Commission on Growth and Development

WORKING PAPER NO.60

Climate Change and Economic Growth

Robert Mendelsohn

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About the Series

The Commission on Growth and Development led by Nobel Laureate Mike Spence was established in April 2006 as a response to two insights. First, poverty cannot be reduced in isolation from economic growth—an observation that has been overlooked in the thinking and strategies of many practitioners. Second, there is growing awareness that knowledge about economic growth is much less definitive than commonly thought. Consequently, the Commission's mandate is to "take stock of the state of theoretical and empirical knowledge on economic growth with a view to drawing implications for policy for the current and next generation of policy makers."

To help explore the state of knowledge, the Commission invited leading academics and policy makers from developing and industrialized countries to explore and discuss economic issues it thought relevant for growth and development, including controversial ideas. Thematic papers assessed knowledge and highlighted ongoing debates in areas such as monetary and fiscal policies, climate change, and equity and growth. Additionally, 25 country case studies were commissioned to explore the dynamics of growth and change in the context of specific countries.

Working papers in this series were presented and reviewed at Commission workshops, which were held in 2007–08 in Washington, D.C., New York City, and New Haven, Connecticut. Each paper benefited from comments by workshop participants, including academics, policy makers, development practitioners, representatives of bilateral and multilateral institutions, and Commission members.

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The working paper series was produced under the general guidance of Mike Spence and Danny Leipziger, Chair and Vice Chair of the Commission, and the Commission's Secretariat, which is based in the Poverty Reduction and Economic Management Network of the World Bank. Papers in this series represent the independent view of the authors.

Abstract

Grim descriptions of the long-term consequences of climate change have given the impression that the climate impacts from greenhouse gases threaten long-term economic growth. However, the impact of climate change on the global economy is likely to be quite small over the next 50 years. Severe impacts even by the end of the century are unlikely. The greatest threat that climate change poses to long-term economic growth is from potentially excessive near-term mitigation efforts.

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Robert Mendelsohn[1]

Introduction

There is no question that the continued buildup of greenhouse gases will cause the earth to warm (IPCC 2007a). However, there is considerable debate about what is the sensible policy response to this problem. Economists, weighing cost and damages, advocate a balanced mitigation program that starts slowly and gradually becomes more severe over the century. Scientists and environmentalists, in contrast, advocate more extreme near-term mitigation policies. Which approach is followed will have a large bearing on economic growth. The balanced economic approach to the problem will address climate change with minimal reductions in economic growth. The more aggressive the near-term mitigation program, however, the greater the risk that climate change will slow long-term economic growth.

It should be understood that climate is not a stable unchanging phenomena even when left to natural forces alone. There have been several major glacial periods in just the last million years. Much of this period has been significantly colder than the climate in the last 20,000 years. Ice covered most of Canada and Scandinavia and frozen tundra extended well into New Jersey and the Great Plains in the United States. These cold periods have been quite hostile, discouraging humans from living in much of the northern parts of the northern hemisphere. In addition, within these long glacial swings, there is also increasing evidence that there have been many examples of abrupt climate change (Weiss and Bradley 2001). These natural changes have had major impacts on past civilizations causing dramatic adaptations and sometimes wholesale migrations. Climate change is not new. Human-induced climate change is simply an added disturbance to this natural variation.

The heart of the debate about climate change comes from a number of warnings from scientists and others that give the impression that human-induced climate change is an immediate threat to society (IPCC 2007a,b; Stern 2006). Millions of people might be vulnerable to health effects (IPCC 2007b), crop

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production might fall in the low latitudes (IPCC 2007b), water supplies might dwindle (IPCC 2007b), precipitation might fall in arid regions (IPCC 2007b), extreme events will grow exponentially (Stern 2006), and between 20–30 percent of species will risk extinction (IPCC 2007b). Even worse, there may be catastrophic events such as the melting of Greenland or Antarctic ice sheets causing severe sea level rise, which would inundate hundreds of millions of people (Dasgupta et al. 2009). Proponents argue there is no time to waste. Unless greenhouse gases are cut dramatically today, economic growth and well-being may be at risk (Stern 2006).

