Submission on the Carbon Pollution Reduction Scheme Green Paper

Dr Peter John Wood[1], September 2008

This submission relates to some of the policy objectives of the Carbon Pollution Reduction Scheme (CPRS) and to some of the preferred positions. I discuss emissions from agriculture, land use, land use change and forestry; the relative merits of regulation by prices and quantities or both (which relates the the question of whether to have a carbon tax, cap-and-trade, or a hybrid approach); the targets and trajectories associated with an international agreement based on a modified contraction and convergence approach; finally, spillovers and carbon leakage are discussed.

1. First I discuss emissions from agriculture, land use, land use change and forestry (the hardest problem). This discussion builds on a submission that I made in response to the *Garnaut Review Issues Paper 1* [1]. There is large scope for reducing emissions in these sectors, but emissions are hard to measure, and some are not accounted for under the Kyoto protocol. There are also other externalities associated with land use change that relate to ecology and biodiversity conservation. This issues relate to the long term security of biological carbon stores and adaptation to impacts of climate change on species loss.

2. The second problem discussed is the prices *vs.* quantities problem. After examining the impacts of the 'fat tail' of the climate change damage function on the issue of prices *vs.* quantities, I conclude that an optimal approach is a hybrid approach where a price floor is maintained by having firms pay an extra fee when they surrender their permits.

3. The third problem discussed is international cooperation, we analyse the contraction and convergence model and discuss both the rate of contraction and the rate of convergence. This analysis builds on the analysis of the *Garnaut Review Supplementary Report* [9].

4. The fourth problem discussed is the issue of spillovers and carbon leakage. After making some general comments, I introduce a simple model of carbon leakage and discuss the implications that this model has for resolving this dilemma.

1. Emissions from agriculture, land use, land use change and forestry

Because LULUCF can have negative emissions, there is a huge capacity for reducing Australia's emissions in this sector (see my submission [1] to the Garnaut Review Issues Paper 1). However, inclusion of LULUCF in an emissions trading scheme is likely to have perverse effects:

- Uncertainties in measurement (and in additionality for offsets) could affect the carbon price in the rest of the ETS, and therefore affect the actual amount of emissions associated with a permit. This would undermine the integrity of the ETS. There are also

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uncertainties in measurement associated with agriculture, especially agricultural soils.

- Inclusion of reforestation in an ETS is likely to lead to hardwood plantations being used as carbon sink projects. Because native forest timber is a substitute good for hardwood plantation timber, there is likely to be increased demand for timber from natural forests. Natural forests are a better carbon store than plantation timber, so this would have the perverse effect of increasing emissions (Wood and Ajani, [3]). The majority of hardwood plantation timber and native forest timber is used for pulp and paper products, so under business as usual conditions there will be little carbon stored in wood products from native forest and hardwood plantation timber harvesting.

- There is a risk that coverage of only some activities would have perverse effects. This suggests that coverage of the whole sector, including activities not accounted for under the Kyoto Protocol may be required. Covering all activities in an ETS may make the measurement problems intractable.

- There are other externalities associated with land use related to ecosystems and conservation of biodiversity. Not including these externalities could also lead to perverse effects. For example, vegetation which plays an important habitat role could be cleared for a carbon sink project. Healthy ecosystems also have greater resilience than unhealthy ecosystems, which has implications for security and longevity of carbon stores. Climate change will lead to increased levels of species loss, so preservation of biodiversity has an important adaptation role. Emissions related to land use and agriculture are associated with part of the carbon cycle that is ultimately based on ecology.

It is therefore not recommended that LULUCF is included in an ETS. Similar arguments apply to some agricultural sectors, such as agricultural soils. While LULUCF and some agricultural sectors are unsuitable for inclusion in an ETS, there are other options for reducing emissions and internalising externalities. These include price based approaches (taxes, which could be negative), regulations, and combinations of both. One half of the problem to secure funding to sequester carbon and protect carbon stores, a government body staffed by people knowledgeable in the field, including ecologists, is probably required. The other part of the problem is to tax and regulate activities that lead to increased emissions in these sectors.

Issues related to how this could work include:

- There will still be uncertainties in measurement of some activities, but these uncertainties won't affect the price of any other activities, so risks associated with uncertainty in measurement are contained, unlike with an ETS.

