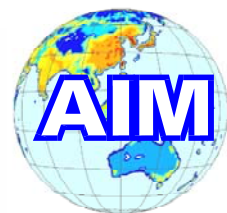


# Comments on the Stern Review

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# Comments on the Stern Review

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### Background and Assessment of the “Stern Review”

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#### 1. Introduction

In relation to the on-going Japan-UK Joint Research Project “Developing Visions for a Low Carbon Society through Sustainable Development,” we, the Asia-Pacific Integrated Modeling (AIM) team and the National Institute for Environmental Studies (NIES), were requested to provide research inputs to the Stern Review. We have been collaborating by providing research results since the beginning of the Stern Review in 2005. Upon publication of the Review in October 2006, members of the AIM team and NIES studied it comprehensively and published the resulting comments on the AIM home page (see <http://www-iam.nies.go.jp/aim/stern/index.htm> or search on “AIM Stern”).

#### 2. Background of the Stern Review in the context of UK government policy

At the Gleneagles Summit in 2005, the UK Prime Minister, Mr. Blair, took up the problem of climate change in the agenda along with the problem of poverty in Africa, and he laid down “The Gleneagles Plan of Action: Climate Change, Clean Energy and Sustainable Development”. In response to the plan, the UK and other G8 and G20 countries and international bodies such as the IEA and the World Bank will formulate their own review of climate change and present it at the G8 summit to be held in Japan in June 2008.

The UK government already published the Energy White Paper in 2003 coordinated by Dr Marshall, an business leader in economic circles. The White Paper proposed a 60% reduction in annual CO<sub>2</sub> emissions by 2050 as a national target. In addition, previous to the Gleneagles G8 Summit, the UK government hosted a meeting of scientists at Exeter in February 2005, bringing together leading experts of climate change from all over the world. These scientists, including Dr. Harasawa from the AIM team at NIES who reported on the impact of climate change in Asia, affirmed that climate change has been already occurring and it is one of the most important world issues in the 21st century. The UK called for the “Ministerial Meeting on the Gleneagles Dialogue on Climate Change, Clean Energy, and Sustainable Development” which was held in Monterrey, Mexico in October 2006. It was attended by Ministers and other officials from 18 major countries, and there was follow-up discussion on the problem of climate change. Through these actions, the UK is strengthening its leadership in the prevention of climate change.

Taking all this into consideration, the UK Treasury (HM Treasury) in July 2005 requested Dr. Nicholas Stern, the former chief economist of the World Bank, to prepare a review of the existing evidence regarding climate change and its economic implications. The objectives of this review were to systematically gather the results of climate-change researches from all over the world through embassies and other organizations and to develop a common global view on the possibility and the effects of the prevention of climate change from an economic perspective. The preparation of the review began in the spring of 2006 by over 20 Stern Review team members with support from researchers in climate policy in academia, international bodies such as the World Bank, and other organizations all over the world, and the review was published on October 30<sup>th</sup>, 2006. Since the publication of the review, Dr Stern has been traveling to various countries to give presentations and raise awareness about the review. This included a presentation at UNFCCC/COP12/MOP2 in Nairobi (United Nations Framework Convention on Climate Change, the Conference of the Parties to the Convention, and the Meeting of the Parties to the Protocol) and a trip to Japan on November 28 and 29, 2006.

One of the remarkable characteristics of the Stern Review is that it was initiated by the HM Treasury. An expert from the UK commented, “Actions for Climate Change used to be led by Department of Trade and Industry (dti) and Department for Environment, Food and Rural Affairs (defra), but without financial back up, their plans had little endorsement. Now with the involvement of the HM Treasury, UK really shows its seriousness on the issue. Also, it has to be pointed out that the Minister of Treasury, Mr. Brown, is a candidate for the next prime minister”. The publication of the Stern Review by the HM Treasury shows that the UK intends

to put emphasis on climate change. As for Dr. Stern himself, researchers in developing countries who have worked with him appreciate him as a sincere scholar and a practical man who has long experience in handling development aid programs for developing countries.

### 3. UK's Strong Leadership

Why are the Prime Minister and other top policy makers in the UK showing such seriousness for the issue of climate change?

