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Differentiating (historic) responsibilities for climate change

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Following the conclusion of the official work of the Ad Hoc Group for the Modelling and Assessment of Contributions to Climate Change (MATCH), this article considers the politically more sensitive aspect of the Brazilian proposal, namely the issue of differentiating (historic) responsibility for, and not merely (causal) contribution to climate change. Its aim is (1) to highlight the fact that, while related, the two issues ('contribution to' and 'responsibility for') are fundamentally different and should not be confused, and (2) to propose a methodology for calculating shares of responsibility as opposed to the shares in causal contribution arrived at through the MATCH results. Two conceptions of responsibility ('strict' or 'limited') are applied in order to operationalize the notion of 'respective capabilities' given in Article 3.1 of the UNFCCC. The key message resulting from the calculations is that causal contribution – while an important indicator of (environmental) relevance to the problem – must not be confused with the moral responsibility for it. The rather large difference between the responsibilities at the two extremes of the scale under both conceptions gives pause for thought as to what sorts of burdens can justly be demanded in any application of the UNFCCC *principle of common but differentiated responsibilities*, whether in the context of the Brazilian proposal or beyond.

Keywords: Brazilian proposal; burden sharing; climate change; equity; historical responsibility; MATCH; moral responsibilities; North–South; responsibility

Suite à la fin du travail officiel entrepris par le Groupe Spécial sur la modélisation et la détermination des contributions aux changements climatiques (MATCH), cet article considère les aspects plus politiques de la Proposition Brésilienne, c'est-à-dire la question des responsabilités (historiques) différenciées, et pas seulement les contributions (selon la relation de cause à effet) aux changements climatiques. Son objectif est (i) de souligner le fait que, bien que liées, les deux préoccupations (« contribution à » et « responsabilité pour ») sont fondamentalement différentes et ne devraient pas être confondues, et (ii) de proposer une méthodologie pour calculer la part des responsabilités par opposition à la part des contributions causales, obtenues à travers les résultats de MATCH. Deux manières de concevoir la responsabilité (« stricte » ou « limitée ») sont appliquées pour opérationnaliser la notion de « capacités respectives » donnée à l'Article 3.1 de la CCNUCC. Le message principal issu des calculs est que la contribution causales – bien qu'étant un indicateur important de la pertinence (environnementale) au problème – ne doit pas être confondues avec la responsabilité morale vis-à-vis de celui-ci. La différence quelque peu large entre les notions de responsabilité de chaque côté de l'échelle donne matière à reflexion quant aux types de fardeaux pouvant être dignement exigés dans l'application du principe de responsabilités communes mais différenciées *de la CCNUCC, que ce soit dans le contexte de la Proposition Brésilienne ou au-delà.*

Mots clés: changement climatique; équité; MATCH; Nord–Sud; partage du fardeau; Proposition Brésilienne; responsabilité; responsabilité historique, responsabilités morales

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1. Introduction

Climate change is increasingly acknowledged to have strong ethical dimensions (Stern, 2006), and global solutions are unlikely to be crafted, or stable, without some broad conception of what would be fair (IPCC, 1996). There is a burgeoning literature on these dimensions (Gardiner, 2004; Brown et al., 2006). Rather than addressing these broad issues, this article focuses on a particular dimension, namely that of historical responsibility, as given political salience through the continuing negotiations spawned by the Brazilian proposal, submitted as part of the negotiations of the Kyoto Protocol in 1997 (UNFCCC, 1997).

The delegation of Brazil presented an approach for allocating reductions in greenhouse gas emissions among OECD countries and economies in transition (the Annex I Parties) based on the effect of their cumulative historical emissions of greenhouse gases (GHGs) included in the Kyoto Protocol, from 1840 onwards, on the global-average surface temperature.

Although it was not adopted during the Kyoto negotiations, the Brazilian proposal did receive support, especially from developing countries, and the Third Conference of the Parties (COP-3) requested the Subsidiary Body on Scientific and Technical Advice (SBSTA) to further study the methodological and scientific aspects of the proposal. This led to continued debate and analysis (e.g. den Elzen et al., 2002, 2005a; Andronova and Schlesinger, 2004; Höhne and Blok, 2005; Trudinger and Enting, 2005; Rive et al., 2006; Rive and Fuglestvedt, 2007).

A follow-up exercise has been carried out by an Ad Hoc Group for the Modelling and Assessment of Contributions to Climate Change (MATCH) (Höhne and Ullrich, 2003) to improve the robustness of calculations and more rigorously assess the uncertainties and methodological choices. This has resulted in the submission of four technical papers to SBSTA and for publication in academic journals (den Elzen et al., 2005b; Ito et al., 2008; Höhne et al., 2009; Prather et al., 2009). While the MATCH process and its resulting publications concentrated on the *causal contribution* of emissions originating from the territory of a country, the present article turns the focus on the *moral responsibility* for climate change. It turns the issue from a scientific into a moral question concerning the interpretation of the results of the MATCH group.

In the past, the distinction between historical contribution and responsibility for climate change has not always been clear, and our intention is to explicate and clarify this distinction. Furthermore, it has been suggested that the past work on historical contributions for climate change, by focusing on the technical, natural science aspects, neglected the ethical and interpretational aspects. Analysis of this earlier work resulted in a clear demand for more discussion of these normative and moral aspects (Botzen et al., 2008; Friman and Linnér, 2008; Klinsky and Dowlatabadi, 2009). This article is in response to those demands.

2. The conceptual framework

2.1. Contribution versus responsibility

Climate impacts – be they anthropogenic, due to natural variability, or other factors – will inevitably have a large number of causes, each causally contributing to the impacts in question. The (moral) responsibility for climate impacts will also typically be shared by a number of actors. The key difference between being morally (partly) responsible for, and (causally) contributing to is that the former is a blameable matter which only makes sense if the impacts are anthropogenic, while the latter is not. The 1628 BC eruption on the Aegean island of Thera (Santorini),[1] it has been argued, led to an average global cooling of 1.5°C over the following 100 years, and consequently to the downfall of the Minoan civilization,[2] but it would be considered ridiculous to hold the mountain morally responsible.

The problem is that in the case of *anthropogenic* impacts, the difference, while still remaining, is sometimes not quite as self-evident. There is a link between a moral agent causally contributing to an impact and being morally (partly) responsible for it,[3] but that does not mean that the two are the same. The difference becomes clearer when considering that they generally imply different shares.

The MATCH project modelling focused on determining the causal contribution of time series of greenhouse gases covered under the UNFCCC to certain climatic impacts, in particular to changes in mean global temperature. The lesson has been that one really cannot speak of causal contributions to climate change *per se*, at least not if one is intent on specifying numerical shares thereof.

