

**What if Mainstream Science
is Right?
The Rout of Knowledge and
Analysis in Australian Climate
Change Policy (and a Chance
of Recovery?)**

Ross Garnaut

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Tel 02 6249 1788; Fax 02 6247 4335;

Email assa.secretariat@anu.edu.au

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Abstract

The integrated wisdom of mainstream science and mainstream economics identifies risks to established patterns of human civilisation from unmitigated or weakly mitigated climate change. These risks are important in all countries, and greater in Australia than in any other developed country. They have been more elaborately analysed in Australia than in most other countries, and our community has had access to large amounts of reliable information on the risks. And yet at times, including the present, Australia has been a significant brake on international progress on mitigation policy.

The Australian political discussion of climate change policy took a new turn with the formation of minority Government after the 2010 election, the establishment of a Multi-Party Climate Change Committee, and a new commission from the Government for me to update independently the 2008 independent *Garnaut Climate Change Review*.

This lecture describes the approach to decision-making on climate change policy utilised in the 2008 Review, discusses and assesses the public commentary on methodological issues after the Review's publication, and concludes with some observations about the role of knowledge and analysis in climate change policy in the new circumstances.

What if Mainstream Science is Right? The Rout of Knowledge and Analysis in Australian Climate Change Policy (and a Chance of Recovery?)

Ross Garnaut

It would be good to have Kenneth Stewart Cunningham (1890-1976) with us here tonight. He knew the importance of developing a sound conceptual framework for shaping empirical inquiry. He knew the value of the discipline of trying to quantify the immeasurable. He knew that there was a point at which measuring the immeasurable had to give way to judgement. He would understand what I have been trying to do in the Climate Change Review. I think he would have enjoyed our discussion.

The Australian context of climate change policy has changed fundamentally since I accepted the invitation to give this year's Cunningham Lecture. Then, the Australian Government had responded to two defeats in the Senate on legislation for an emissions trading scheme (ETS) and the failure of the Copenhagen meeting to realise Australian hopes for an ambitious and binding comprehensive international agreement on mitigation. It had just announced that it would not seek to legislate for an economy-wide, market-based mitigation programme until after 2013. In the 2007 election, both major parties committed themselves to an ETS; in 2010, neither did so. In 2010, both sides of politics were promising to reduce emissions by an amount, 5 per cent from 2000 levels by 2020, that was, at once, quite a challenge and well short of an Australian effort that was commensurate with international commitments after Copenhagen. Neither of the major parties took to the election specific policies that held out reasonable prospects of reaching even the challenging but disproportionately small reduction target that was on the table.

The spreading of modern economic growth to the populous heartlands of the largest Asian developing countries in the early twenty-first century was making the climate change challenge larger and more urgent. Realisation of this reality was starting to touch Australian and international awareness late in the first decade of the new century. That was the time, between the 2007 and 2010 Australian elections, between the Bali and the Copenhagen meetings of the United Nations Framework Convention on Climate Change (UNFCCC), when fundamental questions emerged about whether the Australian and international polities were capable of dealing effectively with the challenge of climate change.

The degree of difficulty had been recognised before its crystallisation in late 2009 and 2010. I had said in the Introduction to the *Garnaut Climate Change Review* ('the Review'):

Climate change is a diabolical policy problem. It is harder than any other issue of high importance that has come before our polity in living memory. Climate change presents a new type of challenge. It is uncertain in its form and extent, rather than drawn in clear lines. It is insidious rather than (as yet) directly confrontational. It is long term rather than immediate, in both its impact and its remedies. Any effective remedies lie well beyond any act of national will, requiring international cooperation of unprecedented dimension and complexity. While an effective response to the challenge would play out

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over many decades, it must take shape and be put in place over the next few years... Observation of daily debate and media discussion in Australia and elsewhere suggests that this issue may be too hard for rational policy making. It is too complex. The special interests are too numerous, powerful and intense. The time frame within which effects become evident are too long, and the time frames within which action must be effected too short¹.

But there was more to the climate change political story than the difficulties. Immediately after the Review's sober assessment cited above, I noted that there was another side to the gloom:

But there is a saving grace that may make all the difference...there is a much stronger base of (Australian community) support for reform and change on this issue than on any other big question of structural change in recent decades [...] Public attitudes in Australia and in other countries create the possibility of major reform on emissions reductions, despite the inherent difficulty of the policy problem².

The Review aimed to provide scope for the 'saving grace' to be effective—to nurture the chance that Australia and the world will manage to develop a position that strikes a good balance between the costs of dangerous climate change and the costs of mitigation. It does this by examining approaches to mitigation in one country which, if followed elsewhere, would add up to a solution³.

The 'saving grace' turned out to have considerable power. It contributed to an election outcome that made climate change a central issue in the formation of a government. This, in turn, led to the establishment of a Multi-Party Climate Change Committee (MPCCC) with the task of forming a view on 'putting a price on carbon' and separately, to a commission from the Government for me to update the Review. Incidentally, while I am an Independent Expert on the Parliamentary Committee, the confidential work of the Committee is carefully separate from the independent and public updating of the independent 2008 Review.

I have said elsewhere that the policy process on climate change through the 2007-10 Parliament was dominated by vested interests to an extent that went beyond the inevitable involvement of business in the democratic process. In the 2010 Hamer Oration at the University of Melbourne, I drew attention to a change in Australian political culture in the early twenty-first century. There was movement away from the focus on broadly based change to increase living standards in the reform era 1983-2001, at times requiring leaders to confront special interests. There was reversion back to older Australian political traditions of responsiveness to short term and sectional pressures on the policy-making process. The effectiveness of sectional pressures on the policy-making process, and the weakness of an independent centre of the Australian policy-making process, were characteristics of early twenty-first century policy-making generally, and not only on climate change. Climate change policy was perhaps more vulnerable; but then, other policy areas were not supported by the saving grace.

