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Sharing the emission reduction burden in an uneven world ☆

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HIGHLIGHTS

- A global environmental contract to reduce emissions without affecting economic catch up is examined.
- The contract builds on a formal decomposition framework.
- The framework disentangles macroeconomic and other influences on emissions.
- The approach yields country-level CO_2 emission targets and peak years applicable as benchmarks.
- Findings are useful to assess ambition and fairness of national contributions in line with the Paris Agreement.

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ABSTRACT

In the climate agreement reached in Paris on the 12th of December 2015, the participating countries agreed to provide information about their Intended Nationally Determined Contribution, and also to assess its fairness and ambition. This study contributes a transparent empirical econometric tool for such an assessment. It shows that, using a formal decomposition framework that uniquely disentangles the macroeconomic and other influences on emissions, effort sharing in global greenhouse gas reductions can be achieved in a way that promotes innovation and environmental efficiency to reduce emissions without interfering with the right of poor countries to catch up economically. Based on GDP projections by the IMF and the OECD in a sample of about 185 countries, it presents country level CO_2 emission targets applicable as benchmarks to assess the adequacy and fairness of national contributions.

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1. Introduction

The global community of nations reached in 2015 an agreement about action to stem the rise in global average temperatures to well below 2 °C above pre-industrial levels (FCCC/CP/2015/L.9/Rev.1). As part of the historic consensus in Paris, also receiving a lot of attention in the media and among specialist circles, the parties agreed to provide information about their Intended Nationally Determined Contribution (INDC), and also to assess its fairness and ambition.[1] Since the national contributions to emission reductions are voluntary, the credibility of the climate agreement rests in part on the INDC assessment process to generate peer pressure conducive to a sufficient level of ambition. As no method for such an assessment has been documented, the Paris Agreement in effect leaves it to the scientific community to come up with a methodology.

In the present paper, we detail a methodology which, arguably, is well suited for the assessment, also including concrete CO_2 emissions targets for about 185 countries until 2050 applicable as

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[1] For discussion about the Paris Agreement in the media and specialist circles, see http://www.nytimes.com/2015/12/13/world/europe/climate-change-accord-paris.html?_r=1; http://www.theguardian.com/environment/2015/dec/13/paris-climate-deal-cop-diplomacy-developing-united-, nations); http://ec.europa.eu/clima/policies/international/negotiations/future/index_en.htm.
Also see, http://www.perspectives.cc/fileadmin/user_upload/Paris_COP_results-perspectives-evaluation14-12-15.pdf, http://wupperinst.org/uploads/tx_wupperinst/Paris_Results.pdf

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benchmarks for the national contributions. The novel methodology to calculate the national emission targets for INDC benchmarking is transparent, as it builds on publicly available data and well established statistical methods. To guarantee a sufficient level of ambition, the benchmarks are computed so that the implied path of global emissions is consistent with the global temperature target laid down in the Paris Agreement with high probability. Fairness is promoted by allocating the national emission quotas in such a way that they do not interfere with the ability of developing countries to catch up with levels of material welfare enjoyed by their affluent peers.[2]

The basic idea to compute benchmarks that are neutral to the catching up process is to decompose national emissions econometrically in a very specific manner; thus, under the selected decomposition, only one of the emission components is sensitive to national income so that only policies which interact with that component interfere with the catching up process. The desired INDC emission benchmarks, applicable to reduce emissions without interfering with the catching up process, can then be calculated by imposing caps on the other emissions components while leaving the one component which interferes with the catching up process to be determined freely.

We show that the desired decomposition can be computed by stochastic frontier analysis of the joint distribution of country-level emissions and national income. The stochastic frontier model divides country level emissions into four parts, one of which captures random variation in the data, and, another, all the emissions that are influenced by national income. The remaining two emission components are independent of national income and applicable to be influenced by environmental policy without interference with the catching up process.

Building on extant literature, notably Herrala and Goel (2012), these two emission components on which caps are placed can be interpreted as: the first best emission frontier, and a specialized environmental efficiency metric (*EEp*) which measures the distance from that frontier. In contrast with some other environmental efficiency metrics used in the literature, whose main focus is on technical efficiency, this efficiency metric is sensitive to all changes in emissions except those that arise from changes in GDP. Besides improvements in low-carbon technology and its diffusion globally, the efficiency metric therefore also reflects changes in economic structure and non-material living standards (i.e., not affected by GDP) to reduce emissions. The correspondence between the proposed decomposition approach and this broad based efficiency metric implies that environmental progress can under the proposed approach be achieved by a broad set of measures to shift the first best emission frontier, and better implementation at the national level to improve environmental efficiency.

