2000), "ERC: A Theory of Equity, Reciprocity, and Competition", *American Economic Review* 90, 166–93.

Bosman, R. and F. van Winden (2002), "Emotional Hazard in a Power-to-Take Experiment", *Economic Journal* 112, 147-169.

Bouma, J., D.P. van Soest and E.H. Bulte (2007), "How Sustainable is Participatory Watershed Development in India?" *Agricultural Economics* 36(1): 13–22.

Bouma, J. A., Bulte, E. H. and van Soest, D. P. (2008). "Trust, Trustworthiness and Cooperation: Social Capital and Community Resource Management". *Journal of Environmental Economics and Management* 56(2), 155–166.

Bowles, S. (2008). "Policies Designed for Self-Interested Citizens May Undermine "The Moral Sentiments: Evidence from Economic Experiments". *Science* 320(5883), 1605-1609.

Brown, G. (2000), "Renewable Natural Resource Management and Use without Markets", *Journal of Economic Literature* 38, 875-914.

Cárdenas, J.C., Stranlund, J. and Willis, C., (2000), "Local Environmental Control and Institutional Crowding-Out." *World Development*, 28, 1719-1733.

Cason, T. (1995), "An Experimental Investigation of the Seller Incentives in the EPA's Emission Trading Auction", *The American Economic Review 95*: 905-922.

Cason, T. (2003), "Buyer Liability and Voluntary Inspections in International Greenhouse Gas Emissions Trading: A Laboratory Study," *Environmental and Resources Economics,* 25: 101-127.

Cason T. and D. Friedman (1997), "Price Formation in Single Call Markets", *Econometrica* 65, 311 – 345.

Cason T. and L. Gangadharan (1998). "An Experimental Study of Electronic Bulletin Board Trading for Emission Permits," *Journal of Regulatory Economics* 14: 55-73.

Cason T. and L. Gangadharan (2006), "Emissions Variability in Tradable Permit Markets with Imperfect Enforcement and Banking," *Journal of Economic Behavior and Organization,* 61: 199-216.

Cason T. and C. Plott (1996). "EPA's New Emissions Trading Mechanism: A Laboratory Evaluation," *Journal of Environmental Economics and Management* 30: 133-160.

Cummings, R., Holt, C., and Laury, S., (2004). "Using Laboratory Experiments for Policymaking: An Example from the Georgia Irrigation Reduction Auction", *Journal of Policy Analysis and Management:* 341-363

Chan, K., R. Godby, S. Mestelman and A. Muller (2002). "Crowding-out Voluntary Contributions to Public Goods". *Journal of Economic Behavior and Organization* 48, 305-317.

Charness, G., and M. Rabin. 2002. "Understanding Social Preferences with Simple Tests." *Quarterly Journal of Economics* 117,817–69.

Chaudhuri, A. (2010). "Sustaining Cooperation in Laboratory Public Goods Experiments: A Selective Survey of the Literature." *Experimental Economics* 14, 47-83.

Croson, R. and Marks M. (2000), "Step Returns in Threshold Public Goods: a Meta- and Experimental Analysis", *Experimental Economics* 2: 239-259.

Cubitt, R., Drouvelis M. and Gächter S. (2011). "Framing and Free Riding: Emotional Responses and Punishment in Social Dilemma Games". *Experimental Economics* 14, 254–272.

Deci, E.L., 1971. "Effects of Externally Mediated Rewards on Intrinsic Motivation." *Journal of Personality and Social Psychology* 18, 105-115.

Denant-Boemont, L., Masclet, D., and Noussair, C. (2007). Punishment, counterpunishment and sanctions in a social dilemma experiment. *Economic Theory 33*, 145–167.

Dijk, J.J., D.P. van Soest and J.H. Ansink (2013), "Strategic Behavior and the Endowment Effect in Repeated Procurement Auctions", VU University Amsterdam, working paper.

Duke, C. and Gangadharan, L. (2008) Salinity in water markets: An experimental investigation of the Sunraysia salinity levy, Victoria, *Ecological Economics* 68, 486-503.

Eckel, C, Grossman, P., and Johnston, R. 2005. An experimental test of the crowding out hypothesis. *Journal of Public Economics* 89, 1543-60.

Fehr, E. and Fischbacher, U., 2005, The economics of strong reciprocity. In: H. Gintis, S. Bowles, R. Boyd and E. Fehr (Eds.), Moral Sentiments and Material Interests: The Foundations of Cooperation in Economic Life. MIT Press, Cambridge, Massachusetts. pp. 151–191.

Fehr, E. and Gächter, S. (2000). Cooperation and punishment in public goods experiments. *American Economic Review* 90: 980–994.

