Taxes vs Permits: Options for Price-Based Climate Change Regulation

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New Zealand Treasury

Working Paper 05/02

March 2005

THE TREASURY

Kaitohutohu Kaupapa Rawa

NZ TREASURY WORKING PAPER 05/02

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MONTH/YEAR

March 2005

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ACKNOWLEDGEMENTS

We would like to thank Steve Rylands, Kevin Guerin, Joanna Smith and Rienk Asscher at the Treasury, Billy Pizer at Resources for the Future and Ross Cullen at Lincoln University for useful comments. This work draws on Motu's Foundation for Research, Science and Technology-funded project "Land use, climate change and Kyoto", and involves indirect input from Landcare, Forest Research and AgResearch. The authors are responsible for all opinions expressed and all errors and omissions that remain.

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Abstract

This paper provides an overview of key issues involved in the choice among market-based instruments for climate change policy. Specifically, it examines the potential net benefits from shifting to a permit system for emission reduction, and the preconditions necessary for this change. It also draws out the implications of New Zealand's specific circumstances and current climate policies for future policy development.

JEL CLASSIFICATION

Q28 – Renewable Resources and Conservation; Environmental Management – Government Policy

Q48 – Energy – Government Policy

KEYWORDS

climate change; emissions trading; permits; taxation; New Zealand

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Executive Summary

New Zealand needs to get climate change mitigation policy architecture right because climate change may become a major regulatory issue. The current policy is a good start, but it is not complete or fully integrated. The purpose of this paper is to provide an up-to-date overview of key issues involved in the choice among market-based instruments for climate change policy. Specifically, it examines the potential net benefits of shifting to a permit system for emission reduction, and the preconditions necessary for this change. It also draws out the implications of New Zealand's specific circumstances and current climate policies for future policy development.

Price-based instruments, ie, taxes and tradable emission permits, are ideally suited to homogeneous long-term pollutants such as carbon dioxide. They allow maximum spatial and temporal flexibility at no environmental cost. They enable New Zealand policy to be consistent with Kyoto and future likely agreements, and are efficient in the short and long term.

Any mitigation policy, whether based on taxes or permits, must confront important questions of design along the following dimensions: stringency of control; breadth of coverage; the definition and measurement of emissions; the incidence of costs; and the important possibility of revenue recycling. Tax systems and permit systems behave differently in some of these areas. Under a tax system, pressure from companies or sectors for special treatment can be addressed only by granting exemptions. This reduces the breadth of coverage. In a permit system, however, grandparenting is a possible response to pressure without reducing breadth of coverage. In contrast, taxing or providing tax rebates for proxies for hard-to-measure sources and sinks such as nitrous oxide or carbon sequestration in forests might be possible. This would allow breadth across greenhouse gases. The difficulties of permit allocation may make integration of these gases slower. The economic incidence of costs in either a tax or a permit system is independent of the legal incidence, ie, it depends not on who fills in the tax form but on how price signals are transmitted through the economy. Efficient taxes and permits impose the same costs on the same people, those who engage in emitting activities or consume goods that embody emissions. Goods and services with inelastic demand or supply carry more tax burden.

The economically efficient emission tax or permit quantity is where the social marginal costs and marginal benefits of abatement are equal. In a world of certainty, taxes and permits can both yield the same optimal outcome. We are unlikely to ever know marginal costs or marginal benefits with certainty, so the tax rate or permit quantity chosen is unlikely to be optimal. Under uncertainty, a tax system and a permit system yield different emissions outcomes with different efficiencies. The quality of the international permit market is critical to the relative performance of each instrument.

A smooth international permit market is not a certainty. However, if firms from a range of countries were able to participate in an international market, the market would probably be fairly smooth and well functioning. The existing European Union (EU) permit market is not a good indication of how an international market is likely to evolve after 2008 because non-EU members currently have very limited access to the market. New Zealand would find trading emission permits internationally much easier under the Kyoto rules that are expected to take effect in 2008.

When the international permit market works perfectly and there is a domestic tax system, the Government holds all New Zealand's international permits and sets the tax rate charged on firms' emissions. In a permit system, firms cover their emissions by buying domestic permits, which can be converted directly into international permits. In either case, the marginal costs of abatement are the costs of changing to cleaner energy sources, increasing energy efficiency, and adjusting production levels. The marginal benefit to New Zealand is just the international permit price. This is because a firm that manages to reduce its emissions by one unit can then sell the permit that would have covered those emissions (or is prevented from having to buy a permit for the emissions). Thus the firm gains the international permit price. Here taxes yield suboptimal results under uncertainty, whereas permits yield optimal results. Fundamentally, this is because permits adjust instantaneously to changes in the international permit price, whereas taxes require a Government decision to change.

In the other extreme case, when there is no international permit market, the marginal cost curve is the same, but marginal benefits consist of the domestic environmental benefit, international favour from abatement, and the indirect effect of our abatement on other countries' emissions. If we assume marginal cost and marginal benefit shocks are uncorrelated, permits are more efficient if and only if the marginal benefit curve is steeper than the marginal cost curve. Otherwise taxes are more efficient. Because of the fuzzy nature of marginal benefits in this case they seem likely to be less responsive to New Zealand's emissions, so we judge that marginal cost will be steeper, favouring a tax system over permits.

These results, with and without an international permit market, suggest that a hybrid tax/permit system could be a good policy option. A hybrid system is a permit system with a trigger price at which firms can buy unlimited permits from the Government. Under normal circumstances this acts like a permit system. However, if the international permit price goes too high, it begins to operate effectively like a tax system.

Two types of risk are associated with emission regulation: exogenous risk, which is caused by factors outside the Government's or an individual firm's control; and endogenous risk, the risk of opportunistic behaviour on the part of firms or the Government. There are four types of exogenous risk. Wealth risk is the risk that New Zealand's target under the international agreement might change. This would alter the number of permits New Zealand holds. Demand risk is the risk that firms' demands for emissions could change as a result of factors beyond their control. Asset risk is the risk permit holders face of capital gains or losses. Price risk is the risk of a change in the opportunity cost of using permits when permit prices change.

Risk allocation matters for efficiency for two reasons. Some agents are able to reduce some types of risk, and will do so if they bear those risks. Agents have different risk aversions, and there are costs to risk-averse agents bearing risk. The costs are the direct welfare cost and induced undesirable behaviour such as reduced investment.

When faced with risks, agents may have the option of reallocating them to less risk-averse parties by using derivative markets, or the agents may make real investment responses to cope better with unexpected changes. If there are good derivative markets, private agents are in a good position to deal efficiently with risk. If good derivative markets do not exist, the Government should take on more of the risk to avoid some very risk-averse parties bearing disproportionately high risk.

Under a domestic emission tax system, risk can be shifted between the Government and private agents by changing how frequently the tax rate is adjusted. The more frequently it is adjusted, the more risk private agents bear. Under a domestic permit system, it is important that legal conditions are conducive to the development of derivative markets. Some permits should be allocated in advance to allow asset price risk to be effectively allocated through derivative markets and move some asset risk away from the Government. The allocation of risk argument suggests that a hybrid tax/permit system would be desirable because firms would then be protected from the risk of very high permit prices that may arise without the global marginal benefit being commeasurably high.

Endogenous risks can arise from either Government or firms' behaviour. The Government may act opportunistically by changing the rules of the game; and firms may lobby the Government for changes that benefit them, strategically under-invest, or misrepresent their costs of abatement. In either regulatory system, policy targets should be made more credible through education and debate. In a tax system, the Government can minimise opportunistic behaviour by avoiding granting exemptions and setting out clearly the conditions for a change in the tax rate and a formula for the new tax rate. In a domestic permit system, permits should be defined as percentages of future targets, which would help reduce the incentive for the Government to interfere with future aggregate targets. In addition, permits should not be grandparented more than necessary and the Government should support clean technologies and tax energy-intensive ones.

With a domestic permit system, market liquidity is important for good information, low transaction costs, fair prices and mitigation of market power. Market liquidity depends largely on the international market, but can be enhanced by having a broad market and simple rules. Market power is unlikely to be an issue unless a large share of permits is grandparented to one company and the international market does not function.

Permits should be defined for one use, they should be infinitely divisible, advance allocations should be defined as percentages of the New Zealand target, each permit should be marked with a "use after" date, and they should be directly convertible to assigned amount units. One-use permits are relatively simple to administer and trade. They also make it easier to define bankability and gradually phase out grandparenting.

Permits should be grandparented when necessary for political reasons, but grandparenting should be phased out on a defined basis. The Government could simply require all firms to buy permits from the international market. Alternatively, the Government could hold periodic auctions with several "vintages" of permit.

We recommend that for fossil fuel carbon dioxide emissions a hybrid permit system with a high trigger price be used. Permits are politically feasible because of the option to grandparent. They are economically optimal if the international market functions. They allow more flexibility in the allocation of risk than taxes, and they would be simple and work well. A hybrid system would protect firms against a failure in the international market, extremely high international prices or the collapse of international cooperation. Carbon sequestration in plantation and indigenous forests should be integrated into the permit system. This would yield huge potential gains, but there are still challenges, primarily in the distribution of permits, which need to be solved. Taxes and subsidies for "projects" for non-fossil fuel emissions should be used temporarily.

Taxes vs Permits: Options for Price-Based Climate Change Regulation

1 Introduction

This section begins by looking at New Zealand's motivation for re-examining our greenhouse gas emission reduction policies. It goes on to outline briefly the policy New Zealand currently plans to use to meet its obligations under the Kyoto Protocol. It concludes with a short discussion of the concepts and basic designs of an emission tax and a permit system.

1.1 Motivation

New Zealand aims to be on a permanent downward emissions track by 2010. This is not looking likely based on current inventories and projections. Thus the Government needs to review the policies it uses to encourage emission reductions. Although the current broad market-based instrument is a charge, the possibility of moving to an emissions trading system is not precluded by politicians.

The Kyoto Protocol covers six greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), and carbon dioxide sinks. An efficient policy to address global warming would tax (make liable) carbon dioxide emissions from forest harvesting and deforestation and subsidise carbon sequestration as well as tax the other greenhouse gases: methane, nitrous oxide, SF_6 and HFCs. The different gases would be taxed at different rates, depending on their estimated effects on global climate change. Adding carbon sequestration and other greenhouse gases increases the complexity of the system. They primarily differ because of measurement issues, differences in the uncertainty about costs and difficulties in choosing an appropriate point of assessment. There is a trade-off between complexity and efficiency. There is no reason why the policy cannot be developed incrementally with new sinks and sources being added as their impact on efficiency becomes greater than their cost in terms of administration and complexity. Initially, if New Zealand is considering a low level of regulation, the additional economic benefits may not be justified given the increase in political and administrative difficulty. The policy chosen should however be designed in such a way that the extension of the system is facilitated. In this paper we focus on carbon dioxide emissions. We talk a little about carbon sequestration, methane and nitrous oxides in Section 6.2 but do not touch on specific issues relating to SF_6 or HFCs.

This paper considers two central regulatory options for carbon dioxide emissions: taxes and an emissions trading system. It aims to provide an up-to-date overview of key issues involved in the choice among market-based instruments for climate change policy. Specifically, it examines the potential net benefits of shifting to a permit system for emission reduction, and the preconditions necessary for this change. It also draws out the implications of New Zealand's specific circumstances and current climate policies for future policy development.

1.2 Current New Zealand policy

In October 2002, the New Zealand Government confirmed the policies that will assist it to achieve its obligations under the Kyoto Protocol.[1]

1. An emissions charge, principally in respect of greenhouse gas emissions from fossil fuels. This may be replaced by emissions trading.

2. The Projects to Reduce Emissions programme, which provides internationally tradable credits for projects that will reduce New Zealand's greenhouse gas emissions.

3. Negotiated Greenhouse Agreements (NGAs), which provide relief from all or part of the emissions charge to firms or industries that would otherwise suffer reduced international competitiveness, in return for the commitment to reduce emissions intensity to world's best practice levels.

4. A partnership agreement between the Government and agricultural sector groups on voluntary research into agricultural greenhouse gas emissions.

5. The Government has retained sink credits and associated liabilities allocated to New Zealand under the Kyoto Protocol in recognition of the carbon sink value of post-1990 forest plantings. These credits will be retained and managed by the Government, at least for the first commitment period. The Government has also assumed the liability created by the Protocol for deforestation, up to a specified cap of 10% of forests expected to be harvested during the Protocol's first commitment period.

6. Forest owners who establish new, permanent "non-harvest" commercial forest sinks will receive fully tradable Kyoto Protocol-compliant emission units in proportion to the carbon sequestered in their forests.

7. A "New Zealand Communities for Climate Protection" (CCP) programme in partnership with the International Council for Local Environmental Initiatives and councils. The CCP programme will reduce greenhouse gas emissions by improving energy efficiency and conservation, enhancing sustainable transportation and urban design, and reducing landfill emissions.

8. The Resource Management Act 1991, which requires that all resource and planning decisions take into account their impact on the environment.

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[1] These policies are taken from New Zealand Climate Change Office Information Sheet "Climate change policy in brief" <http://www.climatechange.govt.nz/resources/info-sheets/policy-in-brief.html>

9. A voluntary policy approach to synthetic gases. The Government has an agreement with industry to limit leakage of SF_6. There is also a voluntary handling, education and recovery programme for refrigeration and insulation uses of HFCs and PFCs.

10. Other policies that include:

    (a) the National Energy Efficiency and Conservation Strategy;

    (b) the New Zealand Transport Strategy;

    (c) the New Zealand Waste Strategy;

    (d) the Growth and Innovation Framework;

    (e) research;

    (f) a public awareness and education programme;

    (g) a Sustainable Energy Framework.

New Zealand has established climate change partnerships with Australia and the United States to enhance dialogue and practical cooperation on climate change issues.

The current package of policies has several drawbacks. It leads to economic inefficiency because the incentives to abate differ across sectors of the economy. It is also administratively complex, with a central emission tax, negotiated exemptions from this tax, and numerous additional schemes.

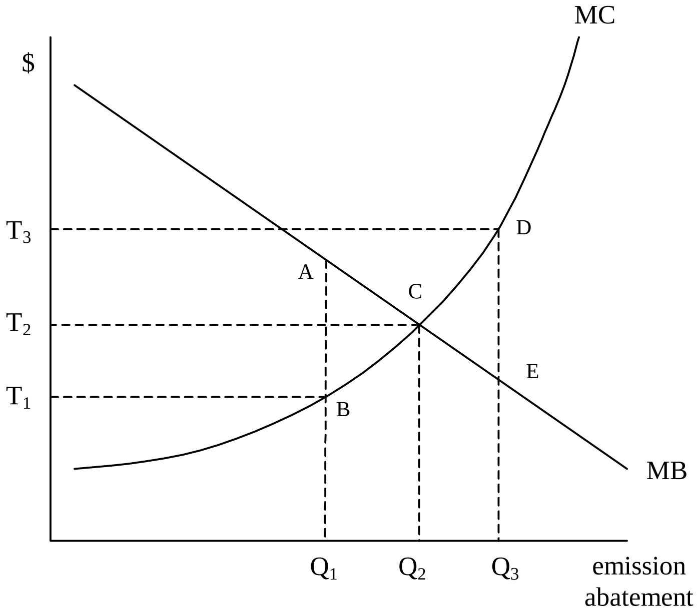
1.3 Basic design of taxes and emissions trading systems

1.3.1 Tax

Under a tax, the ideal is for emissions of greenhouse gases to be taxed proportionately to the harm they cause the environment, causing agents in the economy to reduce their greenhouse gas emissions whenever this can be done at less cost than the value of the tax.

In a theoretical setting, the level of the tax should be set at the price that equates society's expected marginal cost of abatement (MC) with its expected marginal benefit (MB). Figure 1 illustrates the optimal choice of an emission tax, T_2. This results in a quantity of abatement equal to Q_2. If the tax is set too high, at value T_3, abatement will be above optimal, at the quantity Q_3. This results in a net social loss of area CDE. If, on the other hand, the value of the tax is set too low, at T_1, abatement is only equal to Q_1, and the net social benefits foregone are equal to area ABC.

Figure 1 – The optimal level of an emission tax



The amount of abatement carried out by individual agents in the economy depends on the individual marginal cost of abatement curves of these agents. Agents can minimise their total costs by abating until their marginal costs of abatement equal the value of the tax. If all agents follow this optimising behaviour, the marginal costs of abatement are equalised across the economy and the level of abatement is achieved at the lowest total cost to the economy.

