

Market Based Instruments Pilot Program Round 2. Project
R2-48

**ISSUES OF ENFORCEMENT AND REGULATION IN THE APPLICATION
OF MARKET BASED INSTRUMENT**

FINAL REPORT

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User Friendly Summary

The aim of this project was to explore enforcement and regulation strategies that agencies can employ to improve compliance in water quality point and diffuse trading schemes.

This project undertook an extensive review of the literature and in conjunction with industry posed five questions:

- Can the Murphy and Stranlund (2006) study be extended using Lockyer Valley data?
- What are the consequences of moving the liability of diffuse compliance between point and diffuse source firms?
- What are the consequences of having group responsibility for an aggregate emissions target (in terms of a group tax or subsidy) on compliance levels?
- Should the probability of audit be common knowledge in point-diffuse trading programs?
- What are the consequences of having individual pollution levels visible to the group?

The key finding of the research is that the issue of enforcement and compliance in market based instruments is vitally important. Without well crafted enforcement and regulation schemes MBIs are likely to fail. A zero or low probability of audit is likely to result in ineffective schemes and no incentive to trade. It is critical that enforcement and regulation issues be considered explicitly for any MBI.

Glossary

Aggregate compliance – Aggregate compliance relates to whether or not the aggregate emissions of the group as a whole are exceeding the level of emissions provided for under the market based instrument.

Diffuse/Non-point source pollution – pollution that is not traceable to a particular source. Characterised by imperfect knowledge regarding pollutant generation, transport and fate and the inability to perfectly observe its source.

Expected fine – this is the fine that could be expected over the long term and is equal to the probability of audit multiplied by the fine for being non-compliant.

Group ambient audit system – The aggregate emissions of the group as a whole are audited and all individual members of the group face a fine if the group is found to be non-compliant.

Group subsidy/tax system – In this system aggregate emissions of the group are audited and all members of the group receive a tax (fine) if they are found to be non-compliant or a subsidy if they are found to be over-compliant. This is based on Segerson (1988).

Individual compliance – Individual compliance relates to whether or not the individual emissions of a firm are exceeding the level of emissions provided for under the market based instrument.

Individual random auditing system – Individual firms emissions are audited depending on a given probability and face a fine if found to be non-compliant.

Point source pollution – pollution that is traceable to a particular source. There is an ability to observe the source.

Point-diffuse system – Point source firms interact in a market with non-point source firms. Point source firms are buyers of emissions credits while non-point source firms produce and sell emissions credits.

Point-point system – Point source firms are allocated credits and interact in a market (buy and sell credits) with other point source firms.

Risk averse - A subject who wishes to avoid risk. If two investments have the same expected return, but Option A is more risky than Option B, a risk averse person would more likely prefer Option B.

Risk neutral – A subject who is indifferent to the risk involved. If two investments have the same expected return a risk neutral person would be indifferent between them even if Option A is more risky than Option B.

Risk preferring – A subject who is attracted to risk. If two investments have the same expected return, but Option A is more risky than Option B, a risk preferring person would more likely prefer Option B.

Two-fine auditing system – This system involves the aggregate emissions of the group as a whole being audited and all members of the group being fined if the group as a whole is non-compliant. Individual firms also face a probability of having their individual contributions audited and receiving a fine if they are found to be non-compliant.

Two-fine auditing system with exclusion – This system involves the emissions of individual firms being audited depending on a given probability and receiving a fine if found to be non-compliant. The aggregate emissions of the group are also audited and all members of the group fined if the group is found to be non-compliant. However, any audited emissions “found” during individual auditing are excluded from the group fine.

Executive Summary

By exploiting the power of a market to allocate pollution control responsibilities, well-designed emissions trading programs promise to achieve environmental quality goals more cheaply than traditional command-and-control regulations. It is clear, however, that the potential of emissions trading is jeopardized if these programs are not well enforced. While there is a significant body of knowledge on compliance and enforcement of point source emissions trading programs the same cannot be said for diffuse source emissions. Therefore, the aim of this project was to explore enforcement and regulation strategies that agencies can employ to improve compliance in water quality point and diffuse trading schemes.

