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

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Abstract

In a recent paper on climate change, M. Weitzman argues that the traditional cost-benefit analysis cannot be used as a reference tool for designing a climate change policy due to a large uncertainty that cannot be reduced by further analyses. The findings of the 'Dismal Theorem' are, however, based on two critical assumptions: a single geographical unit and two distinct points in time. It assumes a single geographical unit, disallowing the possibility of reallocating resources across different geographical regions under climate change. It also assumes only two time periods, the present and the year 2100, which rules out a dynamic dimension of climate policy such as burden sharing across generations and learning over time. On the empirical side, the author's apprehension of catastrophe is blown out of context since he assumes that all climate scenarios are equally likely to occur and that there would be no policy intervention to control greenhouse gases over time. Finally, impact studies do not support catastrophic results from climate change within this century.

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1. Introduction

A recent publication by M. Weitzman on the economics of climate change shows that a wide spectrum of opinions exists even among economists on how the world should deal with this global problem (Weitzman 2009). He critically asserts that the traditional cost-benefit economic approach for regulating environmental problems cannot be used in designing a global warming policy due to an irresolvable extreme uncertainty regarding climate change. He instead proposes a "generalized precautionary principle" as a guiding tool for climate policy.

In this critique, I argue that the Weitzman's approach is flawed, albeit providing meaningful insights into a decision making under extreme uncertainty, in that it is only concerned about the uncertainty in the far future, but ignores, more often than not, the fundamental issues in global warming, that is, climate change is a global public good. Since the issue is global and involves several centuries to come, an efficient provision of climate mitigation will entail correcting for carbon emitting behaviors, in theory, of all individuals, businesses, countries, and even future generations without any omission across the board, which is the major difficulty of designing a global warming policy (Nordhaus 2008). I will explain in this critique that the Weitzman's analysis fails to capture this fundamental economics of climate change by assuming a single world region and by simplifying his model to two time periods, the present and the future.

The second part of this critique is concerned about his claim on catastrophe. I will discuss his assertions on 10° and 20°C changes in temperature and point out some potential mistakes in understanding the range of climate changes expected in this century or several centuries later. 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.

2. Keys to the Economics of Global Warming

Climate is a global public good; it is shared by everyone in the world (Samuelson 1954, Nordhaus 1977). It is freely available to everyone on the planet. In reality, no single individual or country can protect the climate. The consequences are that the concentration of greenhouse gases has been rising rapidly over the past century. The CO_2 concentration has risen from 310 ppm in 1960 to 380 ppm in 2004 according to the historical recordings in the Mauna Loa observatory (Keeling and Whorf 2005). At the same time, atmospheric temperature has been trending upwards, albeit slightly, over this time period.

Among many policy issues, climate change tops the list of public goods due to its spatial nature of being 'global' (Nordhaus 1992, 2008). A climate policy, in theory, needs to be inclusive of all individuals on the planet. State-based approaches such as California Climate Initiative or the Germany's commitment to cut greenhouse gases substantially immediately would not lead to a solution to the problem. This problem can be solved only by a globally coordinated effort such as setting a harmonized carbon tax across the globe[1]. At present, the key to the success of a global policy lies at large in securing participation from developing countries such as China, India, and Africa. The difficulties in negotiating a global deal with these countries come from the varying realities regarding economic developments and climate damages that these countries are faced with. It does not take long to understand why the recent Copenhagen talks ended without producing any meaningful agreement.

The difficulty of a global warming policy goes beyond a global coordination. The greenhouse gases stay in the atmosphere for about 300 years once they are emitted. A sound global policy should therefore consider the impacts of greenhouse gas emissions on future generations whom we have not even come across and we will never. 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. In other words, every stakeholder in the future should take part in the climate mitigation effort.

