

Using experimental economics to design a diffuse source salinity credit trade policy

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Abstract

This article reports on the use of experimental economics to guide design of an on-ground trial of a recharge cap and trade scheme that will be implemented in 2005. The policy design process involved identifying potential impediments to functioning of a credit trade policy which could prevent cost-effective and environmentally effective outcomes. Experimental economics was used to test efficacy of policy approaches to overcome identified impediments. The rationale for and basic design of four experiments is outlined. A summary of experimental results is presented as well as a discussion of how experimental results findings influenced the design of the on-ground trial. Conclusions focus on future opportunities and challenges for economists in use of experimental economics to design incentive based policy for diffuse source environmental issues.

1 Introduction

As a general rule market-based instruments (MBI) use markets and market like mechanisms to influence policy outcomes. In contrast to policy approaches using explicit directives, they are designed to encourage innovative behaviour through the price signals of market exchange. The potential advantage of MBI approaches to environmental policy is that they can achieve environmental goals at lower cost than alternative policy approaches.

To encourage development of MBI approaches to water quality and salinity from diffuse sources, the Australian Commonwealth Government allocated \$5 million to fund eleven MBI trials in 2003. This paper describes general lessons about design of MBI gained through experience with one of the Commonwealth MBI trials to investigate design of recharge credit trade scheme. The scheme will be implemented as an on-ground trial in 2005 in a dryland farming community in north central Victoria. The basic design proposed involves allowing landholders to enter into obligations to reduce recharge (a major cause of salinity damage in the trial area) in exchange for payments. The scheme will allow landholders who have established obligations to meet them by modifying farm production and management, for example, by successfully establishing perennial pasture or trees or by buying credits from other landholders who succeed in reducing recharge by more than they are obligated to.

Following on success with MBI policy for point source environmental issues such as the US SO₂ credit trading program (Stavins, 2001) there has been increasing interest in MBI for diffuse source pollutants. In more recent years economists and policy makers in many countries (e.g. NZ, Australia, Canada, the United States, and the Netherlands) have offered MBI prescriptions and implementations improve cost and environmental effectiveness of diffuse source environmental issues such as diffuse source nutrient pollution from farms (Randall, 2003; Dwyer 2002; OECD, 2002; Hatton MacDonald, et. al., 2004; MBI working group, 2004).

Realising savings with MBI for diffuse source environmental issues has been challenging. One fundamental challenge has been in developing policy capable of realising savings by focussing on performance with flexibility in compliance when actual outcome monitoring is technically infeasible or very costly (Shortle and Dunn, 2000; Schray, 2003). Another fundamental challenge arises because transactions cost related to administration, auditing, monitoring performance tend to be high as many small disperse sources are typically dealt with in diffuse source environmental issue settings (e.g. Dwyer, 2002); There is some evidence that in at least the few settings where transactions cost have been seriously evaluated, transactions costs can be higher than the savings that can be realised by cap and trade programs (e.g. Feng and Easter, 2003).

A final notable challenge relates to the complex information processing requirement and other transactions costs involved on the part of program participants. For example, in the U.S. 37 programs involving nutrient credit trading between point and diffuse sources are running or being planned according to Randall (2003). Theoretical evaluation by Faeth (2001) suggests that such approaches should allow cost savings because cost of emissions reductions are much less for diffuse than point sources in many cases (up to an order of magnitude less). However, a 2003 analysis by Kuch found that in all 37 programs only 6 trades had taken place. Presumably, at least part of the reticence to trade involves the transactions costs for participants including information costs of understanding payoffs to participation. For example, Hahn (1989) in evaluating SO² trading found very little willingness to trade outside of “bubbles” as such trade required complex individual transactions modelling.

In recognition that many past attempts to implement tradeable permit policy for diffuse source emissions like recharge have failed, the project began with a scoping phase. This involved literature review, social surveying, gross margin and cash flow estimation to gain an understanding of key factors that could impede cost effective implementation of the proposed MBI. experimental economics was used to test the policy designs to overcome identified impediments. Experiments were used to test behavioural response to a range of recharge credit trade policy implementations. The experiments are what some refer to as the context rich variety (Krause, 2005) involving an experimental setting constructed to be representative of the economic decision making and trading environment faced by landholders in area where credit trading will be trialled.

This article describes the use of context rich experimental economics generally and the rationale for and design of four experiments. A summary of experimental results is presented as well as a discussion of how experimental results findings influenced the design of the on-ground trial. In conclusion, more general findings relating to opportunities and challenges in use of experiments to design incentive based policy for diffuse source issues are discussed.

2 Context rich economic experiments for MBI trial design

The approach to economic experiments used varies from the most prevalent practice where students make decisions in environments created with protocols to carefully isolate effects of all but one treatment factor and avoid context or connotation. The experimental approach employed in this study sacrifices some of the perceived control offered by economic experimentation involving setting all factors other than a ceteris paribus treatment factor in ways so that they are unlikely to introduce any confounding effect. So, for example, an experiment to test impacts of communication among participants on outcomes of a discriminate price auction, would run discriminate price auctions with and without communication. Factors other than communication tend to be treated in ways that are unlikely to influence participants' responses. For example, a payoff structure with very little difference in payoff across decision options probably wouldn't be included in such an experiment so that there would be no confusion about what really determined outcomes, information treatment or a flat payoff structure.

A major discovery of cognitive psychology is that the way people make decisions is highly context dependent (Lowenstien, 1999). This has lead some economist to conclude that to inform policy meaningfully, experiments must be designed to include salient features of the context of the policy setting of interest (Lowenstien, 1999; Loomes, 1999; Krause, 200?). Many economists adhering to this way of thinking conclude that while experiments designed to eliminate any confounding effects are useful for isolating influence of single treatment factors, they may not tell us much about how people are likely to react in real world contexts where there are confounding factors. So, for example, an experiment to test the effects of communication on a discriminate price auction outcome conducted without the flat payoff structure characteristic of the setting where implementation is being contemplated, may tell us little about expected behaviour in the actual setting. There is now a growing body of experiments conducted in context rich environments. Results are demonstrating that differences in context lead to differences in bargaining, risk-taking, sharing, and other behaviour (Krause, 2005).

