Global Warming Policy and the Role of Improved Scientific Information

by

Larry Karp

There is a great uncertainty regarding the relation between greenhouse gas stocks and climate change. The economic and environmental consequences of climate change are also uncertain, as is the cost of abating greenhouse gas emissions. Optimal abatement policies depend upon our interpretation of current scientific information, but these policies are insensitive to the anticipation of the future arrival of better information. Ê

Global climate change caused by increased stocks of greenhouse gasses (GHGs) is potentially one of the most serious environmental problems facing mankind. There are several important types of uncertainty associated with this problem: the relation between GHG stocks and climate change is uncertain, as are the environmental and economic costs of climate change; the economic cost of reducing GHG emissions is also unknown. This degree of uncertainty makes it difficult to achieve a consensus about what policies nations should adopt. There is currently substantial disagreement between the official U.S. position and the position adopted by many of its allies.

This article summarizes current information about GHG-related climate change. It then addresses a particular aspect of the controversy surrounding the choice of climate change policies.

The Policy Question

It is widely believed that scientific information about the effect of GHG stocks on climate change will improve over time. This belief gives rise to the following policy question: How should this anticipation of better knowledge in the future affect our current decisions on climate-change policy?

Although this question may appear rather abstract, it has become an important part of the debate on climate change policy. Both sides of this debate have supported their position by arguing that research will lead to better information. One view is that it is better to postpone economically painful cuts in emissions until we learn whether global warming is a serious problem. If we make those cuts now and later learn that the problem is not severe, we will have wasted resources. The other view is that it is better to begin making cuts in emissions now, as a form of environmental insurance. If we delay cutting emissions and later learn that global warming is a serious problem, we will suffer avoidable environmental damages.

In other words, the expectation that we will learn more about climate change has been used to argue that we should delay cutting emissions, and that we should accelerate these cuts. Before describing research that examines how the anticipation of learning should affect policy, we summarize the current scientific evidence of climate change.

Current Information about Global Warming

Clouds and GHGs allow the sun's heat to pass through to the earth, but they form a barrier to the outgoing infrared heat, thus acting as a greenhouse. A greater concentration of GHGs increases this effect, leading to the possibility of climate change and global warming. The atmospheric concentration of carbon dioxide (CO_2), the major GHG, has increased by approximately 30 percent since the industrial revolution.

The Intergovernmental Panel on Climate Change (IPCC), a United Nations-sponsored research group, identifies a number of recent climate changes that are attributable in part to human activity. The estimated global mean temperature has increased by 0.6^0 plus or minus 0.2^0 C over the last fifty years. Continental precipitation has increased by 5 – 10 percent in the Northern Hemisphere, and decreased in some regions. The frequency and intensity of drought and El Niño events have increased. Warming during the 20th century has likely contributed to the global average sea level increase of one to two millimeters per year. Nonpolar glaciers have retreated. The agricultural growing season has lengthened by one to four days per decade during the last forty years in the Northern Hemisphere.

In the absence of policy intervention, CO_2 concentrations are projected to increase by 75 to 350 percent above pre-industrial levels during the next century. Temperature is projected to increase by 1.4 – 5.8^0 C, a change approximately two to ten times larger than the estimated increase during the last century. This projected rate of increase in temperature is probably greater than those experienced during the last 10,000 years. Global average annual precipitation is also projected to increase. At regional levels precipitation may either increase or decrease by 5 – 20 percent. The global sea level is projected to rise by 0.09 to 0.88 meters over the next century. Climate change will reduce available water in many areas, chiefly due to changes in runoff caused by changes in precipitation. The predicted regional effects differ according to the assumptions used in models. For example, under different assumptions, the change in annual runoff may be positive or negative for California.

Models predict that higher GHG concentrations increase the frequency and intensity of extreme events, such as heat waves and heavy rains. There may also be large-scale changes, such as changes in soil and vegetation; a weakening of the gulf stream of oceans and a consequent reduction of heat transported to high altitudes in Europe; and significant loss of polar ice sheets, contributing to the rise in sea level.

If the temperature change is small, temperate area agricultural yields are likely to increase, particularly for cereal crops. Even small temperature increases would likely reduce agricultural yields in tropical and subtropical regions. Human health effects may also vary over climatic regions. Global warming may improve health in cold climates as a result of reduced cold stress, and worsen health in tropical climates due to greater heat stress. These health effects will also depend upon local environmental and economic conditions (e.g., the level of medical infrastructure). There is great uncertainty about the economic effects of these changes, but they are likely to lower income in developing countries. A small temperature change might increase or decrease income in developed countries, but a large change would more likely lower income. Since developing countries are likely to be exposed to most of the dangers of climate change, global inequality would increase.

Four aspects of the climate change problem deserve emphasis. First, GHGs are a global pollutant. GHG emissions created in any part of the world contribute to global stocks. The possibility of climate change is related to these stocks; it does not depend upon which country produced the emissions. GHGs are consequently a global rather than a national problem. Second, the probable effects of climate change differ in different parts of the world. Some regions might benefit from moderate (but not severe) global warming, whereas other regions—particularly the poorer areas—are more likely to be harmed. Third, there is tremendous uncertainty regarding the scale of damages. Under some assumptions climate models predict that the damages are likely to be negligible; under others, damages might be catastrophic.