Firstly, based on the reports from scientists, the political leaders of UK recognize climate change as a real problem which can potentially change the world in the long term; and they seem to have made up their mind to tackle the problem. Judging from the UK's responses at Intergovernmental Panel on Climate Change (IPCC), it is clear that UK recognizes that the first phase, which concerns about scientific evidence for climate change (agenda of the Working Group I of IPCC), has already passed. It agrees that now the actual impact of climate change (agenda of Working Group II of IPCC) has begun to emerge, and that practical actions against climate change (agenda of the Working Group III of IPCC) should take place. Such an attitude of the UK can be seen in the fact that while previously it chaired the Working Group I, now it has moved to chairing the Working Group II in the IPCC Fourth Assessment report which will be published in 2007.

Secondly, based on scientific evidence, the experts in the UK have assessed the form of future society and determined that the world should move to the low carbon society in the long term. While the US withdrew from the Kyoto Protocol, the UK is seeking to be a world leader in the area of global environment. In addition, as emphasized in the conclusion of the Stern Review, UK is making clear the importance of creating an economic mechanism to cope with climate change and intends to push "The European Union Greenhouse Gas Emission Trading Scheme (EU ETS)" at the center of the mechanism.

### 4. Assessment of Stern Review

In international politics there are various conflicting interests. Therefore the results of the Stern Review cannot be followed blindly; however, just because of such a reason, it is quite inappropriate to criticize and deny the effort and the proposal of the Stern Review to avoid the danger of climate change.

Thus, first of all, members of AIM team and NIES examined the Stern Review with the orthodox review style, that is, we evaluated if the results mentioned in the Stern Review were valid in terms of data and explanations and if its discussion was in line with the latest scientific evidence. We discussed the following four major points: 1) assumption of discount rate, 2) cost estimation of climate change impacts, 3) cost estimation of climate mitigation, and 4) the advantage of early action. Our conclusion was that the data used in the review were within the range of existing scientific results; but there are both strong and weak sides in discussions and some are not fully substantiated by scientific findings.

However, it is also necessary to assess the review within the scope of specific characteristics of the review itself. That is, we should recognize that, as mentioned in the title "the Economics of Climate Change", this review covered certain issues and viewpoints which are not addressed adequately by traditional economics. In other words, the Stern Review considers inertia and delay both in the climate system and the social decision making system, owing to the problems such as evidence of climate change in the long term, irreversibility, dispersion of impacts across global regions and also of various decision making bodies. The review should be assessed for its path-breaking effort in bringing in a new dimension in environmental economics, which did not deal with those problems because it has been traditionally carried out with the assumptions of short term, global and mono-value system.

The Stern Review is also a remarkable research carried out with clear intention to avoid the risk of climate change. It is based on the idea that climate change should not be dealt by a conventional and simplistic cost-benefit approach. The review uses a guardrail approach to assess for the safe-side, taking non-economic damage into consideration for discount rate and risk estimation, which could not be included in conventional economics. In addition, it should be pointed out that this review is not merely the result of pure economic analysis but clearly a

report with the intention to lead policy making from the viewpoint of building future “Low Carbon Society” using a backcasting approach.

This review contains many recent research results about the prediction of damage by climate change and its socio-economic implications, and some of those results might be precluding the second Working Group of the IPCC Forth Assessment Report (AR4) which will be published in April 2007. Another remarkable difference from the IPCC AR4 is that this review makes articulate judgment based on the research results considering not only quantitative individual risk but also non-economic risk, and clearly highlights the danger of climate change, whereas IPCC tends to use rather conservative expression due to a large number of review processes by experts and government officials.

### 5. About Various Criticisms

The publication of the Stern Review has stimulated various critiques from researchers, which is making the debate interesting and clarifying the problems and challenges of environmental economics. For example, R. Tol, who is one of well-known leading experts in this field for over a decade, is making pertinent comments from economics viewpoint. Critical comments by W. Nordhaus, who has been energetically working on quantification of climate risk for a long time, cannot be overlooked. There are many other comments and opinions, such as by P. Dasgupta and D. Maddison, that argues both for and against the Review. If the Review is assessed not as a text book of economics but as a report for leading policy making, discussion points should be also different. The Criticism by Marshall Institute, which consistently enumerates the uncertainty of scientific basis, seems a much outdated criticism now. Brief quotations in praise of the Stern Review by Nobel Prize winning economists such as J. Stiglitz and A. Sen have also appeared, but we would be interested to know the analysis and explanations behind such comments.



