Keys to Economics of Global Warming: A Critique of the Dismal Theorem

S. Niggol Seo
Research Professor, Basque Center for Climate Change

Independent Institute Working Paper Number 72

November 3, 2009

100 Swan Way, Oakland, CA 94621-1428 • 510-632-1366 • Fax: 510-568-6040 • Email: info@independent.org •
http://www.independent.org

KEYS TO ECONOMICS OF GLOBAL WARMING: A CRITIQUE OF THE DISMAL THEOREM

S. Niggol Seo[1]
Research Professor
Basque Center for Climate Change

Abstract

M. L. Weitzman in his paper "On Modeling and Interpreting the Economics of Catastrophic Climate Change" argues that a standard cost-benefit analysis cannot be used as a tool for climate change policy since the problem of climate change possesses a large irresolvable uncertainty. I critique his analysis on two grounds: 1) key issues in the economics of global warming and 2) the claim on catastrophe. I point out that the fundamental economics of global warming is to provide a public good that is spatially global and temporally lasting, for several centuries, by a globally coordinated effort. The fundamental issue is how to cooperate on a global scale to regulate greenhouse gases given the divergent needs and preferences of individuals, businesses, countries, and even future generations. I argue that Weitzman misinterprets climate science by assuming that all scenarios are equally likely and that there will be no policy intervention to control greenhouse gases. In addition, he focuses on long-term climate predictions. Finally, impact studies do not support catastrophic outcomes from climate change within this century.

1. Introduction

A recent publication by M. L. Weitzman on the economics of climate change emphatically shows that a wide spectrum of opinions exists even among economists on how we should deal with this important global policy issue (Weitzman 2009). He argues that the traditional cost-benefit economic approach for regulating environmental problems cannot be used to design a global warming policy due to an irresolvable extreme uncertainty. He instead proposes a "generalized precautionary principle." His opinion adds one more perspective to the whole array of policy views on dealing with global warming, which ranges from no policy, voluntary approach, faith-based initiative, development of alternative energy sources, carbon capture and sequestration, clean coals, bio-fuels, geo-engineering, consumer-based solutions, a cap and trade system, and finally to a carbon tax approach.

In this critique, I point out that Weitzman's approach is flawed in that it only looks at one side of the issue, uncertainty in the far future, but overlooks the fundamental issue in global warming, which is that climate change is a global public good. Climate (change) is a global public good that cannot be provided by market forces alone. Since the issue is global and will be present for several centuries to come, an efficient provision of climate change abatement will entail correcting for carbon emitting behaviors of all individuals, businesses, countries, and even future generations without any omission across the board, which is the major difficulty of a global warming policy given the hugely diverse needs and preferences of the participants.

The second point I will make is that uncertainties in global warming debates are smaller than what the general public believes. I will discuss his 10° and 20° Celsius changes in temperature and point out some potential mistakes in understanding the range of climate

change expected in this and subsequent centuries. In addition, I will go through empirical evidence from impact studies to illustrate that they do not support any catastrophic results from climate change within this century.

This critique is composed of two sections. One section will be devoted to the economics of global warming in which I show how the "Dismal Theorem" fails to capture the true problem. The second section will be devoted to fact checking with regard to the literature on global warming. The aim of the second section is to show that global warming uncertainties are not as large as the Weitzman claims.

2. Keys to the Economics of Global Warming

Paul Samuelson, one of the most influential economists in history, made an important point in his article "The Pure Theory of Public Expenditure," published in 1954, that a free market economy cannot provide a certain type of goods optimally to the society when the good is used collectively by the society's members, that is, when the good is a *public good.* When a certain commodity is used by many individuals and an individual cannot be excluded from the use of the good once it is provided, it is not provided efficiently by market forces alone because everyone would want others to provide the good. In this case, public coordination is necessary if the society wants the good to be provided efficiently (Samuelson 1954).

The problem of global warming is perhaps the clearest evidence in support of his claim on public goods (Nordhaus 1977). Climate is enjoyed by everyone in the world; therefore no one cares to protect the climate. In reality, no single individual or country can protect the climate. The results are that greenhouse gas concentrations have been rising

rapidly over the past century. The CO_2 concentration has risen from 310 ppm in 1950 to 380 ppm in 2004 according to the historical recordings in Mauna Loa (Keeling and Whorf 2005), and global communities are increasingly worried that global temperature has been trending upwards over this time period. The key culprit of this problem is the fact that climate change is a global public good.