- Activities that sequester carbon could be funded by money raised from auctioning permits in an ETS, or from other sources.

- Other externalities associated with land use could also be included. These can include habitat loss, habitat restoration, habitat fragmentation, water, species loss and landscape change.

- While covering all activities related to LULUCF and agriculture would be ideal, including activities that cover all emissions may not be practical, especially in the early stages of policy implementation. An alternative to covering the whole sector may be to to focus on activities which have positive and negative biodiversity impacts.

- It would be appropriate to fund activities that promote revegetation reforestation that is environmentally appropriate and based on sound natural resource management policy.
- Funding for the protection of carbon stores, together with biodiversity conservation, is important. Some funds should be set aside for payments to people who choose to covenant their land in such a way that protects and enhances the biodiversity of that land. Traditional carbon taxes and cap-and-trade work with flows, an approach to paying rents for stores is somewhat different. An equivalence factor that may be useful for doing this is described in [17].

The largest source of emissions in the agricultural sector is enteric emissions from livestock. Although these emissions are also hard to measure, it is possible to measure proxies, such as the number of cattle [1]. These emissions could then be dealt with by either applying a carbon tax or including them in an ETS. Activities which reduce enteric emissions and also reduce the amount of livestock will also reduce emissions from rangeland degradation and adverse impacts on biodiversity.

Emissions from deforestation and forest degradation in Australia

Australia's Kyoto accounts do not include the CO_2 emissions from native forest logging - because native forests are allowed to grow back, it does not count as a change in land use. Mackey *et al.* [2] has some important conclusions about the role of natural forests in mitigating climate change:

- Australia's natural forests have far larger carbon stocks than previously recognised (up to 2000 t C ha^{-1}).
- The 14.5 million hectares of Eucalyptus forest in southeast Australia have a carbon stock of 25.5 Gt CO_2.
- Logged forests have a sequestration potential of approximately 7.5 Gt CO_2, if they are not logged further.
- Carbon stored in natural forests is more reliable over long time scales than industrial forests.

Australia therefore has a huge potential for reducing emission from forest degradation. In 2010, a large amount of native hardwood plantations will become available, reducing the need to log natural forests [11]. Reducing emissions from forest degradation could be achieved by either applying a carbon tax (and possibly taxes on other environmental externalities), or by regulation that phases out logging from natural forests.

If Australia can find effective ways of funding the reduction of emissions from land use activities in a way that is accountable and does not have perverse outcomes, this could be used as a prototype for projects that reduce emissions from deforestation and forest degradation (REDD) elsewhere.

2. Prices, quantities, or both?

I argue that the best carbon price signal is a cap and trade system with a price floor. The floor can be maintained by having firms pay an extra fee when they exercise their permits, based on the amount of their emissions. The carbon price then becomes equal to the sum of the permit price and the extra fee. This is similar to having emissions trading scheme combined with a carbon tax.

The discussion in this section relates to the overall framework of the CPRS, which includes preferred positions 3.1 and 3.7. It also relates to the CPRS objectives of economic efficiency, policy flexibility, and minimisation of implementation risk.

The economics of balancing mitigation costs with the costs of climate change

The prices *vs.* quantities question is addressed in Weitzman's 1974 paper [4]. Climate change is more complex than the situation discussed in [4], because of Weitzman's more recent (2008) work [5] (see also my submission [6] on Issues Paper 3 , which discusses Weitzman's recent work). The model in [4] assumes that the costs and benefits of climate change mitigation have uncertainties that are sufficiently small that the cost and benefit functions can be approximated using a second order approximation, and does not take into account risk aversion. Weitzman's recent work [5] shows that with risk aversion, the cost function of climate change (which is the benefit function of mitigation) has a "long fat tail" and what he calls "potentially unlimited downside exposure". This implies that the tail of the probability distribution dominates the cost of climate change, and that the expected cost is infinite unless one introduces a parameter based on how much we are willing to pay to preserve "life or civilization as we know it" (Weitzman's VSL-like parameter).

Rather than attempt to construct a mathematical model that generalises both [4] and [5], I will use some of the results from these models to provide heuristic arguments for a cap and trade scheme with a price floor, as described above.

