Downstream impacts complementary to upstream impacts of intermediate sectors

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Environmental impact accounting has become increasingly important for governments and corporations as they strive to meet climate commitments such as the Paris Agreement. While current methodologies allow for the estimation of direct and upstream environmental impacts, indirect downstream impacts remain largely unaccounted for in standard environmentally extended input-output (EEIO) approaches. Governments rely on EEIO models, particularly the Leontief demand model, to calculate upstream impacts and generate consumption-based accounts. However, there is no widely accepted framework for systematically estimating downstream impacts in a complementary and consistent manner, without double counting or introducing subjective allocation principles. This gap is particularly relevant in the context of emerging regulatory frameworks, such as the Corporate Sustainability Reporting Directive (CSRD), which require companies to account for both upstream and downstream environmental impacts of their economic activities.

This paper addresses this methodological shortcoming by developing a framework for downstream impact accounting that is fully compatible with upstream impact accounting. Previously proposed frameworks relied on the simultaneous use of the Leontief demand model and the Ghosh cost-push model, which leads to double counting unless certain allocation principle are introduced. While the Leontief demand model is widely acknowledged as appropriate for upstream impact (consumption-based) accounting, the use of the Ghosh model has not been used as widely for downstream impact accounting. In the Ghosh model impacts are allocated based on the income of intermediate sectors, rather than final consumption of goods and services as in the Leontief model. Furthermore, there has been a long debate on the economic plausibility of the Ghosh model. Our framework relies solely on the Leontief model and uses the same principles as presented in Table 1 in Lenzen & Murray (2010), but with one crucial difference: "The ultimate responsibility for downstream impacts rests with downstream buyers of final outputs" rather than "...downstream sellers of primary inputs" (1). Thus, both upstream and downstream environmental impacts are allocated using the same responsibility principle.

We present a formal derivation of the downstream environmental impact method, starting from the hypothetical extraction method (HEM). HEM has experienced a minor renaissance in recent years for its usefulness in calculating the upstream environmental impact of a (set of) intermediate sector(s) without double counting or allocating the impacts to the sectors providing the final goods and services to final demand. In the derivation of the HEM method, the equation for the downstream impacts of the extracted sector(s) appears as the natural counterpart to the upstream impacts. The framework does not solve the issue of non-additivity that is inherent in HEM, but we argue non-additivity must logically be present in the impact accounting of intermediate sectors, as well as across national economies in their role as producers, importers, and exporters of environmental goods and services that cause impacts. Although, the framework does ensure additivity of impacts of sectors within the same nation, when all sectors in the nation are extracted simultaneously.

To demonstrate the application of our framework, we conduct two case studies using a global multi-regional input-output model (EXIOBASE). The first case study quantifies both the upstream and downstream greenhouse gas (GHG) emissions of the Norwegian economy, highlighting how the method can be used for national environmental accounting. The second case study focuses specifically on Norwayâ€™s oil and gas sector, illustrating how the framework can be applied at a

sectoral or corporate level.

The results of our analysis demonstrate that downstream environmental impact accounting provides a necessary counterpart to existing upstream approaches, offering a more comprehensive assessment of a sectorâ€™s or nation's environmental impact. This is especially critical for industries or nations primarily engaged in resource extraction or intermediate production, where environmental burdens are often externalized to other sectors and nations in the consumption-based accounts.
Our study contributes to improving corporate sustainability reporting and regulatory compliance, making it easier for corporations and nations to report the full scope of their environmental impacts. Furthermore, the insights gained from downstream impact accounting can support policymakers in designing more effective environmental regulations that account for the full supply chain impact of economic activities.

(1) Lenzen, M. & Murray, J. Conceptualising environmental responsibility. Ecol. Econ. 70, 261â€“270 (2010).