Designing a global mechanism for intergovernmental biodiversity financing

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Summary: The Convention on Biological Diversity (CBD) and the Nagoya Protocol display a broad international consensus for biodiversity conservation and an equitable sharing of benefits. The CBD Aichi biodiversity targets show a need for both additional action and enhanced mobilization of financial resources. A proposal of financial burden sharing among states has not yet been developed. We propose a global scale financial mechanism to support biodiversity conservation through intergovernmental transfers. We develop three design options: ecocentric, socio-ecological and anthropocentric. We analyze the corresponding incentives to reach the Aichi target of terrestrial protected area coverage by 2020. The socio-ecological policy design provides the strongest incentives for states with the largest distance to the Aichi target. Our proposal provides a novel mechanism for global biodiversity financing, which can serve as a starting point for more specific policy dialogues on intergovernmental burden and benefit sharing.

Keywords: biodiversity financing, fiscal transfers, protected areas, international governance

JEL codes: Q28, Q57, R14

In order to safeguard human survival on the planet through conservation and sustainable use of biological diversity, the Convention on Biological Diversity (CBD) aims at institutionalizing benefit sharing and appropriate funding mechanisms. While the convention recognizes national sovereignty as a governing principle, it also affirms that the conservation of biodiversity is a "common concern of humankind".[1] The parties to the convention agreed upon implementing biodiversity strategies, monitoring, and conservation policies nationally. On the international arena, access and benefit sharing (ABS) mechanisms have further been specified in the Nagoya Protocol. These mechanisms are meant to facilitate 'fair and equitable sharing of benefits' that originate from the utilization of genetic resources and 'appropriate funding'[2] In this context benefits are understood in terms of both economic and non-economic values which can be shared between states and between private and state actors.[3-4] Private benefits may refer to direct use values from bioprospecting and marketization of inputs gained from genetic resource material and information.[2,5-7] Public benefits range from insurance values of safeguarding habitats, to ecosystems and life sustaining biospheric systems, to option values of yet unknown future uses, to spill-over benefits that arise from spatial interactions among ecosystems such as the multiple habitats of migratory species.[8]

There are five strategic goals of the CBD for 2020, known as the Aichi targets: i) mainstreaming biodiversity policies, ii) pressure reduction and sustainable use, iii) safeguarding ecosystems, species and genetic diversity, iv) benefit enhancement, and v) improving implementation.[9] Most of the 20 associated target indicators show some but insufficient progress to reach the Aichi targets by 2020, some show no significant overall progress, some show movement away from the target, and very few target elements show sufficient progress.[10] One of the main causes of insufficient progress is inadequate financing.[11-15] Most conservation spending in developed countries comes from domestic sources while developing countries mainly rely on inter- and transnational biodiversity financing.[11] The international funding comes through UN Agencies like the Global Environmental Facility (GEF) who finances CBD related projects and further bilateral agreements.[11] The lack of overall progress towards the Aichi targets calls for additional action and innovative financial mechanisms.[10] Article 10 of the Nagoya Protocol declares that a global multilateral access and benefit-sharing mechanism (ABS) 'to support the conservation of biological diversity' shall be considered by the parties.[2] The ABS mechanisms are expected to create economic incentives for biodiversity conservation but no direct (financial) obligations arise from the formulation of the article and a corresponding mechanism design has yet to be developed.[3-4]

Here we develop three related proposals for such an international financing mechanism. We approach this task guided by a principle of fiscal equivalence.[16] The principle has been developed for the financing of public goods and services. It states that those who benefit from the good in question should also pay for the costs of provision. It is meant to ensure an efficient provision of public goods and services. While private beneficiaries would thus also have to contribute to a corresponding ABS mechanism or fund[7], we will focus on intergovernmental co-financing. Conservation does not just provide national benefits, it also yields transnational public benefits that spill over to other countries such as climate regulation, existence values, insurance values, and genetic information.[8] In case of such spill-over benefits, the principle of fiscal equivalence calls for intergovernmental transfers in order to compensate those who bear the costs of provision.[16] A resulting global ecological fiscal transfer (EFT)[17] mechanism for the benefit sharing across nation states would provide an important and innovative contribution to reaching Aichi targets. This is especially the case since such a mechanism may incentivize nations to supply global benefits of conserving biodiversity through protected areas.[18-22]

