Evaluation of fairness in cost-effective abatement

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The distribution of abatement costs among countries can be an important factor for truthful implementation of international abatement agreements. Cost effectiveness in a Baltic Sea perspective implies that relatively large abatement is carried out in countries with access to low abatement costs. Due to difference in factor prices the costs of abatement measures are low in countries such as Poland, Latvia, Lithuania, Estonia and Russia. If also the impact of measures located in the drainage basins is high due to high degree of leaching from diffuse nutrient inputs and deposition, and/or low-retention hydrological transport into the Baltic Sea, the cost effective allocation will result in relatively high abatement cost burdens for these countries. In general, such an allocation of cost burdens is regarded as unfair (e.g Grasso, 2007).

Although there is general consensus on the requirement of fairness for truthful implementation of environmental cleaning plans, there is less agreement on the operational definition of fairness. In general, two principles are used in economics to evaluate fairness egalitarian and equity (eg. Carraro and Buchner, 2002). The egalitarian principle rests on equal human rights, where citizens have the right to, for example, the same amount of emission of nitrogen and phosphorus. The equity principle, based on the capability approach suggested by Sen (1999), relates burdens of actions to the agents' ability to meet them. The latter is often defined as cleaning cost in relation to the affordability in different countries, which is measured as their values of total production in the economy, GDP.

There is a large literature on measuring inequality related to poverty. A common approach is to calculate so-called Gini coefficients as a measurement of inequality (Gini, 1921). The Gini coefficients are derived from the Lorenz curves, which is illustrated in Figure 1.

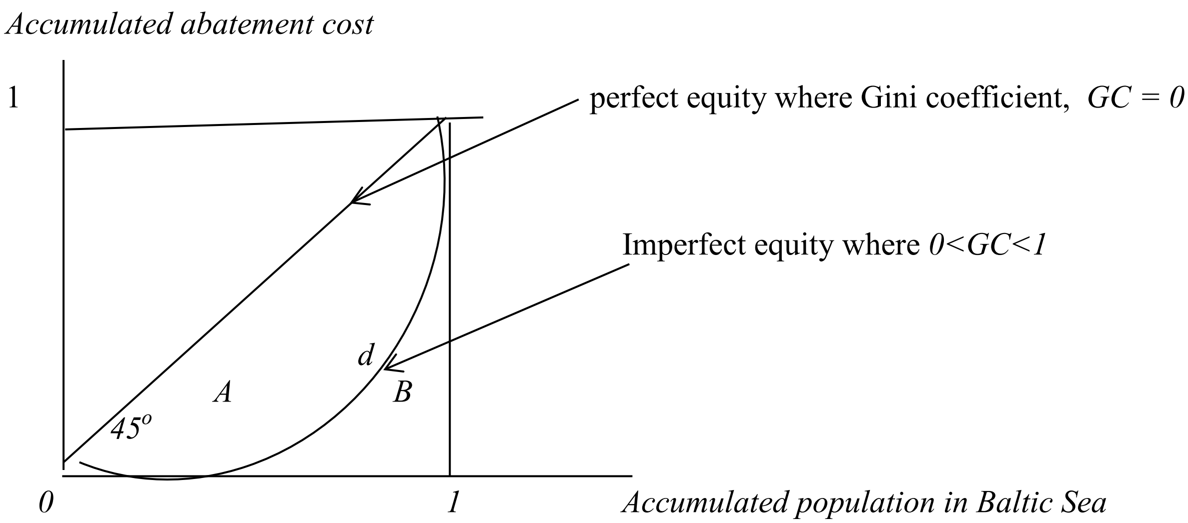

Figure 1: Schematic illustration of a Lorenz curve, L, for the distribution of nutrient loading to the sea among the population in the hydrological catchment area.

The Lorenz curve shows the share of the countries' population in relation to the share of total nitrogen load abatement cost. For example, the point *d* on the Lorenz curve in Figure 1 illustrates that approximately 0.75 of the total population bears 0.25 of the total abatement cost. In a similar vein we can say that the remaining 0.25 of the population accounts for 0.75 of the total abatement cost, which can be regarded as unfair. On the other hand, along the 45^{o} curve we have perfect equality since, along this curve, a certain share of the population carries the same share of the total abatement cost.

The Gini coefficient (GC) is measured as the area between the 45^{o} curve and the calculated Lorenz curve in relation to the total area under the 45^{o} curve, i.e $GC = \frac{A}{A+B}$. This means that $0 \leq GC < 1$. High value of *GC* implies high inequality, and vice versa. At the 45^{o} curve we have perfect equality where $GC=0$.

The calculation of the Lorenz curves is made by first ranking all countries' abatement cost/capita in an ascending order. The next step is to calculate each country's share of total abatement cost and population. In the third step these shares are accumulated up to unity. The accumulated shares are displayed in the graph and sum to one. There are several text books in economics on the calculations of Lorenz curves and Gini coefficients, see e.g. OpenStax (2018) with open source access.