Climate change policy has been subject to sophisticated, detailed and authoritative public discussion. The extent of the 'public interest' discussion of the issue, including through my Review, the working papers and Interim and Draft Reports, and the Government's Green and White papers, has few parallels. The extent of public participation in discussion of the

issue has no near comparators in my experience. Substantial mitigation effort retained strong community support—rather stronger than for any other reform in modern times requiring large structural change.

This is a complex issue. The degree of difficulty exceeds that of policy reform in most or all areas of public policy. But the issue attracts community interest more readily than other reform issues. The community puts more effort into understanding, and as a result provides a more solid basis of support for a leader seeking to secure change.

It seems at first sight that the problem was not with public education and understanding, but in the policy-making process. When push came to shove, the private interests seeking to block, blunt or slow down action prevailed over well-developed community views.

But that is not the final answer. A stronger community view, expressed with greater clarity, would have been more persuasive with the political leadership. It would have constrained more securely the influence of vested interests.

On the complex issue of climate change mitigation, an intellectually engaged community is interested in the views of a range of people that it considers to be experts. This makes the community of scholars, in which this academy plays a leading and essential role, a crucial part of the independent centre of the policy-making process.

On these immensely complex issues, analysts seeking to identify the public interest have to break new ground in methodology. Innovators make mistakes and their followers do better. That is the way of progress in the social as well as the physical and biological sciences. This is where the community depends on the specialists. It is the role of the social scientists to review the work of social scientists; the physical and biological scientists to review the work of the physical and biological scientists.

The Review sought to establish the foundations for a thorough professional discussion of the issues by adopting transparently a comprehensive decision-making framework. The explicit framework made the premises, logic and information leading to decisions transparent for all to see and to criticise. As I said in the Review's introduction:

No answers to questions as complex and difficult as those introduced here ...would seem right, or palatable, to everyone. Perhaps no answers, with their many parts, would seem right or palatable to anyone. Many will disagree with elements or the whole of the conclusions of the Review. Many will disagree with the policy proposals that flow from the conclusions...Tempting though it is to do so, it is neither rational nor helpful to reject conclusions because we do not like them. The conclusions will only be wrong if the premises, information or logic leading to them are wrong. The review has sought to be clear in its premises, information and methodology, so that they can be contested transparently. If the subsequent public policy debate follows these lines, we will improve the chances of Australian and other governments taking good decisions in the year ahead on a sound basis and with widespread community support, and therefore with prospects of policy continuity⁴.

If there is to be success in the second attempt to introduce efficient, economy-wide approaches to substantial reduction in emissions, there will need to be a stronger and clearer message from the independent centre of the polity.

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In this lecture I will summarise the Review's methodology, which I hope will encourage Fellows of the Academy and others to go back to the original text, especially Chapter 1, to identify and to publish criticisms of flaws, or in their absence to support the approach. I will then take up one fundamental issue of methodology that came up explicitly or implicitly in discussion of the Review the last time around: the rate at which future costs and benefits are discounted. The discussion of discount rates raises questions about the treatment of uncertainty, and also about the relationship between the public interest in mitigation in Australia and the actions and reactions of the rest of the world.

This focus means that I will not be talking about alternative approaches to carbon pricing. That is for the future. But at this gathering of the Academy, it is salutary to recall a statement of the Secretary of the Department of Climate Change and Energy Efficiency. In his June 2010 Sir Leslie Melville Lecture, Dr Martin Parkinson⁵ argued that economists have been unhelpful to the public policy-making process on the Emissions Trading Scheme (ETS) proposed in 2008 and 2009. Their squabbles over smaller points had obscured the extent of common ground on a more fundamental issue: the superiority of an economy-wide price signal over regulatory approaches to mitigation. Parkinson was right on that point. One of the papers that I will prepare for public discussion in the course of the update will discuss the economists' debate over alternative forms of carbon pricing. I will be seeking to do that in a way that gives full weight to what I expect is a view shared by almost all members of the Australian economics profession who have turned their minds to this question: that the superiority of broadly based carbon pricing over regulatory approaches to mitigation is (within reasonable limits) large relative to differences between the various instruments of carbon pricing.

1. The framework of decision-making

The Review began with the presentation of a decision-making framework, within which the work was developed⁶. One central question was posed. 'What extent of mitigation, with Australia playing a proportionate part, provides the greatest excess of gains from reduced risks of climate change over costs of mitigation?'⁷

The question was asked from the perspective of the Australian national interest. This was a different perspective around a different question to that asked in other studies on the extent to which mitigation was justified⁸. These studies addressed the question of whether mitigation action was justified for the world as a whole, which turns out to be an easier question than whether mitigation action is justified from the point of view of an individual country. An assessment of whether mitigation is justified for an individual country must deal with all of the complexities that Stern addressed for the world as a whole—plus one. And that additional source of complexity is perhaps the most difficult of all.

The relevant mitigation is global. A single country's action is relevant only in its direct and indirect contribution to global mitigation. Each country's evaluation of whether some mitigation action of its own is justified depends on its assessment of the interaction between its own decision and those of others.

It is not viable for Australia—the developed world's largest emitter of greenhouse gases per head of population, and the developed country that was shown by the Review's analysis to

benefit most from strong mitigation—to free ride on other countries. Australia has to do its proportionate part in a global mitigation effort.

The costs of Australian mitigation depend on the size of its proportionate part in global mitigation. What would be Australia's proportionate part in global mitigation efforts of varying ambition?

The Review devoted three chapters to defining principles that had prospects of being the basis for agreement among the countries that would need to be parties to contribute substantially to an effective global effort. This would need to cover all of the major countries, developed and developing. Only 'prospects', because what is in the end 'possible' depends on complex dynamics of international relations.

The Review proposed to allocate entitlements to a limited budget of greenhouse gas emissions on the basis of modified contraction and convergence, accompanied by side payments to some developing countries in the form of support for adaptation to inevitable climate change and for utilisation of low-emissions technologies⁹.