Fourth, the relation between emissions and environmental problems is cumulative and long lasting. Most GHGs decay very slowly. For example if a ton of CO_2 is emitted into the atmosphere today, half a ton will remain approximately 90 years from now. Other GHGs decay even more slowly. Since the current rate of emissions of GHGs exceeds the current rate of decay, GHG stocks would continue to rise even if emissions (a flow) were stabilized at the current rate. Stabilizing GHG stocks have a persistent effect on the climate. Even if GHGs were stabilized, surface air temperature would continue to rise slightly for a century or more, and sea-levels would rise for many centuries.

Model Description and Results

Our research is designed to shed light on the policy question identified above: How should the anticipation of improved science affect our current policy choice? In order to address this question in a manageable model, we ignore several important issues and concentrate on three of the four aspects of the problem identified above: the problem is global, the relation between environmental damages and GHG stocks is uncertain, and the problem is cumulative and long lasting. We constructed a mathematical model that captures these features, while still being simple enough to be relatively transparent.

Using this model, we calculated the optimal level of abatement over time under two types of scenarios. In the first scenario, we assumed that the relation between GHG stocks and environmental damages is uncertain, but we suppose that the policy-maker never expects to learn about this relation. In the second scenario, we also assume that the relation between GHG stocks and environmental damages is uncertain, but here we suppose that the policy-maker understands that science will improve, i.e., the policy-maker understands that better information will become available. Of course, in the second scenario, the policy-maker does not know whether the future information will be good news or bad news. Thus, in the initial period the only difference in the two scenarios is that in the first, the policy-maker expects never to get better information, and in the second, the policy-maker realizes that information will improve. By comparing actions in the initial period, we can assess the importance of taking into account the expectation that future information about climate change will be better.

Our model summarizes the true relation between GHG stocks and environmental damages using a single parameter, which is unknown to the policy-maker. This unknown parameter equals the average annual reduction in Gross World Product due to a doubling of GHG stocks from the pre-industrial level. (Current stocks are 30 percent above the pre-industrial level.) In the case where the policy-maker does not expect to learn, the parameter ϕ represents the policy-maker's belief about this unknown parameter. We solve this model for four different values of ϕ (percentage of reduction in gross world product).

Table 1. Impact of Reduction in Gross World Product (GWP) on Abatement of GWP Emission and Optimal Carbon Tax

	0.3	1.33	3.6	21	Anticipated learning
Abatement of Green Gasses Emission	2.35	9.80	23.40	77.70	9.60
Carbon Tax	5.32	22.03	52.50	174.19	21.50

For example, ϕ= 1.33 means that the policy-maker believes that doubling GHG stocks would lead on average to a 1.33 percent annual reduction in Gross World Product; this is regarded as a reasonable but optimistic estimate. A reasonable but pessimistic estimate is ϕ= 3.6. The estimate ϕ= 0.3 implies that the policy-maker thinks that GHGs are not a significant environmental problem, whereas ϕ= 21 implies that the policy-maker thinks that GHGs are likely to cause catastrophic damages. A larger value ϕ means that the policy-maker believes that the problem is more severe.

Table 1 provides a partial summary of our results. For columns two to five, the column headings give the value of ϕ used in the experiment; the second row of the table gives the optimal level of abatement in the first period, as a percentage of the "business as usual" (or unregulated) level of emissions. The bottom row gives the carbon tax that would be needed to achieve this level of abatement. For the estimate ϕ= 1.33, the optimal initial level of abatement is 9.8 percent, slightly higher than the level proposed by the Kyoto agreements. As these columns show, the optimal level of abatement is very sensitive to the policy-maker's belief about the severity of the environmental problem associated with GHGs, as reflected by the value of ϕ.

The last column gives the optimal level of abatement and the carbon tax when the policy-maker begins with the belief that a doubling of stocks will cause on average a 1.33 percent reduction in Gross World Product (GWP), but understands that information will arrive over time, changing those beliefs. (Again, the policy-maker does not know whether the news will be good or bad, or how beliefs will change.) The optimal policy in this experiment should be compared with the column labeled ϕ= 1.33, since the only difference between the two experiments concerns the anticipation of future learning.

In this model, anticipated learning causes a small decrease in the level of abatement. To this extent, the model supports the position of those who argue that the anticipation of learning means that we should "wait and see," i.e., act less aggressively to reduce emissions.

A more important result, however, concerns the magnitude rather than the direction of the difference—9.6 percent rather than 9.8 percent. This difference is very small, especially in light of the many approximations built into the model.

Since these results are based upon a specific mathematical model and use a specific calibration, we do not want to exaggerate their importance. However, they suggest the following policy recommendation: Current climate change policy should be based on the best current science; the anticipation of future improvements in science—better information in the future—is not a significant factor in choosing current policy.

For additional information, the author suggests the following references and sources:

IPCC Third Assessment Report-Climate Change 2001, http://www.ipcc.ch/

"Bayesian Learning and the Regulation of Greenhouse Gas Emissions" by Larry Karp and Jiangfeng Zhang, UC Berkeley, Department of Agricultural and Resource Economics, 2002.

Larry Karp is a professor in the agricultural and resource economics department at UC Berkeley. He can be contacted by phone at (510) 642-7199 or by e-mail at karp@are.berkeley.edu. Ê