Among many policy issues, climate change tops the list of public goods due to its spatial nature of being "global" (Nordhaus 1992, 2008). Climate is essentially enjoyed by everyone in the world—even by animals and plants. However, a good climate is costly since it depends on the level of greenhouse gas emissions, which mainly result from human economic activities. While one individual's contribution to the global greenhouse gas level is tiny and negligible, when summed up across the globe it changes the earth's atmosphere. An individual's reduction of greenhouse gases does not make any difference in improving global climate. On the other hand, humanity's collective efforts do improve the earth's climate. Proposals such as a voluntary approach, a faith-based approach, and a consumption-based approach are certain to fail due to the misunderstanding of the key issue in the economics of global warming, which is that climate is a global public good. Similarly, state-based approaches such as the California Climate Initiative or France's commitment to cut greenhouse gases unilaterally by 50 percent by 2020 would not lead to a solution due to, once again, the nature of public goods inherent in this problem.

Therefore, at the deepest level, climate change calls for a globally collective action. This problem can be handled only by a globally coordinated effort such as setting a harmonized worldwide carbon tax. A unilateral approach such as the EU cap-and-trade system would not do much to reduce the level of climate change unless it is extended across

all the countries. Along the same lines, the key to the success of a global effort lies in participation from developing countries. The current deadlock in the negotiations between Europe and the U.S. mainly results from the nature of climate change as a global public good. Similarly, the difficulties in negotiating a global deal with China and India come from the same public-good economics of global warming. To work well, in other words, every country should be on board with the same protocol, but the reality is that countries are faced with different realities regarding economics, politics, international relations, and even climate.

The difficulty of global warming policy goes beyond public goods being global in a spatial context. The greenhouse gases stay in the atmosphere for about 300 years once they are emitted, that is, they are stock pollutants. A sound global policy should therefore consider the impacts of greenhouse gas emissions on future generations. Individuals who will come into being fifty years from now will not face the same economic conditions as we do today. Future businesses will be sufficiently different from today's successful businesses. Moreover, economic as well as political relationships among the countries might be dramatically different. The key issue in including future generations in the climate "roundtable" is, however, not much different from the roundtable of the present stakeholders. That is, there should be no loopholes in the policy, and every stakeholder in the future should take part in the climate mitigation effort. Again, the major hurdles are that all future generations should be on board the climate mitigation effort even though they have not even come and will have drastically different needs, preferences, and economic conditions. In other words, the key difficulty arises from the public goods nature of the climate change problem, that is, climate change is a global stock public good.

Summing up, the keys to the economics of global warming are that climate is a public good, a global phenomenon, and a long-term intergenerational issue. A reasonable policy response should be to provide climate mitigation in the context of a globally coordinated effort in a dynamically designed policy. The most difficult part of global warming economics is how to cooperate at a global scale for the common cause while individuals, businesses, countries, and future generations have diverging needs, preferences, and economic political conditions. The only possible chance of success comes from a global effort in the form of setting a proper price signal on carbon emissions (public bads) in a dynamic fashion by balancing the benefits and costs of a ton of emissions in a way that could force all individuals, businesses, countries, and even future generations equally to reduce emissions. This is the key issue of global warming economics.

Having discussed this so far, I want to emphasize that the discussion about catastrophe from climate change has not been a major talking point addressed by economists. Even without the possibility of a catastrophe, such as a "total collapse of civilization," there needs to be a long-term global effort to curb rising greenhouse gases because climate change will significantly harm economies, especially in the low-latitude developing countries, over the course of this century. The key economic issue regarding global warming remains even after the possibility of a catastrophic collapse is removed from the discussions. Therefore, the keys to the economics of global warming do not lie in the catastrophic future, but rather in the difficulties of dealing with a spatial and temporal public good. The remaining questions are then what the likelihood of a catastrophe is from climate change and what the key economic issue is if there exists a catastrophic potential from climate change.

3. How Large Is the Potential for a Climate Catastrophe?

The primary concern of Weitzman is that climate may change by 10° to 20° Celsius by the end of this century, which is unprecedented and certain to be catastrophic. Borrowing his own language, there remains a thick tail in the probability distribution of climate predictions. Technically, he is concerned with the uncertainty about the magnitude of climate change which he thinks is too large but cannot be removed by further analyses, such as the possibility of 10° to 20° changes in temperature.