The proportionate contribution that Australia would need to make to the global effort within that framework would be a 25 per cent reduction in emissions from 2000 levels by 2020, and a 90 per cent reduction by 2050. If there were no global agreement consistent with this ambitious objective, it was proposed that Australia should adopt commitments that were proportionate to those of others in a more limited international agreement. Failing any international agreement for the time being, it should help to keep hopes of agreement alive by unilaterally working towards a domestic mitigation target of reducing emissions by 5 per cent from 2000 levels by 2020.

Would the substantial Australian costs of mitigation exceed the benefits of climate change costs avoided? A contribution towards the answer to this question was to be made through the Review's cooperation with the Australian Treasury on modeling the costs of mitigation, and the Review's own modeling of benefits. Together these were the most detailed, comprehensive and long-dated modeling exercises ever undertaken on the Australian economy.

The costs of mitigation come through conventional economic channels, which are readily amenable to general equilibrium modeling.

The benefits of mitigation are the avoided costs of climate change. The Review identified four distinct types of benefits of mitigation, which can also be regarded as the avoided costs of climate change. Only one of these is amenable to standard quantitative analysis.

Type 1 benefits of mitigation comprise currently measurable market impacts of climate change, which are avoided by specified degrees of mitigation. Because they are confined to reduced climate change costs only out to the end of the twenty-first century (that being the time horizon of the modeling), they exclude all benefits of mitigation beyond the beginning of the twenty-second century.

Type 2 benefits are similar in nature to Type 1, comprising economic costs of climate change and benefits of mitigation experienced through markets, and in principle amenable to quantitative analysis using standard modeling techniques. However, there is no satisfactory information available to calibrate the models, so that the analyst must rely on estimates embodying judgements about quantities. The quantitative estimates of the

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benefits of mitigation are also confined to impacts to the end of the twenty-first century.

The Review discusses at length the uncertainties in the science. Both Type 1 and Type 2 costs of climate change and benefits of mitigation are calculated from the medians or the means of the probability distributions of possible outcomes that are derived from the science. The uncertainty means that actual costs of avoidable climate change are likely to be smaller or larger than the median from which the costs and benefits have been calculated. Humans facing uncertainty about outcomes that potentially have a large effect on their welfare tend to be risk averse: they are prepared to pay more than the expected value of possible large and negative outcomes to avoid them. This explains the existence of insurance, taken through private markets by individuals and firms. We also see an insurance motive in a number of areas of public expenditure, for example through defence forces.

The insurance value of mitigation is a Type 3 cost of avoidable climate change and benefit of mitigation. The Review did not seek to measure the value of Type 3 or insurance effects. Rather, it sought to draw attention to their high value. Maybe they would have been brought to account more strongly in the policy discussion if we had made crude quantitative estimates of them.

Some other economists see insurance against bad and possibly catastrophic outcomes (Type 3 effects) as the largest element of the case for mitigation¹⁰.

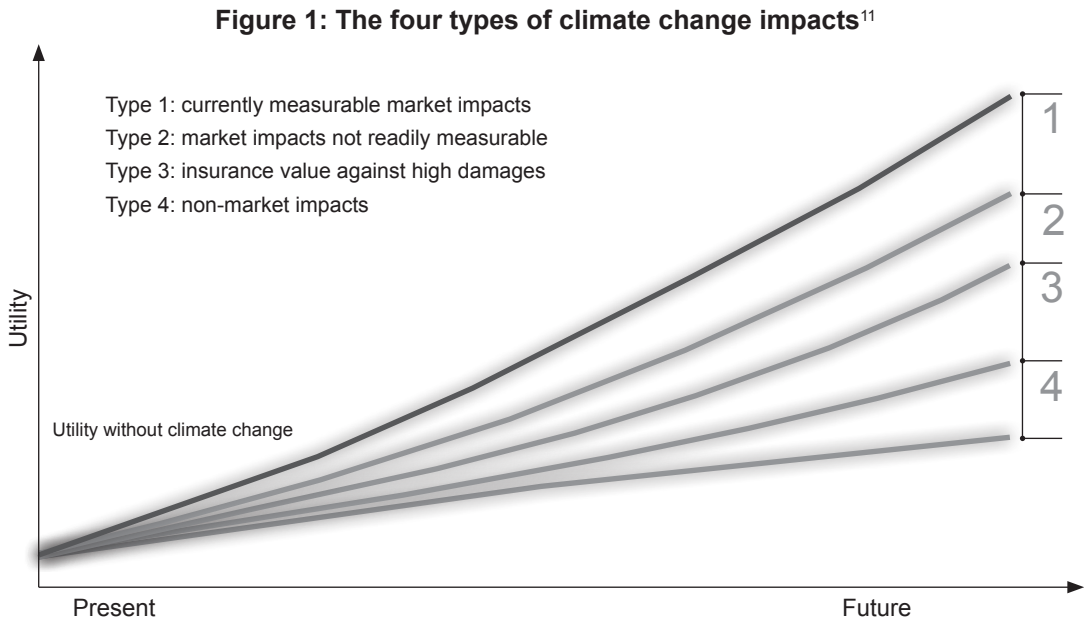
Type 4 avoidable costs of climate change and benefits of mitigation are impossible to measure, and more difficult even than Type 3 to bring to account in analysis, but to most people when they turn their minds to them, are of great importance.

The Review evoked an old tradition in the social sciences and assessed outcomes of policy in terms of utility. We can think of an Australian utility function as rising with consumption of goods and services and also with a number of non-monetary services. The non-monetary services related to climate include environmental amenity, longevity, health, and also welfare of non-Australians. How much do Australians value the existence of the Great Barrier and Ningaloo Reefs, or the continuation of town and rural life in the heartland of old Australia in the Murray Darling Basin?

To include such elements in an Australian utility function is not to place intrinsic value on environmental conservation, although many would argue that we should do exactly that. It is necessary only to accept that many Australians value such things and would be prepared to sacrifice some consumption of goods and services to retain them.