Emissions must then be monitored in some manner to ensure that the correct taxes are paid. The way this is done is likely to vary with the greenhouse gases being taxed. Carbon dioxide is one of the easier greenhouse gases to monitor and regulate. This is because there exists almost a perfect correlation between carbon dioxide emissions from fossil fuels and the carbon content in the fuels. Thus the sources of fuel, of which there are relatively few, can be monitored rather than the emissions themselves. With a sufficiently competitive market, this leads to the same economic effects as would direct regulation of the emissions.

1.3.2 Emissions trading

The idea behind tradable emission permits is that the Government or an international agreement decides what is an acceptable level of greenhouse gas emissions for the country, then the Government gives away or sells permits to emit greenhouse gases that add up to this amount. Firms may trade the permits among themselves, with the result that firms that find it very cheap to reduce their emissions do so, whereas firms that find it expensive to reduce their emissions purchase more permits and are required to reduce their emissions very little, if at all. As a result, when there are no frictions in the permit market, the marginal costs of abatement will be equalised all through the economy, causing compliance to be reached at the least total cost to the economy. The prices of permits move with what firms are willing to pay for them, and thus they come to reflect the marginal cost of reducing emissions.

A permit system can achieve the same optimal level of abatement as a tax system by choosing a cap equal to Q_2 in Figure 1. The permit price would then adjust to T_2.

In order to monitor and enforce such a system for carbon dioxide, authorities would need to measure only fossil fuel imports and production, and keep track of the number of permits importers and producers held. If any firm were found to have insufficient permits to cover its fossil fuel sales in any period, it would face stiff fines and would be required to purchase permits to remedy the shortfall.

1.4 Effects on efficiency of abatement in the short and long term

1.4.1 Short term

Market instruments, namely taxes and permits, cause efficient abatement because they provide incentives to equalise the marginal cost of abatement across all firms and all sectors of the economy. This means that the level of abatement that occurs is accomplished at the lowest total cost. The same effect would be impossible to achieve through a command-and-control system because the Government would require marginal cost information for all regulated firms in order to make the appropriate decisions. Market instruments, on the other hand, give firms incentives to act optimally given their marginal costs, whether or not the Government knows what these costs are.

1.4.2 Investment, innovation and diffusion

The long-run efficiency of abatement of any policy depends largely on the extent to which it encourages firms to invent, innovate and invest in emission-reducing technologies. Because New Zealand is a small country, most new “clean” technologies are developed overseas and adopted by domestic firms. Consequently, incentives to invent and innovate may be less important to our situation, and incentives to invest may be more important.

Price-based instruments provide stronger incentives to innovate than technology standards. Under a technology standard, any firm that identified a cleaner production technology would risk having the use of the technology imposed upon it. Unless the new technology had lower costs than the technology stipulated by the standard, the firm would be disadvantaged by this innovation, thus the innovation would not occur in the first place.

Under a price-based instrument, the incentive a firm has to innovate depends on how easily it can capture the rents from the innovation. This depends on how much of the technology the firm is able to patent, its ability to sell its innovation to other firms, and the ability of competing firms to imitate the innovation.

Sections 3.1 and 3.2 of Kerr *et al*(2002) discuss the dynamic efficiency of invention, innovation and diffusion decisions for New Zealand in more detail.

2 Design issues common to taxes and permits

This section goes into greater depth about the design of greenhouse gas emission tax and permit systems, specifically systems regulating carbon dioxide emissions from fossil fuels. It deals with the stringency of regulation over time, issues about the breadth of coverage of the regulation, defining and measuring emissions, factors that determine who ultimately bears the costs of regulation, and the use of any revenue raised.

2.1 Expected intensity of control over time

The level of intensity of control is, in essence, determined by the price of permits in the international market. The choice faced by the New Zealand Government is then whether to absorb some of the cost of control itself and try to impose a different intensity of control upon the domestic economy. Under a tax system, the Government could do this by setting the tax rate at a level different from the international permit price. In a permit system, some sort of limitation on trading domestic permits internationally would have to be used. This situation is quite different from a standard permit situation, in which the cap determines the intensity of control.

New Zealand could try to achieve domestic compliance without trading permits internationally. In this case, creating domestic permits at the overall quantity of emissions targeted by New Zealand would achieve the objective with minimal difficulty. Setting and changing the tax rate to achieve the target emissions each commitment period at the lowest possible cost is much more difficult. The path of the tax rate within the commitment period, and thus the distribution of emissions over the period, affects the total cost to the economy of making the emission reductions. The Government simply does not have the information required to make optimal tax rate decisions.

2.2 Breadth of coverage

By breadth of coverage, we mean the proportion of the emitting economy that falls under regulation by the tax or permit system. There are considerable potential benefits to broad coverage. Broad coverage implies the marginal costs of emission abatement are equalised across the whole domestic economy, as is efficient. Granting exemptions, on the other hand, often implies that some firms could decrease emissions at lower marginal cost than others, yet are not required to do so. This causes economic inefficiency. The major exception to this generalisation is where firms operate in a competitive international market and are unable to absorb or pass on any extra costs. Imposing costs on them will result in production and emissions simply moving offshore. Thus preferential treatment for “competitiveness-at-risk” firms is theoretically justified. It is difficult to identify competitiveness-at-risk firms. Most New Zealand firms compete internationally to a certain extent. In practice, a differentiated policy may create more problems than it solves.

Broad coverage also means that all businesses face full incentives to develop emission-reducing technology or procedures. The amount of revenue recycling that broad coverage allows could result in considerable tax cuts in other areas. This could give all domestic firms significant competitive advantage over their international competitors.

Additionally, broad coverage means permit markets are likely to be thicker, which is important if there is no international permit market.

The proposed tax system is limited in breadth in two ways. First, it only includes specific types of emissions. The tax covers fossil fuel carbon dioxide emissions, yet excludes net emissions from agricultural methane, forest sinks, SF_6 and nitrous oxide. The rationale for this is that, at least in the short term, the costs of taxing these emissions are too great in comparison with the gains that could be had from a tax. Second, some businesses are negotiating relief from carbon dioxide emission taxes through NGAs. The economic justification is that these businesses would be unable to compete with international firms that are not subject to New Zealand regulation if they were required to pay the tax. In the absence of exemptions, they might not be able to remain competitive and may be forced to downsize or liquidate, with negative consequences for their employees and owners. This gives no real environmental gains, because output and emissions are likely simply to move offshore.

However, NGAs aren't total exemptions from emission regulation. Businesses with NGAs are required to follow some sort of international best practice. This is costly to define and monitor. NGAs still increase the marginal costs of production of firms, and may cause competitiveness issues, although these are not as severe as they would be if the exemptions were not granted. Additionally, exemptions with a stipulation for international best practice remove the incentives of the exempted firms to develop new and improved business practices that reduce emissions but that are not specified in their agreements. Furthermore, while they constrain the production process, they do not pass on any pressure to change consumption or output levels of the good being produced, thus they ignore an important avenue for emission reduction. Exemptions may be very complex to administer, because taxes are levied on upstream firms, but it is downstream firms that are likely to be granted exemptions. Exemptions require the tax embedded in inputs used by the exempted firms to be measured or estimated, which is likely to be difficult and costly.

When a business is exempt from emission taxes or permits, the Government must assume responsibility for its emissions. The Government must either purchase more permits on the international market or sell fewer, and it cannot recover these costs from the emitting firm through taxes or permit sales. The costs of shocks that change emission levels from the unregulated businesses are also borne by the Government and ultimately by taxpayers. The Government can only cover these expenses through general taxation, which causes inefficient distortions in the economy.

If NGAs are not wisely granted, several additional problems may arise. The first involves the effectiveness of the regulation. If NGAs are too easy to obtain, the businesses that produce most of New Zealand's emissions are likely to receive exemptions, and the abatement gains from the emission regulation will be minimal. The second problem is that of leakage. Small firms are less likely to receive NGAs. This is inequitable, and it could also shift production from small firms without NGAs to large firms with them. Consumers may also switch from included to exempt power sources, such as switching from using electricity for heating to burning wood, which is less efficient and may have local environmental impacts.

Even though the proposed tax system covers only some types of emission, it is still valuable to use an economic instrument to regulate those emissions that are covered. The existence of exclusions does not affect the effectiveness of regulation in the sectors that remain, unless they compete with non-regulated sectors.

If narrow coverage is initially chosen, it may become desirable at some point in the future to broaden the coverage of the emissions regulation. Thus any scheme that grants exemptions should include a mechanism to bring companies with exemptions into the system at some point in the future.

In "projects", firms are given emission credits for undertaking emission-reducing investments that would not occur without the support. These are one aspect of the current regulatory system that increases its breadth of coverage. They are intended to encourage emission-reducing action before 2007. The project scheme could be regarded as a nascent emissions trading system, but it is not desirable to view it as a transition to a full permit system. It should be used for learning only. For one thing, the credits are given to downstream firms, not the upstream firms that should be regulated in a permit system. Additionality is also a significant difficulty. That is, credits are only supposed to be given for investment additional to that that would occur without the scheme, but this baseline is very difficult to determine. Projects are very complex to administer, and they could never achieve full coverage. Furthermore, they form a dangerous precedent of paying polluters to reduce emissions as opposed to requiring them to cover their emissions with permits.

2.3 Definition/Measurement of emissions

2.3.1 What is regulated?

For simplicity of monitoring, greenhouse gas emissions themselves would not be regulated. Instead, some observable quantity with a direct relationship with emissions would be regulated. This might be inputs of fossil fuels for carbon dioxide, or stock numbers for methane. The definition of the observable that was monitored would not necessarily have to remain constant over time, but could change as technology or monitoring methods evolved.

For an economically efficient policy, equal incentives to abate must be provided at all margins: output, emissions per unit, fuel choice, investment etc. Any firm or individual considering an action that would increase or decrease emissions should take into account the effects of their action on greenhouse gas emissions. Firms that are being established or considering closing down should recognise the greenhouse gas effects of all their actions. Taxing or requiring permits for all net emissions achieves this outcome and in most cases is also administratively simplest.

In the case of carbon dioxide emissions, nearly all fossil fuel or other carbon source that is imported or extracted will ultimately release a fixed amount of carbon dioxide into the atmosphere. Small adjustments may need to be made for non-combustion uses such as petrochemicals. There is a lag in timing between the import of fuel and its combustion but this is not very large.

2.3.2 Who is regulated?

Any regulation should be imposed at a point where those who are regulated comprehensively (or as much as possible) "control" the pollutant. Those who are regulated may not be the final consumers or emitters who need to change their behaviour but they can completely control emissions because they control the flow of the intermediate product. Their ultimate effect on emissions may be primarily through the price mechanism.

Another issue in choosing the best point of regulation is finding the level at which the costs of monitoring and administering the system (in terms of both reporting costs for firms and costs to the Government) are minimised. In both a tax and an emissions trading system, emissions must be monitored. In a tax system, tax payments must be matched with emissions while in an emissions trading system the ownership of permits must be tracked and permits must be matched with emissions. There may be legal subtleties. Regulation is simplest when it involves the smallest number of the most sophisticated players.

For some greenhouse gases, the choice of point of regulation may have distributional effects. For instance, if regulation occurs at the downstream firm level, firms may expect permits to be grandparented rather than auctioned. In the case of carbon dioxide, regulation would occur upstream, and many of the firms involved would be international oil companies, which would not expect grandparented permits. Auctioned permits may also be more acceptable in a permit system that is preceded by a carbon tax.

The choice of point of regulation could affect the efficiency of regulation if it affected the initial allocation of permits and permit markets did not operate smoothly. If firms are unable to trade easily, the initial allocation affects their ability to emit. However, we expect the permit market to be smooth, so allocation should have little effect on the outcome.

Regulating an emissions trading system in the case of carbon dioxide is not as complex as people may expect. It is clearly optimal to regulate at the highest point possible, that is, where carbon is imported or extracted. At this level there are only a relatively small number of importers and extractors of fossil fuels to be monitored. Relatively good information already exists on their activities. (See Cramton and Kerr (2002) for discussion on the arguments for an "upstream" emissions trading system.) This achieves the environmental outcome at close to minimum cost, and minimises administrative costs and complexity.

2.4 Incidence of costs

Who will pay the costs of climate change policy is not immediately apparent. There are four critical points here:

1. Who actually bears the cost is independent of who legally pays the tax or holds the permit.

2. The incidence of cost and wealth transfers is exactly the same in a smoothly operating permit system with auctioned permits as in a tax system.

3. Taxes are borne by those who engage in activities or consume goods that are associated with high emissions.

4. Taxes are borne by those who demand products for which total demand is inelastic.

2.4.1 Who actually bears the cost is independent of who legally pays the tax or holds the permit

This is a standard result in public finance where markets operate smoothly. For example, suppose a wholesaler pays the tax. The wholesaler is unable to reduce the amount of carbon in its fuel and it faces competitive international and domestic markets in fossil fuels. It has to pass on the full amount of the tax to its purchasers. If the purchaser is a business facing a competitive market with a fixed price (set by an alternative producer that does not use carbon), it is not able to raise its price to consumers who can buy the same good from other non-fossil-fuel-using suppliers at the old price, and the purchaser will absorb the entire price rise on the fossil fuel it uses.

Alternatively, suppose the business must pay the tax on every unit of fossil fuel it purchases. If it reduces its demand for fossil fuel, it will not alter the price offered by the wholesaler, although it will reduce the business's total tax burden. Similarly, it is unable to pass on a price rise to its consumers. Again it bears the full cost of the tax on each unit of fossil fuel it uses.

If the consumer were required to pay the tax on the amount of carbon "embodied" in the product, and they face substitute products without carbon, they will only buy the product if the price is the same as before and therefore the business must again absorb the tax.

The business will of course reduce the amount of tax it must pay by reducing carbon use until the cost of reducing carbon emissions by one more unit is the same as the tax.

2.4.2 The incidence of cost and wealth transfers is exactly the same in a smoothly operating permit system with auctioned permits as in a tax system

If permits are auctioned, every time a wholesaler extracts or imports a unit of carbon (in fossil fuel or other sources), it must buy one permit. The price of this permit will be equal to the tax that would lead to the same level of total emissions. Thus paying for the permit is exactly equivalent to paying the tax and the conclusion from the previous section, that the incidence does not depend on who must buy the permits, holds.

If permits are not auctioned, once they are allocated their effect is still like a tax. If a business emits one more unit, either it needs to buy a permit at the market price or it forgoes the opportunity to sell a permit. Either way the emission costs it the same amount as the tax and it will pass part of the cost on and/or increase abatement depending on its elasticity of supply and the elasticity of demand it faces.

The allocation of permits by a system other than auctioning is simply a wealth transfer and has no effect on incentives to abate and hence no effect on efficiency. It makes no economic sense to allocate permits to wholesalers that can pass on the costs and hence pay little of the tax or permit cost. This is particularly true when many wholesalers are foreign owned.

2.4.3 Taxes are borne by those who engage in activities or consume goods that are associated with high emissions

The incidence of a tax falls upon those who consume goods or services that ultimately required emissions to produce. Kerr (2001) demonstrates this for a petrol tax where she finds that those in middle income ranges will bear the highest tax burden.

2.4.4 Taxes are borne by those who demand products for which total demand is inelastic

In a tax system (and hence equivalently a permit system) when a business or individual faces a higher price due to the tax, they can reduce their demand for the good and/or pay a higher price. If enough buyers can reduce their demands significantly, if for example there are close substitutes, the seller of the good will be concerned about losing their market and will be unable to raise the price as much. For example, if an electricity company faces higher input costs due to a rise in the price of coal it could try to increase the price of electricity but this may encourage people to be more energy efficient or switch to gas for heating and cooking. Thus the electricity company may choose not to raise the price too much but may try both to cut down its use of coal and to absorb the input price rise in its profit.

The businesses and people who will bear the highest cost from a tax on carbon are those with high demand for energy, who are unable to reduce their energy demand and unable to change to a less carbon-intensive fuel. If they are a business they will lose profits and may be forced to close down. Individuals may suffer noticeably lower living standards. It is extremely hard to identify who many of these people and businesses will be in the long run.

