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POLICYNOTE

THE ECONOMICS OF CLIMATE CHANGE

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INTRODUCTION

The 2009 United Nations Climate Change Conference in Copenhagen has been perceived as a failure by many. The high expectations associated with the conference turned out to be inconsistent with the national interests of the participating countries. The outcome of the conference was a general assurance to reduce carbon emission and a loose agreement on the attempt to contain global warming below 2°C. A binding agreement did not emerge from the negotiations.

According to scientists, carbon emission must be reduced by 25-40% of the 1990 level by 2020 to avoid the worst impacts of global warming. The Kyoto Protocol, agreed upon in 1997, committed the participating countries to reduce the emission of greenhouse gases on average by 5.2% of the 1990 level by 2012. In contrast, the planned reductions assured by governments in Copenhagen are less ambitious and, most importantly, not binding; under the accord, Annex I countries agreed to reduce carbon emission on average by 13-19% of the 1990 level by 2020.

Given the experience with the Kyoto Protocol, which failed to reduce carbon emission to the extent agreed upon, one can make an educated guess that the vague and non-binding outcome of Copenhagen is far from sufficient to prevent temperature increases beyond 2°C.

In light of the urgency presented by global warming, this policy note makes a case for ambitious mitigation policies aimed at reducing carbon emission. First, we briefly outline the dynamics of climate change and highlight the costs for developing countries. Second, we argue that the abatement effort, based on conventional economic models, is insufficient. Third, we address the argument that mitigation policies necessarily imply prohibitive economic costs, for example in terms of empoyment. Fourth, more specifically, various mitigation policies, including cap-and-trade, carbon tax, increasing energy efficiency, and renewable energy, are discussed with respect to their economic costs and efficiency in mitigating global warming. Fifth, policy implications are derived.

CLIMATE THRESHOLDS AND THE COST OF CLIMATE CHANGE

Many uncertainties surround the issue of climate change. However, two stylized facts appear to have consensus among geoscientists. First, the extent of global warming observed since the age of industrialization is not natural, but caused by humans. Hence, a reduction of the emission of greenhouse gases is likely to have a decelerating effect on climate change. Second, as has been argued, among others, by Keller et al. (2004), there are tipping points in the climate pattern. These can be understood as thresholds beyond which climate change turns into a self-enforcing process. Once breached, enormous effort would be required to move back below the threshold.

Below the threshold, forces push the current climate state towards a stable equilibrium, as long as exogenous forces such as carbon emissions do not move the state beyond the threshold. If they do, the feedback loop will change sign and the dynamics will reverse. Then the system will be pushed away from the initial equilibrium. To bring the climate state back to a lower equilibrium requires extraordinary effort, since the carbon emission now has to be reduced sufficiently to overcome the thresholds from above. The crucial insight of this view is that a small exogenous shock, a tipping, may be sufficient to completely reverse the dynamics of the system. Hence, subtle early warning signs and early actions are essential to prevent the climate from trespassing this tipping point.

From a cost-minimizing point of view, one should mitigate global warming while it is "cheap", i.e. before the dynamics of the system reverse and accelerate global warming. However, if we are already beyond the tipping point, ambitious mitigation policies are of the highest urgency.

Developing countries are likely to be hit by, and are more vulnerable to, natural disasters caused by global warming. As argued by Banerjee (2010), 90% of the natural disasters today are of meteorological origin. The last century faced a tremendous increase in the frequency of natural disasters, illustrated in Figure 1."Rising greenhouse gas emissions not only threaten our environment, but undermine development and have dramatic and negative consequences for our economic and social well-being, with the most negative effects being felt by the poor" (IPCC 2007). Some consequences of global warming are summarized in Figure 2. This comes as no surprise, as most developing countries are concentrated in either tropical or extremely dry regions. The combination of high risk for natural disasters and poverty remarkably increases the vulnerability of developing countries. Banerjee (2010) argues that

