An experimental approach to assessment of trading and allocation mechanisms for nutrient trading

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Abstract

Regional councils throughout New Zealand are in the process of drawing up plans to enable them to meet the requirements of the Resource Management Act and the National Policy Statement on freshwater. Some councils are working on targets for nutrient leaching at the catchment level and are considering alternative approaches to ensuring these targets are achieved. In this paper we investigate the farm level effects of agricultural policies by employing the methods of experimental economics to investigate alternative mechanisms for farm and catchment level regulations aimed at improving water quality. Results are presented for four cap and trade system designs in order to assess the effect of alternative approaches to allocation of nutrient discharge allowances and rules governing trade or exchange of these allowances. The objective of this study is to assess the utility of cap and trade systems through experimental economics, with a focus on the efficiency and equity of these mechanisms.

Cap and trade systems are promoted as one of the major achievements of environmental economics. However, the move from theory to field implementation is a difficult transition, particularly due to the prevalence of uncertainty and the bounded cognitive ability of real agents. Data from the experiments enables comparison of the results of nutrient trading with the outcomes that would be expected based on economic theory. This assessment of the relative performance of cap and trade systems highlights important findings for environmental regulation. First, catchment profit is around 10% lower than predicted by theory. Second, the distribution of profit among farmers has little in common with that predicted by theory. Third, the trading behaviour of farmers bears little resemblance to theoretical predictions. Overall, these findings highlight the need to carefully assess the efficiency, equity and overall benefits of cap and trade systems for environmental regulation.

Key Words:

Cap and trade, environmental regulation, economic experiments, dairy farming, water quality, New Zealand.

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1   Introduction

This paper describes a set of experiments that were conducted to assess the efficiency and equity of the cap and trade mechanism to reduce nitrate leaching from pastoral farming catchments in New Zealand. While water quality remains high by international standards (Srebotnjak, Carr, de Sherbinin, & Rickwood, 2012), there is evidence of a downward trend with much of this decline being associated with intensification of pastoral farming. This trend matches changes in many parts of the world where water quality is decreasing because of diffuse pollution from pastoral agriculture (Campbell et al., 2005; Drewry et al., 2006). Indeed, diffuse sources are now the primary polluters of waterways worldwide (UNEP,2008).

Dairy production is the primary export industry in New Zealand, contributing around 26% of total goods exports (Schilling, Zuccollo, & Nixon, 2010). New Zealand farmers have achieved major increases in productivity over the last twenty-five years, indeed the primary sector grew faster than the national economy over the period 1978-2005 (Harrington, 2005), but growth and increasing productivity has come at a price. Urine deposition by grazing cows often causes leaching losses of nitrogen (N) in excess of those that can be sustained by freshwater ecosystems (Di and Cameron, 2002). Much reliance has been placed on voluntary mechanisms to promote water quality improvement among New Zealand dairy producers, such as the 2003 Clean Streams Accord; an agreement between New Zealand's largest dairy company Fonterra and regional councils. However, there is growing pressure for regional environmental regulatory bodies (Regional Councils) throughout New Zealand to reduce the nutrient enrichment of waterways through appropriate regulation of agriculture (e.g. EW, 2010).

The need to reduce the environmental impact of agriculture within New Zealand has stimulated the analysis of various regulatory policies (Doole, Marsh, & Ramilan, 2013; Ramilan, Scrimgeour, & Marsh, 2011). Extensive modelling has indicated, in line with economic theory, that abatement cost accruing to a reduction in nutrient outflows will be minimised under a cap and trade system (e.g. Doole and Pannell, 2012; Doole, 2010). However this is based on the various assumptions around the profit maximising behaviour of individual agents. The primary objective of this study is to assess the utility of cap and trade systems through experimental economics, with a key focus on the efficiency and equity of these mechanisms. Data from the experiments enables comparison of the results of nutrient trading with the outcomes that would be expected based on economic theory, assuming optimisation and profit maximisation by rational traders.

Allocation and trading mechanisms for water quality management in New Zealand have been previously investigated using trading games and modelling. The N-trader model was intended to assess various aspects of trading system design including allocation mechanisms, trading rules, transactions costs and the effect of allowing smaller landowners to opt out (Lock, Cox, & Rutherford, 2008). N Trader has been largely superseded by N Manager and was used to assess the impact of a nutrient cap on land use in the catchment of Lake Rotorua (Daigneault et al., 2012). Most recently the Ministry for Primary Industry funded research to examine how transferable permits and water charges could be designed for inclusion within Resource Management Act policy via participatory computer simulations in six stakeholder workshops (Fenemor et al., 2012). As far as we know no previous work on this topic has been carried out in New Zealand using formal experimental economics methods. In the next section we outline this approach and explain that it provides an extremely powerful and low cost approach to testing allocation and trading mechanisms.

2   Review and selection of allocation systems and trading mechanisms

When a cap and trade system is implemented the initial allocation of entitlements (e.g. nutrient discharge allowances) has long been regarded as one of the most controversial aspects (Sturm & Weimann, 2006). This controversy is not surprising since alternative allocation systems are likely to have very different effects on the wealth of individual stakeholders. For example an allocation system based on grandparenting will tend to protect the staus quo, whereas an equal allocation system will typically lead to large gains for some stakeholders and large losses for others. A useful way to structure analysis of alternative allocation systems is to start by thinking about what policy makers and other stakeholders want to use the allocation system to achieve (Friesen & Gangadharan, 2013a). We assume that any catchment level cap will be set in order to ensure that national environmental objectives are met. The way in which the cap is allocated to individuals or organisations can affect efficiency (the level of overall welfare) or equity (the distribution of income and/or wealth), or a combination of these two. In theory (with a well-functioning market and low transaction costs) neither the allocation method nor the trading institution should affect overall welfare. In practice, some trading institutions (e.g. a double auction) may be better at dealing with the various market characteristics, e.g., transaction costs, diffusion of information, market power, etc, and thus some trading systems may be more socially desirable than others.

In any case allocation systems will affect the distribution of income and/or wealth and need to be perceived as broadly fair in order to secure the cooperation of land owners. Kerr (2008) summarising findings from a programme of New Zealand applied research on this topic suggested that the "process should be fair – but also effective" and that the key criteria for assessing fairness were:

i)   Equal splitting is perceived to be fair
ii)   Those who are responsible for damage should pay
iii)   Those who are responsible for benefits should be rewarded, and
iv)   Poor should be protected and rich (wealth and income) pay larger share.

Policy makers may seek to find an acceptable compromise among the various principles outlined by Kerr above that also promotes an appropriate balance between economic, social and environmental benefits, both for the dairy sector and for New Zealand as a whole. Reviews of alternative allocation systems have been carried out by many authors in New Zealand and internationally and notably Tietenberg (1985). In New Zealand these reviews generally focus on the following systems:

a.   Sale or auction of Nitrogen Discharge Allowances.
b.   Equal Allocation Mechanism - proposed for New Zealand by Lilburne & Webb (2010).
c.   Grand parenting (also called grand fathering).
d.   Land Use Capability/Natural Capital (Carran, Clothier, Mackay, & Parfitt, n.d.).
e.   Benchmarking - see Ellerman et al., (2009).
f.   Hybrid Allocation Systems.