Weitzman's approach to prices and quantities is about uncertainty: when there is no uncertainty, they are equivalent, so the choice of instrument depends is based on minimising the expected cost of getting the price or quantity wrong. The standard interpretation of Weitzman's model in [4] is that when the slope of the mitigation cost function is greater than the slope of the mitigation benefit function, price mechanisms (taxes) are better; when the slope of the mitigation cost function is less than the slope of the mitigation benefit function, quantity mechanisms (cap and trade) are better.

One issue that affects instrument choice is that the slope of the cost and benefit functions are also uncertain. Weitzman [4, p.486] shows that when there is uncertainty in the slopes, there are more advantages to a quantity based approach.

Not only does Weitzman's recent work [5] mean that the expected cost of climate change is higher than previously thought, it also describes how obtaining more information about climate change updates the probability distribution of climate change costs in a Bayesian manner - a 'prior' distribution is replaced with a 'posterior' distribution. If the IPCC Fourth Assessment Report estimates of climate change costs are thought of as a 'prior' distribution, inclusion of the latest science can be thought of as a 'posterior' distribution. The posterior distribution may be somewhere in the 'bad tail' of higher costs because:

- The Arctic ice is melting much more quickly, leading to albedo effects, which will heat up the earth further.
- Both palaeoclimate evidence and observations suggest that there is a greater risk of ice sheets such as Greenland melting, leading to greater sea level rises. Albedo effects from Arctic melting is likely to make this worse.
- Evidence that permafrost is melting, releasing CO_2 and methane. Albedo effects from Arctic melting is also likely to make this worse.
- Recent work analysing palaeoclimate data by Hansen *et al.* that suggests that climate sensitivity is likely to be abound 6°C, higher than previous expected values.

While the benefits of mitigation have a long tail, the costs of mitigation can be bounded above. For example, we can choose an expensive technology such as solar power as an upper bound for the cost of mitigation (provided the time period is long enough to manufacture the solar panels) in the electricity generation sector. When introducing a carbon price in one country, the costs in one particular year can also be bounded by purchasing international permits or by banking and borrowing. Even advocates of a very low carbon tax, such as William Nordhaus, assume the existence of a "backstop technology" which functions as a cap on the cost of mitigation in their economic models.

This all suggests that the risk of the cost of climate change exceeding the amount invested in mitigation is far greater than the risk of the cost of mitigation exceeding the cost of climate change. Both the likelihood of climate change costing more and the expected cost of climate change costing more are higher. This risk can be reduced by having a cap-and-trade approach which also has a price floor, as described above.

Because of the long tail, if there was a price cap, there would also be a risk that the cost of climate change would exceed the price cap. Having a price cap is therefore not recommended. A case could be made for countries with low per-capita emissions and per-capita incomes, such as India, to have a price cap, however.

A hybrid scheme with a price floor maintained by firms paying an extra fee when they exercise their permits

Under a traditional cap-and-trade scheme, firms report their emissions each year (or whatever the time period is chosen to be), and are required to have purchased enough permits to account for their emissions. Firms then exercise their permits. A price floor can be introduced by requiring that firms pay an extra fee when they exercise their permits.

It is argued by Hepburn in [7] that a price floor could be maintained by a commitment by the regulator to buy back permits. This is a poor mechanism for maintaining a price floor for a reason argued in the Garnaut Review Draft Report [8], it would be incompatible with the international trade in permits because the regulator would have an unlimited liability. A system where firms pay an extra fee (the floor) on top of the permit price would be compatible with international trade. If we want to sell permits overseas, the extra fee would be paid at the time of sale.

For the floor price to work best, it should be set to be as close as possible to the expected social cost of carbon (which will increase over time). If the role of the floor price was merely to provide insurance against the carbon price being exceptionally low (as was the case in the EU ETS during 2006 and 2007), it would not be necessary - there are better mechanisms from preventing this, such as banking, and making sure that there is scarcity when setting the cap. The idea of setting the floor price to be equal to the social cost of carbon is that the floor price has just as important a role as the permit price in driving emission reductions. There is a good chance that the slope of the marginal cost function of mitigation is higher than the slope of the marginal benefit function over short time scales, which suggests that the floor price will be a better driver of emission reductions.

