ISSN 0819-2642
ISBN 0 7340 2547 5


**THE UNIVERSITY OF MELBOURNE**

DEPARTMENT OF ECONOMICS

RESEARCH PAPER NUMBER 891

DECEMBER 2003

# MISSING ENVIRONMENTAL MARKETS AND THE DESIGN OF "MARKET BASED INSTRUMENTS"

by

Peter Bardsley

Department of Economics
The University of Melbourne
Melbourne Victoria 3010
Australia.

# Missing Environmental Markets and the Design of "Market Based Instruments"

**Peter Bardsley**
**The University of Melbourne**

## Abstract

*Market failure is pervasive in the environmental sector, and naturally occurring markets are, in many cases, unlikely to produce socially optimal environmental outcomes. Despite this, the case for using "market based instruments" has recently become popular in the Australian environmental policy debate. The purpose of this paper is to survey some of the broad issues that arise in this debate. What do we mean by market based instruments, and what is the conceptual foundation for their use? What contribution can they make to Australian environmental policy? What needs to be done to improve policy development and implementation, in order to use these new instruments effectively?*

## Introduction

The term "market based instruments[1]" has recently become popular in the Australian environmental policy debate. While recognising that market failure is pervasive in the environmental sector, so that naturally occurring markets are unlikely to produce socially optimal outcomes, the idea is that often "market like" instruments may still have a valuable role to play. This thesis is in contrast, on the one hand, to centralised regulatory approaches of the "command and control" type, and on the other hand to totally decentralised policies that rely on voluntarism and untargeted subsidies. Sometimes, paying careful attention to incentives and information constraints, it may be possible effectively to decentralise intervention in a way that gains at least some of the benefits that are associated with well working markets. If this can be done then there may be significant benefits in efficiency, in practical implementability, and in the ultimate delivery of environmental outcomes.

From a more conceptual point of view, the issue at stake is the optimal design of institutions in imperfect information environments. Instead of using an "off the shelf" policy instrument, one may try to design one that is tailor-made to the problem at hand. Sometimes we may end up with something that looks like a standard regulatory approach; sometimes it may look quite like a market or an auction; sometimes it may look different to either. The outcome, or the form of the instrument, should not be pre-judged: it should emerge from the actual situation, the policy problem, and the analysis. There are new tools in economic theory (mechanism design) and in experimental economics that have enhanced our capacity to do this kind of economic design. These tools have been used with great success in other parts of the economy (see McMillan 2003, Milgrom 2003, Roth 2002). It is now time to find out what they can do for the environment.

[1] This term is somewhat unfortunate, but it seems to have become embedded in the Australian policy debate.

The purpose of this paper is to survey some of the broad issues that arise in the debate on "market based instruments" and to consider what needs to be done to improve policy development and implementation.

## Back to some basic theory

It is useful, as always, to go back to the fundamental theory of welfare economics and market failure. Speaking in broad terms, we know that, in the absence of non-convexities, if we have a complete set of markets then these markets will deliver a Pareto optimal outcome, and that any efficient outcome can be decentralised in this way. If we put aside the question of non-convexity (for example natural monopolies) then market failure is generically associated with the lack of a full set of markets. For example, in the case of Coase's famous example (Coase 1960) of the smoking factory next to the laundry, there is no market for smoke.

If one asks why such a market might not exist, then the most common answer is probably "transaction costs." However this term is really too vague, and too imprecise, to be very useful. One of the lessons that we have learned about transaction costs is that it is asymmetric information that is very often the root cause of market failure. It is dangerous to do business with somebody if you are at an informational disadvantage; special contractual arrangements may be required[2], or in their absence markets may not exist at all. To understand such market failure it is necessary to be specific. What is the cause: is it information or something else? If it is information, is the problem hidden action, hidden knowledge, or some combination of the two? It is necessary to be specific, because the policy implications are different. In particular, the so-called Coase Theorem need not hold if the transaction costs are due to asymmetric information (Farrell 1987, Maileth and Postlewaite 1990).

