Graz Economics Papers – GEP

GEP 2012–06

Towards a Just and Cost-Effective Climate Policy: On the relevance and implications of deciding between a Production versus Consumption Based Approach

Karl Steininger, Christian Lininger, Susanne Droege, Dominic Roser, and Luke Tomlinson

November 2012

Department of Economics
Department of Public Economics
University of Graz

Towards a Just and Cost-Effective Climate Policy: On the relevance and implications of deciding between a Production versus Consumption Based Approach

Karl Steininger[a], Christian Lininger[b], Susanne Droege[c], Dominic Roser[d], Luke Tomlinson[e]

November 2012

Abstract

The bottom-up national approaches to implement global climate policy under the current United Nations scheme raise concerns about carbon leakage and distributive justice. To limit these concerns, some propose switching to a consumption based emission accounting principle and implementing an associated policy reorientation. We analyse the potential merits of such a switch to a consumption-based approach, in the context of unilateral climate policies implemented by a border adjustment for the carbon content of imports and exports. First, we look into the relationship between the accounting principle and justice considerations. We distinguish the Responsibility Question (Do consumers' or producers' choices bring the emissions about?) and the Policy Base Question (Should consumption or production serve as the policy base?). Second, we investigate whether following a consumption- versus production-based policy implies a difference in terms of cost-effectiveness in achieving the environmental target.

We find that consumers and producers are jointly responsible for emissions. We also find that from the perspective of justice this does not settle the question whether consumption or production ought to serve as the climate policy base. Rather, this depends on the distributive consequences of switching to consumption-based accounting. We find that (global) cost-effectiveness is currently higher when unilateral climate policy by industrialized countries is consumption-based, and accompanied by clean technology transfer. If implemented in terms of border carbon adjustments, justice considerations suggest channeling import tax revenues to developing and emerging economies. We also find that the carbon border adjustment switch need not include export rebates, if these are difficult on political grounds.

Keywords: post 2012 climate policies, CBDR, competitiveness, carbon leakage, border carbon adjustments

JEL Codes: Q56; F42.

Acknowledgments: This article is based on the research project RESPONSE financed by the Austrian Climate Research Programme ACRP of the Austrian Climate and Energy Fund. The paper benefited from extensive discussions within the project team (Birgit Bednar-Friedl, Barbara Buchner, Lukas Meyer, Thomas Schinko, Andreas Türk and Alexa Zellentin), but also from advice by Christoph Böhringer and Hans-Peter Weikard.

[a] Department of Economics and Wegener Center for Climate and Global Change, University of Graz, Austria; [b] Wegener Center for Climate and Global Change, University of Graz, Austria; [c] SWP – German Institute for International and Securtity Affairs, Germany; [d] Department of Philosophy, University of Graz; [e] Department of Politics and International Relations, University of Oxford

1. Introduction

Emissions raise the atmospheric concentration of greenhouse gases (GHGs) on a global level, irrespective of where they are emitted. The environmental impact from any unit of emissions is the same whether it is emitted when heating a private home in Europe or for producing a unit of aluminum for use in a manufacturing process on a different continent (e.g. to produce a car, which may be later delivered to Europe). Consequently there are two perspectives one can take when tracking GHG emissions, carrying over to two different accounting principles, which both address the same ultimate environmental concern of GHG concentration. One can account for emissions at the point of production (production based accounting, PBA), irrespective of by whom and where the produced good is used thereafter (this is the accounting principle currently implemented under the UNFCCC), or one can account for emissions at the point of consumption of goods and services and attribute all emissions that occurred at any location worldwide in the course of production to this consumption (consumption based accounting, CBA).

On a global scale, both accounting principles cover all emissions discharged and therefore yield the same emissions measure. For a single country, however, using a particular concept usually results in different national emission levels. The difference, termed ´net carbon trade balance´, is determined using data on worldwide trade flows in goods and services, taking into account the respective implicit carbon content (carbon embodied in goods). The magnitude and direction of the net carbon trade balance vary considerably across the globe. Industrialized countries currently tend to be net importers of carbon, whilst emerging and developing countries tend to be net exporters (e.g. Peters and Hertwich 2008a, Peters et al. 2011).

While the UNFCCC applies the production-based accounting principle, there are two lines of literature that explicitly or implicitly suggest to switch to consumption based accounting principle, or at least give weight to it in policy design. First, in the literature on emissions embodied in trade, some authors argue that it is "fairer" to make countries responsible either for their consumption-based emissions or for some combination of production-based and consumption-based emissions (Kondo et al., 1998; Munksgaard and Pedersen, 2001; Ferng, 2003; Bastianoni et al. 2004; Peters and Hertwich, 2006). Furthermore, basing international climate policy at least partly on CBA is seen as a means of countering the increase of carbon imports by industrialized countries, which adds to an increase of emissions in countries without binding mitigation policies and thus to a negative emissions trend globally (Peters and Hertwich, 2008a,b; Nakano et al., 2009; Wiedmann, 2009).

Second, the literature on border carbon adjustments indirectly also discusses switching to a consumption based approach. Full border carbon adjustments maintain a production-based accounting principle, whilst correcting the accounting basis by adjusting the price of imports and exports. Border carbon adjustments correct the accounting basis by applying import taxes for carbon-intensive goods originating from non-policy regions, and applying export rebates to those goods consumed in non-policy regions. If applied to all products according to their true carbon content the final outcome is equivalent to CBA. Border carbon adjustments are mostly called for by industry representatives and politicians as a means of addressing the risk that unilateral climate policy action might lead to a loss of competitiveness (Clapp, 2010). Many analyses, however, doubt their effectiveness or political feasibility (e.g. Böhringer et al., 2010a,b; Droege, 2011a,b; Fischer and Fox, 2011).

In this paper we investigate two dimensions of a switch to a consumption-based climate policy approach: justice, i.e. whether a switch is compatible with advancing just burden-sharing; and environmental cost-effectiveness, i.e. whether achieving any global GHG emission reduction level following a production or a consumption-based approach lowers the (welfare) cost of such climate policy. We assume that a global coordinated emissions abatement policy is unlikely to arise in the medium term. Following the outcomes of the UNFCCC COP15 climate negotiations in Copenhagen, bottom-up approaches, which involve emission reduction targets and abatement targets that are chosen by individual countries, are increasingly gaining support.Although further international negotiations are scheduled by 2015, the international regime will need to rely on unilateral action in order to achieve global emissions peaking by 2020.

The structure of the paper is as follows. Section 2 discusses the two different accounting principles and the basic definitions and issues involved. Section 3 discusses the implications of a switch from production to consumption-based accounting and policy on the basis of justice. Section 4 covers the implications of a consumption-based approach for policy coverage and policy-induced leakage. We consider each of the channels that leakage arises from and whether there is an advantage of a consumption-based policy over a production based one, first, in terms of leakage, as the literature so far seems to (at least implicitly) suggest, and second, how this translates to cost-effectiveness, that we are ultimately interested in. Section 5 combines the analysis of justice and cost-effectiveness for the particular case of border carbon adjustments as one means of introducing a consumption-based climate policy. A final section summarizes the main conclusions.

2 The issues at stake when changing the accounting principles

The debate on consumption versus production based accounting, including the leakage debate, is accompanied by strong moral intuitions. Some argue that, because consumers are the ultimate beneficiaries of a good, it is these actors that should be held responsible for any emissions caused in the production of the good. Others feel that producers must take responsibility too, since these actors profit from selling goods and because it is their choice to engage in production of emissions. A unilateral shift of the policy base from production to consumption brings up additional justice concerns. Does the policy region, by including imports in its climate policy base simply aim at protecting its industries from competition from the non-policy-region? If the non-policy region consists of developing and emerging economies, this can be perceived as contravening a just distribution of mitigation burdens in line with the widely accepted principle of common but differentiated responsibilities (CBDR).

Another issue – in a setting of differential climate targets – is the concern that carbon leakage undermines the environmental effectiveness of unilateral emission constraints. Broadly speaking, carbon leakage describes a shift in carbon emissions from one region to another region. There are two main leakage concepts used in the academic discussion on emissions embodied in trade (e.g. Droege 2011a, Peters and Hertwich, 2008a): first, “policy-induced” or “strong” carbon leakage”, and second, “consumption-induced” or “weak” carbon leakage. These two concepts differ in respect to the emissions quantities they refer to, and in the causes of leakage that they analyze.

Consumption-induced leakage describes the overall trend in the global economy that the international division of labor leads to more emissions embodied in imports and exports. Thus, consumption-induced leakage is not necessarily triggered by climate policy measures in a particular region. A high or increasing level of consumption-induced leakage may - but need not be - problematic for the environment. Rather, differing net carbon trade balances may (and typically will) also exist in situations that are economically efficient and where there are no external effects harming the environment.

Observing the international specialization patterns in production, one finds that those countries (or country groups) that discuss or implement the most stringent climate policy (e.g. the EU or other OECD countries) are characterized by a quite significant imbalance in their carbon embodied in foreign trade. Embodied carbon in imported goods far outweighs the embodied carbon in exported goods. A country with a small fraction of basic industries, such as Switzerland, accounts for more than double the amount of GHG emissions under a consumption based accounting than under a production based one. But countries with significant energy-intensive industries, such as France or Austria, also account for almost 50 percent more GHG emissions under a consumption based accounting system than reported under UNFCCC guidelines (Peters and Hertwich, 2008a,b; Munoz and Steininger, 2010).

For this reason, the concept of policy-induced leakage is important to understanding how a country (or country group) can and should shape its unilateral climate policy approach. It can be defined as the increase in emissions in the non-policy region following the introduction of climate policy in the policy region, compared to a reference situation without the policy.[1] The leakage effect can be triggered by a carbon cost differential influencing energy markets, investment and operation decisions of firms, and "green technology" development. Moreover, there could be terms-of-trade effects and thus a related change in income and consumption patterns.