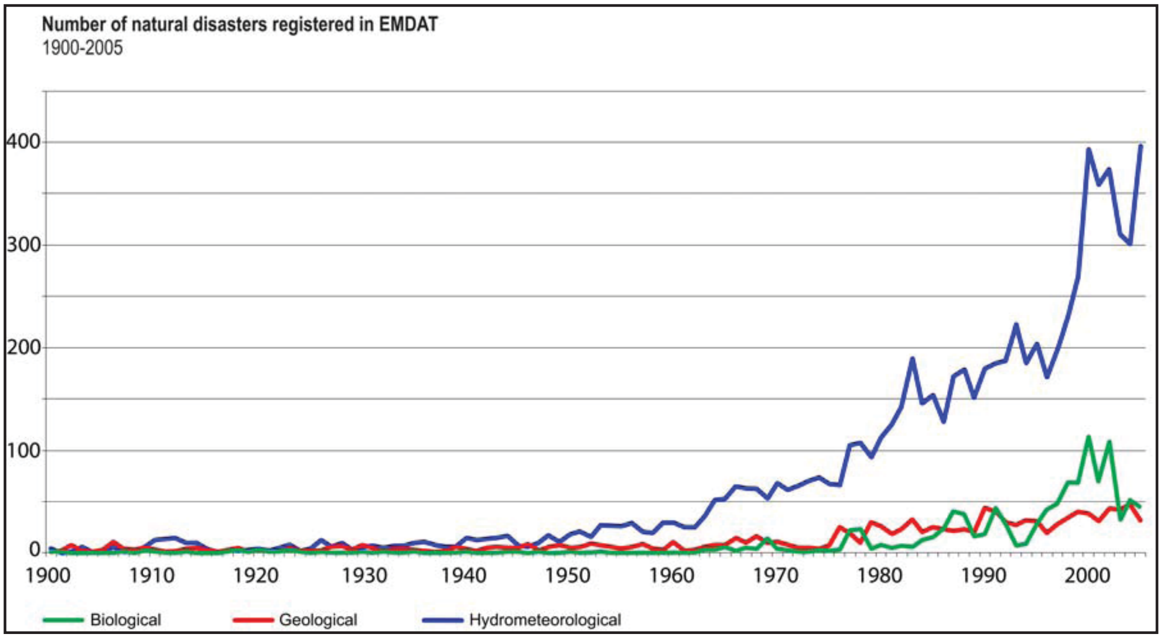

Figure 1: The number of natural disasters (Source: UN/ISDR, taken from Banerjee 2010)

the recovery from extreme weather events like floods and storms in poor, less developed areas takes longer than in affluent areas. Moreover, the lack of heat resistent seeds will generate food shortages for developing economies.

THE OPTIMAL ABATEMENT EFFORT

The influential work by Nordhaus (1992, 2008) provides the standard model for computing the optimal abatement effort needed to balance current abatement costs and future damages. The idea behind the Nordhaus model is that economic growth causes increasing carbon emission, which then increases the overall concentration of CO2 in the atmosphere. CO2 appears to be the most important factor contributing to global warming. Rising temperatures also cause significant economic cost. This cost is usually captured by a damage function, and an abatement effort - an emission control - is required to reduce carbon emission. Depending on the scenario the policy maker accepts, different abatement efforts have to be implemented, each of them applying a different carbon price. However, the effort derived from the Nordhaus model may be too low to be effective in the long run.

As shown by Greiner et al. (2010), the scenarios presented by Nordhaus (1992, 2008) are not reasonable, as they imply perils. They considered two extensions of the baseline model, taking into account slow feedback effects of global warming on temperature and impacts on households' welfare. First, ice sheet disintegration, vegetation migration and green house gas emission from soils, tundra or ocean sediments create positive feedback effects on temperature, which are not considered in conventional Nordhaus-type models. Greiner et al. draw the conclusion that, given the slow feedbacks, cumulative CO2 emission may move the climate beyond the tipping point. Hence, the conventionally assumed abatement effort for the baseline scenario may be too low to reduce global temperatures to the 1990 level. Second, rising temperature may also affect the welfare of households due to an increasing frequency of coastal flooding, heat waves, and other natural disasters. Greiner et al. include the impacts of global warming in the households' welfare functions. They conclude that the optimal abatement effort is higher than if households' welfare is not considered. Both the positive feedback from "temperature to temperature" as well as the impact of temperature on households` welfare require a higher abatement effort than shown in conventional climate change models. The impacts of global warming on employment are also important to take into account.