After review of the main findings from the literature and discussion with key stakeholders, the grand parenting and equal allocation systems were selected for experimental testing. Grand parenting involves the allocation of pollution rights based on historical leaching, while equal allocation involves an allocation of an equivalent level of pollution rights among farmers, regardless of their historical level of leaching. Grand parenting was selected since it is commonly favoured by policy makers and is commonly an important element of established mechanisms. Equal allocation has commonly been advocated in New Zealand because it is considered by some to be fairer than grand parenting. It has been studied and promoted for the Canterbury Region (Lilburne & Webb, 2010) and is also similar to the Land Use Capability/Natural Capital approach which is being implemented in the Manawatu/Wanganui Region.

Cap and trade mechanisms were also reviewed to select two mechanisms for inclusion in the treatment design. These mechanisms may be applied in a wide variety of situations which have markedly different characteristics and where the mechanism designer has been assigned a range of different objectives. The trading institution should be designed to address these specific characteristics and objectives and so in theory, there are a very large number of mechanisms that could be used to implement a cap and trade mechanism for nutrient discharge allowances.

Two of the most popular forms of trading institutions are the Continuous Double Auction (CDA) and the Call Market (CM). In the standard CDA, buyers and sellers tender bids/asks publicly. Typically all of the offers to buy and sell are displayed and open to acceptance, and price quotes tend to progress with time to reduce the bid/ask spread. Trading is open for a limited period of time and occurs bilaterally and sequentially at possibly different prices within a period. For this reason, the CDA is referred to as a discriminatory price auction. In the CM, on the other hand, bids and asks are accumulated and the maximum possible number of transactions are simultaneously cleared at a single price per period. CM is thus referred to as a uniform price auction.

Ketcham, Smith and Williams (1984) studied the CDA in simple laboratory goods markets and reported two important characteristics: (1) Prices converge to the theoretical competitive equilibrium rapidly, and (2) the allocations are highly efficient. CDA has been found to be the most efficient and competitive of laboratory trading institutions (Smith, 1962, as cited in Friesen & Gangadharan, 2013b). For example, Smith, Williams, Bratton, and Vannoni (1982) conducted experiments where traders were randomly assigned to the roles of either buyer or seller and compared the performance of CDA and some versions of the CM. They found that prices were nearer to their theoretical competitive equilibrium values in CDA than in the CM institution.

In one version of the CM institution, a buyer (seller) submits one bid price, and a corresponding maximum quantity he/she is willing to buy (sell) at that price or less (or more). Under this CM institution, the price-quantity outcomes can be explained as the result of an interaction of buyers withholding demand in an attempt to obtain a monopsony profit and sellers withholding supply to achieve monopoly profits which results in a price between the monopoly and the monopsony price. In another version of the CM institution, a buyer (a seller) submits one bid price for each unit that he/she desires to buy (sell). When buyers (sellers) are allowed to submit demand (supply) schedules, CM still does not perform as well as the CDA institution. However, price and efficiency performance improves compared to the first CM version.

Attanasi, Centorrino and Moscati (2010) compared the performance of CDA with that of a search market version of a double auction where each trader is looking for the best counterpart. In contrast to the classical CDA institution, traders are not provided with information about asks and bids when participating in the search market. Only the prices of completed transaction are made public. Bids and offers not leading to transactions remain private information of the two counterparts. They find that while the double auction search market does converge to a long term equilibrium price, the reduction in information reduces efficiency, and thus the open book nature of the standard CDA (i.e., the ability to view all available bids and asks) appears to play a critical role in information dissipation and thus market efficiency.

The studies discussed above are all examinations of market institutions in neutral laboratory environments with the purpose of understanding the basic characteristics of their performance. There have also been a large number of studies on trading institutions that were implemented or planned for specific environmental programs have been evaluated experimentally. An excellent survey of research in this area is provided by Friesen & Gangadharan (2013b).

An example of this line of research is provided by Muller and Mestelman (1994) who investigated a proposal for controlling nitrous oxides in Canada, Southern Ontario, by trade in coupons (emission permits) and shares (entitlements to coupons) in laboratory experiments using several different trading institutions. Discriminative call market experiments were conducted by Cronshaw and Brown-Kruse (1999, as cited in Friesen & Gangadharan, 2013b). Franciosi, Isaac, Pingry and Reynolds (1993, as cited in Friesen & Gangadharan, 2013b) used a computerized double auction market for trading permits and then a revenue neutral call auction, in which traders submit a bidding schedule. The results indicate higher efficiency than obtained in the other experiments modelling the EPA plan. They attribute the mediocre performance of the transaction prices—which do not converge to the competitive equilibrium levels in some sessions—due to the lack of public information about trading prices which are inherent to the open outcry institution. This institution disseminates a lot less information than a double auction institution.

The performance of trading institutions depends on the specific environment in which they are implemented. Although theory would suggest that increased public information would increase market efficiency, the complex market environment employed by Tisdell et al. (2004) did not confirm this prediction. In a laboratory environment where communication between traders is possible and information about the environmental consequences of water extraction is available, Tisdell et al. (2004) compared the impact of open book and closed book call auctions on the level of environmental damage caused by water extraction. They found that an open book call market, which makes bids common knowledge, results in a lower return per unit of environmental damage than the closed book call auction, where potential buyers (sellers) submit sealed bids (offers) to buy (sell).

The CDA institution has been found to be quite efficient when the buying or selling side is concentrated (Muller, Mestelman, Spraggon, & Godby, 2002). However, Muller et al. (2002) found that average prices rise under monopoly and fall under monopsony and profits are redistributed in favour of the agent with market power. Soberg (2000) compared the performance of the CDA where both buyers and sellers can announce bids and ask with one sided auctions where the bid (offer) auction only allowed buyers (sellers) to announce bids (asks). He found that all auction types yielded approximately efficient emission allocations despite the presence of a market power.

Although there are numerous studies in which the CDA institution has been found to be more efficient compared to the CM institution, the resulting different prices for the same good (the right to emit a certain amount of pollution) may not acceptable for farmers. Therefore the CM institution might be preferred, where a uniform price is desired politically. After review of alternative trading institutions and discussions with stakeholders the CDA and CM institutions were selected for experimental testing. The CDA institution was selected because of the many cases in which this has been found to be the mechanisms which leads to the most efficient outcomes. The CM institution was selected since a uniform price might be considered desirable by industry stakeholders.

3 Experimental Design and Methods

3.1 Stylised Catchment
All experiments were conducted with twelve subjects, representing farms of five different types in a stylised farming catchment (Table 1). All farms were assigned an identical nitrogen load of 3 tonnes and it was assumed that profit was maximised with this load. Farm sizes vary between 60 and 200 hectares to account for heterogeneity in the farm population both in farm size and nitrogen leaching rate per hectare (varying from 15 to 53 kg/ha). Two of the farms were assumed to be 'non-optimising', meaning that they can increase their profit per hectare by reducing their nitrogen load

to 3 tonnes. They have a nitrogen load of 4 tonnes with a farm size of 75 hectares. These farms are intended to represent cases where farm profitability can be increased by a reduction in farming intensity (Smeaton, Cox, Kerr, & Dynes, 2011; Vogeler, Beukes, & Burggraaf, 2013).

