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Austria's consumption-based greenhouse gas emissions: Identifying sectoral sources and destinations

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ABSTRACT

Greenhouse gas emissions can be addressed at the points of both production and consumption of goods and services. In a world of inhomogeneous climate policy, missing out policies on either production or consumption leaves an important policy area idle, rendering climate policy inefficient and potentially ineffective. While consumption-based emissions accounts have become readily available at the national level, we here show how their more detailed analysis by sectoral destination (which final demand sectors account for them), sectoral source (in which sectors across the globe those emissions are actually occurring) and the geographical location of the latter can inform a complementary consumption-based climate policy approach. For the example of the EU member country Austria, we find that more than 60% of its consumption-based emissions occur outside its borders, and 34% even outside the EU. The top sectors are a very different list under a consumption-based accounting perspective (construction, public administration (including defense, health and education), and wholesale and retail trade) than under a production-based one (electricity, iron and steel, and non-metallic minerals, such as cement). While for some sectors (e.g. electricity) production-based approaches can work well, emission reduction in other sectors (e.g. electronic equipment) is crucially dependent on consumption-based approaches, as a structural path analysis reveals.

1. Introduction

The international community specifies greenhouse gas (GHG) mitigation as a responsibility at the national level (that can be delegated by subsidiarity to lower levels), with the Paris Agreement supplying the current framework for voluntary, bottom-up pledges (Nationally Determined Contributions, NDCs) (UNFCCC, 2015). Historically it has been standard to focus on emissions that arise from production and consumption processes within the respective national territory. Correspondingly, conventional GHG emission inventories record emissions released by the agents (e.g. industries, private households and public agents) within the geographical borders of a nation. The respective indicator system, a territorial emission accounting framework, also known as Production-Based Accounting (PBA), is employed by the United Nations Framework Convention on Climate Change (UNFCCC, 1997, 2015).

With ongoing economic specialization and the growth of international trade having outpaced growth in global GDP for many decades, production supply chains are spanning many countries, and final consumption in one country is increasingly connected to GHG emissions in other countries, governed by a complex, global web of internationally linked activities. The question of which emissions each country can

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address can thus be answered alternatively. One could consider final consumption to ultimately drive GHG emissions, and thus allocate all emissions along the (international) supply chains to final consumption and to the country where this final consumption occurs in. The corresponding alternative indicator system is Consumption-Based Accounting (CBA) of emissions (Munksgaard and Pedersen 2001; Lenzen et al., 2004; Peters and Hertwich, 2008; Davis and Caldeira, 2010), often also referred to as Carbon Footprints (CF). Corresponding emission inventories are thus based on CBA and record emissions induced by residents' consumption irrespective of where in the world those induced emissions take place. Since production and consumption occur very often in different geographical locations, these two distinct emission accounting frameworks tend to show different pictures of the amount of emissions allocated to a nation which could potentially serve as a policy base.

If we had a world with a globally harmonized GHG mitigation architecture it would be of no relevance to which of these accounting frameworks national climate policies relate to, i.e. whether they address production-based emissions or consumption-based emissions. In a setting where markets are complete, fully competitive, cover all GHG emissions and (at least implicitly) impose a globally uniform (shadow) price on these emissions, markets pass on the incentives fully to all other agents in the supply chain, both upstream and downstream. Thus, either one would be effective and efficient (Steininger et al., 2016). Under the Paris Agreement our current world, however, deviates in at least three aspects from such a setting:

(a) In conceptual terms, mitigation efforts are differentiated across countries, guided by the principle to "protect the climate system […] in accordance with their common but differentiated responsibilities and respective capabilities." (UNFCCC, 1992, Article 3).
(b) In practical terms, the total of current pledges globally is considered to fall short of the level necessary to achieve the Paris target of "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels" (UNFCCC, 2015, Article 2). Current pledges–if successfully implemented–limit temperature increase to below 3° by the end of the century at best (e.g. UNEP, 2016). Individual countries might nevertheless seek to implement higher contributions–up to what they consider their full contribution for reaching the 2° target − if they only could foreclose compensating emission increase elsewhere, i.e. if they could ensure global effectiveness of their efforts.
(c) While all 197 parties to the UNFCCC have agreed to the Paris agreement, which entered into force in November 2016, to date it has been ratified by a subgroup of about three quarters of them (160 as of 11 September 2017), but covering more than 86% of global emissions.