However, he overlooks the fact that climate predictions in the Intergovernmental Panel of Climate Change (IPCC) report are all scenario-dependent. That is, climate predictions are made based on particular scenarios, and these scenarios assume a certain rate of population change, economic growth, technological development, and environmental progress. Since climate predictions are dependent on scenarios, they cannot be treated as absolute independent predictions. Moreover, the scenarios cannot be treated as though they are equally likely to occur. The most likely scenarios, which are also most widely adopted by economic analysis, are B1, A2, and A1B, which are presented in the report. The B1 scenario predicts a 1.8° change, the A1B scenario predicts 2.8° change, and the A1 scenario predicts a 3.6° change by the year 2100 (IPCC 2007). These are the mean changes based on each scenario. According to these mean values, Weitzman's arguments based on assuming 10° to 20° changes are widely off the target. What about the variance of these estimates? The most likely outcomes from these scenarios range from 1.6° to 4.6° change by the end of this century according to the IPCC Report. Even considering the full variance, the changes are not as explosive as presented by Weitzman. Furthermore, these predictions assume that there is no policy intervention to curb greenhouse gases.

The second point is that Weitzman and the climate prediction models do not treat policy factors properly, as is well pointed out by Nordhaus (Nordhaus 2009a). With a global warming policy implemented over the coming decades across the globe to deal with this problem, the world will highly likely contain the explosions in global temperature. Assuming that climate policies will be implemented over time is another way to view the scenarios of the climate models, which are dependent upon socio-economic assumptions.

The third point that I want to make is that although we cannot be sure about climate changes 200 years from now, we can be more certain of a nearer future. Scientists report climate change predictions in around 100 years, for example, in the IPCC report. However, for the next fifty years, they are more certain of what will happen to the climate system. We are more certain that climate will change in the next half-century later by 1° to 3°. One should note that a time frame of a half-century is quite a long period for a global policy design in which the policy can significantly change the climate trend. Fifty years from now, unexpected changes in science, technology, and society are more than possible. Therefore, it makes more sense to plan for the next half-century time frame than for an uncertain and less meaningful one or two centuries.

The final issue is whether climate would cause such large impacts on the globe as to prevent any reasonable policy design. Researchers are not certain of what will happen to market and non-market behaviors due to climate change. However, they have been most concerned from the beginning of climate literature on agricultural impacts and food security. Other than agriculture, people are most concerned about the disasters that would be caused by rising sea levels and disease outbreaks in tropical regions.

Economists have made strides in understanding the impacts of climate change on this area. In Table 1, I show the impact estimates of climate change on agriculture from various authors and various regions. Initially, researchers argued that climate change impacts on U.S. agriculture would be quite large, amounting to $60 billion (in 1990 U.S. dollars), more than a 30 percent loss of U.S. agricultural output from a doubling of carbon emissions (Cline 1992). Subsequent studies debated the figure and reached a conclusion that the loss will be negligible or slightly beneficial if the temperature increase were under 2.5°. The conclusion holds under experimental crop simulation models (Adams et al. 1990, 1999), hedonic models (Mendelsohn et al. 1994), and panel fixed effects models (Deschenes and Greenstone 2007). Studies outside the U.S. are not complete yet, but initial studies indicate that impacts on agriculture, even in the low-latitude countries, might not be serious due to the large adaptation potentials and diverse agricultural portfolios that farmers hold currently, although farmers are likely to face huge burdens if the changing climate renders current agricultural practices uncompetitive in the future. African agriculture is expected to lose only 3 to 7 percent of farm income by the end of this century under the severe climate scenario (Seo 2009a). Latin American agriculture is measured to lose around 5 percent of agricultural income under the most severe scenario by 2060 (Seo 2009b). Empirical evidence points that agricultural impacts which have received the most concern from academic and political circles are likely to be only modest under 2–3° warming within this century.

