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A tradable emissions permit program for nitrogen in Lake Taupo

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Key points : Economists have often advocated the use of market mechanisms to control access to valuable natural resources on the grounds of economic efficiency. The equity implications of creating property rights and markets are less frequently raised. Yet an understanding of equity issues is critical to making informed social and political judgments about the merit of new property right systems. We discuss some of the critical wealth and equity issues involved in the setting of a water quality standard and the allocation of property rights in relation to that standard. The discussion is based on a proposed market in nitrogen emission permits in Lake Taupo, New Zealand which will include diffuse source emissions from pastoral agriculture. The setting of the water quality standard influences the distribution of adjustment costs between landholders and the rest of the community, while the allocation of emission permits influences the distribution of adjustment costs among landholders.

Key words : property rights, emission markets, diffuse source, resource policy

Introduction

Economists have long advocated for the use of market mechanisms to control access to valuable natural resources on the grounds of economic efficiency. However, the equity implications of constraining rights to natural resources through the creation of property rights and markets, and the equity implications of different methods of allocating rights, are canvassed much less frequently. Yet an understanding of the equity issues entailed in the creation of property rights and market mechanisms is critical to the making of informed social and political judgments about the merit of such markets. In this paper we discuss some of the critical issues in the design and allocation of property rights, in particular issues in relation to equity and the distribution of adjustment costs.

The market in emission permits that has been proposed for managing nitrogen emissions from agricultural land in the Lake Taupo region of the North Island of New Zealand provides the context for the discussion. The catchment of Lake Taupo includes pastoral grasslands that support sheep, cattle and dairying enterprises. Apart from agriculture, the other major industries in the region are tourism and forestry.

The proposed market is intended to be a mechanism which will facilitate structural adjustment within agriculture, and between agriculture and other sectors of the economy, such that nitrogen emissions are constrained to the assimilative capacity of the Lake as defined by current water quality targets (Environment Waikato 2003). The current water quality of Lake Taupo is excellent. Levels of the plant nutrients nitrogen and phosphorus in the lakewater are low, and as a result, so are the levels of the microscopic plants called "algae", whose growth the nutrients support. Because of this, the lakewater is clear and blue.

In 2005 a new policy to protect and maintain water quality in the Lake was proposed by the regional government (Environment Waikato) with legislative mandate for sustainable management of natural and physical resources including the ability to control land use to protect water quality. In the long-term, protecting lake water quality is achieved by preventing any increases to the existing loads of nitrogen to the lake. Two broad strategies for restricting any future increases in the nitrogen load to the Lake were:

- (a) To limit, or "cap" the loads from existing manageable sources (pastoral farming and human wastewater)
- (b) To reduce the current load from manageable sources so as to offset the load that is still to come from past land use practices. Scientific estimates have concluded 20 percent reduction in the manageable nitrogen load entering the lake is needed to maintain water quality.

Nitrogen enters the Lake by means of discharges into water or onto land where it reaches ground water and streams. Emissions from point sources such as community or individual sewage treatment and disposal systems are relatively easily monitored and, at least in principle, the quantity and nutrient concentration of these emissions can be controlled. Nitrogen emissions from diffuse sources cannot practically be measured directly. This means the actual contribution of a particular diffuse source such as an agricultural enterprise to the nitrogen emissions entering the Lake cannot be identified. As a general rule, the timing of emissions from diffuse sources cannot be controlled but the quantity of their nitrogen emissions can be controlled in the longer term. Consequently, actions taken to reduce nitrogen emissions from diffuse sources may only be detected as a trend change in the nitrogen load in Lake Taupo over a long time period.

The purpose of the market is to facilitate the transfer of allowable nitrogen emissions between alternative land uses over time in line with changes in economic conditions, and community and individual preferences. The case can be made, on both equity and economic efficiency grounds that the adjustments in land use that are needed to reduce nitrogen emissions to the target level should involve point and diffuse sources of nitrogen. The market in emission permits that is described here provides a

mechanism which would allow for the sharing of the requisite adjustment costs between point sources and diffuse sources of nitrogen . The type of market we describe here has the potential , in principle , to enable the water quality target for the Lake to be achieved with the least cost combination of abatement and other measures .

In creating a market in emission permits three critical issues must be understood and resolved . The first is the political and social issues involved in the setting of standards for water quality . In the next section we discuss property rights and wealth redistribution in relation to creating markets in emission permits . The second issue is the implications for the design of emission permits of the difficulty of measuring emissions from diffuse sources and the inability to control the timing of emissions from diffuse sources . Consequently , we then consider the design of the emission permits and the operation of the emissions market . The third issue to be understood and resolved is the distribution of adjustment costs between landholders . Hence , in the final section we consider the allocation of emission permits with a particular emphasis on the equity principles associated with different allocation methods .