While experiments from context rich settings may allow only limited inference about behaviour in other contexts, they represent in the view of some, the most appropriate way to draw inferences

about behaviour that are valid for specific contexts where policy design is being investigated (Lowenstein, 1999).

Expected utility theory (EUT) based predictions are the benchmark control used in most experimental economics. EUT predictions may best be thought of as behaviour expected to be realised in the asymptote as participants learn with repeated experience in markets to exploit opportunities for gain through trade. An important implication is that EUT may be a useful guide to prediction of behaviour *“displayed by currency traders, or others engaged in repetitive transaction in markets with massive rapid feedback and short-selling. But only a small fraction of economic transactions take place in setting that have these informational or incentive features”* (Lowenstein, 1999).

In settings where novel MBI policy approaches are being applied behaviour consistent with EUT equilibrium seems unlikely at least in early transactions where repetition is a feature of the market structure, but also with market structure where transactions aren't often repeated.

In typical novel MBI trial settings where potential market participants have experience with environmental services market exchange, divergence from EUT are likely. The extent of trade and cost savings that can be expected in such contexts depends on behavioural responses that vary according to the market design, and contextual factors influencing costs and returns involved in learning to use the market mechanism. Participation rates and market outcomes are likely to be conditional on the cost of informational processing, in turn a function of the complexity of the decision environment (Smith 1991, 2002).

One overall goal of this paper is to report on whether evidence from experiments carried out supports the information discovery theory articulated by experimental economists such as Plott (1987) and Binmore (1999) by investigating for all experiments the hypothesis that results should converge toward EUT predicted behaviour with repeated experimental trials. Another overall goal is to test the hypothesis following the logic of Smith (1991, 2002) that convergence toward expected utility theory outcomes will be slower in experiments where the complexity of the decision environment is greater.

2.1 The experimental setting and experimental controls

The experimental sessions were held at the Griffith University experimental economics laboratory in November, 2004, using the MWATER experimental software platform developed and administered by Dr. John Tisdell of Griffith University and the CRC for Catchment Hydrology. Participants were selected from an existing pool of approximately 200 undergraduate students, familiar with experimental protocols and procedures.

To conduct experiments to test policy options for actual recharge cap and trade policy a context rich experimental setting was create. The setting simulates salient characteristics of the decision-making environment, and the main economic and biophysical characteristics faced by subjects of interest. In this case, the management decision making environment faced by landholders in the upper Bet Bet Catchment was simulated in the controlled setting of a laboratory.

The simulated catchment is comprised of a total of 12 heterogenous farms located in three landscape positions with four farms located in each landscape position. The farms represent a synthesis of existing farm management styles, characterised by different levels of farm income and recharge rates, calibrated to simulate the main economic and biophysical characteristics facing farmers in the Bet Bet.

In the laboratory environment, experimental subjects participate in sessions where they repeatedly make land management and trading decisions. To create realistic incentives, subjects are paid according to the combined simulated farm and trading income they achieve in experiments. Throughout the experimental sessions, each participant is randomly assigned to a single farm, and can select from the five possible farm management options, associated with specified recharge and income levels. Each experimental session involved 10 independent, replicate periods of annual management decisions, market trading and where the treatment dictated, a forum for group discussion.

To control for variable learning and to ensure consistent participant understanding of the experimental setting, participants are asked to complete a quiz comprising 10-12 questions

specific to the experimental treatment. After successfully completing the quiz, participants can gain internet access to instruction sets, carefully designed and salient for each treatment. The instructions explain the rules, protocols of the experimental setting and treatment and the characteristics of the experimental farm.

For all experiments, the control treatment is the behavioural response that would be predicted from expected utility theory to result for the given market structure and supply, demand schedules. In all experiments, behavioural responses to the treatments are measured as differences in the recharge volumes traded, market price and aggregate farm income compared to predicted EUT equilibrium values.

2.2 The experiments

2.2.1 Uniform and discriminate price initial credit allocation tendering experiments

There are currently no obligations for farmers to hold recharge below some limit. Thus a first step in trialling credit trade is to establish limits on recharge. Given that any mandatory approach is not institutionally possible at least in the short-run, the only feasible approach to developing obligations for the trial is to pay landholders to enter into a contracted obligation. Economic theory and previous experience (e.g. Stoneham, *et al.* 2003, Bryan *et al.* 2004) suggests that tendering should be a cost effective way to establish obligations.

However, landscape context matters in addressing dryland salinity. Consequently, the best approach to realising cost and environmental effectiveness gains in policy may often involve targeting relatively localised areas with special recharge reduction value. The Upper Bet Bet sub-catchment within the Lodden catchment presents a very favourable trade-off between flow reduction and salt load reduction.

Three difficulties arise with use of tendering in such contexts:

- Because of the small number of land managers there is a possibility that they could successfully collude to seek excessive profits with some tendering designs;
- Even in the absence of landholder collusion, a voluntary tendering process could fail to result in enough participants to achieve the desired level of land management change; and
- The results of social survey work suggest that the issue of low participation rates and unreliable recharge reduction could be particularly acute with tender designs that require more complex information processing.

One approach to minimise these difficulties is the bidding and payment structure of the tender process. In a uniform price auction the purchaser offers a single uniform purchase price which is paid to all successful sellers, regardless of their initial bid. Alternatively, in a discriminate price auction the purchaser pays a range of prices that match the bids offered by successful sellers. A discriminate price auction is also a tendering format that can involve costly learning effort to establish the successful bid range, which may lead to low participation rates.

