Managing Risks and Tradeoffs Using Water Markets

Suzi Kerr

Motu Working Paper 13-13
Motu Economic and Public Policy Research

November 2013

Author contact details

Suzi Kerr
Motu Economic and Public Policy Research
suzi.kerr@motu.org.nz

Acknowledgements

I would like to thank the OECD, the New Zealand Ministry for Primary Industries through the Motu 'Markets and Water Quality' research programme and the New Zealand Ministry for Science and Innovation through the Motu 'Coordination and Cooperation for Effective Climate Policy Design and Implementation' research programme for funding this work. This paper builds on underlying work by a number of Motu researchers including Levente Timar, Simon Anastasiadis, Oliver Browne and Boon-Ling Yeo. Any opinions and interpretations are entirely the author's.

This working paper contributed to the OECD report "Water Security for Better Lives", available online at http://www.keepeek.com/Digital-Asset-Management/oecd/environment/water-security_9789264202405-en#page2.

Motu Economic and Public Policy Research

PO Box 24390
Wellington
New Zealand

Email info@motu.org.nz
Telephone +64 4 9394250
Website www.motu.org.nz

ISSN 1176-2667 (Print), ISSN 1177-9047 (Online).

Abstract
Risk (and often the certainty) of adverse environmental outcomes motivates environmental regulation; other risks also affect welfare outcomes. Economic instruments are one way to reduce environmental risk while maintaining flexibility that helps manage other risks. However regulation not only mitigates risks, it also creates them. While the literature has explored some aspects of risk and economic instruments in great detail, other risks have been largely ignored. Actual and perceived risks are often a barrier to the use of economic instruments so, where they are appropriate, it would be valuable to pay more attention to mitigating risks and demonstrating that they can be mitigated. This note creates a framework for synthesising experience with economic instruments for managing risks relating to water quantity and quality and illustrates it with two New Zealand case studies for which detailed information is available. It also explores some linkages between economic instruments that are not primarily directed at water management – for example emissions trading - and water management outcomes. The surprising outcomes illustrate the importance of context for assessing impact and risk.

JEL codes
D81, Q53, Q57

Keywords
Water quality, Lake Taupo, Lake Rotorua, economic instruments, risk, policy interaction

1. Introduction

Risk (and often the certainty) of adverse environmental outcomes motivates environmental regulation; other risks also affect welfare outcomes. Economic instruments are one way to reduce environmental risk while maintaining the flexibility that helps manage other risks. However regulation not only mitigates risks, it also creates risks and has uncertain outcomes. While the literature has explored some aspects of risk and economic instruments in great detail, other risks have been largely ignored. Actual and perceived risks are often a barrier to the use of economic instruments so, where they are appropriate, it would be valuable to pay more attention to mitigating risks and demonstrating that they can be mitigated.

The environmental economics literature (e.g. textbook treatments such as Tietenberg and Lewis, 2009) has generally treated externalities as deterministic although they may vary by time, location and according to the intensity of pollution. Part of the literature explicitly focuses on the risk of externalities, for example work theoretical work on liability for accidents (Shavell, 1984) and an empirical example, Alberini and Austin (1999). Much literature has explored the economic uncertainty associated with regulation, for example the tax versus permits discussion (Weitzman, 1974), particularly with regard to climate regulation (e.g. Newell and Pizer, 2003). Lichtenberg and Zilberman (1988) began a literature on a 'margin of safety' to account for environmental uncertainty. This has been applied more recently in an agricultural soils context in Kim and McCarl (2009) who stress the importance of balancing an improvement in integrity that can be created through a margin of safety with the risk of counterproductive or unduly onerous policy rules. Montero (2000 and 1999) show how uncertainty about baselines in a voluntary environmental market can lead to significant losses in environmental integrity, and how this can in theory be solved.

This note creates a simple framework for synthesising experience with economic instruments for managing risks relating to water quantity and quality and illustrates it with two New Zealand case studies for which detailed information is available. The aim is to identify a more complete set of risks and raise questions of policy interest that deserve greater attention in the theoretical and empirical literature. It explores some linkages between economic instruments that are not primarily directed at water management – for example emissions trading - and water management outcomes. The surprising outcomes emphasise the importance of context for assessing impacts and risks.

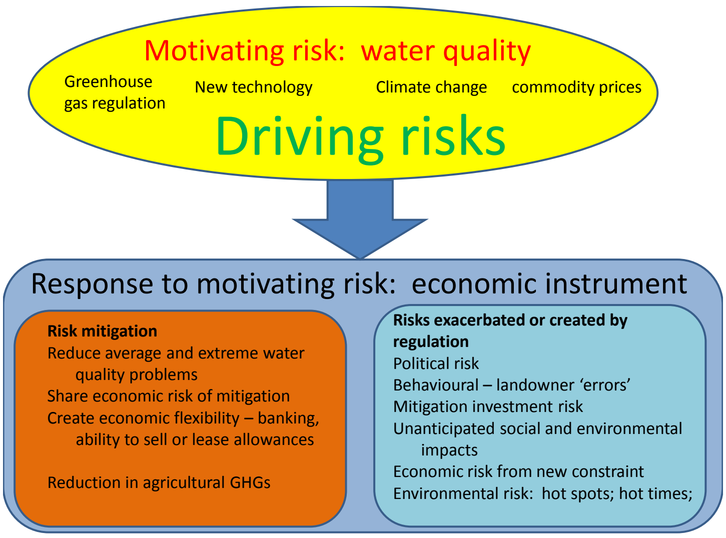
In this paper I focus on risks to water quality as the motivating driver for regulation and water quality markets as the economic instrument. Shortle and Horan (2008) and Selman et al.

(2009) synthesise the literature on the economics of and experience with water quality trading. Shortle (2012) focuses specifically on management of water pollution within agriculture which is also the focus of our case studies here. Selman et al. (2009) survey the existing water quality markets, primarily in the United States. The paper focuses on how previously agreed environmental targets are achieved rather than on the governance and limit setting processes; these have been previously addressed (Grafton, 2011).