The costs of the carbon dioxide policy are both the costs of paying the tax and the real costs of abating the use of carbon and products produced using carbon. The tax payments (or permit costs) are not a real cost to the economy because they are received by the Government as revenue, but they are real costs to firms. The real costs of abatement are the deadweight losses caused by a reduction in the quantity consumed of the products whose production causes emissions.[2]

2.5 Revenue recycling

Both emission taxes and auctioned permits can raise revenue for the Government. If the Government can raise revenue while achieving an environmental goal it can reduce its need to raise revenue elsewhere. Kerr (2001) explains why reducing revenue raised through taxes elsewhere has efficiency gains for the economy:

> Taxes on labour income and on capital cause inefficient distortions in behaviour. For example, with no taxes, wages will be equal to the marginal productivity of the worker (simplistic but roughly true). Each person will work until the value of the extra amount they produce is equal to the extra cost to them of working – their marginal utility of lost leisure. With a labour tax, this decision is distorted because they are paid only a percentage of the value they produce and thus will stop work sooner or choose not to participate in the labour force at all. This is socially inefficient because the social benefit of their work is unchanged, some benefit simply goes to the Government through taxes.[3]

The revenue raised through environmental policy should be used to lower overall taxes, or for independently planned spending, depending on the Government’s fiscal priorities. Adolf Stroombergen did some work on revenue recycling in New Zealand in 1994, and

[2] Kerr (2001) illustrates these losses (page 8).

[3] Kerr, Suzi (2001) "Ecological tax reform", Report prepared for the New Zealand Ministry for the Environment, page 6.

found that GST or income tax would probably be the best tax to cut.[4] Not claiming the revenue for Government use exacerbates the competitiveness impacts of climate policy because the cost of carbon regulation is not partially offset by lower taxes or improved government services. Goulder *et al* (1998) estimate that in the United States, if emission reductions are less than 23%, grandparenting all permits rather than auctioning them would double the cost of the regulation because of the lost opportunity for revenue recycling.

For optimal efficiency, revenue should certainly not be used to compensate the sectors that are directly affected, as this would decrease the efficiency of the regulation and lower the environmental benefit. There may be an argument for transitional assistance, but an industry that fails when it faces the full costs of its activities is not economically efficient, and should not be propped up by the Government in the long run. The revenue should also not be used to fund other environmental or carbon policies, which should be considered on their own merits and funded out of general tax revenue. This form of revenue is no different from any other and should be treated as such.

Nevertheless, politics may suggest the revenue raised is directed towards climate policies. Public perception of a carbon tax or auctioned permit system may be better if those who pay feel the money is being used for good climate policies. This could be a problem if tax revenue is very high. Under the proposed tax system, net carbon tax revenue from a $15 per tonne tax is estimated to be $660 million per annum. It could be very inefficient to commit such a large amount of money to climate policy. As a compromise, it may be desirable to direct visibly some of the revenue to environmental projects that are desirable in themselves. Some of the revenue could also be used for investments that improve adaptation to climate change.

There may also be a case for transitional assistance and retraining of workers affected by industries that are damaged by the policy. If, for social reasons, there are groups toward which the Government would like to direct resources to maintain their standards of living as energy prices rise, such as the elderly, this can be done through increases in superannuation or improvements in health care and other services.

[4] Personal communication with Adolf Stroombergen, Infometrics, July 2004.

3 What are fundamental and unavoidable differences between taxes and emissions trading?

This section discusses the ways in which taxes and permits are unavoidably different. It begins by outlining the manner in which each regulation system would interact with an international permit market and discussing the likelihood of such a market developing. In a world without uncertainty, permits and taxes are equally efficient. However, uncertainty is real and important. The section goes on to examine how the environmental and economic risks faced are different under each system when regulation occurs in an uncertain world, and how these risks would be affected by the presence of an international permit market. The section then discusses the optimal allocation of the exogenous risks associated with emission regulation and how policy can be designed to achieve this risk allocation. Endogenous risks, risks of opportunistic behaviour by private firms or the Government, are then discussed. The section concludes by noting the different cost allocation capabilities of a tax and a permit system, and the possibility of transaction costs in a permit market.

3.1 Interaction with international emissions trading market

This section gives an overview of the way in which a domestic tax or permit system would interact with an international permit system. Further details on the more technical aspects can be found in Kerr (2000).

3.1.1 Tax and an international market

By their very natures, domestic emission tax systems and emission permit systems interact differently with an international permit market. Under a tax system, the Government is fundamentally responsible for achieving compliance with Kyoto for the country. The Government sets the level of the domestic emission tax it considers best, and firms act in their own best interests given the presence of the tax. If, as a result, the country under-complies with its obligations under the Kyoto Protocol, the Government is required to purchase sufficient emission permits on the international market to cover the shortfall in abatement. On the other hand, if over-compliance is achieved, the Government can sell the surplus permits internationally and generate revenue. In this scenario, in the absence of changes in the emission tax rate, shocks to the international permit price are absorbed by the Government.

In the absence of an international emissions trading market, a tax that causes domestic under-compliance will cause the country to not meet its target under the Kyoto Protocol; and a tax that causes over-compliance no longer leads to the benefit of revenue from selling permits internationally.

3.1.2 Permits and an international market

With a permit market, the Government is able to pass liability for reaching compliance-level emissions in covered sectors to private firms. In the simplest case, a domestic emission permit is defined identically to an international permit, and the two can be freely traded on the international market. The Government may choose to allocate (by means of *gratis* allocation or auction) emission permits that add up to the country's emission target to domestic firms. Alternatively, it could require all firms to purchase their own permits on the international market, and could sell the country's allocation internationally. The Government theoretically need do nothing to ensure the compliance of the covered sectors of the economy, although it is responsible for purchasing permits for the uncovered sectors. If a covered firm finds itself requiring fewer or more emission permits, it sells or buys these on the international market. When all domestic firms cover their emissions thus, the country automatically finds itself in compliance. The marginal cost of compliance to each firm here will be equal to the international permit price, provided transactions on the international market are costless. Unlike in the tax scenario, here shocks to the international permit price are borne by private firms.

In the absence of an international market, a permit system can still ensure domestic compliance, but no longer places any limit on the marginal cost that achieving compliance may have.

3.1.3 Why there may not be an international market

Whether a liquid international permit market develops depends critically on the behaviour of the EU. The most likely way for an international market to develop is for the EU's market to be extended to include other countries. However, this would require a change in the governance of the EU market, which is not an insignificant step. The EU may also do other things to hinder the development of a full international market, such as refuse to recognise New Zealand credits gained from forest sinks. Now that Russia has signalled its intention to ratify, it may be easier for the EU to allow trading outside the EU under the governance of the United Nations Framework Convention on Climate Change negotiated rules for International Emissions Trading, Joint Implementation and the Clean Development Mechanism.

Beyond the participation of countries, firm participation in an international market is required to achieve liquidity. If only governments participated in the market, trades would be few and infrequent, and no informative price mechanism would develop. With participation by firms, however, the number of players in the market would increase greatly, and trades would be frequent. For firms to trade on an international market, they must first trade on a domestic market. It is not clear how many countries outside the EU plan to implement domestic permit trading schemes.

If firms from a range of countries were able to participate in an international market, the market would probably be fairly smooth and well functioning. The existing EU permit market is not a good indication of how an international market is likely to evolve after 2008 because non-EU members currently have very limited access to the market. New Zealand would find trading emission permits internationally much easier under the Kyoto rules that are expected to take effect in 2008.

3.2 Environmental vs economic risk

3.2.1 Tax versus tradable permits under uncertainty

Theory in standard domestic regulation situation

In a scenario where the Government has complete knowledge about the aggregate costs and benefits to the country of reducing greenhouse gas emissions, producers know their own abatement costs, and where there is perfect certainty, taxes and tradable emission permits achieve exactly the same abatement at the same cost. However, the Government is likely to know less than producers about the costs of emission abatement, and even producers have imperfect knowledge about these. Furthermore, no one is likely to know the true benefits of abatement with any degree of certainty. Constantly developing technology and an otherwise dynamic, changing world mean neither costs nor benefits are able to be learned precisely, as both are perpetually buffeted by shocks.

In these circumstances, a price instrument such as an emission tax and a quantity instrument such as emission permits offer different guarantees and different risks. A tax limits the marginal cost of abatement, thus providing more economic certainty while making no guarantee about emission levels.

On the other hand, a permit system limits total emissions, thus providing environmental certainty, but does not necessarily limit the marginal cost of achieving the desired abatement level.

If the Government chooses quantity regulation, the optimal choice of quantity is that which maximises the expected benefits minus the expected costs. Similarly, the optimal tax under price regulation is that which maximises the expected benefits minus expected costs, given the way producers are expected to respond to the tax. A classic result shown in Weitzman (1974) is that uncertainty in the costs of abatement, but not uncertainty in the benefits, can have significant effects on the choice between emission taxes and permits, provided shocks to benefits and costs are uncorrelated. The intuition behind the idea that marginal benefit uncertainty does not affect the choice of instrument is that with neither a tax nor a permit system do firms change their behaviour in response to a marginal benefit shock. Thus both instruments yield the same social loss when marginal benefits are not equal to their expected values.

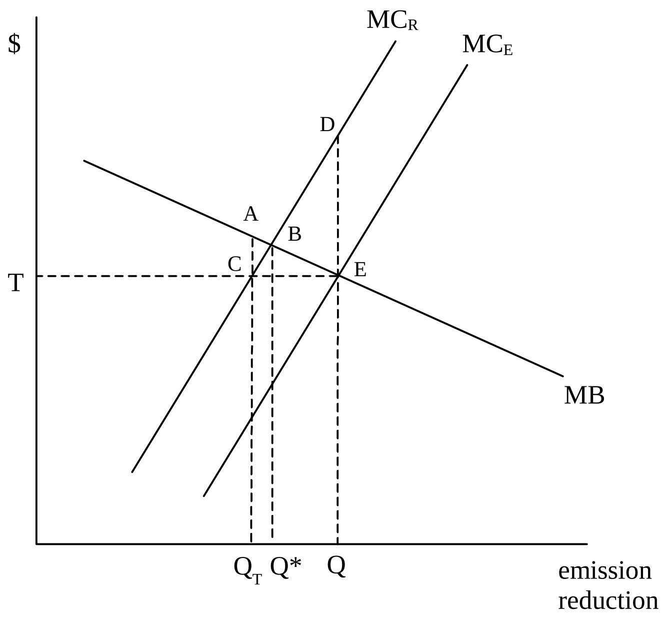
In the unlikely event that the costs of abatement were known with certainty, taxes and permits would yield the same environmental and economic results. However, the greater the uncertainty over the position and shape of the cost curve, the greater the difference between the outcomes likely to be achieved with a quantity instrument and with a price instrument.

Whether a tax or a permit system is preferable depends critically on the slopes of the marginal cost and marginal benefit curves of abatement. In the absence of other considerations, a quantity instrument is preferable if and only if the marginal benefit curve is more steeply sloped than the marginal cost curve. This is illustrated in Figure 2 for marginal cost and marginal benefit curves with different relative slopes. In each panel, MC_E represents the expected marginal cost curve, and MB is the marginal benefit curve. T is the value of the emission tax expected to yield the socially optimal reduction in emissions, and Q is the quantity of emission reduction that would be chosen in the case of a quantity instrument.

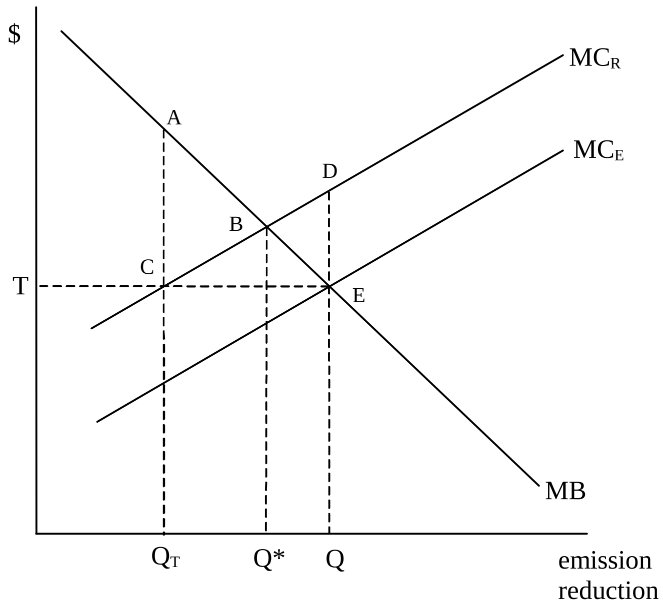
However, suppose actual marginal costs are unexpectedly high at all quantities of emission reduction, represented by the line MC_R, and thus the quantity of emission reduction that is *ex post* optimal is lower, at Q*. Because producers choose their levels of emission reduction with regard to the realised marginal costs, under an emission tax they choose an emission reduction of Q_T. Under quantity controls, producers achieve the targeted emission reduction, but at a higher cost than expected.

Figure 2 – The effect of marginal cost and marginal benefit slopes on the choice between taxes and permits

Case a): Tax preferred



Case b): Permits preferred



Thus under an emission tax the social loss is represented by the triangle ABC (here the loss is in fact a foregone net benefit), whereas under emission permits the social loss is triangle BDE. In the top panel, where marginal costs are steeper than marginal benefits, the loss under a permit system is greater; in the lower panel, where marginal benefits are steeper than marginal costs, the loss under an emission tax system is greater.

When we account for the fact that only the rate of change of atmospheric carbon dioxide can be affected, and only to a limited extent, the problem of choosing a control instrument is slightly different. Newell and Pizer (2003) modify the analysis in Weitzman (1974) to examine how the conclusions are affected when stocks rather than flows of the pollutant cause the harm. This paper concludes that if a permit system limits emissions over any short period of time, a price instrument is preferred because the marginal environmental benefit of abatement curve is flat. However, if permits are bankable, this short-run quantity constraint is absent. In New Zealand's case, the marginal benefit curve is the international permit price (if one exists), and thus is not directly affected by the slope of the international marginal environmental benefit curve. Even if there is no international permit market, environmental benefits are likely to be such a small proportion of New Zealand's marginal benefits, and already horizontal, that the distinction between flow damage and stock damage is irrelevant.

The case of New Zealand with an international regulation system

New Zealand is a small country and is controlling emissions in the context of an international agreement. As a result, its emissions form only a small fraction of world emissions, and there may be opportunities to trade permits with other countries. Weitzman's analysis thus needs to be adapted to some extent before it can be applied to New Zealand. The previous analysis remains appropriate for analysing the problem at a world scale, as in the Kyoto Protocol.

New Zealand's marginal cost curve for abatement captures the domestic cost of reducing New Zealand greenhouse gas emissions. This includes costs such as switching to cleaner energy sources, substituting from production technologies with higher emissions to those with lower emissions, and adjusting production. It is likely that the marginal cost curve is positively sloped and convex, indicating increased costliness of marginal abatement as the level of domestic abatement increases. That is, it is probably very cheap to reduce New Zealand's emissions by a few units, but reductions become progressively more costly as the cheapest methods of emission reduction are exhausted.

The nature of New Zealand's marginal benefit curve, however, depends on the international situation. Specifically, it depends on whether there is a functioning international market for emission permits. The essential difference for the marginal benefit curve when an international permit market exists is that a reduction in New Zealand's emissions will be perfectly offset by an increase in the emissions of another country. In these circumstances, the benefits of abatement are not environmental, but monetary from selling permits. New Zealand is a small country, and thus it is reasonable to assume that it can buy or sell as many emission permits as it requires on an international market without affecting the permit price, provided such a market exists.

The international permit price is driven by factors at the worldwide level. For instance, a change in the international abatement target would alter the international permit price. Such a change could be motivated by changes in the marginal environmental benefit of abatement.

The marginal environmental benefit of abatement is determined by three factors: the stock of greenhouse gases in the atmosphere, the effects of the stock of greenhouse gases on the climate, and the effects of climate changes on human society. In combination, these three factors determine the marginal damage the world would suffer under higher emissions, and thus the marginal environmental benefit gained by abatement.

The future stock of greenhouse gases in the atmosphere is affected by economic growth (population growth or per capita economic growth) and by technological change. In the absence of sufficient technology improvements, higher economic activity in the rest of the world causes higher baseline emissions. These emissions build up in the atmosphere as a damaging stock of greenhouse gases. If the marginal damage caused by each unit of emissions increases as total greenhouse gas stocks increase, higher world emissions increase the marginal benefit of each unit of abatement. Technological advancements in an international setting, on the other hand, may cause world emissions to grow more slowly, or even to fall, without compromising world economic growth.