In rewarding low price bidders with a higher purchase price, a uniform price tender typically allows for greater profits and has the advantage of providing constant price information about successful bidding strategies. A result of lower learning cost with this approach could be higher participation rates.

Experiments to compare the results of tendering with context specific upper Bet Bet supply, demand and market conditions provides an opportunity to test for the potential that there might be differences between participation rates and costs for a uniform and discriminate price tender system.

In the uniform price tender experiments, players are asked to submit bids to the authority to undertake land use change that reduces recharge. The bids are ranked according to price per unit recharge reduction and accepted until a targeted level of reduction is achieved (50% of maximum recharge) or until the bids exceed a prescribed value (in this case \$56 per unit). Regardless of the individual bid value, all successful tenderers are paid a uniform price for recharge reduction efforts. For example an individual who offered to sell at \$28 per unit bid

would be paid \$56 per unit if a \$56 bid were top priced bid that agency buying credits decided to accept.

The discriminate price tender experiments are similar except that participants are paid their actual individual bid prices if their bids are successful. As in the uniform price tender experiments, participants are asked to submit bids to undertake land use change that reduces recharge. The bids are ranked according to price or recharge effectiveness and accepted until the reduction target is achieved (367 units in the 50% reduction case) or the total value of bids exceed a prescribed aggregate budget constraint. Successful tenderers are paid the value of their recharge reduction bid. For example the \$28 bid per unit would be paid \$28.

The objective of the experiments is to test two prior hypotheses about differences between the uniform and discriminate tender processes:

1. There is an additional cost to the agency in a uniform price auction as surpluses are paid to traders. Alternatively as surpluses are appropriated by the purchasing agency in the discriminate price auction, the cost of recharge reduction is predicted to be less.
2. Because a discriminate price auction reveals a different price signal to each participant depending on the value of each individual bid, traders strategically seeking an optimal and maximum price may tend to explore the price opportunities in the market for a longer period compared with strategies in a uniform price auction. As a corollary, the recharge and price values will tend to be more volatile in the discriminate price auction, potentially resulting in a less reliable and more costly recharge outcome.

2.2.2 Tendering experiments with social payments

Social survey results administered as part of this research, feedback from local landholders and the local Working Group raised important concerns that a voluntary tendering process may result in insufficient participation levels to achieve the desired level of land management change. In particular, there was some concern that once the few enthusiastic participants had been engaged primarily in pasture improvement actions, it would be difficult to get further action to reduce recharge, especially tree planting at the locations where this would contribute most to recharge reduction.

Sociological survey work conducted for this project indicates levels of social cohesion within the community are very high, with over 80% of the survey respondents indicating involvement in the local Landcare group (Thompson, 2004). Previous research (e.g. Ostrom 1998, Gintis 2000) reports significant divergence from individualistic profit maximising behaviour in small, cohesive communities. These combined findings suggested that a policy approach to reward participation with some form of collective award for reaching an aggregate recharge reduction level might increase trial participation.

The social payment experiments were variants of the uniform price auction. Payment rates per unit of recharge were a function of aggregate recharge reduction. The standard uniform auction price was paid to successful tenderers if total recharge reduction was less than 50% of maximum recharge. If aggregate recharge reduction exceeded 50% of maximum recharge, players received a two part payment. In addition to the standard uniform price payment, the social or group payment was equally distributed amongst all participants, regardless of recharge reduction efforts.

The experiment involved two treatments of the social payment mechanism. One excluded communication among subjects. The “communication” treatment consists of the same social payment mechanism in addition to a formal forum for group discussion. The discussion forum was designed to test the effect of group crafted social coalitions in improving recharge reduction, increasing market participation and improving individual contract adherence.

To test the efficacy of a social payment strategy, experimental subjects were exposed to three experimental treatments. All treatments involved a uniform price tender auction with an objective of achieving a 70% recharge reduction target.

The first treatment was based on a uniform price tender, as described above. In this case however a 70% recharge reduction target was substituted for the 50% target. Players were paid according to individual farm management and trading performance, with no social payment. Aggregate recharge reduction levels were publicly disclosed at the end of each period.

The social payment involved two payment components. Participants were individually paid at levels commensurate with their individual recharge reduction efforts when aggregate performance by the group was less than 50% recharge reduction. When the value of aggregate reduction exceeded 50% but was and less than 70% payments involved two components. A payment of \$56 per recharge unit was provided based on individual recharge reduction contributions.

An additional social or group payment, was equally distributed amongst all participants, regardless of recharge reduction efforts when aggregate recharge reduction exceeded 50%. The level of additional payment was related to the level of recharge reduction in excess of 50%. Aggregate recharge reduction was publicly disclosed at the end of each period.

The communication treatment consisted of the same payment mechanism as the social payment plus a formal forum for group discussion. The discussion forum aims to test the effect of group crafted social coalitions in improving recharge reduction, increasing participation rates and improving individual contract adherence. The treatment allowed for an initial communication and discussion forum of 10 minutes duration. Subsequent discussion periods are of 3 minutes duration. The intended aggregate recharge reduction was disclosed at the beginning of the period, actual aggregate reduction was disclosed at the end of the period.

The objective of tendering experiments with social payments is to test the prior hypothesis that a uniform price tender with group incentive performance payment should increase the level of voluntary participation in recharge reducing land management relative to a uniform price tender with part of the payment proportional to the sum of total arecharge reduction exceeding a defined "threshold" level.

