Effective climate policies for production and consumption based emission reductions – Extended Abstract -

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1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement both acknowledge globally 'shared but differentiated responsibilities' to reduce greenhouse gas (GHG) emissions and keep global below 2°C (UNFCCC, 2015). The accounting principle in place by the UNFCCC requires all member states to report GHG emissions on a production based principle, as specified by the guidelines for National Greenhouse Gas Inventories by the Intergovernmental Panel on Climate Change (IPCC, 2006). GHG emissions in this principle are allocated to the country in which they physically occur during production (Production Based Emissions – PBE). With a high intensity in global trade, also the topic of emissions embodied in trade emerged on the agenda of emission responsibilities (Afionis et al., 2017). Emissions associated with imports and exports, however, in the current accounting principle are still attributed to the country of physical origin, but not to the country of final consumption. While also other alternative accounting principles are discussed in the literature (see e.g. Steininger et al., 2016), a consumption based accounting principle found the largest response in the literature of the last years (Afionis et al., 2017). With this accounting principle all emissions occurring along the production chain are allocated to the country of final consumption (Wiedmann, 2009).

Several studies in the past decade calculate consumption based emissions (CBE) on a global scale using Multi Regional Input Output (MRIO) method (see e.g. Peters et al., 2011; Peters and Hertwich, 2008; Wiebe et al., 2012; Zhongxiu and Yunfeng, 2014). These studies find developed countries in general as net importers of associated GHG emissions in international trade from developing countries. This imposes stronger responsibilities of GHG emissions towards developed countries and raises new questions of justice, policy effectiveness and policy design (Kander et al., 2015; Steininger et al., 2014, 2016).

Although profound knowledge of historic CBE emerged in the past decade, to the knowledge of the authors there is no study that investigates mitigation policies in terms of CBE reductions. In our study we want to close this gap by simulating five specific mitigation policies for Austria, which were developed to address CBE. By linking a global Computable General Equilibrium (CGE) model with a global MRIO model we evaluate these policies in respect to their reduction of emissions in a production based and a consumption based accounting principle. The model link allows us further to analyze the macroeconomic cost effectiveness of each policy in terms of GDP effects and their incidence on the welfare of four different income groups. This paper thereby contributes to the literature in a methodological way by linking a CGE model with an MRIO model as well as it pushes the frontier of policy evaluation for consumption based emissions.

The structure of the full paper will be as follows. In section two we elaborate the method of the CGE model, the MRIO model, and their linking. Section three specifies the particularities of the investigated Austrian economy and the five emission policies. In section four we show the results of our simulations, while section five concludes and gives policy implications.

Considering the status of ongoing research, we show in this extended abstract a compressed outline of section two and three. In terms of preliminary results, we provide insights on the consumption based and production based emission effects and an outlook on possible conclusions in the last section.

2. Method

Computable General Equilibrium (CGE) models of global extent are state of the art in bottom up climate policy evaluation (see e.g. Böhringer et al., 2012, 2009; Chen et al., 2016; Kuik and Hofkes, 2010; Steininger et al., 2015). At the same time Multi Regional Input Output (MRIO) models are well suited (and widely used) to calculate emissions on a production and consumption based accounting principle (Wiedmann, 2009). Both methods rely on macroeconomic national and international trade data as well as on emission data on a global scale. In our analysis we link both approaches to evaluate emission policies on a production based and consumption based principle, as well as on macroeconomic effects.

An overview of the proceeding for our analysis is given in Figure 1. The database on economic flows and production based emissions we use comes from GTAP 9 (Aguiar et al., 2016). This database contains consistent information on 140 regions and 57 economic sectors for the year 2011, which we use as benchmark. We aggregate the regions into 15 larger world regions and Austria as the country of emission policy implementation. On the sectoral scale we also aggregate into 25 sectors to reduce complexity and computational intensity in our analysis.

A basic description of the used CGE model can be found in Schinko et al. (2014) and Nabernegg et al. (2017). We further specify this CGE model for the Austrian region by a more detailed household representation. This contains a disaggregation of the representative household into four income quartiles via a hybrid method (cf. van Ruijven et al., 2015), based on data of the Austrian consumption survey (Statistik Austria, 2011). Further we implement a labor market including unemployment, based on Austrian specific data (Statistik Austria, 2014). For the production and consumption based emission calculations we use a multidirectional MRIO model, which considers a full feedback from international trade, based on Muñoz and Steininger (2010) and Steininger et al.(2016). The two models are calibrated to the regional and sectoral aggregation as well as to the economy wide averaged regional shares of sectoral import flows in the CGE model.[1]