Developing mechanism designs

Largely unnoticed by the international community, Brazilian states have invented and implemented EFT since the early 1990s. In order to compensate municipalities for the opportunity costs of hosting state and national protected areas on their territory, in 1991 the state of Paraná implemented a mechanism that distributes a portion of tax revenue to municipalities in proportion to the municipal territory designated as protected areas.[17-20] Several other Brazilian states have subsequently implemented their own EFT schemes such that currently 17 out of 26 states have adopted various designs of the instrument.[19-20,22] First impact studies show that the implementation of EFT schemes creates an incentive for the receiving municipalities to increase protected areas.[22-23] In recent years EFT have gained recognition and Portugal has implemented a similar scheme at the national level in 2007.[24] Several proposals have been developed for Switzerland, Germany, Poland, France, Indonesia and India and the EU.[25-32] An adaptation to the global level has been proposed[21] but has not yet been designed or simulated.

We propose three design options. The *ecocentric design* is based on protected areas per country, irrespective of the size of the country or any socio-economic factors. For each country *i*, an environmental indicator, EI, would be calculated as the sum of all protected areas PA weighted with w_k based on the International Union for Conservation of Nature (IUCN) protected area category k according to their contribution to conservation goals (equation 1).

$$EI_i = \sum_{j=1}^{n} w_k PA_{ij} \tag{1}$$

The *socio-ecological design* furthermore takes into account protected areas and the Human Development Index (HDI), such that less developed countries would obtain a relatively larger share of the fund – which constitutes a fairness element (equation 2).

$$EI_i = \sum_{j=1}^{n} w_k \frac{PA_{ij}}{HDI_i} \tag{2}$$

The *anthropocentric design* extends the socio-ecological design by accounting for population density. This increases EI for countries that have both many protected areas and people – which would maximize the number of people that benefit from protected areas (equation 3).

$$EI_i = \sum_{j=1}^{n} w_k \frac{PA_{ij}}{HDI_i} \frac{pop_i}{area_i} \tag{3}$$

The fund would then be distributed among all L countries according to their EI (equation 4).

$$EFT_i = fund \frac{EI_i}{\sum_{l=1}^{L} EI_l} \tag{4}$$

For details on the calculations beyond the general design options see methods.

Resulting financial flows & incentives

To calculate EI under each mechanism, we computed the protected area extent and country areas based on United Nations Environment Programme (UNEP) Protected Planet data for all IUCN categorized protected areas and Global Administrative Areas country shapefiles, respectively.[33-34] For the spatial analysis we followed the UNEP guide; for details see methods. HDI is based on United Nations Development Programme (UNDP) data.[35] Population data are from the World Bank.[36]

We simulate the resulting monetary flows per national CBD party for an arbitrarily chosen total sum of one billion international dollars including all UN Member states except the USA (first column, Figure 1). We compute marginal incentives as a change in EFT flows to a country if it unilaterally increases its protected areas by one per cent of its area, ceteris paribus (second column, Figure 1). The marginal incentives show for which countries it would be most profitable to respond to the mechanism by designating additional protected areas. In order to show the strength of the incentive in relation to a country's wealth, we calculate the marginal incentive as a percentage of GDP (third column, Figure 1).