These statements are largely alarmist and misleading. Although climate change is a serious problem that deserves attention, society's immediate behavior has an extremely low probability of leading to catastrophic consequences. The science and economics of climate change is quite clear that emissions over the next few decades will lead to only mild consequences. The severe impacts predicted by alarmists require a century (or two in the case of Stern 2006) of no mitigation. Many of the predicted impacts assume there will be no or little adaptation. The net economic impacts from climate change over the next 50 years will be small regardless. Most of the more severe impacts will take more than a century or even a millennium to unfold and many of these "potential" impacts will never occur because people will adapt. It is not at all apparent that immediate and dramatic policies need to be developed to thwart long-range climate risks. What is needed are long-run balanced responses.

In fact, the mitigation plans of many alarmists would pose a serious risk to economic growth. The marginal cost function of mitigation is very steep, especially in the short run. Dramatic immediate policies to reduce greenhouse gas emissions would be very costly. Further, by rushing into regulations in a panic, it is very likely that new programs would not be designed efficiently. The greatest threat that climate change poses to economic growth is that the world adopts a costly and inefficient mitigation policy that places a huge drag on the global economy.

Efficient Policy

The ideal greenhouse gas policy minimizes the sum of the present value of mitigation costs plus climate damages (Nordhaus 1992). This implies the marginal cost of mitigation should be equal to the present value of the marginal damages from climate change. The magnitude or severity of mitigation programs depends on the magnitude and severity of climate impacts. Mitigation also depends upon how expensive it is to control greenhouse gas emissions.

Because marginal damages rise as greenhouse gases accumulate, the optimal policy is dynamic, growing stricter over time (Nordhaus 2008). Emission limits should be mild at first and gradually become more severe. Over the long run, cumulative emissions are strongly curtailed. But this optimal policy reduces emissions in the second half of the century more than the first. Partly, this dynamic policy reflects the science of climate change; damages are expected to grow with the concentration of greenhouse gases. Partly, this dynamic policy reflects the discount rate, that immediate costs and damages have a higher value than future costs and damages. Partly, this dynamic policy reflects the fact that technical change is going to improve our ability to control greenhouse gases over time. Resources that are saved for the future can be invested in better technologies that will be more effective at reducing tons of emissions.

Climate Change Impacts

Economic research on climate impacts has long revealed that only a limited fraction of the market economy is vulnerable to climate change: agriculture, coastal resources, energy, forestry, tourism, and water (Pearce et al. 1996). These sectors make up about 5 percent of the global economy and their share is expected to shrink over time. Consequently, even if climate change turns out to be large, there is a limit to how much damage climate can do to the economy. Most sectors of the global economy are not climate sensitive.

Of course, the economies of some countries are more vulnerable to climate change than the global average. Developing countries in general have a larger share of their economies in agriculture and forestry. They also tend to be in the low latitudes where the impacts to these sectors will be the most severe. The low latitudes tend to be too hot for the most profitable agricultural activities and any further warming will further reduce productivity. Up to 80 percent of the damages from climate change may be concentrated in low-latitude countries (Mendelsohn et al. 2006).

Some damages from climate change will not affect the global economy, but will simply reduce the quality of life. Ecosystem change will result in massive shifts around the planet. Some of these shifts are already reflected in agriculture and timber but they go beyond the impacts to these market sectors. Parks and other conservation areas will change. Animals will change their range. Endangered species may be lost. Although these impacts likely lead to losses of nonmarket goods, it is hard to know what value to assign to these effects. Another important set of nonmarket impacts involve health effects. Heat stress may increase. Vector-borne diseases may extend beyond current ranges. Extreme events could threaten lives. All of these changes could potentially affect many people if we do not adapt. However, it is likely that public health interventions could minimize many of these risks. Many vector-borne diseases are already controlled at relatively low cost in developed countries. Heat stress can be reduced with a modicum of preventive measures. Deaths from extreme events can be reduced by a mixture of prevention and relief programs. As the world develops, it is likely that these risks may involve higher prevention costs, but not necessarily large losses of life. Further, winters lead to higher mortality rates than summers so it may well be that warming has little net effect on health.