The stylised catchment is scale neutral and so can represent farm populations with larger average farm sizes by application of a scale factor.

Table 1:   Stylised Catchment

	# of subjects	Farm Size (ha)	Catch-ment Total (ha)	Nitrate leaching (kg/ha)	N Load per Farm (t)	Catch-ment N Load (t)
Low cost dairy (LDC) farms	2	60	120	50	3	6
Medium cost dairy (MCD) farms	2	75	150	40	3	6
Non-optimising (NO MCD) farms	2	75	150	53	4	8
Very high cost dairy farms (VHCD) farms	2	120	240	25	3	6
Sheep and beef (SB) farms	4	200	800	15	3	12
Catchment total	12		1,460	26		38

The characteristics, profitability and cost of abatement for the stylised farms used in the experiments were developed based on expert opinion to minimise sources of variation in the experiments. The differences between farms are limited to farm size and the abatement cost function, which specifies the relationship between nitrate leaching and profit. The low, medium and very high cost dairy farms vary in the cost of abatement, e.g. the expected level of profit reduction from reducing nitrate leaching. For example, the medium cost dairy farm is assumed to be operating at optimal farm intensity with a total annual profit of $102,600 and total nitrogen leaching of 3 tonnes (40 kg/ha). If this farm is required to reduce N leaching by 20%, profit will fall to $96,800. The abatement cost per kg for the first 20% reduction averages $9.76. By contrast, the 'very high cost' dairy farm has a current annual profit of $143,000 and an average leaching rate of 25 kg/ha. This farm would face an average abatement cost of $21.92 per kg for a 20% reduction in N.

The relationship between profitability and nitrogen load is illustrated in Figures 1 and 2 for medium cost dairy and sheep and beef farms. The quadratic shape is appropriate since increasing nitrogen leaching is typically associated with intensification, which first improves profit but then decreases profit due to inefficiencies associated with fixed factors of production (Doole and Paragahawewa, 2012). Note the inclusion of the non-optimal dairy farm with a nitrogen load of 4 tonnes and profitability of $86,483. It is assumed that this farm (with appropriate advice and management skills) would be able to increase profit by reducing nitrogen load.

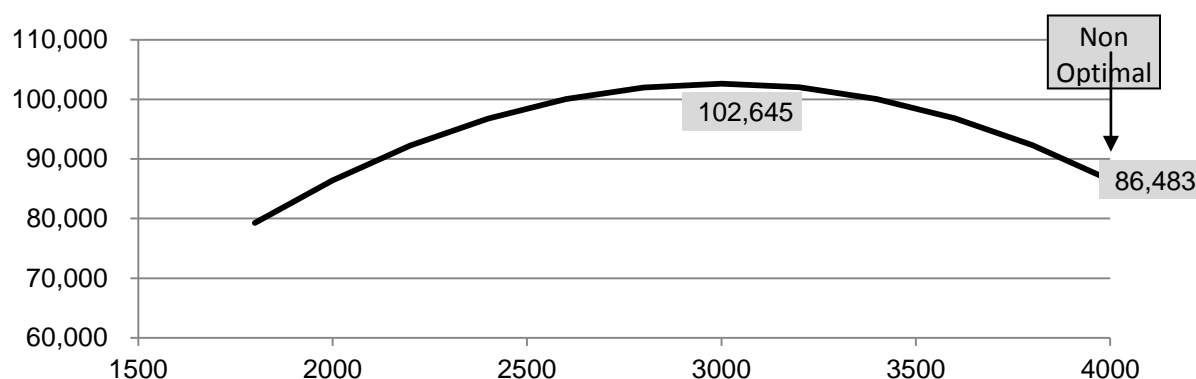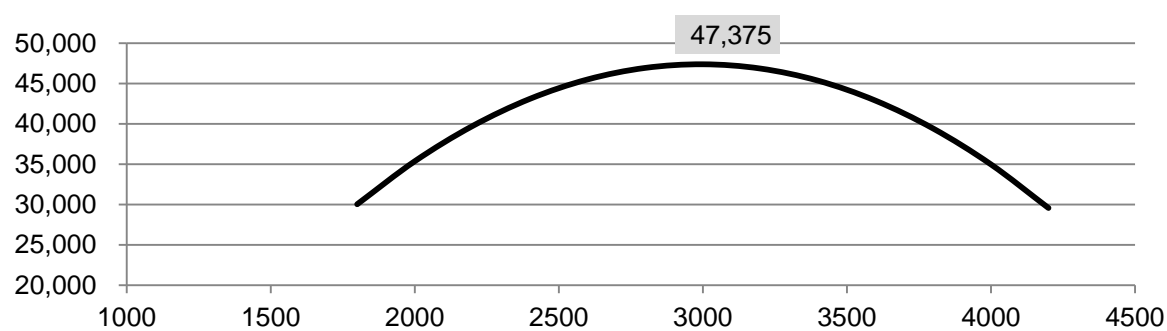**Figure 1:** **Profit vs nitrogen load, medium cost dairy farms**

Figure 2: **Profit vs nitrogen load, sheep and beef farms**

3.2 Allocation Mechanisms

It is assumed that the stylised catchment is leaching nitrogen at a rate which is leading to unacceptable outcomes for water quality. As a consequence, the regulator implements policies that will reduce nitrogen leaching by 20%. In the 'business as usual' case the catchment leaches 38 tonnes at an average rate of 26 kg/ha (see Table1). The required reduction of 7.6 tonnes (20% of 38 tonnes) to 30.4 tonnes is achieved via two alternative allocation mechanisms (see Table 2).

In the first case, grand parented less 20% (GPL20), all farms were required to reduce their nitrogen leaching by twenty per cent. In this case, sheep and beef farms would have to reduce their average leaching rate from 15 to 12 kg/ha, while non-optimising medium cost dairy (NO-MCD) farms would have to reduce from 53 to 42.4 kg/ha.

In the second allocation mechanism—equal allocation less 20% (EAL20)—the reduced catchment nitrogen load of 30.4 tonnes was allocated to all farms based on farmed area, at a constant rate of 21 kg/ha. In this case, dairy farms currently leaching 25 to 53 kg/ha are allocated 21 kg/ha, while sheep and beef farms currently leaching 15 kg/ha are allocated 21 kg/ha. This demonstrates that though some perceive equal allocation as fair; in practice, the outcomes may actually be quite unequal.

Table 2: **Allocation Mechanisms**

	Number of subjects	Farm size (ha)	Current Situation			Grandparented less 20%			Equal allocation less 20%		
			Nitrate leaching rate (kg/ha)	Catchment N load (t)	Share of catch' load	Nitrate leaching rate (kg/ha)	Catchment N load (t)	Share	Nitrate leaching rate (kg/ha)	Catchment N load (t)	Share of catch' load
Low cost dairy farms	2	60	50	6	16%	40	4.8	16%	21	2.5	8%
Medium cost dairy farms	2	75	40	6	16%	32	4.8	16%	21	3.1	10%
Non-optimising medium cost dairy farms	2	75	53	8	21%	42.4	6.4	21%	21	3.1	10%
Very high cost dairy farms	2	120	25	6	16%	20	4.8	16%	21	5.0	16%
Sheep and beef farms	4	200	15	12	32%	12	9.6	32%	21	16.6	55%
Catchment total	12	1460	26	38	100%		30.4	100%	21	30.4	100%

3.3 Scaling and instructions

The average earnings of participants in experiments should be sufficient to induce salient behaviour. This is typically achieved by setting the experiment parameters such that the average expected payment is approximately 1.25 times their outside option. For our initial experiments, the subject pool was drawn from University of Waikato student body. Each session was expected to take slightly less than two hours, and thus the average expected earnings were set at NZ$32 per session. This was achieved by applying a scale factor (1/2800) to the stylised farms to determine the initial profit levels/endowments (Table 3) that participants would earn based on their performance in the real effort task (see Section 3.4) .