The advantage of focusing on the effects of emission time series on certain climate parameters was the purely scientific nature of the exercise, which was meant to prevent the discussions from being dragged into normative or even moral debate. Even in the context of establishing shares in causal contribution, normative issues could not be completely avoided. One of the key normative decisions was the way in which emission time series were associated with particular countries. It is one thing to say that this and that series of emissions have contributed a certain percentage to the increase in global mean temperature over the 20th century, and quite another to say that the United States of America has done so. The former is purely scientific; the latter involves a normative decision of how to identify 'the emissions of the USA' (at a given time). The implicit assumptions of the MATCH team were that (1) the (anthropogenic) emissions associated with a country for a given period are those emitted over its sovereign territory, and (2) the sovereign territory changes over time.[4]

There are a number of problems with this traditional conception, not least that it does not lend itself easily to accommodating 'bunker fuel' emissions from international travel and transport. Another, lesser known, problem with this sort of traditional sovereignty-based definition is that it does not take account of joint contributions and responsibilities, short of pooling the sovereignty of the territories in question. This shortcoming will be discussed briefly in the context of Article 4 of the UNFCCC, which can be interpreted as implying joint North–South responsibility over the (increments in) emissions in developing countries since the Convention was signed in 1992. For the rest of this article, the traditional sovereign territory definition of countries' 'anthropogenic' emissions will be followed, both for determining their relevant causal contributions and their moral responsibilities.

2.2. Types of responsibility: a loosely Aristotelian framework

To be responsible for something harmful is to be worthy of blame for it.[5] Aristotle (1908) contended that blame and praise are bestowed on *voluntary* actions, while *involuntary* ones are pardoned. The key to responsibility for actions is thus their voluntary status, for which he gave two necessary conditions:

1. There is a *control condition*: the action or trait must have its origin in the agent. That is, it must be up to the agent whether to perform that action or possess the trait – it cannot be compelled externally.
2. Aristotle also proposed an *epistemic condition*: 'the agent must be aware of what it is s/he is doing or bringing about' (Eshleman, 2004).

However, ignorance per se seems to be slightly too easy an excuse to justify pardoning, which is why the condition is usually strengthened insofar as the agent *could reasonably have been expected to know*.

Aristotle's conception of 'responsibility' is based in his theory of virtue, which concerns 'passions and actions'. But there are other theories which see the concept rather in the context of duties, in particular in derelictions of duty, which are not (necessarily) actions but are equally liable to give rise to blame. Figure 1 is an attempt at representing the interplay between the distinctions of voluntary/involuntary, harmful/harmless, agency-based/duty-based, and the type/level of blameworthiness (responsibility) attached to their combinations.

Aristotle's conditions on assigning blame to actions (and, by that fact, also to agents) are about whether they are carried out voluntarily or involuntarily. However, as illustrated in Figure 1, blame can also be assigned or withheld regardless of this distinction. If, for example, the effects of an action are *harmless* (category I), then clearly no blame should be attached to it, even if it was voluntary. Moreover, there are situations where, contrary to Aristotle's conditions, 'strict' blame (responsibility) is handed out simply on the ground that the effects are harmful, regardless of whether the harm was done voluntarily or involuntarily (category III.b).

2.2.1. Act-based blame

In the context of climate change, blame/responsibility is usually seen as applying to certain acts, namely the emission of greenhouse gases: i.e. it is act-based. For example, if someone drives a car, and if the emissions resulting from this act are deemed to be harmful, then they may be judged to deserve unreserved blame just because the emissions are harmful (strict blame, ① in Figure 1) or because they drove voluntarily, in the full knowledge of the harmfulness of the emissions and without coercion (unlimited blame, ②). If, however, they can plead reasonable ignorance or coercion, then they may get a (limited) pardon (no/limited blame, ③). Finally, if the emissions in question are classified as harmless, then no-one can justly be blamed (no blame, ④).

2.2.2. Duty-based blame

What is not usual is to consider blaming someone for certain harmful emissions not because they were actively engaged in emitting, but because they had a duty to prevent them. Thus if two individuals, say Jane and John, enter a contract that Jane is to reduce her emissions and that

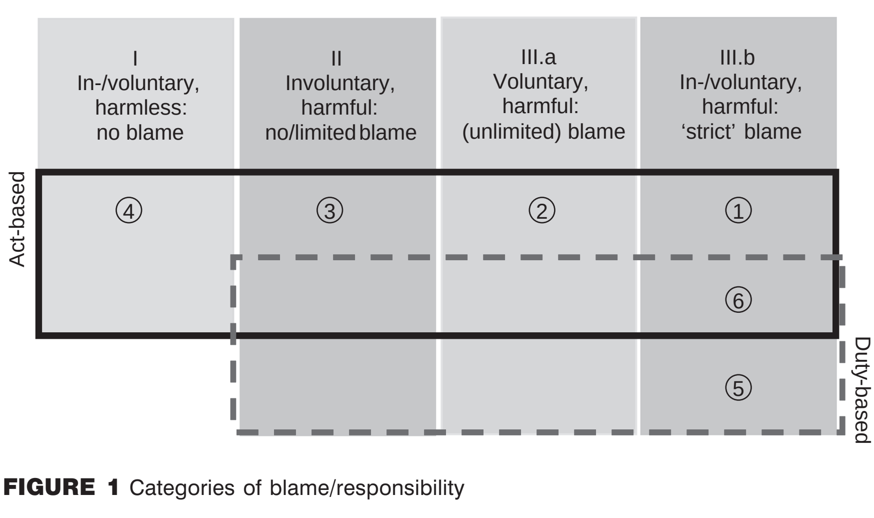

FIGURE 1 Categories of blame/responsibility

John is to bear her additional costs, then it can be argued they both have a joint duty to reduce Jane's emissions, and that, if the reduction does not occur, they could be jointly blamed. The blame may, of course, not lie equally. Jane may have wished to reduce but did not receive the money to do so; or John may have wished to pay for Jane's emission reduction, but Jane had no inclination to do so. The point being that John might have to take responsibility for a certain amount of emissions, even though they were not actually emitted by him (⑤), while Jane may not have to take responsibility for the whole of the emission increment she failed to reduce, because there was a joint dereliction of duty (⑥).