Agricultural studies in the United States suggest that the impacts of climate change in mid-latitude countries are likely to be beneficial for most of the century and only become harmful towards the end of the century (Adams et al. 1990; Mendelsohn et al. 1994). In contrast, there will be harmful impacts to agriculture in African countries (Kurukulasuriya and Mendelsohn 2008a), Latin American countries (Seo and Mendelsohn 2008a), and China (Wang et al. 2009) starting almost immediately and rising with warming. The overall size of these impacts is lower than earlier analyses predicted because of the importance of adaptation. Irrigation (Kurukulasuriya and Mendelsohn 2008b), crop choice (Kurukulasuriya and Mendelsohn 2008c; Seo and Mendelsohn 2008b; Wang et al. 2009), and livestock species choice (Seo and Mendelsohn 2008c) all play a role in reducing climate impacts. The studies above document that current farmers are already using all of these methods to adapt to climate today in Africa, Latin America, and China.

Other sectors that were originally expected to be damaged include timber, water, energy, coastal, and recreation. Forestry models are now projecting small benefits in the timber sector from increased productivity as trees respond positively to a warmer, wetter, CO_2 enriched world (Sohngen et al. 2002). Water models tend to predict there will be damages as flows in major rivers decline. However, the size of the economic damages can be greatly reduced by allocating the remaining water efficiently (Hurd et al 1999; Lund et al. 2006). Energy models predict that the increased cost of cooling will exceed the reduced expenditures on heating (Mansur et al. 2008). Several geographic studies of sea level rise have assumed there would be large coastal losses from inundation (Nichols 2004; Dasgupta et al. 2009). However, careful economic studies of coastal areas suggest that most high-valued coasts will be protected (Neumann and Livesay 2001; Ng and Mendelsohn 2005). The cost of hard structures built over the decades as sea levels rise will be less than the cost of inundation to urban populations. Only less-developed coastal areas are at risk of inundation (Ng and Mendelsohn 2006). Initial studies of recreation measured the losses to the ski industry of warming (Smith and Tirpak 1989). Subsequent studies of recreation, however, noted that summer recreation is substantially larger than winter recreation and would increase with warming (Mendelsohn and Markowski 1999; Loomis and Crespi 1999). The net effect on recreation is therefore likely to be beneficial.

As economic research on impacts has improved, the magnitude of projected damages from climate change has fallen. Early estimates projected that a doubling of greenhouse gases would yield damages equal to 2 percent of GDP by 2100 (Pearce et al. 1996). More recent analyses of impacts suggest damages are about an order of magnitude smaller (closer to 0.2 percent of GDP) (Tol 2002a,b;

Mendelsohn and Williams 2005). The reason that damages have been shrinking is that the early studies (i) did not always take into account some of the benefits of warming to agriculture, timber, and tourism; (ii) did not integrate adaptation; and (iii) valued climate change against the current economy. At least with small amounts of climate change, the benefits appear to be of the same magnitude as the damages. Only when climate change exceeds 2 degrees Celsius are there net damages. Many early studies assumed victims would not change their behavior in response to sustained damages. More recent studies have shown that a great deal of adaptation is endogenous. If government programs also support efficient adaptations, the magnitude of damages falls dramatically. Finally, by examining the effect of climate change on the current economy, early researchers made two mistakes. First, they overestimated the relative future size of sectors that are sensitive to climate such as agriculture. Second, they underestimated the size of the future economy in general relative to climate effects.

Economic analyses of impacts also reveal that they follow a dynamic path, increasing roughly by the square of temperature change (Tol 2002b; Mendelsohn and William 2007). The changes over the next few decades are expected to result in only small net effects. Most of the damages from climate change over the next hundred years will occur late in the century. These results once again support the optimal policy of starting slowly with climate change and increasing the strictness of regulation gradually over time.