In the following sections, we consider the differences with and without an international permit market. In each case, we also consider the choice that the policymaker faces of whether to comply with Kyoto or not.

With a functioning international permit market

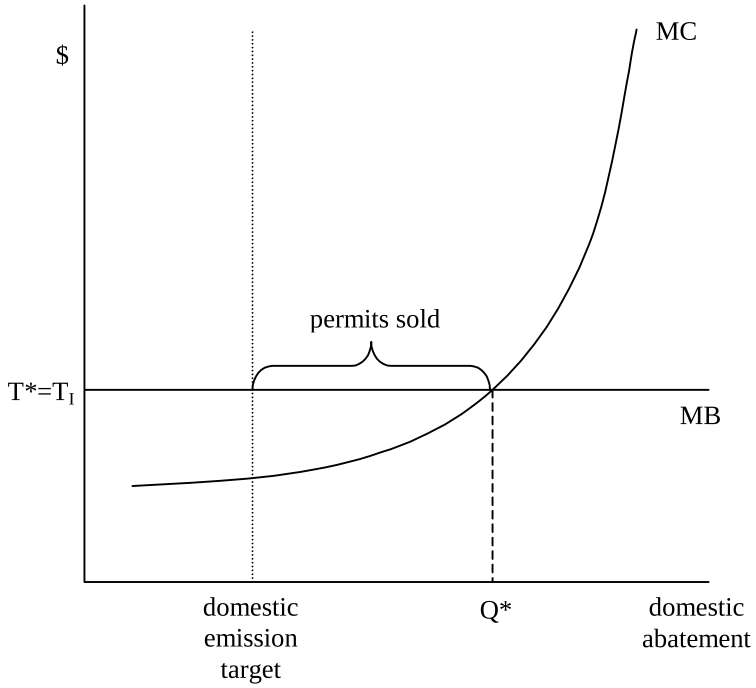
If the international permit market functions well, the distinction between a tax and a permit system in New Zealand lessens. Because firms can buy or sell permits on the international market, a permit system no longer represents a quantity constraint.[5] Under these circumstances, we find that a permit system is optimal under marginal cost or marginal benefit uncertainty, whereas a tax system is not.

In this case, the domestic marginal benefit curve is horizontal and is equal to the international permit price. The international permit price is a marginal benefit because each unit of abatement that occurs in New Zealand allows either a permit to be sold by the country, or one fewer permits to be purchased.

Figure 3 illustrates the likely appearance of the marginal cost and marginal benefit curves. MB is the marginal benefit curve, and MC is the marginal cost curve. T* is the *ex ante* optimal domestic tax level as well as the *ex ante* desirable domestic permit price. It is also equal to the international permit price, T_I. Q* is the *ex ante* desirable quantity of abatement. The difference between New Zealand's domestic emission target under the Kyoto Protocol and the actual quantity of abatement achieved is the permits sold (or bought) internationally by the country.

[5] This is true if the Government does not place restrictions on the quantity of permits that domestic firms can buy or sell internationally. It is possible, however, for the Government to impose trading restrictions on permits, effectively creating a division between the domestic and international permit markets. Under these circumstances, different prices may prevail in the domestic and international permit markets.

Figure 3 – Marginal cost and marginal benefit with an international permit market



Under a tax system, the Government would set the level of the tax at the international permit price. If the resulting abatement were more than sufficient to meet New Zealand's emission target, the Government would sell the additional permits internationally; if it were insufficient, the Government would purchase the required additional permits. Consequently, it is the Government that bears any risk associated with a change in the international permit price.

With certainty, a permit system would have the same effect on abatement as a tax at the value of the international permit price. Firms would abate their emissions where this costs less than the price of the permits, and would use permits otherwise. If the Government either auctioned or allocated permits equal to New Zealand's emission target, the buying and selling of permits by firms to cover their own emissions would mean the Government would not be required to buy or sell permits internationally to achieve compliance with Kyoto. In this case, private firms would bear the risk of a change in the international permit price.

With a costless international permit market, a tax instrument and a tradable permit system where firms can trade internationally will yield the same environmental outcomes under domestic marginal cost uncertainty. These outcomes will be *ex post* optimal. This is because both systems effectively set the same emission price (the price which is both *ex ante* and *ex post* optimal), and then firms choose their actions to maximise their profits given their realisations of marginal cost.

Under shocks to the international permit price, however, a permit system is strictly preferable to a tax system. This is because the permit price adjusts perfectly to the shock by definition, and thus always yields the *ex post* optimal outcome. Unless the tax rate adjusts continuously, under a tax system any shock to the international permit price creates a gap between the marginal benefit faced by firms (the tax rate) and the marginal benefit faced by the country as a whole (the new international permit price). Consequently, a tax system will yield inefficient outcomes under marginal benefit uncertainty.

This situation may be complicated if New Zealand stands to gain international favour by reducing its emissions rather than just purchasing permits to cover them. This is the international discussion about supplementarity, which is based on Article 17 of the Kyoto Protocol (United Nations Climate Change Secretariat, 1998). This Article states:

> The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.

If New Zealand does stand to gain favour in this manner, our marginal benefit curve is the sum of the international permit price and the marginal benefit of this international favour gained by the country. It seems reasonable for the marginal value of this favour gained to be positive and decreasing, and to become negligible at some level above New Zealand's compliance level of abatement.

The dollar value of any favour that New Zealand finds internationally is very difficult to quantify, so it is hard to say anything about the relative sizes of the two aspects of marginal benefits.

Early action may have domestic benefits. Even if New Zealand doesn't need any policies to meet its target in the first compliance period, it may nonetheless gain from starting abatement at this stage. Theory suggests that abatement may be less costly when it is introduced gradually. It is cheaper to replace production technologies with lower-emission technology when they reach the end of their lives and would be replaced regardless, as opposed to replacing capital that still has useful life left in it. Adoption of new technology also takes time, in terms of both the technology itself and developing policy to deal with these issues. Responding to the international permit price may be sufficient to achieve optimal early action. This would justify additional action only if international prices are artificially low.

If there are significant marginal benefits of abatement other than those associated with buying or selling permits internationally, it might be optimal for the tax on emissions to be greater than the international permit price, or for domestic permits to not be identical to international permits. As previously, the *ex ante* optimal tax rate and permit quantity are determined by the intersection of the marginal cost and marginal benefit curves.

Under shocks to the international permit price, the relative desirability of a permit system compared with a tax system will depend on how the domestic price is related to the international price. If the domestic price is equal to the international price plus a fixed wedge, relatively flat marginal benefit curves will tend to favour a permit system, whereas relatively flat marginal cost curves will tend to favour a tax system. This is because domestic permit prices respond fully to an international price change, whereas taxes don't respond at all. The flatter the marginal cost curve is relative to the marginal benefit curve, the less response is desirable.

The Government always has the option of choosing not to comply with the Kyoto Protocol. This option is more attractive when the international permit price is very high and lots of other countries have chosen not to comply. Clearly, a high international permit price when New Zealand has to buy permits means high compliance costs. If a large number of other countries have chosen non-compliance, this becomes more attractive because the international disfavour from non-compliance is likely to be less than when most countries have chosen to comply. If international permit prices are very high, this may mean that abatement is just much more costly than the international community expected. It is likely in such a scenario that domestic abatement will also prove more costly than expected.

Without a functioning international permit market

When the international market for permits is either not functioning at all or is so thin that permits cannot be reliably bought or sold internationally, the functioning of a domestic permit system is more like the traditional case in which quantity is constrained. In this section, we consider the scenario in which the international market is entirely non-existent. However, the actual scenario that evolves is likely to be less black and white.

Without an international market, New Zealand's marginal benefit curve consists of three components: the marginal domestic environmental benefit, international favour gained for compliance, and any indirect effect New Zealand's abatement has on the likelihood of cooperation with Kyoto by other countries.

The marginal environmental benefit includes only that benefit gained by New Zealand from its own abatement. Other countries also benefit from New Zealand's abatement, and in this sense the country can be viewed as a private producer of a public good. As such, our abatement would be worth much more internationally that just its value to New Zealand. Consequently, the marginal domestic environmental benefit will be much lower than the international permit price would be if an international market existed. It may, in fact, be so low as to be negligible. Because New Zealand emissions are such a small proportion of worldwide emissions, marginal environmental benefits for New Zealand are flat across all levels of domestic abatement.[6]

The second component of the marginal benefit curve is international favour that New Zealand would gain if it were to comply with its domestic target in the absence of international emissions trading. This marginal benefit is likely to be positive at low levels of abatement, but can be expected to fall off quickly above compliance-level abatement. It is possible that this marginal benefit may be discontinuous, or at least not smooth, at New Zealand's target abatement level.

If the marginal costs of abatement turn out to be very high, New Zealand may choose not to comply with its Kyoto target. This is more likely in the absence of an international market than when one exists, because a shock that causes domestic abatement costs to be unexpectedly high is more likely than one that causes worldwide abatement costs to be unexpectedly high. As in the case with an international market, New Zealand will receive less international pressure to comply if many other countries have chosen not to.

The final component of New Zealand's marginal benefit curve is the effect New Zealand's abatement has on the cooperation and therefore abatement of other countries. New Zealand's efforts towards abatement are likely to encourage other countries towards compliance with Kyoto, and we will reap the environmental benefits of their resulting increases in abatement.

The value of these environmental benefits to New Zealand depends partly on the effect of climate changes on New Zealand society. The effects on New Zealand society of a certain level of climate change depend on a variety of factors such as the future level of our reliance on agriculture (which may suffer significantly under climate change), the

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[6] The constant level of marginal environmental benefit is likely to move upwards over time because a) stocks of greenhouse gases in the atmosphere are expected to rise, at least in the short term; and b) the marginal damage caused by each tonne of greenhouse gas is likely to increase as the stock of greenhouse gases increases.

extent to which the population will be living by the coast (in danger of rising ocean levels), and how rich, and therefore able to deal with the change, the country will be.

Figure 4 – Marginal cost and marginal benefit without an international permit market

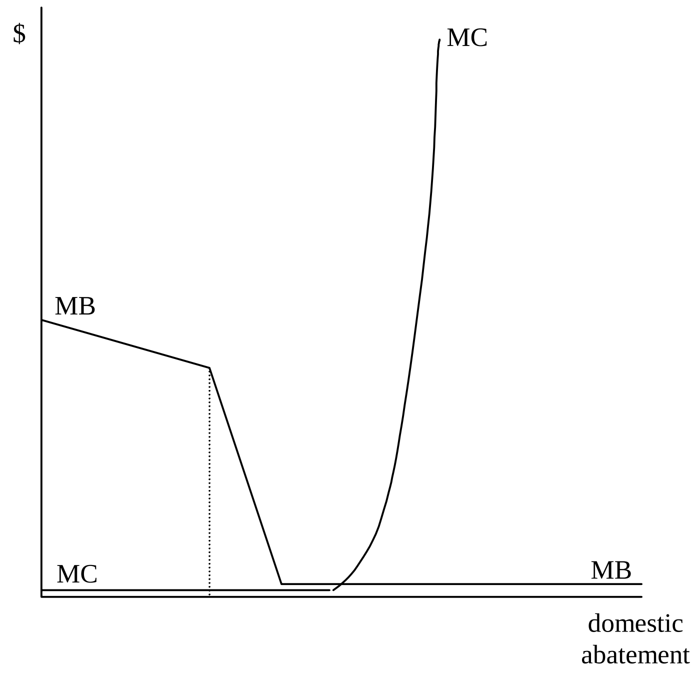


Figure 4 above illustrates one possible appearance of the marginal cost and marginal benefit curves in the absence of an international permit market. MC is marginal costs; MB is marginal benefits. The MC curve is drawn here as being flat and virtually zero at low levels of abatement, then curving up sharply beyond some threshold level of abatement. This is not an unreasonable shape because there is evidence to suggest that New Zealand will be in compliance with Kyoto in the first commitment period even without any policy influence. However, in the short run, if New Zealand tried to reduce emissions significantly, marginal costs might rise steeply.

In the absence of an international market, Weitzman's analysis applies to domestic abatement, and the preferred instrument depends on the relative slopes of the two curves around their point of intersection. If the marginal benefit curve is steeper, a permit system will yield lower expected losses; if the marginal cost curve is steeper, a tax system will yield lower expected losses.

However, one of the main uncertainties about the marginal cost and benefit curves is the point at which the marginal cost curve begins to rise. As illustrated above, the curves could intersect where the marginal benefit curve is flat. In this case a tax may be optimal. However, if the point where marginal costs become significant is at a lower abatement level, marginal benefit might be very steeply sloped at the point of intersection. This would make a permit market more attractive.

3.2.2 When benefit and cost uncertainty are correlated

Weitzman's results assume that shocks to benefits and to costs are uncorrelated. However, this may not always be the case. Stavins (1996) shows that marginal benefit uncertainty does matter for policy choice when there is a correlation between uncertainty in marginal costs and in marginal benefits. However, when marginal benefits are just the international permit price, a domestic permit system remains *ex post* efficient under any combination of shocks. Thus in this section we consider correlated uncertainty only in the case of no international market.

Stavins finds that a positive correlation in the uncertainty in costs and benefits always increases the relative favourability of permits, whereas a negative correlation always increases the relative favourability of taxes.

This result, derived mathematically, makes intuitive sense. With a pollution tax, when the marginal costs of abatement are unexpectedly high, producers reduce their efforts at abatement. If there is a positive correlation between shocks to benefits and costs, at these times the marginal benefits of reducing emissions are also likely to be high. Thus producers tend to reduce their abatement efforts just when these efforts are most valuable. If, on the other hand, cost and benefit uncertainty are negatively correlated, the marginal benefits of emission reduction are likely to be low at the times when producers reduce their abatement effort. Hence, with negative correlation, the response of producers under a tax tends to be appropriate.

Causes of marginal cost and marginal benefit uncertainty in New Zealand

Marginal cost uncertainty

There appear to be two main causes of marginal cost uncertainty: uncertainty in New Zealand's future economic growth, and uncertainty in future technological inventions, innovations and diffusion. The higher economic growth is in New Zealand, the greater will be the country's baseline level of unregulated emissions, and the costlier it will be to reduce emissions to any specified target value. This economic growth may stem from population growth or from growth in GDP per capita. Technological progress can change the costs of reducing emissions by offering more energy-efficient production processes and substitutes for emission-producing energy sources. However, there may be some new technologies that actually cause an increase in emissions.

Marginal benefit uncertainty

The causes of uncertainty in marginal benefit are more numerous. Each of the three factors that determine marginal environmental benefit contains uncertainty. The future stock of greenhouse gases in the atmosphere, the effects of the greenhouse gas stock on the climate, and the effects of climate change on society are all uncertain. However, it is only the stock of greenhouse gases and the effects of climate change on society that are likely to have errors that are correlated with the uncertainty in marginal cost.

If either economic growth or technological change occurs at a pace different from that expected, stocks of greenhouse gases in the atmosphere are likely to differ from expectations. Although world economic growth can be forecast, shocks as large as the collapse of the Russian economy can and do occur, leading to large errors in our expectations. Technological progress and its effects over the long term are inherently unpredictable, adding to our uncertainty over future emissions.

We know little about the severity of the effects on society of any given level of climate change. This will depend on how New Zealand's society and economy develop over time. Specifically, shocks to the importance of our agricultural industry, the geographic distribution of our population, and GDP per capita will alter the strength of the effects of climate change on the country.

These uncertainties apply to domestic marginal benefit and also, on a world scale, influence global marginal environmental benefits. These global marginal environmental benefits in turn may affect the value of international favour gained from abatement and the effect of New Zealand's abatement on other countries' emissions.

The value to New Zealand of the favour gained in international circles for meeting its compliance target is both difficult to estimate and likely to evolve as the international situation changes. The value of this favour may be positively correlated with the marginal global benefits of abatement in the long run. The correlation between global marginal benefits and the benefit for New Zealand of New Zealand's effect on other countries' emissions is likely to be positive. If global marginal benefits are higher, the same amount of foreign abatement is likely to be more beneficial for New Zealand.

Correlations between marginal cost and marginal benefit uncertainty

The main causes of cost and benefit uncertainty have thus been established, and it remains to consider which of these are likely to be positively or negatively correlated with one another. For simplicity, we look here at the correlations between marginal environmental benefit and marginal cost.