## Designing policy

How should we proceed in an environment in which standard market mechanisms will not work? To be more specific, how should we proceed if our analysis leads us to conclude that an information related market failure is at the heart of the problem?

The first and most natural observation to make is that the mere recognition that an informational defect is at the root of the policy problem may in itself be very useful. A direct attack on the information issue may be possible. Policy design, especially in the environmental area, is always a multidisciplinary affair. Environmental policy problems arise because of the interaction of complex biological systems and complex economic systems. Economists, scientists and other professionals must work together on such problems. It may be useful for economists to emphasise to scientists that an informational problem is at the heart of the policy problem. This insight is not likely to be apparent to scientists unless it is pointed out, yet it is the scientists who may be able to do something about it. Technological innovations, for example in the areas of remote sensing, information processing, and the application of landscape scale biophysical models may, if applied creatively, transform the nature of the policy problem. At the very least, scientists should be aware of the informational constraints to policy and of the value of addressing such constraints in their scientific research programs.

[2] The principal-agent literature deals with such arrangements.

Even if we cannot correct or mitigate the information problem directly, we may attempt to design policies that are optimal subject to these informational constraints. There is now an enormous literature on how to do this. Recent texts include Laffont and Martimort 2002, Milgrom 2003, and Salanie 1997, 2002, and recent survey articles include Roth 2002 and McMillan 2003. The key concepts that arise include incentive compatibility, the minimisation of information rents, the optimal allocation of risk in Principal-Agent problems, credible policy commitment and the intertemporal consistency of policy. The typical institutional designs that emerge from this approach include auctions of various kinds, market matching algorithms, non-linear pricing, incentive contracts, menu-based self selection mechanisms, and various hybrids of these. Because there is such a rich body of theory behind these methods, there is a much richer array of policy instruments to work with than is available under traditional command and control approaches. These traditional instruments (quotas, taxes, direct regulation, redesign of property rights …) are of course still available to the policy maker, and may indeed emerge as the optimal instrument in some cases. One of the strengths of the optimal design approach to policy making is that it is based on an in-depth, case-by-case study of each policy problem. In this hand-made approach to policy design, as opposed to an off-the-shelf approach, there is a greater likelihood that there will be a good match between policy and the problem. Another of its strengths is that feasible implementation is built in from the beginning as a design consideration.

In practice, policy making is much messier than this. There is rarely a perfect match between the policy issue and the textbook model. However, by starting with a rich conceptual framework we are in a much better position to find a good practical solution. Furthermore, we must be prepared for second best solutions. For example, many environmental goods have the nature of public goods, and we know that there are no markets to aggregate consumer preferences for these goods. However we do have political markets, which may act as a proxy. We know that voting over public goods may not be optimal (it reflects the preferences of the median rather than the average voter; and once we introduce multiple issues the situation is even less clear), but it may be a good start to work with the policy preferences that emerge through political institutions and political processes.

A second example where a partial solution may be worthwhile occurs where market failure affects only one side of the market. Consider again the case of a public good. Even if there is no effective market to aggregate demand, so that demand must be estimated subjectively or through contingent valuation methods, it may still be valuable to create mechanisms for efficient supply. The literature on efficient procurement is relevant here (see Laffont and Tirole 1993). This ensures at least that the good is produced at minimum cost. It also ensures that the cost of the good is made explicit, as well as clarifying the implicit tradeoffs that are being made. These tradeoffs may usefully be fed back into the decision making process, even if at an informal level.

Finally, while theory provides the starting point for market design, it is by now a well established principle that a program of experimental testing is a key step in the process from design to implementation.

## Markets for biodiversity

As an example of how the modern instruments of market design are being used to create new environmental policy instruments, I would like to consider the Bush Tender habitat procurement auctions that have been developed and trialled by the Victorian Government. I will not discuss these auctions in detail (see Stoneham et al 2003 for a full account). Rather I will focus on the conceptual framework and how it was developed.

