Capstone Proposal

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Carbon Credit Allocation: Global Company Distributing Emission Reductions to Departments and Supply Chain Partners

This capstone thesis will focus on a carbon allocation problem (CAA) at the company level. The project will build on the work of Lakshimi et. al. [1], tackling the dynamic involving a global company (social planner) allocating carbon emission reduction caps to its different department and supply chain partners (agents). The objective of the company is to allocate the emission reduction caps as efficiently as possible; efficiency can be measured with different metrics and properties, though minimising costs is often pivotal.

This problem has been analysed in the literature assuming each agent's cost curve to be known to the social planner [2]. In this context, it can then be solved with the construction of an appropriate greedy algorithm [2]. However, a more realistic scenario treats the agents as independent entities, acting strategically with cost curves unknown to the social planner [1][2]. Then, this problem can be formulated as a game of imperfect information, and tackled developing an allocation mechanism $y(\hat{\theta}) : \Theta \to Y$, $Y \in R^2$, that must specify an allocation $x(\hat{u})$ and a payment function $p(\hat{u})$ for each agent involved; given that the type profile of an agent is a cost function c_i, $y(\hat{\theta})$ must specify $(x(\hat{c}), p(\hat{c}))$.

Lakshimi et. al. develop a strictly budget balanced (SBB), dominant-strategy incentive compatible (DSIC) mechanism [1]. The latter property is especially pivotal to this problem; a budget imbalanced mechanism would imply either (1) monetary support from an agent exterior to the problem or (2) leakage of revenue from the company [1]. Given that a SBB and DSIC mechanism cannot be allocative efficient [6], Lakshimi et. al. minimise the allocative inefficiency of their mechanism. When cost curves of different agents are similar, the inefficiency is insignificant; otherwise, it is 'marked' [1].

In this capstone project, I will focus on developing an allocative efficient mechanism for this class of problems. Relaxing the DSIC property to Bayesian incentive compatibility (BIC), a mechanism can be designed that is both allocative efficient and budget balanced. This project will then focus on the programmatic experimentation of this and other mechanisms, such as the one developed by Lakshimi et. al., allowing the evaluation of allocative inefficiencies in [1]. Implementing a BIC mechanism, experiments will also allow to analyse the outcome of the allocation in a BNE where truth telling is not a dominant strategy, if another equilibrium exists. Hence, dynamics of collusion can be taken into consideration, even though unrealistic, given it is partially in the interest of agents operating under the company for it to allocate caps efficiently.

A richer model

The objectives above are the priority. Given enough time, another dynamic can be analysed.

The global company can evaluate the cost of allocating a certain emission cap M to $n \in N$ agents against the cost of purchasing more emission allowances in a carbon emission exchange market, given a monetary constraint. Notice that the availability of a carbon exchange market and the existence of a constraint monetary subsidy can be taken into consideration to develop a DSIC and allocative efficient mechanism that is not SBB. The social planner would be able to inject money in the mechanism, or acquire future carbon allowances with any positive revenue collected that cannot be redistributed. The monetary constraint can be assumed to be known to the agents, or unknown. The existence of a monetary leeway would also affect

the agents' incentives to collude and reveal untruthful types. The formulation of a DSIC mechanism might then not be sufficient to guarantee truth telling in equilibrium.

While operating in a richer framework, tackling the allocation problem under such axioms is certainly more complex than with the former model. Priority shall be given to the formulation of a BIC, SBB, allocative efficient mechanism.

Cited and Related Works

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