### II. Comments by AIM team and NIES

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#### 1. Characteristics of the Stern Review

The Stern Review is a report written based on the scientific aspects<sup>1)</sup> of climate change and intended to promote policies<sup>3)</sup> to prevent the risks<sup>2)</sup> associated with climate change, and it summarizes and compiles knowledge from an economic perspective<sup>4)</sup>. The report covers the following points.

- 1) The characteristics of decision making under the climate system which are different from conventional economic systems: i.e. irreversibility, inertia in the climate system, the likely long term and multi-generational impact on the world and on future populations, causes and consequences among globally-dispersed agents, the difficulty and expected delays associated with decision-making for attaining global consensus, and economic constraint caused by carbon budget.
- 2) Precautionary approach: i.e. preventing dangerous levels and overshooting of atmospheric greenhouse gas concentration, and projections involving cost estimates and discount rate settings that emphasize the safer route.
- 3) Active guidance to climate change mitigation measures: i.e. giving constructive induction based on climate stabilization targets; not just a marginal policy by a perturbation approach from the present condition, but including the real and actual external diseconomy of carbon dioxide emissions and considering the endogenous development of technology.
- 4) Compiling and organizing scientific economic knowledge concerning climate change: i.e. the report may evoke criticism as it is outside the realm of mainstream economic theory, but it is a bold proposal that amalgamates policy science, economics, and environmental ethics.

#### 2. Discussion points

Based on viewpoints mentioned above, discussion points of the Stern Review are summarized below. As conclusions for policy proposals, the Stern Review strongly asserts the following points:

- ① Current trend of climate change will incur very serious long-term global risks.
- ② The benefits of intensive countermeasure on climate change outweigh the mitigation costs.
- ③ The early policy action has more economic advantage than the late one.

In order to evaluate whether these deductions are logical and sound and the calculations are based on reliable data and assumptions, we discuss the following issues:

- Issue 1 Assumption of intertemporal discount rate: The discount rate (the rate of pure time preference) of 0.1% used for climate impact assessment is quite low and not usual value compared with ones used in the past. The discount rate has a great impact on future valuations, so is this rate appropriate?*
- Issue 2 Cost estimation of climate change impacts: Is the cost estimation of 5 to 20% of GDP based on reliable and unbiased review of previous studies? Is this in line with current research?*
- Issue 3 Cost estimation of climate mitigation: What is the basis for the claim that mitigation costs will be around 1% of GDP? Is this in line with current research?*
- Issue 4 The advantage of earlier intervention and action: Are there clear advantages to enforcing emission reduction earlier?*

### Issue 1. Assumption of intertemporal discount rate

*The discount rate (the rate of pure time preference) of 0.1% used for climate impact assessment is quite low and not usual value compared with ones used in the past. The discount rate has a great impact on future valuations, so is this rate appropriate?*

(the text of the last paragraph, on page ix, in Executive Summary)

**We have also considered how the application of appropriate discount rates, assumptions about the equity weighting attached to the valuation of impacts in poor countries, and estimates of the impacts on mortality and the environment would increase the estimated economic costs of climate change.**

(the text of the 5th key message from the top, on page 143, in Section 6, Part II)

**Modelling over many decades, regions and possible outcomes demands that we make distributional and ethical judgements systematically and explicitly. Attaching little weight to the future, simply because it is in the future ('pure time discounting'), would produce low estimates of cost – but if you care little for the future you will not wish to take action on climate change.**

[Comment]

In box 6.3 on page 161, as well as in the text on page 162 and in Table 6.1 on page 163, the discount rate is set at 0.1%. In order for various future impacts to be evaluated based on the same values as those currently held, the discount rate should be set at 0 %. However, is it evident enough to use 0.1% as the discount rate, but not using 0% or 0.01%? As mentioned in the Stern Review, is it a reasonable explanation to associate the discount rate of 0.1 % with the probability of surviving of human being during the 21st century of 90%, although similar explanation was used in previous studies?