The policy problem to be addressed was how to preserve and manage areas of remnant habitat in the Victorian agricultural landscape. These small, widely scattered areas have survived the process of wholesale agricultural development largely by accident. Because they are the last remnants of what were once widespread ecological systems, they are a valuable biodiversity resource. Being on private land, their management poses difficult problems.

Preservation of remnant habitat is to a very large extent a pure public good. It enhances the survival probability of species and ecological systems whose existence is valued by society. Individual landowners thus have inadequate incentives to protect these assets, because of their public good nature, even though to do so provides an economically valuable service. Of course some landholders derive private value, some of which may be altruistic, from such actions; even so, this value will not include the full economic or social value of the public good. In principle, landowners could specialise in managing biodiversity and sell this service, in exactly the same way that they produce and sell crops and livestock products. However there is no market for biodiversity preservation, and in the absence of such a market these economic gains will not be realised. Bush Tender is an attempt to fill this gap.

There are clear reasons, on both the supply and demand side, why markets for biodiversity preservation do not exist[3]. On the demand side, the standard arguments about free-riding apply, and they are sufficient to show that there will be no effective expression of demand. However, as noted above, this does not mean that there is no role for policy. In the first place, there are political markets and institutions that act as proxy markets in which demand for environmental services may be expressed. These markets may be imperfect, but they are a starting point. In the second place, even if demand is not expressed perfectly, it is worthwhile to ensure that environmental services are provided at minimum cost. This may be achieved if the supply side of the market is working properly.

Bush Tender is concerned almost wholly with this supply side of the market, not with demand. We assume that the government demands these goods on the part of the public, and we do not inquire whether the level of this demand is or is not optimal. The problem is then to ensure the efficient procurement of public goods (Laffont and Tirole 1993). In principle, the government announces that it wishes to fund small scale localised projects, typically undertaken by a single landowner or by several cooperating landowners to protect or rehabilitate an area of remnant habitat. The aim of the government is to acquire, at minimum cost, the optimal portfolio of projects.

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[3] There is some private provision of this public good, and some market activity associated with this provision (for example, the purchase of habitat by birding groups). However this does not mean that there are properly working markets in which biodiversity preservation receives its true economic value.

Information effects stand out as the major impediments to efficient supply of such services. Three such effects may be identified.

In the first place, the value of the services is imperfectly known. Some habitat is extremely valuable; some less so, either because it is degraded or because there are good substitutes. To a large extent, this ignorance is symmetric. Neither the seller (the landholder) nor the buyer (the government) is well informed. On the part of the landholder, this is because of a lack of technical knowledge; on the part of the government, it is because the information is scattered in many diverse locations. Remedying this lack of knowledge is inevitably expensive. Whether it is too expensive is ultimately an empirical matter; assessing this is one of the reasons for running a series of field trials. The cost of learning the value of these potential services that could be purchased depends on the scientific and technical framework that is available.

Good science and good information engineering has been enormously important in the Bush Tender project, as has been close teamwork between scientists and economists. The main elements of this framework have been as follows. Ecologists have created a methodology for assessing and scoring the value of habitat at minimum cost. This assessment requires a visit by a trained field officer, so it is expensive. The cost can be reduced by targeting effort through the use of landscape databases, remote sensing, biophysical models and other ways of making a preliminary low-cost assessment, and by an education process that encourages landholders to come forward with high value proposals.

In so far as this is a search process to discover value enhancing trades, both sides of the market benefit, and we might hope that neither side should have a major incentive to hide or distort information. However there is the potential to run into problems of this kind. If a landholder knows or fears that an endangered species will be found on their land, then they may worry that the government will expropriate their property, either directly or by vigorous enforcement of regulatory frameworks that usually lie dormant for lack of information. On the other hand, the government may fear that a landholder may hold it hostage, attempting to expropriate the full value of the discovery by a threat to destroy it. In this situation the government may be tempted to conceal the value of what has been found.