3. Differentiating contributions and responsibilities

3.1. Methodologies

3.1.1. Causal contribution shares: the MATCH methodology

The methodology of the MATCH project was designed to establish the relative causal contributions by countries to changes in global average temperature. The MATCH percentage figures for countries' shares in contributing to these changes were determined by the anthropogenic emissions that have historically been emitted from their sovereign territory. These percentage shares are themselves relative to the type of impact chosen, and they depend on the sequential order of the emission series in question. However, to simplify the calculations, it is possible to use the sum of the historic emissions – or rather their relative size – as a reasonable approximation for the purposes of this article for their relative causal contributions (den Elzen et al., 2005b; Hope, 2008). Instead of using the MATCH project modelling techniques, the aggregate historic country emissions – using the 1995 global warming potentials (GWPs) for different gases as used under the Kyoto Protocol – emitted between 1890 and the present (2005) are simply used here as determinants of the contribution as well as responsibility shares in question. The proportion between countries' historic emissions since 1890 is used as a proxy measure of the relative size of their contribution to climate change impacts.[6]

3.1.2. Responsibility shares: the allowance-based methodology

The issue of how to measure and compare responsibilities has been controversial for some time, not least with respect to comparisons between the 'large emitters' such as the USA and China. In a recent newspaper article, the IEA chief economist was reported to predict that 'China may overtake the United States as the world's biggest source of greenhouse gases within months'; however, he also 'accepted that on a per capita basis, people in rich countries still emit far more than individual people in China … Historically, China has also contributed little to the present build-up of greenhouse gas emissions in the atmosphere.'[7]

The problem with either aggregate (i.e. country-wide) or per capita emissions measures is that, while they may capture some facet of the relevant notion of 'responsibility', they both fail in capturing others. The percentage shares derived from the aggregate figures clearly capture the causal contribution aspect of responsibilities, but they cannot, by definition, reflect other potentially relevant country aspects, such as population size. Per capita emission figures, on the other hand, do reflect population size, but they are unable to reflect causal contributions, with the effect of assigning the same responsibility to both China and Latvia with 0.8 tC per capita, but a 500-fold difference in aggregate emissions.[8]

There is no general answer to whether responsibility should be measured in absolute (single parameter) or relative (multi-parameter) terms. There are cases of emission-based responsibilities which should be quantified in absolute terms, i.e. in terms involving only one parameter, namely physical emissions. In other cases, it may be necessary to relativize these figures in terms of other relevant parameters, such as population size – when talking about group/country responsibilities – or wealth/economic production. Traditionally, these relativizations have been operationalized by simple parameter divisions such as the well-known per capita and per unit of economic output (GDP) measures.[9]

Aggregate – i.e. country or regional – responsibility for climate change (impacts), as argued in this article, needs to be relativized in the sense that it has to be measured in multi-parameter terms, including – apart from emissions – the size of (certain) populations. However, the traditional operationalization in per capita terms oversimplifies the situation. Instead a (bottom-up) allowance-based methodology is proposed, which generalizes both the traditional absolute and per capita measures.

The idea is that allowances may be allocated to emitters, which they can use against their emissions in calculating their level of responsibility. It is, in general terms, analogous to the system of tax allowances used in most countries in differentiating the tax burden. There can be different kinds of such 'climate change responsibility allowances', depending on the (moral) justification for their allocation. For example, if a certain level of (greenhouse gas) emissions is deemed to be harmless, then one would have to allocate what we would call '*basic allowances*' to cover these harmless emissions, on the grounds that no-one should be held responsible (blamed) for a harmless activity.

Other allowances could be allocated on the basis of basic needs, in turn justified by way of the Aristotelian 'control condition' that one cannot be held responsible for what is not under one's control. This kind of allowance has been implemented by looking at '*subsistence allowances*', based on the assumption that poverty eradication is an overriding moral aim, and that in present circumstances it can only be achieved through activities which generate a certain amount of emissions. There may, of course, be other (basic) needs-based allowances which might need to be considered, such as the requirement to keep the ambient temperatures within certain limits in order to survive. The Aristotelian 'epistemic condition' that one should not be held responsible for actions which one could not reasonably have been expected to know were harmful – mere ignorance is not sufficient – could also be used to justify the introduction of what might be called 'epistemic allowances'. The main difference between these Aristotelian-based allowances and the above-mentioned basic kind is that, while the latter can be seen as 'certificates of harmlessness', the former are merely 'responsibility waivers' applied to emissions which would otherwise have been counted as harmful and blameworthy. The main consequences of this is that, while basic emissions should be transferable, these 'responsibility waivers' should not be, and the latter ought to be used only as a 'back-up' to the former (should both be issued), and not as a complement.

Apart from the question of what sort of allowances should be admitted to be counted against one's responsibility (for climate change), the key issue with this sort of methodology is how to allocate those that have been admitted. We believe that in the case of basic and subsistence allowances, a 'bottom-up' approach to country allocations – i.e. a definition of country allocations in terms of personal ones – is the most appropriate. Note that this does not imply that country emissions have to be defined in the same way. In particular, this bottom-up approach to allocating basic and subsistence allowances is perfectly compatible with the traditional definition of country emissions as the emissions originating from their sovereign territories.

In the case of epistemic allowances – meant to operationalize Aristotle's epistemic condition – there is no need to recourse to such a bottom-up approach to country allocations, particularly if one adheres to the traditional definition of country emissions. All that is necessary, on either the personal or the country level, is to ensure that all the emissions which happened in justifiable ignorance of their harmfulness be covered by allowances.

As concerns personal basic allocations, it can be argued that they should be allocated on egalitarian principles for the same reasons as those given in support of the per capita allocation of global emission permits.[10] The bottom-up methodology then implies that countries can disregard $b \times p_i$ of their emissions in responsibility calculations, where b is the global per capita figure of harmless emissions, and p_i is the population of country/region i. This illustrates how population figures enter the allocation-based country responsibility measures, and that they are quite different from the traditional per capita measures.[11]

The difference becomes even more marked if some of the other population-related allowances are considered. While there are arguments for a differentiated allocation (in accordance with particular needs) in the case of subsistence allowances, it is clear that if they are allocated equally they would normally not be allocated to the whole population of a country, but only to those who are eligible by living below some predetermined poverty line. In other words, it is possible that the allocation of subsistence allowances to a country is dependent on population size, thus generating a (population-)relative responsibility measure. But – unlike in the traditional per capita methodology – the populations in questions do not include all residents, but only 'special needs' groups; namely the country's poor. The proposed allowance-based methodology thus manages to reflect certain population sizes in establishing country/regional climate change responsibilities without the danger of unjustifiably diminishing within-country responsibility differences – by letting the responsible (carbon-)rich hide behind their (carbon-)poor compatriots – as can happen in the case of the traditional per capita methodology.

