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Switching to carbon-free production processes: Implications for carbon leakage and border carbon adjustment

Thomas Schinko [a,*], Birgit Bednar-Friedl [a,b], Karl W. Steininger [a,b], Wolf D. Grossmann [a,c]

[a] Wegener Center for Climate and Global Change, University of Graz, Brandhofgasse 5, A-8010 Graz, Austria
[b] Department of Economics, University of Graz, Universitaetsstrasse 15, A-8010 Graz, Austria
[c] International Centre for Climate and Society, University of Hawaii at Manoa, 1680 East-West Road, Honolulu, HI 96822, United States

HIGHLIGHTS

- A carbon-free technology switch in iron production considerably reduces total leakage.
- Border carbon adjustment (BCA) may impede domestic industrial decarbonisation.
- A targeted technology policy is superior to BCA in fostering low-carbon investments.
- But implemented as a transitory instrument, BCA reinforces technology policy.

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ABSTRACT

Climate policy under partial global compliance raises concerns regarding carbon leakage. While border carbon adjustment (BCA) measures are a potential remedy, they have also been criticised on various grounds. This paper therefore investigates whether a policy fostering the switch to carbon-free technologies can substitute for BCAs. A reason for the effectiveness of a targeted technology policy is that major leakage prone sectors (such as iron and steel), have two main sources of carbon emissions, combustion of fossil fuels and industrial processes. While combustion emissions can be reduced relatively easy by increasing energy efficiency, reducing process emissions requires a switch to low-carbon production processes, e.g. in steel production by deploying electrolysis based on large-scale solar electricity. We show by means of a multi-regional computable general equilibrium analysis that such a switch in steel production technology can eliminate a significant fraction of carbon leakage and also increase sectoral output and welfare. Since the necessary technologies are not available at large scale yet (however, are likely to be by 2020), a transitional BCA scheme may be a crucial supportive instrument to foster such technology switches. Yet, in the long run BCA should be phased out to preserve the incentive for carbon-free innovation.

1. Introduction

To avoid dangerous and irreversible climate impacts, the global average temperature should not rise more than 2 °C above pre-industrial levels (European Parliament and the Council of the EU, 2009). Therefore greenhouse gas emissions have to be reduced substantially (GEA, 2012; Meinshausen et al., 2009). Although COP 17 in Durban and COP 18 in Doha set a roadmap for further international negotiations by 2015 (UNFCCC, 2013), the international regime will rely on unilateral action in order to achieve global emission reductions by 2020. Thus, the continued efforts by the European Union (European Commission, 2011, 2008), as e.g. the expansion of its emissions trading scheme from 2013 onwards, will not be met by comparable actions by other large countries or world regions - giving rise to competitiveness concerns of trade exposed industries as well as carbon leakage. Consequently, part of the emission reductions achieved within the EU will be compensated by emission increases elsewhere, e.g. due to increased imports of carbon intensive products by the EU.

As a remedy to both concerns, carbon leakage and reduced international competitiveness of trade exposed, energy intensive sectors, BCAs in the form of import tariffs and/or export rebates applied to international trade flows to/from regions with less stringent climate policy have been suggested (Droege, 2011; Fischer and Fox, 2012). Yet, others have questioned the implications of such BCAs e.g. with regard to effectiveness as well as equity and strategic incentives to protectionism (e.g. Böhringer et al., 2012a; Weitzel et al., 2012; Holmes et al., 2011). Hence in this paper we discuss an alternative

* Corresponding author. Tel.: +43 316 380 8460; fax: +43 316 380 9830.
E-mail address: thomas.schinko@uni-graz.at (T. Schinko).

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approach to BCAs: a switch to a carbon-free technology in a leakage prone sector which may succeed in both restoring competitiveness and reducing the scope of carbon leakage.

The effectiveness of BCA has been questioned on various grounds. One major drawback of BCAs is that they directly address only one of the leakage channels, i.e. the competitiveness and industrial relocation channel.[1] A recent Energy Modeling Forum (EMF) model comparison study on leakage and border carbon adjustment has found that the leakage reduction potential of BCAs is in the range of 15% to 60%, with a mean value of a third (Böhringer et al., 2012a). Furthermore, BCAs can be blamed as protectionist, with the environmental argumentation only disguising the true motivation, as BCAs can have a substantial implication via a significant terms-of-trade effect from a macroeconomic perspective (Böhringer et al., 2010). Finally, BCAs have been questioned with respect to their practical implementability: The absence of a world-wide consumption-based carbon accounting system, the administrative burden associated with its implementation, as well as the potential conflicts with international trade law render BCAs difficult to implement (Cooper and Droege, 2011; Cosbey et al., 2012).