We encounter here some issues that are pervasive in problems of this kind. The first is the question of how the gains from trade are to be shared. At the very least, the government must be able to meet a participation constraint. Participants must not be made worse off (for example by the risk of expropriation) by participating. This leads into the second issue. The government must be able to credibly commit to this position. In the process of searching for trades, or later in contracting for the supply of services, new information will inevitably come to light. If the government cannot commit not to take advantage of this and not to exploit the landholder by renegotiating when this new information comes to light, then the initial gains from trade may be seriously eroded. Either the landholder may not participate in the first place, or may do so only at a very high price. This issue becomes especially important when we come to repeated contracts and long term relationships. To some extent these problems arise and must be dealt with in the formal structure of the policy mechanism. But there is also an important cultural component of trust and respect that must not be lost sight of.

Once the value of the environmental service becomes apparent, a second information problem arises, due to asymmetric information about costs. Some components of the cost (for example the value of materials) may be readily apparent, but some components (for example the value of the resource in alternative use) will be private information. In any bilateral contracting with the government, the landholder has an incentive to overstate this private cost. This problem is well understood, at least in principle (see for example Laffont and Tirole 1993), and it is known that auctions, of one form or another, perform well in this situation. A discriminating price closed bid auction (a "Treasury Bill auction"; see Menezes and Monteiro 1995) is used to induce competition and honest bidding by landholders.

A third, quite serious information problem now arises. This is the problem of monitoring whether the agreed actions have in fact been carried out. This hidden action problem, commonly called "moral hazard" (a term from the insurance literature), is also well understood (see Salanie 1997), at least in principle. It can be addressed through careful attention to contract design, and through the clever use of technology. We know that the optimal contract must focus on the ultimate objective (the desired ecological outcome), even though this is difficult to measure, especially over the short term. We also know that it must take into account actions that are easier to monitor (for example erecting fences), which are connected to the final outcome in an indirect or instrumental way. We also know that, in order to provide appropriate incentives, the landowner must accept some responsibility for the final outcome, even though this outcome is risky and not entirely within his or her control. In practical terms, this means that the optimal contract will be balanced between paying for inputs and rewarding outputs, and that it will balance the need to provide incentives with the need to protect the landholder from carrying too much risk.

This seems a very difficult, perhaps impossible, task. However good science, and creative use of technology, can come to the rescue. Since defective information is the source of the contracting problem, a direct attack on the information issue can transform the contracting problem into one that is more tractable. The approach that is being explored is to provide landholders with digital cameras and to write into the contract a schedule of photo-points and photo dates, to create an effective monitoring regime. Files can be downloaded in digital form for evaluation and record keeping. This regime can be backed up through remote sensing technology and random site visits. While technology cannot provide complete information, it can greatly reduce the informational transaction costs and make feasible a richer array of contracting possibilities. One can go further. By photographing both treatment sites and control sites, it is possible to measure not only whether simple actions (say the erection of a fence) have taken place, but also to assess ecological outcomes (for example changes to vegetation cover relative to a control site). It may be possible to train landholders to perform more complex measuring tasks. This approach makes it feasible to reward outcomes as well as inputs. The proper use of control sites also allows one to compensate, to some degree, for seasonal effects, and thus to reduce the risk imposed on the landholder.

Stepping back from the formal analysis of auction design and contract theory, a very important part of this project is to transform the role of landholders from passive to active. Once a market of some sort is created, landholders can produce biodiversity services in the same way that they produce other commodities. They should be able to bring all their skills and intimate local knowledge to this task, once they learn how to do it. Centralised command and control cannot hope to achieve this.

Experience in the field (see Stoneham et al 2003) has confirmed that this approach seems to be workable. There is some evidence that the cost of procurement under this approach is very favourable in comparison to alternatives. There is also evidence that both field officers and landholders believe that it is working well. There are also benefits of a wider kind. The bidding schedule provides good information on the supply curve for these environmental services. With only an imperfect estimate of demand we cannot say with confidence that the equilibrium price in this market represents the marginal social value of these services (though it is arguably the best estimate available). However it does provide a good indication of the tradeoffs between various policies affecting some types of biodiversity preservation or destruction. For example it provides a shadow price for evaluating the cost of similar habitat destruction in activities such as forestry. It also provides a price signal to non-participating landholders of the true economic value of habitat and other resources for biodiversity preservation.