In contrast to the literature on economic impacts, the Stern Report predicts large damages. However, most of the losses in the Stern Report occur in the twenty-second century. Stern tries to argue that these damages are equivalent to losing 5 percent of GDP a year starting immediately. However, the argument is based on a false assumption that the discount rate is near zero. He argued that the only reason to discount for time at all is because there is a possibility that the earth would be destroyed by an asteroid. This assumption has been heavily criticized in the economics literature since it makes no economic sense (Nordhaus 2007; Dasgupta 2008). Stern also talks about the importance of adaptation but gives little credence to any impact studies that included adaptation. In Stern's defense, he does take into account of uncertainty and low-probability, high-consequence events. However, in general, he tends to overestimate the expected value of these impacts. For example, he assumes that climate change will cause extreme events to grow exponentially. This is a misinterpretation of data on historic damages from extreme events that are due to economic growth, not climate damages (Pielke and Landsea 1998; Pielke and Downtown 2000).

The consequences of catastrophic events are possibly quite severe. If there is large-scale melting of the Greenland ice sheets or West Antarctica, it could lead to dramatic sea level rise especially after several centuries. There is no question that this would force mankind to retreat from rising seas and build new cities inland. However, given the long time frame involved, it is not clear that the cost of such a relocation is as dramatic as it might at first seem. There is no question that the land along the coast would be lost. But new coastal land would appear so that what is actually lost is interior land. Buildings would not really be lost as new cities would be built in anticipation of rising seas. Older cities along the old coast would gradually be depreciated until they are abandoned. Although this may seem like a huge loss, most of the buildings built 500 years ago no longer exist. Finally, it is uncertain whether catastrophic events will occur. These damages must consequently be weighed by the low probability they will occur.

Mitigation Costs

The literature on mitigation predicts a wide range of costs. On the more optimistic side, there are a number of bottom-up engineering studies that suggest mitigation may be inexpensive. Some studies argue that one could even stabilize greenhouse gas concentrations at negative costs (IPCC 2007c). The engineering studies suggest one could reduce emissions by 20 to 38 percent by 2030 for as little as $50 per ton of CO_2 (IPCC 2007c). There is even a super-optimistic technical change camp that argues emissions could be cut by 70 percent by 2050 for as little as $50 per ton of CO_2 (Stern 2006).

The empirical economic literature suggests mitigation cost functions are price inelastic (Weyant and Hill 1999). Using today's technology, the average abatement cost for a 70 percent reduction in carbon in the energy sector is estimated to be about $400 per ton of CO_2 (Anderson 2006). The short-run mitigation function is very price inelastic. The long run is less clear. With time, it is expected that the short-run marginal cost curve for mitigation will flatten. However, whether it ever gets as flat as the optimistic engineering models project is not clear.

An inelastic short-run marginal cost function implies that large reductions of emissions in the short run will be very expensive. There simply is no inexpensive way to reduce emissions sharply in the short run. Renewable energy sources such as hydroelectricity have largely been exhausted. Solar and wind power are expensive except in ideal locations and circumstances. Other strategies such as shifting from coal to natural gas can work only in the short run as they cause more rapid depletion of natural gas supplies.

In the short run, a rushed public policy is likely to be inefficient. It will likely exempt major polluters as Europe now does with coal. Very few national mitigation programs regulate every source of emission. Most countries have sought to reduce emissions in only a narrow sector of the national economy. Rushed programs will likely invest in specific technologies that are ineffective, such as the United States has done with ethanol. Ethanol produces as much greenhouse gas as gasoline. The inelasticity of the marginal cost function implies that mitigation programs that are not applied universally will be very wasteful.

Regulated polluters will spend a lot to eliminate a single ton while unregulated polluters will spend nothing.

Universal participation also requires that all major emitting countries be included. The signatory countries that limit emissions under the existing international Kyoto agreement are responsible for only about one quarter of global emissions. The United States and China generate another one half of emissions and all the remaining developing countries approximately emit the other quarter. Whereas Kyoto countries are beginning to spend resources on mitigation, non-Kyoto countries spend little to nothing. Even within the Kyoto countries, many countries are failing to reach their targets. By failing to get universal application of regulations, the current regulations are unnecessarily wasteful. Without near universal participation, the cost of mitigation doubles (Nordhaus 2008). In fact, the current Kyoto treaty is so ineffective that global emissions are rising at the pace predicted with no mitigation at all. Global CO_2 emissions in 2006 were 8.4 gigatons of carbon (GtC).