Fehr, E., and Schmidt, K. M. (1999). A theory of fairness, competition and cooperation. *Quarterly Journal of Economics* 114, 817–868.

Fischbacher, U., Gächter, S. and Fehr, E. (2001). Are people conditionally cooperative? Evidence from a Public Goods experiment. *Economics Letters* 71(3), 397–404.

Franciosi R., R. M. Isaac, D. Pingry, and S. Reynolds (1993). An Experimental Investigation of the Hahn-Noll Revenue Neutral Auction for Emissions Licenses, *Journal of Environmental Economics and Management*, 24, 1-24

Frey, B. S. and Jegen, R. (2001). Motivation crowding theory. *Journal of Economic Surveys 15* , 589–611.

Friedman, M. (1953). The Methodology of Positive Economics, in *Essays in Positive Economics*, Chicago: The University of Chicago Press: 3-43.

Friesen, L. and L. Gangadharan (2013). Environmental Markets: What Do We Learn from the Lab", *Journal of Economic Surveys*, forthcoming.

Gächter, S., Renner, E., and Sefton, M. (2008). "The long-run benefits of punishment", *Science* 322, 1510.

García-Gallego, A., N. Georgantzís, R. Hernán-González and P. Kujal (2012), "How do Markets Manage Water Resources? An Experiment", *Environmental and Resource Economics* 53: 1-23.

Garrido (2007) Water markets design and evidence from experimental economics *Environmental Resource Economics*, 38: 311-330

Gerlagh, R. (2011), "Too much oil", *CESifo Economic Studies* 57(1), 79–102.

Gintis, H., Smith, E.A. and Bowles, S., 2001. Costly signaling and cooperation. Journal *of Theoretical Biology* 213, 103-119.

Gneezy, U. and Rustichini, A., 2000. Pay Enough or Don't Pay at All. *The Quarterly Journal of Economics*, 115(3), 791-810.

Godby, R., S. Mestelman, R.A. Muller and J.D. Welland (1997). Emission trading with shares and coupons when control over discharges is uncertain. *Journal of Environmental Economics and Management*, **32**, 359-81.

Goeree, J., Palmer, K., Holt, C.A., Shobe, W. and Burtraw, D. (2010). An experimental study of auctions versus grandfathering to assign pollution permits. *Journal of European Economic Association* 8, 514 – 525.

Güth, W., Schmittberger, R., and Schwarze, B. (1982), "An experimental analysis of ultimatum bargaining". *Journal of Economic Behavior and Organization* 3, 367-88.

Harrison G. and E. Rutstrom (2008), "Experimental Evidence on the Existence of Hypothetical Bias in Value Elicitation Methods," Chapter 81 in *Handbook of Experimental Economics Results*, 2008, vol. 1, Part 5, 752-767.

Hasson, R., A. Lofgren and M. Visser (2010), "Climate Change in a Public Goods Game: Investment Decision in Mitigation versus Adaptation", *Ecological Economics* 70: 331-338.

Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., and McElreath, R. 2001. In Search of Homo Economicus: Behavioral Experiments in 15 Small-Scale Societies, *American Economic Review* 91, 73-78.

Herrmann, B, C. Thöni, and S. Gächter (2008), "Antisocial Punishment Across Societies", *Science* 319 (5868), 1362-1367.

Huffman, W., Rousu, M., Shogren, J., and Tegene, A, "Who do Consumers Trust for Information: The Case of Genetically Modified Foods?" *American Journal of Agricultural Economics* 86: 1222-1229.

Huffman, W., Rousu, M., Shogren, J. and Tegene A. (2007). "The Effects of Prior Beliefs and Learning on Consumers' Acceptance of Genetically Modified Foods," *Journal of Economic Behavior and Organization* 63:193-206.

Irwin, J., G. McClelland, M. McKee, W. Schulze, and N. E. Norden (1998). "Payoff Dominance vs. Cognitive Transparency in Decision making", *Economic Inquiry* 36(2), 272 – 285.

Isaac, M. and J. Walker (1988a), "Group Size Hypotheses of Public Goods Provision: An Experimental Examination", *Quarterly Journal of Economics* 103: 179-199.

Isaac M. and Walker J. (1988b) Communication and Free Riding Behavior: The Voluntary Contributions Mechanism, *Economic Inquiry* 26: October 1988.

Kahneman, D., J. Knetsch, and R. Thaler (1990), "Experimental Tests of the Endowment Effect and the Coase Theorem," *Journal of Political Economy* 98, 1325-1348.

Khadjavi, M., Lange, A. (2013), "Doing Good or Doing Harm: Experimental Evidence on Giving and Taking in Public Good Games", University of Hamburg.

Ledyard, J. (1995). *Public Goods: A Survey of Experimental Research*. Princeton University Press.