THE ECONOMIC BENEFITS OF ABATEMENT

The opposition to effective climate policies is frequently fueled by fear of enormous economic costs. Policy makers justify their reluctance to implement ambitious mitigation policies by referring to the danger of losing jobs to competitors and rising unemployment. Mittnik et al. (2010) has shown that these fears are not justified by addressing the effect of different tax-based climate policies on employment and output. In a study on nine countries, they show empirically that the least favorable outcome is obtained when only a carbon tax rate is imposed on carbon intensive industries, and the revenue is not used for other purposes such as reducing other tax rates, subsidizing wage or payroll tax or the development of other (less carbon intensive) products. However, they also study cases when the revenue is used for other purposes. The empirical results show that the policy measure of imposing carbon tax and subsidizing the development of less carbon intensive products has the greatest net gains in terms of output and employment. The response analysis for a number of countries suggest that budget-neutral green

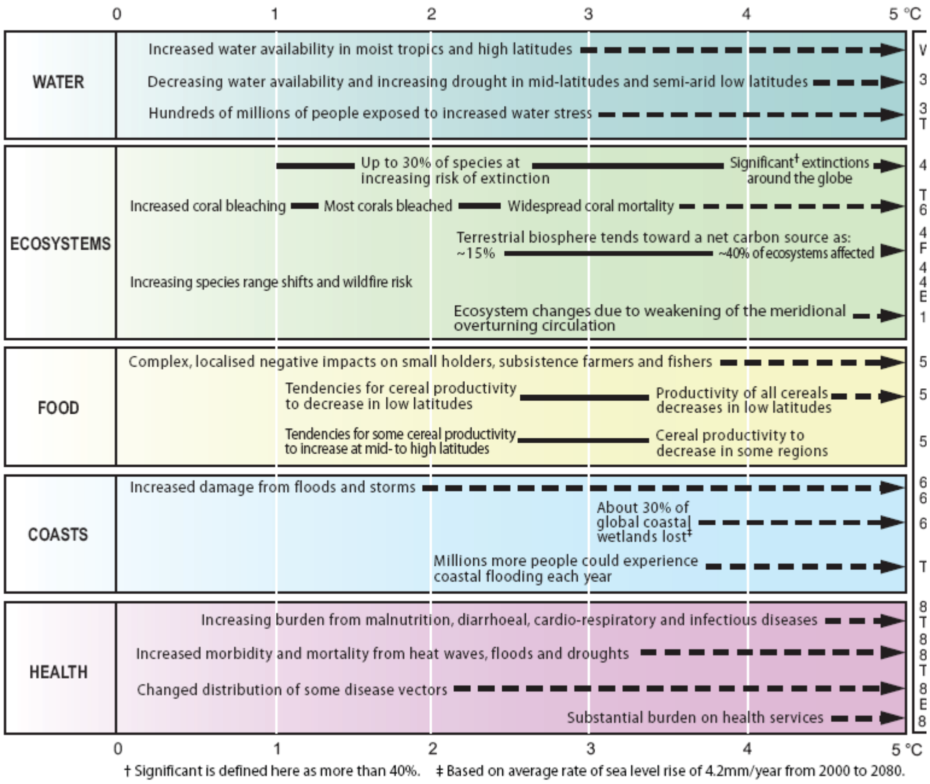

Figure 2: Some examples of the effects of climate change (Source: IPCC 2007, p. 51)

policies, which favor low-carbon intensive sectors at the expense of the high-carbon intensive sectors, have either only very small negative effects on employment and output growth or even small positive net effects. For Germany, Figure 3 depicts the cumulative responses of aggregate output and aggregate employment to a budget-neutral policy shock that raises taxes on carbon-intensive industries and subsidizes low-carbon industries. Both responses are positive. This supports the argument of the "double dividend" of climate policies. They not only reduce carbon emission but cause a net gain in employment.