Table 3: **Initial profit levels vs Scaled profit levels**

Farm Type	Farm profit level in stylised catchment	Scaled profit in experiments
Low Cost DF	$87,552	$31.30
Medium Cost DF	$102,645	$36.70
Non Optimising MCDF	$86,483	$30.90
Very High Cost DF	$143,022	$51.10
Sheep and Beef	$47,375	$16.90

Subjects (university students) were told that they were taking part in an experiment in the economics of decision making where they would have the option to trade coupons in a market. At the beginning of each round, subjects have the opportunity to buy or sell coupons. The bidding screen for treatment one (Double Auction, GPL20) is shown as Figure 3 below.

Coupons were required to use the various production systems, each of which was associated with a different profit level. The experiment was described in this way with no mention that the research was directed towards an environmental policy issue, to avoid any influence on behaviour that might result from subjects perceiving that they were acting as farmers trading pollution rights. An example of the instructions provided to participants is included as Appendix 1.

Figure 3: Bidding Screen

In the second stage of each round (after trading has been completed), subjects selected a production system. A production system is defined as a given farm plan—consistent with a given level of production, profit and leaching—that is available given the fixed resources of the particular farm type. The production systems, as well as the number of coupons required to use each system, were always shown on the left side of their production decision screens. An example of a production decision screen is shown as Figure 4 below.

Figure 4: Production Decision Screen

3.4   Real effort task

The implications of leaching restrictions for farm profit have been extensively studied (e.g. Monaghan, 2009; Doole, 2010; Doole and Pannell, 2012). The experiments were designed taking into account this body of literature. We assume that reduction in N leaching at catchment level has a positive cost and that this will influence farmer behaviour. Farmers will expect that reducing N leaching will reduce their overall income and subsequently will try to find ways to minimise their loss relative to the profit they made prior to introduction of leaching restrictions. They are likely to regard this level of profit as their reference point in considering the impact of such restrictions.

To replicate these incentives in the experiments a 'real effort task' was implemented in all sessions as a means of allocating endowments to subjects. A real effort task seeks to increase the realism of an experimental task through bolstering the affinity between subjects and their accumulated rewards, by making subjects earn their wealth through performing a physical task, ranking their relative effort and allocating funds accordingly. The task involved data entry over a twenty-minute period with points being awarded for the total amount of data entered correctly and points being deducted for data entry errors. Subjects were then allocated farms based on their ranking in the real effort task. For example, the subjects who came first and second were allocated VHCD farms (initial scaled profit $51.10), while the four bottom-ranked subjects were allocated sheep and beef farms (initial scaled profit $16.90).

Subjects were told that they had earned the initial profit level as an initial endowment level, but that their final earnings would be based on their final profit level after a 20% reduction in nitrogen was enforced. More specifically, their final cash payout depended on their earnings via participation in the market/production portion of the experiment. If their market/production earnings were less (more) than the cash earned via the real effort task, then the difference was subtracted (added) to those initial cash balances. Subjects had the opportunity to trade coupons to alter their final production level and profit (including income/expenditure on trading coupons). Under both GPL20 and EAL20 scenarios, all farm types were allocated reduced nitrogen loads, associated with lower profit levels (except for sheep and beef farms under equal allocation). Thus, each subject was presented with an opportunity to try to return to their 'reference' profit level or even a higher level during the duration of the experiment.

3.5   Treatments

There were four treatments in the experiments. This represented a full factorial of the two allocation mechanisms (GPL20 and EAL20) and the two market mechanisms (CDA and CM) (Table 4). Five experiments were conducted for each of four different treatments, with twelve subjects participating in each session. In each session, subjects were able to trade coupons in ten separate periods (as well as two initial test periods).

Subjects were paid according to their results from one of the ten periods that was selected at random. Since the experiment design is 10 periods (plays) of a one-shot game (market), this procedure minimizes income effects across each period of the market and reduces the cost of incentive payments while providing a financial incentive for subjects to perform as well as they could in all periods. The four treatments, treatment numbers, allocation systems and trading mechanisms are presented in Table 4 below.

Table 4:   Treatment Details

	Double Auction	Call Market
Grandparented less 20% GPL20	Treatment 1 5 sessions	Treatment 3 5 sessions
Equal Allocation less 20% EAL20	Treatment 2 5 sessions	Treatment 4 5 sessions

3.6   Theoretical gains from trade

The implementation of economic experiments allows us to compare the actual decisions of agents taking part in experiments with results predicted from economic theory. The theoretical results consistent with the composition of the catchment (abatement cost functions, farm numbers and types) were generated through solving a mixed integer nonlinear programming (MINLP) model of the nutrient trading system using the General Algebraic Modelling System (Brooke et al., 2012).

When coupons are allocated using a grand parenting regime and each individual farm is required to reduce their nitrogen leaching by 20%, total catchment profit (scaled) of $368.60 would be reduced by 12% to $322.40 (Table 5). If farms are allowed to trade coupons, they will be purchased by the VHCD farms (for which abatement is expensive) and sold by NO-MCD farms, which are able to increase profit by reducing N leaching. Trading enables these two farm types to improve their overall profitability such that an overall catchment profit of $359.40 is reached – with 20% less nitrogen leaching[2]. Based on the facts and assumptions inherent in this stylised catchment, trading reduces the cost of meeting the 20% reduction target, with overall catchment profit falling by only 2% compared to the initial level before imposition of the N reduction regulation.

When nitrogen leaching is reduced by 20% and coupons are allocated under an equal allocation regime, total catchment profit (scaled) of $381.00 would be reduced by 47% to $200.80 (Table 6). If farms are allowed to trade coupons, they will be sold by sheep and beef farms and purchased by all dairy farm types. Under this scenario, all farm types would gain from trade with net benefits ranging from $3.20 (VHCD farms) to $19 for sheep and beef farms. Trade enables catchment profit to exceed the pre-restriction level of $381.00, if trading induces the non-optimising dairy farm to adopt a profit-maximising level of N use. Overall, these results show that: (1) nitrogen leaching restrictions impose a cost; (2), trade allows these losses to be mitigated (at least in theory) through allowing equalisation of abatement costs; and (3) equal allocation imposes a significant cost on farmers when trading is not permitted, as it does not account for specific farm differences when allocation is performed.