The Interim Report and the Evaluation of the Round One programs report recognize the importance of enforcement in a market-based mechanism, acknowledging that “[a] necessary condition for the effective implementation of MBIs is adequate monitoring and enforcement” (Grafton 2005, p. 8). This project directly addressed that necessary condition for effective implementation of MBIs.

The project undertook an extensive review of the literature and in conjunction with industry posed five questions: (1) Can the Murphy and Stranlund (2006) study be extended using Lockyer Valley data?, (2) What are the consequences of moving the liability of diffuse compliance between point and diffuse source firms?, (3) What are the consequences of having group responsibility for an aggregate emissions target (in terms of a group tax or subsidy) on compliance levels?, (4) Should the probability of audit be common knowledge in point-diffuse trading programs?, and (5) What are the consequences of having individual pollution levels visible to the group?

The key finding of the research is that auditing and regulating MBIs is vitally important. No or low probability of audit is likely to result in ineffective schemes and no incentive to trade. Further, trade has the potential to increase compliance with environmental targets. Compliance becomes financially viable for some emitters with trade than would have been possible without trade. Increased enforcement may be mediated via market prices rather than increased compliance. It is also important to consider who is liable for variations in emissions. Fewer credits are produced when non-point sources are liable for stochastic variation in realised emission levels compared to situations where point sources are liable, or there is high variation between nominal and actual emission levels. In terms of the form of auditing, a two-fine auditing systems may be superior to simple individual random audit system without trade. With MBIs, trade may overcome the need for group ambient fines for common pool resource damages. In terms of groups, community awareness of non-compliance may inhibit trade and lead to strategic pricing in retaliation to a lack of contribution by others to solving a common pool resource problem. Finally, if the probability of audit is low then it is not advisable to make it public. If the probability of audit is high this research found that making it common knowledge would increase compliance. In the long run firms’ expectations will match the actual probability of audit.

Achievement of Project Objectives

The Evaluation of Round One Projects specifically identifies trading between point and diffuse sources as a research priority for the second round of pilots (Grafton 2005, p. 3). This project addressed this gap by designing and testing a market that facilitates both point-point and point-diffuse trading in order to achieve water quality goals at least cost, while specifically accounting for compliance incentives and strategies for enforcement.

As the Round One projects have shown, water quality trading among point sources is likely to yield substantial benefits. Since discharge from diffuse sources accounts for a significant share of water pollution, an expanded trading program that incorporates diffuse sources is essential for achieving environmental targets cost-effectively. Trading between point and diffuse sources also offers some significant challenges. The management of diffuse source pollution is problematic because (a) by definition, discharges from diffuse sources are unobservable or too costly to monitor, and (b) diffuse loadings are stochastic due to weather-related factors such as rainfall. Limited information about the processes of natural variation and problems associated with monitoring and measurement leads to adverse selection and moral hazard problems (Braden and Segerson 1993; Shortle and Dunn 1986; Segerson 1988). Moreover, although point-diffuse trading programs have been implemented in the United States, little research has focused on how these programs will be enforced. This study extended the body of knowledge to include empirical factors.

Both the Interim Report and the Evaluation of the Round One programs recognize the importance of enforcement in a market-based mechanism, acknowledging that “[a] necessary condition for the effective implementation of MBIs is adequate monitoring and enforcement” (Grafton 2005, p. 8). Nevertheless, it appears that none of the Round One projects addressed how these programs will be enforced, or, more importantly, recognizes how various enforcement strategies may affect compliance decisions or the performance of the market.

The project’s objective was to address the gap by using the tools of experimental economics to design and test enforcement strategies for market-based mechanisms. The project achieved its objective, answered an extensive array of important enforcement and regulatory questions, and provided important insights for policy makers in the design of enforcement and regulation procedures for MBIs.