(in box 6.3 on page 161)

Then discounted utility (with constant population) is given by:

$$W = \int_{t=1}^{\infty} U(t)e^{-\delta t} dt \quad (3)$$

where **W** is social welfare and  **$\delta$**  is the utility discount rate. The value of  **$\delta$**  is taken to be 0.1% per annum, so that the probability of surviving beyond time **T** is described by a Poisson process  $e^{-\delta T}$ , where  **$\delta$**  is the annual risk of catastrophe eliminating society, here 0.1%. So the probability of surviving beyond, say, 2106 is  $e^{-0.001 \times 100}$ , which is 90.5%. The Appendix to Chapter 2 discusses the implications of this choice in more detail.

With regard to Issue 1, the following three points should be studied:

- 1) It is necessary to have peer review on application and implication of a discount rate for impact analysis and a discount rate for mitigation analysis, particularly under the estimation in regional and sectoral aggregations like in the Stern Review.
- 2) The discount rate used for impact analysis in the Stern Review is "the rate of pure time preference" regarding the intertemporal (but not consumption) utility. This requires a consideration of ethical issues. Is it certain that this will be 0.1%?
- 3) With regard to impact analysis in previous studies, evaluations have been conducted for the impact cost up to 2100, but in the Stern Review, expanding the time horizon to 2200 represents a dramatic change. Moreover, the use of a small discount rate for this period will have a major effect on the evaluation, but how much it would be?

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With regard to 1), W.D. Nordhaus, for example, established the same discount rate in the DICE model in order to evaluate global warming mitigation and impact by using the same utility function. The concepts of opportunity costs have a major effect on the discount rate for mitigation, whereas it is the approach of multi-regional and multi-generational equity that accounts for a major portion of the discount rate for impact.

With regard to 2), if the degree of impact appearing at present is the same as the impact that will appear in the future and the future impact is evaluated to be the same as that appearing at present, the discount rate should be zero. The reason for setting a value slightly larger than zero is that otherwise the technical problems are considerable. If a value of zero is used for the discount rate  $\delta$  shown in the equation, the function becomes infinity and the problem becomes unsolvable.

With regard to 3), the discount rates set in estimates in previous studies were at least 2 - 3%. We have been unable to find an example which uses a value of 0.1%. If future impact is to be evaluated using values that are close to present values, it is expected to lead to the conclusion that more early action is needed.

For details, see Section 2.4 "The long-run impacts of climate change: evaluation over time and discounting" and Section 2A.2 "Intertemporal appraisals and discounting" (both in Part 1).

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### Reference information:

Explanation of discount rate in Chapter 4, Working Group 3 (WG3), the IPCC Second Assessment Report (SAR)

### Descriptive approach and normative approach

- Descriptive approach: empirical
  - Asks what people will select, including with regard to the tradeoff between maintaining the present course and shifting to a new course, and what degree of investment in GHG reduction will be replaced with other types of investment.
  - A high discount rate is set and comparatively low expenditures for measures to mitigate climate change are anticipated.
- Normative approach: normative and ethical
  - Asks how the impact on future generations should be evaluated.
  - A low discount rate is set and high expenditures for measures to mitigate climate change are anticipated.

### Generational compensation

- Descriptive approach
  - Envisions the compensation provided to other generations from a certain generation, no matter for what environmental losses.
  - Asserts that a course that maximizes consumption should be selected when transferring benefits from a generation in which the present value of consumption is comparatively high.
- Normative approach
  - Major restrictions are imposed on the transfer of benefits to future generations, and the only method of transferring benefits is climate change action.