As illustrated in Figure 1, I separate the relevant risks into the 'motivating' risk, that is, the primary target of the regulation; the 'driving' risks, which include the motivating risk as well as other external causes of risk – economic, meteorological, biological and from innovation; and the risks that arise from the regulatory response – specifically use of economic instruments. These regulatory impacts are divided into:

1) risk mitigation, which is largely intended and covers both impacts on the motivating environmental problem and positive side effects on economic and other environmental risks; and
2) risks exacerbated or created by regulation. These include political, behavioural, compliance, social, economic and environmental risks that could be created or exacerbated by the economic instrument.

Figure 1 Motivating, driving and response risks in water quality management



The motivating risks we are primarily focused on are those related to water. For water quantity issues these are drought and flood, which are uncertain and have large impacts, and the uncertain ecosystem damage they cause (e.g. risk of loss of biodiversity); for water quality they are loss of visibility, algal blooms, sickness and inability to drink water or use it for recreation, and damage to ecosystems. The average level of water quantity and quality in any time period are driven by average climate, geophysical conditions, land use and management. The variability is driven by weather, accidents, and year to year variability in land management – possibly in response to short-term economic drivers.

Some of the longer-term drivers for water stressors are deterministic and dealt with in standard literature – e.g. land-use change trends; fertiliser use trends; irrigation trends; - others are themselves uncertain. These include new technologies (that can be good or bad for water – resource sparing or using), climate change and the associated regulation, and changes in economic conditions such as commodity prices.

Limits on leaching, other pollutant flows, land use (especially catchment protection) and water use can blunt the impact of what would otherwise be costly extreme events. A market mechanism can also provide a mechanism for sharing the risks that remain – for example, water markets cannot avoid drought but can help allocate such water as is available more efficiently, and can induce investment in efficient storage.

Economic instruments (in common with other regulations) can also create new risks. These need to be weighed against the risks that are mitigated. The new risks can be political (particularly because new regulations tend to lead to uneven allocation of costs relative to benefits and to affect land values); risks of errors by individuals who may take time to adapt to new conditions; investment risk that is exacerbated by dealing both with potentially unfamiliar technologies and the need to respond to an uncertain regulatory environment; environmental (if trading could lead to 'hot spots' or 'hot times' - concentrations of pollutants at a point in time rather than space; and risk of unintended impacts on social or untargetted environmental outcomes. Any change leads to conditions that people are unfamiliar with, and hence that involve more uncertainty.

In section two I present short case studies on two New Zealand water quality markets – one that has recently been implemented and another that is still being designed. In section three I illustrate the risk framework through its application to these two markets. In section four I consider interactions among environmental markets, with an empirical focus on two markets, for water quality and greenhouse gas emissions from land use. This helps identify how the interaction of externalities and markets can lead to unexpected risks, but also lead to opportunities to reduce risk and ease the path for regulation.

2. Two Case Studies: Taupo and Rotorua

2.1. Lake Taupo

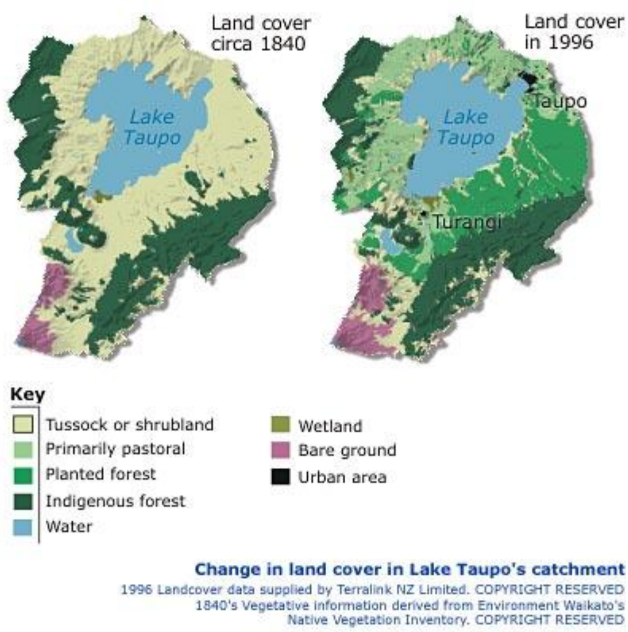
The Taupo nitrogen trading scheme is of particular interest as it is the first non-point-source to non-point-source (NPS) cap and trade scheme worldwide (Shortle, 2012). Despite the importance of NPS pollution worldwide, to date, water quality trading markets have predominantly been set up to facilitate nutrient discharge reductions by point sources, such as sewerage plants and mines. Where agricultural NPSs are involved, they are generally not subject to a cap on emissions, and instead can choose to participate and decrease nutrient discharges in return for emission reduction credits that point sources purchase to offset their own discharges (Selman et al., 2009). The Taupo scheme is innovative as controlling diffuse NPS nutrient discharges is its central aim. Young et al. (2010) and Duhon et al (2012) have discussed the process of creating the system, and evaluated its early operation.

Lake Taupo is New Zealand's largest lake with a catchment of nearly three and a half thousand square kilometres of pastoral farms, plantation forestry, native forest and a small urban area. The lake has been described as 'iconic'. It is a major destination for domestic and international tourism. Although Lake Taupo currently exhibits exceptional water quality, scientific investigation has revealed a gradual but steady decline in key indicators of water quality over the past three decades (Vant, 2008). Intensified pastoral and urban land use over the past 35-50 years has resulted in increased nutrient levels in the lake, leading to decreasing water quality and clarity (Young, 2007). Water quality is expected to decline further even if current discharge levels are capped because of considerable time lags in the Lake Taupo catchment between nutrient application to land and its eventual arrival in the lake via ground water. This time lag is thought to be greater than 100 years in some parts of the catchment (Vant, 2008; Hadfield, 2008).

Nitrogen losses from agricultural land uses have been identified as the primary cause of increased nutrient loads into the lake. Total nitrogen discharges into the lake are around 1360 tonnes per year, of which only 556 tonnes per year come from manageable or human-induced sources. Pastoral (dairy and sheep beef) activities account for 92% of all manageable sources of nitrogen loss.