Given the likely continuation of unilateral emissions reduction targets by the EU until 2020, and also with the 2009 cap-and-trade debate in the US, some politicians have called for the introduction of carbon import taxes to tackle the leakage potential. In the US, border adjustment provisions can be found in the documents on a potential US cap-and-trade regime (Kuik and Hofkes, 2010). Whilst both political debates only focus on those imports that could undermine the effectiveness of the domestic carbon pricing policy, full carbon border adjustment (taxing imports and rebating exports) is in effect equivalent to a consumption-based carbon reduction policy.

We depict the two accounting principles in Figure 1. For the analysis of unilateral climate policy we split the world into two regions: one that follows a carbon abatement policy (the policy region, denoted by A in Figure 1) and a second one that does not (the non-policy region, denoted by N).

[1] The IPCC defines carbon leakage as "the part of emission reductions in Annex B countries that may be offset by an increase of the emissions in the non-constrained countries above their baseline levels" (IPCC, 2007). This definition can be applied in absolute terms (tons of GHG) or in relative terms (%).

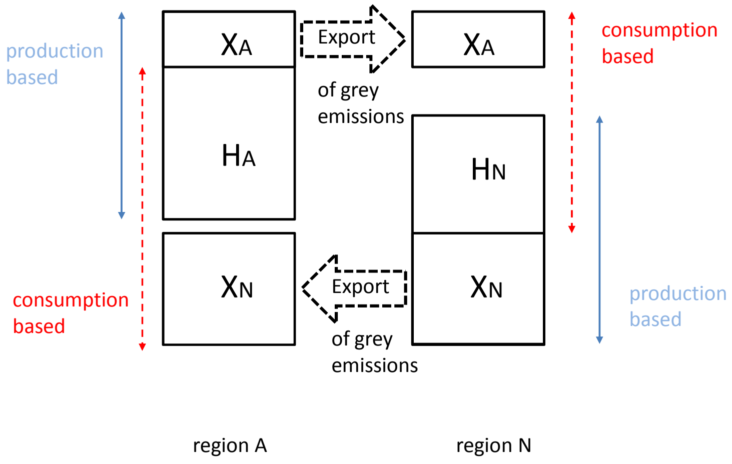

Figure 1: Emission accounting concepts

Note: Figure 1 is a simplified representation, neglecting through-trade

Region A produces goods for both domestic supply (related emissions denoted by H_A) and export (related emissions denoted by X_A). The same holds for region N. When accounting emissions according to the production based principle, the sum of H_A and X_A is the relevant basis for accounting for the emissions of region A, while the sum of H_N and X_N is the basis for region N.

If, however, we are interested in the volume of emissions ultimately triggered by the consumption of goods in either one of the two regions, i.e. a consumption accounting principle, we consider region A´s home production and its imports as the relevant basis, and thus add up H_A and X_N for the consumption based emissions of region A. Correspondingly for region N (see Figure 1).

While both regions could be industrialized or emerging economies, we consider – without loss of generality, but induced by current international discussion – region “A” (the policy region) as consisting of (a fraction of) industrialized countries, and of “N” as emerging and developing economies (and the remaining industrialized countries). In Figure 1, the consumption based emissions for region A are larger than production based ones, and the reverse is true for region N, depicting the current difference between industrialised and developing countries.

3 Evaluating the shift to consumption-based policy under the justice perspective

It is widely agreed that the just distribution of burdens between different nations is a key concern of climate policy design. In this section, we examine whether shifting from PBA to CBA promotes international justice in climate policy. We proceed in two steps. First we ask the "*responsibility question*": Are consumers (respectively consumer countries) or producers (respectively producer countries) responsible for emissions? Second, we ask the "*policy base question*": Should we interpret references to emissions in climate policy as references to the consumption or production of emissions? More precisely, the policy base question consists of two questions: Should we interpret an emission reduction target as a target to reduce the consumption or production of emissions (the *target base question*) and should we interpret a tax on emissions as a tax to be levied on the consumption or production of emissions (the *tax base question*)?[2]

3.1. The Responsibility Question

Let us start with the question whether producers or consumers are responsible for emissions. This question is ambiguous because the expression of responsibility refers to very different concepts in ordinary language (cf. Hart 1968, 211). Two of these concepts stand out. When we see the orderliness in a child's bedroom and say that Anna is responsible for it, we could either mean that Anna brought the room in order or that it is Anna's duty to bring the room in order. In the first sense, agent A is responsible for outcome O in the case that *A brought O about*. In the second sense, A is responsible for O in the case that *A has duties with respect to O* (such as the duty to bring O about or the liability to compensate others for problems to do with O).[3]

When we discuss the responsibility question, we are interested in the *first* of these two senses of responsibility. We want to know whether the producers or consumers of a certain good count as the agents who *brought* the emissions embodied in this good *about*. In other words: We want to know whether consumers or producers must regard the emissions embodied in this good as "their" emissions. Once we know who is responsible for the emissions in the first sense of responsibility (i.e. whether the consumer or the producer brought the emissions about) it is then a *further* question who is responsible for emissions in the second sense of responsibility (i.e. whether the consumer or the producer has a duty to pay for these emissions). The two questions can be separated since not all plausible principles of climate justice ascribe the duty to pay for emissions to the agents who brought the emissions about. The answers to these questions could be different as illustrated by the Ability to Pay Principle. It is the most prominent example of a principle of climate justice that does not ascribe a responsibility in the second sense (i.e. a duty to pay for emissions) to those agents who are responsible in the first sense (i.e. to those who brought the emissions about).

From this point forward, we discuss responsibility for emissions only in the sense of bringing the emissions about. Moreover, when we say that an agent brings emissions about, we mean that an agent brings them about *voluntarily*. An agent voluntarily brings emissions about if she (i) *knowingly and avoidably* (ii) *causes* the emissions.[4] The second term (ii) tells us that responsibility is about *causation*. The first term (i) makes a qualification, i.e. that the type of responsibility we are concerned with includes an element of *voluntariness*. A ball is responsible for knocking down a vase in a purely causal sense but it did not *voluntarily* cause the outcome. Similarly, if we could not have avoided certain emissions (say, from breathing) or could not have known the relevant facts about these emissions, we are not responsible in

[2] "Instrument base" would be a more comprehensive term than "tax base". A price instrument (such as a carbon tax) is not the only policy instrument for which the consumption versus production issue is relevant. For a quantity instrument (such as tradable emission rights) we also need to specify what policy base it refers to, i.e. whether emission rights are rights to consume or produce emissions.
[3] For some related - and partially contrasting – distinctions, see for example Miller (2007, 83-84), Scanlon (1998, 248-9), or Vallentyne (2008, 58-59).
[4] For similar – and partially contrasting – criteria for this type of responsibility, see for example Braham and van Hees (forthcoming), Lippert-Rasmussen (2009), or Stemplowska (forthcoming).

the sense of voluntarily bringing these emissions about. The fact that these emissions are in the atmosphere would not be rooted in our *choice* to emit them.[5]

Given these clarifications, we can now ask whether consumers or producers are responsible for emissions. Is it more appropriate to say that either consumers or producers have knowingly and avoidably caused the emissions? Three points can be made. First, there is no hope of arriving at an uncontroversial answer to this philosophically intricate question. Second, there are cases where the avoidability condition or the knowledge condition is clearly *not* fulfilled. The emissions stemming from the actions of the extremely poor, for example, do not reflect these people's choice to emit. The extremely poor might not know about the emissions and, even if they did, it might have been unavoidable for them to bring these emissions about. To this extent, the extremely poor are not responsible for the emissions originating in their actions. Third, there are many cases in which the conditions of avoidability and knowledge are clearly fulfilled. In such cases, the question of consumer vs. producer responsibility boils down to the question of which of the two agents counts as *causing* emissions. According to many theories of causation *both* agents have to count as causing emissions (cf. Honoré 2010, 3.1). Some theories of causation would stress that for both it is true that the emissions would not have been released *but for their choices*. Other theories of causation stress that these are either *necessary parts of a sufficient set* of conditions for the release of emissions, or that they are *substantial factors* that contribute to this event. Whatever theory of causation one presupposes, the producer's choice both to produce and to do so with a production method that involves emissions, as well as the consumer's choice to create a demand, are both causes of emissions. Producers and consumers are therefore *jointly* responsible for emissions. Attempts to determine relative shares in such a case of joint causation is a theoretically very challenging task (cf. Braham and Van Hees 2009, 325).[6]

To summarise the first step: an agent is responsible for emissions if she voluntarily – i.e. knowingly and avoidably – causes emissions. On the one hand, if either consumers or producers cause emissions unknowingly or unavoidably, then these actors are not responsible for them. On the other hand, for many of the relevant cases in policy-making, it seems uncontroversial that the agents voluntarily pursue the course of action that brings the emissions about. In these cases, the correct answer to the responsibility question takes consumers and producers to be jointly responsible.

3.2 The Policy Base Question

We now turn to the second step: the policy base question. When investigating whether a given mitigation target should be interpreted in terms of a consumption-based or a production-based target, or whether a carbon tax should be applied to the consumption or the production of emissions, the fact that responsibility is shared between the producer and the consumer is

[5] Many duties in the context of emissions are dependent on whether an agent is responsible for emissions in the sense of knowingly and avoidably bringing emissions about. It should be noted, however, that there may also be duties that depend on responsibility in other senses, e.g. on responsibility in a purely causal sense (cf. Miller 2007, 101) or on responsibility in a sense that includes further clauses, in particular a clause about wrongfulness. It should also be noted that the clause about voluntariness needs to be carefully fleshed out. The knowledge condition, for example, needs to include not only the actual knowledge of agents but also what they are liable to know. Also, there are thorny issues to do with partial knowledge (risks): If the agent knew that harm *could* ensue from emissions and it turns out that it *does* ensue, can the agent count as having voluntarily chosen the ensuing harm? The avoidability clause also needs further specification. For example: Do the emissions of poor or exploited agents count as unavoidable?