Figure 5 below illustrates one set of likely correlations. An exogenous improvement to technology could have several effects. First, it could cause global emissions and thus greenhouse gas stocks to be lower than expected,[7] which could decrease the marginal benefits of domestic abatement by altering the environmental benefits to New Zealand directly. Second, the technology shock might make society more able to cope with the damage caused by climate change, which would also decrease the marginal benefits by decreasing the benefits of reducing climate change. Third, the technology shock could directly decrease the marginal costs of abatement. These relationships imply a positive correlation between marginal cost shocks, which are negative here, and marginal benefit shocks, which are also negative here.

[7] This is true even if all Kyoto targets are exactly met, because the Kyoto Protocol doesn't cover all emission sources or all countries.

Figure 5 – Correlations caused by a technological improvement

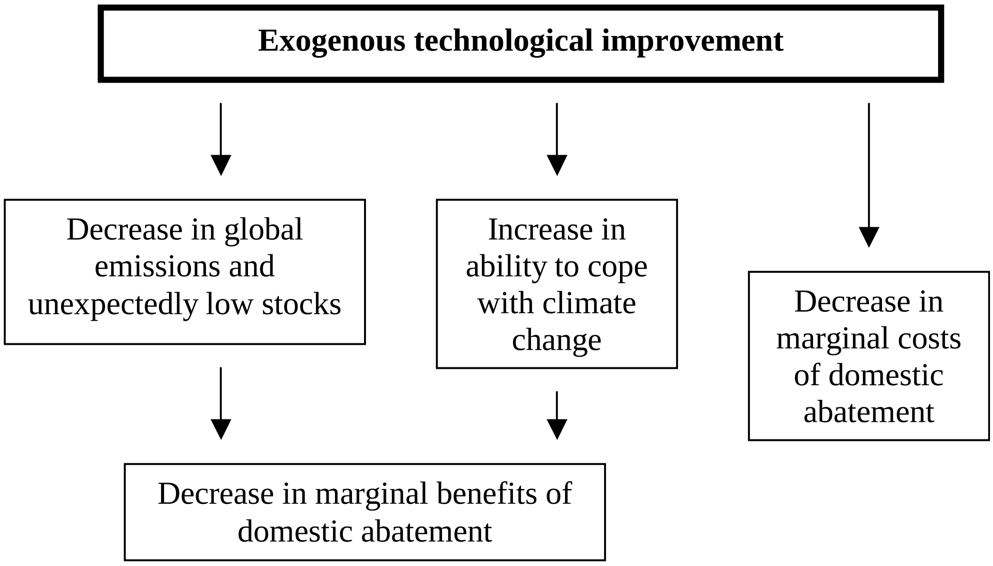
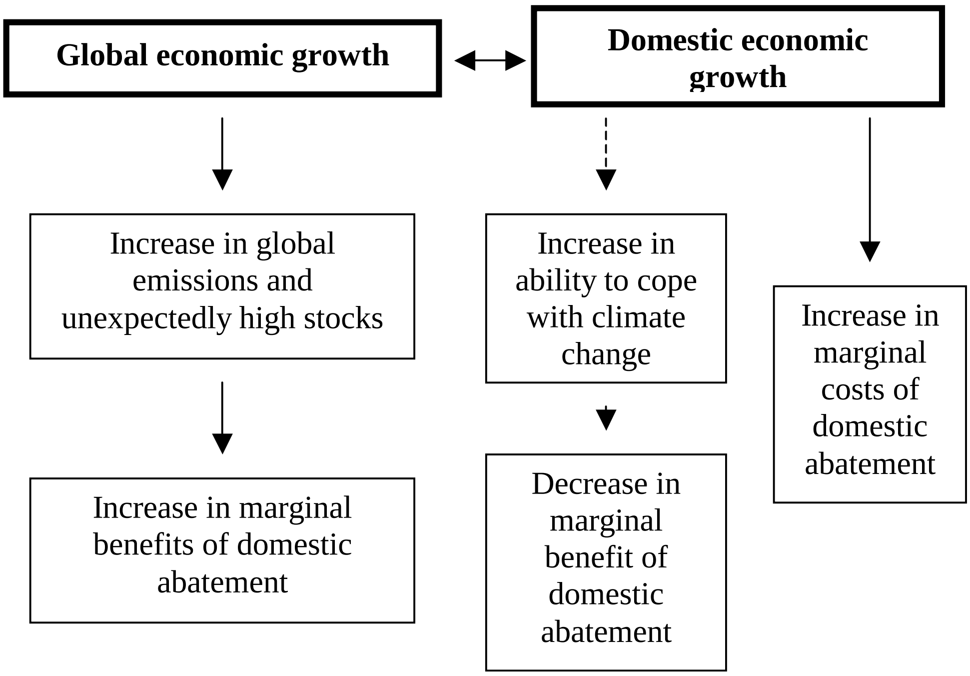


Figure 6 below illustrates a second set of possible correlations. On the left-hand side, global economic growth that is not matched by improved emissions technology would cause unexpectedly high global emissions and greenhouse gas stocks, which would drive up the marginal benefit of abatement. As above, this change in the marginal benefit would act through direct environmental benefits.

Figure 6 – Correlations caused by global and domestic economic growth



However, shocks to global economic growth are likely to be positively correlated with shocks to domestic economic growth. This domestic growth has two possible effects. First, it could increase the ability of New Zealand to cope with climate change, thus decreasing the marginal benefit of abatement by reducing the benefits of preventing climate change. Second, domestic growth would increase the marginal cost of abatement by driving up domestic baseline emissions. Under the assumption that the positive shock to marginal benefits from higher global emissions is greater than the negative shock from a greater ability to cope, this set of correlations implies a positive relationship between marginal benefit and marginal cost uncertainty.

However, it is also possible that there is a positive correlation between global economic growth and technological advancements. In this case, marginal costs and marginal benefits both have forces driving them in both directions, and it cannot be determined which are likely to be greater. Consequently, the sign of the correlation between marginal cost and marginal benefit uncertainty cannot be determined in this case.

In the absence of strong proof of a high correlation between global economic growth and technological advances,[8] the above analysis suggests that a positive correlation between shocks to marginal cost and to marginal benefit is more likely than a negative correlation.

Results for New Zealand with correlated uncertainty

In the absence of an international permit market, with no correlation in benefit and cost uncertainty, a steep marginal benefit curve favours permits and a flat one favours taxes. When uncertainty is correlated this result may be slightly modified. Positive correlation increases the desirability of permits, whereas negative correlation increases the desirability of taxes. It appears more likely that New Zealand faces positively correlated shocks to its marginal cost and marginal benefit curves, suggesting a permit system may be more appropriate. However, New Zealand's marginal cost curve is still likely to be steep enough that taxes are still the preferred instrument.

3.2.3 Environmental vs economic risk: summary

Whether a domestic tax or permit system would yield preferable environmental and economic outcomes when the marginal cost and marginal benefit of abatement are subject to uncertainty depends critically on the presence or absence of a good international permit market. Figure 7 summarises possible scenarios and the preferable control instruments in each.

The optimistic scenario includes a good international permit market and an international permit price that is high enough for the only marginal benefit of domestic abatement to be the international permit price. This scenario is shown on the very left-hand side of the figure. In this case, domestic permits are not only preferable to taxes, but are efficient. If the international price is very low, the marginal benefit of international favour for domestic abatement is important and the solution ceases to be clear-cut.

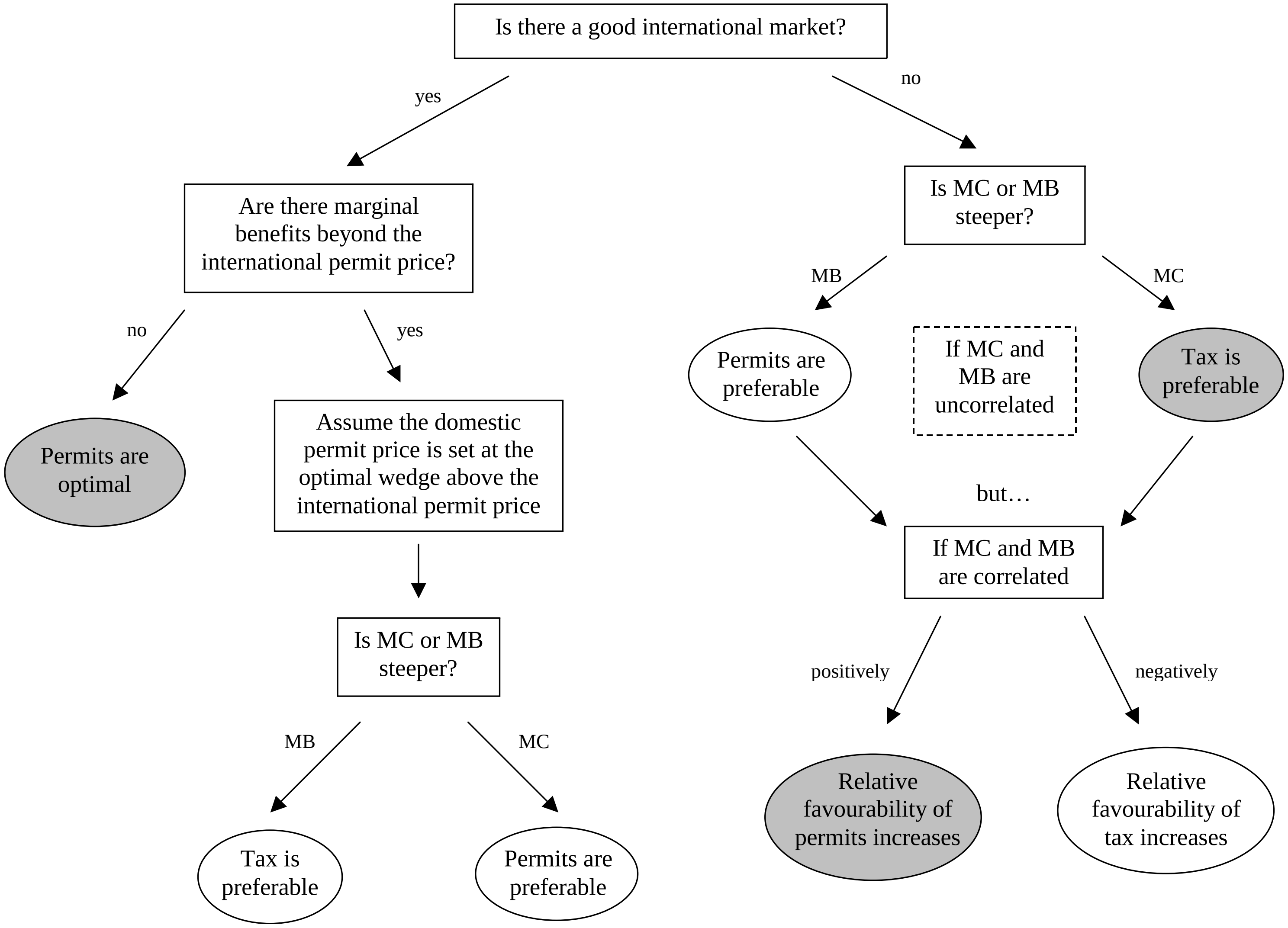
A less optimistic scenario involves a poor international market, shown by the first right-hand fork in the figure. This puts us in Weitzman's familiar world. We believe that the domestic marginal cost curve is likely to be steeper than the marginal benefit curve, which implies that a tax would be preferable if marginal cost and marginal benefit shocks were uncorrelated. This is shown by the first right-hand option past the initial right fork in the figure.

[8] A high proportion of technological breakthroughs are serendipitous, although the diffusion of technology may be linked to economic growth.

However, we believe that marginal cost and marginal benefit shocks may be positively correlated, which increases the relative favourability of permits, though not necessarily enough to make permits preferable to taxes. This is shown by the left-hand branch of the final fork on the right-hand side of the figure.

In the end, the choice between taxes and permits for domestic regulation returns to whether there will be a good international permit market. With such a market, permits are preferable. Otherwise, taxes are preferable. If there may not be an international market, but we want to be able to take advantage of the efficiency gains of a permit system if such a market develops, a domestic hybrid system of permits with a trigger value could be desirable. This option is discussed in Section 5.

Figure 7 – The economic efficiency choice between domestic taxes and permits



3.3 Allocation of risks and incentives to respond to risk

The risks associated with greenhouse gas emission regulation can broadly be classified as either exogenous or endogenous. Exogenous risks are those that cannot be influenced by either the Government or regulated firms. These risks were discussed in Section 3.2. They include events such as changes in technology that reduce the costs of abatement and unexpected domestic economic growth that raises domestic baseline emissions. Dealing with these risks is discussed in Sections 3.3.1 and 3.3.2. These sections consider what the risks are, who should optimally bear them, and how policy should be designed to ensure that these agents do in fact bear the risks. They draw upon material from Kerr (2003a).

Endogenous risks, on the other hand, are the result of the behaviour of either the regulator or the regulated parties. These risks generally involve either an opportunistic change of the rules of the game by the Government, or strategic investment or lobbying by regulated firms. Dealing with these risks is discussed in Section 3.3.3.

3.3.1 Optimal allocation of exogenous risk

Identifying uncertainty and defining risk

With either a tax or a permit system, a reduction in genuine uncertainty improves the efficiency of the choices that agents make. Although uncertainty may take a very long time to actually be resolved, in the shorter term it can often be evaluated and the likelihood of specific outcomes established. When uncertainty has been reduced to risk (when the possible outcomes and the likelihood of each has been established) agents can respond optimally to it.

Determining the risks largely involves monitoring relevant developments in other parts of the world and evaluating how they affect the likelihood of specific outcomes for New Zealand. For instance, although New Zealand is unlikely to develop breakthrough “clean” technologies, it is important for firms’ investment decisions and for future greenhouse gas regulations whether these are on the verge of becoming economically viable. The decision of the United States on whether or not to ratify the Kyoto Protocol has huge implications for New Zealand, and the emission abatement efforts of other countries are also relevant to the New Zealand situation. Information about the state or likelihood of such developments is a public good to New Zealand; therefore, monitoring of relevant world events is unlikely to occur at the desirable level in the absence of Government intervention. This means there is a role for the Government in monitoring and disseminating information on international developments that relate to emissions.

How firms and the Government should respond to risk

Four types of exogenous risk are associated with emission regulation. The first is “wealth” risk. This is the risk that New Zealand’s domestic emission target will change, meaning a change in the number of permits the country as a whole holds. The second risk is domestic demand risk, or the risk that a shock such as a rise in demand for a firm’s output will cause an increase in the firm’s emissions. It must then either increase its demand for permits or pay more emission taxes. The third risk is asset risk, where holders of existing permits receive capital gains or losses when permit prices change. The fourth risk is price risk, or the change in the opportunity cost of using permits when permit prices change.

Asset risk and price risk are negatively correlated with each other. Wealth risk is probably correlated with asset risk and price risk, in that a decrease in the number of New Zealand permits is likely to be associated with an increase in permit prices.

Two main strategies can mitigate or efficiently reallocate some of the types of risk. Price risk can be reduced by certain investment responses. Any one agent can avoid asset risk and wealth risk entirely by not holding any permits, although these risks are then faced by other agents. An agent that does hold permits may be able to manage its asset or wealth risk efficiently through a portfolio.

Firms have a number of possible investment responses to help mitigate the effect of price risk. They choose investment types that allow them the most flexibility to adjust their emissions. This involves choosing capital with a high proportion of variable costs and with a relatively short lifetime and investing in a mix of technologies. Firms are then in a good position to reduce the effects of price risk by adjusting their production level or production technologies at short notice. This changes their emission levels and either permit use or tax payments in response to the shock. Similarly, firms find an option value to waiting when there is uncertainty over future permit prices or carbon tax rates, and may reduce risk to themselves by delaying investment decisions. Research conducted by firms helps to resolve some uncertainty.

When a domestic permit system is operating, firms may be able to partially insure against price risk by the precautionary banking of permits, if this is permitted by the system. The private sector is also well positioned to develop a number of risk-allocation mechanisms such as derivative transactions associated with permit trading (eg, forward trades or options). These mechanisms allow more risk-averse firms to pass some of their asset risk to risk-neutral firms. The Government may also choose to enter these derivative markets.

The Government has a limited ability to mitigate exogenous risk. However, it is able to fund research and monitoring that can lead to the resolution of some uncertainty. In its own investments it is able to reduce risk in the same manner as any firm.