Reflecting upon this fundamental economics of climate change, the 'Dismal Theorem' is a poor representation of what a policy should address in dealing with climate change, a global stock public good. Specifically, the Theorem has only one entity in the model, the world as a whole. Therefore, it does not reveal a large variation of climate change predictions and resulting damages across the regions. Some regions will experience a higher degree of warming and/or a higher degree of changes in precipitations. Some regions will be highly vulnerable to climate change while others are not. Since there is only one world region faced with an extremely large warming of 20°C in the 'Theorem', global warming should dominate all the decisions in this hypothetical world. If the model were to include a dozen world regions some of which are risk averse while others are risk neutral, and some of which are highly vulnerable while others are less vulnerable, the dismal theorem would not hold since reallocating economic resources from one region to another is always possible (Seo et al. 2009).

In addition, the Theorem considers only two time periods, now and 2100. The climate change scenario in the dismal theorem is therefore one time shock of abrupt nature: it cannot explain a gradual change in temperature over time. The consequence is that it cannot model dynamic policy factors properly. It cannot explain the role of adaptations in the dynamic process. It cannot explain technological advances over time. It cannot explain different needs of different generations over time. This assumption essentially removes the possibility of burden sharing across generations in dealing with climate change. Since the burden falls entirely on the current generation, the required commitment of the current generation becomes prohibitively large, i.e. everything should be done today. In addition, learning over time in dealing with climate change cannot be included in the model, magnifying both the damage from climate change and the cost of abatement. If a more elaborate decadal modeling is to be introduced in the 'Theorem', the major findings would not hold since the effect of one time shock is shared among generations at lower costs.

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[1] Technological solutions may exist, but are not proven up until now. See the conclusion section for discussion.

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

The primary concern of the Weitzman's is that climate may change by 10° to 20°C by the end of this century, which is unprecedented and is certain to be catastrophic. Borrowing his language, there remains a long fat tail in the probability distribution of climate predictions. He is concerned about 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, although such possibilities may or may not exist, these extreme predictions cannot be treated to have equal chances of realization as other predictions for the following reasons.

First, climate predictions in the IPCC report are all scenario dependent. That is, climate predictions are made based on the socio-economic scenario which assumes 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, all the scenarios cannot be treated to have an equal likelihood to occur. The most likely scenarios, also most widely adopted by economic analyses, are B1, A1B, and A2, which are presented in the report (IPCC FAR 2007). The B1 scenario predicts 1.8 degree change, the A1B scenario predicts 2.8 degree change, and the A1 scenario predicts 3.6°C changes by the year 2100. These are the mean changes based on each socio-economic scenario. According to these mean values, Weitzman's arguments on 10 to 20°C changes are widely off the mark. What about the variance of these estimates? The most likely outcomes from these scenarios, including all other scenarios considered in the report, range from 1.6 degree to 4.6 degree change by the end of this century. Even considering the full variance, the changes are not as explosive as presented by Weitzman.

The second reason is that Weitzman and climate prediction models do not treat climate policy factors properly, as is pointed out by Nordhaus (Nordhaus 2009a). With a global warming policy implemented over the coming decades across the globe, the world will highly likely contain the explosions in the global temperature. With a carbon tax imposed globally over the next 100 years and greenhouse gases are slashed increasingly over time, climate policy models suggest that the increase in global mean temperature will be contained well below a 3°C increase.

On the impact side, I examine whether climate change would cause such large impacts on the globe as to prevent any reasonable policy, i.e. a policy that balances the benefits against the costs. Researchers are not certain of what will happen to market and non-market economic activities due to climate change. However, they have been most concerned from the beginning of climate literature on agricultural impacts due to its role as a provider of food security and a major income source for low-latitude developing countries where climate damage is expected to be largest. Other than agriculture, people are most concerned about the disaster that would be caused by rising sea levels and disease outbreaks in the tropical regions due to climate change.