[6] If we are serious about responsibility, there is no reason why we should limit our focus to consumers and producers defined in a narrow way. Political regulators (cf. Caney 2009, 135), companies that develop carbon-intensive production technology, and celebrities who seduce consumers to a carbon-intensive lifestyle are all examples of agents who knowingly and avoidably cause emissions.

often not directly relevant. This is for four reasons: (i) not all justice principles refer to responsibility; (ii) not all justice principles that refer to responsibility do so for principled reasons; (iii) responsibility-sensitive justice principles are often concerned with who bears the tax burden rather than with on whom the tax is levied; (iv) current climate policy is very far from the ideal of justice.

(i) *Not all principles of international justice rely on responsibility in the first place.* There are a number of principles that distribute burdens between nations independently of the nations' responsibility for emissions. According to these principles, the choice of the policy base must be made on considerations aside from the correct attribution of responsibility. The most prominent example of such a principle is the *Ability to Pay Principle*: Nations must pay in proportion to their wealth (or some other measure of capacity) rather than in proportion to the amount of emissions they are responsible for. In one version – a *Subsistence Emissions Principle* – nations are exempted from mitigation duties when emissions necessary for basic needs are at stake. Another example of a responsibility-independent principle is the *Equal Costs Principle*: climate policy should yield equal per capita costs regardless of each nation's contribution to the problem. A further principle that does not rely on knowing who is responsible for emissions is the *Beneficiary Pays Principle*. This principle is concerned with who benefits from emissions rather than with who brings them about.[7]

Admittedly, only few subscribe exclusively to one of the responsibility-insensitive principles. Many support principles of justice that actually do rely on responsibility ascriptions such as the *Polluter Pays Principle* (one must pay in proportion to the emissions one is responsible for) or the *Equal per Capita Principle* (everyone must reduce the emissions they are responsible for down to a certain level).

(ii) *Not all who want to implement responsibility-sensitive principles are concerned with responsibility for principled reasons.* Rather, the support for a principle can for example also be driven by ease of implementation or ease of monitoring. The Equal per Capita principle can be supported not only because there is something just about equality but also because the equal split serves as a *simple* focal point for negotiations. There is support for the Polluter Pays Principle not only because it is just to make the emitter pay for the harm that her emissions cause but rather because the Polluter Pays Principle *incentivises* the emitter to reduce her emissions. From a consequentialist perspective the Polluter Pays Principle is simply an instrument to achieve emission reductions (or to achieve them cheapest in terms of overall cost) rather than a just way of distributing burdens.

Thus, responsibility-sensitive justice principles can be partly justified on the basis of factors such as: the ease of implementation and monitoring, simplicity, or incentives. It seems obvious, then, that these factors can also have a say in one's choice between production and consumption based versions of responsibility-sensitive justice principles. Rather than wondering whether the producer or the consumer is the "true" emitter, we can take an instrumental perspective on the policy base question. If, for example, production-based accounting is firmly established in the UNFCCC and if one considers ease of implementation

[7] Of course, producing emissions and consuming emissions are both correlated with benefiting. One might therefore estimate an agent's benefits from emissions by taking the agent's production and consumption of emissions as indicators. However, even if one were to distribute costs to consumers and producers on this basis, it would still be the *benefits* from emissions that do the justificatory work for these payments rather than the *responsibility* for emissions.
It is not always clear whether benefits are taken to be intrinsically relevant or as an indicator. Lenzen et al. (2007, 35), for example, are explicit in ascribing responsibility for emissions in proportion to value added *because* value added is taken as an approximation for control or influence over emissions. In contrast, the wording used by Peters and Hertwich (2008, 61) and Weisbach (2010, 19) is less clear.

to be a legitimate criterion for choosing certain burden-sharing principles, then one might also consider ease of implementation to be a legitimate criterion for choosing to stick with the established production policy base. Thus, the relevance of the responsibility question is narrowed down: It is relevant only if one supports responsibility-sensitive principles (such as the Polluter Pays Principle) and only if one does so for principled reasons.

(iii) *Many justice principles are interested in the distribution of the tax incidence rather than in the point of revenue collection.* As far as the choice of tax base alone is concerned, a third reason further limits the relevance of the responsibility question. When deciding between consumption and production as the tax base, we decide about on whom the tax is *levied*. However, many principles of justice in burden-sharing are not concerned with who actually pays the tax but rather with who bears the tax *incidence*. And since the agent who pays the tax – regardless of whether it is the consumer or the producer – can partially or fully pass on the tax burden, choosing a tax base is only a *means* for bringing about what many principles of justice ultimately focus on: a certain distribution of *burdens*. If, for example, the Polluter Pays Principle demands that the agent who is responsible for emissions bear a burden in proportion to his emissions and if – as we claim – the producer and the consumer are jointly responsible for emissions, then it is still not obvious that one should partially tax the consumer and partially tax the producer. Splitting the burden between the two in proportion to their responsibility might just as well be achieved by only taxing the producer (and letting him partially pass on the tax burden).

(iv) *Current climate policy is very far from the ideal of justice*. There is no guarantee that in this non-ideal state of affairs we can best improve resemblance with the ideally just state by using the tax base and target base that we would use in the ideal state of affairs. Imagine for the argument's sake a policymaker who believes that in an ideally just world a production-based Equal per Capita Principle would be implemented and that, according to this principle, Europe currently ought to reduce its production-based emissions by 50%. Assume further that in our non-ideal world, Europe has actually only agreed to a 20% reduction and that the policymaker is now faced with the question whether to implement the 20%-reduction-target in production-based or consumption-based terms. It might well be that a consumption-based 20%-target yields a state of affairs that resembles the ideal more closely than interpreting the 20%-target according to the policymakers preferred production-based responsibility ascription.[8]

3.3 Choosing the policy base – some guidance from a justice point of view

To summarize: In a first step we claim that the producer and the consumer are jointly responsible for emissions. This seems to imply at first sight that climate policy should rely on a mixed policy base, i.e. partially on consumption and partially on production. In a second step we argue that this implication does not always hold. The correct answer to the responsibility question is only directly relevant for the policy base question if we subscribe to a *responsibility-sensitive principle of climate justice* and if we do so *for principled reasons* and if *levying a tax* on the truly responsible agents actually achieves the outcome of our

[8] Note that it is in general very difficult to judge which non-ideal policy resembles the ideally just option best. Also, resemblance with the ideal is not the only consideration for choosing policies: It also matters whether the policy opens up promising and permissible paths for the future. On such concerns, see for example Gilabert and Lawford-Smith (forthcoming), Rawls (1999), Swift (2008).

These difficulties are relevant because in the real world we might sometimes only have the option of implementing a *purely* production-based policy or a *purely* consumption-based policy whereas the philosophically correct answer to the responsibility question suggests a policy base that relies on *joint* responsibility. Determining which of the two pure versions resembles the correct joint version more closely relies on controversial judgments.

preferred principle of justice and if choosing the policy base according to the correct answer to the responsibility question promotes justice *even in non-ideal circumstances*. Only if all of these four conditions are fulfilled can we rely on the answer to the responsibility question to argue for a mixed policy base.

It is likely, however, that one of these "ifs" will not be given. How should we then decide on a consumption or production policy base? Here is a rough outline of the method we suggest. First, one needs to determine the ideally just distribution of *burdens* that one's favored burden-sharing principle prescribes. Second, one needs to determine the distribution of burdens resulting from interpreting a *given* non-ideal climate policy (i.e. *given* feasible reduction targets and *given* feasible tax rates) in both production and consumption based policy terms. Third, one needs to examine whether the consumption-based or the production-based interpretation of a feasible climate policy leads to a state of affairs that resembles the ideally just distribution of burdens better.[9]

What results does this method yield? Assume that our burden-sharing ideal is the principle enshrined in article 3.1 of the UNFCCC in 1992: "The Parties should protect the climate system (…) in accordance with their common but differentiated responsibilities and respective capabilities." This principle has a responsibility-sensitive and a responsibility-insensitive part. In the crudest of assessments, it demands that the industrialised countries – based on their high responsibility and high capacity – bear a large share of the burdens, at least a larger share than they do now. The question would therefore be: Does a shift to consumption as the policy base increase the burden for industrialised countries? If we look at the *target base*, a shift to consumption would probably increase the burden for industrialised countries (given their higher consumption of emissions compared to their production of emissions) and it would therefore promote justice. On the other hand, if we look at the *tax base* and if we do so in a situation in which the industrialised policy region has a tax on emissions but the developing policy region does not, then a shift to consumption might well decrease the burdens of industrialised countries at the expense of developing countries and therefore counteract justice. However, this depends ultimately on *how such a shift is designed*. In principle, the distribution of burdens could always *be made* compatible with our favored principle by complementing any shift of policy base by side payments or by increasing the reduction target for those industrialised countries that would gain from a shift. We will elaborate the different implementation options and their implications for justice in section 5.

3.4 Summary

Unfortunately, there is no simple answer to the question whether consumption-based or production-based accounting is better from the perspective of international justice. We argue that in a broad range of cases the following conclusions hold: Firstly, as far as responsibility for emissions is concerned – in the sense of knowingly and avoidably causing emissions –, consumers and producers are jointly responsible. Secondly, the responsibility issue is not directly relevant for the choice of the target base and the tax base of climate policy. Lastly, any given implementation of the switch of policy base is fine from the perspective of justice as long as it is designed such as to shift burdens from those who currently bear more burdens than justice demands to those who currently bear less than justice demands.

[9] Note that this method is *indirectly* still dependent on responsibility ascriptions: In order to determine the *ideally just* distribution of burdens, we often need to know whether the producer or the consumer or both are responsible for emissions.