Following growing community concern about water quality, Waikato Regional Council set a goal to restore water quality to 2001 levels by the year 2080. Under New Zealand Resource Management Act, the Regional Council is responsible for water quality (Kerr et al., 1998). The policy designed to achieve this goal consists of three key components: a cap, a public fund for buy-backs, and trading. The catchment level cap on nitrogen losses serves to limit nitrogen losses at historical levels and prevent further increases. A computer model OVERSEER is used to model leaching from each of the roughly 250 farm participants based on auditable data. Each farm is benchmarked to initially grandparent allowances and then must comply with a management plan to ensure compliance. The Lake Taupo Protection Trust, a public fund with contributions from local, regional and national communities, is charged with permanently reducing the cap by 20% through the purchase and conversion of land or purchase and permanent retirement of farmers' nitrogen allowances. The nitrogen trading system allows farmers to trade allowances with other farmers or with the Trust. To make a trade, both the buyer and seller must submit an updated nitrogen management plan for Council approval.

Figure 2 Land cover in Lake Taupo catchment

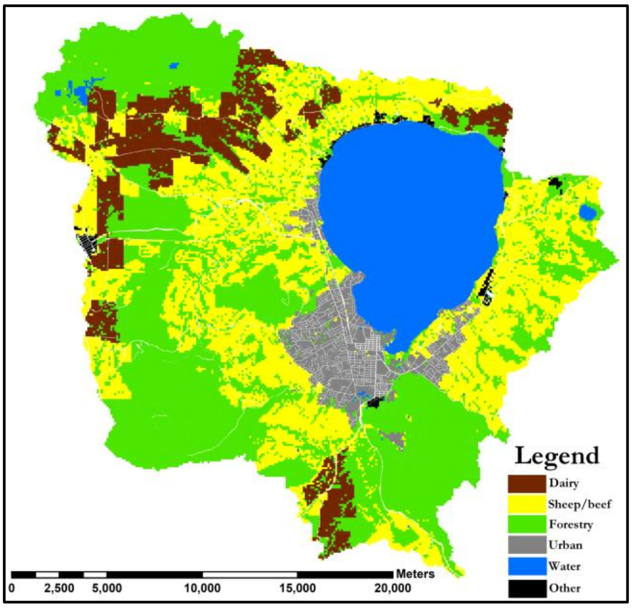


The policy became fully operative in July 2011 after resolution of some legal challenges but trades had been being negotiated since 2007 when the Lake Taupo Protection Trust was given the ability to make NDA purchase decisions (Young et al., 2010). The first Trust and private trades were completed in January 2009.

2.2. Lake Rotorua

In contrast, Lake Rotorua does not yet have a nutrient trading system. It has had a weakly monitored freeze on leaching from each farm since 2005 and active negotiations on more stringent rules are occurring among landowners and other local stakeholders and with the regional government. Rotorua is interesting because it has a more severe water quality problem than Taupo and because it is one of 16 lakes in the area but the only one where nutrient trading is likely to be part of the solution. It offers an opportunity to learn from the Lake Taupo experience and refine the nutrient trading model even further. It has been the location of considerable policy and integrated modelling research.[1] One issue of specific interest is the role of groundwater lags. It is estimated that 53% of the nitrogen reaches the lake via groundwater with lags up to 120 years (Rutherford et al., 2011).

Figure 3 2010 Land use in the Lake Rotorua Catchment[2]



The key differences between the Taupo trading system and that being proposed for Rotorua (Kerr et al., 2012) are that the Rotorua system attempts to avoid a need for approved farm management plans or Regional Council approval for trades by using a self reporting system; that more certain and swift non-compliance penalties are being explored (Rive, 2012); and that initial allocation of allowances is likely to be less generous to farmers. These all reflect both learning from the Taupo experience and the need for more stringent reductions. Allocation may also be done on a different basis reflecting concerns about the fairness of grandparenting, particularly for Maori landowners who regained control of their land only under recent Treaty of Waitangi settlements, and those who have undertaken voluntary mitigation.

3. Framework for Evaluation of Risk and Economic Instruments

I now expand on the structure given in Figure 1 as a framework for evaluating the effectiveness of economic instruments for managing risks associated with water quality and

[1] For a range of papers on nutrient trading for Lake Rotorua see http://www.motu.org.nz/research/detail/nutrient_trading

[2] Map created by Motu from data from the ROTAN model (Rutherford et al., 2009).

quantity. This paper focuses on the commonalities across issues - water quantity and water quality – and instruments – tax/charge and markets.

The critical difference between management of water quantity and quality is that the benefits from better quantity management are largely private (access to secure water) while the benefits from quality management are public (either environmental, recreational or lower costs of drinking water treatment). This difference has fundamental implications for incentives to fight regulation and to comply. The physical costs of water transfer and the inaccuracy associated with measuring the impacts of individual behaviour on water quality compared with the relative ease of measuring water take are also critical differences. Institutionally water quantity management is handled very differently from water quality.

In this paper I focus most on environmental markets. The critical differences with other economic instruments – e.g. taxes or charges – are two: first, a cap and trade market provides much more direct control over environmental outcomes (and less over marginal costs); and a market allows a separation between the actors who mitigate/reduce and the actors who ultimately bear regulatory costs, because of the ability to allocate allowances to address political and distributional concerns (Hahn and Stavins, 2011).

One other salient comparison is between Payments for Ecosystem Services (PES) systems and environmental markets. In contrast to a tax where the polluter pays, in a PES system the provider of a positive externality is subsidised. As with negative externalities, positive externalities are of public interest only where transaction costs are too high for those with direct benefits to coordinate with providers. Currently there are few examples where government has coordinated negotiations between potential beneficiaries and providers of ecosystem services but not directly funded the services. Payments for ecosystem services between private actors that do not require government coordination are just normal market activity. The critical differences relative to environmental markets are the same as with taxes: less control over environmental outcomes and less flexibility in cost sharing. The beneficiary (often the tax payer or an otherwise regulated entity) must pay. It is hard to avoid paying landowners for activities they would have done anyway. If regulated entities are the main payers, this is essentially an environmental market with voluntarily provided offsets and all the challenges associated with those Van Benthem and Kerr (2012). Most current water quality markets are structured this way (Selman et al., 2009).

When several ecosystem service markets or payment/tax systems interact it is critical to take account of the interactions between them. Many efforts to value ecosystem services in order to provide payments ignore this. A payment for one ecosystem service (e.g. greenhouse gas mitigation) reduces the marginal value of complementary ecosystem services (e.g. water quality). This is discussed further below.