Discount rate = “the rate of pure time preference” + “elasticity of marginal utility of consumption” x “rate of change in consumption”

- The reasons that discount rate under the utility measured in the unit of consumption is positive:
  - “The rate of pure time preference”: Low degree of concern with regard to future generations
  - “Elasticity of marginal utility of consumption” x “rate of change in consumption”: belief that future generations will be wealthier than the present generation

### Issue 2. Cost estimation of climate change

*Is the cost estimation of 5 to 20% of GDP based on reliable and unbiased review of previous studies? Is this in line with current research?*

(the text of the second last paragraph from the bottom, on page x, Executive Summary)  
**In summary, analyses that take into account the full ranges of both impacts and possible outcomes - that is, that employ the basic economics of risk - suggest that BAU climate change will reduce welfare by an amount equivalent to a reduction in consumption per head of between 5 and 20%. Taking account of the increasing scientific evidence of greater risks, of aversion to the possibilities of catastrophe, and of a broader approach to the consequences than implied by narrow output measures, the appropriate estimate is likely to be in the upper part of this range.**

[Comment]

In Chapter 6, an evaluation of the cost of impact was conducted using the integrated assessment model named PAGE2002, and the estimated cost was greater than that based on existing knowledge. The major reason given to explain the higher estimated cost is that points not considered in previous integrated assessment models were taken into consideration in the Stern Review as follows (the numbers shown in square bracket are estimated by reviewing Table 6.1 on page 163):

- Types of impact considered
  - Cost of non-market impacts such as human health and the environment [approximately 1.5 times market impacts]
  - Cost of rapid, large-scale impact due to system changes [approximately 2.9 times market impacts]
- Climate behavior response to greenhouse gas emissions
  - Effect of climate change amplifying feedback that has become known since the Third Assessment Report (2001) [approximately 30% greater than cases in which there is no feedback effect]

The economic loss of 20% due to global warming that appears in both the chapter headline and summary is calculated by using the Balanced Growth Equivalent (BGE). The BGE is determined for cases in which climate change does and does not occur, and the difference between these two values indicates the size of the cost of impact, in the form of the equivalent permanent percentage loss in consumption from the present to the future. The discount rate of 0.1% per annum has been used which is much smaller than the one frequently used in previous studies. As a result, when the BGE is used to tabulate impact cost in terms of time, there is a comparatively greater emphasis on the impact after the climate has changed greatly in the future, and so ultimately the estimate of the cost of impact is high.

The result of the 20% economic loss includes not only the newly considered impact mentioned above and the climate change amplifying feedback, but also a 25% increase in impact that was considered as a result of regional weighting done in order to take equity into account. With all of these factors taken into account, the impact was estimated as approximately  $(1 + 1.5 + 2.9) * 1.3 * 1.25 = 8.775$  times as compared to the case of market impacts only. In the case of market impacts alone,, climate change amplifying feedback and equity were not taken into consideration.

It is necessary to note that, both in the summary and the text, the Review appears to make an effort to over-emphasize the “20%” value that is the value for the combination of cases in which the impact is most severe, even though the Review evaluates multiple cases with regard to the type of impact and climate behavior in order to assess uncertainty in the evaluation method. In addition, the summary of knowledge of climate change impacts in Chapter 3 to Chapter 5 is not necessarily exhaustive and may have a bias toward negative predictions. Almost all of the previous research into the impact of climate change targets specific regions,

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and not enough research has been conducted into the world as an aggregate. There are many points of disagreement, such as the monetary value of human life used for the people affected by climate change. Moreover, the Stern Review includes the impact of indoor air pollution caused by gases other than CO<sub>2</sub> such as NO<sub>x</sub> and SO<sub>x</sub>.

Although the value of 20% is greater than the figures cited in the research up to now, it can be considered as a possible value. The lower side of the range (close to 5%) appears more plausible.

(Table 6.1 on page 163)

<b>Table 6.1 Losses in current per-capita consumption from six scenarios of climate change and economic impacts*.</b>				
<b>Scenario</b>	<b>Economic</b>	<b>Balanced growth equivalents: % loss in current consumption due to climate change</b>		
		<b>Mean</b>	<b>5<sup>th</sup> percentile</b>	<b>95<sup>th</sup> percentile</b>
<b>Baseline climate</b>	<b>Market impacts</b>	2.1	0.3	5.9
	<b>Market impacts + risk of catastrophe</b>	5.0	0.6	12.3
	<b>Market impacts + risk of catastrophe + non-market impacts</b>	10.9	2.2	27.4
<b>High climate</b>	<b>Market impacts</b>	2.5	0.3	7.5
	<b>Market impacts + risk of catastrophe</b>	6.9	0.9	16.5
	<b>Market impacts + risk of catastrophe + non-market impacts</b>	14.4	2.7	32.6

\*Utility discount rate = 0.1% per annum; elasticity of marginal utility of consumption = 1.0.