Achievement against M and E Framework

One of the key objectives of the National Action Plan is to improve the governance framework with regard to property rights and regulatory reforms for water and land use. It is recognised that necessary conditions for the implementations of MBIs are the enforcement of targets and monitoring the actions of major stakeholders. In light of this, the primary knowledge gaps this project addressed were the problem of enforcing MBIs and the feasibility of trade between point and nonpoint sources.

An extensive review of the literature on enforcement and regulation of market based mechanisms combined with consultations with industry stakeholders produced five key questions:

1. Can the Murphy and Stranlund (2006) study be extended using Lockyer Valley data?
2. What are the consequences of moving the liability of diffuse compliance between point and diffuse source firms?
3. What are the consequences of having group responsibility for an aggregate emissions target (in terms of a group tax or subsidy) on compliance levels?
4. Should the probability of audit be common knowledge in point-diffuse trading programs?
5. What are the consequences of having individual pollution levels visible to the group?

Each of these questions was explored experimentally using specialised software, instruction sets and quizzes specifically developed for the question at hand¹. The experiments were conducted using standard experimental protocols at the Griffith University Experimental Economics Laboratory.

Can the Murphy and Stranlund (2006) study be extended using Lockyer Valley data?

Biophysical and economic data on the Lockyer Creek catchment collected and developed jointly with MBI project R2 -46 has been used to generate models of total suspended solids (TSS) to serve as a proxy measure of water quality. These models have provided the basis for a series of contextualized experiments that extend the work of Murphy and Stranlund (2006). This research examined the relationship between firms' production decisions that result in pollution emissions and firms' holdings of pollution permits. The basic experimental design is presented in Table 1.

Table 1. Experimental Design: Murphy and Stranlund Experiments.

¹ A comprehensive report and copies of instructions and quizzes used in the experiments can be found in Appendix A and B.

| Option | Treatment level | Probability | Sessions |
|--------|--------------------|-------------|---------------------------|
| 1 | Medium (π_H) | 0.70 | 3 sessions (15 rounds) |
| | Medium (π_L) | 0.35 | 3 sessions (15 rounds) |
| 2 | Medium (π_H) | 0.70 | 3 sessions (15 rounds) |
| | Medium (π_L) | 0.35 | 3 sessions (15 rounds) |

The results of stylized market experiments were compared with the predictions of theoretical models. The main results of this research include the finding that although increased enforcement does lead to a higher level of compliance (permit holdings that match pollution emissions), this effect is partly offset by the effect of market prices.

Although a number of options were considered for designing contextualized experiments for the Lockyer based on the work of Murphy and Stranlund (2006), two main alternatives were chosen for further study. These options provide experimental models that can be used as a basis for examining alternative monitoring and enforcement strategies for market-based instruments. These options also enabled alternative software packages for replicating the basic model of Murphy and Stranlund (2006) to be compared.

Option 1 requires farmers to hold permits to farm the riparian buffer zone. Model results for the Lockyer were programmed into the original software used by Murphy and Stranlund (2006) and experimental sessions were conducted that replicated their Median (π_H), Median (π_L), and Low treatments². Examination of experimental results provides guidance for ongoing research, although a number of operational difficulties were evident with the original software. As a result, this option has since been programmed into TESS, a more sophisticated software package developed at Griffith University.

Option 2 is a model of riparian re-vegetation that allows farmers to produce units of vegetation which can then be traded in a market. Farmers can minimize the costs of riparian rehabilitation by purchasing units in the market and other farmers, with lower marginal costs, can profit by selling units surplus to their needs in the market. The number of replicates conducted with this option enabled a mixed model analysis comparing the enforcement strategies Median (π_H) and Median (π_L). The results of this analysis concur with conclusions drawn by Murphy and Stranlund (2006). The results of these pilot experiments

² The Median (π_H) and Median (π_L) treatments had equal expected values of the fine. However, Median (π_H) consisted of a high probability of audit and low penalty while, Median (π_L) consisted of a low probability of audit and high penalty. The Low treatment was both a low probability of audit and low penalty.

and preliminary data analysis have also indicated additional fruitful areas for the ongoing research project.