Gren and Destouni (2012) have calculated Lorenz curves and Gini coefficients for both egalitarian and equity principles for nutrient abatement and costs among countries with coastal zones to the Baltic Sea. The curves and associated Gini coefficients were calculated in the cost-effective solution for reaching the targets set in the Baltic Sea Action Plan (BSAP) by Helcom (2013). The egalitarian principles were then defined as equal rights per capita to emit nitrogen and phosphorus, and the equity principles as equal abatement cost per capita and equal share of abatement cost of gross national product (GDP). Lorenz curves for the egalitarian principle on equal nutrient load per capita are illustrated in Figure 2.

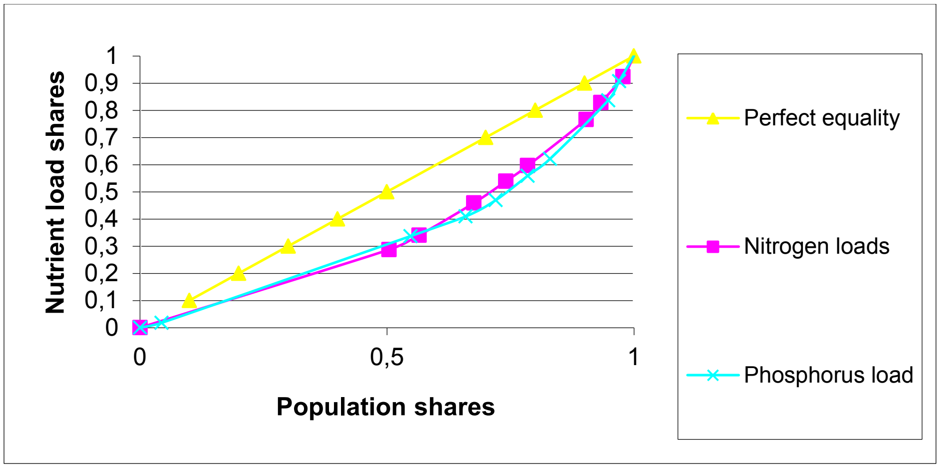

Figure 2: Lorenz curves for nutrient load and population shares for countries with coastal zones to the Baltic Sea in the cost effective solution for reaching BSAP targets.
Source: Gren and Destouni (2012)

As shown in Figure 2, the distribution of nitrogen and phosphorus loads on the population are similar for the two nutrients, where approximately 50% of the total population accounts for 30% of the nutrient loads. The calculated Gini coefficients show that these distributions are relatively fair compared with distribution of abatement cost and abatement cost in relation to GDP (Figure 3).

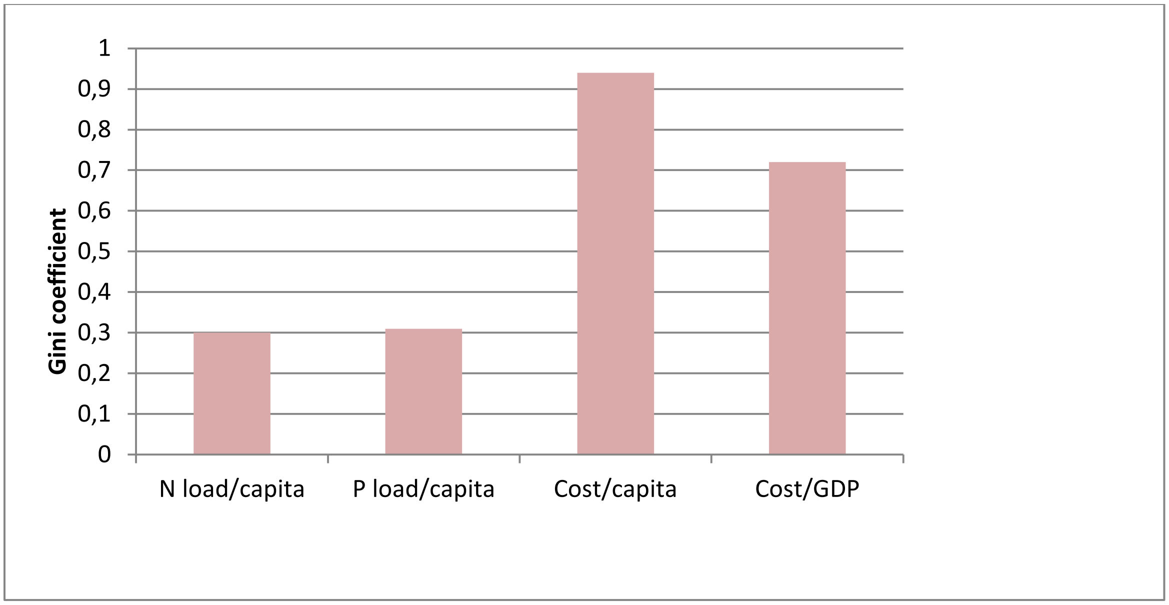

Figure 3: Gini coefficient for measurement of fairness with respect to the egalitarian principle (N load/capita, P load/capita, abatement cost/capita), and to the equity principle (abatement cost/GDP (gross domestic product)) in the cost effective solution for reaching BSAP targets. Source: Gren and Destouni (2012)

The calculated Gini coefficients in Figure 3 show that the fairness outcome is dependent on choice of criterion. Gini coefficients based on the egalitarian principle point out relatively high degree of fairness, and coefficients based on the equity principle the opposite. The calculated Gini coefficient for allocation of abatement cost per capita is three times that for allocations of nutrient loads.

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