A formal analysis indicates that an arrangement of this type requires a multi-step global environmental process to ensure convergence towards a global emission target, an essential feature (the stocktake as defined in Art.14) of the Paris Agreement. Under the proposed decomposition approach to INDC assessment, the global stocktake serves to assess progress in terms of global emission levels, and to revise the benchmarks for national contributions accordingly, also taking into account the latest income projections. The stocktake furthermore reveals to what extent possible problems in achieving sufficient emission reductions on a global scale stem from lack of progress in lowering the efficiency frontier and from improving environmental efficiency. Such diagnostic insights may then be helpful in designing strategies at the global and local levels to further progress, in particular providing guidance to the technology framework established by Art. 9 of the Paris Agreement.

For the empirical application, we use World Bank data on CO_2 emissions and income projections from the IMF and the OECD to calculate national emission benchmarks for about 185 countries, including the main polluters, up until the year 2050. In the simulations, global emissions follow a path that according to previous studies contains the global temperature increase within the desired limits with high probability (Scen. RCP2.6 detailed in IPCC (2014)).

The simulations lead to the conclusion that the desired path to contain global emissions must rely to a large extent on innovation of new technologies, economic structures and improved diffusion to lower the first best frontier of minimum emissions: this frontier must fall by almost ninety percent by 2050 if the global emissions target is to be reached. In relative terms, improvement in environmental efficiency can play, at best, only a secondary role in emission reduction. For most developed countries, the calculated emission benchmarks lie between 10% and 30% of the current emission levels. The fast growing developing countries turn out to have higher benchmarks to reflect their expected rapid speed of economic development.

The study contributes to the large literature on effort sharing (Höhne et al., 2014; Rezek and Rogers, 2008; Tavoni et al., 2013) an innovative decomposition approach that does not interfere with nations' catch up process. Various scholars have addressed the issue of emissions control and abatement costs using other methodologies and benchmarks (see, for example, Baer (2013), Bianco et al. (2014), Bode (2004), den Elzen et al. (2005, 2013, den Elzen and Höhne (2010), den Elzen and Lucas (2005) and Höhne et al. (2014); and Cropper and Oates (1992), Mäler, and Vincent (2003. 2005) and Tyteca (1996) for reviews of the broader literature). The disentangling of the macroeconomic (GDP)-related and other emissions using the stochastic frontier analysis as a basis for burden sharing is the main contribution of the present work, besides, of course, the focus on the very recent Paris Agreement.

The interpretation of the various components furthermore builds on previous work on measurement of environmental efficiency by frontier models (Halkos and Tzeremes, 2014; Lansink and Wall, 2014; also see Zofio and Prieto (2001)). Within that field, the decomposition tool corresponds with the environmental efficiency approach by Herrala and Goel (2012). While their approach to calculate environmental efficiency is well defined, it is somewhat non-standard in the field, as it defines environmental efficiency based on policy rather than technological criteria. Our analysis shows that, due to its close link with environmental policy, it can play a useful role in assigning emission targets.

The methodology is formalized in the following section. We then present the empirical analysis, and some concluding remarks.

2. Methodology

Consider a situation where countries $i \in I$ meet at year t to set emission targets of CO_2 for year T. The preferred global emission target $\overline{CO2}_T$ is known based on scientific knowledge about the detrimental effects of emissions. The remaining task is to agree on targets for individual countries $\overline{co2}_{i,T}$ applicable as benchmarks for their emission reduction efforts to ensure that the global target is achieved:

$$\sum_I \overline{co2}_{iT} = \overline{CO2}_T \tag{1}$$

In this sense, this framework captures the essence of 'adequacy of national contributions' laid down in the Paris Agreement. For

[2] For more discussion on ambition, see IPCC (2014), http://www.ipcc.ch/, and on fairness see A. Shah, "Climate Justice and Equity", http://www.globalissues.org/article/231/climate-justice-and-equity.