4 Policy-induced leakage and environmental policy cost-effectiveness

From an economic perspective the cause of climate change – the unrestricted emission of greenhouse gases - is a market failure in the form of an externality (e.g. Stern, 2007). The prescription therefore is internalization. Whatever instrument is chosen, ultimately internalization will be reflected in a correction of prices. In a first best world, i.e. one in which all externalities are corrected, the effect of the policy instrument does not depend on whether it is applied to emissions accounted for via production or via consumption. Take, for example, a carbon tax: the tax base (or more generally: policy base) is identical in both cases – all emissions worldwide. And, as tax incidence analysis tells us, the burden of two policies sharing the same base is ultimately borne by the same individuals and thus provides the same incentives, leading to the same emission reduction at the same cost. A similar argument holds true for other policy instruments. If, however, the policy base does not include all global emissions, the equivalence between production-based and consumption-based emissions accounting breaks down – in that case, as can be seen from Figure 1, the base of the two policies (the emissions targeted by the policies) is not the same anymore. To evaluate two climate policies which result in different outcomes, economists usually refer to one or more of the following criteria: environmental effectiveness, cost-effectiveness, and distributional consequences (IPCC, 2007). We focus on the first two in the following, and take up the discussion of distributional consequences in detail in section 5 again.

4.1 The measurement of environmental effectiveness by carbon leakage

Environmental effectiveness can be defined as the extent to which a policy meets its intended environmental objective (IPCC, 2007). As climate change is triggered by the global concentration of GHGs, the appropriate environmental objective for climate policy is a reduction in global emissions and not just in emissions of a single country or a group of countries – even if the policy is pursued unilaterally.

For a meaningful comparison of the environmental effectiveness of a production- versus a consumption-based policy, one has to fix one aspect (or "common feature") across the two policies. Typical choices for such a "common feature" would be: (i) compare two policies that apply the same carbon price; or (ii) compare two policies that achieve the same emissions reduction in the policy region. One then determines which of the two policies being compared results in a larger reduction in global emissions.

A quantity which reflects the impact on global emissions in this context is policy-induced carbon leakage (as defined in chapter 2) It measures an unintended global effect by unilateral climate policy and can be stated in absolute terms, i.e. in tons or megatons of CO_2 of additional emissions in the non-policy region. More often, however, a relative measure is used – the leakage ratio. It is defined as the increase of emissions in the non-policy area divided by the reduction in the policy area. It thus sets the unintended effect of the policy in relation to the intended effect.

Using the notation introduced in section 2, the leakage ratio l for a policy with production as its base (PB) adopted by region A is thus given by

$$l^{PB} = \frac{\Delta H_N + \Delta X_N}{-(\Delta H_A + \Delta X_A)}. \qquad (1)$$

Δ denotes the change in a variable compared to a reference state with no policy in A. Note that if one compares policies that bring about an equal emissions reduction in the policy region, then leakage ratio and global emissions reduction are concepts that convey the same information and can therefore be used interchangeably: the policy with the smaller leakage ratio is the one that brings about a larger reduction in global emissions, and therefore this is the environmentally more effective one. In such a setting, leakage can thus be used as an indicator of environmental effectiveness. The correspondence between leakage and global emissions reduction, however, breaks down if one compares policies that share, for example, the same carbon price, but that do not lead to an equal emissions reduction in the policy region: in that case, only the global reduction in emissions (but not the leakage ratio) qualifies as a measure of environmental effectiveness.

If one analyses a policy with consumption instead of production as the policy base and wants to use the leakage ratio as an indicator of its environmental effectiveness (in reaching a target stated in terms of emissions accounted on a consumption base), then the leakage ratio definition has to be adjusted accordingly. Again, the leakage ratio must set the unintended effect of the policy in relation to the intended effect (which is now a reduction of H_A+X_N, the emission in consumption directly addressed by the policy, see Figure 1). Thus, the leakage ratio for a policy with consumption as its base (*CB*) is defined as follows:

$$l^{CB} = \frac{\Delta H_N + \Delta X_A}{-(\Delta H_A + \Delta X_N)} \qquad (2)$$

Starting from a climate policy that is framed within the current UNFCCC system of production-based accounting, consumption-based accounting can be introduced by means of full carbon border adjustment. This switch in the accounting-base and its impact on the environmental effectiveness of the policy, can be assessed using equations (1) or (2) as follows: (a) in case the emissions reduction target is still stated in terms of emissions in production (and border adjustments have, for example, been introduced to avoid leakage from industrial activities in the policy region), the leakage ratio for both policies should be calculated by equation (1). Note that one has to assure that the emissions reduction in the policy region – the denominator of equation (1) – is the same for both policies. (b) in the case that one wants to compare a switch of both the target and the policy-base, it is necessary to calculate the leakage ratio for the production-based policy by equation (1), and the one of the consumption-based policy by equation (2). Again, the emissions reduction in the – now differently defined – policy regions must be the same for the leakage ratio to be a meaningful indicator for comparing the effectiveness.

4.2 Channels for policy-induced carbon leakage

Carbon leakage is driven by follow-on effects of the relative price changes caused by the introduction of a carbon price in parts of the world. The more important of these effects can be classified as “leakage channels”. We will discuss four such channels:

- Competitiveness channel: Carbon pricing raises the costs and thus the prices of goods produced in the policy region. Consumers and producers demanding intermediate products substitute cheaper products from non-regulated regions for these now more expensive products. Both production and (as a consequence) emissions rise in the non-policy region.

- Energy market channel: Most GHG emissions stem from the burning of fossil fuels. Abatement in one region leads to a drop in demand and thus the world price of fossil fuels. This in turn increases demand for fuel and thus emissions in other (non-regulated) parts of the world.
- Income channel: The cost of abatement measures and the change in relative prices triggered by the introduction of the abatement policy changes the global income distribution, which in turn may change demand and thus the amount of leakage;
- Technology spillovers channel: In the policy region, climate policy creates an incentive to develop "green technologies". These then "spill over" to the non-policy region and cause "negative leakage" (i.e. a drop in global emissions) there (Barker et al., 2007).

To quantify all of these channels, general equilibrium modeling has been broadly applied. While these analyses produce a wide range of leakage rates (between -14 and 130%) depending on the model setups, such as, inter alia, technological changes, supply elasticities of fossil fuels, the degree of heterogeneity of traded goods, market structure, or capital mobility, the central estimates fall into a smaller range of 5 to 30% (Droege et al. 2011; Lanz et al. 2011, Böhringer et al. 2012). For certain sectors which are either energy intensive or characterized by a high level of process emissions, leakage ratios might, however, be far larger than these estimates which only give an aggregate number for economies as a whole (Monjon and Quirion, 2009; Bednar-Friedl et al., 2012).

When looking at the relevance of each single channel of the above, the literature so far indicates that the competitiveness channel and the energy market channel are responsible for the largest fractions of policy-induced leakage (see Burniaux and Martins, 2011). Only few authors discuss the income channel; they argue that it "is likely to be a second-order effect, at least over the medium time-horizon" (Burniaux and Martins, 2011) and therefore "typically negligible" compared to the other channels (Gerlagh and Kuik, 2007). These findings, however, refer to past and current climate policy and not yet to the probably large redistributions of global income a more stringent future climate policy might involve. Least of all is known about the size of the technology spillovers channel. The few studies that exist (e.g. Gerlagh and Kuik, 2007), however, do not rule out that spillovers are actually larger than leakage through all other channels.

4.3 Climate policy cost-effectiveness and leakage

Although carbon leakage is a criterion widely used in the academic literature and in political discussions, its value for ex ante policy assessments is limited. From an economic point of view the aim of climate policy measures should be to achieve the largest global emissions reduction for given global costs (or the least costs for a given emissions reduction), i.e. cost-effectiveness. However, only if we compare two policies that achieve the *same* emissions reduction in the policy region at the *same* cost, the policy with less leakage will also be the more cost-effective one. Usually, switching from a production-based to a consumption-based policy will change the global costs of the national policy, even if we keep either the carbon price or the emissions reduction in the policy region constant. Given this change in global costs, knowing only the leakage effect cannot help us identify the more cost-effective of the two policies, because we then would need both the costs and the global emissions reduction in order to make our choice.

An important issue concerns which costs the criterion of cost-effectiveness refers to – global costs or the costs incurred by the region introducing the policy? Note that a policy with minimal global cost permits to achieve also minimal cost for the policy region for given costs to the rest of the world. Thus cost-effectiveness should be calculated in terms of global costs. This argument, of course, assumes that it is possible to redistribute costs between world regions – but, as we will discuss below, any politically feasible switch from a production- to a consumption-based policy framework also will involve such redistributions.

4.4 Comparison of leakage and cost-effectiveness for different policy bases

A number of arguments suggest – at least at first sight – that a climate policy with consumption as its base might lead to less leakage and/or greater cost-effectiveness than one with production as the accounting base:

i. *In a partial equilibrium (single sector) setting, a production-based policy will in general lead to leakage through the competitiveness channel, but a consumption-based policy definitely will not* .To derive this result, it is necessary to calculate the leakage ratio of the consumption-based policy using equation (2) and to make a number of assumptions, the most important one being that producers can fully pass on the costs of the carbon price to consumers.[10] An intuitive understanding of this result can be obtained by looking at Figure 1: A production-based policy in region A drives a wedge between the prices of domestic production (where emissions H_A are subject to policy) and imports (where emissions X_N are not subject to policy), goods that are substitutes for each other; and equally between the prices of imports (containing X_A) and domestic production (containing H_N) in region N. Consumers in both regions try to avoid the carbon costs by buying more of the good that is not taxed, thus causing leakage. A consumption-based policy, on the other hand, puts an explicit or implicit carbon price equally on the emissions in goods that are substitutes for each other (H_A and X_N in region A). Thus consumers cannot avoid the carbon costs by buying goods that are not subject to the climate policy.

ii. *The size of leakage through the energy market channel does not depend on the choice of policy base* – it only depends on the amount of emissions reduction brought about by the policy in the first place; but it is irrelevant, in which sectors or countries this reduction is achieved. Thus, it is the other leakage channels, but not the energy market channel that decide under which policy base overall leakage is smaller.

iii. *With current worldwide production patterns, a consumption-based policy by industrialized countries includes a larger share of global emissions than a production-*

[10] This assumption is satisfied if there are constant returns to scale in production. Another necessary assumption is that it is possible to substitute imports for domestic goods in the policy region; and domestic goods for imported goods in the non-policy region, i.e. the relevant cross-price elasticities of demand are not zero in all relevant sectors.

based policy. This result is due to the far higher carbon-intensity of the exports of emerging economies compared to the exports of most industrialized countries.