As well as the differences in the *efficiency* with which different mechanisms enable traders to reach the optimal level of overall catchment profit (Tables 5, 6), the different mechanisms will also have different consequences for *equity*. For example, the grand parented allocation system would mean that sheep and beef farms that want to intensify land use would have to purchase nitrogen discharge allowances, whereas under the equal allocation system sheep and beef farmers would be allocated allowances in excess of current usage which they could sell to other farmers. Accordingly, the experiments presented here focus on both the efficiency and equity outcomes associated with the alternative treatments.

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[2] MCDF can also (in principle) increase their profit by purchasing one coupon.

Table 5:   **Optimal Outcome GPL20**

Farm Type	Number of subjects	Scaled initial profit level	Initial profit 20% N Red'n (no trade)	Optimal # of coupons to buy/sell	Profit level with coupons after trade	Plus/ minus cost of coupons	Final earnings per farm	Gains from trade per farm
Low Cost DF	2	$31.30	$25.86	-	$25.86	$0.00	$25.86	$0.00
Medium Cost DF	2	$36.66	$28.29	Buy 1	$32.93	-$4.40	$28.53	$0.24
Non Optimising MCDF	2	$30.89	$53.06	Sell 3	$50.25	$13.20	$63.45	$10.39
Very High Cost DF	2	$51.08	$32.29	Buy 2	$48.99	-$8.80	$40.19	$7.90
Sheep and Beef	4	$16.92	$10.81	-	$10.81	$0.00	$10.81	$0.00
Catchment Total	*12*	*$367.60*	*$322.40*	*4*	*$359.40*	*$0*	*$359.40*	*$37.00*

Note: This table is based on an equilibrium price of $4.40.

Table 6:   **Optimal Outcome EAL20**

Farm Type	Number of subjects	Scaled initial profit level	Initial profit 20% N Red'n (no trade)	Optimal # of coupons to buy/sell	Profit level with coupons after trade	Plus/ minus cost of coupons	Final earnings per farm	Gains from trade per farm
Low Cost DF	2	$38.00	$0.00	Buy 5	$32.60	-$15.50	$17.10	17.10
Medium Cost DF	2	$36.70	$3.30	Buy 4	$32.90	-$12.4	$20.50	17.20
Non Optimising MCDF	2	$30.90	$20.60	Buy 4	$50.30	-$12.40	$37.90	17.30
Very High Cost DF	2	$51.10	$42.70	Buy 1	$49.00	-$3.10	$45.90	3.20
Sheep and Beef	4	$16.90	$16.90	Sell 7	$14.20	$21.70	$35.90	19.00
Catchment Total	*12*	*$381.00*	*$200.80*	*28*	*$386.40*	*$0*	*$386.40*	*$185.60*

Notes: i) This table is based on an equilibrium price of $3.10. ii) The initial profit level for LCDF is $6.70 more than for GPL20 to avoid negative returns after the initial re allocation.

4   Results

4.1   Assessment of efficiency by treatment

In this context we use the term *efficiency* to refer to the overall level of profit achieved (across all subjects) as a proportion of the optimal level of profit that could be attained by an optimal allocation. We assess the overall efficiency of the different treatments by comparing the total profit levels of the twelve subjects in the different treatments with the theoretically predicted level of catchment profit with trade.

Results for final earnings in each period and session across the four treatments are summarised in Table 7. These results can be used to begin to assess the extent to which trading can enable total profit to be increased after a reduction in N allocation; and the ways in which allocation system and trading mechanism affect outcomes.

Results in Table 7 are averaged across all periods (1-10) and separately averaged across periods 1-3, 4-7, 8-10 and for period 10 only. The averages presented for just a subset of the entire period provide some indication of how quickly subjects learn how to maximise profit in a trading setting within this experimental setting. It can be seen that profit increases over successive periods in treatments 1, 2 and 4 as subjects 'learn' how best to optimise their profits. The lack of any improvement in treatment 3, may be attributed to the lack of information dissemination using the call market mechanism and the small number of potential profit increasing trades under the grand parented allocation system. In the discussion below, we focus on results for periods 8-10, after learning has occurred, since we expect that these results will more closely match the outcomes of a trading system involving informed and trained farmers, particularly given their experience with trading that is expected to be much greater than with the students who participated in these experiments.

Table 7:   **Total profit, with and without trade vs optimal profit**

Allocation mechanism	Period	*Experimental Outcomes*		*Expected Outcomes*	
		Double auction	Call market	No trade profit	Optimal outcome
		(T1)	(T3)		
Grand-parented	1-10	327	326	322	359
less 20%	1-3	325	326		
	4-7	325	326		
(GPL20)	8-10	331	327		
	10	335	327		
		(T2)	(T4)		
Equal allocation	1-10	319	302	201	386
less 20%	1-3	299	287		
	4-7	325	300		
(EAL20)	8-10	332	320		
	10	348	311		

Note: T1 to T4 refer to treatments 1 to 4

The optimisation model described in Section 3.6 identifies that under the grand parented allocation (GPL20), catchment level profit would be reduced from \$368 to \$322, in the absence of trade. However, trading within this model allows profit to be increased to \$359. Table 7 indicates that after learning (periods 8-10), trading enables a slight improvement in profit to \$331 (DA) or \$327 (CM). While this improvement is statistically significant (5% level, periods 1-10), it would not be sufficient to justify the establishment of a trading mechanism. Additionally, it can be seen that the gains from trade (\$9 DA, \$5 CM) are only 24% (DA) and 14% (CM) of the level of gains (\$359-\$322=\$37) determined by theory. These relatively poor outcomes appear particularly significant, given that the experiment retains a deterministic specification within which subjects are able to learn over an extended period with the only variability arising from the behaviour of other subjects, and not arising from important economic variables, such as output and input prices, or climate.

The optimisation model described in Section 3.6 identifies that under equal allocation (EAL20), catchment level profit would be reduced from $381 to $201, in the absence of trade. However, trading within this model allows profit to be increased to $386. Table 7 indicates that within the experiment, trading enables a substantial improvement in profit to $332 (DA) or $320 (CM). The substantial improvement achieved with trading under the equal allocation system appears to be a direct outcome of this allocation system which results in large incentives for some subjects to sell and other subjects to buy. In contrast, the grand parented allocation is already far closer to the profit-maximising allocation, so there are far fewer opportunities for profitable trade. Nevertheless, the gains from trade obtained in the experiments are 29% (DA) and 36% (CM) lower than predicted by theory. These shortfalls are large, particularly given the deterministic specification adopted within the experiments that renders these lower bounds of what may be expected in reality.

Across both mechanisms, as expected, the double auction (DA) produces more efficient results than the call market (CM). The difference in efficiency is less marked under the grand parented allocation, where the expected level of trade is lower.

It is important to note that the results reported above are averages across multiple periods and sessions. Figure 5 illustrates the way in which these results are distributed for treatment one. It can be seen that trade increased profit by 0 to 5% in 68% of cases and by 5 to 10% in 8% of cases. On the other hand, trade resulted in a reduction in profit in 24% of cases. It should be noted that this includes results for all periods; although, as noted above, performance improves in successive periods due to learning. Clearly this distribution of outcomes would have important implications for whether trading is perceived to be a desirable policy instrument. Those who end up with reduced profits (24%) are unlikely to be in favour, while those who achieve a marginal increase may not feel that it is worth the effort and risk involved. Even those few farmers who achieve the largest gains (of 5-10%) may not be strong advocates.

