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Ancillary benefits of climate policy in a small open economy: The case of Sweden ☆

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ABSTRACT

It is increasingly recognised that GHG reduction policies can have important ancillary benefits in the form of positive local and regional environmental impacts. The purpose of this paper is to estimate the domestic ancillary pollution benefits of climate policy in Sweden, and investigate how these are affected by different climate policy designs. The latter differ primarily in terms of how the country chooses to meet a specific target and where the necessary emission reductions take place. The analysis relies on simulations within the energy system optimisation model TIMES-Sweden, and focuses on four non-GHG pollutants: Nitrogen Oxides (NO_X), Non Methane Volatile Organic Compounds (NMVOC), inhalable particles ($PM_{2.5}$), and Sulphur dioxide (SO_2). The simulations permit detailed assessments of the respective technology and fuel choices that underlie any net changes in the estimated ancillary effects. The results indicate that the ancillary benefits constitute a far from insignificant share of total system costs, and this share appears to be highest in the scenarios that entail the largest emission reductions domestically. This result reflects the fact that carbon dioxide emission reductions abroad also implies a lost opportunity of achieving substantial domestic welfare gain from the reductions of regional and local environmental pollutants.

1. Introduction

The balance of evidence suggests that anthropogenic emissions of greenhouse gases – out of which carbon dioxide is the most significant – are having a distinct negative impact on the global climate (e.g., IPCC, 2007). Since the Framework Convention on Climate Change was concluded in 1992, nations have been negotiating commitments to stabilise and then reduce emissions of greenhouse gases, which will otherwise continue to build up in the atmosphere. The debate on climate change policy, particularly with respect to the Kyoto Protocol in 1997, has been heavily focused on the economic costs and feasibility of the proposed mitigation plans. Despite concerns about the costs of Kyoto implementation – expressed by politicians, analysts, and industry representatives in industrial countries – the Protocol was ratified by a large number of states and therefore came into force in February 2005. Some nations, such as the USA and Australia, based their decisions to withdraw from the Kyoto process in part on the high perceived costs for their respective economies. Also in the countries that have ratified the Protocol continued concerns exist, not the least about the future costs of the additional policy measures needed to stabilise greenhouse gas concentrations. This became evident during the 2009 Copenhagen (COP15) meeting at which no new global commitment of continued reductions of greenhouse gas (GHG) emissions could be reached.

One of the most important strategies to reduce GHG emissions is to move away from the use of fossil fuels. In substituting carbon-free fuels for fossil fuels other harmful emissions are likely to be reduced along with the reduction of carbon dioxide, e.g., in replacing coal with renewable energy sources the emissions of regional air pollutants such as nitrogen oxides (NO_X) and sulphur dioxide (SO_2) are reduced as well. The resulting reductions in damages to health, crops and materials represent real economic benefits, i.e., reduced costs that typically are referred to as the ancillary benefits from climate mitigation (e.g., Ekins, 1996; Hourcade et al., 2001; Burtraw et al., 2003). Clearly these side-effects can also be negative (e.g., increases in the emissions of particles when diesel replaces gasoline in the transport sector),

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but many previous studies show that compared to a baseline scenario the net economic cost of climate policy could be reduced substantially (e.g., Repetto and Austin, 1997; Boyd et al., 1985; Van Vuuren et al., 2006). In addition, by addressing the impacts of ancillary benefits and costs the optimal abatement strategy may change in terms of the reduction level, the timing of policy measures as well as the allocation of mitigation efforts across the different sectors of the economy (OECD, 2002; Kuosmanen et al., 2009).

The objective of this paper is to estimate the ancillary pollution benefits of climate policy in a small open economy, and compare the outcomes of different climate policy designs. We analyse policy designs that differ in terms of how the country chooses to meet a specific target in the year 2020 including where the necessary emission reductions take place. Sweden is used as a case country, and methodologically we employ the so-called TIMES-Sweden model, a dynamic technology-rich energy system optimisation model. It represents a partial equilibrium model of the entire Swedish energy system, including stationary sources as well as the transport sectors. In addition to the supply and energy conversion sectors, five different demand sectors are described: agriculture, commercial, residential, industry and transportation. TIMES-Sweden permits the analysis of several non-GHG pollutants, including Nitrogen Oxides (NO_X), Non Methane Volatile Organic Compounds (NMVOC), inhalable particles with a diameter less than 2.5 μm ($PM_{2.5}$), and Sulphur dioxide (SO_2). For each climate policy scenario the model is here used to address three different ancillary benefit measures: (a) total reduced damage cost; (b) reduced damage cost per reduced tonnes of CO_2; and (c) reduced damage costs as a share of the total increase in system costs following the imposed climate policy.