Risk allocation considerations

When deciding who should optimally bear certain risks, several factors are important. First, the degree to which agents can control the risk and their ability to mitigate it should be considered. It is clearly more efficient for an agent with a greater degree of control over a risk and the ability to reduce it to be faced with that risk. This induces more efficient risk management than the situation where those facing a risk cannot control it and those who can control the risk have no incentive to do so. This point can be illustrated with an example of an electricity generation company. If this company uses hydro lakes to generate electricity, it should bear at least some of the risk to carbon emissions of these lakes running dry. Otherwise it would not have any incentive to use the lake water wisely, or to have clean alternative generation methods on hand for dry seasons. If the Government were to bear all the emissions risk of the lakes running dry, the electricity company could use all the water and turn to environmentally unfriendly generation methods at no cost to itself. This would clearly be inefficient.

Second, greater risk should be placed with those who can bear it at less cost. That is, those who are less risk averse. In general, the Government and large companies are less risk averse than are small companies and individuals. There are two costs to risk-averse agents bearing risk. The first is the direct welfare cost. The second is the undesirable behaviour that may be induced by the agent having to bear the risk. For instance, if risk-averse firms are unable to share the risk of their investments they will invest less than is optimal for society.

The optimal allocation of risk depends on the instruments that parties have available to mitigate risk. One important distinction is between the cases with and without good markets for risk. If perfect risk markets are operating, firms can efficiently reallocate risk amongst themselves so that more risk-averse agents bear less risk, and less risk-averse agents bear more. Good risk markets are possible only if there is an international permit market; potential New Zealand buyers and sellers are too few for such markets to develop without the presence of international players.

If there are good risk markets, the Government has no comparative advantage in bearing most exogenous risks. These risks tend to be correlated over the economy, and are not small relative to the size of the economy. As a result, the Arrow-Lind (1970) risk-pooling argument for the assumption of risk by the Government does not apply. If the Government were to bear a negative exogenous shock, the cost would ultimately be covered through taxation, with the associated distortions that this brings. Private firms, on the other hand, are able to use the risk markets to allocate risk efficiently among themselves.

However, there are reasons why risk markets may not be perfect even if there are international permit markets. Suppose a firm planning to undertake a risky investment manages to share the risk through either debt financing or equity. In either case, the firm no longer bears the entire risk of the investment. Furthermore, under debt financing the firm making the loan faces much of the loss if the investment goes poorly, whereas the investing firm reaps most of the gains if the investment goes well. Consequently, the investing firm has an incentive to choose a much riskier and higher-yielding investment than it would if it bore the entire risk itself. The presence of asymmetric information over the risk and expected returns of potential investment projects means the firm making the loan cannot prevent a very risky project being chosen. This is the problem of adverse selection.

Once the investment has been chosen, asymmetric information causes further problems. The investing firm has more control over the investment than do any other firms that take on some of the risk. Because these other firms cannot perfectly monitor the investor, under a risk-sharing arrangement the investing firm has less incentive to take care with the investment than it would if it bore the entire risk itself. This is the problem of moral hazard. As a result of the adverse selection problem and the moral hazard problem, other firms are unwilling to take a share of the risk associated with the investment, and perfect risk markets are unable to develop.

In this situation, although the Government really has no comparative advantage in dealing with the adverse selection or moral hazard problems, it may be efficient for the Government to bear some of the risk. If the risk were left solely with firms, many of the firms that ended up bearing disproportionately large risk would be small firms that were most risk averse. This is not really an equity issue because firms choose to take on risk when they invest. However, it does mean that firms will invest less than would be socially optimal. By assuming some of the risk, the Government encourages more investment and achieves an efficiency gain.

If the Government assumes some of the risk, it must choose which investment projects to support, even though it is not in a good position to determine which projects are likely to be the most valuable. Although it risks funding projects that yield poor financial returns, it might value the learning benefits of risky projects enough to make the risks worthwhile.

3.3.2 Policy design and optimal exogenous risk allocation

Both an emission tax and a tradable permit system have a degree of flexibility in their design that allows the allocation of risk to be altered. This section discusses the transmission of exogenous shocks and specific design and implementation issues that can be used to allocate risk optimally.

Transmission of exogenous risks with a domestic permit market

When domestic emissions are regulated by means of permits, exogenous shocks feed through as changes in the price of permits (spot, forward, future and option). When permit prices rise, those holding permits receive capital gains, and everyone faces higher opportunity costs of using permits. Shocks to New Zealand's emission target are also felt as wealth shocks, whereby some agents face decreases in the quantity of permits they hold.

The change in permit prices occurs as a result of a shock to either the supply of or demand for permits. Because supply is of a different nature with and without a functioning international permit market, the nature of exogenous shocks also differs in these two cases.

In the absence of an international permit market, the supply of permits is perfectly inelastic. Here, supply shocks include such events as changes in the domestic emission target, which is set internationally, a domestic decision to move either into or out of compliance with Kyoto, or a change in the net emissions from an unregulated sector that is passed on to the permit system.

When there is a liquid international permit market, New Zealand can purchase as many permits as it wishes at the prevailing international price, thus the domestic supply of permits is horizontal at this price. Consequently, any shocks to either the international demand or supply of permits affect domestic supply. In this case, supply shocks include a change in international aggregate emission targets, a change in international economic growth or activity, or a change in the abatement technology used internationally.

Domestic demand shocks have the same causes whether or not an international permit market exists. They include shocks to the abatement technology used domestically, natural events such as cold weather, and economic growth and business cycles. These shocks are only large enough relative to the total market to affect permit prices when there is no international permit market. However, in every case they affect the total costs of the firms whose demands for permits are affected.

Although most shocks are transmitted as changes in the price of permits, the incidence of these changes does not necessarily fall primarily upon permit holders. For instance, firms might be in a market position that allows them to pass cost changes on to their customers or their employees. These people may be extremely risk averse, and thus this situation may be highly undesirable.

Policy design implications for a permit system

In a permit system, firms are better able to handle risk if they are given flexibility to redistribute the risk over time and among themselves. In practical terms, this means the Government should allow permits to be banked, which allows firms to smooth marginal costs of abatement over time, and should ensure legal conditions are optimal for the establishment of derivative markets. These two tools allow the private sector to deal well with short-term and cyclical risks. If the permit market is too thin for derivative markets to develop, the Government may be able to provide derivatives such as forward trades, thus allowing firms to hedge against price risk. In this case, the Government assumes the price risk.

One important tool the Government has for changing the allocations of wealth risk between the public and private sector is the definition of permits. For instance, if permits were defined as flows in perpetuity with the stipulation that to reduce the aggregate target the Government would be required to buy back a proportion of these permits, the Government would bear the wealth risk of exogenous changes to aggregate emissions targets. This could prove extremely costly to the Government, and is unlikely to be desirable even in the absence of greenhouse gas regulation risk markets.

One way to transfer wealth risk to private firms is by defining permits as percentages of uncertain future targets. If an exogenous change in the domestic emissions target occurs, the cost of this wealth shock is wholly borne by permit holders through a change in the value of their permits. There is a precedent for this type of system in New Zealand fisheries management, where fishing quotas are expressed as percentages of total yearly catches, which are set annually. Whether this method is chosen or not, it is strongly advisable to build into the original system a method of reducing the aggregate target at less than prohibitive cost to the Government.

If permits are defined as one-off emissions of a specified number of tonnes of carbon dioxide equivalent, changing the auction or allocation mechanism can shift the asset risk. The essential choice is how far in advance to auction or allocate permits. If permits are auctioned regularly (for example, yearly) and only permits that become valid in the near future are auctioned each time, the Government faces the asset risk if the permit price changes in the future. However, if each auction includes permits that won't become valid until various dates in the more distant future, permit holders bear a larger proportion of the asset and wealth risks.

Price risk to firms can also be reduced by means of a hybrid tax/permit system, which is discussed more fully in Section 5. This may be such that firms trade in permits under normal circumstances, but they are able to purchase as many permits as they wish at some price above the expected permit price. This price acts as a ceiling on permit prices, and thus protects private agents against massive permit price increases. Under such a system, the Government faces the risk of having to purchase these additional permits on the international market at the high price to which they have risen and only being able to sell them domestically at the specified lower price.

Finally, disproportionately large risk is likely to be placed on some very risk-averse agents no matter how permits are defined. As discussed previously, this has a direct welfare cost to these agents. They may be small firms or customers or employees of affected businesses. To help combat the negative effects of this, the Government could provide a safety net for vulnerable agents in the economy. This safety net might include such policies as job-retraining programmes. Particularly vulnerable agents include workers with skills specific to carbon-intensive industries, low-skilled workers in general, and very poor people who live in cold areas or who depend on cars.

Transmission of exogenous risks with a tax system

The total risk under a tax system is the same as that under a permit system. The difference, however, is in the way this risk is transmitted. Under an emission tax system, the Government effectively owns all the country's permits and sells them on demand to businesses at a fixed price. A decrease in New Zealand's permit allocation in the absence of an international permit price change, for example, hits the Government as a wealth shock. The Government would not change the tax rate in these circumstances because international permit prices are unchanged, thus it faces the direct cost of buying more or selling fewer permits internationally. Changes in the international price of permits directly affect the Government as an asset shock. The Government is able to pass price shocks on to emitting firms by changing the emission tax rate.

Policy design implications for a tax system

A tax system cannot reallocate wealth or asset risk away from the Government, and ultimately taxpayers. Price risk, on the other hand, can be transferred to private agents. Under a permit system, some price risk can be transferred from private agents to the Government via a hybrid permit/tax system or through the Government offering forward trades. Under a tax system, the regularity of changes in the tax rate determines with whom the price risk lies.

A balance must be achieved between the economic inefficiency of a tax rate that differs from the international permit price, and the inefficient risk allocation that arises when risk-averse firms, consumers and employees bear the price risk. Changes in the tax rate are also costly. This balance is likely to involve a tax rate that roughly tracks the international permit price over the long run, but does not follow all its short-term fluctuations.

3.3.3 Strategic incentives

Opportunistic behaviour is possible because it is impossible to write a contract that covers every contingency. Emission regulations are necessarily incomplete contracts, and thus post-contractual opportunism on the part of the Government or private firms is possible. The problem is exacerbated by the fact that the Government cannot preclude opportunistic behaviour in the future on the part of itself or its successors.

Possible opportunistic behaviour by the Government

Under a permit system, Government opportunism may take a number of forms. This opportunism may be driven by lobbying or political pressures, new information about the costs to Government of current regulation, or changes in vested interests. The Government's opportunistic behaviour might include:

1. Changing the aggregate target when this is not in response to changes in the optimal target;

2. Changing the method of permit allocation (eg, a shift from auction to *gratis* allocation or a change in the allocation between firms and sectors if *gratis* allocation is already used);

3. Changing the definition of permits (eg, from tonnes of carbon dioxide equivalent per year to proportions of the target); and

4. Confiscating existing permits.

If firms believe that the Government may make changes such as these, their tendency to invest more slowly and to invest in less capital-intensive activities when they are faced with exogenous shocks will be magnified. If permit holders believe their permits may be confiscated, they will be reluctant to bank them. This inhibits efficient smoothing of marginal costs over time. If firms believe that the Government may be influenced into making these changes, they may pursue rent-seeking activities. That is, they may put resources towards trying to convince the Government to make changes that will transfer benefits from others to themselves. These activities consume scarce resources without creating value, and thus are inefficient for society even though they may be in the self-interest of the firms involved.

Under a tax system, a major danger is that future governments will view the tax as a source of revenue and will seek to increase it beyond the optimal level. Changes in the international permit price may provide impetus for suboptimal tax setting at levels either above or below the optimal level. If the international permit price falls, the Government may choose not to decrease the tax rate similarly because its tax revenue would be likely to fall. Alternatively, if international permit prices were rising the Government might succumb to pressure to not increase the tax rate, or to grant exemptions from paying the tax. Any of these behaviours would be suboptimal from an efficiency standpoint.

Possible strategic behaviour by firms

Firms may attempt to influence government decisions, both current and future, by strategic investment, lobbying or misrepresenting abatement costs.

Abatement can be achieved at much lower cost if the transition to lower emission levels is spread over a longer period of time, rather than being forced in a short period of time. A longer timeframe would allow firms to develop and put in place low-emission and energy-efficient technology over the next decade or two. The optimal policy path for this requires a policy tightening in the future. However, the Government cannot commit to such a tightening. The future Government may find itself agreeing to international targets that are not stringent, or it may opt for non-compliance with Kyoto.

If the Government sets a low domestic emission tax rate on the understanding that firms are to invest in emission-lowering technology in preparation for increased target stringency in the future, firms may choose not to do so. They may strategically under-invest in the hope that they will be able to negotiate relief from compliance in the future. The future Government, faced with the choice of either granting relief from compliance or potentially causing a serious recession, may well choose to grant relief. One way the Government could grant relief is by opting out of Kyoto. Even if the Government intends to follow a policy profile other than tightening over time, firms may choose to under-invest strategically in the same manner and cause the same problems.

One other way firms may hope to influence government decisions is through lobbying. This might be sectorally based, where firms in one sector try to pressure the Government into putting less of the burden of abatement onto them, and more onto other sectors. If permits are granted by *gratis* allocation, one easy way a transfer of burden could occur is through a change in the permits allocated to different sectors. Changes of this nature are generally driven by political pressure as opposed to economic efficiency. Firms might also try to make their abatement costs appear much higher than they actually are, or make their competitiveness appear at risk from emission regulation. For many industries, abatement costs are very difficult for the Government to estimate with any accuracy. Firms may exaggerate these costs in order to force the Government to opt out of Kyoto or to attain emission regulation exemptions for themselves.

Policy design to prevent opportunistic behaviour

Although the risk of opportunistic behaviour cannot be eliminated, it can be minimised by carefully designing the regulatory system with an eye to reducing the possibilities for undesirable strategic behaviour. The Government can tackle the problem of strategic under-investment in several ways. Supporting the invention and diffusion of clean technologies would lessen the under-investment problem. Alternatively, under a permit scheme the Government could sell permits well in advance, but not allow them to be used in advance. This would create a pressure group that did not want future targets to be looser than expected because it would cause them capital losses. Pressure from this group would help to counteract pressure from other groups that favoured less stringent targets.

If permits are specified as percentages of future targets, there is no pressure group to fight against less stringent targets, but the Government is unable to make revenue gains by changing the target.

One important way of decreasing the likelihood of strategic behaviour is by making the emission regulation contract as complete as possible. For instance, with a tax system the conditions under which the tax rate may be changed should be specified; with a permit system, the conditions sufficient to cause a change in the target should be stated. If *gratis* allocation is used for permits, the method by which this allocation is decided should be clearly defined. Putting the trading system design into legislation makes it more difficult for future governments to make opportunistic changes.

Under a permit system, some policy designs clearly offer less opportunity for strategic behaviour. Auctioning is preferable to *gratis* allocation because the Government does not have the option of changing the allocation between sectors.

Taxes are not vulnerable to pressure to change their allocation. The Government cannot alter the design of a tax system to reduce its vulnerability to pressure to lower the tax rate or grant exemptions.

Desirable firm behaviour is more likely if the credibility of policy targets and policy measures is established *ex ante*. Policy targets are more credible if there is social consensus on the goals of climate change policy, which may be gained through an education programme and broad public debate.

3.4 Flexibility in distribution of costs

Both a tax system and a permit system lead to approximately the same abatement actions by the same individuals and the same incidence of costs. A permit system offers the flexibility to allocate permits to certain groups rather than auctioning all permits. These allocations are transfers of wealth and will not affect incentives to abate. They are costly to the Government and the economy in the way that all government payments are because of the need to raise tax revenue to cover them. They do however provide political flexibility and the ability to address distributional issues.

3.5 Transaction costs and permit market inefficiency

In an emissions trading market efficiency requires that permits are traded. This is not necessarily a costless or perfectly competitive process. No trades are required in a tax system. In Section 4.6 we discuss the sources and likely significance of transaction costs in more detail.

4 Instrument-specific design issues

This section examines a number of design issues that are specific to either a tax system or a permit system for controlling greenhouse gas emissions. Most of the issues are important only if the international permit market does not function well. The section begins by discussing the importance of market liquidity, which is one of the goals of many aspects of the design of permits. It then examines possible difficulties that could arise if permits are complex and are not well understood. The section considers the possibility of market power developing in a permit market and methods to avoid this. It covers and gives recommendations regarding the issues that relate to defining and allocating permits. The section then addresses the question of transaction costs in a permit market. It concludes by recognising the design issues that are specific to taxes.

