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Analysis

Give and take: How the funding of adaptation to climate change can improve the donor's terms-of-trade☆

Oliver Schenker [a,*], Gunter Stephan [b,c]

[a] ZEW Mannheim, Germany
[b] Universität Bern, Oeschger Centre of Climate Change Research, Switzerland
[c] Universität Bern, Department of Economics, Switzerland

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ABSTRACT

This paper discusses the interplay between international trade, regional adaptation to climate change and financial transfers for funding adaptation. It combines insights from a theoretical model of North-to-South transfers with the findings of a calibrated dynamic multi-region multi-sector computable general equilibrium model that takes into account the impacts of climate change and the adaptation to it. Assessing the effects of adaptation funding indicates that funding of adaptation in developing regions can be Pareto-improving. Not only will developing regions, which do not own sufficient resources for adapting optimally, profit from receiving adaptation funding. Terms-of-trade improvements in the high and middle income donor countries can dominate transfer costs and hence lead to a net-welfare gain in almost any developed region except North America. As such our consideration adds a new argument for financially supporting adaptation in the developing world besides the well-known ones such as fairness and incentives for participation in a global climate treaty.

1. Introduction

Mitigation and adaptation are the main strategies for responding to the threat of global climate change. Although the reduction of greenhouse gas emissions remains the primary objective in the political debate, measures for moderating the impacts of global climate change and reducing the climate vulnerability of communities and regions become increasingly important for at least two reasons. First, due to the inertia of the climate system, climate change is unavoidable to some degree, even if emissions of greenhouse gases are reduced radically (Farber, 2007). Second, while benefits of mitigation are independent of where emissions are abated, benefits of adaptation are primarily local. In other words, mitigation is a global public good that requires internationally coordinated efforts whereas adaptation is more likely to be implemented locally with sufficient pace and scope. Not surprisingly the lack of progress in negotiating a successor of the Kyoto Protocol has turned attention towards adaptation measures that can be more easily implemented without global coordination.

Adaptation to climate change can be costly. The World Bank (2010) estimates that until mid of the century the developing countries' costs for adapting to a 2 °C warmer planet could be in the order of 70 to 100 billion US$ per year. This is above the range of what the UNFCCC (2007) has projected. According to their study, which assumes an approximately 1.5 °C warmer planet by mid of the century, between 28 and 67 billion US$ have to be spent in developing countries on climate change adaptation by 2030. Independent of the exact figures, adaptation is a challenge to the poorest. On the one hand these countries generate much of their national income in climate-sensitive sectors such as agriculture, fishery or tourism. On the other hand these countries are mostly located in tropical and sub-tropical latitudes, where temperature today is already beyond the optimum for most of these sectors (Mendelsohn et al., 2006). Hence, although the least responsible, the developing countries have to shoulder the highest burden but do not own the resources necessary for coping efficiently with the risks associated to climate change (Parry et al., 2007).

Without support by the developed world, developing countries might become more vulnerable to climate change what could pronounce the

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* Corresponding author at: Zentrum für Europäische Wirtschaftsforschung (ZEW) Mannheim, L7, 1, D-68161 Mannheim, Germany.
E-mail address: schenker@zew.de (O. Schenker).

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inequality between industrialized and developing countries (Barrett, 2008). For this reason among others, several funds for supporting adaptation in the developing world have been established since the 7th Conference of the Parties (COP7) to the UNFCCC at Marrakech (Morocco) in 2001. The most important ones are the Least Developed Countries Fund, which should support the 49 least developed countries, the Special Climate Change Fund, which provides financial assistance to all developing countries, and, based on Article 12 of the Kyoto Protocol, the Adaptation Fund. Finally, at the COP17 meeting in Durban (South Africa), the Green Climate Fund was established, which should be the main fund for financing mitigation and adaptation in developing countries given the target to mobilize 100 billion US$ annually by 2020.

Fairness and equity are major arguments why the industrialized countries should assist the developing countries in responding to climate change. But there are further arguments, which are in the focus of this analysis. Global climate change can affect the production in climate-sensitive sectors such that world market prices will rise. A recent example became evident with the collapse of Australia's rice production in 2008. Six years of drought, combined with other factors, caused a doubling of the world market price of rice. This led to panicked hoarding and violent protests even in developed countries such as Italy (see Bradsher, 2008). In other words, output losses in one country might cause prices to rise. The resulting terms-of-trade (ToT) effects can pertain to real income losses even in countries, which are geographically far distant from the specific impact. This could be of particular importance at places where direct impacts of climate change are moderate and where sufficient resources for adaptation exist. Using a calibrated model of world trade combined with estimates on regional impacts of climate change, Schenker (2013) shows that in the US, where direct market impacts are moderate, ToT effects are responsible for about 15% of the country's total expected costs from climate change.