One consequence of (iii) is that *a consumption-based policy by industrialized countries is more cost-effective if – as is usually presumed – marginal abatement costs rise with the percentage of emissions reduction*. Then it is cheaper to reduce a small percentage of the larger consumption emissions base than a larger percentage of the smaller production emissions base.

iv. A related point to (iii) is that currently there are *more low-cost abatement opportunities in developing and emerging economies* than in industrialised countries. A consumption-based policy followed by industrialized countries brings part of the economy of the developing countries – X_N in Figure 1 – into the scope of the policy, e.g. by applying import tariffs on the carbon content in X_N. As a consequence, part of the required abatement will be achieved making use of these low-cost abatement opportunities. Thus the overall cost of the policy will be lower than with a production-based policy.

Although these arguments might seem to be intuitively appealing, none of them guarantees that a climate policy based on consumption-based accounting indeed leads to less leakage or greater cost-effectiveness. For this to be the case, a number of additional conditions must be fulfilled.

First, results obtained in a partial equilibrium setting like (i) disregard important relationships at the macroeconomic level. One such relationship is the mutual dependence between imports and exports, as countries face limits to the size of their trade deficit. Thus, if export revenues of emerging economies drop because emissions embodied in these exports are taxed, these economies will also have to scale back their imports. As a reaction, they may be forced to produce goods they used to import from industrialized countries themselves, yet most likely with higher carbon intensity. Thus, *a drop in export revenues can cause carbon leakage* (see e.g. Houser et al., 2008; Jakob and Marschinski, 2012). Little is known about the possible size of this effect – import substitution by emerging economies requires a change in the structure of their economies. It is, however, possible to avoid this effect by avoiding or compensating income losses of developing countries caused by a switch of the policy base.

Second, much of the appeal of consumption-based accounting rests on conclusions (iii) and (iv), based on the different carbon-intensities between imports and exports of industrialized countries (Peters and Hertwich, 2008b). A climate policy that generates (explicitly or implicitly) the very same carbon price for home production and imports will make use of efficient emission reduction options and thus for the case of consumption based policy lower the overall cost of global emission reduction. This no longer holds if the unit carbon price charged for home and import goods differs. Practical implementation might favour a unit tax per good, based on best available technology carbon content, which might grossly understate the true carbon content of imports, for example, and thus leave cheap abatement options unexploited.

Another qualification has to be made as an equal carbon price (or tax rate) per unit of emissions does not necessarily have an equal effect on emissions reduction in industrialized and in developing or emerging economies. Basically, the effect a tax has on emissions depends on (a) the reaction of demand for the taxed product to the price increase caused by the tax (the price elasticity of demand); and on (b) the ease of reducing emissions in the production of the taxed product – either, in case of fuel combustion emissions, by switching to a less carbon intensive fuel or by increasing fuel efficiency; or by switching to a completely different "greener" product or production technology.

Many studies investigate argument (a), e.g. Fischer and Fox (2012). However, reducing emissions by reducing the exports of emerging economies might not only result in distributional effects in a direction deemed unfavourable for reasons of justice (see section 5), it also is a questionable strategy from an environmental point of view. As argued above, income losses from the loss of export revenues might actually cause leakage. Thus the favoured strategy could be emissions reduction by method (b) – or, to put it bluntly: *the aim of a switch to a consumption-based policy should not be to reduce, but to "green" the exports of emerging economies.*

Thus, a crucial precondition for a switch to a consumption-based policy to indeed reduce global emissions is that emerging and developing economies are equipped with the technology to make their production more environmentally friendly. Otherwise, the often cited "low-cost abatement opportunities in developing countries" – see argument (iv) above – remain a theoretical concept, but can actually not be adopted by these countries because they do not possess the required technology.

Additionally, the availability of clean technology in developing and emerging economies will also depend on the size of the "technology spill-over channel", the only one of the leakage channels that actually reduces global emissions. This channel rests on a two-step process: (i) the introduction of carbon pricing creates incentives to develop "green" technology in the sectors included in the policy base; and (ii) these "green" technologies spill over also to sectors not included in the policy base. The size of the overall effect will jointly be determined by (i) and (ii).

Regarding (i), a switch of the policy base from production to consumption excludes the industrialized countries', but includes the developing and emerging economies' exports in the policy and thus introduces carbon pricing to (part of the economy) of these countries. Whether this will actually trigger the development of green technology in developing and emerging economies will however depend on whether these countries have appropriate research facilities at their disposal. We suspect that at least in many of the developing countries this might not be the case; and thus, without additional support from industrialized nations, the desired technological innovations in developing countries might not materialize. Regarding (ii), the "spill-overs", we however expect that these will be enhanced by a switch to CBA. This is due, firstly, to the fact that under CBA there will not only be "inter-regional", but also "intra-regional" spillovers, e.g. from the export sector to the domestic production sector in developing economies. Barriers to "intra-regional" or even "intra-country" spillovers should, however, be lower than barriers to spillovers across regions. Secondly, the introduction of carbon pricing in parts of the economy of developing countries also increases the incentive to actually put to use spillovers that have already occurred, but that would otherwise have remained unexploited. To summarize, we thus expect that a switch to CBA will at least enhance step (ii) of the "spillovers leakage channel", and thus improve access to clean technology in developing and emerging economies, while there remain doubts about its effect on step (i).

4.5 Summary

Overall, we find that a switch to a consumption-based policy – although perhaps intuitively appealing – is not certain to lead to a more cost-effective reduction in global emissions. It will ensure higher cost-effectiveness, however, if a number of – in practical terms quite demanding – preconditions are met. One crucial precondition is the availability of “clean” technologies in developing and emerging economies, which can also be fostered by technological transfer.

5 The role of border carbon adjustments in achieving justice and cost effectiveness

As we have seen in the two previous sections, changing the accounting base for GHG emissions from production to consumption has a number of implications for justice and cost-effectiveness. For a combined evaluation on justice and cost-effectiveness grounds we will now consider the particular case when such a switch is implemented by the policy region A using a border carbon adjustment system. This border carbon adjustment would include imported goods in the policy base and would exclude exports in order to imitate a CBA of emissions. It thus represents one possible implementation of a consumption-based policy. Could this deliver a just, in terms of burden distribution, and cost-effective, i.e. reducing overall burdens, climate policy outcome? In general, distributional impacts and cost effectiveness do not go hand in hand. Rather, an efficient allocation of resources might well cause negative distributional impacts and *vice versa*. International climate policy is confronted with this trade-off as well. The interesting question is thus: how can border carbon adjustments be introduced by industrialized countries such that a shift to a consumption based policy actually delivers on both ends, i.e. on justice and cost-effectiveness?

We discuss the different effects of border carbon adjustments with respect to the justice and the effectiveness dimension of unilateral climate policy in sequence.

5.1. A switch to unilateral consumption-based policy and related justice

One result from section 3 on justice was that *both* the consumer and the producer of a good are jointly responsible for the emissions caused. However, this does not imply a specific choice of the basis for a political measure. Rather, whether a policy approach is just should be evaluated in terms of the actual effects of the policy. The incidence from a carbon price, for example, which is levied on the producer but which is (fully or only partly) passed through to the consumer could actually deliver a distributively just result. It is generally agreed that shifting burdens away from developing countries constitutes an improvement in terms of justice.

How does the distribution of burdens change when the introduction of border carbon adjustments leads to a switch from a production- to a consumption-based climate policy? While the effects depend on a number of parameters, a general tendency can be outlined.

A border carbon adjustment – following the logic of a switch in emissions accounting as shown in figure 1 – consists of an import tariff on the carbon content of imported goods and an export rebate for the carbon content in exported goods. The impact of the border adjustment for imports from region N to region A on the producers in N and the consumers in A depends on the actual cost pass-through rate in region A. This depends on the market structure in which the importer competes. If there is no full cost pass-through, both consumers in A and producers in N will share the direct burden. As an additional *macroeconomic* effect, the import tariff will improve the terms of trade of the region introducing the tariff, if this is a large country with an impact on world market prices. However, this will happen at the expense of the rest of the world. The export rebate will have the reverse effect.[11]

Given the current carbon trade flows, if the policy region A consists of (a share of the world's) industrialised countries, more emission are embodied in its imports than in its exports. Thus, the import tariff revenue is larger than the expenditure on the export rebate. The economic effect of the import tariff – the terms of trade gain of industrialised countries – will generally dominate the economic effect of the export rebate. The non-policy region N – emerging and developing economies in our setting – therefore suffers a welfare loss[12]; the policy region A, on the other hand, might even experience a welfare gain, if the distortion losses caused by the tariff are smaller than the terms-of-trade gains. Note, that we are comparing the two policies for a setting where both policies achieve the same environmental benefit (in terms of global emission reductions), and only look at costs for a thus given and equal environmental benefit. According to this line of reasoning, *a switch to a consumption-based policy – by application of border carbon adjustments – leads to a redistribution of the costs of the policy, most likely to the disadvantage of developing and emerging economies.* Empirical evidence of the effects can be found in Boehringer, Fischer, and Rosendahl (2010), Burniaux, Chateau and Duval (2010), McKibbin and Wilcoxen (2009), Gros et al. (2010), and Mattoo et al. (2009). The negative response of many developing countries is also an indication of the additional burdens they expect for themselves from a unilateral introduction of border carbon adjustment measures.

