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Evolution of the global distribution of carbon dioxide: A finite mixture analysis

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ABSTRACT

Economists and environmental policymakers have recently begun advocating a bottom-up approach to climate change mitigation, focusing on reduction targets for groups of nations, rather than large scale global policies. We advance this discussion by conducting a rigorous empirical analysis of the global distribution of carbon emissions along several important dimensions: groupings, polarization, mobility, and volatility. In contrast to previous work, our empirical analysis is both comprehensive and data-driven. We discuss how robust empirical evidence may aid policymakers in forging a heterogeneous carbon abatement policy.

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1. Introduction

The political economy of climate change mitigation is typically focused on policies that allow for heterogeneous abatement targets across individual or groups of countries (Asheim et al., 2006; Pizer, 2006), often motivated by recognition of heterogeneity in the marginal cost or benefit from abatement (Barrett, 1997; Botteon and Carraro, 2001; McGinty, 2007; Kolstad, 2010).[3] The literature generally uses game-theoretic models to study participation, commitment, and self-enforcement of international environmental agreements, to determine whether self-enforcing international environmental agreements can be developed under assumptions of cross-country heterogeneity since homogeneity in the marginal benefit and/or cost of abatement is unrealistic (Barrett, 1997). Further, disaggregated policies are a direct response to a growing consensus that a singular global policy is destined to fail, the classic irreconcilable disagreement being conflicted interests between developed and developing countries because of different perspectives on climate responsibility given past, present, and future emissions. Indeed, studies have shown that heterogeneity in marginal damages can lead to participation from a larger number of countries (e.g., McGinty, 2007), and heterogeneity in abatement targets can Pareto dominate a single agreement (Asheim et al., 2006). Alternatively, Barrett (2013) details how a threshold in climate change which produces catastrophic losses can work as a self-enforcing mechanism for an international environmental agreement with heterogeneous countries.

Clearly, such theoretical models incorporate heterogeneity in the form of heterogeneous marginal benefits (or costs) from abatement in order to maintain analytic tractability. Yet, there are two apparent shortcomings of this restriction. First, marginal benefits from abatement are not observable within or across countries, posing substantial challenges for any empirical analysis derived from theory or attempting to justify theory. Second, there are myriad other differences across countries that are not captured by differences in marginal benefits of abatement – e.g., resource endowments, income levels, or energy use – that are likely to influence the decision to participate in any international agreement. Therefore, while theory may point towards potential improvements to single global policies (e.g., Asheim et al., 2006), it is difficult to guess which countries may choose to join a particular sub-global agreement. One is left to wonder: what might these sub-global groups (coalitions) look like?

There is a growing empirical literature that has investigated aspects of global carbon emissions, including convergence (e.g., Strazicich and List, 2003; Van, 2005; Aldy, 2006; Panopoulou and Pantelidis, 2009), polarization (e.g., Duro and Padilla, 2008, 2013; Duro, 2010), and distributional dynamics (e.g., Van, 2005; Bassetti et al., 2013).[4] A comprehensive review of these papers yields the general conclusions that there is evidence of likely conditional convergence of emissions in developed countries but a general divergence of global emissions, and clustering of global emissions into at least two groups that are characterized by some degree of polarization. Our reading leads us to two shortcomings in previous empirical studies: the use of empirical models that require prior assumption of the number of global emissions groups or are suitable for analyzing a single characteristic of global emissions (e.g., convergence *or* polarization); and a relatively loose connection of the empirical results to economic policy development or theoretical model validation.

Our first goal is to contribute to the growing literature in support of heterogeneous abatement targets by providing a comprehensive econometric analysis of distributional differences in carbon emissions across countries and over time in a *unified* framework, to identify groups of countries that are statistically similar on *measurable* dimensions. Our second goal is to build tighter links from our empirical results to related theoretical and policy discussions (along the lines of, e.g., Asheim et al., 2006; Pizer, 2006) by providing a detailed discussion linking our empirical insights to the characterization of the groups of countries that might underlie a heterogeneous mitigation agreement. Our link from empirics to theory and policy is based on insights regarding endogenous group formation, univariate

[3] In this article, we adopt the definition of a heterogeneous proposal (regime) following Asheim et al. (2006): "... a regime consisting of two separate agreements, one for each region." Note, however, that we allow for an arbitrary number of groups, and we refrain from adopting the terminology 'region' to denote heterogeneous groups, as this seems to imply geographical heterogeneity, a restriction on heterogeneity that we do not impose.

[4] A more thorough comparison of our approach here with any of these aspect specific methods would be fruitful for comparison, but is beyond the scope of the current research agenda.