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CLIMATE CHANGE: AN INCONVENIENT MAYBE*

CAMBIO CLIMÁTICO: UN QUIZÁS INCONVENIENTE

GONZALO EDWARDS**

Abstract

The subject of Climate Change is here to stay for at least the rest of the 21st century. The extent to which climate change can be expected; the importance in its determination of anthropogenic factors, relative to natural causes; its impact on world agriculture, migration patterns and economic growth; the costs involved and the best practices to mitigate the consequences, are all still subject to great controversy and remain in the realm of the speculative, in spite of specific matters where a relative consensus has been reached, and despite media efforts to show only the more alarmist view. It is this controversy that gives the name to this essay, which advertently paraphrases former United States Vice-President Al Gore's movie An Inconvenient Truth.

Key words: *Climate Change, environment, Kyoto Protocol, Stern Review, discount rate.*

Resumen

El Cambio Climático es un tema que permanecerá con nosotros por, al menos, el resto del siglo XXI. La magnitud del cambio; la importancia de los factores antropogénicos en su determinación; el impacto en la agricultura, flujos migratorios y crecimiento económico; los costos involucrados y las mejores prácticas para mitigar las consecuencias, son temas donde todavía existen grandes controversias, a pesar de existir relativo consenso en ciertos temas específicos y a pesar de los esfuerzos de los medios comunicacionales de mostrar sólo la visión más alarmista. Es esta controversia la que da el título a este ensayo, el que intencionalmente parafrasea el título de la película del ex Vicepresidente de Estados Unidos, Al Gore: Una Verdad Inconveniente.

Palabras clave: *Cambio climático, medio ambiente, Protocolo de Kyoto, Informe Stern, tasa de descuento.*

JEL Classification: *Q54.*

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1. Introduction

The subject of Climate Change is here to stay for at least the rest of the 21st century. The extent to which climate change can be expected; the importance in its determination of anthropogenic factors, relative to natural causes; its impact on world agriculture, migration patterns and economic growth; the costs involved and the best practices to mitigate the consequences, are all still subject to great controversy and remain in the realm of the speculative, in spite of specific matters where a relative consensus has been reached, and despite media efforts to show only the more alarmist view. It is this controversy that gives the name to this essay, which advertently paraphrases former United States Vice-President Al Gore's movie An Inconvenient Truth.

What follows is an attempt to show the different current views on the subject, with a deliberate emphasis on the economics involved. After a brief introduction to the science of climate change, the essay will unfold based on two major pillars of the current discussion: the Kyoto Protocol and the Stern Review on the Economics of Climate Change.

2. What is Climate Change?

Climate change, as the name suggests, is the variation in the earth's global climate caused by natural processes, internal or external to the earth and by human activities. This essay, like most recent discussions, centers on the latter.

Human activity, together with natural processes, is responsible for the emission or release of greenhouse gases into the atmosphere, making the earth progressively warmer. The earth receives most of its energy from the sun, mainly in the form of electromagnetic radiation which has a very short wavelength. This characteristic lets the energy pass through the atmospheric gases and reach the earth's surface. Then, the earth releases the solar energy back into space as longer-wave-length infrared radiation, some of which gets trapped in the atmosphere. The more greenhouse gases there are in the atmosphere, the more energy that is trapped, making the earth warmer.

Greenhouse gases, whether anthropogenic or not, are responsible for around 33 degrees centigrade in world average temperature. In the absence of the atmosphere, world temperature would be on the order of –18 degrees centigrade.[1]

As Table 1 shows, the most important greenhouse gas is water vapor and clouds. The most important gas where human activity has a direct influence is carbon dioxide, followed by methane. Even these gases, however, are greatly influenced by natural causes. The aerobic decomposition of organic matter and natural fires affect the amount of carbon dioxide in the atmosphere, while the decomposition of organic matter under anaerobic conditions is a major natural source of methane. Chlorofluorocarbons, used as refrigerants and as cleaning solvents, are strictly anthropogenic.