Thus, from a welfare point of view, the import tariff would create a terms-of-trade effect in favour of region A. This is a distributional effect which is not desirable from a justice point of view. One instrument to counter such an unfavourable implication is to use tariff revenues accordingly. Border carbon adjustment revenues from import tariffs can in principle be either allocated to the importing country (region A) or to the exporting country (region N). From the perspective of justice, it is desirable that industrialized countries allocate the revenues from the border carbon adjustments to exporting countries (and thus to developing and emerging economies).

Export rebates for producers in A, on the other hand, reduce the price of the exported goods. Exports will become cheaper and the importing countries' consumers will not have to pay a carbon price. This reduces the climate policy burden of consumers in region N. The terms-of-trade effect of the rebates thus work in favour of the welfare in the non-policy region N, if region A is a large country. Thus, the rebate does reduce the – for region N negative –

[11]This result rests on the assumption that the Marshall-Lerner condition is satisfied, i.e. that the sum of the import elasticities of the two regions exceeds unity. Empirically, this condition usually holds in the middle to long run.

[12]The term "welfare" as used here refers only to welfare derived from the consumption of goods, but excludes benefits from emissions reductions. While the non-policy region as a whole suffers a welfare loss, there may well be countries in that region that experience welfare gains, e.g. countries dependent of fuel imports which gain from reduced fossil fuel prices.

terms-of-trade effect we expect from import tariffs. Export rebates thus help on the justice side.

Note, that as an additional effect a redistribution of welfare (or income) may have an effect on leakage (income leakage channel). If the terms-of-trade effect is left uncompensated and thus developing and emerging economies produce and consume less, their emissions will drop. However, as we have argued above, there are good reasons to prevent or compensate income losses of developing countries, which then would not trigger such a leakage effect.

5.2. A switch to unilateral consumption-based policy and related cost-effectiveness

A switch to a CBA has the potential to increase the cost-effectiveness of unilateral climate policy measures by an industrialised country (as elaborated in section 4). The larger emissions base covered by the climate policy and the presumably cheaper abatement options in emerging and developing economies drive this result. However, this effect can only be realized if emerging and developing nations are equipped with the technology required for "green" production. Furthermore, to fully exploit the potential cost-savings, carbon taxes at the border should as accurately as possible reflect the true carbon content of the goods taxed.

Discussions on the practical implementation of border carbon adjustments often concentrate on import tariffs, but disregard export rebates. Thus, a final important question in the analysis of CBA is what the consequences of the implementation of such a "one-sided" border policy are. Trade economists usually favor "symmetric" policies, i.e. import tariffs as well as export rebates, as these tend to minimize distortion losses that stem from relative price-level effects (Lockwood and Whalley, 2008; Mattoo et al., 2009). Symmetric policies are therefore in general more cost-effective. Also, with the current divergence in carbon prices between industrialized and emerging economies it is clearly more expensive to increase abatement in industrialized countries (as would be the case without export rebates) than to achieve an equal amount of emissions reduction in emerging economies. Granting export rebates does lower emission reduction in industrialized countries, but raises the competitiveness of – usually cleaner – export products in the non-policy region market place, which is more relevant for overall cost-effectiveness of climate policy.

The pursuit of cost-effectiveness would therefore call for a policy that involves both import tariffs and export rebates. Unilateral climate policy, however, is usually not motivated by the search for a policy that would be optimal under optimal circumstances but by the adoption of a feasible policy under severe political constraints. One aim of unilateral climate policy usually is to cover as many emissions as possible to tackle a global problem. And often the inclusion of the policy region's exports in the policy base, i.e. foregoing export rebates, is the only politically feasible way to bring more emissions into the scope of the policy, even if this is achieved by incurring more costs than by a policy with export rebates. At any rate, the welfare cost difference between a policy with and a policy without export rebates should not be too large: as argued in section 5.1, the effect of the import tariff will quantitatively by far outweigh the effect of the export rebate, as the imports of industrialized countries contain far more emissions than their exports.

5.3. Empirical insights on the role of border carbon adjustments

We have seen that if certain preconditions – such as accessibility to green technologies for developing countries – are met, the switch to a consumption-based climate policy by means of border carbon adjustments can help on both justice and cost-effectiveness grounds. The quantitative relevance on both accounts of such a switch, however, does depend on a range of parameters, and especially the combination thereof.

We will thus conclude our analysis with a check of the empirical evidence, again for the case of consumption-based policy implemented by means of border carbon adjustment. Quantitative analysis on burden distribution and cost-effectiveness in global climate policy is usually carried out by means of computable general equilibrium analysis. For the issue at hand we can make use of the availability of a consistent comparison of twelve multiregional global CGE models accomplished within the Energy Modeling Forum on leakage and border carbon adjustment measures (Böhringer et al., 2012). The twelve models are all necessarily based on the same base year economic and environmental data base, but differ in structural design and parameter settings. They thus supply an analysis for a range of parameter settings that are currently considered relevant. In terms of leakage channels they cover the competitiveness, the energy market and the income channel, but not the technology spill-over channel (which, as we have argued, is difficult to quantify, but tends to supply more benefits for the case of consumption-based approaches).

In terms of GHG emission reduction the comparison study uses one fixed global emission reduction scenario across all simulations.

> Given the uncertainty of external cost estimates for carbon emissions, the consistent comparison of alternative unilateral climate policy designs implies a cost-effectiveness approach where we keep global emissions constant. In other words, without quantification of emission damages, welfare comparisons only make sense between scenarios with identical global emission levels where the gross benefit of abatement across all regions is the same. For all policy simulations, the global emission constraint is set to achieve an effective emission reduction equal to the 20% emission pledge of the abatement coalition. The global emission constraint requires that the initial emission cap of the abating coalition is scaled endogenously to compensate for emission leakage (note that the scaling already applies to the reference scenario without [border carbon adjustment,] BCA). In this framework, leakage reduction through [border carbon adjustment,] BCA [,] implies that unilaterally-abating regions must cut back domestic emissions to a lesser extent than in the reference scenario in order to meet the global emission constraint. (Böhringer et al. (2012), in press, p.3f.)

In order to illustrate our case, we analyse climate policy by the EU who unilaterally pursues a climate policy with a carbon price and a stringency level of 20% emissions reduction. To carry over as a global emission reduction a stronger EU emission reduction would have to be achieved in case of leakage. Comparing the different models for the same policy scenario (simulated for the base year 2004) we find that the welfare loss (in terms of Hicksian equivalent variation) of unilateral policy with import tariffs only and revenues thereof granted to the EU is 1% to 0.1% (see Figure 2). The eight other world regions outside the climate policy coalition are modeled separately and are aggregated to "non-Annex 1" and "Rest-of-Annex 1", respectively for Figure 2.

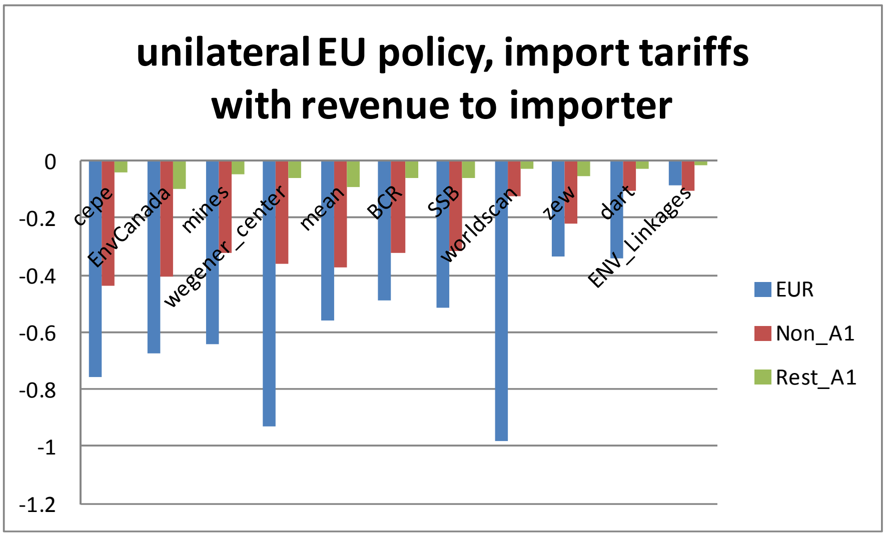

Figure 2: Hicksian equivalent variation for unilateral EU climate policy with carbon import tariffs, results across 12 global CGE models

Note: for descriptions of models that generated this data base see Böhringer et al. (2012)

Let us first compare the welfare (and thus burden) implications for EU, "Rest of Annex 1" and "Non-Annex 1" for the case of unilateral policy without border carbon adjustment to that with border carbon adjustment by means of import tariffs (and revenue either going to importing or exporting country). For the sake of clarity, we do not report all individual models results in the following (the spread being similar as shown in Figure 2 across models), but only the mean of the twelve model results (see Figure 3).

