Consistent Allocation of Emission Responsibility in Energy Supply Chains

Extended Abstract

In a globalized world, energy supply chains are increasingly complex and spread across several jurisdictions. Fossil fuels are often extracted, refined and ultimately burnt in different countries. Accounting and assigning responsibility for these carbon emissions is an essential component of any integrated climate action program. Harrison (2015) notes that the United Nations' Framework Convention on Climate Change (UNFCCC) only assigns responsibility for emissions that occur within a country's border. Thus, neither is an exporter of fossil fuels assigned any responsibility towards the inevitable emissions generated while they are burnt, nor is the importer assigned responsibility towards the extraction emissions associated with the fossil fuel.

Although a significant fraction of carbon emissions in the fossil fuel supply chain arise during the consumption stage, the upstream stages of extraction and refining often contribute close to 20% of the total supply chain emissions. Unconventional petroleum deposits such as the Canadian oil sands typically entail higher upstream emissions during the extraction, transportation of the denser bitumen through pipelines, and the refining stages. Acknowledging the necessity of assigning extended responsibility, the Canadian federal government announced in 2016 that Canadian energy regulator, National Energy Board (NEB), would factor in upstream emissions during the environmental impact assessment stage for proposed energy projects. Upstream emissions are defined as emissions associated with “all industrial activities from the point of resource extraction to the project under review”. This has significant implications for several pipeline projects across Canada that transport crude oil or refined products to refineries.
and shipping terminals. The upstream emissions attributable to a proposed project could be compared against a rejection threshold level of emissions whereby the regulator, NEB, sets a predetermined level of upstream emissions beyond which the project will be rejected (Schaufele, 2016), or the regulator could also require the firm to offset some or all of the associated upstream emissions. A rejection threshold policy or offset requirements that take into account all upstream emissions of an energy project would have to be calibrated, depending on the stage of the supply chain the project is situated at, or otherwise it risks inducing distortionary effects by favouring upstream energy projects over more downstream ones. This is primarily a consequence of double counting by attributing to each entity in the supply chain all associated upstream emissions. Another drawback of such a double counting method is that with a carbon offset program, it opens up the possibility of multiple parties claiming the same carbon offset as part of their mitigation efforts, damaging the credibility of carbon offsetting (Schneider et al., 2014).

In this work, we formulate a cooperative-game theoretic model of the energy supply chain represented by a directed tree, wherein the players (or nodes) correspond to the extractors, distributors, refineries and end-consumers. We then provide a consistent accounting and implementation mechanism, derived from the nucleolus of the associated cooperative game, to allocate responsibility for emissions in energy supply chains while embodying the principle of upstream responsibility. We further discuss certain natural consistency properties satisfied by the nucleolus that render it a desirable allocation mechanism in the specific context of energy supply chains that span multiple legal jurisdictions, as is often the case practically.

We develop a quadratic time algorithm to compute the nucleolus allocation of the associated cooperative game, and provide a linear-time heuristic approximation that coincides
with another allocation mechanism proposed in the environmental literature. We then proceed to provide a policy implementation framework by constructing a novel sequential non-cooperative alliance formation game and it is shown that an energy supply chain governed by two simple and easily implementable policies induces profit maximizing firms to arrive at the nucleolus allocation. The self-implementing nature of the policy framework for the nucleolus and its consistency property make the nucleolus an attractive allocation scheme in fossil fuel supply chains that span multiple legal jurisdictions. Finally, we provide a case study based on a proposed energy project in Western Canada — an extension of the Trans Mountain oil pipeline. This contextualizes our work, and further, hopefully, will also serve as a useful case study for policy makers and NGOs in their evaluation of the liability of similar energy projects in other regions.

References