Given these aspects characterising a fragmented, bottom-up climate architecture, it becomes very relevant for individual countries to consider both policy strands, production-based as well as consumption-based policies, and, as we argue in the following, it may be highly relevant to use policies of both types, complementing each other.

The initial introduction and discussion of the concept of consumption-based emissions (Kondo et al., 1998; Munksgaard and Pedersen, 2001; Ferng, 2003; Bastianoni et al., 2004; Rodrigues et al., 2006; Lenzen et al., 2007) was often framed in the context of "responsibility". It pointed out that final consumption can be held "responsible" for emissions, with the − mostly implicit − conclusion that this end point in the supply chain thus is offering a necessary point of policy intervention. Normative research, on the other hand, has shown that for "responsibility" in a causal sense of "contributing to climate change" (and following a compensatory justice perspective) there are serious limits making it practically impossible to allocate specific shares of contribution among producers and consumers (for an overview see e.g. Steininger et al., 2014). But this finding does not reduce the relevance of the point of final consumption as a very appropriate point of policy intervention. The identification of such points of policy intervention is our focus in the present paper.

Over the last decade, extensive quantifications of consumption-based accounts at the national level have been generated (initially by Peters and Hertwich, 2008; Hertwich and Peters, 2009; Peters, 2010; Munoz and Steininger, 2010; Davis and Caldeira, 2010), with a few groups offering even a consumption-based emissions online data base (e.g. Eora, Lenzen et al. (2013)).

Recently, further emission allocation possibilities along the supply chain were identified, beyond the just two points of allocating all emissions to either producers or to consumers. These alternatives are the allocation to resource extraction (extraction-based principle; Davis et al., 2011), or splitting across producing agents according to their respective shares in value-added (income-based accounting; Lenzen et al., 2007; Andrew and Forgie, 2008; Lenzen and Murray, 2010; Marques et al., 2012). It is worth noting that available consumption-based accounting meanwhile extends well beyond carbon accounting: it has been analyzed for air pollution (e.g. Kanemoto et al., 2014), biomass (e.g. Erb et al., 2009; Peters et al., 2012), biodiversity (e.g. Lenzen et al., 2012a), water (e.g. Feng et al., 2011; Hoekstra and Mekonnen, 2012), material use (e.g. Muñoz et al., 2011; Bruckner et al., 2012; Wiedmann et al., 2013), and land use (e.g. Meyfroidt et al., 2010; Weinzettel et al., 2013). Tukker et al. (2016) combine the last three of these (water, material and land use) with carbon in a unified dashboard approach for indicating Europe's environmental and resource footprint. Similarly, Ivanova et al. (2016) undertake for 43 selected countries an environmental impact assessment in terms of GHG emissions, water, material and land use requirements, yet just focusing on household consumption.

In analyzing national policy addressing these emissions it is helpful to categorize the instruments. We use the policy classes of the trade and environment report WTO and UNEP (2009), expanded by Girod (2016): (i) price and market mechanisms for internalization, (ii) financial mechanisms to promote the development and deployment of climate-friendly goods and technologies, (iii) technical requirements to promote the use of climate-friendly goods and technologies (standards), and (iv) information (labels). These categories in fact are broad and cover instruments that can either address the production side or the consumption-side. E.g., carbon pricing in the form of cap-and-trade usually addresses production-based emissions, but can be transformed to a consumption-based approach when either integrating border carbon adjustment or including consumption explicitely into emissions trading schemes (i.e. for example, imposing a charge on carbon-intensive products at the time of their release for consumption; Ismer and Haussner, 2016). Similarly, financial mechanisms can promote the *production* of climate friendly goods (e.g. feed-in tariffs) or their *consumption* (e.g. electric vehicle support).

The policy instrument among those that can be considered a consumption-based policy instrument that to date has been subject to probably most extensive empirical analysis is border carbon adjustment (or border tax adjustment) (for a model comparison of results see e.g. Böhringer et al. (2012)). More comprehensively, Girod (2016) screens EU directives under the consumption-based perspective, and Barrett and Scott (2012) and Scott and Barrett (2015) analyze instruments for the UK case. We contribute to this literature–a literature still comparatively small in addressing the national scale–by a sectorally detailed analysis. Many policies addressing consumption-based emissions cannot be specified at the macro level (such as border carbon adjustment is), but need to be more specific–addressing the peculiarities of particular sectors.

To further open up ground for this line of research, in the present paper we analyze the sectoral structure of national consumption-based emissions in much more detail, i.e. we identify the hotspots in both dimensions, sectors of destination (i.e. sectors of final consumption