An additional reason why the need for BCAs has been questioned is that the problem of carbon leakage induced by unilateral climate policies has been found as not sufficiently substantial. Many current state-of-the art models find that leakage rates triggered by climate policy in Annex I countries only (except Russia) range up to 20% (Böhringer et al., 2012a). Yet, some studies find considerably larger rates when the policy region is smaller (e.g. 32% for EU only policy region instead of 19% for a policy region of Annex I countries except Russia; Balistreri and Rutherford, 2012). Leakage rates are also found larger when alternative model specifications are used e.g. alternative structures of international trade (from 13% to 19% for the Annex I without Russia policy region; Balistreri and Rutherford, 2012), the additional consideration of imperfect competition in energy markets (for a carbon policy in OECD countries and the Former Soviet Union, 60% or higher; Babiker, 2005), or the inclusion of industrial process emissions (for the EU only policy, a shift from 29% without process emissions to 38% with those emissions; Bednar-Friedl et al., 2012b). In this paper, we will build on this last development, as ignoring industrial process emissions leads to both downward biased leakage rates and reduced effectiveness of BCAs due to inappropriate rate setting but also due to lower elasticity of substitution between emissions and other inputs in process-emission prone sectors (Bednar-Friedl et al., 2012b).

In contrast to combustion based emissions which can be reduced by increasing energy efficiency, thus leading to modest leakage, reduction of process emissions is much more difficult. On the one hand, this is due to the fact that industrial process emissions arise in a few sectors only which are simultaneously energy intensive and internationally trade exposed (iron and steel, cement and chemicals). Hence, the burden of emission reduction is intensified for a few sectors, inducing a replacement of domestic production by imports of such carbon intensive products. On the other hand, industrial process emissions can only be mitigated by switching the production process, if low-carbon ones are available, or through substitution by materials with low carbon footprint, or by reducing activity. Thus, reduction of process based emissions basically requires a switch in production technology, often not readily available at reasonable costs. As a consequence, for avoiding process emissions, carbon-free innovation is crucial. Moreover, carbon-free technology switches are ultimately necessary to achieve emission reduction levels of 85% or higher until 2050, a target indicated e.g. by European Commission (2011). We here test for the implications of successful carbon-free innovation on both leakage and BCA system design, by focusing on the iron and steel sector and in particular on one possible technology (electrowinning with a system of solar electricity supply as a prerequisite).

As argued above, the literature has repeatedly pointed out that BCA measures in most circumstances are – when compared to direct climate policy abroad, such as carbon taxes – relatively costly and thus inefficient. Nevertheless they could function as an effective coercion strategy to give the incentives to implement direct climate policy abroad (e.g. Winchester et al., 2011; Li and Zhang, 2012).

In this paper we look at a related but different question: the interaction of BCAs with another policy aiming at the reduction of carbon emissions in the domestic market rather than abroad. We focus on the potential of a targeted technology policy fostering low-carbon technologies in process emission intensive sectors to serve as a substitute for BCAs or to even outperform them. Building on a multi-sector multi-region CGE analysis with industrial process emissions (Bednar-Friedl et al., 2012a, 2012b), we investigate the interaction between low-carbon technology switches and the climate policy instrument of BCA. Once a carbon-free production process has become available – at reasonable cost – in process-emission prone sectors, of what relevance is the problem of carbon leakage and what does this imply for the need for and effectiveness of BCAs in climate policy?

We find that the availability of a carbon-free production process that becomes competitive in the mid-term in just one of the process-emission prone sectors, iron and steel, significantly reduces aggregated leakage of the whole economy - the sectoral leakage rate is reduced by a factor 14, and total leakage is reduced from 38.5% to 29.0%. The demand for BCAs is thus substantially lower in such a situation. The demand may turn towards a different format of BCAs, however. The incentive for firms to invest in carbon-free process development in the first place depends on instruments such as carbon (pricing) policies. As a result carbon intensive production could relocate, or – due to instruments such as BCAs – remain within the EU and invest in carbon-free process development. The incentive for such investment increases with knowledge that BCA protection is only transitory, and firms need to prepare for a medium-term setting without BCAs.

The structure of the paper is as follows. In the following section, we set out the model structure, taking account of process emissions. Section 3 gives an empirical overview of the relevance of process emissions across world regions and discusses options for carbon-free production technologies in process-emission prone sectors. In Section 4 we analyze the macroeconomic and carbon implications of a switch to a carbon-free technology in the iron and steel sector. Section 5 discusses the implications of our results with respect to the interaction of BCAs and targeted technology policies for the design of climate policies.

2. Model and data

To assess the consequences of a switch to a carbon-free technology for carbon leakage and the effectiveness of BCA, we employ a multi-sectoral multi-regional CGE model. This is a common approach for analyzing the effects of climate policies on competitiveness and carbon leakage (e.g. Babiker, 2005; Balistreri and Rutherford, 2012; Bednar-Friedl et al., 2012a, 2012b; Böhringer et al., 2012a, 2012b; Böhringer, 2000, Burniaux and Martins, 2012, 2000; Fæhn and Bruvoll, 2009; Fischer and Fox, 2007; Kuik and Gerlagh, 2003; Paltsev, 2001).

[1] The following four channels of leakage are usually distinguished for situations of unilateral climate policy: energy market channel (climate policy region fossil energy demand decline lowers world energy prices and thus raises fossil demand by non-policy regions), competitiveness and relocation channel (as we discuss in this article), income channel (climate policy may induce changes in world income distribution and thus potentially also new geographical patterns of emissions) and technology spill-over (induced new technology development in climate-policy regions spreading across the globe).