Figure 5: **Distribution of Catchment Profit, DA, GPL20**
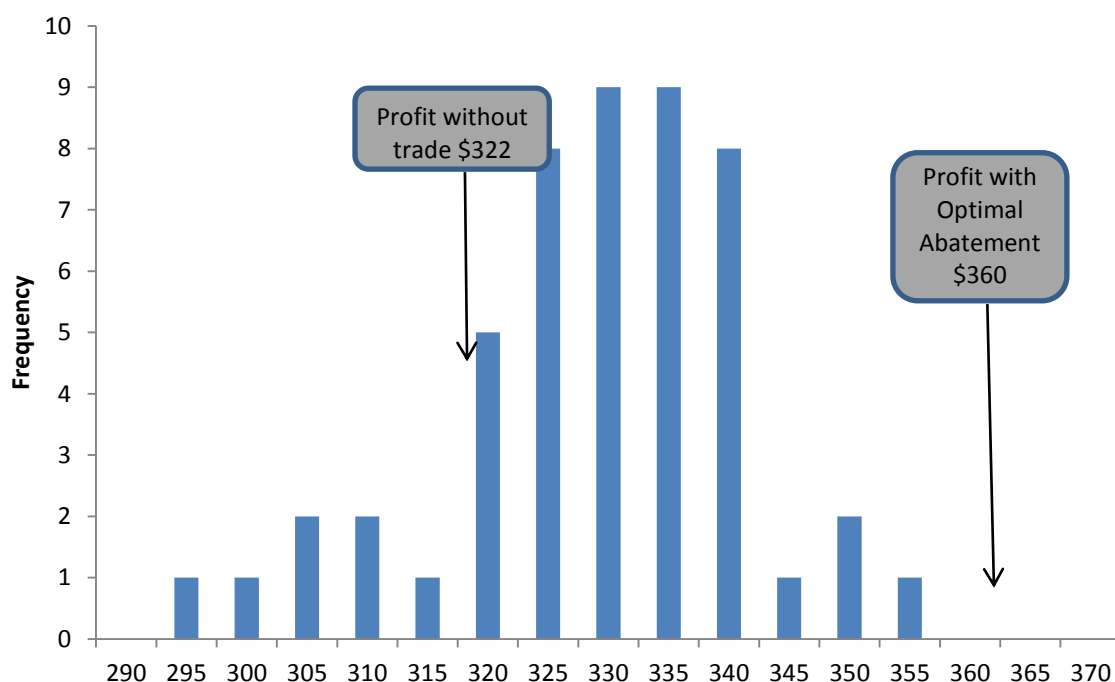
4.2   Analysis of Number of Coupons Traded

This section compares the trading behaviour of experimental subjects to the optimal level of trading predicted in the optimisation model presented in Section 3.6.

In the absence of arbitrage, the optimal number of trades is six for the GPL20 allocation and 28 for EAL20. It can be seen from Table 8 below that the number of trades was well in excess of the optimal level for treatments using the double auction trading institution e.g. treatment 1 (all periods) and treatment 2 (periods 6-10). These excess trades may be a consequence of subjects attempting to make profits from arbitrage (e.g. buying low and selling high or vice versa).

The call market institution produces a marked reduction in the number of transactions since only bids which are above/below the market clearing price, result in actual trades. It can be seen that the call market (treatments 3 and 4) resulted in a level of trades which was near optimal (treatment 3, periods 9-10) or below optimal (treatment 4).

Table 8:   Number of Coupons traded, by period and treatment

Period	Treatment			
	1	2	3	4
	DA	DA	CM	CM
	GPL20	EAL20	GPL20	EAL20
All periods	*20.3*	*30.4*	*4.8*	*15.2*
1	17.6	25.6	3.2	8.8
2	18.8	23.0	3.4	11.6
3	17.4	28.0	3.6	11.8
4	18.2	27.4	4.8	16.2
5	17.8	27.6	5.2	18.0
6	23.2	30.0	5.4	14.2
7	21.2	36.8	5.2	17.2
8	20.8	34.2	5.0	16.8
9	25.4	32.4	5.8	17.8
10	22.8	39.4	6.4	19.8
Optimal	*6*	*28*	*6*	*28*

In Tables 9 and 10 net purchases are compared with optimal net purchases across farm types. Note that net purchases are made up of number purchased, less number sold, so for example, NOMCDF had average purchases of 2.37 units and average sales of 3.83 units, resulting in net sales of 1.47 units (treatment 1).

Table 9: **Actual vs Optimal Net Purchases GPL20** *(average periods 8-10)*

Farm Type	Optimal Net Purchase	Actual Net Purchase		Performance (actual/optimal)		WTP /*WTA* $ per unit		
		DA	CM	DA	CM	1st	2nd	3rd
LCDF	0	-0.57	-0.40			*-4.2*		
MCDF	1	0.30	-0.50	30%	-50%	4.6	2.8	
NOMCDF	-3	-1.47	-0.80	49%	27%	*0.9*	*-0.9*	*-2.8*
VHCDF	2	1.93	1.43	97%	72%	10.4	6.3	
SB	0	-0.10	0.13			*-4.8*		

Note: where actual net purchase negative, WTA is presented in italics.

Under GPL20 using the double auction trading mechanism VHCD farms purchased an average of 1.93 units, only slightly less than the optimal number of 2. This may be related to the fact that their willingness to pay (based on the profits from alternative production systems) for one unit should be far higher (10.4) than for other farm types.

The largest discrepancy between actual and optimal behaviour was observed for NOMCD farms. This farm type recorded net sales averaging 1.47 per farm whereas they would have optimised their profits by selling three units. This reluctance of NOMCD farms to sell within the optimal price range may explain the higher than expected prices, the lower than optimal purchases by MCD farms and the fact that LCD farms recorded net sales of 0.57 units.

Table 10: **Actual vs Optimal Net Purchases EAL20** *(average periods 8-10)*

Farm Type	Optimal Net Purchase	Actual Net Purchase		Performance actual/optimal		WTP /*WTA* $ per unit		
		DA	CM	DA	CM	1st	2nd	3rd
LCDF	5	2.70	2.43	54%	49%	8.9	7.7	6.5
MCDF	4	4.27	3.13	107%	78%	10.2	8.3	6.5
NOMCDF	4	2.67	2.63	67%	66%	10.2	8.3	6.5
VHCDF	1	1.07	0.80	107%	80%	6.3	2.1	-0.5
SB	-7	-5.35	-4.50	76%	64%	*-1.6*	*-1.2*	*-0.9*

Under EAL20 (DA), VHCD and MCD farms purchased slightly more than the expected number of units. Sheep and beef farms sold an average of 5.35 units – less than the optimal level of 7 units. This may in part explain the higher than expected prices and the fact that LCD and NOMCD farms purchased fewer than the optimal number of units.

Overall, it is important to note that the trading behaviour observed in the experiments is different from that predicted by theory. Indeed, the consideration of bounded cognitive ability in an experimental setting appears to effectively restrict the degree to which cap and trade systems replicate theory.