For any country the choice between domestic GHG-reduction efforts on the one hand and financing similar efforts abroad on the other is important. In accordance with the Kyoto Protocol and the EU Burden Sharing Agreement, Sweden is committed to an Assigned Amount Unit (AAU) for the compliance period 2008–2012 corresponding to an increase by 4% compared to the 1990 emission level. Still, in an attempt to precede stricter future requirements Sweden decided in 2002 on a national emission target stating that during this five-year period the country's greenhouse gas emission level must not exceed five times 96% of the 1990 level. An important implication of this policy target has been that if a firm that participates in the European Union Emissions Trading Scheme (EU ETS) buys permits, a corresponding emission reduction has to be made in the non-trading sector (e.g., through adjustments in the CO_2 tax) (Carlén, 2004; Söderholm and Pettersson, 2008). In this way emission reduction burdens are transferred from the trading to the non-trading sector. Other than Germany and Great Britain, Sweden is the only EU country that has decided to focus on a national emissions target, addressing thus emissions made on domestic soil. In a Government Bill (2008/09:162) a new target is outlined, namely to decrease domestic emissions in the non-trading sector by 40% by the year 2020 (compared to the 1990 level). In meeting these stricter reduction requirements the Swedish government aims at locating one third of the obligated carbon dioxide reduction in other countries, thus increasing the reliance on international flexible mechanisms in the nation's compliance strategy.

Previous studies indicate that accounting for the local and regional ancillary benefits arising from climate policy that are achieved jointly with the reduction of carbon dioxide can be significant in the Swedish case, and may thus partly strengthen the case for the present adoption of a domestic emissions target. For instance, Östblom and Samakovlis (2004, 2007) employ the static general equilibrium model EMEC to evaluate the economic impacts of Swedish climate policy in the presence of benefits to health and labour productivity following reductions in nitrogen dioxide (NO_2) emissions. Their results indicate that the costs of climate policy could be substantially reduced, and the benefits of international emissions trading for the Swedish economy become less pronounced once the ancillary benefits of nitrogen dioxide reductions are taken into consideration. Similar results for Sweden are presented in Nilsson and Huthala (2000), where the EMEC model is used to address the ancillary impacts of both nitrogen oxides and sulphur dioxide. Bye et al. (2002) provide a review of the cost of climate policies and the associated ancillary benefits in the Nordic countries, the UK and Ireland.

The approach in this paper differs from many earlier studies in a number of ways. First, a number of previous energy system studies use the estimated monetary damages costs for different non-GHG pollutants, and investigate, for instance, the consequences on CO_2 emissions of internalising these external costs (e.g., Das et al., 2007; Klaassen and Riahi, 2007; Krook Riekkola and Ahlgren, 2003). While these studies thus address the climate-related ancillary benefits of other environmental policies, we instead focus on the corresponding side-effects of different climate policy designs. These earlier studies also address only the external costs of the electricity (and heat) sectors. Furthermore, another set of previous studies employ general equilibrium models to analyse the ancillary impacts of GHG mitigation (Davis et al., 2000; Östblom and Samakovlis, 2007), while we instead adopt a technology rich bottom-up representation of the entire energy system. Van Vuuren et al. (2006) employ a similar bottom-up approach but with a focus on Europe (divided into East, Central and West), and with no results for neither individual countries nor different climate policy designs.

The TIMES-Sweden model can explicitly address important discrete technology shifts and their consequences in the presence of stringent climate policy. Moreover, the model covers the entire chain from energy supply to useful energy per demand segment, something which facilitates the identification of the sectors and technologies where the ancillary benefits are most prevalent. Moreover, in line with Östblom and Samakovlis (2004, 2007), the present paper also addresses the ancillary benefits arising from different climate policy designs for a small open economy, but unlike the previous studies we highlight in more detail the technology choice trade-offs involved in abating emissions domestically or relying more extensively on CO_2 emission reductions abroad. Specifically, we investigate how the estimated ancillary benefits are influenced by changes in the stringency of the policy target, the CO_2 permit price within EU ETS and the energy sector's rate-of-return requirement. We also present detailed results for the electricity and transport sectors, and highlight important differences in fuel mixes across the different policy scenarios. Finally, the range of non-GHG pollutants considered in the analysis is also wider, not the least given the inclusion of particles ($PM_{2.5}$) and NMVOC, substances that are typically ignored in most previous studies.

Section 2 presents the TIMES modelling framework, and clarifies how the assessment of ancillary benefits can be incorporated into the model simulations. In Section 3 we discuss the different policy scenarios, while Section 4 presents the model simulation results. Finally, some concluding remarks are provided in Section 5.

2. An energy-economic modelling framework

2.1. The TIMES modelling framework

In order to estimate the economic costs and the future emission levels for each policy scenario the TIMES-Sweden model