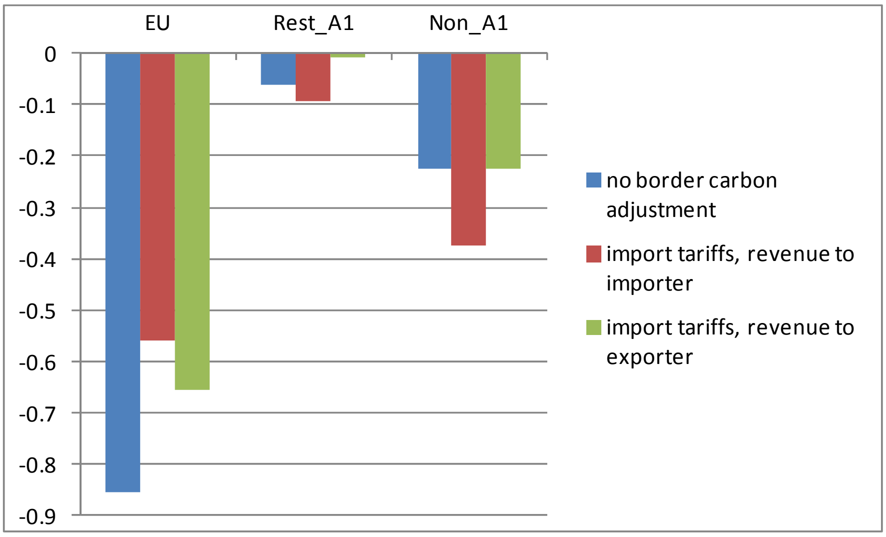

Figure 3: Hicksian equivalent variation for unilateral EU climate policy with and without carbon import tariffs, mean results across 12 global CGE models

Note: for descriptions of models that generated this data base see Böhringer et al. (2012)

The welfare impact results displayed in Figure 3 make it clear that, even in the case of unilateral EU policy without border carbon adjustment, non-coalition countries carry some burden as well. The burden is larger for Non-Annex 1 (0.2%). When we switch to a framework with border carbon adjustment by means of carbon import tariffs, the mean result across models is that the welfare loss for EU decreases. The welfare effect for Non-Annex 1 countries triggered by this switch depends on how carbon tariff revenues are spent. If they go to the EU (the importing region), welfare cost of unilateral EU climate policy for Non-Annex 1 (as well as for Rest-of-Annex 1) double. If revenues go to the exporting countries, however, welfare for Non-Annex 1 does not decline any further than it did when introducing the unilateral policy without border carbon adjustment. (For Rest-of-Annex 1 countries welfare loss is even reduced, as they are the main exporters to EU).

In terms of cost-effectiveness the globally fixed environmental target across simulation scenarios makes it possible to use the level of the carbon price in the policy region as an indicator of cost-effectiveness (see Table 1). We find that the introduction of border carbon adjustments lowers this price by 10%, and thus the import tariff policy exhibits higher cost-effectiveness than EU unilateral climate policy without border carbon adjustment.

	CO_2 price [US2004$/t]
no border carbon adjustments	57,27
import tariffs, revenue to importer	51,71
import tariffs, revenue to exporter	52,03
full border carbon adjustment, rev to imp	51,39
full border carbon adjustment, rev to exp	51,71

Table 1: CO2 price variation indicating cost-effectiveness of unilateral EU climate policy with and without carbon import tariffs, mean results across 12 global CGE models

Note: for descriptions of models that generated this data base see Böhringer et al. (2012)

Thus, summarizing and in line with our previous argument, the models confirm that (a) the introduction of a border carbon import tax increases global cost-effectiveness, and that (b) it is crucial to distribute tax revenues to the exporting countries in order not to increase burdens for Non-Annex 1 countries.

Finally, when analyzing full carbon border adjustment (i.e. impart carbon tariffs as well as export carbon rebates) we find the following quantitative results. In terms of cost-effectiveness the carbon price within the EU decreases further, indicating a yet higher cost-effectiveness, but quantitative results show that this rise is only ½ per cent, and thus minor. Welfare results are given in Figure 4. While granting export rebates does reduce welfare costs to EU, in terms of welfare implications they are not relevant for Non-Annex 1. As far as justice for Non-Annex 1 is concerned, it practically only matters that import tariff revenues are distributed to the exporting countries.

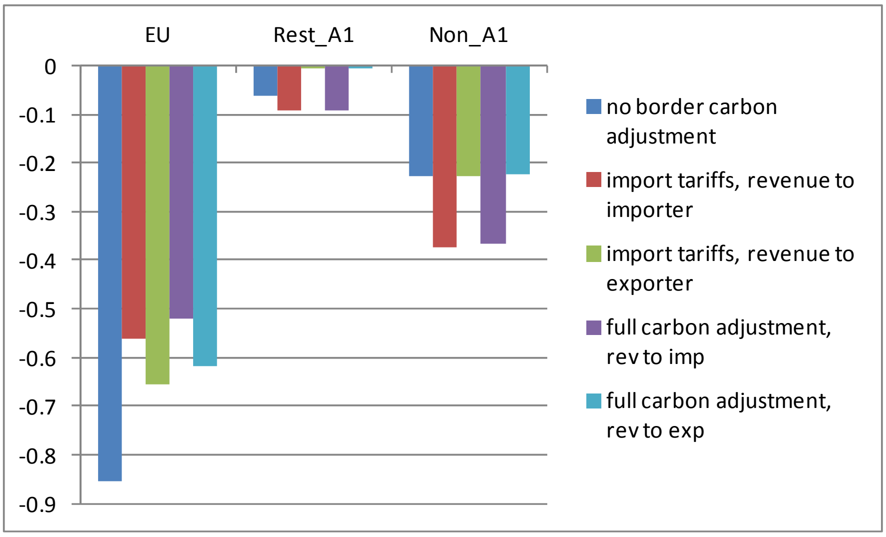

Figure 4: Hicksian equivalent variation for unilateral EU climate policy with and without border carbon adjustment, mean results across 12 global CGE models

Note: for descriptions of models that generated this data base see Böhringer et al. (2012)

5.4 Summary

For a switch to consumption-based policy by means of border carbon adjustment we find that the likely benefits on justice and effectiveness grounds that come with such a switch, while dependent on actual parameter settings, are confirmed by a quantitative comparison of simulation results within twelve global CGE models. When introducing border carbon adjustment it is crucial to distribute tariff revenues to the exporting and not to the importing countries in order to have a just outcome.

Second, and not shown in empirical analysis, the burden for Non-Annex 1 economies can be lifted when the accessibility of clean technologies for them is improved, which could be accomplished by technology transfer. Obviously, technology transfer to region N eases N´s adjustment to deal with carbon import tariffs implemented by region A. The technology also increases overall cost-effectiveness. In the extreme case with no clean technologies available in N an introduction of carbon import tariffs does not induce a change in N´s export production towards a cleaner one, but just reduce N´s exports. To the contrary it does induce N to import less cleaner products from A and produce more for the home demand itself, albeit with dirty technologies. Allowing for technology transfer changes this situation and enhances the cost-effectiveness of a unilateral climate policy.

Third, while we have shown that export rebates could help on both accounts, justice and cost-effectiveness, we also have found that empirically their impact on both criteria seems negligible (i.e. within the quantitative frameworks available so far).

Other arguments against granting export rebates if the policy region is an industrialised country (or a group of such countries) include the fact that that unilateral climate policy makers would want to cover as many global emissions as possible. Without export rebates the policy base is even larger than under CBA, as also goods consumed outside the policy region are covered. This is more expensive than rebating the exported goods for their carbon costs, but this increase in overall unilateral climate policy costs do not have a large impact on welfare of the policy region.

Second, from the point of view of the developing countries, the rebates for exports from region A could be regarded as unfair competition. Rebates make the exports cheaper compared to the production based climate policy. As policymakers in developing countries often regard their industries as the key for economic development, there is some strong political objection to be expected from them.

Third, given the claim that historical emitters (i.e. the industrialized countries) should be the leaders in combating climate change, the exemption of parts of the industry from their domestic climate policy could be regarded as undermining the credibility of frontrunners, such as the EU.

6 Conclusions

By investigating the implications of a unilateral switch in climate policy from production to consumption-based policy, we find it crucial to design a consumption based approach such as to move the final welfare distribution closer towards a just outcome.

We also find that the application of border carbon adjustments by an industrialized country does not automatically resolve the challenges of justice and effectiveness faced when implementing a carbon abatement policy on a unilateral basis. Furthermore, the application of import tariffs can have welfare effects that undermine justice considerations by shifting the burden towards lower income countries through the terms of trade effects. At the same time, such tariffs enable a cost effective unilateral policy if they address those goods that have a higher average emissions-intensity and a lower marginal abatement cost. For cost-effectiveness to occur, however, clean technologies have to be accessible.

As a result, achieving an effective and just policy base switch requires support on two fronts. First, the implementation of import tariffs requires financial transfers from the abatement policy region to the non-policy region in order to compensate for any associated income loss in the non-policy region. Revenues of import tariffs can be devoted for that end. Second, technological transfers are also required to ensure that emission abatement occurs at the point of least cost.

However, the application of export rebates which is an integral part of the unilateral switch in the accounting base, undermines the dynamic incentives to bring about abatement in the emissions-intensive export sectors of the abatement policy region. Whilst export rebates do have a positive effect on developing countries in terms of welfare, it is small. In other words, the potential of export rebates to reduce welfare losses in developing countries that arise from carbon import tariffs is low, given current carbon trade balances between developing and industrialized countries. If the granting of export rebates turns out to be a humbling block in climate negotiations, their introduction thus can be easily omitted without much loss on justice and cost-effectiveness accounts.

References

Barker, T., S. Junankan, H. Pollitt, P. Summerton (2007). Carbon leakage from unilateral enviromental tax reforms in Europe, 1995-2005, *Energy Policy* 35: 6281-6292.

Bastianoni, S., F. M. Pulselli, et al. (2004). "The problem of assigning responsibility for greenhouse gas emissions." *Ecological Economics* 49.