Property rights in water quality

Establishing and enforcing water quality standards by constraining economic activities which generate nitrogen emissions necessarily involves restructuring the rights and obligations of individuals , which necessarily means redistributing wealth within the community . This restructuring and redistribution occurs irrespective of the mechanism that is used to enforce the standards , though the mechanism that is used will influence the precise nature of the restructuring of rights and the resulting redistribution of wealth .

The establishment of limits on nitrogen emissions in order to achieve a water quality standard requires that the existing structure of rights and obligations has become unacceptable to one or more persons or institutions in the community . The decision to proceed with placing limits on emissions requires a political judgement about the strength of public concern with the existing rights structure , and a political judgement about the public acceptability of any proposed changes to that structure .

Livestock farmers in the Taupo catchment discharge nitrogen into ground and surface waters through their agricultural activities . In principle , such emissions are prohibited under legislation governing the protection of natural resources (section 15 of the Resource Management Act 1991) . While point sources of nutrient have been regulated for decades , the late realisation of the connection between water quality in the Lake and diffuse nitrogen leaching under pastoral farms from stock urine patches meant development of grazing land in the catchment went unchecked . The discharge of nitrogen emissions by landholders is now in conflict with the rights that others in the community wish to exercise with regard to the quality of water in the Lake . Under the existing rights structure , these others were unable to obtain compensation for any diminution of the rights they wished to exercise as a result of the deterioration of water quality in the Lake . Hence , the unconstrained right of landholders to discharge nitrogen amounted to a presumptive privilege (Bromley 1991) . In other words , the right to discharge nitrogen took precedence over the rights of others where the two were in conflict without imposing any obligation on the part of dischargers to compensate others for their loss . This state of affairs may seem to have unfairly favoured dischargers but this is not the case as it simply reflects the fact that the right to discharge diffuse sources of nitrogen from farming enterprises had not been perceived to infringe on the rights or activities of others (Weingarten 2001) . It is only evident now that nitrogen emissions infringe on the rights of others and , as a consequence , the community wishes to restrict emissions .

The creation of a mechanism that establishes rights to water quality that prevail over the rights of landholders involves a substantial restructuring of the rights of individuals . If this restructuring of rights is to entail the creation of a market of some kind in nitrogen emissions , a prerequisite to the creation of that market is that the right to discharge nitrogen be an exclusive and enforceable right , that is , a property right . To be exclusive , the existing privilege that *all* individuals in the catchment currently possess to discharge nitrogen must be surrendered . Those individuals who are included in the subsequent allocation of rights to nitrogen emissions as a property right receive an exclusive right to a restricted level of emissions in exchange for surrendering their previously unrestricted privilege . Those individuals who are not included in the subsequent allocation of emission rights forfeit their right to nitrogen emissions . In the Taupo case , all individuals forfeit rights to engage in activities that create nitrogen emissions beyond their endowment of allocated emission rights . For farmers , this means in practical terms they will be restricted in the extent to which they can intensify their farms by increasing stocking rates . For foresters , this means in practical terms they will be prevented from converting their forestry enterprises to potentially more profitable dairying enterprises . In short , the creation of a market in rights to emissions involves the restructuring , in some form , of the emission rights of all individuals and constrains the set of economic opportunities available to them in the future (unless they acquire the required rights) .

The removal of the privileged status of the right to discharge nitrogen has further ramifications . The unrestricted right to discharge nitrogen was part of the parcel of rights attendant upon land ownership . To create rights to water quality which prevails over the previously unrestricted rights of landowners to discharge nitrogen implies that the attenuation of the parcel of rights attendant upon land ownership in this manner is justifiable . Consider , for example , that nitrogen emissions occur as the result of an agricultural enterprise operated by a landholder . In operating the enterprise the landholder exercises claims over a bundle of rights of which the right to discharge nitrogen is one (Coase 1960) . The ownership of land is the source of the

legitimacy of the landholder's claims over this bundle of rights. To the degree that the landholder is prevented from exercising claims over other rights in the bundle by the restriction of the right to discharge then the other rights that constitute the bundle are attenuated. This attenuation may take the form, for example, that the number of livestock is restricted. Hence, the proscription of unconstrained rights to discharge nitrogen involves an attenuation of property rights in rural land by restricting the uses which may be made of the land by the landowner.