Ledyard, J.O. and Szakaly-Moore, K. (1994), Designing organizations for trading pollution rights, *Journal of Economic Behavior and Organization*, 25: 167-196.

List, J.A. (2007), "On the Interpretation of Giving in Dictator Games", *Journal of Political Economy* 115(3), 482-493.

List J. A. and M. Price (2013), "Using Field Experiments in Environmental and Resource Economics", NBER working paper 19289.

List J. and C. Gallet (2001). "What Experimental Protocols influence Disparities between Actual and Hypothetical Stated Values?", *Environmental and Resource Economics* 20(3), pages 241-254.

Lusk et al. (2001) Lusk, J., M. Daniel, D. Mark, and C. Lusk. 2001.Alternative Calibration and Auction Institutions for Predicting Consumer Willingness to Pay forNon-Genetically Modifi ed Corn Chips." *Journalof Agricultural and Resource Economics* 26:40–57.

Masclet, D., Noussair, C., Tucker, S., and Villeval, M.. (2003). "Monetary and Nonmonetary Punishment in the Voluntary Contributions Mechanism", *American Economic Review* 93, 366–380.

McCabe, K., S. Rassenti and V. L. Smith (1990). "Auction Institutional Design: Theory and Behavior of Simultaneous Multiple-Unit Generalizations of the Dutch and English Auctions," *American Economic Review* 80(5), pages 1276-83

Meier, S. (2007). "A Survey of Economic Theories and Field Evidence on Pro-Social Behavior". In: Frey, B.S. and A. Stutzer (eds.), *Economics and Psychology – A Promising New Cross-Disciplinary Field*. Cambridge: MIT Press, 51-87.

Mellström, C. and M. Johannesson (2008), "*Crowding Out in Blood Donation: Was Titmuss Right*?", *Journal of the European Economic Association*6, 845–863.

Milinski, M. (2013), "Experiments on Collective Risk", in Shogren, J. (ed), *Encyclopedia of Energy, Natural Resource and Environmental Economics*, Amsterdam: Elsevier, forthcoming.

Milinski, M., R.D. Sommerfeld, H-J. Krambeck, F.A. Reed and J. Marotzke (2008), "The collective-risk social dilemma and the prevention of simulated dangerous climate change", *Proceedings of the National Academy of Sciences* 105: 2291-2294.

Muller, R.A., Mestelman, S., Spraggon, J., and Godby, R. (2002), Can double auctions control monopoly and monopsony power in emissions trading markets?, *Journal of Environmental Economics and Management* 44: 70-92.

Murphy, J.J., Dinar, A., Howitt, R.E., Rassenti, S.J. and Smith, V.L. (2000). The design of "smart" water market institutions using laboratory experiments. *Environmental and Resource Economics* 17: 375-394.

Murphy, J.J., Dinar, A., Howitt, R.E., Rassenti, S.J., Smith, V.L. and Weinberg, M. (2009), The design of water markets when instream flows have value. *Journal of Environmental Management* 90: 1089 – 1096.

Murphy, J., and Stranlund, J. (2006). Direct and market effects of enforcing emissions trading programs: an experimental analysis. *Journal of Economic Behavior and Organization.* 61, 217-233.

Murphy, J., and Stranlund, J., (2007), A laboratory investigation of compliance behavior under tradable emissions rights: Implications for targeted enforcement, *Journal of Environmental Economics and Management,* 53: 196-212.

Nikiforakis, N. (2008). Punishment and counterpunishment in public goods games: Can we govern ourselves? *Journal of Public Economics* 92, 91–112.

Normann, H.-T. and Ricciuti, R. (2009) Laboratory experiments for economic decision making. *Journal of Economic Surveys* 23: 407-432.

Noussair C., (2003) "Innovations in the Development of Bundled-Item Auctions", *Proceedings of the National Academy of Sciences* 100(19), 10590-10591.

Noussair C., Robin S. and Ruffieux B. (2002) Do Consumers Not Care About Biotech Foods or Do They Just Not Read the Labels? *Economics Letters* 75: 47-53.

Noussair C., Robin S. and Ruffieux B. (2004a) Do European Consumers Really Refuse to Buy GM Food? *Economic Journal* 114(492), 102-120

Noussair C., Robin S. and Ruffieux B. (2004b) "Revealing Consumers' Willingness to Pay: A Comparison of the BDM Mechanism and the Vickrey Auction", *Journal of Economic Psychology* 25(6), 725-741.

Noussair C., Robin S. and Ruffieux B. (2004c) "A Comparison of Hedonic Rating and Demand Revealing Auctions", with Stephane Robin and Bernard Ruffieux, *Food Quality and Preference* 15(4), 393-402.