3.2. The data

The calculations made in this article are based on data coming from a variety of sources. The same emissions dataset as in the latest modelling effort of the Ad Hoc Group for the Modelling and Assessment of Contributions to Climate Change (MATCH) is used. This includes 192 countries and three sectors: energy and industry (CO_2, CH_4, N_2O), agriculture/waste (non-CO_2), and land use change and forestry (CO_2) from 1750 to 2100. It is derived with an algorithm that combines emissions estimates from various sources in the following hierarchy:

- National submissions to the UNFCCC published in the Greenhouse Gas Inventory database (UNFCCC, 2007)
- CO_2 emissions from fuel combustion as published by the International Energy Agency (IEA, 2006)[12]
- Emissions of CH_4 and N_2O as estimated by the US Environmental Protection Agency (USEPA, 2006)
- CO_2 emissions from fuel combustion and cement production as published by Marland et al. (2003)
- Regional historical data from the EDGAR-HYDE dataset (Klein Goldewijk and Battjes, 1995).

The emissions of different greenhouse gases are multiplied by their global warming potential and added up, leading to a single amount of carbon dioxide equivalent (CO_2-eq) emissions.[13]

The source data takes into account changing geographical borders, but only for energy and industrial CO_2. Other gases and sectors are based on current sovereign territory. If a currently existing country did not exist over the whole period, emissions are backward-extrapolated based on the country's current sovereign territory.

Historical population data was taken from the HYDE database (Klein Goldewijk, 2007) and Penn World Tables (PWT, 2006) and, where these were not available, the World Development Indicators 2006 (World Bank, 2006).[14] Poverty headcount ratio (as a percentage of population) at $1 and $2 per day and GDP data (PPP current international $) were obtained from the same source as for calculating the size of poor populations.[15]

4. Results

4.1. Context

Causal contributions were calculated for all countries, but for simplicity we have chosen to focus on six countries – three from Annex I (Japan, Russia and the USA) and three from non-Annex I (Brazil, China and India) – and five groups: the European Union before and after the 2004 enlargement (EU-15, EU-25), the Organization of Petroleum Exporting Countries (OPEC), the Alliance of Small Island States combined with the Group of Least Developed Countries (AOSIS+LDC – 76 countries), and the group of industrialized countries listed in Annex I of the UN Framework Convention on Climate Change (Annex I). In order to understand the contribution and responsibility figures discussed in the following two sections, it is important to appreciate certain basic economic and demographic facts about these entities, concerning their relative wealth and population sizes.

Figure 2 depicts three non-emission parameters for the year 2005 that are of interest in the subsequent analyses of contribution to and responsibility for climate change by these countries and country groupings, namely their share in global wealth (defined in terms of current PPP GDP), in global population, and in global poverty, measured in terms of the number of people living on $1 or less per day. Not surprisingly, the developed and developing world (Annex I/non-Annex I; North/South) are not the same with respect to these three dimensions: while the 20% of the world

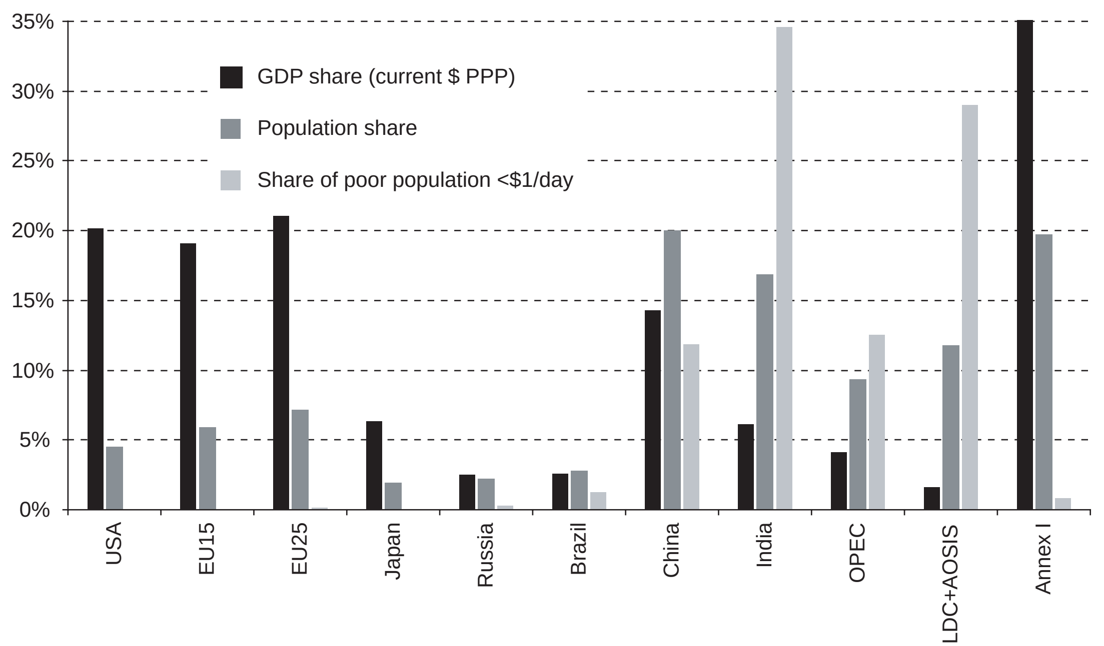

FIGURE 2 Economic and demographic context

population that lives in the North (Annex I) owns 56% of global wealth, the South is home to 99.2% of the global very poor. These proportions will have some impact on our responsibility calculations, which is why it is important to keep in mind that they can change considerably depending on the level of poverty one considers. This issue will be revisited below in the sensitivity analysis section, but just to give an example, and to give an idea of what these shares stand for in absolute terms, consider the fact that China's global share in extreme poverty of 12% translates into 129 million people, and India's 35% into 377 million; while the population of those living below $2 (PPP) per day is 454 million in China and a staggering 881 million in India.

4.2. Differentiating causal contributions

According to the simplified methodology chosen for the purposes of this article, the share of a country's – or group of countries' – contribution to climate change is given by their share in global historic GWP-weighted GHG emissions. However, to be able to calculate these shares, some further parameters need to be specified, such as the time frame, the types of emissions, and the countries or group of countries to be considered. For the purposes of this article, the chosen time horizon is 1890,[16] and the emissions are those considered under the Kyoto Protocol.

4.2.1. Reference case (RC) contributions

Historically, industrialized countries (as listed in Annex I) have contributed the majority of GHGs, namely 54.5% – a figure which in the present simplified methodology represents their share in the causal contribution to the climate change problem. The causal contribution shares in detail, as represented in Figure 3, are (in descending order of magnitude): USA (19.7%), EU-25 (17.8%), EU-15 (14.8%), China (10.8%), OPEC (7.3%), Russia (6.5%), AOSIS+LDC (5.7%), Brazil (4.3%), India (3.9%) and Japan (2.8%).