The strictness of the standard that is set for water quality determines the extent to which emission rights will be constrained and the degree to which the bundle of property rights entailed in owning land will be attenuated. The stricter the standard, the greater the reduction of presumptive privilege in favour of rights with regard to water quality and the greater the attenuation of other rights in the bundle of rights attendant on land ownership. While the adoption of a quality standard may be thought to be a technical matter, it does in fact involve choices regarding the redistribution of rights and wealth between individuals. Importantly, the private and social costs imposed by declining water quality must be seen by the community to be an adequate justification for infringing the historical privilege of rural landholders to discharge nitrogen and for invoking changes in the management and use of rural land. Consequently, the setting of a water quality standard is not just a technical matter but also a matter for informed social choice.

Design of emission permits

Measurement of emissions A fundamental issue in designing tradable permit programs that incorporate emissions from diffuse source is the inability to accurately and cost effectively measure emissions over a whole property (Higson and Kaine 2004). An additional difficulty in regard to nitrogen emissions into Lake Taupo is the lag between land use activities and subsequent effects in the Lake. Much of the rain falling on the Taupo catchment is stored underground—in some cases for many years—before entering streams, and then the Lake. Hence, groundwater in the Taupo catchment contains nitrogen that was leached from land which has not yet entered tributary streams or the Lake. Hence, measurement of emissions of nitrogen from land in Taupo is not feasible and, furthermore, there is not a direct relationship between current emissions and current nitrogen concentrations in the Lake.

These two difficulties have three consequences. First, emissions from diffuse sources can only be estimated on the basis of land use factors that are associated with emissions, such as livestock numbers and type, grazed area, soil type and so on. Second, a market in tradable emission permits, like any other policy intervention, would have to operate independently of immediately observed changes in nitrogen concentrations in the Lake because such changes reflect emissions in the relatively distant past. Third, the volume of emissions that are permitted should change over time in response to new information on the relationships between the factors and emissions, and new information on the relationship between emissions and water quality in the Lake.

Consideration of these consequences resulted in the conclusion that nitrogen emission permits would be best described in terms of an imputation process embodied in a nutrient budget model. Hence, the cornerstone of the market is the Overseer[®] nutrient budgeting model for agricultural land uses (Wheeler et al 2003). By defining emission permits in terms of processes embodied in the nutrient model the difficulty of measuring actual nitrogen emissions is avoided and the measurement difficulties typically associated with diffuse source pollution are circumvented. Furthermore, as emissions are determined in the model on the basis of estimated relationships between emissions and farm characteristics, the model can be used to infer constraints on those characteristics which are inputs to agricultural production processes such as livestock numbers and types. This means that the nitrogen permits for a particular farm can also be expressed in terms of the contextual characteristics of that farm as well as units of nitrogen emissions. This has four advantages:

- Landholders can evaluate permits in terms of the economic value of the combinations of production inputs and management practices possession of the permit allows. This is consistent with Lancaster's product attribute theory (Antonelli 2004; Lancaster 1966; Lancaster 1971; Hoehn et al 2003);
- Monitoring of landholders' compliance by Environment Waikato as the regulatory authority is facilitated as inputs to agricultural production processes are measurable;
- Trades can be visualised in terms of familiar farm management measures which facilitates the exchange of emissions between landholders;
- Under the Resource Management Act, resource consents for emission permits that are expressed in terms of permissible combinations of inputs into agricultural production processes may be traded whereas consents for emissions permits defined as a polluting discharge into water cannot (Milne and Mooar 2002; Sharp 2002).

Actual emissions are linked to nitrogen concentrations in the Lake in two ways. First, as new knowledge is acquired about the relationship between farm characteristics and emissions then the nutrient model may be updated. As a consequence we would expect that over time estimated and actual emission will become more closely correlated.

Second, this new knowledge may result in revisions in the aggregate volume of nitrogen emissions that may be permitted to enter the Lake. Such revisions necessarily require a corresponding adjustment in the aggregate volume of estimated emissions that is allowed under the permits that have been issued. We would expect that over time the aggregate volume of estimated and

actual emission would become more closely aligned as information on the relationship between emissions and farm characteristics is accumulated .

Control over emissions Earlier we argued that the setting of a standard for water quality was probably the most important determinant of the distribution of adjustment costs between landholders and other members of the community . The time horizon over which the standard is to be achieved has a critical impact on the distribution through time of those costs . The limited control landholders can exert over nitrogen emissions effectively prevents them from substantially adjusting their emissions in the short term without making highly disruptive changes in their land management . Consequently , the more rapidly aggregate emissions must to be reduced in the short term to achieve the desired water quality , the greater the burden of adjustment costs will fall on landholders .