Noussair C. and Tucker S. (2005) Combining Monetary and Social Sanctions to Promote Cooperation, *Economic Inquiry* 43: 649-660

Nyborg, K. and Rege, M., (2003). Does Public Policy Crowd Out Private Contributions to Public Goods. *Public Choice* 115, 397-418.

Ostrom, E., Walker, J., and Gardner, R. (1992). Covenants with and without a sword: self governance is possible. *American Political Science Review* 86: 404–417.

Porter, D., Rassenti. S.,Shobe, W., Smith, V., and Winn, A., (2009), The design, testing and implementation of Virginia's NOx allowance auction, *Journal of Economic Behavior and Organization*, 69: 190-200.

Rabin, M. (1993). Incorporating fairness into game theory and economics. *American Economic Review* 83, 1281–1302.

Rand, D., Dreber, A., Ellingsen, T., Fudenberg, D., and Nowak, M. (2009), "Positive interactions promote public cooperation", *Science* 325, 1272–1275.

Richter, A. and D.P. van Soest (2012), "Global Environmental Problems, Voluntary Action and Government Intervention", Chapter 10 in E. Brousseau, T. Dedeurwaerdere, P.A. Jouvet and M. Willinger (eds.), *Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms*, Oxford: Oxford University Press, 223-248.

Roth, A. and Murnigham, J. (1978). Equilibrium behavior and repeated play of the prisoner's dilemma. *Journal of Mathematical Psychology* 17, 189-98.

Rousu, M., Huffman W., Shogren J. and Tegene A. (2007). Effects and Value of Verifiable Information in a Controversial Market: Evidence from Lab Auctions of Genetically Modified Food. *Economic Inquiry* 45, 409-432.

Shogren, J., M. Margolis, C. Koo, and J. List (2001), "A Random *N*th Price Auction", *Journal of Economic Behavior and Organization* 46, 409 – 421.

Sinn, H.-W. (2008), "Public policies against global warming: A supply side approach", *International Tax and Public Finance* 15(4), 360-394.

Smith, (1962), "An Experimental Study of Competitive Market Behavior", *Journal of Political Economy*, 111-37.

Stern, N. (2007), *The Economics of Climate Change*, Cambridge University Press, Cambridge.

Stoop, J.T.R., D.P. van Soest and J. Vyrastekova (2013), "A Tale of Two Carrots: The Effectiveness of Multiple Reward Stages in a Common Pool Resource Game", in M. Price and J. List (eds.), *Handbook of Economic Experiments and the Environment*, Cheltenham: Edward Elgar, forthcoming.

Stranlund, J., Murphy, J., and Spraggon, J., (2011), An experimental analysis of compliance in dynamic emissions markets, *Journal of Environmental Economics and Management*, 62: 414-429.

Tavoni, A., A. Dannenberg, G. Kallis and A. Löschel (2011), "Inequality, Communication and the Avoidance of Disastrous Climate Change in a Public Goods Game", *Proceedings of the National Academy of Sciences* 108 (29), 11825-11829.

Tisdell, J., (2007), Bringing biophysical models into the economic lab: An experimental analysis of sediment trading in Australia, *Ecological Economics* 60: 548-595.

Titmuss, R.M. (1970), *The Gift Relationship*. Allen and Unwin.

van der Ploeg, F. and C. Withagen (2012), "Is there really a green paradox?", *Journal of Environmental Economics and Management* 64: 342-363.

van Soest, D.P., J.T.R. Stoop and J. Vyrastekova (2013), "Cooperation in multi-person social dilemmas: The Public Goods game revisited", Tilburg University, mimeo.

Vickrey, W. (1961) "Counterspeculation, Auctions, and Competitive Sealed Tenders". *The Journal of Finance* **16** (1): 8–37

Vickrey W. (1962) "Auctions and Bidding Games." In Recent Advances in Game Theory. The Princeton University Conference.

Vyrastekova, J. and D.P. van Soest (2003), "Centralized Common Pool Management and Local Community Participation", *Land Economics* 79(4), 500–514.

Vyrastekova, J. and van Soest, D. P. (2008). On the (in)effectiveness of rewards in sustaining cooperation. *Experimental Economics* 11(1), 53–65.

Walker, J. M. and Gardner, R. (1992). Probabilistic destruction of common-pool resources: Experimental evidence, *Economic Journal* 102, 1149-1161.

Van Boening M. and N. Wilcox (1996), "Avoidable Cost: Ride a Double Auction Roller Coaster", *American Economic Review* 86(3), 461 – 477.

Weber R. (1983) Multiple-object auctions, in Competitive Bidding, Auctions, and Procurement, (ed. R. Engelbrecht-Wiggans, R.M. Stark, and M. Shubik), New York University Press,