The cases that we would argue are central for the market imports are highlighted. The non-market effects are of great importance but involve difficulties in evaluation.

### Issue 3. Cost estimation of climate mitigation

*What is the basis for the mitigation costs will be around 1% of GDP? Is this in line with current research?*

(the text of the paragraph under Figure 3, on page xii, Executive Summary)

**Achieving these deep cuts in emissions will have a cost. The Review estimates the annual costs of stabilisation at 500-550ppm CO<sub>2</sub>e to be around 1% of GDP by 2050 - a level that is significant but manageable.**

(the text of the fourth paragraph above Figure 3, on page xiii, Executive Summary)

**Resource cost estimates suggest that an upper bound for the expected annual cost of emissions reductions consistent with a trajectory leading to stabilisation at 550ppm CO<sub>2</sub>e is likely to be around 1% of GDP by 2050.**

(the text of the third paragraph from the bottom, on page xiv, Executive Summary)

**Looking at broader macroeconomic models confirms these estimates.**

[Comment]

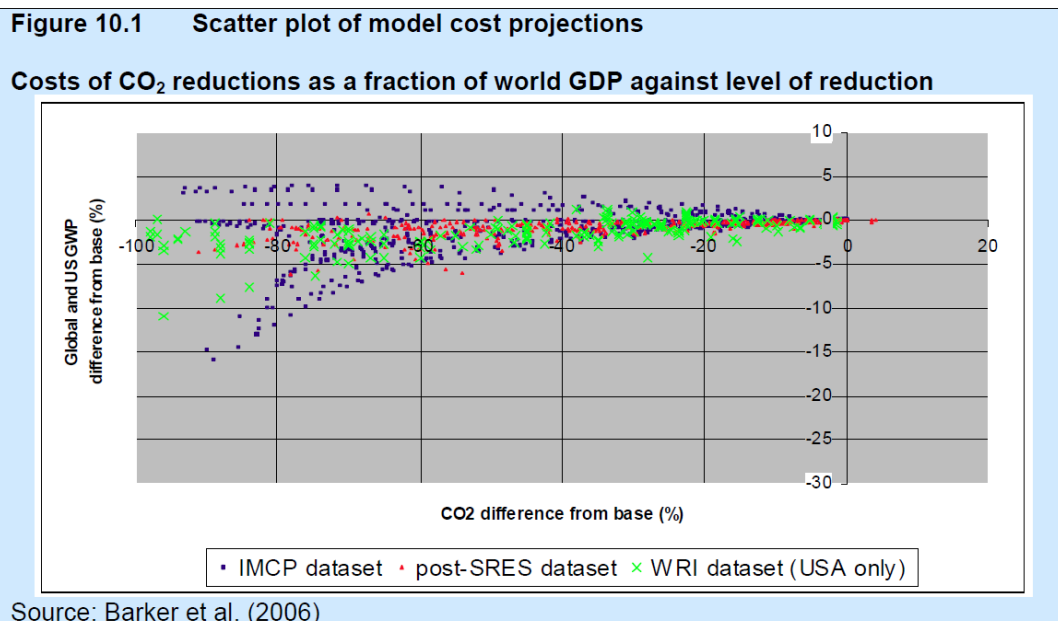
In Fig. 9.3 on page 230, the Stern Review states that, to achieve the target of stabilizing greenhouse gases at levels of 500 - 550 ppm CO<sub>2</sub>eq, emissions must be reduced to 18 Gt CO<sub>2</sub> by 2050 and to 7 Gt CO<sub>2</sub> by 2075. It further notes that, in the case of the "business-as-usual" (BAU) approach, emissions would be 61 Gt CO<sub>2</sub> by 2050 and approximately 70 Gt CO<sub>2</sub> by 2075. With regard to the estimate of the cost of stabilization of greenhouse gases to the target level, according to a paper by Dennis Anderson, using the Monte Carlo Simulation in which technical development, fossil fuels, the acceptance or rejection of the introduction of CCS and other external factors were altered, the cost of action for the entire world by 2050 was estimated at -0.6 to 3.5% of GDP, with an average value of 1% (assuming that future technological development would reduce technological costs to 3/4 of current levels by 2050). This is confirmed by Fig. 10.1 which summarizes in a single figure the results of comparative studies using various models.