As nitrogen in the form of nitrate leaches from urine patches when high or prolonged rainfall causes water to drain through the soil , critical nitrogen management factors revolve around stock type and density and autumn and winter grazing management . At present measures for reducing diffuse emissions of nitrogen from agriculture in the Taupo catchment are limited . While technologies such as pasture treatments that slow nitrate leaching , pasture species that contain less nitrogen and livestock treatments that target critical leaching risks in autumn and winter are under investigation , none of these technologies have been proven in the field (Thorrold 2006) . Nitrogen fertiliser is little used by drystock farmers in the catchment . Consequently , major reductions in nitrogen emissions can only be achieved in farming at present by reducing stocking rates to levels that threaten the viability of farming enterprises . The case has been made that where those costs threaten the livelihood of landholders , other members of the community should at least partially compensate landholders for the adjustment costs incurred by them . The Resource Management Act (1991) requires Environment Waikato as the regulating authority to manage the use and development of land in the Lake catchment in a way , and at a rate , that enables people and communities to provide for their wellbeing while protecting the water quality fo the lake in the long term . Compensation for continued wellbeing could be made in a variety of ways such as using public money to purchase and retire land from agricultural production as suggested by Environment Waikato (2003) .

The period of time in which emission permits are denominated is , then , another fundamental issue in designing a market in tradable permits . On the one hand , permits should not be denominated in periods of time that are shorter than the rate at which at least some landholders can implement abatement actions . Otherwise landholders may find themselves contravening the conditions of their permits and lacking the practical capacity to comply with those conditions . On the other hand , permits should not be denominated in periods of time that are substantially longer than the rate at which most landholders can implement abatement actions . To do so would unnecessarily reduce the rate of transfer of emission permits between alternative land uses thereby reducing the efficiency of the market and imposing economic losses on the community . In addition , the aggregate volume of potential emissions authorised through the permits should change over time in accord with changes in the capacity of the environment to assimilate emissions .

With regard to Lake Taupo , the variations in the capacity of the Lake to assimilate nitrogen occur over a long time horizon even though there is substantial variability in the volume of emissions from land in the short term . The Lake is buffered from external shocks as nitrogen entering the Lake is estimated to cycle within the Lake for up to two decades before entering the Waikato River at Huka Falls which is the only outfall from the Lake (see Power et al 2002) . Hence , the dynamics of nitrogen cycling in Lake Taupo means seasonal variations in emissions may be safely ignored and emission permits can be specified in terms of an average annual rate of emissions .

Emission permits will be issued to current landholders in the catchment as part of a well-established resource consent process conducted by Environment Waikato . The permits are to be issued for the life of the resource consent (probably 15 years) and are allocated in accord with landholders' emissions as estimated by the nutrient budget model . The permits contain a farmer self-derived plan , verified by the consenting authority , setting out the combinations and levels of inputs into agricultural production processes that are authorised given the characteristics of the landholder's farm . The permit also contains a statement indicating the corresponding average annual volume of emissions that is authorised until such time as the resource consent expires , or the permit is traded . The permits are temporarily or permanently transferable either in whole or in part but such transfers or trades must be authorised by Environment Waikato in order for the associated resource consents to be adjusted accordingly .

Allocation of permits The third critical issue in the creation of property rights is the way in which adjustment costs are distributed among those that receive an allocation of rights . The distribution of losses and gains among landholders themselves will depend heavily on the procedure employed to determine the initial endowment of emission rights received by each landholder .

Allocation by rule The creation of regulations , industry standards or codes of conduct governing activities that result in emissions are all procedures for implicitly allocating emission rights among landholders . The effects of these allocation procedures on the adjustment costs of landholders and other stakeholders in the catchment depend heavily on the actual design

of the regulation, standard or code. This makes generalisations about the effects of these allocation procedures difficult.

A set of regulations might be formulated defining the types of activities that may be undertaken by landholders and specifying the manner in which those activities may be conducted. If this set of regulations were applied uniformly to landholders then, to the degree that the rate of emissions varies depending on location specific factors such as livestock type, soil type and topography, it implicitly assigns emission rights differentially among landholders. In these circumstances, adjustment costs will be distributed among landholders in line with the degree to which they are required to invest in abatement measures or scale down, change or close enterprises in order to conform to the regulations. The resulting distribution of adjustment effort may bear little relationship to the historical distribution of emissions among landholders. Consequently, this approach may be relatively ineffective in achieving the water quality standard. This approach is also likely to be inefficient to the degree it prescribes the type of adjustments landholders must make to reduce nitrogen emissions.