Table 1: Impacts of Global Warming on Agriculture

	Authors and methodologies	Ag% of GDP	Impact (% GDP)
USA*	Adams et al. (1999), experimental	1.2	-0.06%
	Mendelsohn et al. (1994), Hedonic	1.2	+1.2 to -0.7 % (of farmland values)
	Deschenes and Greenstone (2008), Panel	1.2	+0.01%
Africa	Seo (2009a)	16.4	-0.80%
Latin America	Seo (2009b)	7.2	-0.30%

*Another hedonic study Schlenker et al. (2005) was not included because authors only examined rainfed farms, excluding irrigated agriculture.

Another area that has worried many people is the possibility of coastal inundation due to rising sea levels. In Table 2, I present recent estimates of the impacts of climate change on coastal cities. The estimates are based on detailed studies on the U.S. coasts (Yohe and Schlesinger 1998, Nordhaus and Boyer 2000). They account for adaptation behaviors in that people in coastal areas can decide either to build walls or move away, depending upon the possible outcomes. In the U.S., it is estimated that the impact from sea level rise caused by CO_2 doubling would be less than one-tenth of one percent of the U.S. GDP. The table shows the estimates across the world. It indicates that coastal disasters due to climate change will be limited. However, these estimates still overestimate sea level impacts since they ignore the fact that most major coastal cities already have second and even third backup systems in preparation for natural disasters even without concerns about climate change.[2]

Table 2: Coastal Vulnerability by Region (by CO_2 doubling)

Region	Coastal index*	Coastal impact (% GDP, 2005)
USA	1.00	-0.10
Latin America	1.00	-0.10
Europe	5.16	-0.52
Russia and Canada	0.95	-0.09
Middle East and North Africa	0.52	-0.05
Sub-Saharan Africa	0.23	-0.02
East Asia	4.69	-0.47
China and Central Asia	0.71	-0.07
India and South Asia	1.00	-0.10
Oceania	1.00	-0.10

* Ratio of fraction of area in coastal zone in country to that fraction in the United States. "Coastal zone" is defined as that part of the region that lies within 10 kilometers of an ocean.

* Author's estimates based on Nordhaus and Boyer (2000), Yohe and Schlesinger (1998).

Finally, many people are concerned about the health impacts of climate change. An increase in malaria may significantly disrupt the world. However, as I show in Table 3, most climate-related diseases, mainly malaria, are concentrated in sub-Saharan Africa (Murray and Lopez, 1996, Lopez et al., 2006). There are almost no occurrences of malaria-related deaths in developed countries and only small numbers of DALY (Disability Adjusted Life Years) losses. Comparing the results with those in Singapore, which eliminated the disease during the past several decades, and the fact that malaria occurrence has decreased substantially in India and South Asia over the past decade, it clearly indicates that as Africa develops economically

over the next several decades, the numbers of malaria-related deaths will likely shrink rather than expand, even under global warming.

Table 3: Climate-Related Diseases by Income Groups (numbers in thousands)

	Low and middle income		High income		World	
	Deaths	DALYs	Deaths	DALYs	Deaths	DALYs
All causes	48,351	1,386,709	7,891	149,161	56,242	1,535,871
Malaria	1,207	39.961	0	9	1,208	39,970
Percentage of Malaria	2.50%	2.9	0%	<1%	2.10%	2.60%

* Modified from Lopez et al. (2006)

4. Conclusion

This paper provides a critical review of the Weitzman's Dismal Theorem, which states that climate uncertainties are so large that a standard cost-benefit analysis cannot be applied to the problem of climate change. I critique his analysis in terms of the key economic issue in global warming debates and a critical examination of climate uncertainties.

The problem of climate change is fundamentally caused by the issue of public goods, i.e., a collective use of the climate by everyone on the globe. The solution is extremely elusive due to the truly global nature of climate change. Everybody in the world is responsible for the quality of climate and enjoys its good quality. The problem becomes even more difficult to grasp since it involves a stock pollutant, which will stay for several centuries in the atmosphere. A fundamental issue with the economics of global warming is therefore to

provide a public good that is both spatially global and temporally long-lasting, thereby demanding globally coordinated action. To put it differently, a fundamental issue in global warming is how to work cooperatively on a global scale to provide this public good in an efficient and effective way. The only chance lies in regulating polluters in the present and the future by setting a proper carbon penalty in a dynamic fashion by balancing the benefits and the costs of emissions. The penalty should be set by accounting for a long-term impact of greenhouse gases.