2.2.3 Open and closed call credit trade market experiments

The recharge credit trade market that will be trialled can be administered as what economists refer to as a "closed call" auction or an "open call" auction. In a closed call market potential buyers submit sealed bids to buy and potential sellers submit sealed offers to sell. The market is "called" and trades are executed by a clearing-house. In this case, the clearing house can be thought of as a recharge management authority. The authority computes a single "equilibrium price" at which all trade takes place based on the aggregate supply of and demand for credits. When the price has been computed, the authority notifies successful traders and announces the market price and informs successful traders of the individual volume traded only.

An important characteristic of the closed call auction is the limited disclosure of bidding information which is restricted to the market price and volumes trade specific to successful traders. There is no public disclosure of individual bidding information or the individual volumes traded. In contrast, an open call market all individual bidding and volume offers are publicly declared.

To experimentally test the cost savings potential of an open and closed call credit market in a context rich way, a simulated decision environment was created where subjects had the choice of a range of farm management options. Farm management choices with higher recharge were associated with higher income. Each subject faced a recharge cap equal to 50% of the recharge associated with the highest income farm management option.

Subjects had the choice of acting in one of three ways in each decision making "period". They could choose a farm management option that exactly satisfied their recharge quota, choose an option with recharge in excess of their cap and make up the deficit by buying credits, or choose an option which required less recharge credits than their quota and offer for sale the excess credits.

Failure to satisfy their recharge quota resulted in subjects being penalised such that non-compliance was more costly than to taking actions to satisfy the recharge quota.

The objective(s) of these experiments were test for behavioural responses differences to the open call closed call and no trade market structure treatments measured as the recharge volumes traded, market price differences across experimental treatments.

2.3 Experimental results

2.3.1 Credit trade results

The open call results

The results of the open call cap and trade experiments are presented graphically in Figure 1 illustrating total recharge units traded and Figure 3 illustrating market price.

Consider first the results portrayed in Figure 1— The flat line in the figure marked **model** represents the EUT prediction of volume of recharge units traded. The lines marked **exp1** and **exp 2** represent trade that actually occurred in the first and second trading experiments (ten repetitions with the same 12 subjects), and the line marked **exp avg** represents the quantity traded in each experimental repetition averaged over experiments 1 and 2.

The figure indicates that for the entire 10 periods, the volume traded in an open call market is highly volatile and unpredictable. The continuing variability of observed volumes traded suggests that participants were continuing to explore for an optimal strategy up to the final periods of the experiments. Despite increased experience and practice in making farm and trading decisions, the volume traded did not converge to a predicted equilibrium value.

Figure 3 shows the market prices realised in the open call experimental treatment. The flat line marked **model** represents the EUT predicted market price. The lines marked **exp1**, **exp2**, and **exp avg** represent the market price of trade observed in experimental sessions 1, 2 and the average over the two sessions in each trading round respectively.

The figure illustrates a similar pattern of volatile and unstable market prices for all periods as that observed for the volume of recharge units traded.

Closed call results

The results of the closed call cap and trade experiments are presented graphically in Figure 2 illustrating total recharge units traded, Figure 4 illustrating market price. The top flat line in Figure 2 marked **model** represents EUT predicted level of trade. The lines marked **exp1** and **exp2** represents trade that actually occurred in the first and second trading experiments, and the line marked **exp avg** represents the quantity traded in each experimental repetition averaged over experiments 1 and 2.

The figure shows that on average over the two experimental sessions in the first four repetitions approximately 60% of the potential to trade was realised (81 of a potential 144 units were traded). Although with increasing market experience there was an observed increase in the amount traded (by the last three repetitions an average of 117 of 144 units were traded), the average quantity traded remained less than the predicted value for all 10 periods. The level of convergence in period 10 was 82% compared to a single predicted equilibrium quantity.

Results not shown graphically include the finding that in the first two periods the average gains to trade were relatively low. In the third through sixth periods less than half of potential gains to trade were being realised on average across both rounds of experiments. In the last two rounds optimal gains from trade were being realised. In period 10, the average aggregate farm income of \$64,878 differed by 1.2% compared to the modelled optimal trading strategy value of \$65,762.

The experimental gains from trade in period 10 represents an increase of 17% in farm income compared to the regulatory no trade value and a decrease of 19% compared to the maximum recharge land management strategy.

Figure 1-Total Recharge Units Traded In An Open Call Credit Trade Treatment

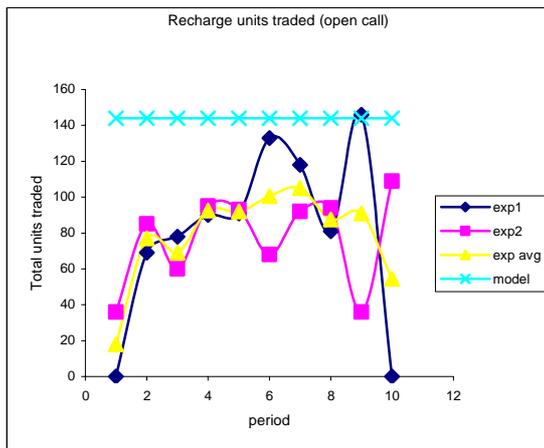


Figure 2 - Total Aggregate Recharge Units Traded Closed Call Credit Trade Treatment

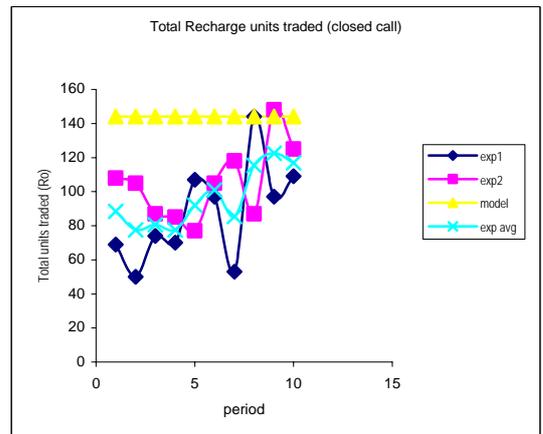


Figure 3 - Market Price Of Recharge Units Traded In An Open Credit Trade Treatment