4.3 Assessment of outcomes by farm type and treatment

Outcomes for different farm types can be assessed by comparing average final earnings with optimal earnings. For example, low cost dairy farms (LCDF) were able, on average, to exceed the optimal level of earnings with a trade performance of 107% (DA) and 101% (CM) (Table 11). This analysis of performance by farm type confirms the efficiency results reported above. It can be seen that trade performance for GPL20 is better than for EAL20 and that the call market performs less well than the double auction, especially under EAL20 (Tables 11, 12). However, most importantly, it is evident that performance appears to vary with farm type, especially under the equal allocation system (DA) where performance varies from a low of 9% (MCDF) to a high of 120% (SB). The previous section outlines that profit is around 10% lower at the catchment level when we consider real behaviour, rather than results from an optimisation model. Additionally, this section highlights that as well as this aggregate effect, there is also a large impact on the distribution of changes in profit according to farm type. Thus, as well as inefficiency arising with the consideration of real behaviour, we also have a loss of equity in terms of how gains are distributed across the regulated population.

Table 11:   Comparison of Trade performance, by treatment, by farm type (%)

| | | GPL20 | | EAL20 | | |
| | | DA | CM | DA | CM | |
	Type	1	3	2	4	All
VHCDF	1	84%	88%	92%	90%	88%
MCDF	2	94%	93%	9%	14%	53%
LCDF	3	107%	101%	31%	37%	69%
NO-MCDF	4	83%	87%	64%	65%	75%
SBF	5	104%	92%	120%	105%	105%
	All	94%	92%	63%	62%	78%

Tppercent = final earnings/optimal final earnings

Table 12:   Comparison of Trade performance, by treatment, by farm type ($)

| | | GPL20 | | EAL20 | | |
| | | DA | CM | DA | CM | |
	Type	1	3	2	4	All
VHCDF	1	-6.4	-5.0	-3.6	-4.6	-4.9
MCDF	2	-1.8	-2.1	-18.6	-17.5	-10.0
LCDF	3	1.8	0.3	-11.8	-10.8	-5.1
NO-MCDF	4	-10.7	-8.0	-13.8	-13.1	-11.4
SBF	5	0.4	-0.8	7.1	2.0	2.2
	Total	-3.3	-3.1	-8.1	-8.8	-5.9

*Tradeperf = Actual earnings from trade minus optimal earnings ($). **Note**: The variables Tppercent and Tradeperf include initial endowment and so do not provide a perfect measure of trade performance only.*

5   Conclusions

Use of the cap and trade mechanism to manage water quality has been extensively analysed and discussed in New Zealand over the last two decades. One such scheme, involving a small number of landholders, has been implemented in the catchment of Lake Taupo (Greenhalgh & Selman, 2012). Opposition to the introduction of such schemes has tended to focus on political feasibility and unease over the social acceptability of trading pollution rights. Amongst environmental economists, concern has centred on the size of transaction costs and whether these would be low enough to enable efficiency gains to be realised. There has been little discussion around the extent to which the behaviour of economic agents will match theoretical predictions, thus enabling the efficiency gains which are predicted to arise from trade in nitrate discharge allowances.

The experiments described in this paper were designed to assess the behaviour of economic agents facing production and trading decisions similar to those that would be faced by pastoral farmers in a New Zealand catchment with nitrate leaching in excess of the sustainable level for healthy fresh water ecosystems. The experiments were based on a stylised catchment of 12 farms and five different farm types with heterogeneous abatement costs. Twenty, two-hour experimental sessions involving 240 subjects and ten trading periods per session were conducted using four treatments; a full factorial of two allocation mechanisms and two trading institutions.

The use of economic experiments to test the relative performance of cap and trade systems highlights important findings for environmental regulation. First, catchment profit is around 10% lower than predicted by theory. Second, the distribution of profit among farmers has little in common with that predicted by theory. Third, the trading behaviour of farmers bears little resemblance to theoretical predictions. Moreover, these findings have been identified in an experimental setting in which many stochastic processes central to agricultural production have been ignored, such as price and climate variability. Thus, they represent an optimistic portrayal of learning that suggests that these predictions are lower bounds of what may be observed in reality.

Overall, these findings highlight the need to carefully assess the efficiency, equity and overall benefits of cap and trade systems for environmental regulation. The findings reported in this paper suggest that the cap and trade mechanism may not lead to expected efficiency gains, especially under the grand parented allocation scheme. However, the strength of this conclusion will be bolstered through broader application of such experiments and/or consideration of more variability within the processes incorporated in the defined tasks.

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Appendix 1

Example of Instructions (Treatment 1, Double Auction, GPL20)

Experiment Instructions: Part 2

General Instructions

This is an experiment in the economics of decision-making. In this part of the experiment, you will participate in a series of 10 rounds. Each of the rounds is independent of each other. That is, you will engage in the same scenario 10 times in a row. At the end of each round, all your cash balances, inventories, etc... will be reset to their initial values. Even though you will make decisions for 10 replications of the scenario (play 10 rounds), you will only be paid for one of them. Upon completion of the 10 rounds, the experimenter will roll a 10 sided die to determine which of the rounds will be used to determine your earnings for this part of the experiment.

Each round is divided into two stages. In stage 1 you will have the option to trade "coupons" in a market, and in stage 2 you will decide which production system you want to use.

Coupons

At the beginning of each round, each trader will be given an endowment of "coupons." There are 12 traders. 6 traders are endowed with 2 coupons, 4 traders are endowed with 4 coupons, and 2 traders are endowed with 7 coupons. Therefore, the total number of coupons in the market is 42. Coupons are required to use the various production systems available to you. More specifically, each production system has a coupon requirement and thus you must have enough coupons in your inventory to cover the coupon requirement of the production system you select. These coupon requirements will be presented on your bidding screen. Note, you are required to have at least one coupon to ensure you can use at least the lowest production system.

Production Systems

In the second stage of each round (after trading has been completed in stage 1), you will make your choice of production system. The production systems as well as the number

of coupons required to use each system are always shown on the left side of your production decision screen (as illustrated in Figure 1) and bidding screen (as illustrated in Figure 2). **NOTE**, the numbers on this example screen **<u>are different</u>** from the actual numbers used in the experiment, and you won't learn your actual values until the experiment begins.

You will begin each round with an Initial Production System and an allocation of coupons. This system is written in blue font in the table and the initial allocation of coupons in red font. Your Initial Production System and coupon allocation was determined by your performance in part 1. The money you earned in part 1 represents the profit you receive if you decide to use the same production system as your Initial Production System. Notice that the Production Profit associated with your Initial Production System and Cash balance is the same as your part 1 earnings in the left hand column of Figures 1 and 2. Therefore, if you produce at your Initial Production System, then your production profit is unchanged. Conversely, if you decide to change your production system then your production profit for the round will either increase or decrease as illustrated on production table presented on your bidding screen. If your production profit increases, then the *additional profit* will be added to your earnings from part 1. If your production profit decreases, then the *loss* will be deducted from your part 1 earnings.