[1] See Pidwirny (2006), chapter 7, section h.

TABLE 1
GREENHOUSE GASES IN THE ATMOSPHERE

Water vapor and clouds	72.0%
Carbon dioxide (CO_2)	17.9%
Methane (CH_4)	5.3%
Nitrous oxide (NO_x)	1.7%
Chlorofluorocarbons (CFC)	1.7%
Other halocarbons	1.4%

Source: World Resources Institute.

Some of these gases trap infrared radiation better than others. A ton of methane, for example, is equivalent, in terms of its trapping capacity, to 23 tons of carbon dioxide, according to the Intergovernmental Panel on Climate Change (IPCC).[2]

The concentration of greenhouse gases in the atmosphere is increasing. Carbon absorption from the atmosphere is less than carbon released into it. Carbon is released when trees and fossil fuels are burned, and its absorption is reduced when growing trees are cut. The oceans are among the great gas absorbers. While solubility is greater the greater the gas concentration in the atmosphere, it is lower the higher the temperature of the water.

According to estimates by the IPCC Fourth Assessment Report (2007), carbon-dioxide concentration has increased from a pre-industrial value of 280 ppm to 379 ppm in 2005. The last decade (1995-2005) has seen an annual increase of 1.9 ppm. On the other hand, the global atmospheric concentration of methane has increased from a pre-industrial value of about 715 to 1.774 ppb in 2005.

Carbon dioxide and methane concentrations in the atmosphere are closely related to each other and to temperature, according to Petit, *et al*. (1999), who studied the climate history of the past 420,000 years through the Vostok ice core in Antarctica. They show that during this period, there have been four 100,000 year cycles and that carbon-dioxide concentrations have been, at least during this long period, in the 180-280 ppm range, concluding that "present-day atmospheric burdens of these two important greenhouse gases seem to have been unprecedented during the past 420,000 years".

It may be interesting to note that the pre-industrial carbon-dioxide concentration value of 280 ppm was in the upper limit of the "natural" 100,000 year cycle. Thus, the increase seen in the last century can be regarded as an addition to that maximum.

[2] The IPCC is a scientific intergovernmental body set up in 1988 by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP).

3. The Kyoto Protocol

It is against this background that the Kyoto Protocol was signed in 1997 and ratified in 2005. Its declared objective was to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

Based on the IPCC prediction that the global average temperature would rise between 1.4 and 5.8 degrees centigrade between 1990 and 2100, considering different scenarios, the Kyoto Protocol required industrialized countries to reduce emissions by 2012. Annex 1 countries[3] were compelled to reduce emissions of greenhouse gases, on average, by 5.2%, relative to 1990 levels. This corresponded to a 29% reduction with respect to expected emissions in 2010. Non-Annex 1 countries were not required to reduce emissions but were allowed to implement Clean Development Mechanisms (CDM) and to sell Certified Emission Reduction Units (CERs) to Annex 1 countries.

Table 2 shows, for selected countries, changes in greenhouse-gas emissions from 1990 to 2004 and compares them to the Kyoto Protocol targets for 2012. While many countries like the Czech Republic, Estonia, Germany, the Russian Federation and the United Kingdom, are meeting the targets, others are clearly not on the right track to doing so. The European Community, particularly Finland, Italy, the Netherlands, Portugal and Spain; Japan and New Zealand are having great difficulties reaching their stated goals.

If, as a whole, Annex I countries have been fairly successful in reducing carbon emissions, it may be largely attributed to the dismantling of the industrial complexes behind the Iron Curtain and the substitution of coal as an energy source in the United Kingdom. Neither phenomenon can be attributed to climate change considerations, meaning that their real commitment and capacity to further control emissions are still to be demonstrated. Additionally, the fact that excess reductions can be bought by other countries to meet the Kyoto targets, while in general an efficient way to control emissions, may have meant more greenhouse-gas production than hoped for. Soviet Union countries, for example, can sell gases they would probably not be producing even if they had been allowed to do so.