4.1 The importance of market liquidity

It is important for a permit market to be as liquid as possible, and thus many design features of permits are directed towards achieving this objective.

Liquidity is important for the efficient operation of a market for many reasons. If a market is liquid there are many trades and prices are observed frequently. This gives good information on the value of carbon permits both to the Government and to other possible users and/or purchasers of the permits. Improved information combined with the ability to buy and sell permits at any time at the market price makes it easier for companies to manage their risk and makes it possible for players to specialise in holding the permits and absorbing risk. If the market is not liquid, some players who would like to buy permits at the current price will not be able to and will be forced to reduce their economic activity. At the same time others will have too many rights, which they will either not use at all or use without much economic gain. Limited liquidity could have equity implications. In a liquid market it is much less likely that the difficulties arising from concentration will arise. Any firm will be able to enter the energy market by buying permits and it will be difficult for existing players to maintain high prices when many units are traded by many players.

Improving the liquidity and information flows in the market not only improves efficiency but in many cases it seems to raise the initial auctioned value of the rights. Lack of information reduces the number of bidders and creates tremendous uncertainty, which appears to lower permit values (it could theoretically raise them). In the Individual Transferable Quota (ITQ[9]) market permit values were initially very low and rose faster than the rate of interest as the market became established. If the Government is selling the rights it gains less revenue from the low prices, thus has less ability to lower distortionary taxes.

4.2 Effects of possible complexity of permits

If permits are complex and not well understood, various problems could arise and need some consideration. Complex permits could create transaction costs in trading if not all traders understand the permits and brokers do not develop to facilitate trading. If permits

[9] ITQs are tradable quota for regulating fisheries.

are so complex they are non-transparent it could create enforcement difficulties. Highly complex permits also raise administration costs.

There is probably a trade-off between a theoretically perfectly designed permit system and the ease of implementing it. The difficulties involved should be borne in mind when designing the permit. If only a few sophisticated players are required to hold permits, the complexity is not such a constraint. The Government will simply have to hire some sophisticated analysts to maintain and operate the system.

Carbon dioxide permits do not need to be complex. The Government should endeavour to avoid the complexities that could arise if the permit system overlapped with NGAs or projects.

4.3 Risks from, and methods to avoid market power

If there is no international permit market, it may be possible for a large New Zealand firm to strategically influence a domestic permit market to its benefit. However, if the international market is functioning, no domestic firm will be large enough to cause the problems discussed in this section.

4.3.1 Strategic manipulation of permit markets

There are two possible forms of manipulation. A company can try to lower the price of permits to reduce its costs of compliance (CMM[10]) or the company can try to raise the costs to its competitors and hence exclude them or capture market share by raising the price of permits (EM[11]).

Cost-minimising manipulation

A firm can lower the price of permits in a static one-period market (such as an auction) by reducing its demand for permits. It will only do this if the price reduction it causes is sufficient for its total expenditure on permits to fall by more than the increased abatement cost it incurs. To be able to have a significant effect on price the firm (or firms) must make up a considerable share of potential buyers.

If one firm reduces its demand for permits to lower prices, the Government loses potential revenue and other firms that hold permits lose. Marginal costs of abatement are not equalised because the firm lowering permit prices must over-abate to reduce its demand for permits and other firms will only abate until their marginal costs equal the new lower permit price. This means there is a higher cost to the economy as a whole. It also means that there is less of an incentive for the non-manipulating firms to innovate to reduce abatement costs so there is dynamic inefficiency.

If permits are initially allocated by auction and major players can collude during the auction to reduce bids, the Government will receive little revenue. After the auction the firms could freely trade permits at their true price to achieve allocational efficiency. Every firm would gain from this because they would buy their initial permits at lower prices.

[10] Cost minimising manipulation. Hahn, Robert W (1984) "Market power and transferable property rights." *Quarterly Journal of Economics 99*: 753-765.

[11] Exclusionary manipulation. Misiolek, Walter S and Harold W Elder (1989) "Exclusionary manipulation of markets for pollution rights." *Journal of Environmental Economics and Management* 16: 156-166.

However, the Government must compensate for foregone revenue through smaller reductions in distortionary taxes.

Exclusionary manipulation

Under very specific circumstances, a firm or group of firms acting in collusion may be able to manipulate the permit market in order to prevent a potential entrant from entering their product market. This requires that this firm (or firms) owns most of the permits in the market. Consequently, it cannot occur if permits are spread across a range of industries. If the required conditions are met, the firm can bid up permit prices by under-selling or by over-buying relative to its true supply/demand. In order to enter the product market, the new firm must purchase permits to cover all its emissions. If the permit price has been pushed too high, this may be prohibitively expensive, and the firm may be prevented from entering the product market. This effect is unlikely even in a domestic programme because so many different sectors are involved.

The very nature of permits may encourage permit ownership to concentrate. Concentration might occur because, as an asset, permits have certain risk/return characteristics that are more attractive to some players. In addition some players have better information about the value of permits, which reduces their risk and makes them more likely to hold permits. Players that are involved in the energy market will be likely to place higher value on permits because of the "option value" they carry in an illiquid market. Permits provide the firms with security that they can emit carbon dioxide even if it is difficult to find a seller of permits. Therefore these firms may buy up a high percentage of the permits. If some players see the possibility to control the market they will be willing to pay more for permits because of the possible benefits they will gain from oligopoly or monopoly power in either the permit or energy markets. The concentration of permits was observed in the ITQ market with increased concentration in the industry as a whole.[12]

Under this type of manipulation, marginal costs of abatement will not be equalised so that there will be a higher overall cost of compliance. There will in this case be excessive incentives to innovate and invest. The Government will gain revenue but at the expense of distortions and other firms will face higher abatement costs.

Most importantly, this form of manipulation can be used to monopolise a product market so the effects go beyond the carbon dioxide market. If a company is able to exclude its competitors, then standard welfare losses, reduced innovation, lower quality and higher consumer prices will result.

4.3.2 How can strategic manipulation be avoided?

1. Do not limit who can hold permits. There may only be a small number of firms that are required to surrender permits at the end of each period, but they should not be only ones allowed to hold or trade permits.

2. Do not allow permits to become too concentrated. Existing law may be sufficient to prevent this occurring. However, if it is not, some limitation on concentration should be introduced. For example, do not permit any one company to hold more than 20% of the permits available for use in any one year.

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[12] The increased concentration in the fishing industry was also due to technology changes partly in response to the increased security of fish stocks. There is no counterpart to this effect in a carbon trading market.

3. Auction some permits each year so existing firms never hold too high a percentage. If they have to buy a lot of permits for different time periods in the auction it becomes expensive in the short term to push the price up.

4. Expand the permit system to cover more sectors, eg, forestry, to increase responsiveness of supply to changes in price due to reduced supply from existing holders.

5. Make permits bankable so there are more out there to sell, ie, increase price responsiveness.

6. Make trading anonymous to make cartels difficult to sustain.

Strategic manipulation of the price in permit markets could only be an issue with no international trading, and is unlikely in any case.

4.4 Recommendations for defining permits

4.4.1 Permits defined for one use or in-perpetuity/eternal

By "one use" we mean that the permit is defined as the right to emit one tonne of carbon once. For example, a permit might state: "This permit gives the holder the right to emit one tonne of carbon dioxide equivalent after January 1999". A permit in perpetuity gives the right to emit a flow of permits. For example, the permit might state: "The permit gives the holder the right to emit one tonne of carbon dioxide equivalent each year from the year 1999 to perpetuity".

We recommend permits should be one-use, infinitely divisible, and defined as proportions of the target rather than in tonnes. Defining permits for one use only, as opposed to several uses or "in perpetuity" has the advantages of administrative simplicity relative to the several-uses definition, and increased homogeneity. Homogeneity makes trading more efficient, reduces complexity and makes compliance easier to monitor. With one-use permits, it would be easier to phase grandparenting out over time. This could have enormous revenue-recycling benefits.

In addition, it is harder to define bankability with an "in-perpetuity" permit. With a normal property right it is not possible to use it twice in one period, eg, with land it is not possible to not farm in one period and use the same piece of land twice in the second period. In many environmental tradable permit markets the timing of emissions is critical and bankability is not allowed. In this situation, a permit in perpetuity can make sense because it is the right to emit a flow of emissions each year. In the carbon market, however, we are concerned with the accumulation of emissions. A permit in perpetuity that was not used one year would have to be convertible into a permit that allowed those emissions to be used in a later year. This becomes a "one-use" permit system.

Infinite divisibility benefits market liquidity by removing some of the lumpiness of transactions and encouraging small trades. If very small trades are possible, the number of market participants will increase, and small emitters will not be penalised by having to buy more emission rights than they wish to use.

Defining permits as proportions of the target rather than in tonnes has the effect of shifting the cost of reducing the country's target from the Government to private agents. The country's target would only change between commitment periods, thus during each commitment period the permits would behave as if they were defined in tonnes. However, firms that banked their permits beyond the end of one commitment period would face the risk that their value in terms of emissions could decrease.

Each permit would need to be marked with a date before which it cannot be used. This would ensure that the country is cumulatively in compliance up to any given date. Domestic permits would be directly convertible to assigned amount units (AAUs – the internationally tradable permits created by the Kyoto Protocol). One option would be to simply use AAUs as domestic permits. This would create problems, however, if a hybrid system were used and the trigger price reached. The Government would want to be able to freeze convertibility to AAUs.

4.4.2 Length of bankability of permits

By "bankability" we mean that a permit dated January 1999 does not need to be used in January but could be saved (banked) and used in a later period. The Government may want to define a limit on how long the permit can be banked. Thus the permit may be defined as: "This permit gives the holder the right to emit one tonne of carbon dioxide after January 1999 and before January 2009".

Bankability should probably match any international rules on banking of AAUs. The advantage of long allowances for bankability is that it allows businesses individually and the private sector as a whole to find the optimal path for emissions.

However, given uncertainty and the relatively short horizons of most businesses, it is probably not necessary to make the bankability infinite to achieve most of the gains from intertemporal optimisation. In actual markets, most banking has been for the purpose of short-run smoothing so that permits are banked for only one or two years at most. This is more a response to limited liquidity and short-term individual shocks than an overall constraint on permits in the market. When the market is actually operational, if there is too high (much more than rising at the rate of interest) a value on future rights relative to current rights, this would be an indication that the limit on bankability is a real constraint and should be reconsidered. The specifications of the Kyoto Protocol allow for permits allocated in the first commitment period to be banked into the second commitment period, so a domestic system in which the same was permitted would seem sensible, and would aid New Zealand's compliance with Kyoto.

4.5 Allocating permits

4.5.1 Auctioning vs grandparenting

Auctioning permits is economically preferred to grandparenting because it is less distortionary. However, some grandparenting may be required for political feasibility. The transition to a permit system would be eased if firms covered by NGAs were to receive grandparented permits in quantities based on best practice levels of emissions at a given date.

It is important to require that at least some firms buy emission permits for two main reasons. First, the revenue gained by the Government would allow the economy to enjoy some of the benefits of revenue recycling. Second, equity would be increased because those bearing the cost would be more widely spread through the economy. Most importantly, this would set a precedent that would make it possible that in the long run, emitters would pay for emissions and revenue would be recycled.

It may be desirable to phase the grandparenting out over time, so the Government should ensure that this option is not precluded by the design of the permit system.

4.5.2 How to auction permits

In a perfect market with perfect information all permits could be auctioned immediately. The Government could invest the money gained and if it needed to buy back permits simply repurchase them with the return from the investment. Alternatively, the Government could require firms to purchase permits on the international market and sell its own surplus in the same way, essentially using the international market as its auction mechanism. However, given that markets may not be perfect, the Government needs to take into account issues of market power, liquidity and maximising government revenue.

If we use "one-use" permits we have a series of permits dated for years out into the indefinite future. The later permits cannot be used for many years but could be sold in advance. One option would be to sell all permits with all dates immediately. Alternatively, the permits for each year could be sold at the time they can be used. We propose a mixed system where all current permits are sold as well as a percentage of the permits from each future year, with the percentage declining for more distant dates. Thus there would be annual auctions of a variety of different types of permit.

We recommend that annual auctions sell the remaining current permits and some for each future year out for about 25 years. For example, in 2005, all permits that are dated for use only after January 2005 would be auctioned. In addition 75% of the permits dated January 2006, 50% of those dated 2007, 25% of those dated 2008, 15% of those for 2009 and so on would also be auctioned. In the year 2006, the remaining 25% of permits for 2006 would be auctioned together with an additional 25% from 2007 etc. The percentages chosen here are purely for illustration. The idea would be to have a sizable percentage of permits for each of the current year and immediate future years traded every year.

Market power can only arise if one small group gains control of most permits that are available for use in a given year. If not all permits are allocated in advance, the Government can always counteract the market power by auctioning permits and thus making them available to new entrants. With annual auctions of all different types of permit (ie, with different start and end dates), a minimum level of liquidity will be guaranteed in the market. Finally, gradual auctions will allow experience to develop in the private sector, so the uncertainty about permit values will decrease, probably allowing the Government to sell them for higher values and make more revenue. This prevents private companies that have good information about the value of permits making large speculative gains early in the market and buying many permits cheaply.

4.5.3 Fully define rights – minimise restrictions and uncertainty

If when or how permits can be used is limited, the permits are less valuable to firms. Some restrictions are necessary to maintain the integrity of the system but each restriction should be evaluated to ensure that it is strictly necessary. Uncertainty increases the risk associated with holding a permit and makes it less valuable. Some uncertainty is unavoidable and cannot be controlled by the Government. This risk should not necessarily be absorbed by the Government to raise prices, because risk bearing has a real cost to the Government as well as to the private sector. However, the Government can create unnecessary uncertainty if it does not design the permits clearly and if it makes the value of those permits overly vulnerable to political changes.

4.6 Transaction costs, efficiency and incidence of costs

In a carbon dioxide market among importers and extractors, transaction costs could arise from five sources. Transaction costs are a problem because they mean some firms do not trade efficiently and thus overall costs are increased. They are a direct use of resources. They also may bias against some firms that are less able to trade and hence face higher costs of compliance.

One obvious transaction cost would occur if there were expensive administrative procedures that must be followed to have trades approved and to make trades. In this case, players would only trade when they could make a significant gain.

Second, both a tax and a permit system involve some cost of optimising. That is, it is costly for businesses to identify their static marginal cost curves. The difference with a permit system is that it is possible to bank permits, so businesses must also predict their future marginal cost curves in order to make good permit-banking decisions. Firms under either a tax or a permit system need to predict their future costs to make optimal investment decisions in any case.

Third, there are costs of finding the market distribution of prices and then finding a partner. These can be minimised by creating an anonymous centralised trading mechanism where aggregate price (including the distribution of prices) and quantity information is periodically released and buyers are matched to sellers. The traders would have to have the confidence of the players. They would have to provide information on trading to the Government (though not necessarily price information) for monitoring and enforcement purposes but this function would not need to be carried out by the Government. Large traders may prefer to negotiate directly when they have identified possible trading partners.

Fourth, if there is concern about the validity of the rights being traded, transaction costs are created. This is unnecessary and can be avoided by accurate registration of rights in real time (ie, as they are traded) so that buyers can check claims of ownership at low cost.

Fifth, negotiation costs between trading partners will depend on the liquidity of the market. If many players become involved in speculating on rights and creating rights (eg, from forestry) the market will be liquid and a market price will emerge. If the market is illiquid, large trades will involve negotiation and bargaining, which could be expensive. However, trades will tend to be repeated between the same partners and as trading patterns and prices become established, costs of negotiation will fall.

4.6.1 International trading and efficiency of permit market

Transaction costs will be heavily affected by the presence or absence of international trading of permits. If trading occurs within a liquid international permit market, transaction costs for domestic agents are likely to be very low; if the permit market is limited to New Zealand, participants will be much fewer and transaction costs could potentially be a great deal higher. Without an international permit market, fewer derivatives are likely to develop, trading will be lumpier, the price will be more volatile, and market power may be possible in very specific circumstances.