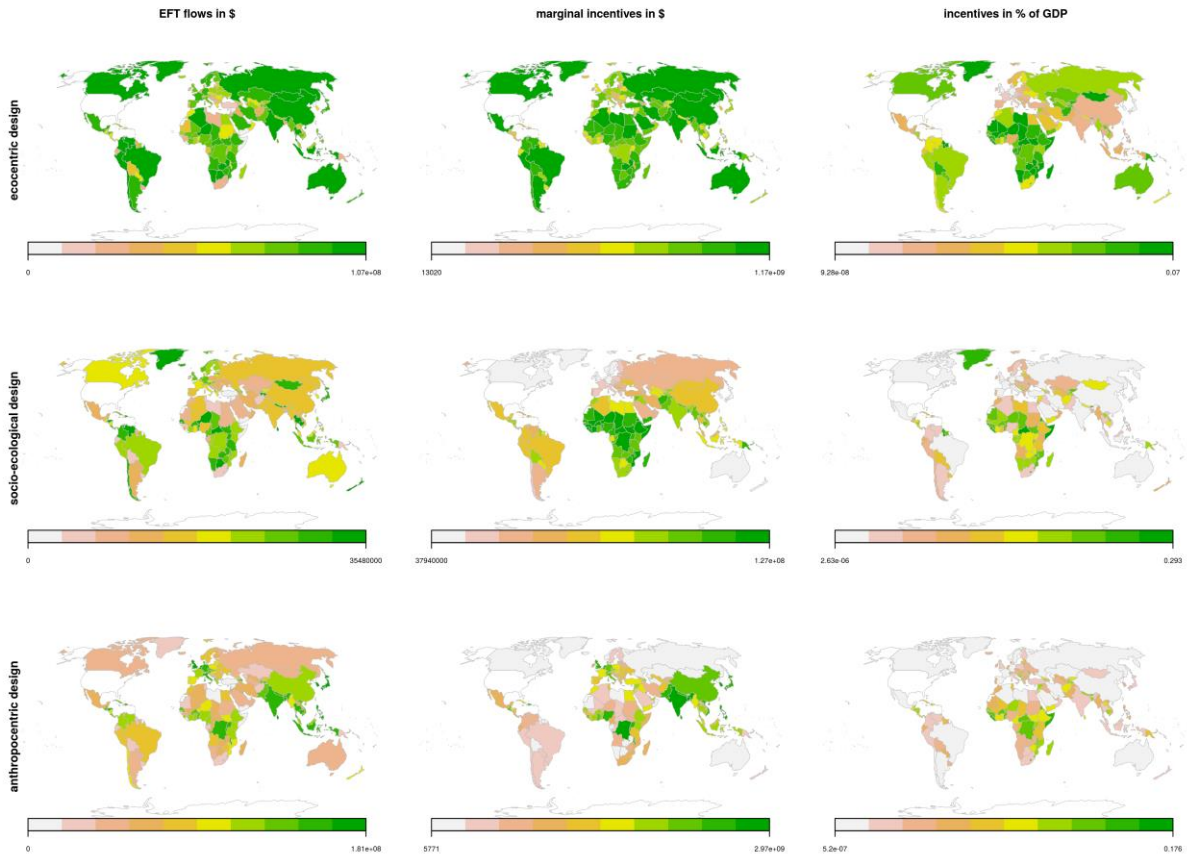

Figure 1: Global maps of different EFT designs and the resulting incentives. Incentives are computed as the marginal and per GDP change in EFT flows for a unilateral protected area increase of 1 per cent total area per country, ceteris paribus. The countries are color coded in deciles and the legends display an equal spacing per decile. Maps have a Robinson projection. Source: authors` elaboration.

Figure 1 displays that the ecocentric design benefits mostly large countries, since they provide the largest protected areas, incentivizes large countries most, and provides the strongest relative incentives per GDP in Greenland and Africa. The socio-ecological design benefits poorer countries in Africa, Latin America and Oceania, but also Greenland and parts of Northern Europe. It provides the largest marginal incentives mainly in Africa and South Asia. The anthropocentric design benefits small island states, and several countries densely populated states with large protected areas across South (East) Asia, Africa, Europe and Latin America. The marginal incentives are highest in some Middle-Eastern and small island states. In relation to GDP the anthropocentric mechanism design incentives are strongest in small island states.

Design choice based on Aichi target 11

In order to assess which mechanism design is the best choice we evaluate how far countries are from reaching Aichi target 11, which states that by 2020 17 per cent of all terrestrial land shall be protected (Figure 2).