A strong critique is provided on the grounds of climate change literature on uncertainties in temperature increase and impact estimates. I argue that Weitzman misinterprets climate science by assuming that all scenarios are equally likely. Second, he assumes no policy intervention to control greenhouse gases. In addition, he focuses too much on long-term predictions—200 years from today—which are less relevant in setting a near-term climate policy. Finally, impact estimates do not point towards catastrophic outcomes from climate change within this century.

Although not addressed in this paper, I want to conclude by bringing up the possibility of new technological solutions such as, such as carbon capture and storage and climate engineering, which are likely to become a realistic options in the future (Barrett 2008). A globally harmonized carbon tax implemented over the next centuries should provide the fundamental mechanism to stop the unbridled explosion in atmospheric greenhouse gases, while inducing the development of new technological solutions. The whole discussion then comes back to the difficulties in negotiating a global deal given the nature of climate change as a global stock public good.

References

Adams, R., C. Rosenzweig, R.M.Peart, J.T. Ritchie, B.A. McCarl, J.D. Glyer, R.B. Curry, J.W. Jones, K.J. Boote, and L.H. Allen. 1990. Global climate change and US agriculture. *Nature* 345: 219–224.

Adams, R., M. McCarl, K. Segerson, C. Rosenzweig, K.J. Bryant, L.B. Dixon, R. Conner, R. Evenson, and D. Ojima. 1999. The economic effects of climate change on US agriculture. In *The Impact of Climate Change on the United States Economy* (Eds. R. Mendelsohn and J. Neumann), Cambridge, UK: Cambridge University Press.

Barrett, S. 2008. The Incredible Economics of Geoengineering. *Environmental and Resource Economics* 39: 45–54.

Cline, W. 1992. *The Economics of Global Warming.* Washington DC: Institute of International Economics.

Deschenes, O. and M. Greenstone. 2007. The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather. *American Economic Review* 97: 354–385.

IPCC. 2007. Summary for Policymakers. In Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.) Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

Keeling, C.D., and T.P. Whorf. 2005. Atmospheric CO_2 records from sites in the SIO air sampling network. In *Trends: A Compendium of Data on Global Change.* Carbon

Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.

Lopez, A.D., Colin D. Mathers, Majid Ezzati, Dean T. Jamison, and Christopher J. L. Murray. 2006. *Global Burden of Disease and Risk Factors.* New York: World Bank and Oxford University Press.

Mendelsohn, R., W., Nordhaus, and D., Shaw. 1994. The Impact of Global Warming on Agriculture: A Ricardian Analysis. *American Economic Review* 84: 753–771.

Nordhaus, W. 1977. Economic Growth and Climate: The Case of Carbon Dioxide. *American Economic Review* 67:341–346.

———. 1992. An Optimal Transition Path for Controlling Greenhouse Gases. *Science,* 258(5086):1315:1319.

———. 2008. *A Question of Balance.* New Haven: Yale University Press.

———. 2009a. *An Analysis of Weitzman's Dismal Theorem.* New Haven: Yale University Press.

———. 2009b. *Projections of Sea Level Rise.* New Haven: Yale University Press. Retrieved from http://nordhaus.econ.yale.edu

Samuelson, P. 1954. The Pure Theory of Public Expenditure. *The Review of Economics and Statistics* 36: 387–389.

Seo, S.N., 2009a, "Is an Integrated Farm More Resilient Against Climate Change?: A Micro-econometric Analysis of Portfolio Diversification in African Agriculture," Food Policy. doi:10.1016/j.foodp01.2009.06.004.

———. 2009b. Assessing Relative Performances of Econometric Models in Measuring the Impacts of Climate Change. *Review of Regional Studies* 38: 1.

Yohe, Gary W. and Michael E. Schlesinger. 1998. Sea Level Change: The Expected Economic Cost of Protection or Abandonment in the United States. *Climatic Change* 38: 337–342.

Weitzman, M. L. 2009. On Modeling and Interpreting the Economics of Catastrophic Climate Change. *Review of Economics and Statistics* 91(1): 1–19.

---

[1] Dr. S. Niggol Seo received a Ph.D. in Environmental and Natural Resource Economics with a focus on global climate policy from Yale University and has been working with the World Bank since 2003 on various climate projects. He is a Research Professor at the Basque Center for Climate Change in Spain.

[2] A most recent estimate can be found in the website of Nordhaus (2009b), which predicts a slightly larger, but not explosive, sea level impacts.