4.7 Design issues specific to taxes

A range of issues is specific to the design of an emission tax system. Unlike permit prices, a tax rate must be adjusted administratively over time. A tax system is likely to raise more money than a permit system in which some permits are grandparented, and thus the question of what to do with the money raised becomes even more pertinent. Finally, additional government intervention may be required to achieve international compliance under a tax system.

5 Options for mixed tax-permit systems

Rather than a pure emission permit system or a pure emission tax system, it is possible to have a system that is a hybrid of the two. In any hybrid system, indeed in any emission regulation system, it is imperative to avoid double taxation, which is both inequitable and distortionary. In a hybrid system, however, it may be less obvious that double taxation is occurring, so greater care must be taken to design a system in which it does not occur. One option for a hybrid is a permit system with a safety valve that prevents the marginal cost of abatement going too high. Another option is to tax some sectors of the economy and regulate other sectors through a permit system.

The option of a hybrid system with a trigger price may be chosen because it limits the permit prices that may be faced by private agents. It involves two components. Permits that add up to target emissions are auctioned or allocated and then traded as in a normal permit system. However, beyond this permit trading there is a trigger price at which private agents can buy unlimited additional permits from the Government. When the trigger price is reached, all conversion of domestic permits to international permits must be frozen to avoid firms buying at the trigger price and selling at the higher international price. The political process of setting trigger prices is conceptually the same as the process for setting a tax but may be easier because the trigger price is less likely to have any real effect than the tax. Consequently, the domestic permit price will never rise above the trigger price, and marginal abatement costs will be bounded from above. If the trigger price is set very low, the system will behave like a tax system; if the trigger price is set very high, it will behave like a permit system.

The effect of such a system is to transfer some of the price risk involved with a permit system from private agents to the Government. While this reduces the risk faced by private agents, it increases risk to the Government, which must purchase any additional permits desired by agents at the international permit price and sell them at the lower trigger price.

Pizer (1998) evaluates a hybrid system of this type using a global integrated climate economy model. This paper finds that, at a worldwide scale, this type of hybrid system has welfare benefits over a straight tax or straight permit system. However, these results apply to a no-government world economy in which the cost of emissions above target is decreased production caused by environmental damage, thus they may not apply unaltered to New Zealand.

It may also be optimal to have a “floor” price to avoid domestic prices falling to zero if an international market collapse, such as some countries falling out of compliance by massively overselling permits, leads international prices to fall lower than is globally optimal in the long run. If international prices are very low, New Zealand may find that the non-market benefits from international favour from domestic effort, effects of others’ domestic efforts, and maybe early action mean that New Zealand’s marginal benefit does not really fall to zero and the Government still wants to induce some abatement effort.

Differences in risk aversion across sectors might also make it worth regulating some sectors by means of a tax and using permits elsewhere. The upstream firms involved in producing carbon dioxide emissions from fossil fuels are fairly few, large, and tend to have a high degree of sophistication. However, in some sectors large upstream firms like these may not exist, and the small, downstream players might be very risk averse and poorly equipped to use a permit market efficiently. If the firms in this sector were taxed rather than included in a permit system, the Government would assume the risk of permit price changes that these firms would otherwise face. This system allows the Government to protect vulnerable agents. Also, unlike firms, the Government has the option of not complying with Kyoto. This could be implemented by making the hybrid system available only to selected small players and not allowing them to sell permits when they buy at the trigger price.

A system in which some sectors are taxed and others are regulated by permits might be useful because of monitoring difficulties in specific sectors or differences in risk aversion. If monitoring in a particular sector such as forestry sinks were especially difficult, it might be preferable to use a blunt instrument such as tax breaks to regulate this sector. This could be combined with a permit system for the rest of the economy to create a mixed system. If climate regulation becomes more stringent and/or international permit prices rise, the value of incorporating these other sectors in the permit system will rise and may outweigh the costs of incorporating them.

This type of combination system fails to equalise marginal costs of abatement across all sectors, and the differential treatment of different sectors may cause political difficulties. A combined tax and permit system may also require more administration than a pure tax or pure permit system. These costs could well be offset by the abatement gains that such a system could yield.

5.1 Transitioning to hybrid permits for carbon dioxide emissions

For reasons discussed previously, it would be politically very difficult to transition to a comprehensive tax system. There are many reasons why New Zealand may want to transition to a comprehensive hybrid permit system. This section outlines the reasons to go to a permit system, specifically a hybrid permit system, and the transitional issues involved in the change.

It would be politically feasible to achieve broad coverage of carbon dioxide emissions under a permit system because there is the option of grandparenting to some sectors or firms. Given an international permit market and uncertain marginal cost and benefit of abatement, a permit system produces optimal outcomes; a tax system does not. Permits give more flexibility in the allocation of emission regulation risk than taxes. Finally, a domestic permit market would be simple and probably fairly efficient.

A hybrid permit system in which there was a trigger price at which agents could purchase as many permits as they wanted from the Government would offer an additional advantage over a pure permit system. If the trigger price were set significantly above the expected permit price, the system would behave like a permit system in normal circumstances, with all the benefits described above. This system would also provide protection against failure in the international market or the collapse of international cooperation. If the international market were to become very illiquid or the international permit price were to rise very high, domestic agents would be protected from the extremely high permit prices and marginal abatement costs. At this point, the system would effectively behave largely like a tax system, which yields more efficient outcomes in the absence of an international permit market.

The transition to a hybrid permit system could be eased in several ways. Businesses that were already paying an emission tax would not find it too great a leap to go to purchasing emission permits at auction or from the international market. They could be required to begin purchasing permits to cover their emissions. It would be a larger step for businesses acting under voluntary emission reduction agreements to be required to start purchasing permits to cover their emissions. These firms could receive permit allocations based on their existing agreements, at least in the short term. They would still face the full marginal incentive to abate until their marginal abatement costs equalled the permit price, but would not suffer the inframarginal damage of having to pay for permits to cover all their emissions. They could sell the grandparented permits to the upstream firms that require permits. This grandparenting of permits could be gradually phased out under agreed rules.

Some projects have been awarded emission credits, which can be sold domestically or internationally, under the current system. The existing credits could also be used in the permit market. It may be desirable to replace the current project scheme with policies aimed at learning and information.

6 Future directions: emissions and sequestration from land use and other greenhouse gases

In New Zealand, agriculture produces the highest total greenhouse gas emissions of any sector, producing around half of New Zealand's total greenhouse gas emissions (New Zealand Climate Change Office, 2003). Most of these emissions are land-use related, primarily through animal emissions of methane and nitrous oxide. In contrast, the forestry sector is a net "sink" of carbon dioxide; growing forests absorb carbon dioxide. The main opportunities for reduction in greenhouse gas emissions related to land use are from potential carbon sequestration through increasing forestry and reduction of emissions related to ruminant animals and nitrogen fertiliser use.

6.1 Carbon sequestration in plantation forests

Plantation forest currently covers around 7% (1.8 Mha) of New Zealand's total land area (Ministry of Agriculture and Forestry (MAF), 2004). *Pinus radiata* makes up 89% of the planted area, and has an average rotation length of 27 years (New Zealand Forest Owners' Association *et al*, 2003). In 2000, the average carbon stored in the New Zealand plantation forest estate was approximately 100 tonnes per hectare (New Zealand Climate Change Office, 2003). MAF estimates that around 640,000 hectares of forested land are Kyoto forests, but who owns Kyoto forests is not clear (MAF, 2004).

PA Consulting Group (2001) estimates that over 9.4 million hectares of land are suitable for forestry (although this is not a prediction of likely conversion). The Forest Industry Council envisions four million hectares will have converted to forestry by 2025 (New Zealand Forest Owners' Association *et al*, 2003). However, new planting rates have been falling since the mid-1990s. Without an incentive to increase plantation area, New Zealand may become a net source rather than a net sink (Te Morenga and Wakelin, 2003).

No comprehensive instruments have been introduced to encourage the planting of harvestable forest. Current Government policy is focused on the development of a "Forestry Industry Framework Agreement" which includes assistance for regional and industry development, including marketing and skill development (Ministry for the Environment, 2004). The Government has agreed to accept full liability for deforesting or harvesting Kyoto forests (forests planted on previously unforested land after 1 January 1990), and liability up to a specified (10%) cap for non-Kyoto forests for the first commitment period (Hodgson, 2004a).

The gains to any instrument could be large relative to the costs. Forestry sequestration is a relatively simple process for limiting the increase in atmospheric levels of carbon dioxide (IEA Greenhouse Gas R&D Programme, 2004). The most feasible option for landowners would be simply to convert marginal pastoral land to forest.[13] Reforestation on marginal land would also have secondary environmental benefits through reductions in erosion and flood risk.

[13] Alternatively, they could alter management techniques (eg, selective logging) of currently forested land.

The "point of assessment", who has the right to earn credits and bears liability for loss of credits, also needs to be decided. In New Zealand, ownership of forest and the land underneath the forest can be separated. The landowner and forest owner are separate entities for at least a third of New Zealand's forests. Information on who owns the land and who owns the forest is needed before deciding who should gain credit and where liability should be placed. Grandparenting of credits to either forest owners or the owners of the land on which the forest stands would involve huge one-off transfers of wealth so if the point of assessment is linked to the way credits are grandparented, as is likely, this is a critical distributional issue. Kerr and Brunton (2004) discuss this in detail.

Plantation forest area is relatively easy to monitor and this can be achieved reasonably cheaply with the combined use of satellite data and ground truthing (Kerr et al, 2004). Alternatively, forest information could be self reported by landowners (or forestry companies). Because the rotation length of plantation forests is long, on average 27 years, and incentives to harvest early are weak, costs could be reduced by monitoring at longer time intervals without much reduction in environmental integrity. Abstracting carbon sequestration information from area measurements is possible using models being developed as part of the national inventory process.

However, some data gaps would need to be addressed. The carbon models rely on age-class information and this is lacking. This is a one-off problem, as once the initial age-class structure is known, ages will be able to be inferred from future satellite pictures.

Optimally, marginal pastoral land would be converted to forestry. These forest blocks would likely be small. Currently, small blocks of less than 1,000 hectares comprise around a third of the total planted area (MAF, 2003). The scattered nature of these kinds of block would create costs in terms of the Government having to deal with many farmers. Monitoring/Measurement issues would also arise because of limits in satellite identification of small blocks. Satellite measurements would not create any environmental integrity issues as any error should not be biased nationally, but there are possible equity issues at the local level, especially with errors exacerbated when measuring changes (New Zealand Climate Change Office, 2003). Local, on-the-ground measurement would increase administration costs and may induce bias, but may be worthwhile when carbon dioxide prices are high and hence equity concerns are important.

Environmental integrity may be lost if plantation forestry is rewarded but scrub reversion is not. Around 6,000 hectares of scrub were cleared for new forest planting in 2001 (New Zealand Climate Change Office, 2003). Marginal land that might have reverted to scrub without a reward may be converted to plantation forestry in response to a reward, with no environmental gain or possibly even environmental losses.

6.2 Carbon sequestration in reverting indigenous forests[14]

Around 2.6 million hectares of land in New Zealand are estimated to be reverting to indigenous forest (Ministry for the Environment, 2000). Potentially, if all marginal pastoral land currently containing scattered manuka/kanuka (or "scrub") were converted to full cover shrubland, about four million tonnes per year additional total carbon could be sequestered (Whitehead *et al*, 2002). Kerr (2003b) estimates a potential yield of up to

[14] Joanna Hendy is the primary author of Section 6.2 but does not take responsibility for the document as a whole.

$117 million annually from forest reversion. Additional environmental benefits include erosion control, flood risk reduction, biodiversity benefits and cultural benefits.

Landowners' options range from abandoning land in response to a policy and allowing it to revert naturally (as a result of its own seed bank), to actively managing it, including fencing it off and removing pests to optimise carbon storage.

Current Government policy for rewarding reversion is covered by the proposed permanent forest sink mechanism where landowners would be rewarded for increases in carbon over commitment period 1, 2008 – 1012, subject to the landowner covenanting the forest for permanent protection (Hodgson, 2004b).[15] Other forestry protection mechanisms exist, such as the QEII National Trust and Nga Whenua Rahui under which land is covenanted for 25 years then there is a renewed kawenata (agreement) with landowners (Kerr, 2003b).

Carbon returns from indigenous forest are unlikely to be sufficient so that indigenous forest will displace plantations or agriculture on land where these are good options, but will be relevant for encouraging reversion on unused or bare marginal land. Most marginal land is found in poorer rural areas such as East Cape, Northland and Taranaki (Kerr, 2003b). Allowing reversion to indigenous forest could become profitable on this land, particularly if carbon returns are combined with other scrub-related industries, such as manuka honey and pharmaceuticals (Harmsworth, 2003).

Some commentators have suggested that farmers may be reluctant to let land revert because they may lose the option-value on that piece of land, fearing that the Government may not allow them to clear it in the future if changes in prices or costs mean it becomes more productive (Kerr et al, 2004). This suggests that there needs to be an opt-out option in any policy that is implemented.

It would be difficult to reward only land that would not otherwise be protected (Kerr, 2003b). In the absence of carbon dioxide credits, indigenous forests are not protected for profit. The complexity of the issue suggests that it may be best to be overly generous and reward all land newly protected after a certain date.

The scattered nature of marginal farmland may mean that monitoring, measurement and administration costs will be high. The Government would have to deal with many owners/farmers over a large area. Small, scattered plots are harder to measure by satellite, and errors would be exacerbated when rewarding changes in areas.

The gains from a policy for reverting forest may be large, but the costs of full integration into a permit system may be significant. Therefore, in the short term, temporary measures such as subsidies or tax breaks for newly protected reverting scrub may be preferable to a comprehensive instrument.

6.3 Agricultural methane

Enteric emissions from grazing ruminant animals are responsible for about 87% of New Zealand's total methane emissions, and 99% of methane emissions from agriculture (O'Hara et al, 2003). Most methane emissions are from sheep and beef farming and dairy.

[15] Some harvest of the forest is allowed after 35 years, subject to the constraint that a continuous canopy cover is maintained.

A feasible short-term mitigation option is diet manipulation to decrease emissions. Increasing feed intake decreases the methane emission per unit of intake and increases productivity – methane represents a loss to the animal of about 6% of the gross energy in the feed. However, data on abatement potential, costs and viability are currently lacking.[16]

Current Government policy exempts the agricultural sector from price measures provided adequate research is undertaken. Potentially, animal slaughter numbers could be monitored and emissions calculated using national averages. However, implementing a price-based instrument for methane emissions would result in large financial transfers between farmers and the Government with possibly a very low level of environmental gain (Hendy and Kerr, 2004). With a permit system, the complicated question of allocating permits would need to be addressed.

6.4 Nitrous oxide emissions

Nitrous oxide emissions make up over a quarter of non-carbon dioxide emissions. Nitrous oxide is primarily related to nitrogen fertiliser application on both farmland and cropland and to animal numbers. As well as reductions in greenhouse gas emissions, proper management of agricultural nitrogen could lead to a reduction in the nitrate pollution of waterways.

Various animal, grassland and cropland management options are available. These involve more efficient fertiliser application, reductions of nitrogen in feed (although this may lower productivity), and effluent management. There are interactions between nitrate pollution of waterways and nitrous oxide emissions, with the possibility of "win-win" management options.

Observing and monitoring management techniques on a farm-by-farm basis would be very costly. In this case, a blunt instrument such as taxing fertiliser may be preferable to avoid these high costs.

6.5 Other greenhouse gases

The non-carbon-dioxide greenhouse gases that do not arise from agriculture form a very small proportion of New Zealand's greenhouse gas emissions. Most methane and nitrous oxide emissions are from agriculture, although there are minor contributions from waste, energy and industry. The other three greenhouse gases, PFCs, HFCs and SF_6, combined only contribute about 1% of New Zealand's total emissions. Current policy relating to these three gases involves a voluntary approach, with agreements negotiated between the Government and industry. The Government has recently launched a discussion paper on ways to reduce synthetic greenhouse gas emissions.[17]

Measurement issues for emissions of these three synthetic gases are very different from those for carbon dioxide. Given the small volume of these emissions and the potentially very large costs of developing and monitoring a system for regulating them, it is unlikely to be efficient to include them in a permit system in the near future. However, strategies aimed at learning about ways to limit these emissions might find a place in policy a great deal sooner.

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[16] See O'Hara *et al* (2003) for discussion of methane and nitrous-oxide related issues.

[17] See www.beehive.govt.nz/ViewDocument.cfm?DocumentID=21144.

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