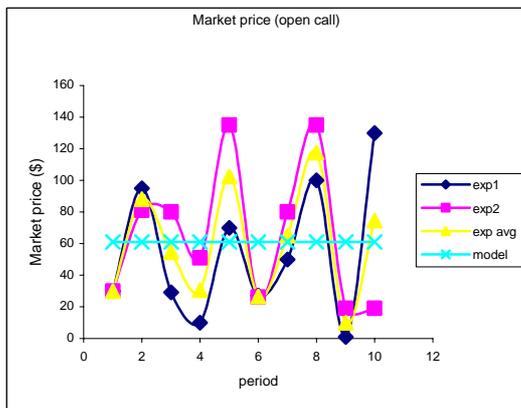
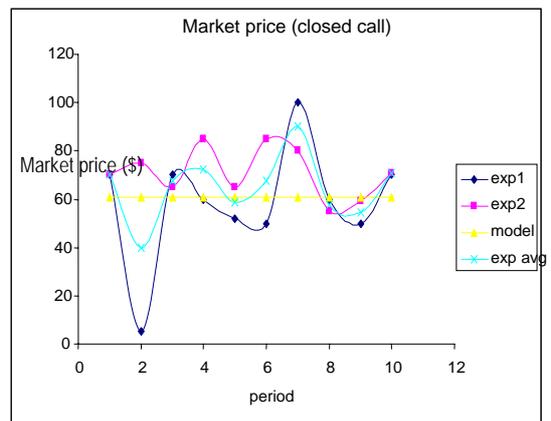


Figure 4 - Market Price Of Recharge Units in a Closed Call Credit Trade Treatment



2.3.2 Uniform and discriminate price tender auction treatments

Results of the uniform and discriminate price auction are compared in Figures 5 and 6 where Figure 5 represents total recharge reduction, and figure experiment participant income.

The line marked **model** in Figure 5 represents EUT recharge level prediction. The line marked **discriminate** represents the mean recharge reduction of the two discriminate price tender sessions and the line marked **uniform** represents the mean recharge reduction of the two uniform price tender sessions.

In most periods the total recharge reduction observed in the uniform price tender was within 20% of the EUT prediction of 367 units. The lower values observed in period 4 and 9 are a result of sub-optimal decisions by a single player, corrected in the consecutive period. Convergence of experimental results toward a theoretical realisable volume of trade took longer in the discriminate price tender treatment. In periods 8, 9 and 10, the theoretical potential for trade in recharge units of 367 units was realised.

Figure 6 depicts the extent that the potential income realised through trade in the uniform and discriminate price tenders was actually realised. The upper flat line marked **model up** represents the EUT predicted income for the uniform price tender experiments. The lower flat line marked **model dp** represents the EUT predicted trade income in a discriminate price tender. The lines marked **discriminate** and **uniform** in Figure 6 represent the average income actually realised in the discriminate and uniform price tender treatments respectively.

The results indicate noticeable differences in trading income across treatments. The trade income observed in the uniform price tender is less than the EUT predicted value in all periods, and remained stable across most periods. For the discriminate price auction, income exceeded the theoretical prediction from period 3 and rapidly increased in periods 6-10. In period 10, aggregate income to participant exceeded the EUT prediction for the discriminate price tender by 29% and 28% in experimental repetitions 1 and 2.

The responses to a discriminate price tender in the simulation appears to be a result of the discriminate price tender experimental design simulating a purchasing strategy of a recharge agency that prioritises achieving recharge reduction targets as opposed to being constrained by a reduction budget. Higher than EUT predicted bids for reduction units were therefore purchased if the 50% recharge reduction stipulated in the target had not been fulfilled by purchasing sufficient units offered by lower priced bidders. This result is similar to the recently reported experimental result reported by Cason and Gangadharan (2005) who compared uniform and discriminate price auction for land management. They found that most offers in the uniform price auction experiment they conducted were within 2% of cost, while most offers in the discriminative price auction were at least 8% greater than cost.

Sensitivity within the experimental context to this purchasing strategy, the sub-optimal decisions of a single player appears to provide the opportunity for strategic, prolonged and opportunistic behaviour by other players. This is the behaviour and trade income observed in the discriminate price auction experiments after period 6. Disaggregation of the decision choices made by players into specific periods indicates that players 1 and 7 altered their selected farm options in the latter periods, resulting in a substantial reduction in income for player 1 and an increase for player 7.

Figure 5 - Aggregate Recharge Reduction Observed In A Uniform And Discriminate Price Tender Auction Treatment