The United States and Australia, which decided not to ratify the Kyoto Protocol and therefore are not parties to it, have continued to increase their emissions during the period. The United States is responsible for 24% of anthropogenic carbon emissions in the world and Australia, the leading coal exporter in the world, is heavily dependent on coal for its electric-generating capacity.

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[3] Annex I countries (industrialized countries): Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States of America. Australia and the United States of America did not ratify the Protocol and therefore are not required to reduce emissions.

The main problems with the Kyoto Protocol today are enforcement and the capacity of countries to meet the targets.

TABLE 2
CHANGES IN GHG EMISSIONS FROM 1990 TO 2004 FOR SELECTED ANNEX I PARTIES

Country	Changes in Emissions 1990-2004 (%)	2012 Emission Reduction Target under the Kyoto Protocol (%)[b]
Australia	25.1	[a]
Canada	26.6	–6
Czech Republic	–25.0	–8
Estonia	–51.0	–8
European Community	–0.6	–8
Finland	14.5	–8 (0)
France	–0.8	–8 (0)
Germany	–17.2	–8 (–21)
Greece	26.6	–8 (25)
Italy	12.1	–8 (–6.5)
Japan	6.5	–6
Netherlands	2.4	–8 (–6)
New Zealand	21.3	0
Portugal	41.0	–8 (27)
Russian Federation	–32.0	0
Spain	49.0	–8 (15)
Sweden	–3.5	–8 (4)
United Kingdom	–14.3	–8(–12.5)
United States	15.8	[a]
All Annex I Parties to the Convention	–3.3	
Annex I Kyoto Protocol Parties	–15.3	–5

Source: United Nations Framework Convention on Climate Change.

[a] Australia and the United States, while parties to the Climate Change Convention, are not Parties to the Kyoto Protocol.

[b] The national reduction targets as per the "burden-sharing" agreement of the European Community are shown in parentheses.

Enforcement requires that sanctions be laid upon countries or parties that do not keep their commitments. The Kyoto Compliance Mechanism does specify that countries that have exceeded their emissions targets during one period must reduce emissions enough in the next period to make up for the excess in the previous period, plus an additional 30 percent; else they will not be allowed to sell emission permits in the next period. However, it is very difficult to determine

whether or not a country is non-compliant. Additionally, the mechanism has an important disadvantage in that sanctions also have a negative effect, through the price system, on countries that are in compliance with the agreement. As Hovi and Kallbekken (2004) point out, "This creates incentives for strategic behavior in the Enforcement Branch. If at least some members of the enforcement branch take these effects into consideration, a country that is technically in non-compliance might be able to escape punishment."

Many countries have had a hard time meeting the targets due to the public-good nature of emissions reduction. A country target has to be met by the different actors within that country. Regulations are not easy to implement and enforce, especially when the regulators themselves deem free-riding at the international level as the rational choice.

4. The Stern Review

The Stern Review on the Economics of Climate Change, published October 30, 2006, is undoubtedly one of the most comprehensive reviews on the economics of climate change.[4]

In a nutshell, the Review concludes that "the benefits of strong, early action on climate change outweigh the costs." The Review suggests a goal of greenhouse-gas stabilization in the range of 450-550 ppm of carbon dioxide equivalent (CDE)[5] by 2050. At present, the concentration is 430 ppm. To reach the goal, the Review estimates that emissions should be reduced by at least 25%, relative to current levels. If the goal is attained, temperature is expected to rise, on average, in the range of two to three degrees centigrade, relative to pre-industrial levels (1750-1850).

Warming, according to the Review, will have severe consequences. Glaciers will melt, increasing flood risk; crop yields will decline, especially in Africa; worldwide deaths from malnutrition and heat stress will increase; and rising sea levels will result in tens to hundreds of millions more people flooded each year.