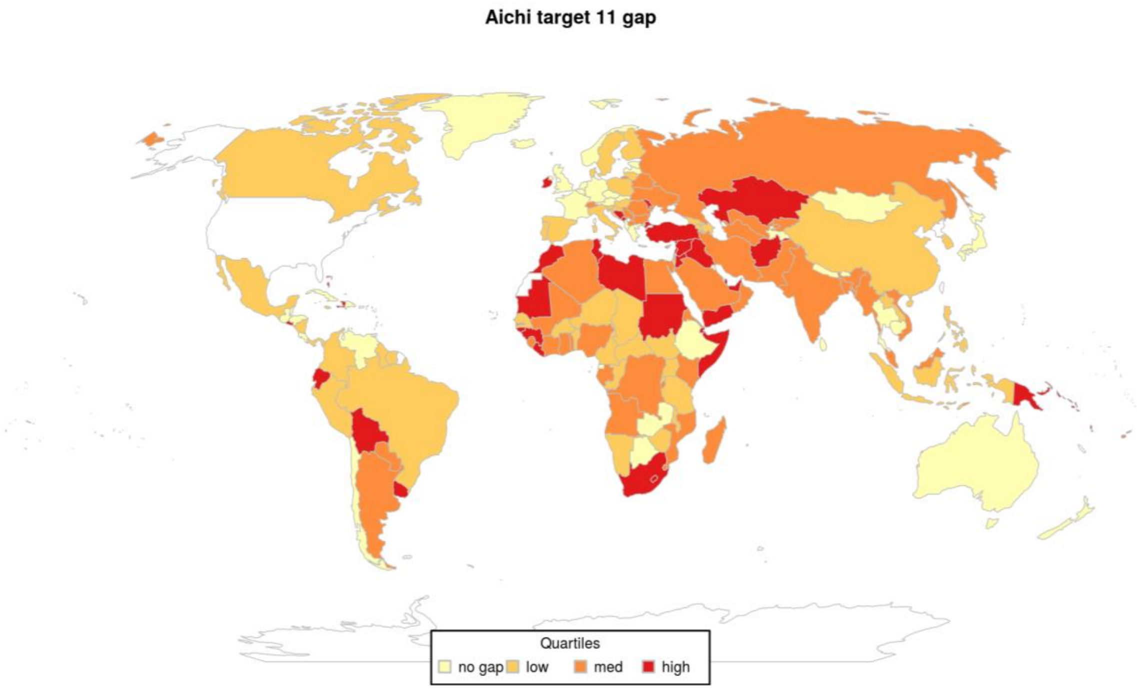

Figure 2: Global map of countries' gaps to fulfill Aichi target 11 of 17 % terrestrial protected areas by 2020, calculated as 17 minus countries current protected area share in percent. Only IUCN categorized protected areas are considered. The countries are grouped in quartiles. Quartile colors are light yellow for a distance of less than 0 up to 1.14, lightorange for up to 8.91, darkorange for up to 15.10 , red for up to 17.00. Non-CBD countries are white. The map has a Robinson projection. Source: authors` elaboration.

We grouped the countries' distances to Aichi target 11 by quartiles and computed the distribution of both marginal and per GDP incentives per quartiles for each of the three mechanism design options. The design choice is based on the following consideration. The strongest incentive should go to those countries that are the farthest from reaching the Aichi target. They are the ones that need to increase protected area share the most and should thus be incentivized most. Figure 3 provides combined violin and box plots of incentives per design for both marginal and per GDP incentives. In contrast to the ecocentric and the anthropocentric designs, the socio-ecological design consistently provides the highest median incentive (per GDP) for the quartile of countries that have the largest distance to reaching Aichi target 11.