The key findings of these experiments were:

- Price volatility is much lower when auditing is certain compared to when the audit is random.
- Compliance becomes financially viable for some emitters with trade than would have been possible without trade.
- Price volatility is much lower when the probability of an audit is certain than when the audit is stochastic.
- In this monitoring and enforcement model, the effect of any increase in enforcement is mediated via an effect on market prices (Murphy and Stranlund, 2006).
- The monitoring and enforcement strategy combined with alternative institutional arrangements may exacerbate problems associated with price volatility.

The implications of these findings include:

- The issue of price stability is important for a number of reasons.
- Price stability encourages investment in R & D and new abatement technology (Cason and Gangadharan, 2006).
- Price stability has also been identified as a particular problem when introducing new permit markets.
- Anderson and Sutinen (2006) identified high levels of price volatility as one reason markets may fail to equilibrate and is one reason that stakeholders may be averse to new market-based instruments.
- This emphasizes the importance of good institutional design.

What are the consequences of moving the liability of diffuse compliance between point and diffuse source firms?

The stochastic variability of non-point pollution outcomes is an important aspect of diffuse source management. Liability for actual emission levels may well impact on the performance of such markets and the decisions to participate in emission reduction activities. To answer this question, a series of experimental market designs were employed. The decision to produce emission reduction credits is assumed to occur prior to trade. Realisation of actual emissions is likely to occur at some time in the future. Unless the agency and so society in general is prepared to accept liability of differentials between notional and actual reductions then the liability must be realised by one of the trading parties. Following trade, reconciliation occurs. This was explored with and without the option to bank credits and with and without a secondary market, as shown in Table 2.

Table 2. Experimental Design: Liability experiments.

| Liability | Decision, reconciliation, compliance | Decision, trade, compliance with banking | Decision, primary market, reconciliation, secondary market, compliance with banking |
|-------------------|---|---|--|
| Point Sources | 3 sessions 12 rounds | 3 sessions 12 rounds | 3 sessions 24 rounds |
| Non-point Sources | 3 sessions 12 rounds | 3 sessions 12 rounds | 3 sessions 24 rounds |

The extent of variability is important. To explore the sensitivity of the outcomes a range of variability (low and high) were used³. Low variability involved a range of 0.8 to 1.2 and high a range of 0.2 to 1.8 multipliers for stochastic variation between actions and realized outcomes.

The data from this series of experimentation were analyzed in terms of aggregate compliance and market activity. The key findings of the experimentation were:

- Aggregate compliance
 - There is a significant difference in aggregate compliance between having point and non-point source producers liable for differentials in emission reductions.
 - Fewer credits are produced when non-point sources are liable.
 - Non-point players opt to produce more traditional crops when faced with high variability of credit return from less profitable crops, irrespective of whether they were liable or not.
- Market activity
 - The trade income for non-point sources is dependent on the liability rules, variation in credit production and their ability to bank.
 - The trade income for point sources depends primarily on banking. When nonpoint source pollution players can bank credits, point sources earn less income from trade.

Table 3. Experimental Design: Liability experiments with stochastic variation.

| Liability | Low stochastic variation | High stochastic variation |
|------------------|---------------------------------|----------------------------------|
|------------------|---------------------------------|----------------------------------|

³ In certain treatments (see Table 3), participants were subject to variation between their actions and realized outcomes.

| | Compliance | Compliance with banking | Compliance | Compliance with banking |
|-------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Point sources | 3 sessions 12 rounds | 3 sessions 12 rounds | 3 sessions 12 rounds | 3 sessions 12 rounds |
| Non-point Sources | 3 sessions 12 rounds | 3 sessions 12 rounds | 3 sessions 12 rounds | 3 sessions 12 rounds |

The implications of these findings include:

- Placing the liability of stochastic variation with the producer (non-point polluter) would be assumed to be a simple solution.
- The experimental results, however, suggest that it results in fewer credits being produced and so lower aggregate reductions in emissions than when the point sources are liable.
- Banking plays an important role in trade. When players are able to bank credits they are able to spread the liability over time.