A floor price maintained by an extra fee would not be incompatible with secondary markets. The permit market would be similar to an options market, the permit price will be very low if it is expected that the carbon price will be not be higher than the extra fee, and will have significant value if the carbon price is higher than the extra fee. In a traditional cap-and-trade market, the permit price only has significant value when it is expected that the cap is not higher than the amount of emissions, this will continue to be the case.

Because there is still a cap and trade scheme, there is still the advantage of a definite cap. This reduces the risk of excessive climate change compared to a pure carbon tax. International negotiations are predominantly based on a cap-and-trade approach, especially for developed countries. This hybrid approach would still be compatible with international negotiations.

A disadvantage of cap-and-trade approaches is that if an activity significantly reduces the cost of mitigation, it is difficult to adjust the cap so that this will result in more mitigation. Activities that may have this effect include successfully addressing a market failure, or a technology breakthrough. Under cap-and-trade, there are reduced costs when this happens, but the benefits are not realised by the environment because the carbon price will become less than the social cost of carbon. The hybrid approach discussed here does not have this problem, technologies and reforms that reduce the cost of mitigation will result in further mitigation because the carbon price will be maintained by the price floor.

It was suggested in the Garnaut Review Draft Report that increased fossil fuel prices may lead to Australia meeting its Kyoto requirements, and that it may therefore be a good idea to start with a carbon tax, before introducing an ETS. An alternative approach would be to start with a carbon tax, but when introducing an ETS, the carbon tax is maintained as an extra fee, that firms pay when exercising their permits.

3. Targets, trajectories, and international cooperation

The Garnaut Review *Supplementary Draft Report* [9] introduced a modified 'contraction and convergence' principle in which countries start reducing their emissions in 2013, and convergence (when all countries are allocated the same amount of per-capita emissions) occurs in 2050. In this section we analyse the emissions reductions that would be required by Australia in 2020 in a contraction and convergence model for different rates of contraction (corresponding to a stabilisation target) and convergence (corresponding to a convergence date).

Some of the CPRS objectives that relate to the discussion here include promotion of international objectives, fairness, and environmental integrity. We make some recommendations about modelling contraction and convergence scenarios, and some recommendations about what the 'gateway' for emissions in 2020 should be.

Garnaut has stated [9, page 5] that

> "Australians can think of many reasons why their situation is different from that of other developed countries, and why their emissions reduction targets should be less demanding. So can people from every other country. There will be no progress towards an effective international agreement if each country lays out all of the special reasons why it is different from others, and why it should be given softer targets. When climate change negotiators from any country list reasons why their country has special reasons to be treated differently, and take them seriously, we should be quick to recognise that the negotiators, and the countries they represent, intentionally or not, are inhibiting effective international agreement."

Because Australia is a very high per-capita emitter (the world's highest Annex I per-capita emitter), targets based on a late convergence date such as 2050 give Australia much softer targets compared to an earlier convergence date. It would therefore inhibit effective international agreement if Australia was to insist in a 2050 convergence date, or targets based on a 2050 convergence date. Garnaut has also stated [9, page 14] that

> "Developing countries will generally favour earlier convergence towards equal per capita rights than is embodied in the Review’s proposal. High-emitting developed countries would obviously find it more congenial to have later convergence. There will need to be extensive discussion within the international community, involving varying proposals for allocation of emissions entitlements, before there is a chance of agreement."

In order to investigate what implications this has for Australia's emissions reduction trajectory, we have analysed a contraction and convergence model for different stabilisation targets and different convergence dates. This model is based on the Global Commons Institute *Contraction and Convergence Options* model [11]. The model that we have used has the following limitations, which means that (like many models) the results are best thought of as 'ballpark estimates', but are estimates that increase our understand of how different contraction and convergence rates affect greenhouse reduction targets:

- The model is based on CO_2 emissions that are not from land use change. Other greenhouse gases have not been included. Emissions data is only included up to the year 2000.
- Contraction and convergence starts in the year 2000.

- The model does not include other modifications that are described in the *Garnaut Review Supplementary Report* [9, page 15].
- The population projections used to estimate per-capita targets for Australia in 2020 are different to some of the population projections used to estimate targets for Australia in 2020 relative to 2000 levels.
- Carbon cycle feedbacks could significantly increase the emissions reductions required for a given stabilisation target [10].