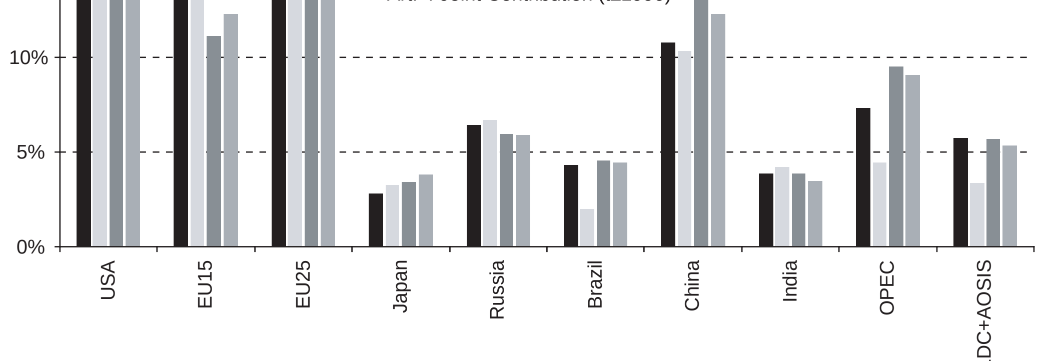

FIGURE 3 Causal contributions to climate change

These proportions can vary significantly depending on the sorts of gases and sources/sinks that are taken into consideration. For example, if emissions from land use, land-use change and forestry (LULUCF), which are relatively uncertain, are excluded, Annex I contributions increase by almost one-fifth (+10.2 percentage points), most of it absorbed by the USA (+5.2% points) and the EU (+4.3/+3.7% points), with the chief beneficiaries Brazil (–2.3% points), AOSIS+LDC (–2.3% points) and OPEC (–2.9% points). The last may seem somewhat surprising, but is explained by the fact that the non-Middle Eastern OPEC members tend to have lower contribution shares if LULUCF emissions are excluded; indeed, the share of Indonesia drops from 3.7% to 0.8% under this exclusion.

However, if one is talking simply of 'causal contributions to climate change', all the (officially) recognized sources and sinks – including those from LULUCF – should be taken into account, which is why the reference case is chosen for determining causal contribution shares.

4.2.2. Joint contributions

As mentioned earlier, there are reasons to think that certain emissions, even though emitted over the sovereign territory of one country, should be assigned joint responsibility between different countries. The example put forward above was the case of emission increments in developing countries since 1992, when the world adopted the UNFCCC, and in particular its Article 4.

There may be other reasons as to why one might wish to introduce a joint responsibility for certain parts of 'sovereign' emissions, such as those embedded in exports, accounting for one-third of total emissions in 2005 in China, for example (Peters and Hertwich, 2008; Weber et al., 2008). Indeed, a recent study contends that:

> the extent of 'exported carbon' from China should lead to some rethinking by government negotiators as they work towards a new climate change agreement. It suggests that a focus on emissions within national borders may miss the point. Whilst the nation state is at the heart of most international negotiations and treaties, global trade means that a country's carbon footprint is international. Should countries be concerned with emissions within their borders (as is currently the case), or should they also be responsible for emissions due to the production of goods and services they consume? (Wang and Watson, 2007: 1).

The method of determining shared responsibilities used in this article is able to accommodate this sort of joint responsibility by introducing 'joint contributions'. And while the actual calculations of responsibility shares below will all be based on the more traditional sovereign-contributions-only approach embodied in the reference case (including LULUCF), it is useful to give an illustration of how the inclusion of such joint contributions might change the picture. The implementation of joint contributions (as illustrated in Figure 4 for China), which is meant to reflect the duties under Article 4, simply assumes that the increment in emissions since and above the 1992 level are to be shared 50:50 by the countries in question and the rich industrialized (Annex II) countries[17] – divided among them in proportion to their GDP.

In order to have any significant variance from the sovereign country measures at all, the time horizon has also been limited to start in 1990. For the industrialized world, the switch to this sort of 50:50 joint contribution would mean an increase of 3 percentage points since 1990, most of it going in roughly equal proportions to the USA and the EU (+1% point each), and benefiting mostly China (–1.3% points). Given that these differences would practically disappear if one were to use the reference case (beginning in 1890) it was decided not to proceed along these lines for the moment.

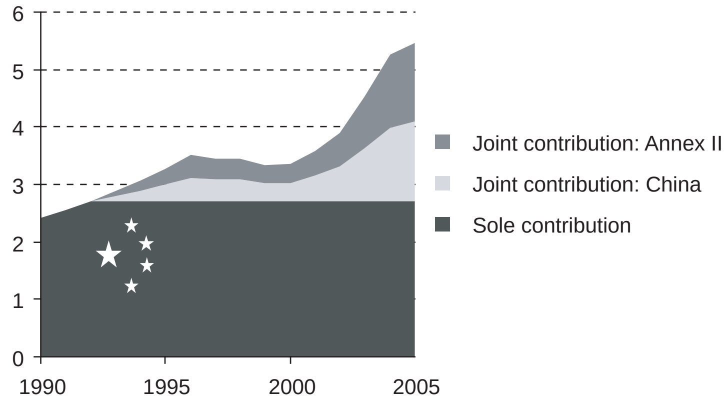

FIGURE 4 China's joint contribution

4.3. Differentiating moral responsibilities

4.3.1. Strict responsibility

Strict responsibilities, according to the adopted allowance-based approach, are determined by the level of aggregate historic emissions – representing causal contributions – and a per capita allocation of the global total of harmless emissions. There has been some debate in the literature as to how much could be emitted globally without imposing harm, particularly in the context of defining what has become known as 'ecological space'. MacGregor (2006: 2), for example, explains his choice of 4 GtC-eq (14.7 $GtCO_2$-eq) as follows:

> The earth's natural ecosystems (both land and sea) currently absorb roughly half of the anthropogenic emissions of CO_2, thus buffering us from the full climate impacts of our emissions. However, this is a 'moving target' since future changes in climate will affect this rate of natural absorption. This in turn influences the future rate of change of atmospheric CO_2 since the warmer climate accelerates decay of carbon in soils and leads to large release of CO_2, which causes further warming. Moreover, the population is projected to increase. The current size of the global natural carbon sink is estimated to be 3–5 billion tonnes of carbon (GtC-eq) – approximately 2 GtC-eq by ocean and 1–3 GtC-eq by land, depending on differing rates of deforestation. A global level of 4 GtC-eq is often used (Retallack, 2005; Monbiot, 2007).