Figure 1: Production Decision Screen

For example, your initial production system is level 7 with a coupon requirement of 7 coupons. If you decide to produce at your Initial Production System (level 7), then your production profit (earnings from part 1) will stay the same (excluding sales or purchases of coupons). If you decide to change your production system from your initial level 7 to level 8, then your production profit would decrease by $1.40 (i.e. $1.40 would be deducted from your earnings from part 1 of $$45.70) and you would require a total of 8 coupons. If you decide to change your production system from level 7 to level 5, then your profit would decrease by $5.90 (i.e. $5.90 would be deducted from your earnings from part 1 of $45.70) and you would need a total of 5 coupons. Note that in this example your initial allocation of coupons is only 4 and thus you would need to purchase coupons in the market to select any production system above level 4.

Why might you decide to change from your Initial Production System? Recall, that you must have a sufficient number of coupons to use a given production system. Some participants will find that the coupons they are allocated are not enough to continue with their Initial Production System. Therefore, to be able continue with this system, you may need to purchase more coupons via the market in stage 1. The price of coupons in the market may be such that your overall earnings are lower than if you used a production system that requires fewer coupons. To assist you with your decision-making on whether to buy, sell, or not to trade coupons, we've created a column in your production table labeled *Change in Profit from Trading*. This column presents your change in production profit for each unit you may decide to buy or sell from your initial allocation of coupons.

For example, the Initial Production System illustrated in Figure 1 above is 7 which requires 7 coupons, but you only have an initial allocation of 4 coupons, which limits the choice of production system to 4 or below. To continue with your Initial Production System you will need to purchase 3 coupons in the market. If you are able to purchase the additional 3 coupons in the market, then you will be able to continue to use your Initial Production System and thus avoid a reduction in production profit of $13.40 (that will be subtracted from your part 1 earnings). Recall, your overall earnings in the round also includes the price you have to pay for the 3 additional coupons you will need to produce at system 7. Therefore, if the price you have to pay in the market is greater than $13.40 for the 3 additional coupons, then you will have a lower overall

level of earnings than simply producing at system 4 with your allocation of 4 coupons. More specifically, from the *Change in Profit from Trading* column in Figure 1, you can see that your production profit increases by $7.50 if you are able to purchase a 5th coupon and produce at production level 5. Therefore, if you have to pay more than $7.50 for the 5th coupon, then your overall earnings will be lower than if you simply produced at level 4 with your initial allocation of coupons. However, if you can purchase the additional coupon for less than $7.50, then your earnings will increase for buying the 5th coupon and producing at level 5. Similarly, from the *Change in Profit from Trading* column, your profit will increase by $4.40 for the 6th coupon and thus, once again, any price paid over (under) $4.40 will result in a lower (higher) overall earnings in moving from levels 5 to 6.

On the other hand, you might decide to sell some coupons and change to a production system that has a lower coupon requirement. For example, if you change to system 3, the *Change in Profit from Trading* column shows that your production profit decreases by $10.40. Although, you only need 3 coupons to produce at level 3. If you can sell your 1 surplus coupon for more than $10.40 then you will have a higher overall level of earnings than simply producing at system 4 with your allocation of 4 coupons.

Earnings

As previously explained, you will play a total of 10 rounds. However, your earnings will be calculated by a random selection of one of these rounds. That is, the experimenter will roll a 10-sided die to determine which of the 10 rounds will be used to calculate your earnings from part 2. Additionally, your Initial Production System and its associated Initial Production System Profit was determined by your performance in part 1 of the experiment.

Your earnings for each round of part 2 is calculated as

Round Earnings = (Production Profit + Proceeds from Selling Coupons – Amount Spent when Buying Coupons) – (Initial Production Profit)

The money that you will take away at the end of the experiment is your earnings from part 1 PLUS your earnings from part 2.

The Market

Recall that at the beginning of each round, each trader will receive 4 coupons, and that your initial cash balance and Initial Production System were determined by your performance in Part 1 of the experiment. At the end of each round, all your cash balances, inventories, etc... will be reset to their initial values. Only 1 of the 10 rounds will count towards determining you overall earnings in today's experiment.

Figure 2: Bidding Screen

In stage 1 of each round, you will have the opportunity buy and/or sell coupons in a market. Each trading round will last 180 seconds. An example of the market screen is shown above. On the left hand side of the bidding screen, you are provided information on the Production Systems available to you. More specifically, column 1 presents the Production Levels, and the Production Profit associated with each Production Level is presented in column 2. The change in production profit for each production level you deviate from you initial production level is provided in column 3. Column 4 shows the coupon requirement for each of the Production Levels.

At any time during the market, anyone is free to make an offer to buy a coupon at a price they choose; likewise, everyone is free to make an offer to sell a coupon at a price they choose. Also at any time during the round, everyone is free to buy at the best offer price specified by someone wishing to sell, and everyone is free to sell at the best offer price specified by someone wishing to buy.

If you wish to purchase a coupon, you can do so in two ways:

1. You can submit an **offer to buy** a coupon, which may then be accepted by another participant that wants to sell a coupon. You do this in the column on the right hand side of the screen by typing the amount you are willing to pay for each coupon in the box marked "Enter price at which to buy" and the quantity you want to buy in the box marked "Enter quantity to buy". To complete the offer to buy, press the button at the bottom of the column labeled "List Purchase Price". You will then see your new offer to buy list in both the "Your Offers to Buy" column and "All Offers to Buy" column.

2. You can press the "Buy" button. This will accept the highlighted offer to sell from the "All Offers to Sell" column, which shows all the available offers to sell in ascending order so that the lowest price is at the top. The highlighted price is the lowest price that isn't your offer to sell. All of your offers listed in the "All Offers to Sell" column are in blue font.

Similarly, if you wish to sell a coupon, you also can do so in two ways:

1. You can submit an **offer to sell** a coupon, which may then be accepted by another participant that wants to buy a coupon. You do this in the column on the left hand side of the screen by typing the amount you are willing to sell each coupon in the box marked "Enter price at which to sell" and the quantity you want to sell in the box marked "Enter quantity to sell". To complete the offer to sell, press the button at the bottom of the column labeled "List Sale Price". You will then see your new offer to sell list in both the "Your Offers to Sell" column and "All Offers to Sell" column.

2. You can press the "Sell" button. This will accept the highlighted offer to buy from the "All Offers to Buy" column, which shows all the available offers to buy in descending order so that the highest price is at the top. The highlighted price is the highest price that isn't your offer to buy. All of your offers listed in the "All Offers to Sell" column are in blue font.

You can remove any of your offers to buy or sell at any time. To do so, click on the offer that you'd like to remove from the market (which will highlight that offer) and then click the "Remove" button at the top of the corresponding column.

The "Transaction Prices" column shows all the prices at which a coupon has been bought or sold in the current round.

Your offers to sell are limited by your available inventory of coupons (i.e., you cannot sell more units than you have), and your offers to buy are limited by your available cash balance and the price (i.e., you cannot buy more than you can afford). Since any offer you make to the market to buy or sell is potentially a binding contract, you must have the available cash or coupon inventory to facilitate this transaction. To help you keep track of all of your commitments to the market, the program calculates your available cash and coupons for additional transactions at the top of each of the corresponding offer columns.

A summary screen will be provided at the end of each round similar to the one below.

Figure 3: Summary Screen

Practice Round

Before we begin making decisions for real money, we will conduct two practice rounds for you to get comfortable with the trading software. These two practice rounds do not affect your experiment earnings.