THE VARIETY OF MITIGATION POLICIES

A variety of mitigation policies aimed at reducing carbon emission have been suggested. Here, we shall briefly present them and discuss their pros and cons with respect to economic costs and efficiency.

Cap and Trade

"Cap-and-trade" is a decentralized market system for carbon trading. It imposes limits on total allowable carbon emission. These allowances are then distributed to emitters or other stakeholders. Firms trade the allowances for pollution on a market. Supporters of the cap-and-trade system such as Keohane (2009) argue that the market mechanism would allow for flexibility and efficiency by optimally distributing the allowances. Firms able to reduce emissions relatively inexpensively would do so to a larger extent than those firms who face high reduction costs. Moreover, it is argued that the cap-and-trade system provides a strong market incentive to implement more carbon efficient technologies. However, cap-and-trade has some severe downsides that were experienced in the EU when it introduced a cap-and-trade system in 2005.

First, emission prices exhibit disproportionate volatility due to uncertainty regarding the overall quota and financial speculation. According to an estimate by Nell et al. (2009) the carbon price, in case of emission trading, is even ten times more volatile then stock prices, which are already about seven times more volatile than the the GNP. This volatility increases the uncertainty firms face when planning long-term investments. Furthermore, efforts to reduce carbon emission will decrease whenever its price is low.

Second, the cap-and-trade scheme does not seem to work effectively in practice due to inherent implementation issues. For instance, it requires extensive monitoring to ensure all emissions are recorded. This implies that actual polluters can be identified. Moreover, permission rights were not auctioned off, but distributed arbitrarily to special interest groups. Many industries were left out, and the cap could not be enforced effectively. Often, the issuance of new pollution rights caused the carbon price to crash.

Third, as has been demonstrated by Uzawa (2003), on a global scale the market-based system unfairly burdens developing countries. The dollar price of a carbon ton will mean a much bigger percentage penalty for low income economies than for the industrialized world.

Carbon Tax

A carbon tax, which is a proportional tax on carbon emission, has some considerable advantages over the cap-and-trade system as has been argued by Nell et al. (2009) and Nordhaus (2007). Because there would be one "metric" for all, it allows for a globalized standard. The carbon tax's clear price trajectory would drive long-term investment. Other advantages include universal applicability, better efficacy, and lower set-up costs due to existing administrative