Stern and other climate advocates recommend that strict regulations be placed on emissions immediately. Stern recommends regulations that would increase the marginal cost of emissions to $300 per ton of CO_2. The stricter regulations would reduce emissions by 40 GtC per year (70 percent) by 2050. If the marginal cost does not fall, the cost of this program will be $1.2 trillion per year by 2050. Of course, it is likely that long-term marginal costs will be lower with technical change. Assuming that costs fall by 1 percent per year, the marginal cost would fall to $200 per ton of CO_2 by 2050. The overall cost of the Stern program would be $800 billion per year in 2050. The present value of mitigation costs in the Stern program is estimated to be $28 trillion (Nordhaus 2008).

The optimal regulations that minimize the present value of climate damages and mitigation costs are more modest. They would begin with prices closer to $20 per ton of CO_2 then rise to $85 per ton by 2050 (Nordhaus 2008). That would lead to a 25 percent reduction in greenhouse gases by 2050 rather than the 70 percent reduction in the Stern program. The present value of the global mitigation costs of the optimal program this century is estimated to be $2 trillion (Nordhaus 2008). These costs are an order of magnitude less than the cost of the Stern program.

Conclusion

This paper argues that the impacts from climate change are not likely to affect global economic growth over the next 40 years. The size of climate change during this period is projected to be too small to have much of a global net impact. In the second half of the century, warming will be large enough to detect but even by 2100, the annual net market impacts are predicted to be between 0.1 and 0.5

percent of GDP. These impacts are simply not large enough to affect economic growth this century.

Catastrophic climate change could impose large annual losses on society. However, such events are currently have a low probability and will occur far into the future. It is not self-evident that more dramatic mitigation policies are the most appropriate tool to address low-probability, high-consequence events. It is not clear how much mitigation would change the probabilities of these events occurring. Second, a tool that is more flexible and immediate would be more effective. What is needed is a tool that could be implemented once it is clear there is actually a catastrophic event underway. Geoengineering—seeding the upper atmosphere with particles—appears to be a better strategy for handling catastrophic events than mitigation. Society can choose to engage in geoengineering only if it is clear a catastrophe is imminent. Geoengineering is relatively inexpensive. But most importantly, geoengineering is immediate and can reverse the consequences of decades of greenhouses gases in a matter of a few weeks. Finally, geoengineering is flexible. The particles will fall to earth in a matter of a few months. There are of course environmental concerns with intentionally managing the earth's climate. We need to learn more about what those consequences might be. However, faced with the possibility of a catastrophe, it seems that geoengineering is simply too good a policy tool not to develop.

Economically optimal mitigation policies would not pose a great threat to economic growth. Policies that balance mitigation costs and damages would lead to regulations that are not especially burdensome. The present value of mitigation costs of an optimal policy would be $2 trillion for the entire century.

Of course, not every country will be affected alike. Low-latitude countries will bear the brunt of climate damages (Mendelsohn et al. 2006) and will likely see damages immediately. Low-latitude economies with large shares of rainfed agriculture are especially vulnerable and may see reductions in agricultural income of 60 percent or more by 2100 (Seo and Mendelsohn 2008a). Similarly, some countries may face higher mitigation costs. Countries that are growing more quickly, are heavier energy consumers, and are more dependent on coal will face higher costs.

The biggest threat climate change poses to economic growth, however, is not from climate damages or efficient mitigation policies, but rather from immediate, aggressive, and inefficient mitigation policies. Immediate aggressive mitigation policies could lead to mitigation costs equal to $28 trillion (Stern 2006). This is 14 times higher than the mitigation costs of an optimal policy. If these policies were no more efficient than current policies, the costs could easily rise to $56 trillion. These misguided mitigation programs pose a serious threat to economic growth. They would impose heavy additional costs on the global economy that cannot be justified by the limited reductions in climate risk that they offer.

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Grim descriptions of the long-term consequences of climate change have given the impression that the climate impacts from greenhouse gases threaten long-term economic growth. However, the impact of climate change on the global economy is likely to be quite small over the next 50 years. Severe impacts even by the end of the century are unlikely. The greatest threat that climate change poses to long-term economic growth is from potentially excessive near-term mitigation efforts.

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