I now focus on common issues across quality and quantity and across tax/charge/PES and markets.

3.1. Risks Mitigated by Economic Instruments

Given one specific motivating risk for regulation, a critical characteristic of any policy is how effectively it addresses that environmental risk. Evaluating that requires assessing outcomes and identifying the causal effect of the policy used.

3.1.1. Measures of Effectiveness/Outcomes

There are at least three key measures of policy outcomes: environmental; total cost; and distribution of cost. These are important regardless of regulatory form.

If the environmental outcome cannot be measured, or modelled with any degree of certainty, the policy cannot be assessed, and an economic instrument is unlikely to have been able to be designed effectively given that it aims to internalise the environmental effect. Regulators frequently have measures at the catchment or river-reach scale that can be used to assess aggregate performance; they may also have measures of behaviour (water use or nutrient leaching) at the source level. In a risky environment, they need to relate specific behaviour – possibly at both specific times and places – to outcomes. This is difficult for water quality where groundwater lags, when nitrogen travels through aquifers, and attenuation make it difficult to relate leaching to stream/water body measurements. In addition, what the public sometimes cares about is algal blooms which have a stochastic element to them even for given nitrogen loads.

For water quantity, even with good monitoring of water takes, similar issues arise with aquifers that are recharging and where background water availability (e.g. rainfall, small dams) is not easily monitored. Uncertainty about the true distribution of precipitation, especially with climate change, makes it hard to assess how well a regulatory regime will deal with future water availability shocks (floods or droughts). Our monitoring and modelling systems are frequently inadequate, and the natural complexity and variability in the system is often sufficiently great, that it can take a long time to assess a change in the state of the environmental outcome.

One advantage with environmental markets – particularly cap and trade rather than those involving voluntary offsets - relative to other regulations, is that they require clear definition and enforcement of allowances and hence higher quality data and greater control. This focuses regulators' attention on cumulative catchment wide impacts. In addition, the more comprehensive the system is, the lower the environmental risk will tend to be.

While value added, employment and other economic and social outcome indicators may be relatively easily collected giving some indication of achievement (or not) of goals, and direct costs of the policy to government are sometimes available, it is difficult to measure the full cost of a policy without assessing a counterfactual level of profit, especially where the costs mostly arise from lost opportunities. This is true for all policies though markets do generate price data which helps.

3.1.2. Causality: Was Success or Lack of it Because of the Regulation?

How is the achievement of environmental goals, and risk associated with them, different under an economic instrument? With a cap and trade system, if the target is binding and compliance is strong, the system will achieve its stated goal and the system will have an environmental effect. However it can be hard to assess these conditions directly.

In an environmental market, if there is a real positive price, that is a signal that the regulation is having at least some effect. In the Taupo case, the price is positive and high but it is probably set purely by an arbitrary calculation of the Trust so far. Anecdotal evidence suggests however that although the Trust has bought more than half the allowances it needs to achieve the target reductions, it will have difficulty purchasing the remaining allowances at the current price. This suggests the regulation is binding. Another signal is that if people buy units it suggests at least some faced a positive cost of compliance. In Taupo there are relatively few private purchases so far but there are some (Duhon et al., 2012). This suggests the system is binding and actors expect meaningful levels of compliance.

Before we can assess whether the economic instrument addressed economic risk we need to know if the economic instrument led to reductions in economic cost – was the flexibility available actually used? There is no ex post academic study of cost savings in water-quality trading market relative to a more rigid regulation that I am aware of. In any case the size of gains depends critically on the allocation of reduction obligations under the counterfactual rigid regulation. Trading activity gives some indication of market function and gains from trade. There is some empirical analysis of water trading markets (for example Chong and Sunding (2006); Turral et al. (2005) and Brewer et al. (2008)). In some early water quality trading markets there were few or no trades. This has sparked a considerable literature on transactions costs in water quality markets – and was part of the motivation for using a cap-and-trade approach, which avoids the need for assessment of each trade, in New Zealand (McDonald and Kerr, 2011). In the Taupo market, which has been fully operating only since July 2011, as of July 2012 there had been 32 trades involving 30 different traders and 17% of all allowances. Many of these are purchases by the Trust which do not indicate the value of flexibility because reductions were voluntary, but 10 are private trades to ease compliance with the caps.

The use of water quality markets to reduce economic risk is even less studied that the impact on average cost outcomes. If allowances can be banked or easily leased out temporarily, markets allow regulated sources to share economic risk. In the Taupo case some leases have occurred but high transactions costs are probably inhibiting others. Banking is not allowed in any existing scheme (that I am aware of) but could be possible in catchments with groundwater lags or lakes with long residence times of where regulation is progressively more stringent so early gains are more valuable than later ones.

A surprising benefit of water quality trading for economic risk management occurred in the Lake Taupo example. One driver for landowners' desire for trading rather than alternative regulation was that the property market had become illiquid as a result of regulatory uncertainty. Farmers who wanted to retire knew that with a cap and trade system, and the Trust acting as a liquid buyer of allowances, they would be able to extract a large share of the value of their property by selling allowances even if they were unable to sell the farm. Thus the water quality market reduced the risk of illiquidity (driven by regulation) in a related market.

In summary there are theoretical reasons and some empirical evidence that environmental markets can improve environmental and economic outcomes but evidence is weak so far particularly in terms of risk.