The poorer countries and people are predicted to suffer the most. This is consistent with the observation that income in developed countries comes mostly from indoor activities.[6]

To achieve the suggested cuts in emissions, the Review estimates "the annual costs of stabilization at 500-550 ppm of carbon dioxide equivalent to be around one percent of [global] GDP by 2050, a level that is significant, but manageable."[7] Otherwise, the damages would reach at least twenty percent of GDP.

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4 The Review, written by Sir Nicholas Stern, former Chief Economist of the World Bank, was commissioned by the Chancellor of the Exchequer, reporting to both the Chancellor and the Prime Minister of the United Kingdom.

5 Carbon dioxide equivalent is the concentration of carbon dioxide that would cause the same level of radiative forcing as a given type and concentration of greenhouse gases.

6 See Schelling (2006) for a discussion of this point.

7 Stabilization costs contemplated here consider only the upper half of the suggested concentration goal of 450-550 ppm.

Critics of the Stern Review abound, with its science and economics seriously questioned. Arguments against the science in the Review are comprehensively summarized in the paper by Carter, *et al*. (2006), who carried out a thorough survey of the literature.[8] In turn, the main exponents today of the arguments against the economics in the Review are clearly Nordhaus (2006), Dasgupta (2006) and Weitzman (2007).[9] I will present the major critical points from both areas and then expose some still unsolved questions.

Carter, *et al*. (2006) argue that "many of the specific claims that are endorsed in the Review have been seriously challenged in the scientific literature, while the text plays down the great uncertainties that remain." These critics do not deny the possibility of future climate risks. They do, however, think that stressing only one side of the probability distribution (the alarmist side) is not good science.

Climatology is a new science. There are great uncertainties regarding the way in which clouds react to different climate forcings, such as greenhouse gases and aerosols. There are scientific articles which attribute half the warming in the twentieth century to solar changes, while others say that aerosols are more important than greenhouse gases in climate determination.[10] These recent results, according to the article, have not been incorporated into the climate change models.

Concerns over anthropogenic global warming, continue Carter, *et al*., are based on a graph which appeared in the IPCC's Third Assessment Report of 2001, showing that the nineties were the hottest decade in the millennium and 1998 the hottest year. However, this result has been challenged, among others, by two reports, one by the National Research Council and one by Edward Wegman, Chair of the National Academy of Sciences Committee on Applied and Theoretical Statistics. Wegman goes so far as to state that the committee believes that the assessments that the decade of the 1990s was the hottest decade of the millennium and that 1998 was the hottest year of the millennium cannot be supported by the analysis. The truth is that good global-temperature series

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8 The authors are R. M. Carter, Professor in the Marine Geophysical Laboratory of the James Cook University in Australia; C. R. de Freitas, Associate Professor in the School of Geography and Environmental Science at the University of Auckland; I. M. Goklany, Science and Technology Analyst at the United States Department of the Interior, who represented the U. S. at the IPCC; D. Holland, Associate Professor of Mathematics in the Center for Atmosphere Ocean Science; and Richard Lindzen, Alfred Sloan Professor of Meteorology, Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology.

9 William D. Nordhaus is Sterling Professor of Economics at Yale University; Partha Dasgupta is Frank Ramsey Professor of Economics and Fellow of St John's College, University of Cambridge; Martin Weitzman is Professor of Economics at Harvard University.

10 Aerosols, which reflect sunlight back to space, thus cooling the planet, are harmful to human health, through their effect on respiratory diseases. It may well be that greenhouse gases have been offset in the past by man-made sulphate aerosols. If aerosol levels are reduced, with beneficial health effects, then global warming would increase. It should be said, however, that there is still a strong scientific debate concerning aerosols and their effects both on human health and on climate.

only exist starting in 1958. If it were to be proved that medieval times were warmer, as believed before the studies showing the nineties as the hottest decade of the millennium, then "the models could not replicate this without giving more weight to natural variability and, perforce, their ability to identify anthropogenic forcing would be decreased."[11]

The Stern Review would also have failed in not considering studies by NASA and the Russian Academy of Sciences, both of which have predicted that cooling will occur early in the twenty-first century as solar activity decreases. Additionally, there seem to be causality problems in the analysis of ice cores. The data would indicate that increases in temperature in ancient times preceded parallel increases in carbon dioxide concentrations by hundreds of years.