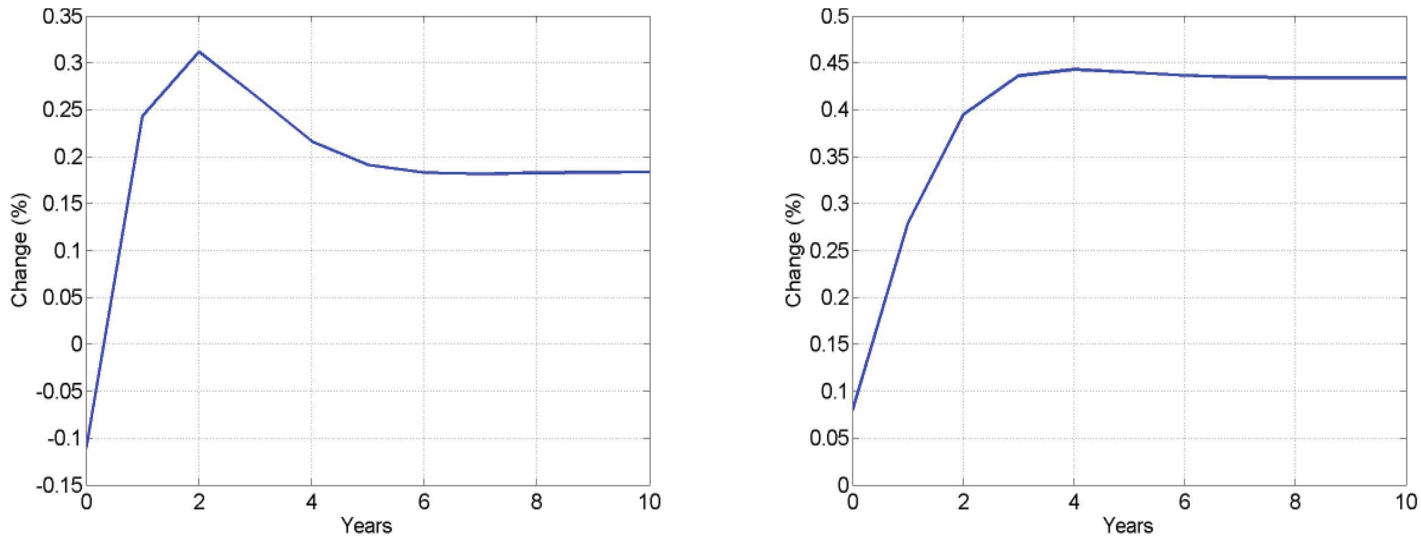

Figure 3: Cumulative impacts of a budget-neutral shock on output (left) and employment (right) (Source: Mittnik et al. 2010)

institutions. Uzawa (2003) proposes a global carbon tax system under which the tax rate applied in a country is proportional to the country's per capita income. Moreover, he proposes to establish an International Fund for Atmospheric Stabilization funded by income from the carbon tax. The aim of the International Fund, according to Uzawa, should be to narrow the income gap between developed and developing countries, a gap that has been growing in recent decades. Moreover, as above shown, a carbon tax is revenue generating whereby the revenue can be used to subsidies less carbon intensive activities.

Increasing Energy Efficiency

Since economic wealth is empirically correlated with carbon emission, countries are reluctant to sufficiently reduce carbon emission. Hence, Weizsäcker et al. (2009) and Weizsäcker (2010) argue to reverse the relation between wealth and carbon emission. Measures must be taken to increase carbon efficiency, especially in rich countries. According to Weizsäcker et al. (2009) this could be achieved by two approaches: first, reducing carbon intensity of energy; second, reducing energy intensity in the production of output. Weizsäcker et al. stress the latter. Various measures could be taken politically to reduce the energy intensity of the GDP, all of which culminate in the adoption of new environmentally friendly technology. Weizsäcker et al. also point to the problem of the rebound effect. Known as the Jevons Paradox, this refers to a state when all efficiency gains have been absorbed by additional consumption and population growth. From this, Weizsäcker et al. conclude that reducing the rebound effect and decoupling energy services from energy consumption will not work without higher prices for carbon emissions and energy. Hence, raising the energy efficiency can only be a complementary measure supporting a carbon tax or a cap-and-trade system.

Renewable Energy

As has been argued by Popp (2010), investments in renewable resources could also substantially contribute to reducing global warming. Climate policy could be designed to trigger innovation and the adoption of green technology. Currently, carbon free energy sources are more expensive than conventional sources. Market forces provide insufficient incentives for the development and diffusion of environmentally friendly technologies. There are environmental externalities. Pollution created in the production or use of a product are not normally included in the price of the product. Thus, neither firms nor consumers have an incentive to reduce pollution on their own. This limits the market for technologies that reduce emissions, which in turn reduces incentives to develop such technologies. These issues need to be addressed by environmental policy. Moreover, the fact that knowledge is a public good impedes private research in renewable energy. Hence, Popp concludes that both environmental as well as research and development (R&D) policies are needed. Environmental policy should create a demand for clean technologies. R&D policy, especially in basic and applied research where benefits are difficult to capture through market activity, can help lower the cost of climate policies. However, while R&D policy plays a role, it is not a substitute for environmental policy. R&D policy can help with the development of new technologies, but also with the diffusion of existing technologies. The diffusion and transfer of technology for renewable energy is in particular important in supporting the climate policies of developing economies.