3.2. Risks Created by Economic Instruments

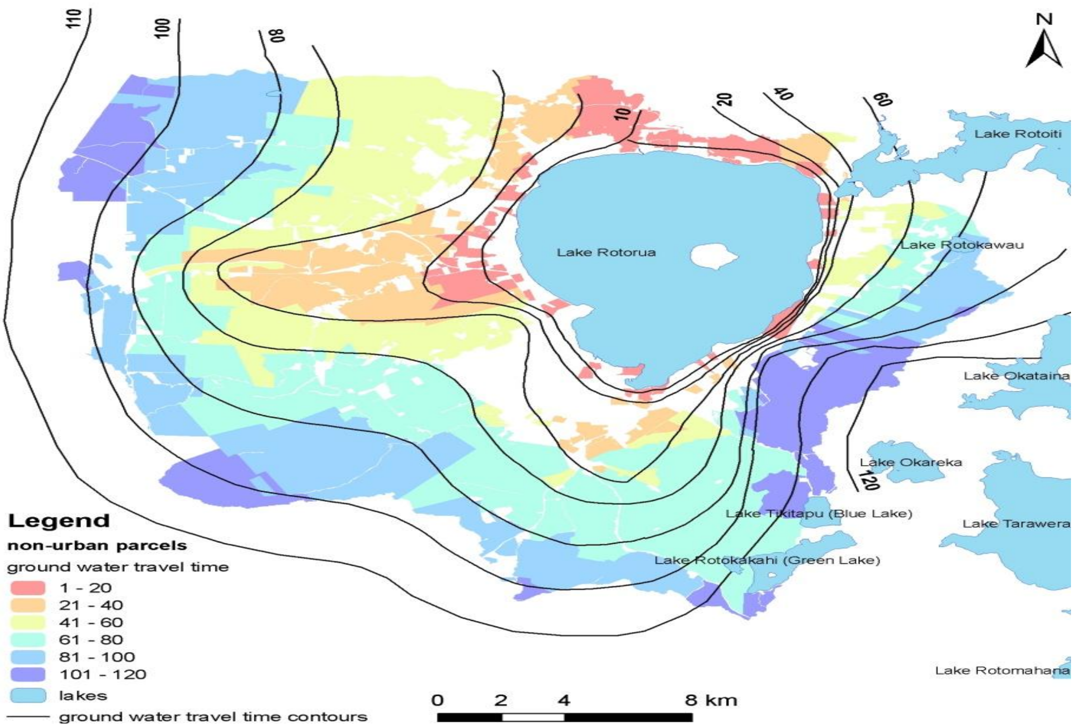
One frequent concern about the flexibility offered by economic instruments is that it will lead to adverse environmental outcomes. A simple example of this is 'sleeper permits' where, usually in water regulation, a move from a fixed permitting regime to a trading regime means that permits that would not have been used because they were held by someone who was unable to get value from them, are sold to someone else who uses them thereby increasing total pressure on water. Addressing this requires carefully matching the total number of permits to the environmental cap required.

A more complex issue is that of 'hot spots' where trading leads to a concentration of allowances in one location and, combined with a non-linear damage function, leads to serious environmental effects. In a catchment with effects that accumulate over time (e.g. with aquifers) trading and banking could lead to 'hot times'.

Assessing the risk of hot spots generally depends on empirical simulation of specific design features. If they are considered to be a serious issue, trading ratios can be used to incorporate spatial differences in impact (Tietenberg (2006); Horan and Shortle (2005); and Farrow et al. (2005)). These are hard to implement in practice and often lead to very high transaction costs.

Less focused policies simply apply an offset to all trades, on the not entirely unreasonable assumption that any movement away from the status quo increases risk. Offsets are particularly used for trades from non-point sources to point sources because of the lower accuracy of measurement of non-point source emissions (Selman et al., 2009). In the Lake Dillon scheme in Colorado, USA, two units of discharge reduction by NPSs are required for any one unit increase in discharge by PSs (Woodward, 2003). This may make less sense than intuition would suggest however. Non-point source leaching reductions might have the greatest impact at time of high environmental impact (floods). Thus, although they are uncertain they may have a disproportionate impact on reducing environmental risk.

Figure 4 Modelled Groundwater Lag Zones for Lake Rotorua



Source: NIWA ROTAN model. Rutherford et al. (2009).

In both Lake Taupo and Lake Rotorua, spatial hot spots were not considered important because the impacts are on well-mixed lakes but there was concern that reductions in different locations could lead to different timing of impacts, and hence the risk of 'hot times' with particular concern that short-term environmental gains would be low. Figure 4 shows the likely locations and large differences in groundwater lag times in the Rotorua catchment.

Kerr et al. (2007) present the theory for how this temporal difference in impact as a result of groundwater lags could be incorporated in an environmental market. Anastasiadis et al. (2011) empirically model the likely implications in Rotorua for the efficiency of markets that do and do not account for temporal differences. They find that it is unlikely to make any difference in Rotorua and that only under quite unusual conditions would accounting for temporal variability in impact through groundwater be valuable.

Thus environmental markets may reduce risk by providing tighter control over cumulative impacts but may also create risk as a result of flexibility and lack of oversight of individual decisions with environmental impacts that regulation may not control.

Environmental markets with strong caps and limited banking/borrowing can also create economic risks by removing flexibility to respond to shocks. Two clear cases of failure of market-based policy are seen in nitrous oxide regulation. In both California and in Chile, when there were shocks to the electricity system, driven by deregulation in one case and the withdrawal of natural gas supplies from Argentina in the other, electricity generators reverted to the use of dirty fuels. This led nitrous oxide emissions to rise dramatically leading to extreme pressure on nitrous oxide markets and ultimately breaching of limits. Stronger compliance would have led to unacceptable economic costs.

Another key economic risk is associated with investments in response to regulation. Whether economic instruments create more or less investment risk than other forms of regulation is really a question about the credibility of the regulation. On the one hand a more efficient economic instrument that creates property rights contingent on its continuation, and hence strong vested interests, may seem more politically robust. On the other hand, rules within environmental markets have been regularly changed and affect all actors, sometimes in profound ways. There may be less ability for any single actor to seek special treatment to protect their investment against a change in general market rules rather than against a specific application of a regulation that applies only to them. Finally environmental markets create political and social risks. While there are political advantages from flexible allocation of cost, the high visibility of allocation of allowances relative to implicit rights under other forms of regulation and a movement of political oversight from case-by-case determinations to systemic decisions changes the political actors involved and the nature of their decisions. The process could be smoother or rockier but the stakes in each decision are certainly much higher.

Movement of allowances is associated with movement of economic activity. This can have social impacts that are unanticipated and hence possibly poorly managed. Any new regulation brings some risk of poor management by those who are regulated, but a market may create the opportunity for individual errors on a much larger scale. Premature sale of allowances through lack of understanding of their value, or of the need for allowances to carry out existing activities, can have long lived effects on individuals.