For the past two decades, economists have made strides in understanding the impacts of climate change on these areas of great concern. 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 the U.S. agriculture would be quite large, amounting to $60 billion (in 1990 US dollars), more than a 30% loss of the U.S. agricultural output from a carbon doubling (Cline 1992). Subsequent studies debated the figure and reached a ‘conclusion’ that the loss will be negligible or slightly beneficial under a 2.5°C increase in temperature. 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 US are not complete yet, but initial studies indicate that impacts on agriculture, even in the low-latitude countries, might not be large due to large adaptation potentials and diverse agricultural portfolios that farmers currently hold, although farmers are likely to face a huge burden to adapt to a new climate as it would make current practices uncompetitive in the future. From a newly developed Geographically scaled Micro-econometric analysis of Adapting Portfolios to climate change (G-MAP approach), African agriculture is expected to lose around 7% of farm income by 3.5 degree C increase under the severe climate scenario (Seo 2009a). Latin American agriculture is measured to lose around 5% of agricultural income under the most severe scenario by about 3 degree warming from various spatial models (Seo 2009b). These 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 degrees of warming within this century.

Table 1: Impacts of Global Warming on Agriculture

Region	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 (2007), Panel	1.2	+0.01%
Africa	Seo (2009a), G-MAP	16.4	-0.80%
Latin America	Seo (2009b), Spatial	7.2	-0.30%

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

Another area that worried many concerned people is the possibility of coastal inundation due to a rising sea level. In Table 2, I present recent estimates of the impacts of climate change on coastal cities. The estimates are based on detailed dynamic studies on the US coasts (Yohe and Schlesinger 1998). They account for adaptation behaviors in that coastal areas can decide either to build walls or leave the area depending upon the possible outcomes. In the U.S., the loss is estimated to be less than one-tenth of one percent of the U.S. GDP from the sea level rise caused by CO_2 doubling. The table shows the estimates across the also world. It indicates that coastal disasters due to climate change will be limited. However, these estimates might still be overestimating sea level impacts since it ignores the fact that most major coastal cities have already 2nd or even 3rd backup systems in preparation for natural disasters even without concerns about climate change. For the interested readers, a most recent estimate of sea level rise is found in Nordhaus (Nordhaus 2009b).

Table 2: Coastal Vulnerability by Region (by CO2 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) and Yohe and Schlesinger (1998).
* For the most recent estimates, see Nordhaus (2009b).

Finally, many people are concerned about health impacts of climate change. An increase in malaria incidence may significantly disrupt the world. However, according to the most recent WHO (World Health Organization) statistics, 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 DALYs (Disability Adjusted Life Years) losses in the early 21st century. Comparing these results with those in Singapore which eliminated the disease during the past several decades and the fact that malaria occurrence has decreased substantially during the time period from 1996 to 2006 in India and South Asia (See the two sources cited above) , it is clear that as Africa develops economically over the next several decades, the numbers of malaria-related deaths will likely shrink rather than expand, even after factoring into the effects of global warming on disease outbreaks.

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 tackle climate change. Two assumptions in the Weitzman's model lead to the explosive estimate of the currently required sacrifice to stop climate change. First, it assumes a single world region. Consequently, this model does not allow possibilities of reallocating economic activities across geographical regions. Second, the model assumes that there are only two time periods, 2000 and 2100. Since there is only year 2100 other than the present, the mitigation commitment required today becomes prohibitive. It eliminates the possible burden sharing across generations and the gradual learning over time through experience.

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)

A strong critique is provided on the grounds of the claim on extreme temperature increases and catastrophic impacts. The possibility of catastrophe is blown out of context since Weitzman ignores the fact that climate predictions are all scenario dependent and assumes that all scenarios are equally likely to come to pass. Second, he assumes no policy intervention to control greenhouse gases. Finally, impact estimates do not point towards catastrophic outcomes from climate change within this century.

Although I did not go through in this critique, I want to conclude by mentioning that the possibility of using a carbon-free energy source, developing a new energy, a carbon capture and storage technology, and climate engineering is likely to become a realistic option in the future, although we cannot rely on this possibility now (Barrett 2008). These possibilities are climate related uncertainties which are also as important and crucial as the possibility of catastrophe. These possibilities, however, are ignored in the Weitzman model. A globally harmonized carbon tax implemented over the next centuries will provide a fundamental break to the unbridled explosion in greenhouse gases in the atmosphere and induce these new technologies which can be possibly adopted in the future as a feasible alternative solution.

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