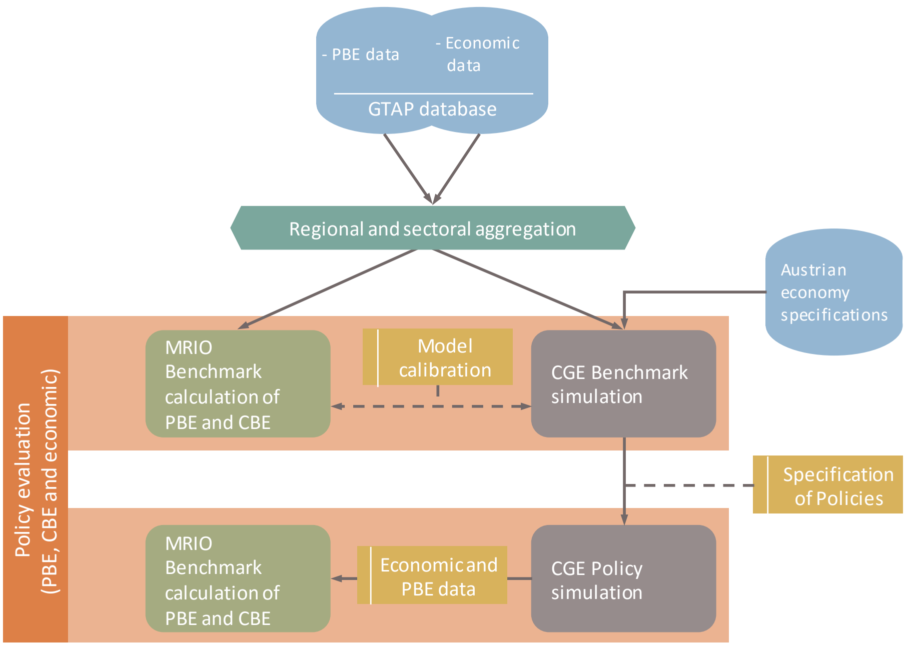

Figure 1 | Methodological proceeding and model linking for the analysis.

[1] To validate the regional and sectoral aggregation as well as the model calibration, we compare benchmark CBE calculated with the full resolution of 140 regions, 57 sectors and detailed import flows with CBE from the calibrated aggregated model and find regional differences of less than 5%.

For our policy evaluation we implement five mitigation policies, as specified in the following section, in the CGE model. After simulating each of the mitigation policies, we generate full global economic and production based emission data from the CGE model which serves as input for the after policy calculation of CBE in the MRIO model. To incorporate emission reductions from technology changes we model PBE in term of combustion emissions from fossil fuels and industrial process emissions in the CGE model (cf. Schinko et al., 2014).

3. Policies

For the choice of mitigation policies investigated in our analysis, we take into account Austrian specific circumstances. We first identify three areas in terms of emission hotspots of consumption in Austria (cf. Muñoz and Steininger, 2015). In these areas overall five policies are specified considering the Austrian social, legal, and economic possibilities (cf. Vogel et al., 2017).

When comparing consumption based emissions with production based emissions on a sectoral level for Austria, we find a rather strong shift of large emitting sectors from electricity and energy intensive sectors (like iron and steel or mineral products) towards the construction sector, government services and trade (see Figure 2). For our policy areas we consider this as follows. We focus on *construction* as it has overall the largest sectoral consumption based emissions. Further, we consider *health* as a policy area, as it is the major contributor in the sector of government services. As third policy area we consider *transport*, as we want to address not only emissions in the transport sector as such, but also emissions in the sector of motor vehicles and parts as well as household direct emissions from fuel use.