Non-market services tend to be what economists call 'superior goods', in that the relative value that people assign to them rises with incomes. If, as expected, average incomes of Australians continue to rise through the twenty-first century, higher value will come to be placed on preservation of the natural estate. It is likely, then, that people will be willing to trade increasing amounts of material incomes for specified improvements of services available through non-market processes. A very low rate of substitution between non-market services and conventional consumption of goods and services at high incomes, in the presence of large impacts from climate change, would challenge the proposition that continuing increase in consumption of goods and services exchanged in markets would necessarily lead to higher average utility in the distant future.

Figure 1 illustrates diagrammatically how the four Types of avoidable climate change impact affect utility.



2. Comparing the costs and benefits of mitigation

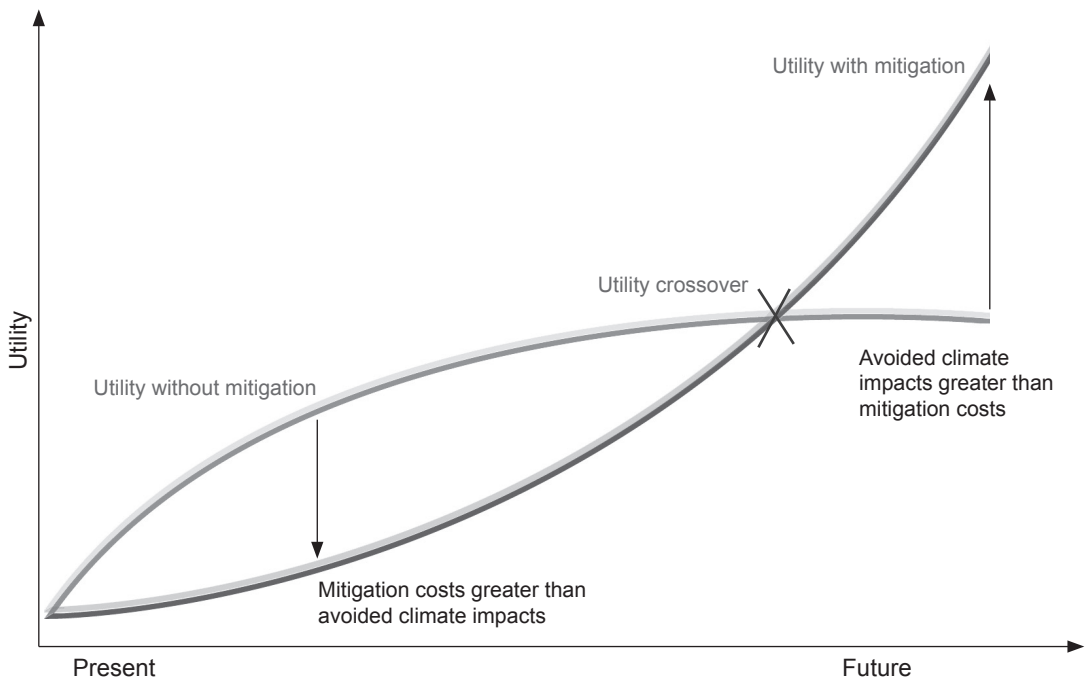
One reason for setting out the four Types of cost of climate change and potential benefits of mitigation was to avoid the tendency to focus only on effects that can be measured more or less precisely, and to ignore the immeasurable. Depending on the discount rate which is used to convert future welfare into a present value, the potentially measurable impacts, Type 1 and Type 2 effects in the twenty-first century only, may be a modest part of the potential benefits of mitigation.

Let us now bring together the stories of the costs of mitigation and the benefits of reduced climate change. Let us do it conceptually at first, and then fill in some numbers.

Expectations of the level of national utility over time in the absence of mitigation are plotted as the light grey line in Figure 2¹² (next page). National utility can be expected to rise over time, as it probably has through all long periods of Australian history. The dark grey line plots expectations of utility over time at a given level of national mitigation, which is associated with a defined degree of global mitigation.

The costs of mitigation accrue early and the benefits of avoided climate change come later. The utility curve without mitigation is above the utility curve with mitigation in the early years. However, where the utility curve with mitigation is associated with substantial global mitigation, at some point the dark line may rise above the light line. We call this the crossover point.

Figure 2: Utility with and without mitigation¹³



The two curves together, in this case, describe the shape of a fish. The body of the fish covers years in which the net current benefits of mitigation are negative. The area of the body of the fish represents the excess costs of mitigation in the years to the crossover point. The tail of the fish covers years in which the net benefits of mitigation are positive. The tail of the fish grows in depth and total area with time.

The big question for policy is whether the area of the body of the fish exceeds that of the tail. Future utility has to be valued at present values, so the difference in the annual levels of utility between the two curves defining the fish have to be discounted to the present at an appropriate discount rate. The choice of discount rate influences the size of the body relative to the tail.

The length of the body is the time that it takes to get to the crossover point.

Beyond the crossover point, the length of the tail is determined only by any limit on the future time over which society remains concerned for the utility of Australians. Few older Australians would discount heavily the welfare of their grandchildren's generation relative to that of their own. Our grandchildren can be expected to have a similar view of the welfare of their own grandchildren's generation. Quiggin¹⁴ has pointed to the logical implication that the community should be regarded as caring about the welfare of humans for generations without limit into the future.

3. The discount rate

The value of avoided irreversible effects of climate change extends forward to the point at which the life of the human species may have been extinguished by some separate influence. There is some chance of extinction at any time, at least in the contemporary human state of knowledge about weapons of mass destruction and capacity to control their use, and the low level of knowledge and capacity relevant to avoidance of the risks of the earth colliding with extra-terrestrial bodies. The probability of extinction is not high in any year and perhaps in any century, but it is above zero.

If we are to include the welfare of all future generations in our assessment of utility, how should we value the future relative to the present?