What are the consequences of having group responsibility for an aggregate emissions target (in terms of a group tax or subsidy) on compliance levels?

In dealing with diffuse pollution problems, monitoring the actions of individual firms is often difficult or simply cost prohibitive. In most cases only ambient pollution levels are observable and the actions of individual polluters cannot be inferred because ambient pollution is highly variable. As a result, firms choose a lower than optimal level of abatement because of moral hazard problems. Solutions suggested in the literature include the imposition of various tax/benefit schemes based on ambient pollution levels; individual contracts and collective and random fining; combined individual and collective penalty systems, and options for self reporting.

In answering the question, ‘What are the consequences of having group responsibility for an aggregate emissions target (in terms of a group tax or subsidy) on compliance levels?’, the project explored the options of both a pure ambient fine system and a Segerson-inspired (1988) ambient tax/subsidy scheme as shown in Table 4.

Table 4. Individual and group penalty system

| Trade | Individual random fining | Group ambient fine | Two-fine System |
|----------|--------------------------|-------------------------|-------------------------|
| No Trade | 4 sessions 20 rounds | 4 sessions 20 rounds | 4 sessions 20 rounds |
| Trade | 4 sessions 20 rounds | 4 sessions 20 rounds | 4 sessions 20 rounds |

| Trade | Two-fine System with exclusion | Group system subsidy/tax |
|----------|--------------------------------|--------------------------|
| No Trade | 4 sessions 20 rounds | 4 sessions 20 rounds |
| Trade | 4 sessions 20 rounds | 4 sessions 20 rounds |

The data from this series of experimentation were analyzed in terms of aggregate and individual compliance, net cost and market activity. The key findings of the experimentation were:

- Aggregate Compliance
 - Individual random auditing produces a lower level of aggregate compliance compared to a group ambient fine.
 - A two-fine system produces higher aggregate compliance compared to individual random auditing without trade. With trade, they produce the same level of aggregate compliance.
 - Two-fine systems and group ambient fining do not produce significantly different levels of aggregate compliance.
- Individual Compliance
 - Two-fine auditing maximized individual compliance in terms of the proportion of players meeting their individual targets with and without trade.
 - Group ambient fining did not produce a significant difference in individual compliance compared to individual random auditing.
- Net Cost Analysis
 - The expected fine of each auditing system was equal
 - Individual random auditing resulted in lower fines being imposed compared to the group ambient fine or two fine systems.

- The group ambient fine or two fine systems were not significantly different in terms of total fines paid.
- Market Activity
 - Trading under the threat of a group fine produced lower average market prices for emission credits, compared to trade under an individual random audit system.
 - Trading under the threat of a group fine produced higher average traded quantities of emission credits compared to trade under an individual random audit system.

Should the probability of audit be common knowledge in point-diffuse trading programs?

The literature on enforcement and regulation generally assumes that the monitoring probability is known to firms, and that this information is used by firms as they make their compliance choices. However, in most field situations firms are not told the monitoring probability. The question here is whether the regulatory authority should release the probability of audit. To explore that question an experimental design as shown in Table 5 was developed.

Table 5. Experimental Design for Unknown Probability of Audit Experiments

| PROBABILITY OF AUDIT | UNKNOWN PROBABILITY OF AUDIT |
|----------------------|------------------------------|
| 20% | 3 SESSIONS 15 ROUNDS |
| 80% | 3 SESSIONS 15 ROUNDS |

An important determinant of how people react to unknown probabilities of audit is their risk preference. It is commonly assumed in the economic theory of monitoring and enforcement that people are risk neutral. To explore this important assumption, a variety of risk preference measurements were undertaken prior to each experiment. A brief description of each of the measurement instruments is given in Table 6.