The same alarmist pattern is apparent in the Review's treatment of climate impacts, according to Carter, *et al*. Only four of the forty scenarios developed by the IPCC were considered when drawing the main conclusions, leaving out two of the six "illustrative" scenarios chosen by the IPCC as "equally sound". The two excluded scenarios are less alarmist than those included.

Some of the papers relied upon by the Review to state that there is a significant melting of the Greenland ice sheet, show a slight net gain in the mass of the ice sheet during the last decade, since although the ice margins are shrinking, ice is building up inland due to higher snowfall. The temperature along the Greenland coast has registered little change since the first instrumental measurements in the 1780's.

The bottom line in all this discussion seems to be that the science behind climate change is not yet settled. Many questions just remain unsolved. The question of what will happen with the global climate is undoubtedly an issue which will interest scientists for decades to come.

This essay, however, as mentioned in the introduction, was to emphasize the economics involved. This means analyzing what we should do in the face of the uncertainties presented, both in terms of climate changes and climate impacts.

Nordhaus (2006) has emphasized the role of the discount rate in the Review, stating that "… the Review's radical revision arises because of an extreme assumption about discounting."

Nordhaus bases his critique on the Ramsey-Koopmans equation on optimal growth, pointing out that Stern assumes the economy to be on the long-run equilibrium path of an optimal Koopmans-type growth model.

The equation is

$$r_t = \delta + \eta\, g$$

where r_t is the consumption annual rate of discount. δ is the pure annual rate of time preference. A rate of zero would indicate that people with equal income in different generations are treated equally when projects are evaluated today. η is the utility-function-curvature parameter. If the parameter is too low, then

[11] Carter, *et al*., *op. cit*., p. 175.

an extra dollar in the hands of a very rich person is valued almost the same as the same extra dollar in the hands of a very poor person. g is the annual rate of growth in per capita consumption.[12]

This equation has two observables (r_t and g) and two normative parameters (δ and η). Stern assumes $\delta = 0.1\%$ and $\eta = 1$, which is not consistent with the observables. If a low (high) δ is used, then a high (low) η should go with it, if one wants the discount rate on consumption (r_t) to fit the macroeconomic data on growth and interest rates.

By using a low discount rate (low r_t), the Review advocates immediate and very radical actions to slow climate change. This is, according to Nordhaus, "… dramatically different from earlier models that use the same basic data and analytical structure [but different discount rates]. One of the major findings in the economics of climate change has been that efficient or "optimal" economic policies to slow climate change involve modest rates of emissions reductions in the near term, followed by sharp reductions in the medium and long term. We might call this the climate-policy ramp, in which policies to slow global warming increasingly tighten or ramp up over time…

"… The exact mix and timing of emissions reductions depends upon details of costs, damages, and the extent to which climate change and damages are irreversible."

Nordhaus uses his own DICE-2006 Model[13] to show that the Review's conclusion, that radical actions should be taken immediately, arises "because of an extreme assumption about discounting". The inclination of the policy ramp depends crucially on the discount rate. The higher the discount rate, the more inclined the ramp. The "optimal price of carbon" for 2005, using the DICE-2006 model, goes from 17.12 to 159 dollars per ton depending on the rate of discount, with the higher number being the result when using Stern's low discount rate.[14]

Nordhaus goes on to point out that a climate-policy ramp, "… while it may not satisfy the most ardent environmentalists, if followed they would go far beyond current global emissions reductions and would be a good first step in a journey of many miles."