How much value should be attached to climate change impacts that occur beyond the lifetimes of most people who are alive today? In comparing utility across generations, we need to determine the discount rate. In the Review's quantitative assessments, only the market costs and benefits of median impacts (Types 1 and 2) of climate change mitigation are assessed, and only to the year 2100. Nevertheless, any view formed on discounting is important also in assessment of qualitative climate change impacts in the longer term, and their implication for mitigation policy today. (Not recognising that high discount rates affect the value of what we have called Type 3 as well as Type 1 and Type 2 benefits of mitigation is a weakness in Weitzman's 2008 heavy reliance on the insurance value of mitigation).

We can think of a discount rate normatively (how should we value future benefits?) or positively (how do we observe people valuing the future?). The Review looked at both ways, starting with the normative.

There are two reasons why society may place less value on a unit of income and consumption in the future than on the same income and consumption today. The first element in the discount rate is the rate of pure time preference, that is, the rate at which future utility is discounted simply because it is in the future. Many of the philosopher kings of economics, from Ramsey to Sen¹⁵, have argued for a pure rate of time preference that is close to zero, thus placing no discount on the utility of people in the future just because today these people are young or not yet born. For example, as DeLong¹⁶ pointed out, a rate of pure time preference of 3 per cent means that somebody born in 1995 'counts for twice as much as someone born in 2020'. This flies in the face of the utilitarian principle underlying most economic analysis: that equal weight should be placed on each person. Most people would think it flies in the face of common sense. Dasgupta¹⁷, in his critique of the Stern Review's approach to discounting, also supports a rate of pure time preference close to zero. This approach is supported by Quiggin's idea of the continuing chain of valued humanity. By contrast, some economists, including Nordhaus¹⁸, a pioneer of economic modeling of climate change, use a pure rate of time preference of 1.5 per cent or higher, calibrated to yield an overall discount rate that matches the observed overall cost of capital to the economy (see below).

The Review judges that a near-zero pure rate of time preference is appropriate. The only reason for a positive rate of pure time preference is the risk of human extinction in any one

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year. This should be a low number, and the Review uses a rate of pure time preference of 0.05 per cent. This is similar to the parameter value used in the Stern Review¹⁹. The second element in the discount rate is the marginal elasticity of utility with respect to consumption. This is a measure of society's concern for equity in income distribution. We accept that a dollar of incremental income means less to the utility of the rich than of the poor. The people of tomorrow will have higher material incomes and wealth than people today, although this is likely to be offset by reduced environmental amenity in assessment of utility. It is reasonable to value future income at a lower rate than current income, insofar as future income is higher. How much less? Higher and lower values have been suggested, but no one contests that income has diminishing marginal utility with increased income. There are compelling theoretical reasons for using an elasticity of 1, and Quiggin²⁰ argues that this is the most common choice in the literature. By contrast, Dasgupta²¹ argued that an elasticity of 1 implies that 'distribution of well-being among people doesn't matter much', and that higher values more adequately reflect distributional concerns and observed savings rates. These savings rates, however, vary greatly between countries and through time. Recent work by Smith²² argues that an elasticity even of 1 implies savings rates within the range of contemporary experience. Research suggests that personal income tax systems, on average, in developed countries embody a parameter value of 1.4²³. Stern used a parameter value of 1, Nordhaus of 2.

A parameter value of 2 is radically egalitarian. Applying it to budgetary decisions would require us to go much further in taking income and wealth of the rich and giving it to the poor than is contemplated anywhere in the contemporary world. Nevertheless, this parameter value has been taken seriously in the reputed literature, so the Review included it in the range that it applied in its quantitative analysis.

The Review uses two alternative parameter values for the marginal elasticity of utility, 1 and 2, a range that accommodates strongly diverging views on how much should be spent now to benefit future, presumably richer, generations. Under an elasticity of 1, future income is discounted at the same rate as the increase in per capita income (plus the rate of pure time preference), while at an elasticity of 2 it is discounted at twice that rate.

The average annual growth rate in Australian per capita income from 2013 to 2100 in the base case of the Garnaut-Treasury modeling is 1.3 per cent. Thus the two normatively derived real discount rates used by the Review for assessment of discounted net costs of mitigation of climate change in Australia are 1.35 per cent and 2.65 per cent.

The argument for being careful about the sacrifice of current utility through expenditure on mitigation in pursuit of future income is a powerful one. But there is one important qualification. The rate of substitution between conventional consumption and non-market services is likely to be low when incomes and material consumption are much higher than they are today. Climate change may greatly diminish the availability of non-market services for future generations. As a result, one cannot be sure that, despite much higher material consumption, the average utility of people in future will be greater than the average utility today. Hence, linking the marginal elasticity of utility to the growth in per capita income may lead to higher than intended discount rates. Furthermore, if reality turns out to be consistent with the bad end of the probability distribution of outcomes from climate change, there is a possibility that utility may be lower for many people in future than at present.

There is another view, that market rather than normative discount rates should be applied. Market discount rates reflect the time preferences that are revealed in actual decisions on savings and investment, which are the vehicles for arbitrage between future and current economic activity. This raises two questions. First, is discounting a normative or a positive issue?²⁴ Second, if the market rate is relevant, what is the appropriate market discount rate? There is a strong case in principle for setting the discount rate normatively on a large issue of systemic importance. Nevertheless, the Review sought to see what difference it would make to these Australian calculations if it were thought appropriate to use the market rate. So what is the appropriate market rate?

It was thought appropriate to use the market rate for sovereign debt in countries like Australia. These are the rates at which the private sector is prepared to lend in the absence of risk. They would seem to be more appropriate than equity market rates, which are much higher, reflecting perceptions of firm-specific and other risks that are not relevant to the current analysis.

The mid-point of the range of normative discount rates discussed above roughly coincides with the inflation-adjusted long term market rates of return of government bonds in Australia and the United States, which stand at 2.2 and 2.1 per cent respectively. Is there a contradiction between using a discount rate in the range 1.25 to 2.65 per cent in summing utility of income over the generations, and applying a higher rate, 4 per cent, in pricing emissions permits and allocating capital over the twenty-first century in the Garnaut–Treasury modeling that is discussed in the Review? No. The Garnaut–Treasury rate of 4 per cent is our assessment of the ‘Hotelling rate’ that the market would come to apply in decisions that determine the optimal rate of depletion of the atmosphere’s limited capacity to absorb greenhouse gases. It is advisedly a rate embodying all the commercial risks involved in holding permits and investing in emissions-related activities. The Review’s 4 per cent used in the modeling of permit price trajectories, embodies a risk-free real interest rate of a bit above 2 per cent and a risk premium in markets for permits of a bit below 2 per cent²⁵.