We obtain the emissions reduction level for 2020 from the per-capita target by using ABS population projections for 2020 [12]. These projections estimate that the Australian population in 2020 will be between 22.85 million and 24.48 million.

Contraction and Convergence Scenarios			
Target	**350ppm**	**450ppm**	**550ppm**
110-year industrial CO2 emissions	**325 Gt C**	**442 Gt C**	**660 Gt C**
Emissions reduction commitment for 2020 relative to 2000			
Convergence 2030			
Per capita	**-66%**	**-61%**	**-53%**
Level	**-57% to -60%**	**-50% to -53%**	**-39% to -44%**
Convergence 2040			
Per capita	**-57%**	**-50%**	**-40%**
Level	**-45% to -49%**	**-36% to -40%**	**-22% to -28%**
Convergence 2050			
Per capita	**-51%**	**-43%**	**-31%**
Level	**-37% to -42%**	**-27% to -32%**	**-12% to -18%**
Garnaut Equivalent [9, page 47]			
Per capita		**-40%**	**-30%**
Level (Garnaut population projections)		**-25%**	**-10%**
Level (ABS population projections)		**-23% to -28%**	**-10% to -16%**

We make the following observations:

1. For a convergence date of 2050, the model estimates per-capita 2020 targets for

Australia that are very similar to the per-capita targets suggested by the Garnaut Review for stabilisation scenarios of 450ppm and 550ppm.

2. The magnitude of the 2020 emission reduction levels suggested by the Garnaut Review are at the lower end of the levels obtained from the Garnaut per-capita target from using the ABS population projections, especially for the 550ppm target.

3. The 2020 emission reductions required for earlier convergence dates are significantly deeper than those required for a 2050 convergence date.

It is important to remember that an international agreement based on the contraction and convergence model or the modified contraction and convergence model involves trading of emission allowances. It is likely that many of the deeper 2020 targets above would be achieved involving significant purchases of international permits.

We make the following recommendation:

Recommendation: *The Australian Government estimate and publish the emissions reductions required for Australia if an international agreement based on the modified contraction and convergence model was to have a convergence date of 2040 or 2030. The emission reductions required for 550ppm, 450ppm, 400ppm and 350ppm stabilisation targets should also be estimated, and different scenarios involving carbon cycle feedbacks should be analysed.*

It is possible to make the case for earlier convergence dates than 2030. One approach that would encourage developing countries to participate in an international agreement is a pure per-capita approach [12]. All participating countries are allocated permits based on their population and average per-capita emissions. High per-capita emitters would buy permits from low per-capita emitters. This is the same as the end point of a contraction and convergence approach.

The problem of choosing a convergence date in very similar to the permit allocation problem in a domestic ETS -- do large polluters get free permits to pollute based on their previous emissions, or do they have to pay for the right to pollute, and buy the right to pollute off the public? The former situation is a form of rent-seeking, the latter situation is based on the polluter pays principle. A slow rate of convergence implies much higher rents that go to high per-capita emitters such as Australia.

Achieving an international agreement that avoids dangerous climate change is a difficult problem. Reducing emissions in an ad-hoc policy world can be thought as a "prisoner's dilemma", but achieving a good international agreement, like many bargaining problems, can be thought of as a game of 'chicken'. Strategic moves sometimes involved with bargaining problems like this can include prior commitments and promises, delegation and mediation, and threats [16]. Australia needs to aims for strong international target and avoid participating in rent-seeking during this process. We therefore make the following recommendation:

Recommendation: *Australia should be flexible on convergence dates, but drive a hard bargain and aim for an ambitious stabilisation target that is no higher than 450 ppm. Choosing an emissions reduction target now based on a 550 ppm target is incompatible with a successful international bargaining strategy. If we are to choose a "gateway" for a 2020 target before international negotiations conclude, then the contraction and convergence model suggests that the 2020 gateway should be 25-60% less than 2000 emissions.*

4. Spillovers, carbon leakage, and EITEs

In this section we are interested in emissions reductions when there may not be an international agreement. We will also discuss some issues related to spillovers that are general. Some of the discussion relates to the question of assistance for emissions-intensive trade-exposed industries (EITEs), and preferred positions 9.1-9.9. Relevant scheme objectives include promotion of international objectives, fairness, and implications for the competitiveness of traded and non-traded industries.