Agarwal et al. (1999: 108), in turn, contend that 'terrestrial sinks are national property, but oceanic sinks, which absorb to the order of 2 btC [7.3 $GtCO_2$] per year, belong to human kind and are common global property'. The figure of 7 $GtCO_2$ as the global total of basic allowances has been adopted here, for the present purposes to be allocated – in accordance with their global commons status – on a per capita basis.[18]

Numerically, this choice implies an overall industrialized country (historic) climate change responsibility of 64%. The largest single country share is that of the USA with 25.6%, followed by the EU (19.1%, 15.9%), in turn followed by a cluster in the upper single-digit range – namely OPEC (7.4%), Russia (7.3%), China (6.4%), Brazil (5.2%) – and finally a number of countries with low or negligible responsibility: AOSIS+LDC (4.1%), Japan (2.8%) and India (0.3%) (Figure 5).

While it will not be surprising that individual SIDS and LDCs have in reality no historic responsibility for the climate change problem (on average 0.05%), what may be less expected is to

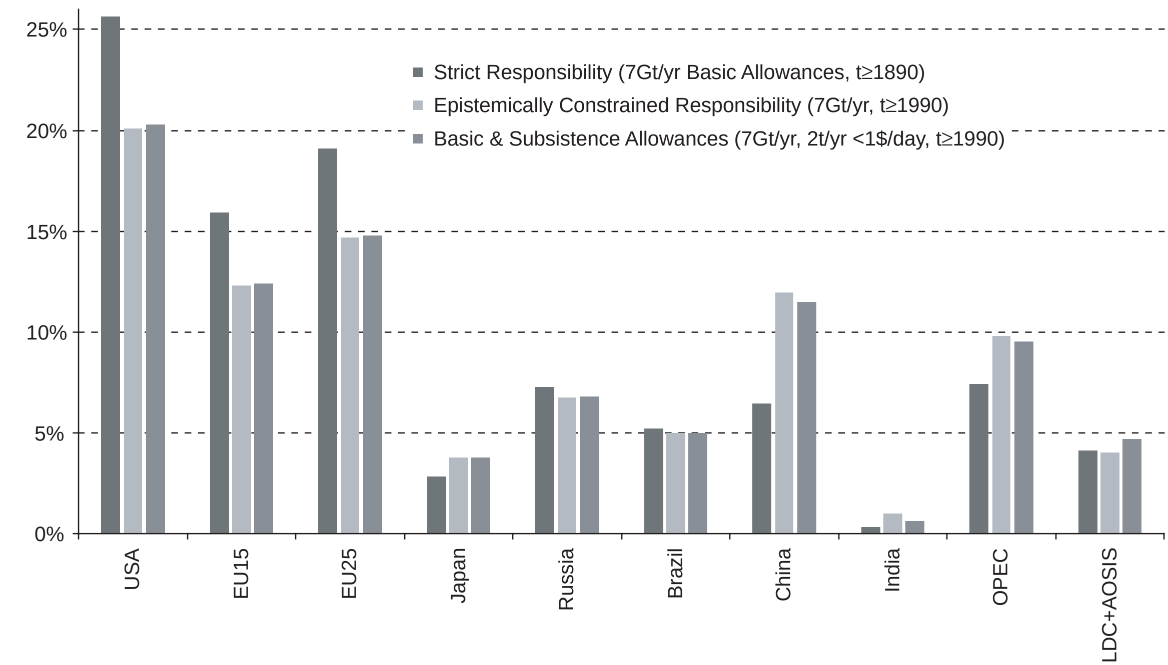

FIGURE 5 Moral responsibilities for climate change

find India at the extreme end of our responsibility spectrum. The reasons for the extremely low Indian responsibility share are its relatively modest causal contribution share of around 4%, and its rather large share of the global population (16.9%).[19]

4.3.2. Limited responsibility: epistemic constraints (EC)

There has been a robust difference of opinion – more often than not along the North–South divide – about whether it is fair to use this sort of strict historic responsibility, or whether countries should be granted mitigating circumstances, such as ignorance of the effect of their actions. For the present purposes this sort of Aristotelian epistemic constraint of full responsibility has been implemented here by excluding emissions before 1990 from the calculations, on the grounds that after that year, which saw the beginning of the UNFCCC negotiations and the publication of the first IPCC reports, no government could reasonably plead ignorance of the problem.[20]

This plea for ignorance to be treated as a mitigating circumstance does shift the burden of responsibility significantly from industrialized to developing countries, with Annex I as a whole losing 10 percentage points. The USA (20.1%) and the EU (12.3%, 14.7%) both lose over one-fifth of their responsibility relative to their historic strict responsibility shares, while China (12%) picks up about the same number of percentage points, but in this case this means almost a doubling of responsibility relative to the strict measure. In relative terms, by far the worst off is India (1%), which more than triples its responsibility under such a switch to ignoring most of the historic contributions. And yet it still remains at the bottom of our responsibility scale, due to the extremely low baseline. However, the North–South picture is not quite as homogeneous as might be expected (‘industrialized countries lose responsibility, developing countries gain’). Japan (3.7%), for instance, gains one-third in responsibility, while Brazil (5%), and AOSIS+LDC (4%)

would actually be slightly better off. But, on the whole, the fact remains that, in general, a limitation of responsibility by considering only post-1990 contributions benefits the industrialized countries.

4.3.3. Limited responsibility: EC with subsistence allowances

As mentioned earlier, Aristotle's conditions on limiting full responsibility lend themselves not only to justifying these epistemic dispensations, but also a certain dispensation for subsistence emissions, or rather emissions needed to overcome (extreme levels of) poverty. For the purposes of this article, these needs-based dispensations have been implemented as an additional constraint on the above-mentioned epistemic dispensation case. In other words, pre-1990 contributions continue to be disregarded in this context. This leaves two parameters to be determined: Who should be eligible for the subsistence allowances, and how much should they be? The most readily available data is listed in the World Bank Development Indicators, which contains figures for people living on less than \$1 and \$2 per day (World Bank, 2006). As to the question of how much poor people should be allowed to emit without incurring responsibilities, per capita subsistence allocations of less than the relevant global per capita basic allowance will not register.[21] Given that the per capita emissions of the developing world are currently estimated to be 3.7 and 2 tCO_2-eq with and without LULUCF, respectively, our decision was to allocate 2 tCO_2 per poor inhabitant per annum, to be subtracted from the aggregate historic emissions (instead of the basic allowance).

In this case of \$1 per day as the 'poverty threshold' – referred to simply as 'limited responsibility' – the annual subsistence allowance of 2 tCO_2-eq (which is larger than the basic allowance per capita level) is used instead of the basic allowance for each inhabitant with an income of less than \$1 per day. The results benefit developing countries more than developed ones, and yet the shift of half a percentage point in responsibility towards Annex I (53.8%) is clearly not compensating for the shift in the other direction due to the introduction of the epistemic constraint. The USA gains 0.2 percentage points relative to the epistemologically constrained case, while India and China jointly lose nearly 1 percentage point. And the situation does not differ significantly if one moves the poverty threshold to \$2 per day: the USA gains another 0.6 percentage points, while China and India jointly lose 1.2 percentage points. In other words, the choice of poverty threshold – at the assumed level of 2 tCO_2-eq for the subsistence allowance – is not a particularly sensitive one, certainly not in comparison with the effects of the chosen epistemic constraint, or the overall level of basic allowances.