The range of normative rates used by the Review, presented above, straddles the market rate that is judged to be most appropriate. The market rate for sovereign debt might even be the point in the normative range that I would prefer if forced to choose. It happens that not a lot hangs on the point chosen within this range; there is no conflict between normative and positive approaches.

The analysis for the Review has been calibrated with percentage points of Gross National Product (GNP) or consumption. The use of a discount rate that is higher than the rate of growth of GNP will cause the present value of a percentage point of current GNP to be greater than that of a percentage point of future GNP. The use of a discount rate that is lower than the rate of growth of GNP causes the present value of a percentage point of future GNP to exceed that of a percentage point of current GNP.

In Australia, the modeling points to the expected rate of GNP growth (2.1 per cent over the remainder of the twenty-first century) falling within the middle or higher than the middle of the range of discount rates thought to be relevant (1.35 to 2.65 per cent). It follows that near the mid point of the normative range—near the appropriate market discount rate—

the present value of a percentage point of GDP in the early twenty-second century will be similar to that of a percentage point of GDP now²⁶.

4. The size of the body compared with the tail

The utility curves with and without mitigation in Figure 2 in principle included all four climate impacts. Conceptually, they are not confined to the readily measurable Type 1 and the measureable-in-principle Type 2, or to the twenty-first century effects that were incorporated into the quantitative analysis.

The Review took care to explain that the Type 3 and Type 4 effects were potentially of large importance, as were Type 1 and Type 2 effects beyond the twenty-first century. The twenty-first century Type 1 and 2 effects alone were nevertheless calculated and compared with the costs of mitigation, at the two discount rates thought to cover the range of possibly appropriate values. This was the starting point of assessment of the costs and benefits of mitigation. The analysis of Type 3 and Type 4 effects, and all benefits of mitigation beyond the twenty-first century, are treated alongside and outside the quantitative analysis.

The Review's modeling showed that with Type 1 and Type 2 benefits of mitigation alone, confined to this century alone, economic welfare (measured by GNP), is higher at the end of the century with mitigation than without. Going back to the fish, the crossover point is in the 2060s. The net present value of GNP over the century as a whole is lower with than without mitigation, because the large outlays on mitigation in the first half century are still being recouped from the net benefits of mitigation late in the century. With mitigation, GNP is 3.2 (mitigation directed at 550ppm) or 4.0 (450ppm) per cent lower over the whole twenty-first century if a 1.4 per cent discount rate is applied. It is 3.3 (550) or 4.2 (550) per cent lower if a 2.7 per cent discount rate is applied. Type 3 and Type 4 benefits of 550ppm and especially 450ppm mitigation are extremely high by the end of the century.

The level of GNP is much higher than the level without GNP at the end of the twenty-first going into the twenty-second century. The surplus of benefits over costs of mitigation is poised to claw back the twenty-first century present value deficit in a relatively short time. So just taking Type 1 and Type 2 benefits a small distance into the twenty-second century caused the net present value to be positive, without taking into account Type 1 and 2 effects into the more distant future, or Type 3 and Type 4 effects. On these bases, the Review drew the strong conclusion that there was substantial value in 550ppm mitigation, and higher value in 450ppm mitigation.

This conclusion is not materially weakened by use of the higher (2.7 per cent) discount rate. Australia may be in a different position from other developed countries in this respect, amongst other things because of its tendency to higher growth in economic output associated with stronger population growth.

Despite the efforts to explain the limited focus of the quantitative exercise, the costs and benefits of mitigation that were expressed in numbers were treated more seriously. Evening up the balance will be a challenge for the Update of the Review.

5. Questions about the discount rate

No opponents of strong mitigation contested in a comprehensive way the logic or data of the case that the Review made for strong mitigation, and for the 450ppm rather than the 550ppm objective, in the Australian national interest.

Alongside considerable support, there was some criticism that the Review used a discount rate that was too low.

One such criticism was by Michael Porter, from the Committee for the Economic Development of Australia (CEDA) who argued that the discount rates used by the Garnaut and Stern reviews were unreasonably low²⁷.

The choice of discount rate is crucial to the judgements made in the Review; a rate materially higher than the higher of the two used in the Review would cause the conclusions on strong mitigation to be much less clear-cut. It is therefore worth exploring the critique in some detail.

The first thing to say is that lumping the Review's treatment of the discount rate in with Stern's is simply lazy, given the substantial differences. On the differences, it is not that I thought that Stern was wrong; but rather I anticipated views of the kind that Porter put forward, and demonstrated that using rates that took into account alternative ways of looking at the issue did not materially affect the conclusions for Australian policy. As I noted earlier, the Review in fact used two discount rates. A 'low' discount rate which incorporated the same value for the marginal elasticity of substitution of consumption used by Stern which was a value of one, and a 'high' discount rate that used a value of two for the marginal elasticity of substitution of consumption. In addition, the Review showed that should it be thought that a market discount rate was appropriate, the appropriate market discount rate fell within the range of the normative rates applied in the Review's quantitative analysis. In arguing against the Garnaut and Stern reviews' choice of discount rates, Porter drew on arguments by Nordhaus in particular, that future generations would be better off and that 'low' discount rates failed to discount future incomes appropriately.

First, the presentation of rising per capita incomes by Porter ignores the way the Review's modified contraction and convergence approach provided substantial headroom for developing country growth.

Also, it is worth noting Ken Arrow's conclusions in regards to climate change action, especially as Porter draws on Arrow to support his arguments against the discount rates used by, he says erroneously, Garnaut and Stern.