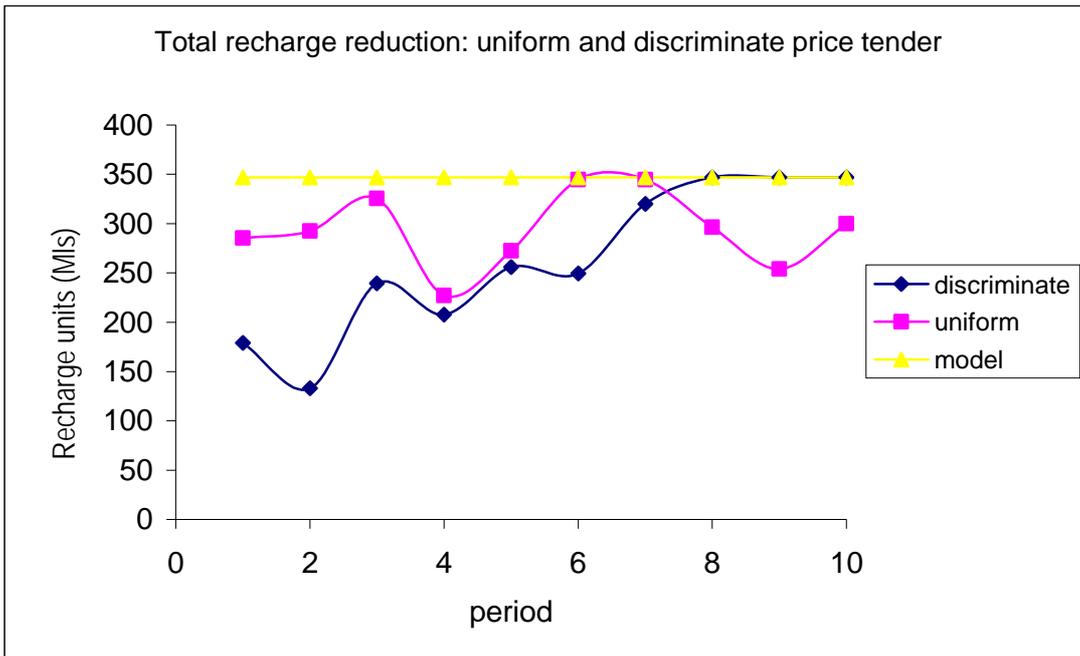
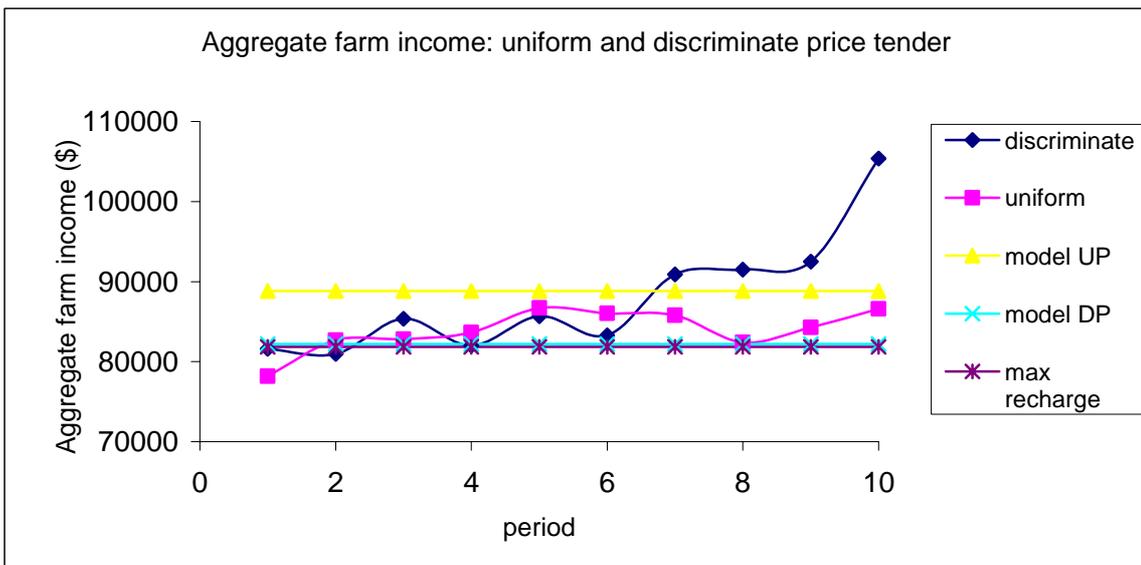


Figure 6 - Aggregate Farm Income Observed In A Uniform And Discriminate Price Tender Auction



2.3.3 Social payment and communication treatment

Results of previous experimental sessions (Tisdell and Ward 2004), a social survey carried out for the project (Thomson, 2004) and literature based insights (Ostrom 1998) indicate that a socialised group payment may act as an incentive to improve levels of voluntary participation and community cooperation, expressed here as more cost effective recharge reduction. Similar empirical evidence (Gintis 2000, Ostrom 1998) indicates that the formal provision of a forum for discussion and communication acts to reinforce group developed resource governance and to improve individual voluntary adherence to cooperative strategies.

The observed results of the social payment treatments were compared to the equilibrium (predicted if participants behaved as fully informed profit maximisers) and results of the uniform price tender with individual payments. Figure 7 graphically illustrates total recharge reduction, and Figure 8 depicts aggregate farm income.

In Figure 7, the line marked **uniform price** represents the average observed recharge reduction (two sessions of 10 periods each) when payments are made according to individual land management and trading performance only; there is no social payment related to group aggregate reduction. The line **social pymt** represents the average recharge reduction observed when, in addition to payments for individual performance, a social payment is paid based on aggregate recharge reduction achieved by the group as a whole. The line **communication** represents the level of recharge when the treatment includes a social payment and provision for a formal forum for discussion for all players prior to the selection of a farm management option. The line **model** represents a 70% reduction target of 528 units the recharge value that would be predicted with EUT for a uniform price tender.

Aggregate recharge reduction for the uniform price and communication treatments converged to within 20% of the recharge reduction target of 528 units from period 4 and remained within 20% of predicted reduction volumes for the remaining 6 experimental periods.

Aggregate reduction observed for the social payment treatment converged to within 10% of the reduction target for periods 3-9¹. Experimental results provided little evidence of any difference in aggregate recharge reduction for the uniform treatment (resulting in 95% of the EUT recharge reduction prediction) with social payment and communication compared to 94% of the EUT recharge reduction prediction for a uniform price tender in period 10.

In Figure 8, the line marked uniform price represents the average observed trade income when payments are made according to individual land management and trading performance only. The line social pymt represents the average recharge reduction observed when a social payment is paid equally to all players, contingent on aggregate recharge reduction being above the threshold level of 367 units. The line communication represents the level of recharge when the treatment makes provision for a formal forum for discussion for all players prior to the selection of a farm management option. The line model represents the predicted trade income for all three treatments if all participants behaved to maximise profit, understood their farm characteristics perfectly and responded optimally to available price information.