POLICY IMPLICATIONS

First, ambitious global and national attempts to reduce the emission of greenhouse gases are of urgent need. Mitigation policies this far have not been efficient enough. The Kyoto Protocol, phasing out in 2012, failed in reducing global carbon emission sufficiently. The conference in Copenhagen, expected to implement a more rigorous agreement on mitigating carbon emission, was unable to create a binding commitment. However, as this policy note argues, serious measures against climate change are long overdue. Given the pattern of climate change, we may soon reach the tipping point at which global warming turns into a self-enforcing process. This will cause the economic costs of climate change to rise rapidly, especially in the least responsible developing countries. According to recent evidence, calculations based on Nordhaus' work, which are prevalent in policy debates, seem to be too optimistic. They do not account for the self-enforcing acceleration of global warming or the negative impact of global warming on peoples' welfare. Hence, it can be argued the optimal abatement effort of the baseline Nordhaus model is too low. All of this reinforces the need for fast and ambitious action to create binding agreements to contain global warming below 2°C among governments.

Second, despite their reluctance to implement ambitious mitigation policies and to ratify binding international agreements on carbon emission, the US has to take a lead role in the struggle against climate change. Looking at the figures, the responsibility of the US becomes obvious. As Posner and Weisbach (2010) report for 2005, the US and China produce roughly the same amount of CO2 each year (US 7,219 and China 6,964 million tons). However, China produces only one quarter of the US emissions, if measured per capita (US 28.5 and China 5.5 tons). Hence, from a normative point of view, if one perceives current per capita pollution as the fair benchmark, then the industrialized world, especially the US, has to reduce its carbon emissions significantly more than developing countries. This holds even more if one considers the cumulative CO2 emission per capita that has been emitted into the atmosphere since the beginning of industrialization (US 623,3 and China 82.9 tons).

Third, even if the US does not take on a leading role, the rest of the world should still engage in ambitious mitigation policies. In particular Europe`s role is important in this context. There exist tipping points for adopting climate policies. If there is a critical mass of countries adopting internationally coordinated mitigation policies, the incentive for the US to avoid such policies (competitiveness) will vanish. Moreover, it is not implausible that those countries investing most in green technology will be rewarded by high green economic growth in the future, even though they may lose competitiveness in the short run. Currently, China seems to aim at this comparative advantage in the long run.

Fourth, the fear of job loss resulting from implementation of mitigation policies is not justified. As shown by Mittnik et al. (2010), the employment cost of climate policies would be either minor, or the net effects could even be positive. Reasonable mitigation policies may imply a "double dividend": reducing carbon emission while increasing employment. Overall, employment and output are likely to rise if the income from a carbon tax on high-carbon industries is used to subsidize low-carbon industries or develop renewable energy sources.

Fifth, effective climate policy should rest upon two pillars:

To establish effective economic incentives, the producers/consumers of carbon intensive products must bear the costs of carbon emission. The cap- and-trade system is not advisable due to its deficiency in effectively reducing carbon emission. As argued above, the high price volatility of emission rights increases uncertainty and triggers speculative booms and busts. Moreover, low-income countries are burdened disproportionately by the price for emission rights. Rather than a cap-and-trade scheme, we suggest following Uzawa's (2003) recommendation to urge governments to consider the idea of a global carbon tax with an international fund to compensate for the unequal burden between North and South and assist low-income countries in adopting green technologies.

We recommend governments ambitiously initiate research in renewable energy sources and green technologies. As soon as policies aimed at internalizing the external cost of carbon emission become effective, carbon-intensive technology will become relatively more expensive and the demand for green technology and carbon-free energy will rise. To provide and accelerate the development of this technology in both high- and low-income countries, massive public investments in R&D accompanying mitigation policies are needed.

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