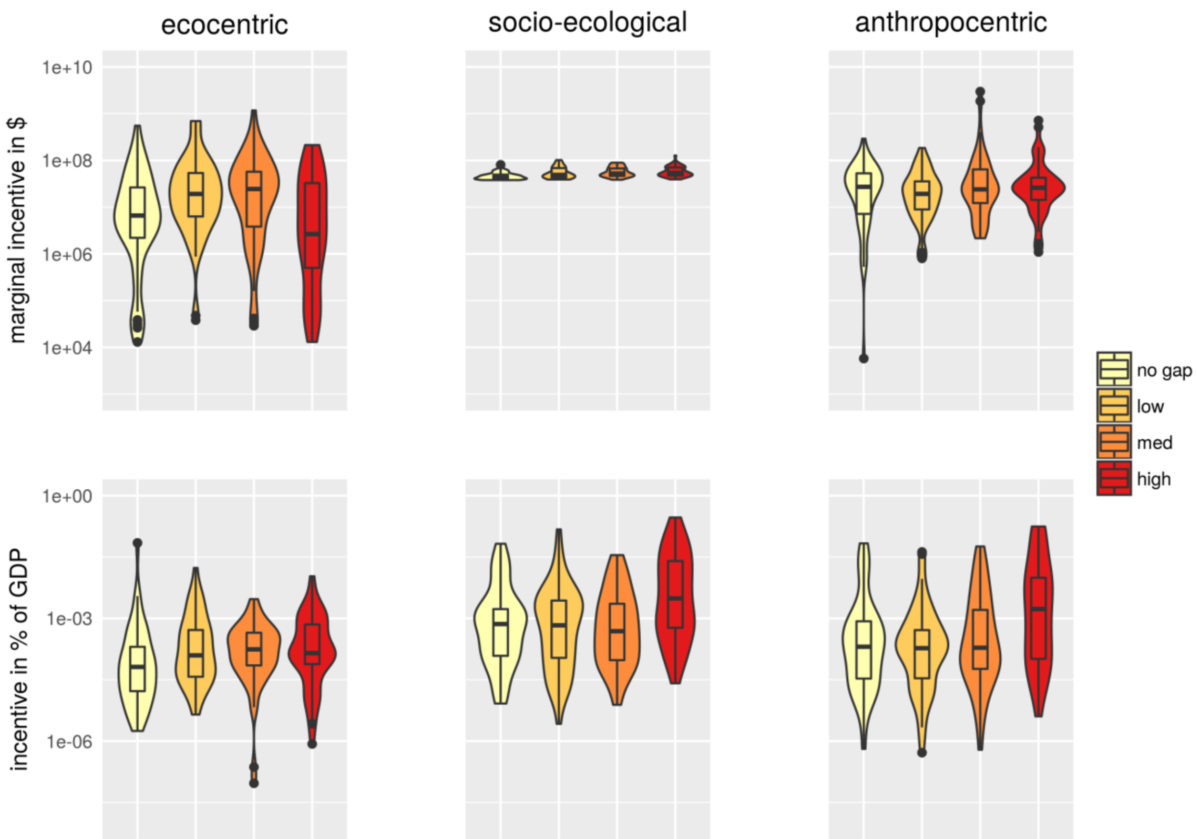

Figure 3: Per quartile distribution plots of incentives for the design options. The outer violin shape displays the data distribution through indicating probability density by width. The inner boxplot show the median at the bar, first and third quartile points as limits of the box, and outliers as points. The first row indicates the marginal incentive in terms of an EFT change from a unilateral per country increase of its protected area share by one per cent. The second row indicates the incentives as an EFT change in percentage of GDP. Countries are categorized into quartiles according to countries' distances to fulfill the Aichi target of 17 % terrestrial protected areas by 2020. The quartiles are "no gap" for a distance of less 0 up to 1.8, "low" for up to 8.9, "med" for up to 15.2 , and "high" for up to 17. The Y-axes are log to base 10 transformed and equal across the design options per row. Source: authors` elaboration.

Design choice implications

Distributing a biodiversity funds according to the location of protected areas compensates for past efforts and sets incentives for creating additional protected areas since they become a source of income.[19,21] We contribute the first policy design study on a global intergovernmental fiscal transfer scheme to support biodiversity conservation. The socio-ecological design option allocates the fund such that those countries showing the least progress towards reaching a 17 per cent protected area share by 2020 receive the strongest financial incentive to designate additional protected areas.

Thereby we would expect these countries to have the highest probability to respond to an implementation of the global EFT with increasing their protected area share. The mechanism can thus help to reach Aichi target 11. Although Aichi target 11 is one of the few targets that shows sufficient progress, recent contributions argue that humanity needs to protect half the Earth in order to safeguard biodiversity.[37-38] We would thus expect that Aichi target 11 will be increased after 2020. The design choice would still be the same if the distance to 30 or 50 percent was the underlying criterion. Important possible future extensions include biodiversity targeting, directing flows where biodiversity is highest or most threatened, and the inclusion of marine protected areas. But even in its most basic form the mechanism would contribute to other Aichi targets than just target 11. It would help to mainstream biodiversity (target 1) into fiscal planning and other policy arenas (target 2) for its intergovernmental fiscal nature. It is an mechanism that provides positive incentives for biodiversity conservation (target 3). It would help to reduce the loss of habitats (target 5) and since the less strict protected area categories are taken into account it would also help to ensure sustainable land management (target 7). It also links well with the Nagoya Protocol on ABS (target 16). It would require financial resources to set up an EFT fund at the global level and is thus in line with target 20 on increasing biodiversity financing.