In the paper cited by Porter, Arrow²⁸ notes that he prefers to use a value of 2 for the marginal elasticity of consumption, one of the values used in the Garnaut Review.

Using this value, Arrow then calculates from Stern's analysis discount rates for when the present value of the benefits of action on climate change exceed that of the costs. He finds that the benefits exceed the costs for any value of the social (or pure) discount rate of less than 8.5 per cent.

5.1 Questions about the discount rate and the treatment of uncertainty

The international discussion of mitigation over the past two years has focused more strongly on Type 3 costs of climate change: the value of mitigation as insurance against outcomes near the high end of the probability distributions. Weitzman²⁹ has been influential, and the Review's upward adjustment of 'business as usual' global emissions brought the bad end of the probability distribution into clearer focus everywhere.

In this context, there is a stronger case for mitigation when outcomes are uncertain than there would be with a certain outcome with the same mean or median.

And yet in some of the Australian public discussion, it has been common to assert that the presence of uncertainty makes it appropriate to adopt weaker approaches to mitigation. This error has been made by economists, who honestly and disarmingly say that they are not scientists, but that there is uncertainty, which means that we should not do as much as if we were certain about the outcome³⁰.

This view is based on a misreading of the scientific discussion of uncertainty. It is good for non-scientists to recognise their limitations. I hope that I always do so. But this whole field of concern begins with the science, and it is incumbent on economists entering the public policy debate at least to inform themselves on what the scientists are saying.

Reading the scientific literature, taking into account the range of opinions on various matters, and the Royal Society's recent paper on uncertainty about climate science, the informed non-scientist is left in little doubt about the way in which the scientific community sees uncertainty in climate change. Uncertainty relates to the dispersion in the probability distribution around mean or median outcomes, and not about whether there is any impact at all. (Disconcertingly for an economist brought up on the probability theory of Keynes and Knight³¹, the science literature tends to use the word 'uncertainty' to cover as well what I would think of as 'risk'). The focus is on mean or median outcomes. Actual outcomes may turn out to be more benign or more severe than the mean. The advance of knowledge may change the mean or median, or make the dispersion of the probability distribution around the mean larger or smaller. Only a smaller dispersion of the probability distribution would be regarded as a reduction in risk or uncertainty.

The Update of the Review will present a paper for public discussion in early 2011, reviewing the literature on developments in scientific knowledge since the *Garnaut Climate Change Review* was published in 2008. This will include explicit consideration of whether new knowledge has shifted the mean or median of the probability of outcomes from climate change, or changed uncertainty (the dispersion of the probability distribution around the mean or median). Any increase in uncertainty would strengthen the case for strong mitigation, by increasing its insurance value. Of course, a reduction in uncertainty would have the opposite effect. A change in the mean or median could either weaken or strengthen the case for strong, early mitigation.

5.2 Questions about the discount rate and the relationship between Australian and global mitigation

The Review's focus on Australian decisions in the Australian public interest is different from the global focus of earlier studies, including those of Stern, Nordhaus and Cline. The

global mitigation effort is the sum of the separate but inter-related mitigation decisions of individual sovereign countries. It is the sum of explicit or implicit decision processes in all countries, of the kind that the Review and its update are seeking to assist in Australia. The comparison of the costs and benefits of mitigation for Australia depends on making a correct call on the global mitigation effort to which the Australian mitigation is calibrated. At the same time, it should be recognised that Australians have a strong interest in effective global mitigation, and that our own actions should be designed to encourage an effective global mitigation regime.

For this part of my discussion I will focus only on the issues related to the discount rate.

If you do the same calculations for the world as a whole as the Garnaut Review did for Australia, you are probably led to apply a higher discount rate. This is the case whether you use the normative or the positive approaches to discount rates that were discussed by the Review.

On the normative approach, there is a wider gap between future (say end of twenty-first century) and present utility for the average citizen of a developing country than for the average citizen of Australia. It is appropriate, therefore, to discount future utility in the developing country at a higher rate than in Australia. Most of humanity resides in the developing countries, so those countries' higher rates are appropriately influential in global calculations.

On the positive approach, real interest rates in sovereign debt markets are substantially higher in developing countries than in Australia. Part of the differential may reflect greater scarcity of capital in a world of imperfect mobility of capital.

For this reason, the comparison of costs and benefits of a given percentage reduction in emissions is much less likely to be positive for mitigation in a developing country than in Australia or other developed countries. This is part of the practical rationale behind treating low-income countries differently in the allocation of entitlements to a limited emissions budget. It is part of the practical rationale for the use of modified contraction and convergence as a framework for allocation of entitlements across countries. It is part of the practical rationale for incorporating payments from developed to developing countries in support of mitigation and adaptation to climate change.

There are also compelling ethical reasons for support of convergence towards equal per capita entitlements to emit greenhouse gases, and for support from developed to developing countries for mitigation and adaptation.

The important point for current purposes is that the proposed allocation of mitigation effort across countries and the support for mitigation and adaptation makes the cost of meeting emissions targets manageable for developing countries. It makes it possible for developing countries to be part of and to comply with an international agreement. There is a greater chance that developing countries will enter and honour international agreements if they have opportunities to reduce emissions at low cost and to sell excess entitlements on the international market. The incorporation of these elements into a global mitigation regime makes it more likely that developing countries' own calculations of the costs and benefits of mitigation will pass tests of their own national interests.

What if Mainstream Science is Right?

It follows that it is not necessary to take into account the high discount rates of developing countries in assessment of Australia's own interest in mitigation.

Of course, the Review's proposals on principles for allocation of a limited global emissions budget were just that: proposals for discussion. They have been extensively discussed in developing countries since September 2008. There have been comments that convergence on equal per capita entitlements from 2050 leaves established large emitters in the developed world—first among them Australia—in privileged positions for too long. There has been comment, notably in India, that contraction and convergence does not acknowledge the developed countries' historical responsibility for the substantial depletion already of the earth's capacity to absorb greenhouse gases without dangerous climate change.