The result itself is no different from the values that have been reviewed by the IPCC and other international agencies, but caution is needed with regard to cases in which the GDP is increasing. In the Innovation Modeling Comparison Project (IMCP) (a comparative study of numerical simulations conducted using multiple models for the results of endogenous technological development), a quantitative analysis was conducted through modeling of the effects of endogenous technological developments. Among these, a certain model that was used envisioned active roles of technological developments and produced extremely positive answers. To use a bit of hyperbole, it could be said that, "At the present time, researchers have energy to spare, so they should be able to conduct further research and develop many technologies to resolve the 500 - 550 ppm CO<sub>2</sub>eq restrictions. Depending on the approach, this will accelerate technological development and be a boon to the economy as well." The analysis of the cost of these efforts is greatly dependent on the BAU settings. Even if the BAU society already implemented action, the costs would be extremely high if the society were one that did not have room to make reductions, while they would be low if the society had room to make reductions. Depending on the situation, a society like the one in the Porter hypothesis can be envisioned, in which environmental restrictions increase industrial competitiveness.

However, with restrictions of 500 - 550 ppm CO<sub>2</sub>eq, the temperature rise will be 2.5 - 3.0°C of the level prior to the Industrial Revolution, and this does not match the British government's target of 2°C. The Stern Review holds that the level can be held to 2 - 2.5°C with restrictions of 400 - 450 ppm CO<sub>2</sub>eq. But given that CO<sub>2</sub> concentrations alone have already reached 380 ppm and costs would be approximately three times the costs of the 500 - 550 ppm CO<sub>2</sub>eq restrictions, it would be difficult to reduce greenhouse gas concentrations in the atmosphere in line with the 400 - 450 ppm CO<sub>2</sub>eq restrictions. The evaluations in anticipation of mitigation action are conservative despite the concern for the major impact in the future.

For details, see Chapter 9 and Chapter 10

(Figure 10.1, on page 242, Chapter 10)



Source: Barker, T., M.S. Qureshi and J. Kohler (2006): The costs of greenhouse-gas mitigation with induced technological change: A Meta-Analysis of estimates in the literature, 4CMR, Cambridge Center for Climate Change Mitigation Research, Cambridge: University of Cambridge.



### Issue4. The advantage of early action

#### *Are there clear advantages to enforcing early emission reduction?*

(the text of the middle of paragraph, on page i, Executive Summary)

**The benefits of strong, early action on climate change outweigh the costs.**

[Comment]

This subject is at the foundation of the Stern Review. It is for this purpose that the review was conducted, focusing on such topics as the approach to the discount rate and the cost of both impact and mitigation.

In order to make the above-mentioned argument, the following points must be clarified:

- 1) Impact resulting from procrastination in implementing mitigation action,
- 2) Basis for the belief that costs will be lower if early action is implemented, and
- 3) Treatment of the uncertainty inherent in both of the above points.

With regard to 1), in order to avoid sudden temperature rise, it has been pointed out that the extent of the temperature rise during a 10-year period must be kept to 0.2 degree or less (guardrail) [Ferenc, et al., 1997]. However, according to the analysis by means of an integrated assessment model, namely the IMAGE model [Vuuren, et al., 2006], major reductions are impossible at an acceptable cost with the current level of technology, and even if all possible efforts are made, it would not be possible to hold the 10-year temperature rise to 0.2°C or less until 2030, and hence overshooting of the GHG concentration level will be unavoidable. We recognize that early action on reductions are necessary in order to avoid the impact of global warming, but it should consider the trade-off between the cost of mitigation action and the cost of impact.

With regard to 2), it has been asserted that, rather than rushing to implement mitigation action, conducting careful preparations and then implementing full-fledged efforts will lower the cost of its action. This approach holds that, as a result of the technological development that is expected to occur in the future, the cost of mitigation action is certain to gradually decrease, so rather than forcing ourselves to introduce many expensive technologies and impose an economic burden, it would be better to introduce many cheaper technologies in the future to reduce economic losses. The WRE scenarios in this connection are particularly well-known [Wigley, et al., 1996].