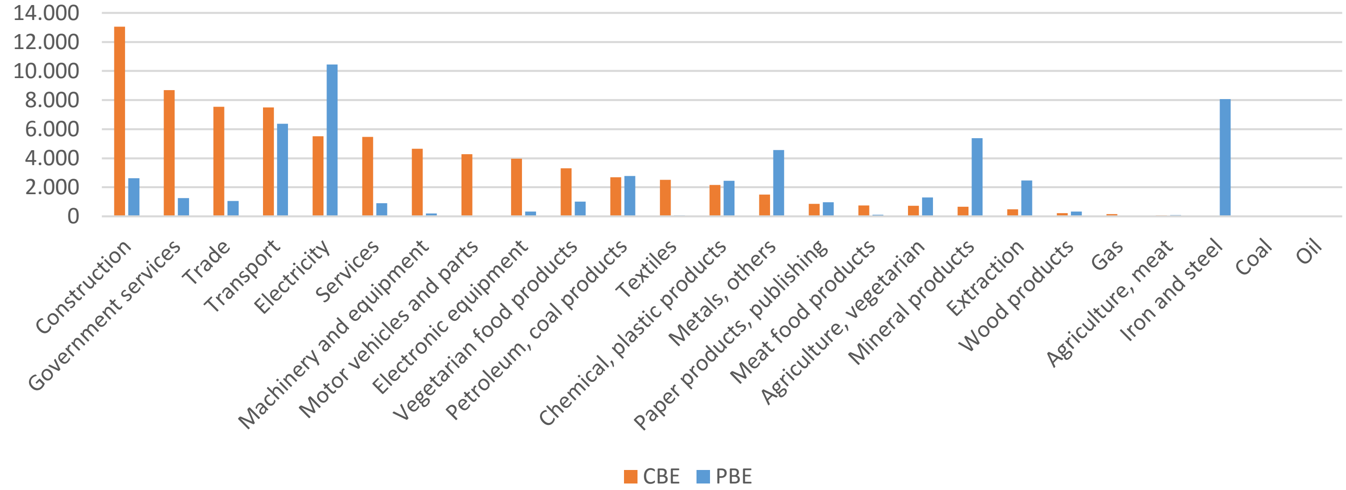

Figure 2 | Austrian 2011 CO_2 emissions attributed to the 25 economic sectors on a consumption based (CBE) and a production based (PBE) accounting principle in 1000 tons of CO_2. Note that household direct emissions for transport, heating and others are not included in the figure.

The specific policies for Austria, as summarized in the following, are assessed in a stakeholder process and evaluated also in terms of political feasibility and flexibility (cf. Vogel et al., 2017). *Construction:* (i) a change in the safety and fire regulations for construction materials raising the maximum admissible building height for wood frame structures; (ii) an information obligation on vacant dwellings tied to a renovation subsidy. *Health:* (iii) obligatory Environmentally Preferable Purchasing Programs (EPP) for hospitals and health institutions. *Mobility:* (iv) an obligation to implement employee mobility plans, joint with public subsidies and other support measures; and (v) higher vehicle taxes for emission-intensive cars, linked to CO2 labels.

4. Results and conclusions[2]

The results of the implemented emission policies are given in this section only in terms of Austrian emission reduction on a production based and consumption based accounting principle. Further results will be included in the full paper.

The emission reductions from the outlined emission policies are given in Figure 3. We find that both policies in the construction area show a higher reduction in CBE than in PBE, while an information obligation on vacant dwellings results only in a marginal reduction of PBE. With a change in the safety regulations the building height for wood frame buildings is increased and therefore the material input structure in the construction sector changes from steel and concrete to wood based products. The largest effect in terms of emission reduction comes from the EPP policy in the health area. This policy shows also the same size for PBE and CBE reductions. This is the reason, as the design of EPPs triggers a switch to less carbon intensive products. In the health sector it turns out, that this product substitution is overall as effective to reduce PBE as CBE. Emission policies in the area of mobility result in relative large reduction of CBE but not of PBE because of the effects from the vehicle tax. As mobility plans reduce emissions mainly in terms of household direct emissions from fuel use, CBE and PBE diminish in the same range with this emission policy. Vehicle taxes, however, induce a rebound effect in fuel consumption what results in increased PBE. At the same time imports of motor vehicles declines, which does not account to PBE but strongly diminishes CBE.

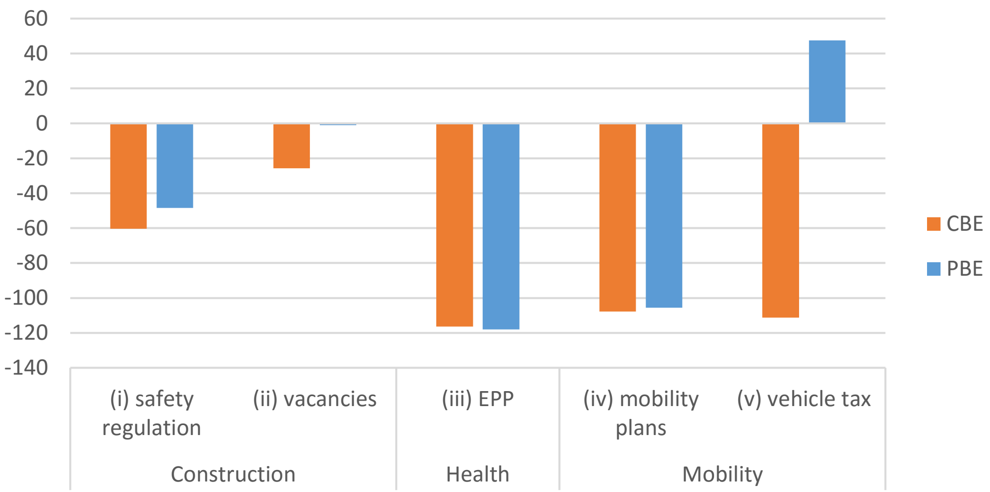

Figure 3 | Change in production based (PBA) and consumption based (CBA) CO2 emissions in Austria from policy implementation in 1000 t CO2, difference to Benchmark.

To get also an insight on the cost effectiveness of the emission policies macroeconomic effects will be considered in the full paper. We compare the shown emission reductions to the GDP effect on the economy from each policy implementation. Further, distributional implications will be examined for the four income groups. We decompose the overall welfare effect for each income group into a change of consumer prices, transfer payments as well as capital and labor income (including unemployment effects).

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[2] Please note, all results presented in this section are preliminary and may be subject to changes.

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