Thus economic instruments do create new risks; it is unclear whether these are greater than those generated by other regulations of equivalent environmental stringency.

3.3. When is the Risk Mitigation from an Economic Instrument Likely to Outweigh the Potential New Regulatory Risks?

As I have discussed, economic instruments can reduce environmental risk and create more flexibility to deal with economic risks but can also create new risks. We have some understanding of the conditions under which the flexibility of an economic instrument is valuable. It is driven by the level and heterogeneity of marginal costs of control or value (Newell and Stavins, 2003). It is also driven by the nature of the pollutant and the extent to which that enables flexibility without environmental effects. Uniformly mixed, accumulative pollutants allow most flexibility because it matters little where or when pollution occurs. The equivalent for water would be water systems with significant storage and easy transfer of water, and where the key environmental impacts are in the major waterways rather than small tributaries so cumulative impacts matter more than local impacts.

These geophysical situations will obviously also be ones where the use of economic instruments will cause least environmental risk. The size of the upside benefit of more systematic coverage of sources and uses, leading to less environmental risk under economic instruments, will be very catchment specific.

We know less about the political risks arising from different regulations both during the process of initial creation and also during ongoing implementation. Ongoing political risk can lead to pressure to change regulations and hence to investment risk. Similarly we have little information on whether environmental markets are systematically likely to lead to more mistakes by less informed actors relative to other regulatory forms. The errors are likely to be more visible but may be no larger.

4. Effects of Other, Non-Water-Related, Environmental Markets on Water Security and Quality

People often talk about (and even model) environmental / ecosystem service values as though they are independent. In reality the marginal value of an ecosystem service changes when complementary or conflicting ecosystem services are regulated. An existing regulation can either reduce or increase the value and cost of regulating a second ecosystem service. One example of this is the interaction between land-related climate change mitigation and water quality. Others would be links between water quality and quantity, climate change and water quantity, and any of these and biodiversity values. These interactions occur for all forms of regulation but are particularly visible with economic instruments and especially environmental markets where allowance prices are visible and the cost of regulation and its distribution depends not only on abatement costs but also on the value and initial distribution of allowances.

4.1. Climate Change – Emissions Trading

The Lake Taupo water quality market has vividly illustrated the potential for positive interaction between land-related climate change regulation and water quality regulation. Nearly all trades to date have involved some land conversion into forestry (Duhon et al., 2012). These farmers have not only sold nitrogen allowances, but have also sold carbon credits through New Zealand's emissions trading system (Mighty River Power, 2010).

In the Lake Rotorua catchment, Yeo et al (2012) have modelled the interactions between these markets for the planned Lake Rotorua catchment nutrient trading system, the existing forestry component of the New Zealand Emissions Trading System (ETS) (Karpas and Kerr, 2011) and the potential regulation of agricultural greenhouse gas emissions in New Zealand (Kerr and Sweet, 2008).

They find that emissions trading alone can lead to large gains in water quality, while water quality trading has even larger impacts on greenhouse gas emissions (in this case where the nitrogen cap is very stringent). For sheep/beef farmers, the loss of farm profits as farmers de-intensify and in some cases convert to forestry is larger under the combination of both regulations because their profitability in sheep/beef production becomes so low relative to alternative uses. In contrast, for dairy farmers, the combination of two regulations makes it easier to stay in dairy farming than under water quality regulation alone. This is because the strong mitigation response by sheep/beef farmers to the combined regulation reduces their demand for nitrogen allowances, lowers the price of nitrogen allowances in the catchment, and makes it more profitable for dairy farmers to pay for nitrogen and continue to farm.

Table 1 Effects and costs of combined GHG and Nitrogen policies with no free allocation of nitrogen allowances[3]

			Sheep / Beef Farms		Dairy Farms	
	N leaching (tonnes/year)	**Net GHG emissions (tonnes/year)**	**Abatement cost – loss of profit from farming ($/ha/year)**	**Econ profit – includes permit cost and revenue ($/ha/year)**	**Abatement cost – loss of profit from farming ($/ha/year)**	**Econ profit – includes permit cost and revenue ($/ha/year)**
No regulation	506	137,133	$-	$480.28	$-	$1,368.80
GHG only	392	70,239	$42.98	$422.67	$41.96	$1,041.37
N only	134	-34,415	$125.66	$152.27	$937.04	$92.11
Both N and GHG	134	-75,663	$409.27	$246.01	$448.50	$245.00

Another interesting impact of the combined regulations is that both sheep/beef and dairy farmers are better off with the GHG (emissions trading) regulation as well as the nitrogen cap if they are required to purchase all their allowances (and able to sell carbon credits). For sheep/beef, the benefit comes from carbon credit revenue; for dairy, it is because of the fall in the cost of the nitrogen allowances they purchase.

A contrasting case, where the two environmental markets could come into conflict arises in the Manawatu catchment where the emissions trading policy could induce land conversion into maize which is associated with high nitrogen losses (Daigneault et al., 2012). They also find that if an emissions trading system is already operating, the addition of a nutrient trading system could lead to real environmental gains at relatively low cost. In contrast, if the water quality regulation already exists (with a low level of stringency) adding the GHG regulation provides little gain at high cost. Clearly the interactions are sensitive to local conditions. As discussed above with respect to payments for ecosystem services, the marginal environmental value from additional regulation is sensitive to the existing regulation for other related services.

5. Conclusion

Theoretically economic instruments for environmental regulation can not only be more efficient, but in some circumstances can reduce environmental and economic risks as well.

[3] Table derived from Yeo et al., (2012).

However, they can also create risks, particularly if they are poorly designed. The scale of environmental and economic risk is probably more driven by the quality of the design of the specific instrument rather than the broad choice of instrument. There are examples of poorly designed market and non-market water regulations.

The economics literature is beginning to address the risk aspects of economic instruments for water regulation but is still poorly developed, particularly with regard to water quality. Empirical evidence is sparse.

Actual and perceived risks are often a barrier to the use of economic instruments so, where they are appropriate, it would be valuable to pay more attention to mitigating risks and demonstrating that they can be mitigated.