This indicates that in a world with highly integrated markets climate change does not only affect regions directly but has indirect consequences, which become visible for example through changes of relative prices. In other words, adaptation is not only a mean of self-protection. Adaptation can also be a strategy for offsetting ToT effects caused by climate change. This immediately gives rise to two questions: (1) How do climate change, adaptation, terms-of-trade and regional competitiveness interact? (2) If the developing countries do not own sufficient resources for adaptation, would it not be in the interest of the industrialized countries to finance adaptation in the developing ones in order to reduce terms-of-trade effects? Answering these questions both qualitatively and quantitatively is the aim of this paper.

First, we consider this issue within the framework of a stylized model of adaptation and international trade. We discuss how regional welfare is affected by spreading climate impacts through trade on the one hand and by financially supporting adaptation on the other. That transfers affect the welfare of donors and recipients has been extensively discussed in the literature (for a survey, see Suwa-Eisenmann and Verdier, 2007). In particular, the so-called transfer paradox, i.e., conditions, under which the industrialized donor gains economic welfare while the recipient developing country loses welfare, has received considerable attention. ToT deterioration is the principal reason for such a result as is recognized since the pioneering work of Bhagwati et al. (1983). Our paper contributes to this literature by analyzing a special case of a tied transfer: Adaptation funding can improve the productivity of the climate-sensitive sector in the recipient country and hence might improve welfare globally. However, this is only the case if the recipient country is not able to adapt optimally by itself to climate change.[1]

Second, we quantify the findings of the theoretical model within the dynamic multi-region multi-sector computable general equilibrium model MITACC. MITACC includes a detailed representation of the regions' ability to adapt to climate change with a top-down perspective on the remainder of the regional economies. Thereby, and this is a novelty, climate change impacts depend on changes in both precipitation and temperature.

Over the last 20 years integrated assessment based on Computable General Equilibrium (CGE) models became a tool for evaluating alternative ways of thinking about climate policy. However, most existing models do not include adaptation explicitly as policy option. Just recently a small group of researchers started including adaptation as a decision variable into CGE based integrated assessment models (see Agrawala et al., 2011; Fisher-Vanden et al., 2013). Early attempts either discuss anticipatory adaptation (Bosello et al., 2009, 2010), which requires to invest into stocks such as dikes for flood protection, or reactive adaptation (de Bruin et al., 2009), which typically applies to agriculture where climate impacts can be moderated almost instantly through changing crops or adjusting planting and harvesting times. These papers have improved our understanding of the trade-off between mitigation and adaptation strategies. But none of these papers gives answers to the questions raised above. To our knowledge the present paper is the first one, which analyzes theoretically and numerically the interplay between investments into climate change adaptation, terms-of-trade and adaptation funding.

We find that climate change, if following the projections of a global climate model, has significant and regionally different effects on agricultural production. This comes along with ToT losses for most parts of the developed world. Adaptation funding in the range as foreseen by the Green Climate Fund not only reduces the costs of climate impacts in the developing world's agricultural sector. It also improves the ToT in almost all developed countries and has positive effects on the welfare of almost all regions relative to a situation without funding. An exception is North America, which loses ground on the international market for agricultural goods if compared to a world without adaptation funding.

The rest of the paper is organized as follows. Section 2 presents the theoretical model and discusses the main channels through which adaptation funding works. Section 3 introduces the key features of the numerical model. In particular it explains how adaptation is made explicit in MITACC and how the model is calibrated. The scenarios as well as the results of the numerical analysis are presented in Section 4. Section 5 concludes.

2. First Insights from Theoretical Considerations

Consider a stylized model with two regions and two commodities, which are traded on open international markets under perfect competition. For vividness, regions are called North (N) and South (S). South represents the developing part of the world that is relatively vulnerable to climate change but has insufficient capacities to adapt against its impacts. North represents a region of relatively high wealth but relatively low direct exposure to climate change. Commodities differ with respect to their vulnerability to climate change. Some are provided by sectors, which are sensitive to climate change. Typical examples are agriculture, forestry and fishery, tourism, the energy sector and the water sector, which includes water supply and management. Other goods and services are supplied by sectors, which are almost unaffected by climate change such as telecommunication, construction, financial services or industrial manufacturing.[2]

Let good v be the aggregate of commodities, which are supplied by climate-sensitive sectors, and let good w be the aggregate of goods and services from sectors where climate change impacts are almost negligible. As commonly accepted in the integrated assessment literature (see Nordhaus, 2010), the effect of climate change on the production in climate-sensitive sectors is expressed in percentage output losses. Therefore, let $\theta^r(Q, a^r)$ be the region-specific climate impact factor, which is a function of the atmospheric carbon dioxide (CO_2) concentration Q as well as the region's expenditure a^r for adapting to climate change

[1] Note that we neglect principal-agent problems where recipient countries may have incentives to exaggerate their needs as well as situations where the resources from a donor crowd out own adaptation efforts.

[2] For a classification of sectors see Nordhaus and Boyer (2000).