Aggregate farm income came close to converging with the EUT prediction for all treatments by period 4. the results provide limited evidence that the communication treatment increased recharge reduction supply. 99% of the EUT predicted income was achieved by period 10 for the uniform price with social payment and communications, while 97% the EUT predicted income was achieved for the uniform price treatment.

¹ Dis-aggregation of the data into individual periods indicates two players changed their decision choice and subsequent level of contribution to aggregate recharge reduction in period 10. Observed aggregate reduction in recharge remained within 20% of the reduction target in the final period 10. The observed change in strategy in the final period of a finite repeated public contribution game is commonly noted in the literature (Ostrom 1998, Kagel and Roth 1995, Friedman and Sunder 1994).

Figure 7 - Aggregate Recharge Reduction Observed In The Uniform Price, Social Payment And Communication Treatments

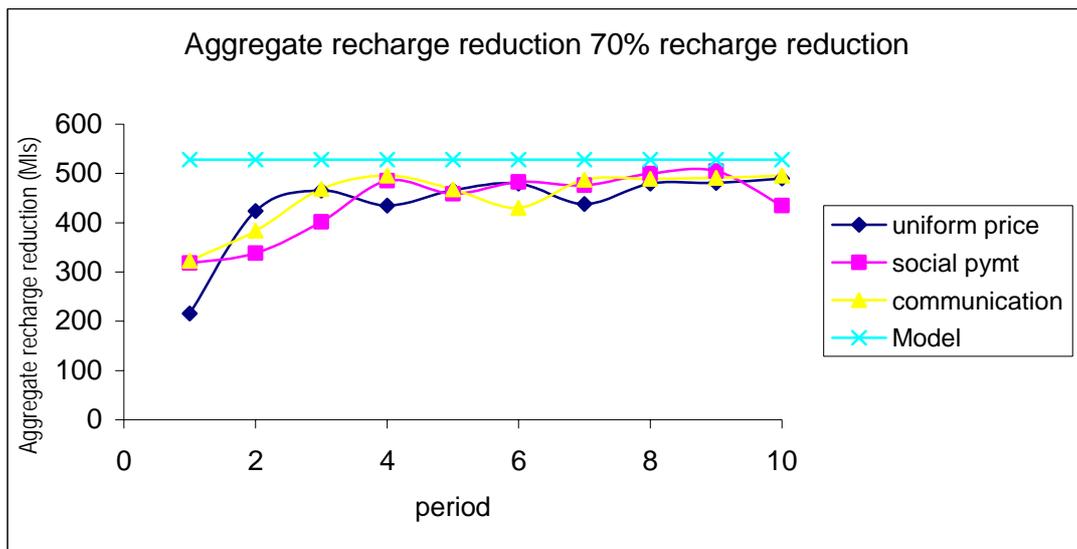
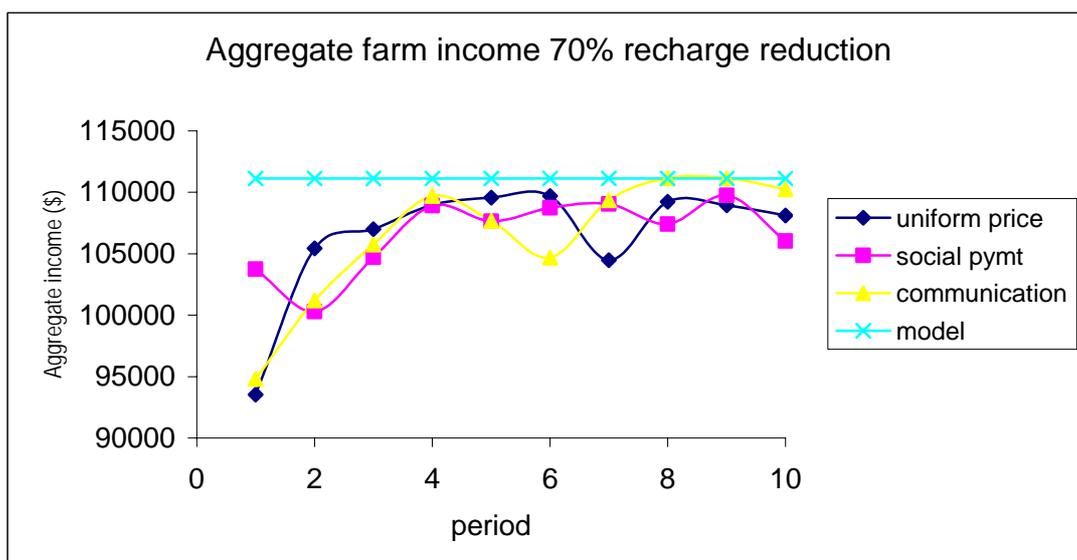


Figure 8 - Aggregate Farm Income Observed In The Uniform Price, Social Payment And Communication Treatments



3 Summary and conclusions

This article reports on the use of experimental economics to guide design of an on-ground trial of a recharge cap and trade scheme that will be implemented in 2005.

There are currently no obligations for farmers to hold recharge below some limit. Thus a first step in trialling credit trade is to establish limits on recharge. Given that any mandatory approach is not institutionally possible at least in the short-run, the only feasible approach to developing obligations for the trial is to pay landholders to enter into a contracted obligation through a tender process.

Three difficulties arise with use of tendering in such contexts:

- Because of the small number of land managers there is a possibility that they could successfully collude to seek excessive profits with some tendering designs;

- Even in the absence of landholder collusion, a voluntary tendering process could fail to result in enough participants to achieve the desired level of land management change; and
- The results of social survey work suggest that the issue of low participation rates and unreliable recharge reduction could be particularly acute with tender designs that require more complex information processing.