Addressing climate change requires the resolution of a prisoner's dilemma, and preferably resolving it quickly. The prisoner's dilemma can be thought of as a multiplayer repeated game, with communication between players, this makes it easier to resolve. In some ways present mitigation actions are more important in how they contribute to resolving the prisoners dilemma than their direct affect on emissions.

The most successful algorithms in experiments involving simulated multiplayer prisoner's dilemmas have been 'tit-for-tat' strategies, this suggests that the issue of reciprocity is important.

Weitzman's recent work [5] affects the cost of not cooperating, but does not effect the marginal benefit from free-riding. This affects the pay-off matrix in a way that increases the chance of resolving the prisoner's dilemma (but also increases the cost of not resolving the prisoner's dilemma). How much this affects the prisoner's dilemma depends on how much different agents value Weitzman's "VSL-like parameter", and how much risk aversion they have. Other factors include the disaggregated climate change impacts, how much an agent values environmental goods, and what discount rate they use.

We shall look at how carbon leakage and fossil fuel exports exports affect this prisoner's dilemma. Suppose that a carbon price reduced the production of a trade exposed emissions intensive good. Loss of production could increase the goods price, which could increase production elsewhere (where there is not a carbon price). Similarly, if we were to reduce exports of a fossil fuel (e.g. coal), there could also be a price effect.

Assuming market clearance and no non-linear (bubble like) price effects, some manipulation of partial derivatives leads to the following equation:

$$R = \frac{\triangle Q_o}{\triangle Q_e} \approx \frac{\partial Q_o}{\partial Q_e} = \frac{Q_o \epsilon_s}{Q_t \epsilon_d - Q_o \epsilon_s}$$

where:

- R is the ratio of the change in quantity supplied from overseas (from countries that do not apply a carbon price) to the change in quantity exported (from countries that do apply a carbon price) - this value will be negative;
- Q_o is the quantity supplied from countries that do not apply a carbon price;
- Q_e is the quantity exported from countries that do apply a carbon price;
- Q_t is the total quantity supplied ($Q_t = Q_e + Q_o$);
- ε_s is the price-elasticity of supply, for expanding supply;

- ε_d is the price-elasticity of demand, which will be negative.

The above equation has the following implications:

- The magnitude of R will be less than 1, unless the elasticity of supply is infinite or the elasticity of demand is zero, in which case the magnitude of R will be equal to 1. This suggests that the common assertion from industry that "any loss in production will be offset by an increase in production elsewhere" is technically incorrect.

- As Q_o approaches zero, R will approach zero. So the greater the coverage of the carbon price, the less that leakage is a problem, even if coverage is not complete. Because the above equation would affect the payoff matrix, when the coverage is greater, the prisoner's dilemma will be marginally easier to resolve.

The above equation suggests that sectoral agreements to apply a carbon price in trade exposed sectors would be a useful approach. Even if the coverage of the sectoral agreement is not complete, the agreement would still be advantageous to resolving the prisoner's dilemma. Because the mathematics of whether to apply a carbon price to fossil fuel exports is also governed by this equation, sectoral agreements among fossil fuel exporters, especially coal exporters, would be a useful mechanism for increasing the coverage of the carbon price.

Levies on exports may be a better alternative to border adjustments on imports or protectionism for emissions intensive industries. There is a precedent for this - in order for China to reduce the incentive for other countries to re-introduce levies on textile imports, it imposed a small levy on its textile exports. It has been suggested that this tactic could help unlock climate change negotiations [14]. At present, a levy on Australia's coal exports could significantly the coverage of a carbon price. This could be used to fund RD&D in carbon capture and storage technologies, although arguments against "picking winners" suggest that it is best to support a portfolio of low emissions technologies.

While reducing carbon leakage would affect global greenhouse gas emissions, the ultimate way that the carbon leakage problem will be solved will be for the successful resolution of international climate negotiations, and full coverage of a carbon price. Protection of emissions intensive industries will encourage, through reciprocity, the protection of these industries elsewhere, and more costs overall. It may be that the best approach to carbon leakage would be to ignore it. This would suggest that assistance to trade exposed emissions intensive industries could be reduced.

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