References

Alberini, Anna and David H. Austin. 1999. "Strict Liability As a Deterrent in Toxic Waste Management: Empirical Evidence From Accident and Spill Data", *Journal of Environmental Economics and Management,* 38:1, pp. 20–48.

Anastasiadis, Simon and Suzi Kerr (forthcoming) 'Does complex hydrology require complex water quality policy?' *Australian Journal of Agricultural and Resource Economics.* Available as *Motu Working Paper 11-14,* Motu Economic and Public Policy Research

Brewer, Jedediah; Robert Glennon; Alan Ker and Gary D. Libecap. 2008. "2006 Presidential Address: Water Markets in the West: Prices, Trading and Contractual Forms", *Economic Inquiry,* 46:2, pp. 91-112.

Chong, Howard and David Sunding. 2006. "Water Markets and Trading", *Annual Review of Environment and Resources,* 31, pp. 239–64.

Daigneault, A.; Suzie Greenhalgh and Oshadhi Samarasinghe. 2012. "Economic Impacts of GHG and Nutrient Reduction Policies in New Zealand: A Tale of Two Catchments," paper prepared for the AAEA Organised Symposium at the 56th Annual Australian Agricultural and Resource Economics Society Annual Meeting, Fremantle, Western Australia, 8-10 February 2010.

Duhon, Madeline; Hugh McDonald and Suzi Kerr. 2012. "Nitrogen Trading in Lake Taupo: An Analysis and Evaluation of an Innovative Water Management Policy," Motu Economic and Public Policy Research, Wellington.

Farrow, Scott; Martin Schultz; Pinar Celikkol and George Van Houtven. 2005. "Pollution Trading in Water Quality Limited Areas: Use of Benefits Assessment and Cost-Effective Trading Ratios", *Land Economics,* 81:2, pp. 191–205.

Grafton, R. Quentin. 2011. "Economic Instruments for Water Management," *ENV/EPOC/WPBWE(2011)13,* Environment Directorate, OECD, Paris, France.

Hadfield, John. 2008. "Statement of Evidence of John Hadfield Before the Environment Court,"

Hahn, Robert W. and Robert N. Stavins. 2011. "The Effect of Allowance Allocations on Cap-and-Trade System Performance", *Journal of Law and Economics,* 54:4 Markets, Firms, and Property Rights: A Celebration of the Research of Ronald Coase , p. S267-S294.

Horan, Richard D. and James S. Shortle. 2005. "When Two Wrongs Make a Right: Second-Best Point-Nonpoint Trading Ratios", *Amer.J.Agr.Econ.,* 87:2, pp. 340-52.

Karpas, Eric and Suzi Kerr. 2011. "Preliminary Evidence on Responses to the New Zealand Forestry Emissions Trading System," *Motu Working Paper 11-09,* Motu Economic and Public Policy Research, Wellington, New Zealand.

Kerr, Suzi; Megan Claridge and Dominic Milicich. 1998. "Devolution and the New Zealand Resource Management Act," *Treasury Working Paper 98-7,* New Zealand Treasury, Wellington, New Zealand.

Kerr, Suzi; Hugh McDonald and Kit Rutherford. 2012. "Nutrient Trading in Lake Rotorua: A Policy Prototype," *Motu Working Paper 12-10,* Motu Economic and Public Policy Research, Wellington, New Zealand.

Kerr, Suzi; Kit Rutherford and Kelly Lock. 2007. "Nutrient Trading in Lake Rotorua: Goals and Trading Caps," *Motu Working Paper 07-08*. Motu Economic and Public Policy Research, Wellington.

Kerr, Suzi and Andrew Sweet. 2008. "Inclusion of Agriculture in a Domestic Emissions Trading Scheme: New Zealand's Experience to Date", *Farm Policy Journal,* 5:4, pp. 43-53.

Kim, M and Bruce A. McCarl. 2009. "Uncertainty Discounting for Land-Based Carbon Sequestration", *Journal of Agricultural and Applied Economics,* 41:1, pp. 1-11.

Lichtenberg, Erik and David Zilberman. 1988. "Efficient Regulation of Environmental Health Risks", *Quarterly Journal of Economics,* 103:1, p. 167.

McDonald, Hugh and Suzi Kerr. 2011. "Trading Efficiency in Water Quality Trading Markets: An Assessment of Trade-Offs," *Motu Working Paper 11-15,* Motu Economic and Public Policy Research, Wellington.

Mighty River Power. 2010. "Media Release: Carbon Transaction Supports Environmental Benefits to Lake Taupo," Accessed 30 October 2012, Mighty River Power Media Center. Available online at http://www.mightyriver.co.nz/Media-Centre/Latest-News/2010-Archive/Carbon-Transaction-Supports-Environmental-Benefits.aspx_.

Montero, Juan-Pablo. 1999. "Voluntary Compliance With Market-Based Environmental Policy: Evidence From the U.S. Acid Rain Program", *The Journal of Political Economy,* 107:5, pp. 998-1033.

Montero, Juan-Pablo. 2000. "Optimal Design of a Phase-in Emissions Trading Program", *Journal of Public Economics,* 75, pp. 273-91.

Newell, Richard G. and William A. Pizer. 2003. "Regulating Stock Externalities Under Uncertainty", *Journal of Environmental Economics and Management,* 45, pp. 416-32.

Newell, Richard G. and Robert N. Stavins. 2003. "Cost Heterogeneity and the Potential Savings From Market-Based Policies", *Journal of Regulatory Economics,* 23:1, pp. 43-59.

Rive, Vernon. 2012. "Nutrient Trading in Lake Rotorua: Design, Implementation and Enforcement - Legal Issues," Vernon Rive Environmental Law. Available online at http://www.motu.org.nz/publications/detail/nutrient_trading_in_lake_rotorua_design_implementation_and_enforcement_-_le.

Rutherford, Kit; Chris Palliser and Sanjay Wadhwa. 2011. "Prediction of Nitrogen Loads to Lake Rotorua Using the ROTAN Model," *Report Prepared for the Bay of Plenty Regional Council,* National Institute of Water and Atmospheric Research, Hamilton.

Rutherford, Kit; Chris Palliser; Sanjay Wadhwa and NIWA. 2009. "Nitrogen Exports From the Lake Rotorua Catchment - Calibration of the ROTAN Model," National Institue of Water & Atmospheric Research Ltd.