Experimental economics was used to compare the performance of alternative tender processes to minimise these difficulties. One experiment is a uniform price auction where the purchaser offers a single uniform purchase price which is paid to all successful sellers, regardless of their initial bid. Another experiment involves a discriminate price auction where the purchaser pays a range of prices that match the bids offered by successful sellers. Key prior expectations about differences between the uniform and discriminate tender processes were that:

3. The cost to the agency in a uniform price auction will be greater as surpluses are paid to traders. Alternatively as surpluses are appropriated by the purchasing agency in the discriminate price auction, the cost of recharge reduction is predicted to be less.
4. Because a discriminate price auction reveals a different price signal to each participant depending on the value of each individual bid, traders strategically seeking an optimal and maximum price may tend to explore the price opportunities in the market for a longer period compared with strategies in a uniform price auction. As a corollary, the recharge and price values will tend to be more volatile in the discriminate price auction, potentially resulting in a less reliable and more costly recharge outcome.

The experimental results did not confirm the first expectation. The trade income observed in the uniform price tender is less than the EUT predicted value in all periods, and remained stable across most periods. For the discriminate price auction, income exceeded the theoretical prediction from period 3 and rapidly increased in periods 6-10. In period 10, aggregate income to participant exceeded the EUT prediction for the discriminate price tender by 29% and 28% in experimental repetitions 1 and 2.

The responses to a discriminate price tender in the simulation appears to be a result of the discriminate price tender experimental design simulating a purchasing strategy of a recharge agency that prioritises achieving recharge reduction targets as opposed to being constrained by a reduction budget. Higher than EUT predicted bids for reduction units were therefore purchased if the 50% recharge reduction stipulated in the target had not been fulfilled by purchasing sufficient units offered by lower priced bidders. Sensitivity within the experimental context to this purchasing strategy, the sub-optimal decisions of a single player appears to provide the opportunity for strategic, prolonged and opportunistic behaviour by other players.

The results (especially the continued suboptimal behaviour by some participants could be interpreted as evidence in supporting prior expectation 2 above and the more general Smith (1991, 2002) hypothesis that convergence toward expected utility theory outcomes will be slower in experiments where the complexity of the decision environment is greater.

We recognise that the results may well be only relevant to the specific experimental context and posit in particular that the relatively small differences in payoffs to alternative actions that characterise the setting may be one factor that contributes to difficulty some participants appeared to have in discovering optimal strategies

Sociological survey work conducted for this project indicates levels of social cohesion within the community are very high, with over 80% of the survey respondents indicating involvement in the local Landcare group (Thompson, 2004). Previous research (e.g. Ostrom 1998, Gintis 2000) reports significant divergence from individualistic profit maximising behaviour in small, cohesive communities. These combined findings suggested that a policy approach to reward participation with some form of collective award for reaching an aggregate recharge reduction level might increase trial participation.

To test the potential for social payments to enhance willingness to enter into contracts to reduce recharge, variants of the uniform price auction were run but with social payment components. The experiments involved two social payment treatments one with communication one without. As a control treatment a uniform auction with the same total payoff but no social payment was run.

For both the control and social payment treatments rates of convergence with toward EUT outcome were high. Generally outcomes were quite similar across treatments, though the results did provide limited evidence that the communication treatment increased recharge reduction supply. 99% of the EUT predicted income was achieved by period 10 for the uniform price with social payment and communications, while 97% the EUT predicted income was achieved for the uniform price treatment.

Again, we suspect that the particular results were likely at least to some extent an artefact of the particular experimental context. Because participants were able to extract nearly all possible gains to trade even without social payment and communications, there was relatively little opportunity to obtain additional gains when social payments and communication treatments were introduced. Possibly if experiments had been constructed such that gains realised with baseline treatment were less, gains from social payment and communication might have been more.

To understand implications of credit trade market structures, behavioural responses differences to the open call closed call and no trade market structure treatments were tested experimentally. Conceptually, an open call market should lead to quicker convergences and as participants receive more information with structure (price and quantity of bids are posted with structure while with a closed call bidders are only informed about success or failure of their own bids.

Observed experimental results were not consistent with prior expectations. Indeed, the open call volumes traded and price was substantially below EUT prediction on average and exhibited large variations from period to period. In contrast, with the closed call structure, prices and quantities traded converged to near EUT predictions by the last three periods.

Again, the results could be interpreted as evidence in supporting prior expectation 2 above and the more general Smith (1991, 2002) hypothesis that convergence toward expected utility theory outcomes will be slower in experiments where the complexity of the decision environment is greater. Again, we recognise that the results may well be only relevant to the specific experimental context and posit in particular that the relatively small differences in payoffs to alternative actions that characterise the setting may be one factor that contributes to difficulty some participants appeared to have in discovering optimal strategies.

Ultimately, the objective of the experimental component of the MBI trial was to provide an empirical basis for selecting appropriate instruments to establish reliable recharge reduction obligations and cost effective recharge trading opportunities in the on ground trial implementation phase. Consequently, we believe that the very context specific findings are relevant and the choice of several design features for the trial that will be implemented was influence by experimental outcomes:

- A payment to farmers to establish property right obligations using a uniform price tender process as experimental evidence suggested that the information simplicity of this format result in relatively high participation rates for inexperienced participants. A uniform auction format is also preferred as it does not introduce the opportunity for strategic rent seeking that discriminate price auction did in experiments ;
- Trading in recharge credits using a closed call market structure was chosen to avoid potential for unreliable supply response as was witnessed as an experimental outcome;
- A group performance payment to promote participation and harness non-market and social motivation will be included, despite limited experimental evidence of the efficacy of this approach.

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