Nordhaus, using Stern's forecast of a 1.3 % annual rate of growth in income per capita, rightly points out that this would mean that income per capita would increase from 7,600 dollars in 2006 to 94,000 dollars in 2200, in real terms. If income were to decrease by 20% as a result of climate change, then income would "only" be 75,200 dollars in 2200 (10 times the current level). Thus, the Stern Review advocates reducing current consumption to prevent the decline in consumption of future generations who are in either case projected to be much

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12 For a discussion of this equation in the context of environmental economics, see Dasgupta (2001) and Edwards (2002).

13 DICE stands for Dynamic Integrated Model of Climate and the Economy. The model was originally developed in the early 1990s.

14 The Stern Review, based on the PAGE Model, sets this number at 311 dollars per ton. The sensitivity of the results to the rate of discount is best estimated, however, when using just one model in the comparison.

richer than the present generation. As Nordhaus puts it, "while this might be worth contemplating, it hardly seems ethically compelling."

Dasgupta (2006) focuses his analysis of the Stern Review on the parameters chosen. The Review, according to Dasgupta, adopts an egalitarian attitude when treating the different generations (low δ, equal to 0.1% per annum), but adopts an "inegalitarian" attitude across people when present-future considerations are absent (low η, equal to 1).

On the other hand, he points out, the Stern Report considers 1% of GDP to be a small price to pay for solving the problem. However, this is equivalent to 570 billion dollars, which is seven times the total international aid for all purposes, including education, the eradication of poverty, etc.

Dasgupta does clarify, however, that "To be critical of the Review isn't to understate the harm humanity is inflicting on itself by degrading the natural environment…

"But the cause isn't well served when parameter values are so chosen that they yield desired answers."

Weitzman (2007) takes a different road, concentrating on the uncertainties involved and on the ways to deal with them. He sees climate change as an "opportunity for economists to take stock of what we know about this subject, how we know it, what we don't know, and why we don't know it."

Weitzman returns to the Ramsey equation arguing that the rate of growth in per capita consumption, g, in a greenhouse gas world, must be considered random, with a thick left tail. There is a high probability that consumption growth be low. He adds: "If, as the Stern Review puts it, "climate change is the greatest externality the world has ever seen," then a cost-benefit calculation of what to do about it is the greatest exercise in Bayesian decision theory that we economists have ever performed."

Weitzman does consider the worst-case scenarios as really frightening: ice melts in Greenland and Antarctica, islands going underwater, changes in rain patterns, massive migrations, species extinction, etc. These disasters are associated with temperature changes in the right tail of the distribution, and correspond to the left tail of the distribution of "g". The distribution of the change in temperature (ΔT) thus has a high variance, due to the uncertainty of the effect of GHG's on temperature.

Using the "results" of the Fourth IPCC Report (2007), which predicts that the total temperature change for the next 100 years has a mean of 2.8 degrees Centigrade, with a 15% probability of temperature rising over 4.5 degrees, and a 3% probability of it exceeding 6 degrees, he indicates that nobody knows what a 6 degree temperature change might mean.[15]

Weitzman contends that the above probabilities are as "subjective" as they can be, and that the "more objective" part of the distribution is the central part.

[15] Weitzman does not enter directly into the model-uncertainty problem. As Schelling (2006) points out, "translating a change in temperature into a change in climates is full of uncertainties. … the models probably cannot project discontinuities because nothing goes into them that will produce drastic changes. There may be phenomena that could produce drastic changes, but they are not known with enough confidence to introduce into the models."

Tails are not known and whatever is said about them is highly speculative (i. e. the further away from the mean, the more "diffuse" the probabilities).

The conclusion that arises from the above reasoning is that models have to deal with tail (or catastrophe) uncertainty directly, even if probabilities are "diffuse".

Under this reasoning, centered on the tails of the distribution, the relevant questions change: What are early-warning signs of impending runaway environmental disasters like melting ice sheets, or temperature changes that may be greater than 6 degrees? How much would it cost to put in place the very best system of sensors that money can buy for detecting early-warning signals of impending climate catastrophes? How early might the warning be before the full effects are felt? What can we do if we receive such an early signal? Is there a last-minute measure to reverse a catastrophe or its effects? For example, should we send sulfate aerosols to the higher part of the atmosphere? How does the tail thickness of climate-change disasters compare with the tail thickness of aerosol geoengineering, or the tail thickness inherent in widespread nuclear power?