4.4. Sensitivity analysis

4.4.1. Strict responsibility

The only parameter (apart from the choice of a per capita allocation, as discussed above) is the total size of the overall basic allowance, i.e. the level of (annual) emissions deemed to be harmless. We therefore tested the sensitivity of this assumption for a possible range of values.

It could be argued, for example, that all GHG emissions are harmful, since a fraction of the CO_2 stays in the atmosphere for hundreds of years, and that the basic allowance should therefore be zero. Another line of argument could be that the basic allowance should be levelled at 7 $GtCO_2$-eq, which is the current sink of CO_2 by the oceans (the default used here). A further suggestion could be that the basic allowance should be set at the level allowed for stabilizing the climate system at a global temperature increase of 2°C, which is here assumed to be 12 $GtCO_2$-eq.

Figure 6 presents the change in strict responsibility as a function of the basic allowance from 0 to 12 $GtCO_2$-eq. It can be observed that the strict responsibility of developing countries (with

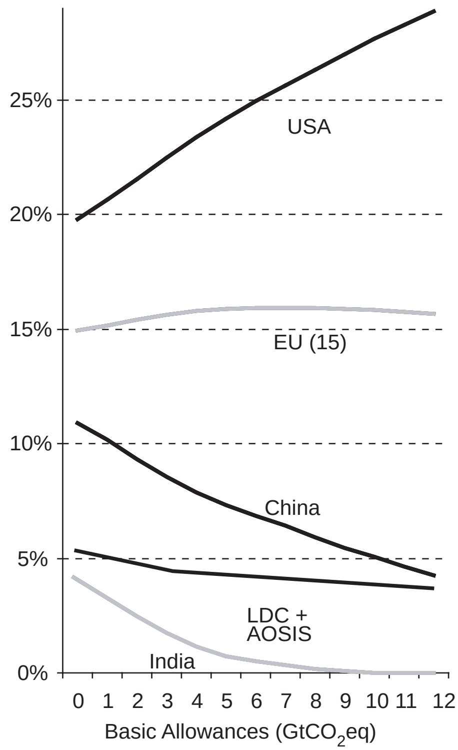

FIGURE 6 Strict responsibility: basic allowance sensitivity ($t \geq 1890$)

high population compared to emissions) decreases when the basic allowance is increased. For China it decreases by a factor of 2, for India it even declines to zero.[22] In contrast, the strict responsibility of developed countries (with low population compared to emissions) increases, e.g. by one-third for the USA.

4.4.2. Epistemically constrained responsibility

The sensitivity to choosing the cut-off dates for when emissions are accounted to different years between 1890 and 1990 was also tested (keeping all other settings constant, i.e. 7 $GtCO_2$-eq basic allowance for the strict responsibility).

Moving the cut-off date from 1890 to 1990 decreases the relative contribution of developed countries (which started earlier with their emissions), while it increases the relative contribution of developing countries. As recent emissions dominate the results, moving the cut-off date after 1950 has a greater impact than moving the cut-off date before 1950 (by the same amount of time).

4.4.3. Subsistence allowances

The effect of subsistence allowances is determined by (1) their relative size compared with the basic per capita allowance – the subsistence allowance is only granted if it exceeds the global per capita level of the basic allowance, in which case it is used in lieu thereof, (2) the poverty threshold ($1 or $2 per day), and (3) the level of the per capita subsistence allowance.

In order to avoid the misuse of subsistence allowances, countries are divided into poor and non-poor segments, treating each like a sovereign moral agent, i.e. without allowance transfers between them. The aim of this is to prevent the non-poor from having (parts of) their culpable emissions pardoned by illegitimately claiming them as 'subsistence emissions'. The culpable emissions of each segment are calculated as their emissions minus their allowances, and those of the country by the sum of the values of the two segments.

Figure 7 shows the effects on Chinese and Indian responsibilities of changing the poverty threshold ($1 and $2 per capita per day) under variations of the subsistence allowance level from 0 to 4 tCO_2-eq per capita (around the chosen default of 2 tCO_2-eq per capita), for the default global basic allowance of 7 $GtCO_2$-eq, and – for comparative purposes – with no basic allowances (both focusing only on post-1990 emissions).

It can be observed that with a basic allowance of 7 $GtCO_2$-eq per year, the effect of the subsistence only starts to have an influence above 1 tCO_2-eq per capita. For China, the responsibility share declines with increasing subsistence allowance. It declines much faster under the $2 per capita poverty definition than with the $1 per capita definition. For India, with a very high share of poor population, the floor of responsibility is reached at a subsistence allowance of around 1.5 tCO_2-eq per capita. It is higher for the $1 per capita case, since the share of the poor population is lower. While for India the effect of the basic allowance is very significant, it is less so for China.

The values for no basic allowance and no subsistence allowance correspond to the causal contribution shares *post-1990*, which are not necessarily the same as those of the (post-1890) reference case contributions discussed earlier.

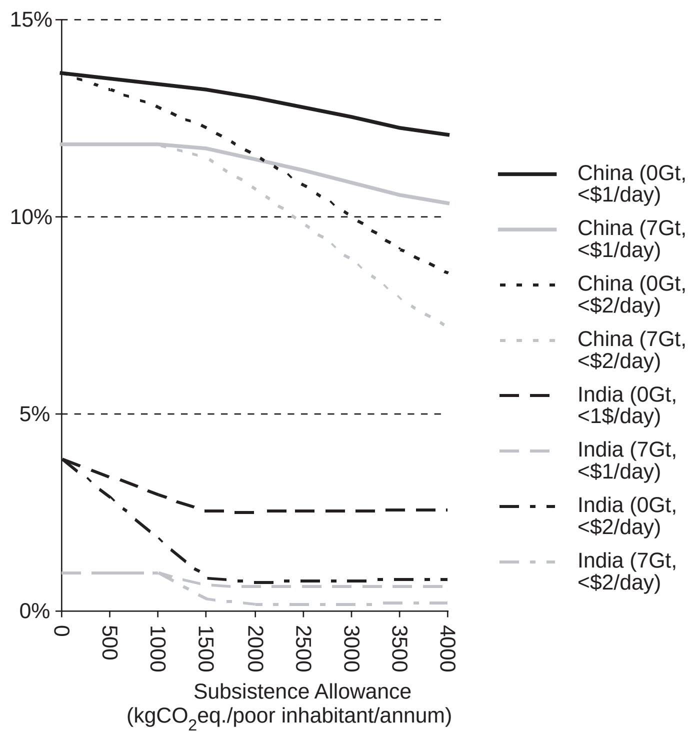

FIGURE 7 Subsistence allowance sensitivity ($t \geq 1990$)

5. Concluding remarks

The aim of this article was to put forward and discuss a methodology for the numerical differentiations of responsibility for climate change as opposed to calculating causal contributions to climate change. For explanatory purposes, this was done on the basis of aggregate GWP-weighted historic emissions as a proxy. Moving to fully fledged climate modelling techniques as used in MATCH could be done in the future, but would change the relative contributions and resulting responsibilities by as much as 10% (per cent, not percentage points) for most countries.