## The Murray-Darling Basin

As a second example of the role for "market based instruments" in environmental policy it is interesting to consider the case of the Murray-Darling. The riverine systems of the Murray-Darling Basin are one of Australia's great economic and environmental resources yet one of the most degraded and at risk. It has been recently asked what role market based instruments might play in the management of these rivers. More generally, what is the place for formal economic design in the management of this highly complex system?

It is interesting to consider, at least in outline, some of the broad parameters of the problem[4]. In a full analysis it would of course be important to start with a detailed understanding of historical relations and existing institutions before recommending how one might move towards an optimal set of arrangements – there is no attempt to do this here. But it is also quite informative to consider the issues from first principles, especially as some of the issues are different from those discussed above in relation to the Bush Tender project.

In discussing Bush Tender, we started with the demand side. We observed that although we are dealing with a public good, there are proxy political markets which give a measure, although imperfect, of demand. In the case of the Murray-Darling, the situation is much more complicated. From an economic decision making point of view, one of the most striking characteristics of the Murray-Darling problem is that it is an inter-jurisdictional one. Several state governments are involved, as well as the federal government. While there is undoubtedly a great deal of common ground in the objectives of these bodies, there is also scope for disagreement. Any institution[5] through which these bodies interact, either cooperatively or in rivalry, defines the rules of a game. Game theoretic tools and concepts can be used to analyse and evaluate the performance of such an institution from an economic perspective. Furthermore it is possible, using techniques from game theory and experimental

[4] I am indebted to Mark Eigenraam for some of the ideas in this section. See Eigenraam 1999, Eigenraam et al 2003.

[5] For example, the Murray Darling Basin Commission.

economics, to attempt to design optimal institutions[6]. Any "Market Based Instrument" approach to the management of the Murray Darling Basin should ideally start at this level. Reform at this level may be difficult or impossible, but it is necessary to understand the constraints under which one operates.

Still considering the demand side, we observe that we are dealing with a very complicated system, with complex externalities and interactions involving water, salt, river flow, and groundwater. These interactions involve biological, physical and economic systems. Even a superficial consideration of the complexity of the system suggests that a centralised command and control approach will probably achieve only a limited amount. It is important to note the water (and salt) are not ends in themselves. What matters are economically relevant outcomes. In particular, we are concerned with environmental outcomes. These outcomes may be to some extent localised (for example by their upstream or downstream location), and they are likely to be influenced in specific and nonlinear ways by river management (for example, by floods).

All this suggests that if "market based instruments" are to play an effective role then decentralised, active environmental managers will be required, with the power to trade actively in salt and water markets. The role of these managers is to express demand for environmental outcomes at a local level. These agents will need to have incentives that are closely aligned with those of the global river manager. In order to align incentives, information is extremely important. So once again we return to the importance of measurement, evaluation, monitoring, and the interpretation of outcomes through scientifically valid frameworks. The scientific infrastructure is in fact crucial. One way to think of this approach is that we would be bringing into the market artificial agents with specially designed environmental property rights to trade on behalf of the environment. The precise rules and incentive structures under which such a group of environmental managers might operate is again a question that can be addressed through the tools of market design and experimental economics.

The supply side is to some extent more straight-forward than in the Bush Tender example. In so far as the problem is one of river management, trading in water, river flows, and salt is likely to be the main mechanism to achieve environmental outcomes[7]. Thus the effective use of "market based instruments" depends on well working markets for water and salt. Existing water markets are imperfect and salt markets rudimentary. There may be very considerable environmental benefits from reform of these existing markets, provided that it is accompanied by the creation of agents who can trade on behalf of the environment.

The main role for economic design in managing this river system would seem to be in specifying the nature of the environmental managers who would trade on behalf of the environment. This means specifying the incentives of these agents (a problem in contract design), and the environment in which they operate (a problem in market design).