Alternatively, a voluntary code of conduct might be formulated defining the types of activities that may be undertaken by landholders and specifying the manner in which those activities may be conducted taking into account site specific factors that influence emissions such as livestock type, soil type and topography. Such a code would implicitly assign emission rights among landholders roughly in line with their historical level of emissions. Adjustment costs are likely to be distributed among landholders in line with the degree to which they are required to invest in abatement measures or scale down, change or close enterprises in order to conform to the code. To the degree this approach prescribes the type of adjustments landholders must make to reduce their emissions this approach is likely to be inefficient in achieving the water quality standard.

Allocation by sale Allocation procedures which involve the sale of permits can appear attractive as the landholder is explicitly forced to pay for the privilege of polluting. However, the application of the polluter pays principle by employing auction or tendering procedures to distribute permits may be unwarranted in this context for three of reasons. First, landholders will have experienced a diminution in rights and loss of wealth because of the loss of the presumptive privilege to discharge. This will be experienced as the restrictions on land use and income, increased costs entailed in abatement measures, or both. To require that as well as bearing these costs and losses, they purchase their initial endowment of discharge rights was argued to be unfair. Second, the adoption of a water quality standard is intended to restrict nitrogen emissions to a point at which the risk of any undesirable affects on other parties are deemed acceptable by the community. Consequently, landholders cannot be regarded as engaging in activities that are punishable because they are ignoring the rights of others or the environment. Third, for the sale of emission rights to be meaningful the volume of emissions available for purchase must be less than the current or anticipated rate of emissions in aggregate. If this is the case, then at least some landholders must be in a position to immediately reduce emissions. With respect to agricultural discharges this cannot be done without threatening the viability of the businesses involved.

Allocation by gifting One method for gifting permits is to allocate the same volume of permits among all landholders irrespective of their historical emissions. This is often termed averaging. This method of allocating permits had one critical disadvantage. Under this method those landholders who face the greatest adjustment costs in terms of reductions in income and increases in costs as a result of the imposition of limits on emissions will be required to obtain emission rights from landholders who face the lowest adjustment costs if all landholders are allocated the same emission rights. Consequently, this type of allocation merely serves to redistribute adjustment costs among landholders in such way as to transfer wealth from those experiencing the greatest economic disruption to those experiencing the least economic disruption. This outcome was considered inequitable (Environment Waikato 2003).

Permits may also be gifted on the basis of historical emissions. This method has been criticised for penalising landholders that may have acted in the past to reduce their emissions because they receive a smaller endowment of permits. Conversely, those that have not taken such desirable actions are rewarded with a greater endowment of permits. The validity of this criticism depends, among other things, on the extent to which abatement measures were uniform in their effectiveness and efficiency. Some landholders may have been able to implement abatement measures at relatively low costs while the costs to others of similar measures may be relatively high. Alternatively, the measures may be ineffective in some circumstances. Hence, the fact that a particular landholder has not adopted abatement measures is not, of itself, sufficient grounds for concluding that the landholder has, in some sense, disregarded the rights of others or failed to follow accepted industry practice and should necessarily be penalised by being allocated a smaller endowment of emission rights.

Conclusion Studies (Blomquist 1992; Riker and Sened 1991; Libecap 1989; Stavins and Whitehead 1992; Ostrom 1990) indicate that the successful implementation of markets in tradable emission permits depend on five fundamental conditions. These are that the emission rights are widely recognised among stakeholders as a scarce and valuable resource, there is widespread agreement among stakeholders; that there is a recognised need for new institutions to allocate emission rights; that a market mechanism is consistent with existing community and institutional norms for allocating resources; that the rules governing the operation of the market are appropriate for local conditions; and that stakeholders participate in the processes for changing those rules. In our view the circumstances with respect of Lake Taupo meets these conditions.

The principles underlying the rules governing the market in emission permits that we have described here suit the circumstances in Taupo. Given that measurement of nitrogen emissions is problematic and that nutrient cycling in Lake Taupo occurs over decades, a market in emission permits based on the use of a nutrient budget model to estimate emissions seems the only practical way of managing nitrogen emissions from rural land in order to protect the quality of water in Lake Taupo.

Economists have long advocated for the use of market mechanisms to control access to valuable natural resources on the grounds of economic efficiency. The equity implications of constraining rights to natural resources through the creation of property rights, and the equity implications of different methods of allocating rights, are canvassed less frequently. Yet an understanding of the equity issues entailed in the creation of property rights and market mechanisms is critical to the making of informed social and political judgments about the merit of such markets.

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