Table 6. Risk Preference Measurements

| Method | Description |
|--------|-------------|
|--------|-------------|

| | |
|-------------------------|--|
| Paired lottery choices | Based on Holt and Laury (2002) this procedure measures risk preferences over potential gains inferred using the crossover point between two lists of paired binary lotteries |
| Probability equivalence | Probability equivalence methods were used to measure preferences under conditions of risk and ambiguity over potential gains |
| Certainty equivalence | Certainty equivalence methods were used to measure preferences under conditions of risk and ambiguity over both potential gains and losses |
| Likert scale | A Likert scale was used to measure preferences on an 11 point scale from “unwilling to take risks” to “fully prepared to take risks” |

The data from this series of experimentation were analyzed in terms of aggregate and individual compliance, expected probability⁴ and market activity. The key findings of the experimentation were:

- As subjects expectations regarding the probability of audit converge to the actual probability of audit, their compliance choices follow.
- Only some measurements of preferences are useful guides for compliance choices.
- Expectations evolve over time to converge with the actual probability of audit.
- Trade may interact to affect the convergence of expectations regarding the probability of audit to the actual probability of audit.
- The test suggested in the literature for determining whether or not to communicate the probability of an audit to firms is recommended for the medium term.

In terms of risk preferences it was found that the measurement procedures reveal that different numbers of subjects are categorized as risk-preferring, risk-neutral or risk-averse depending on the measurement procedure used. As discussed above, this is one of the main reasons for using a selection of measurement procedures. Because a standardized procedure for measuring risk preferences has not been established for use in experimental economics, any single procedure cannot be relied upon. Therefore, it was important to use a several different procedures for measuring risk preferences. This also had the advantage that preferences can be measured by an item that matches the framing of other experimental decision tasks.

Although the results vary depending on the particular measurement of risk preferences used, these results demonstrate that the assumption of risk neutrality has questionable validity. Further experimentation on risk preferences and the consequences of having

⁴ Subjects were asked to estimate what they believed the probability of audit to be. Their expectation of audit was then able to be compared to their compliance decision.

predominately risk averse or risk preferring participants in an MBI program definitely warrants further investigation.

What are the consequences of having individual pollution levels visible to the group?

While the regulating authority is only able to observe individual actions through random audits, in small and regional catchments it is likely that farmers will be able to observe other farm activities more easily. Observing others undertaking actions to reduce group pollution levels or free riding on the actions of others is likely to impact on (a) the willingness of farmers to undertake actions and (b) the willingness of farmers to trade with those who do not undertake remediation actions. The ability of farmers to observe others was incorporated into the experimental setting through an actions table. The ability of farmers to choose who they traded with was investigated using a posted offer market environment. To explore this in the laboratory, a series of experiments was designed as shown in Table 7.

Table 7. Posted offer Market with individual information

| POSTED – OFFER TRADE IN EMISSION CREDITS | GROUP REPORTING | AUTHORITY REPORTING |
|---|-------------------------|----------------------------|
| NO TRADE | 4 SESSIONS 15 ROUNDS | 4 SESSIONS 15 ROUNDS |
| TRADE | 4 SESSIONS 15 ROUNDS | 4 SESSIONS 15 ROUNDS |

The results were analysed in terms of aggregate compliance and trade. The key findings are:

- Group awareness of individual contributions does not change aggregate actions of the group.
- Market prices of offers to posted-offer markets significantly increases (as a form of retribution) when individual contributions are observable.
- Those who did not contribute ‘fairly’ to the group target are less successful in trade in posted offer markets to the financial detriment of all.

A possible interpretation of these results is that players who do contribute ‘fairly’ and see others not meeting their share take retribution not by reducing their production but rather increasing the price of their offers and so the cost of buying credits.

In conclusion, to successfully meet our research aims within the 18 month period of the project has required a substantial undertaking in terms of developing research questions and methods, developing software and conducting experiments at Griffith University. Five key questions concerning the enforcement and regulation of market based instruments were selected as a result of an intensive literature review and in-depth consultation with industry stakeholders, both at the government and firm levels. The results of the experiments have many significant implications for market based instruments. Yet this research has only

investigated a fraction of the many issues raised by the question of how to effectively enforce and regulate market based instruments.