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[6] There is an enormous literature on mechanism design, which deals precisely with problems of this kind. For a survey of such institutional evaluation and design from the perspective of "the Economist as Engineer," see Roth 2002.

[7] It may also be desirable to engage in other activities, such as engineering works.

## What we need to do

Returning again to the basic principles of welfare economics, the standard recipe applies. The first step in the economic policy process is to analyse what is going on. Who are the agents? What are their decision variables? How much do they know, how much can they observe? What are their incentives?

The second step is diagnosis. Is there a market failure, or is the outcome optimal? If there is a market failure, what is its source? The fundamental theorems of welfare economics provide the basis for this diagnosis.

The third step is to find a remedy that addresses the source of the market failure.

So far, the process is classical, and it may be found in any text on public economics. The "market based instruments" or economic design approach suggests that, in searching for a remedy, we should not just take existing markets and institutions as we find them. By careful design we may be able to modify these institutions, or to create new markets and institutions, in such a way that we remedy some or all of the market failure. I would suggest that the Bush Tender habitat procurement auctions have attracted attention not so much for the particular application, but because they demonstrates a new approach to policy development with much wider scope for application.

Theory provides an indispensable road into this market design process. It provides the appropriate concepts, directs attention to the important issues, and it gives some general outline of what the optimal solution would look like. However it cannot provide a stand alone solution. A great deal of expert judgement is called for, and there is an equally indispensable role for experiments and pilot schemes.

It is very important that policy makers appreciate that market design is a process, and not be mislead by identifying it with the outcome in any particular case. Let us take for example the Bush Tender project, which has lead to something of a fashion for auctions. It is an error, but unfortunately one that can be made by unsophisticated policy makers without the appropriate conceptual background, to assume that the use of "market based instruments" just means the use of auctions. In the case of Bush Tender, an auction is indeed a key part of the policy package. However it is just one part – contract design and the integration of economic design with biophysical modelling are equally important – and it is a particular kind of auction, implemented in a particular way. In the case of the Murray-Darling Basin, which we also considered above, auctions may not play such a central role. Copying an auction without understanding the reasons for it, or the way that it is integrated with other instruments, can only lead to disappointment and bad policy. See Klemperer 2002a,b for some truly spectacular examples of policy disasters of this kind. Unfortunately, bad outcomes due to bad design can discredit the use of new instruments and new approaches. This would be unfortunate, since these new ideas may allow us to deliver much better environmental and economic outcomes.

Economists are well placed to explain to policy makers the nature of good policy, and to damp down unrealistic expectations. In particular, it is unrealistic to expect that new instruments can be developed and implemented very quickly, especially in such a complex area as environmental policy.

What then are the prerequisites for the application of economic design principles in environmental policy? The first is good theory. The toolkit of the traditionally trained agricultural economist or environmental economist probably needs to be updated. We

need people with training not just in price theory and classical welfare economics, but also in information economics, game theory, mechanism design, experimental economics and economic design. Meeting this need is an issue that should be addressed at the education and recruitment level. So far as I am aware, no Australian University offers a subject in Economic Design. It should also be addressed at the policy formation level. Policy makers should be aware that they may need to go beyond their traditional sources of advice.

The second prerequisite is good experimental economics, which goes hand in glove with good theory. Virtually the same remarks apply. In particular, so far as I am aware, no Australian University offers a subject in Experimental Economics.

The third prerequisite, which is clear on both theoretical grounds and in experience, is that there needs to be a close partnership between economists and environmental scientists. The ecological systems that we deal with are complex, and require sophisticated understanding and management. The economic systems are equally complex, especially with respect to decentralised decision making, incentives and information constraints. Economic design in the environmental area requires an integration of expertise in both areas.

The final prerequisite, which is perhaps implicit in the first three, is meticulous attention to detail. Given these prerequisites, "market based instruments" as implemented through a disciplined process of economic design, have an important role to play in environmental policy.

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