The proposed mechanism is thus well aligned with the current regime complex for biodiversity protection.[39-41] It furthermore has the benefit of being implemented in similar forms among Brazilian states and in Portugal, such that actual experiences can be further explored and analyzed regarding design principles and outcomes. The main value added by the current proposal, however, consists in the upscaling of an existing instrument for biodiversity conservation to the global level. As such it fills a gap on how ABS mechanisms can be implemented and provides an innovative contribution to the current debates. We would expect that our three-fold mechanism design proposal may serve as a starting point for a more specific science-policy dialogue on benefit and burden sharing of biodiversity conservation between the CBD, the Intergovernmental Platform on Biodiversity and Ecosystem Services, and the broader community.

Methods

This section includes methodological details on: a) the calculation of protected areas per country, b) the construction of a dataset including socio-economic control variables, c) the computation of distributive patterns per mechanism design option, d) the computation of distance to Aichi target 11, e) the computation of assessment criteria for design option selection. All source code in both python and R can be found at a personal github repository at: [link to be inserted] such that the results of the analysis are entirely reproducible.

(A) Calculation of protected areas per country

We downloaded the UNEP-WCMC global data set of protected areas from www.protectedplanet.net (version May 2017) as a .gdb file. We used ArcGIS (version 10.4) to compute the share of IUCN protected area categories per country with the following algorithm (based on adapted form of the UNEP-WCMC method): we repaired geometry features for both point and polygon data were repaired; protected areas with statuses ‘Not Reported’ and ‘Proposed’ were omitted. We excluded protected areas that are classified as 100 % marine, and point data that had no reported area. The point data was reprojected to World Equidistant Cylindrical coordinate reference system (CRS) (ESRI:54002), points were buffered such that the buffer area matched the reported area and reprojected to World Behrmann CRS (ESRI:54017); polygon data was directly reprojected to World Behrmann CRS;

reprojected polygon and buffered point data were merged into a single .gdb. Spatial data on country outlines was obtained from Global Administrative Areas database (www.gadm.org) and reprojected to world Behrmann CRS. For each of the IUCN protected area categories (Ia, Ib, II, III, IV, V, and VI) the corresponding protected areas we dissolved, repaired and iteratively erased from overlaps with former category areas, repaired again, and the country intersection with protected areas was tabulated. Finally, the attributes were exported as a .csv file.

(B) Construction of a dataset including socio-economic control variables

The per country IUCN category protected area data was loaded into **R** (version 3.4.1). Only countries party to the CBD were selected (including Greenland). UNDP data on HDI was added from http://hdr.undp.org/en/data (2015 data, published 2017). Per country data on population and GDP per capita, PPP (constant 2005 international $) was downloaded from Worldbank Database through the "***WDI***" package. All these datasets were joined into a single dataframe;

(C) Computation of distributive patterns per mechanism design option

*W*e used weights for IUCN protected area categories to account for their different contribution to conservation goals based on an adaptation from weights in the Brazilian EFT scheme: w=(Ia=1, Ib=0.9, II=0.8, III.0.7, IV.0.5, V=0.3, and VI=0.1). The design option payments per country were calculated according to formulas 1-4 in the main text.

(D) Computation of distance to Aichi target 11

The distance, *D*, was calculated as$D_i = 17 - \sum_{j=1}^{J} PA_{ji}$, for all$J$protected areas in per country$i$. *C*ountries were then grouped in quartiles according toD_i.

(E) Computation of assessment criteria for design option selection

The marginal incentives per countries were computed as the additional transfer for a unilateral increase of a 1 per cent protected area increase with a probability distribution over IUCN protected area categories corresponding to global average probabilities of the categories. The per GDP incentives were calculated as marginal incentive as a percentage of a country's GDP. Both the marginal and per GDP incentives were plotted in box plots according to the quartiles of distance to Aichi target 11.

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Supplementary Information

The source code and data for the computational anaylsis can be found at a personal github repository: link – to be inserted later in order not to infringe anonymity

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Contributions

ND conceived the research, has conducted the computational analyses and written the first draft. JF directed this project. JF and TR hosted ND. IR supervises the larger research project. All authors have equally contributed to mechanism design, evaluation criteria and revision of the original draft.

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