The establishment of a global mitigation approach is inevitably a long iterative process. Through the iterations it will be necessary to recalibrate from time to time Australian expectations of what is a reasonable domestic effort, given international progress.

6. The role of knowledge and analysis the second time around

I will conclude the lecture by answering briefly a simple question: what if the mainstream science is right?

What if the science supported by the overwhelming majority of scientists who are qualified in the various disciplines related to climate, is broadly right? What if all of the Academies of Science, in all of the countries of scientific achievement, are not deluded or enticed into error by the availability to their members of certain types of research grants?

If they are broadly right, we would probably see a threat to our prosperity rather larger than any of the issues that do the rounds of public discourse on long-run economic development. The threats would manifest themselves in large problems in a few decades, and as the dominant problem well before the end of this century. The challenges beyond this century are difficult to reconcile with continuity in modern human civilisation.

If the mainstream science is broadly right, later in this century we will probably not be squabbling about whether a 37 per cent reduction in allocations to Murray-Darling irrigators is too much; but rather working hard to improve the chance of there being any water at all to allocate. If the mainstream science is broadly right, defence and immigration would probably have radically different contexts.

Probably, because there is uncertainty. It may be worse than this, or better. There is no reason to think the chances of better are higher than the chances of worse.

We should think about it, because there's a chance that the mainstream science is right. When we think about it, those of us who are not climate scientists would need reasons beyond the current state of knowledge to think anything except that they are probably right. Certainly more likely to be right than people who have not spent the months and years and decades learning the subtleties of this complex area of knowledge. I hope that we here at least—members of this other learned academy that takes seriously the development and testing and accumulation of knowledge—can agree that there is enough of a chance that the mainstream physical and biological science is broadly right, to invest in understanding the implications for human society. After all, ours is the Academy that Australians look to

for knowledge on how the immense pressures that we are in the process of placing on our societies may change human life on earth.

If we thought about the respective credentials of those who line up with the mainstream science, and those who are prepared to take their chances with information from other places, we would think that this issue was at least one of the fateful public policy matters of our time.

I suppose that is where I was when I accepted my first commission to prepare the Climate Change Review from Kevin Rudd and all the Premiers and Chief Ministers in April 2007.

I was deeply steeped in the question for eighteen months after my commission. I was asked to come up with an independent assessment of Australia's interest in domestic and international climate change policy. With an excellent team of mostly young people, I sought to work through the implications of the science being broadly right; the implications for humanity on a global scale and in Australia if there were no effective mitigation; the costs and benefits of various approaches to mitigation.

To their credit, the commissioning leaders respected the independence that had been written into my terms of reference, although my conclusions as they came through in interim and draft reports, working papers and the Final Report, were not always what they would have preferred to hear.

I sought to make my premises, logic and sources of information clear for all to see. On a matter as complex as this, and breaking new conceptual ground, I was not going to get it all right at once.

I came to the conclusion that we should be doing a great deal at home and abroad to increase the chances of effective mitigation. The extent of interest in the subject, in Australia and abroad, surprised me. More than ten thousand filled the town halls of the mainland capitals to hear about and to discuss the draft report. More than ten thousand sent in submissions. People struggled through unfamiliar lines of logic in the Final Report, and sent emails to me or stopped me in the street or coffee shop to discuss some detail.

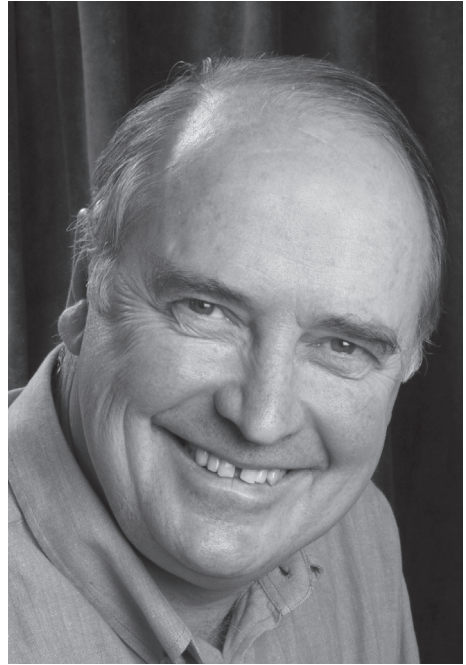
It was the extent of community realisation that this was an issue beyond the weft and warp of day-to-day politics that gave us the unusual result in the 2010 election and the chance to have another try.

Some of you, my colleagues in the Academy, are already deeply engaged in aspects of this important subject. I hope that more of you join us, at least to the extent of seeking to follow the logic of the 2008 Review and the Update that will follow. The Australian community will need the engagement of the people who spend their lives with knowledge and analysis to help them to a satisfactory conclusion the second time around.

Australia has mostly been a laggard in the great international challenge of climate change mitigation. That has made it less likely that there will be a satisfactory global mitigation. It is unlikely that Australia will come to play its proportionate part in an adequate global effort unless there is a strong independent centre of our public life that holds some ground for the public interest against the huge investments that will again be made in false information and the distortion of the political process. The learned academies are an essential part of that independent centre.

What if Mainstream Science is Right?

Professor Ross Garnaut (AO) is a Vice-Chancellor's Fellow and a Professorial Fellow in Economics at the University of Melbourne as well as a Distinguished Professor of the Australian National University. In 2009, Ross Garnaut was awarded the degree of Doctor of Letters, *honoris causa*, from the Australian National University and was made a Distinguished Fellow of the Economic Society of Australia. In September 2008, Professor Garnaut presented the Garnaut Climate Change Review to the Australian Prime Minister. This review, commissioned by the Australian government, examines the impact of climate change on the Australian economy and provides potential medium to long-term policies to ameliorate these. In November 2010 the Minister for Climate Change and Energy Efficiency commissioned Professor Garnaut to update his 2008 Review. The Garnaut Climate Change Review – Update 2011 will present its final report to the Government by 31 May 2011.



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