This article is not intended to engage in a debate about which of the two conceptions of responsibility (‘strict’ or ‘limited’) with the chosen parameter values is more appropriate, or whether the causality of developing-country emissions should be partially attributed to Annex II countries, not least because the answer may well depend on what one wishes to do with the results. However, the order of magnitude difference in the responsibility of the two extremes of the scale under both conceptions does give pause for thought as to what sorts of burdens can justly be imposed, particularly given the discrepancy between the affluence and wealth of the exponents at either end of the spectrum of responsibilities that we considered in this article.[23]

Indeed, it stands to reason that burden-sharing on the basis of responsibility alone – as proposed in the original Brazilian proposal – without taking into account the second and lesser-quoted element mentioned in Article 3.1 of the UNFCCC, namely ‘respective capabilities’, would not be appropriate. In other words, fair burden-sharing would have to be based on a combination of the responsibility shares discussed here and some differentiated index of capability.

Notes

1. See Manning (1999).
2. 1647 BC: +0.65°C; 1559 BC: –0.9°C, relative to present temperature. See Petit et al. (1999): ‘the eruption on Thera could have lowered annual average temperatures by 1 to 2 degrees across Europe, Asia and North America … the summer temperatures would have dropped more – suggesting years of cold, wet summers and ruined harvests Cecil (2001)’.
3. Although moral responsibility can exist even in the absence of causal contribution (see discussion of duty-based responsibilities below).
4. The data takes into account changing geographical borders, but only for energy and industrial CO_2. Other sources are based on current territory.
5. Strictly speaking it is either blameworthy or praiseworthy, but in the present context the former suffices.
6. We would like to emphasize, however, that our methodologies could easily be adapted to be used with the full MATCH modelling techniques. We need to note that using GWP factors can only be considered an approximation, as over the long time spans considered here, static factors ignore the feedbacks and long-term changes in global warming potentials. While the radiative impact of additional emissions declines with increasing concentration in the atmosphere, the damaging impacts of climate change increase non-linearly. This led Hope (2008) to the conclusion that the marginal damages of a unit of emission are, to a reasonable approximation, independent of concentration, which allows us to use aggregate contributions to GHG emissions to form causal contribution shares.
7. See John Vidal, ‘China could overtake US as biggest emissions culprit by November’, *Guardian*, London, 25 April 2007 [available at www.guardian.co.uk/business/2007/apr/25/china.pollution].
8. Data source: the *Climate Analysis Indicators Tool* (CAIT) [available at http://cait.wri.org/].
9. Baer et al. (2007), for example, suggest ‘cumulative per capita CO_2 emissions from fossil fuel consumption since 1990’ as a ‘reasonable’ definition of responsibility. Ultimately, however, they use country-wide emission contributions adjusted by measures of income distribution in the population to calculate global responsibility shares, because it is impossible to express the percentage responsibility of a per capita share.

10. Note, however, that the two are not the same: to be allocated an emission permit, *per se*, is not tantamount to being given a responsibility allowance for the specified amount of emissions; in the same way in which being given the legal licence to produce tobacco does not give one immunity with respect to the consequences of tobacco use!
11. For example, if it is agreed that all the emissions in question are harmful, then the basic global per capita allocation $b = 0$, implying that the resulting basic country allocations are equally 0 for all countries regardless of their population size, and thus that the allocation-based responsibility measures are independent of population figures. Per capita measures, in contrast, reflect population size by definition.
12. This dataset was supplemented by process emissions from cement production taken from Marland et al. (2003) in order to cover all industrial CO_2 emissions.
13. See Höhne et al. (2009), section 2.1, for a detailed description of the emissions dataset, including issues of completeness and uncertainty.
14. Because population data for the years 1890–1959 is not available for 29 small countries (making up 11 million inhabitants out of approximately 3 billion worldwide in 1960), their emissions allowances of these 70 years are not counted towards their total share. This leads to a very slight increase in the share of LDC+AOSIS in the calculation of responsibility with emissions allowances for 1890–2005.
15. Poverty data for 24 least developed countries was unobtainable. For these countries, the poverty headcount ratios at $1 and $2 per day have been set to a level comparable to that of other LDCs (50% and 75%, respectively). The time series of poverty data is not complete for all countries. Poverty shares have therefore been extrapolated for the missing years using existing data.
16. Data before 1890 is less complete. Roughly 10% of the effect of total aggregated emissions is left out when starting in 1890 instead of 1750, the start of industrialization (see Höhne and Blok, 2005).
17. As it happens, in 2004 the share of Chinese CO_2 (energy) emissions allocated to Annex II in this fashion was precisely the share of its embedded export emissions as calculated by Wang and Watson (2007).
18. Strictly speaking, we should also have allocated basic allowances according to the sinks capacity of the respective sovereign territory, but given the uncertainties on how much these are, we decided to err on the side of caution and just consider oceanic sinks.
19. The position of Japan in this strict responsibility scale also suggests that burden sharing according to responsibility alone may not really be tenable, and that it would have to be complemented with some 'respective capacity' component, as referred to in Article 3.1 on the UNFCCC.
20. This is, of course, not quite the same as saying that they could not reasonably have been expected to know even before this – as referred to above – but, for the sake of argument, we shall use 1990 in accordance with the principle of the presumption of innocence ('giving the defendant the benefit of the doubt').
21. Sixteen times the annual (1990–2005) basic allowance budget of 7 $GtCO_2$-eq, divided by the sum of global annual population figures over the period = 1.2 tCO_2-eq.
22. In contrast to the subsistence allocation model, no domestic distinctions are made in this strict responsibility case between population segments, i.e. basic allowances are freely transferable within country.
23. Affluence (GDP per capita, PPP): USA = $41,890, India = $3,452. Wealth (GDP, PPP): India = $3.8tr, USA = $12.4tr (both in 2005). *Source:* World Bank (2006).

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