Bednar-Friedl, B., T. Schinko, K.W. Steininger (2012), The relevance of process emissions for carbon leakage: A comparison of unilateral climate policy options with and without border carbon adjustment, *Energy Economics* (forthcoming) online first: http://dx.doi.org/10.1016/j.eneco.2012.08.038

Boehringer, C., C. Fischer, K. E. Rosendahl (2010a). The Global Ewffects of Subglobal Climate Policies, *The B.E. Journal of Economic Analysis & Policy*, 10 (2), (Symposium), Article 13

Boehringer, C., A. Lange, T. Rutherford (2010b). Optimal emission pricing in the presence of international spill-overs: decomposing leakage and terms-of-trade motives, NBER Working Paper 15899, National Bureau of Economic Research, Washington.

Boehringer, C., T. Rutherford, E. Balistreri (2012), The Role of Border Carbon Adjustment in Unilateral Climate Policy, Insights From An EMF Model Comparison, *Energy Economics* (forthcoming).

Braham, Matthew and Martin van Hees (2009), "Degrees of Causation, *Erkenntnis*, 71, 323-344.

Braham, Matthew and Martin van Hees (forthcoming), "An Anatomy of Moral Responsibility", *Mind*.

Burniaux, J., J. Chateau and R. Duval (2010), “Is there a Case for Carbon-Based Border Tax Adjustment?: An Applied General Equilibrium Analysis”, *OECD Economics Department Working Papers*, No. 794, OECD Publishing.

Burniaux, J.-M., J.O. Martins (2011). Carbon leakage: a general equilibrium view, Economic Theory 9 (January), doi: 10.1007/s00199-010-0598-y

Caney, Simon (2009), "Justice and the distribution of greenhouse gas emissions", *Journal of Global Ethics*, 5:2 ,125 — 146.

Clapp, C. (2010). Levelling the Playing Field in a Fragmented Carbon Market: Do Carbon-Based Border Tax Adjustments Work? Climate Science and Policy. Available on the internet: http://www.climatescienceandpolicy.eu/2010/09/levelling-the-playing-field-in-a-fragmented-carbon-market-do-carbon-based-border-tax-adjustments-work/. Retrieved March 7, 2011.

Droege, S. (2011a). "Do border measures have a role in climate policy?" *Climate Policy* **11**(5).

Droege, S. (2011b). Using border measures to address carbon flows, *Climate Policy* 11: 1191-1201.

Droege, S., H. van Asselt H, T. Brewer, M. Grubb, R. Ismer, Y. Kameyama, M. Mehling, S. Monjon, K. Neuhoff, P. Quirion, K. Schumacher, L. Mohr, W. Suwala, Y. Takamura, T. Voituriez, X. Wang (2009). Tackling leakage in a world of unequal carbon prices, Report Climate Strategies.

Gilabert, Pablo and Holly Lawford-Smith (forthcoming), "*Political Feasibility. A Conceptual Exploration*", Political Studies.

Ferng, J.-J. (2003). "Allocating the responsibility of CO2 over-emissions from the perspectives of benefit principle and ecological deficit " *Ecological Economics* 46.

Fischer, C., A. K. Fox (2012). Comparing Policies to Combat Emissions Leakage: Border Carbon Adjustments versus Rebates. *Journal of Environmental Economics and Management* 64 (2), 199–216.

Gerlagh, R., O. Kuik (2007). Carbon Leakage with International Technology Spillovers, FEEM Nota Di Lavoro 33.2007.

Gros, D., Christian Egenhofer, Noriko Fujiwara, Anton Georgiev, Selen Sarisoy Guerin (2010), Climate Change and Trade: Taxing carbon at the border?, *CEPS Paperbacks*.

Hart, H.L.A. (1968), *Punishment and Responsibility: Essays in the Philosophy of Law* (Oxford: Clarendon Press).

Honoré, Antony, "Causation in the Law", *The Stanford Encyclopedia of Philosophy (Winter 2010 Edition)*, Edward N. Zalta (ed.), http://plato.stanford.edu/archives/win2010/entries/causation-law/.

Houser, T., R. Bradley, B. Childs, J. Werksman, R. Heilmayr (2008), *Leveling the Carbon Playing Field*, World Resources Institute.

IPCC (2007). Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Interngovernmental Panel on Climate Change, Metz, B., O.R. Davidson,P. R. Bosch,R. Dave, L. A. Meyer, Eds.; Cambridge University Press: Cambridge, UK/New York.

Jakob, M., R. Marschinski (2012), Interpreting trade-related CO2 emission transfers, *Nature Climate Change*, doi:10.1038/nclimate1630

Kondo, Y., Y. Moriguchi, et al. (1998). "CO2 emissions in Japan: influences of imports and exports." *Appl Energy* 59.

Kuik, O., M. Hofkes (2010). Border adjustment for European emissions trading: competitiveness and carbon leakage. *Energy Policy* 38(4), 1741-1748.

Lenzen, M., Murray, J., Sack, F., Wiedmann, T. (2007), “Shared producer and consumer responsibility – Theory and practice”, *Ecological Economics*, 61, 27–42.

Lippert-Rasmussen, Kasper (2009), "Justice and Bad Luck", in: Edward N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy (Fall 2009 Edition)*, http://plato.stanford.edu/archives/fall2009/entries/justice-bad-luck/.

Lockwood, B. and J.Whalley (2008), “Carbon Motivated Border Tax Adjustments: Old Wine in Green Bottles?”, NBER Working Paper No. 14025.

Mattoo, A., Subramanian, A., van der Mensbrugghe, D. and J. He (2009), Reconciling Climate Change and Trade Policy, *World Bank Policy Research Working Paper* No. 5123. World Bank, Washington D.C.

McKibbin, Warwick and Peter Wilcoxen (2009), The economic and environmental effects of border tax adjustments for climate policy, *CAMA Working Paper* 9/2009.

Miller, David (2007), *National Responsibility and Global Justice*, Oxford: Oxford University Press.

Munksgaard, J. and K. Pedersen (2001). "CO2 accounts for open economies: producer or consumer responsibility?" *Energy Policy* **21**.

Muñoz, P., K. W. Steininger (2010). Austria's CO2 responsibility and the carbon content of its international trade. *Ecological Economics*, 69(10): 2003-2019.

Nakano, S., A. Okamura, N. Sakurai, M. Suzuki, I. Tojo, N. Yamano (2009). The Measurement of CO2 Embodiments in International Trade: Evidence from the Harmonised Input-Output and Bilateral Trade Database, OECD Science, Technology and Industry Working Papers, 2009/3.

Peters, G. P. (2008). From production-based to consumption-based national emissions inventories, *Ecological Economics* 65: 13-23

Peters, G. P. and E. G. Hertwich (2006). "Pollution embodied in trade: the Norwegian case." *Global Environmental Change* 16.

Peters, G., E.G. Hertwich (2008a). CO2 embodied in international trade with implications for global climate policy. *Environmental Science and Technology*, 42(5):1401-1407

Peters,G., E.G. Hertwich (2008b). Post-Kyoto greenhouse gas inventories: Production versus consumption. *Climatic Change*, 86(1-2):51-66.

Peters, G., J.C. Minx, C.L. Weber, O. Edenhofer (2011). Growth in emission transfers via international trade from 1990 to 2008, Proceedings of the National Academy of Science of the United States.

Rawls, J., 1999, *The Law of Peoples*, Cambridge, MA: Harvard University Press.

Scanlon, T. (1998), *What We Owe to Each Other*, Cambridge, Mass.: Harvard University Press.

Stemplowska, Zofia (forthcoming), "Luck Egalitarianism", in: Gerald Gaus and Fred D'Agostino (eds), *The Routledge Companion to Social and Political Philosophy*.

Stern, N. (2007). The Economics of Climate Change, Cambridge University Press.

Swift, Adam (2008), "The Value of Philosophy in Nonideal Circumstances", *Social Theory and Practice*, 34 (3), 363 – 387.

UNFCCC (1992). "United Nations Framework Convention on Climate Change."

UNFCCC (1997). The Kyoto Protocol to the Framework Convention on Climate Change. Available on the Internet: <http://unfccc.int/essential_background/kyoto_protocol/background/items/1351.php>.

UNFCCC (1998). Decision 2/CP.3. Methodological issues related to the Kyoto Protocol. (FCCC/CP/1997/7/Add.1)

Vallentyne, Peter (2008), "Brute Luck and Responsibility", *Politics, Philosophy & Economics*, 7, 57 – 80.

Weisbach, David “Negligence, Strict Liability, and Responsibility for Climate Change” Discussion Paper 2010-39, Cambridge, Mass.: Harvard Project on International Climate Agreements, July 2010.

Wiedmann, Thomas (2009). A review of recent multi-region input-output models used for consumption-based emission and resource accounting, *Ecological Economics*, 69: 211-222.

Wyckoff, A. W. and J. M. Roop (1994). "The embodiment of carbon in imports of manufactured products: implications for international agreements on greenhouse gas emissions." *Energy Policy* 22.

Graz Economics Papers

For full list see:

http://www.uni-graz.at/vwlwww/vwlwww_forschung/vwlwww_gep.htm

Address: Department of Economics, University of Graz,
Universitätsstraße 15/F4, A-8010 Graz

06–2012 **Karl Steininger, Christian Lininger, Susanne Droege, Dominic Roser, Luke Tomlinson**: Towards a Just and Cost-Effective Climate Policy: On the relevance and implications of deciding between a Production versus Consumption Based Approach

05–2012 **Miriam Steurer, Robert J. Hill, Markus Zahrnhofer, Christian Hartmann**: Modelling the Emergence of New Technologies using S-Curve Diffusion Models

04–2012 **Christian Groth, Ronald Wendner**: Embodied learning by investing and speed of convergence

03–2012 **Bettina Brggemann, Joern Kleinert, Esteban Prieto**: The Ideal Loan and the Patterns of Cross-Border Bank Lending

02–2012 **Michael Scholz, Jens Perch Nielsen, Stefan Sperlich**: Nonparametric prediction of stock returns guided by prior knowledge

01–2012 **Ronald Wendner**: Ramsey, Pigou, heterogenous agents, and non-atmospheric consumption externalities