Selman, Mindy; Suzie Greenhalgh; Evan Branosky; Cy Jones and Jenny Guiling. 2009. "Water Quality Trading Programs: An International Overview," *WRI Issue Brief: Water Quality Trading No. 1,* World Resources Institute, Washington DC. Available online at http://pdf.wri.org/water_trading_quality_programs_international_overview.pdf.

Shavell, Steven. 1984. "A Model of the Optimal Use of Liability and Safety Regulation", *The RAND Journal of Economics,* 15:2, pp. 271-80.

Shortle, James S. 2012. "Water Quality Trading in Agriculture," OECD, Paris, France. Available online at http://www.oecd.org/dataoecd/5/1/49849817.pdf.

Shortle, James S. and Richard D. Horan. 2008. "The Economics of Water Quality Trading", *International Review of Environmental and Resource Economics,* 2, pp. 101-33.

Tietenberg, Tom. 2006. *Emissions Trading: Principles and Practice,* Second ed., Washington, DC: Resources for the Future.

Tietenberg, Tom and Lynne Lewis. 2009. *Environmental and Natural Resource Economics,* 8th ed., Boston, MA: Pearson Education, Inc.

Turral, H.; T Etchells; M Malano; H Wijedesa and P Taylor. 2005. "Water Trading at the Margin: the Evolution of Water Markets in the Murray-Darling Basin", *Water Resources Research,* 41:W07011.

Van Benthem, Arthur and Suzi Kerr (2013)'Scale and Transfers in International Emissions Offset Programs' *Journal of Public Economics* Volume 107, November, pp. 31-46

Vant, William Nisbet. 2008. "Statement of Evidence of William Nisbet Vant," before the Environment Court, January 2008.

Weitzman, Martin L. 1974. "Prices Vs. Quantities", *Review of Economic Studies,* 41:4, pp. 477-91.

Woodward, Richard T. 2003. "Lessons About Effluent Trading From a Single Trade", *Review of Agricultural Economics,* 25:1, pp. 235-45.

Yeo, Boon-Ling; Simon Anastasiadis; Suzi Kerr and Oliver Browne. 2012. " Synergies between market-based instruments for regulating interdependent pollutants: a numerical analysis of nutrient and greenhouse gas emissions trading schemes in New Zealand" Motu Economic and Public Policy Research, Wellington, New Zealand.

Young, Justine. 2007. "Statement of Evidence of Justine Young," before the Environment Court, January 2007.

Young, Justine; Geoff Kaine and Environment Waikato. 2010. *Application of the Policy Choice Framework to Lake Taupo Catchment,* 20 ed., Hamilton: Environment Waikato.

Recent Motu Working Papers

All papers in the Motu Working Paper Series are available on our website www.motu.org.nz, or by contacting us on info@motu.org.nz or +64 4 939 4250.

13-12 Grimes, Arthur, and Sean Hyland. 2013. "Housing Market Dynamics and the GFC: The Complex Dynamics of a Credit Shock".

13-11 Anastasiadis, Simon and Suzi Kerr. 2013. "Mitigation and Heterogeneity in Management Practices on New Zealand Dairy Farms".

13-10 Grimes, Arthur and Sean Hyland. 2013. "Passing the Buck: Impacts of Commodity Price Shocks on Local Outcomes".

13-09 Allan, Corey, Arthur Grimes and Suzi Kerr. 2013. "Value and Culture."

13-08 Maré, David C., and Richard Fabling. 2013. "The Incidence and Persistence of Cyclical Job Loss in New Zealand".

13-07 Grimes, Arthur, and Nicholas Tarrant. 2013. "A New Zealand Urban Population Database".

13-06 Fabling, Richard, and David C. Maré. 2013. "Firm-Level Hiring Difficulties: Persistence, Business Cycle and Local Labour Market Influences".

13-05 Crichton, Sarah, and David C. Maré. 2013. The Impact of Wage Subsidies on Jobseekers' Outcomes and Firm Employment".

13-04 Crawford, Ron, and David C. Maré. 2013. "Investigation of Options for a New Longitudinal Household Survey: Issues and Options Paper".

13-03 Dixon, Sylvia, and David C. Maré. 2013. "The Costs of Involuntary Job Loss: Impacts on Workers' Employment and Earnings".

13-02 Grimes, Arthur, and Sean Hyland, with Andrew Coleman, James Kerr and Alex Collier. 2013. "A New Zealand Regional Housing Model".

13-01 Fabling, Richard, and Lynda Sanderson. 2013. "Export Performance, Invoice Currency, and Heterogeneous Exchange Rate Pass-Through".

12-14 Motu Economic and Public Policy Research. 2012. "Roadmap for Implementing a Greenhouse Gas Emissions Trading System in Chile: Core Design Options and Policy Decision-Making Considerations".

12-13 Fabling, Richard, Arthur Grimes and David C. Maré. 2012. "Performance Pay Systems and the Gender Wage Gap."

12-12 Kerr, Suzi. 2012. "The Economics of International Policy Agreements to Reduce Emissions from Deforestation and Degradation."

12-11 Coleman, Andrew. 2012. "Pension Payments and Receipts by New Zealand Birth Cohorts, 1916–1986."

12-10 Tímár, Levente. 2012. "Spatial and Temporal Responses to an Emissions Trading System Covering Agriculture and Forestry: Simulation Results from New Zealand."

12-09 Grimes, Arthur, Les Oxley and Nicholas Tarrant. 2012. "Does Money Buy Me Love? Testing Alternative Measures of National Wellbeing."

12-08 Woods, Darian, with Andrew Coleman. 2012. "Price, Quality, and International Agricultural Trade."

12-07 Olssen, Alex, Wei Zhang, David Evison, and Suzi Kerr. 2012. "A Forest-Profit Expectations Dataset for New Zealand, 1990–2008".

12-06 Kerr, Suzi, and Alex Olssen. 2012. "Gradual Land-Use Change in New Zealand: Results from a Dynamic Econometric Model".

12-05 Abramitzky, Ran, and Isabelle Sin. 2012. "Book Translations as Idea Flows: The Effects of the Collapse of Communism on the Diffusion of Knowledge".