Communication

In accordance with the communication strategy the project conducted a series of industry and stakeholder workshops and is in the process of preparing conference presentations and journal articles. Our communication strategy included:

- Lockyer data collection and methodology
- Lockyer and Monitoring and Enforcement experimental designs
- Landholder experimental demonstration⁵
- Stakeholder experimental demonstration
- Final industry workshop to present final report.

The communication strategy adopted proved to be highly successful with workshops being held at key points in the decision and/or information stages. These workshops not only provided stakeholders with an overview of our progress and findings but allowed these stakeholders to contribute their ideas and comments to the research.

In particular, the landholder and stakeholder experimental demonstrations gave participants a 'hands on' insight into how market based instruments may function and proved to be a highly successful method to convey our research and its implications.

The implications of this research have significance at a number of levels and therefore, require exposure at the local, state, federal and international level. In order to provide this exposure, the future communication of this research will be via a number of approaches at varying levels, including:

- Presentation to the Scientific Advisory Panel, SEQ Healthy Waterways Partnership.
- Presentation at the International Ecological Economics Society Conference.
- Presentation at the 11th International RiverSymposium.
- Preparation and submission of journal articles for publication.
- Meetings with key State and Federal agencies

Implications

In summary, the policy implications of the research are:

⁵ This workshop was conducted with the great assistance of GrowCom (an industry advisory organisation)

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1. Trade has the potential to increase compliance with environmental targets. Compliance becomes financially viable for some emitters with trade than would have been possible without trade.
 2. Increased enforcement may be mediated via market prices rather than increased compliance.
 3. It is important to consider who is liable for variations in emissions. Fewer credits are produced when non-point sources are liable for stochastic variation in realised emission levels compared to situations where point sources are liable, or there is high variation between nominal and actual emission levels.
 4. Two-fine auditing systems may be superior to simple individual random audit system without trade. With MBIs, trade may overcome the need for group ambient fines for common pool resource damages.
 5. Community awareness of non-compliance may inhibit trade and lead to strategic pricing in retaliation to a lack of contribution by others to solving a common pool resource problem.
 6. If the probability of audit is low then it is not advisable to make it public. If the probability of audit is high this research found that making it common knowledge would increase compliance. In the long term, firms' expectations are likely to match the actual probability of audit.
 7. Auditing and regulating MBIs is important. No or low probability of audit is likely to result in ineffective schemes.

Conclusions and recommendations

The project's aims and objectives were completed and exceeded. A well thought through and implemented plan of engagement with industry and key stakeholders at vital points in the project has greatly contributed to this success. These workshops aided the project at every stage – collecting data from the focus catchment, for feedback on the literature review and the development of the research questions, and as experimentation progressed. A final workshop is scheduled to present the findings and policy implications of the research to industry stakeholders.

The objective of the project was to explore how the simple point source enforcement and regulation model of Murphy and Stranlund could be extended to non-point situations. The project has done this and has also explored several other important non-point enforcement and regulation issues. These include the consequences of varying the liability for stochastic diffuse source pollution; the nature of preferences, risk and uncertainty and their influence on compliance decisions; a variety of enforcement schemes for ambient pollution; and the important interplay of audit probabilities and disclosure; all with and without trade.

The issue of enforcement and compliance in market based instruments is vitally important. Without well crafted enforcement and regulation schemes MBIs are likely to fail. The nature of natural resource management often involves common pool resources and diffuse sources with negative externalities and benefits. Regulation and enforcement becomes more difficult in such situations. This 18 month project has but just begun to explore the issue of enforcement and regulation of market based instruments. Further research is required to develop and test enforcement and regulation schemes across the variety of natural resource markets that exist and could evolve as MBI schemes in Australia mature. Auditing and regulating MBIs is central to the success of every MBI. A zero or low probability of audit is likely to result in ineffective schemes and no incentive to trade. It is critical that enforcement and regulation issues be considered explicitly for any MBI.

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