Weitzman recommends "to supplement mainstream economic analysis of climate change (and mainstream ramped-up mitigation policies for dealing with it) by putting serious research dollars into early detection of rare disasters and by beginning a major public dialogue about contingency planning for worst-case scenarios."

To conclude this essay, some additional unsolved issues will be briefly exposed.

One important question concerning the climate change discussion has to do with the burden of proof. Who do we believe first? The cornucopians, who honestly believe that continued progress and provision of material items for mankind can be met by advances in technology, or the neomalthusians, who sincerely believe that if we do not act fast and radically in reducing greenhouse gases, the world may come to an end, at least in the way we know it. How much evidence is needed to be convinced that the "alternative hypothesis" should be accepted or that the "other side" is right? An interestingly possible result concerning this point would be that the minority position ends up being "right". If the majority is neomalthusian, then fast action will be taken and the problem will disappear. If, on the other hand, the majority is cornucopian, then nobody will do anything and global climate change would ensue.

Another question has to do with human interference in the environment. Is it the same, in terms of utility, to have a two-degrees temperature change produced by increases in solar activity, as to have the same change but produced by anthropogenic factors? If solar activity and other natural factors were to be responsible for the most of temperature changes, would that constitute an excuse not to worry about the human influence on the environment?

Still another issue that must be solved has to do with the distribution of costs, including control, adaptation and technology development. While the problem may be considered more political than economic, it does have economic ramifications. The lion's share of the burden could be laid on those who produce the most greenhouse gases; on those who have, in the past, produced the most greenhouse gases; on those who benefit the most from GHG reductions; on the richer countries; on all of the above or on some of the above. The "initial rights" of the different countries constituted a crucial subject in the Kyoto Protocol,

and the problem will present itself again soon, as the Protocol covers only the period until 2012. The Bali Conference in December 2007 only agreed on a road-map with the goal of reaching an agreement by 2009 to determine what to do after 2012.

When discussing whether we should follow a climate-policy ramp or take immediate and radical actions, the question of transfers should also be addressed. For example, if today's price of carbon emissions is set too high, huge rents may accrue to some economic agents, which may, or may not, be warranted. It is true that transfers are generally considered neutral in the economics profession, since it typically assumes a Kaldorian criterion when evaluating public policies. However, huge transfers, as those involved here, may bring in high political resistance.

A related issue has to do with the sunk costs behind existing investments. Switching to cleaner technologies should be a gradual process, replacing the older technologies as these depreciate.

In relation to future generations, are their interests best served through climate-change related sacrifices of the present generation? Or, should the present generation spend its intergenerational contribution in educational and health services, which also promote the future generations' well being? The moral of this entire story, of course, is that caring about the future generations also requires the consideration of opportunity costs.[16]

This essay is well ended with Weitzman's concluding remark: "History will judge whether the economic analysis of the Stern Review ended up being more wrong or more right, and, if it was more right, whether as pure economic reasoning it was right for the right reasons or it was right for the wrong reasons." Clearly, the subject of Climate Change is here to stay for at least the rest of the 21st century.

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[16] The Copenhagen Consensus, led by Bjørn Lomborg, adjunct professor at the Copenhagen Business School, and author of The Skeptical Environmentalist, seeking to establish priorities for advancing global welfare, assembled a panel of prominent economists to evaluate and rank a series of problems, based on cost-benefit analysis. The result: battling AIDS and malaria came at the top of the list, then poverty and malnutrition, followed by tariff-barriers, access to potable water, education, etc. Climate change was at the bottom of the list. While these results have been challenged by the scientific community, they rightly show a major concern for the alternative costs involved.

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