However, even the WRE scenarios hold that cost reductions resulting from technological development efforts starting from the present time and ongoing efforts to diversify options will be indispensable. Furthermore, factors that must be taken into consideration include the following:

- (a) Once the design and implementation of a high-carbon society moves ahead, particularly in developing countries and other places where development will progress rapidly in the future, switching to a low-carbon society later may require enormous investment in equipment and other changes.
- (b) The effect of introducing a carbon tax will be useful not only in reducing short-term energy supply and demand but also in the long-term investment in a low-carbon infrastructure.
- (c) Certain technological development efforts may induce spontaneous new technological progress (endogenous technological development), and strict environmental restrictions may give rise to new technological innovation (the Porter hypothesis).

With regard to 3), there is uncertainty inherent in the identification of damage resulting from global warming, the setting of appropriate objectives, and the identification of the cost of mitigation action. Moreover, even if mitigation action succeeds in stabilizing levels at 500 - 550 ppm CO<sub>2</sub>eq at a cost of 1% of GDP, the impact of global warming due to a temperature rise of 2.5 - 3.0°C will be unavoidable, and the resulting damage and the cost of appropriate adaptation measures to reduce the impact of global warming must be taken into consideration in a comprehensive manner. Although the issues relating to these points are considered to some

degree in the Stern Review, the advantages of early action are not derived with overwhelming certainty as a consequence of the consideration of these issues. Even while including a certain degree of arbitrariness, the review limits itself to surmising the advantages of early action from a broad-based perspective.

Sources:

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- Wigley, T.M.L., R. Richels, and J.A. Edmonds (1996). Economic and Environmental Choices in the Stabilization of Atmospheric CO<sub>2</sub> Concentrations, *Nature* 379, pp. 240-243.

### 3. Conclusion

The Stern Review is within the scope that does not greatly deviate from previous studies. However, it breaks with the short-term perspective of mainstream economics in current research, in that it has a strong tinge of global environmental ethics symbolized by the discount rate of 0.1%. The report also strongly asserts that the natural systems that are affected by global warming and the human systems of the people whose lives are dependent on these natural systems must be discussed from a more long-term perspective. Moreover, the Review clearly shows that, if we use this perspective to take another look at the existing natural science knowledge relating to global warming, the prospects for technological progress, and the uncertainties in these areas, the damage that would result from a failure to curb global warming would be far greater than the costs needed for restrictions. Viewed from the methodology of a cost-benefit analysis, the reasoning in the Stern Review contains many shortcomings, and it does not propose specific targets for curbing climate change. However, even with only the scientific knowledge that we possess at this point, it succeeds in clearly stating that full-fledged, large-scale policies to mitigate global warming possess a high degree of economic rationality.

In our view, Sir Nicholas Stern, who has a thorough knowledge of the field of economics, deserves high praise for conducting such a constructive evaluation based on a careful review of the issues.

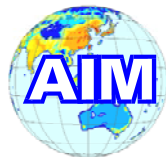




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The Asia-Pacific Integrated Model (AIM) is a set of computer simulation models developed by National Institute for Environmental Studies and Kyoto University, for assessing policy options on climate change and sustainable development. The original AIM is an integrated “top-down and bottom-up” model and comprises three main models – the greenhouse gas (GHG) emission model (AIM/Emission) that estimates future GHG emissions due to socio-economic activities in global regions and evaluates policy options, the global climate change model (AIM/Climate) that analyzes increase of atmospheric GHG concentration and its effect on global temperature and regional climate change, and the climate change impact model (AIM/Impact) that analyzes climate change impacts and risks for environment and human beings in different regions. AIM is used for assessing policy measures such as direct and indirect effects of mitigation policies, evaluation of uncertainty inherent in policy assessment, comparison of mitigation cost and its effects, in order for GHG emissions reductions and avoidance of the danger of climate change.

AIM website: [http://www-iam.nies.go.jp/aim/index\\_ja.htm](http://www-iam.nies.go.jp/aim/index_ja.htm)