Fairness issues in emission permits allocation for climate policies: a study in experimental ethics

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Abstract

This paper analyses a range of fairness issues raised by the initial allocation of tradable carbon emission permits. The key objective is to enlight to what extend the allocation of GHGs emission permits may or should be used for income redistribution. For that purpose, the paper presents and analyses the main results of a quasi-experimental approach of the ethical preferences of the agents when they are faced with various mechanisms for allocating carbon emission permits. Since countries differ in regard to demographic or economic development viewpoints, they may have very different adaptation capacities. The Kyoto Protocol states that climate policies have to take into account "common but differentiated responsibility" of the countries, for this reason a special attention is given to the postwelfarist approach of ethical issues which demands an explicit account of responsibility considerations in resource allocation. In order to identify the parameters that should be taken into account in the allocation process, the ETES (*Equal Transfer for Equal S*) axiom is tested on four variables: population, GDP *per capita*, marginal abatement cost, and initial level of carbon emission. The quasi-experiment shows evidence of a hierarchy among these variables and that the degree of compensation should vary among situations.

Key words: distribution, fairness, experimental ethics, tradable emission permits

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Thought it is a global issue, climate change does not have similar impacts on all countries and, symmetrically, climate policies do not affect all countries in the same way and limiting the greenhouse gases (GHGs) emissions does not demand similar efforts for each of them. These inequalities can be related to the geography, the history and the economic development of the countries that condition the nature and scope of the observed and forecasted damages and, to some extend, their capacity to limit their emissions through less CO2 intensive energy resources. Thought some resources can be transferable, several countries' characteristics are not. Countries differ in regard to demography, economic development, adaptation capacity, and this statement raises ethical questions, particularly on the legitimacy of initial endowments (Kujal and Smith, 2008).

This paper analyses these questions in an empirical perspective. More precisely, the legitimacy of using the initial allocation of tradable emission permits (TEP) for distributive purposes and for the correction of existing inequalities is tested within a quasi-experimental protocol. The central point is related to the concept of responsibility that was emphasized by postwelfarist analysis as a focus point in resource allocation issues.

In its 10th article, the Kyoto protocol states that the emissions limitation efforts have to take into account the "common but differentiated responsibility" of the parties. This legal position can be related to the postwelfarism ambition and the possible ways of differentiation can be more precisely studied.

Fleubaey and Maniquet (2005) state that redistribution should allow (1) to compensate the influence of contingent circumstances on the position of individuals (compensation property) and (2) to emphasize the responsibility of each individual relative to his/her voluntary choices (responsibility property). The objective is then to articulate the equality and responsibility concepts (Roemer, 1995), or said differently; to delimitate the field of individual responsibility and look for a compensation process as it is emphasized by Bossert and Fleurbaey (1996, p. 343):

> *« the underlying ideas is that redistribution mechanisms should correct inequality which is due to characteristics of the agents that ought to be considered « irrelevant », whereas the influence of « relevant » characteristics is to be preserved »*.

The objective here is to identify, within the TEP allocation framework, the criteria that satisfy the so-called natural reward axiom (Bossert and Fleurbaey, 1996). For that purpose, a quasi-experimental protocol aims at revealing the ethical[1] preferences of the subjects related to the characteristics of the permits allocation system.

[1] According to Harsanyi (1955), ethical preferences of individuals related to social welfare are based on an impartial and impersonal point of view. Ethical preferences must be distinguished from altruistic

During the 80's, along with the boom of experimental economics, several authors have been treating principles of justice. Experimental ethics consists of collecting data on the beliefs and judgements of individuals within controlled protocols in order to test empirically the theoretical principles proposed by the normative literature (Serra, 2000, 2007). In this field, experiments cannot follow the experimental method *stricto sensu*. The specificity of experimental ethics is not related to its objectives, nor to the method, but to the nature of the collected data that consist of ethical preferences, which have been well considered (Rawls, 1971)[2]. To achieve this, the protocol has to encourage impartial reasoning[3].

Before describing the experimental protocol (3) and results (4), we briefly present the process of TEP allocation, in order to place the experiment and the results in its appropriate context (1). The upcoming chapter describes the different stages in the process - from the decision to limit emissions of greenhouse gases to the final allocation constraints. We subsequently model the situations that result (2).

1. From the initial to the final allocation

The allocation mechanism of carbon emission permits can be characterized as follows[4] :

1. The global amount of acceptable carbon emissions is fixed.

2. The negotiation process allocates the emission quota among the concerned countries.

3. The countries can trade their carbon emission permits.

4. The equilibrium of the market is the final allocation that must fit with real emissions. When the market is efficient, all marginal abatement costs are equal and the global abatement cost is minimal.

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preferences that imply the individuals to attribute a positive value to the well-being of the others. Le Clainche (2004, p. 4) emphasized that: "The ethical preferences are more restrictive than altruistic preferences – Individual that is endowed with ethical preferences is for example let to accept the sacrifice of his proper wealth in exchange for the attachment that he pronounces towards a rule of allocation that he consideres just and impartial".

[2] Rawls introduces a distinction between what is reasonable and what is rational for an individual: reasonable individual understands that he must comply with the conditions of justice even if it harms his own interests. This distinction is similar to that made by Harsanyi (1955) on ethical preferences and personal preferences.

[3] Some studies lead the subjects to adopt an impartial reasoning using the fiction of the impartial observer and generate ethical *opinions* (Yaari and Bar-Hillel, 1984); other studies refer to the procedure of the *veil of ignorance* and observe ethical *behaviours* (Frohlich and Oppenheimer, 1992).

[4] Practically, the two first steps are not separated since, for any country, the willigness to accept a global limitation objective is quite dependant upon the dotation it will get within. The real process is probably a tangled hierarchy. We aim, here, at giving an insight on the logic of the process.

The objective of the following experimental approach is to test whether the initial allocation of TEP should be used to correct certain inequalities between countries and identify the characteristics that the allocation mechanism should be based on, in order to be considered fair. Our study therefore relates to "step 2" of the allocation process and ignores the possibilities of exchange that would allow countries to buy or sell permits ("step 3"). The establishment of a market changes the nature of the problem because the cash transfers it generates transforms it into a problem of local justice (in the sense of Elster, 1992) in a problem of global justice.

To obtain rich and varied information from the questionnaire used in our study, it was chosen to confront subjects with a large number of different situations.

2. Modelling the TEP initial allocation issue

Let Q be the global quantity of permits and q_i the quantity of permits allocated to country i (i = N), with the constraint $\sum_{i=1}^{N} q_i = Q$.

There are several ways to allocate emission permits (the formalization of some allocation systems is specified in Annex 1). Each allocation is determined by a function of the form f: $\overline{a}_i \rightarrow q_i$, with $\overline{a}_i$ is the characteristics profile of the country i.

According to each formalized allocation systems, the country profiles are characterized by four variables, which may cause inequality among them[5]: population, GDP[6] *per capita*, marginal abatement costs (MAC), and the baseline emissions (BE) which are the emission levels in the absence of regulation.

In this experiment, the distributional problem is presented as a problem of sharing of GHGs emissions abatement effort and not of allocating a total quantity of emission permits. This was done because "effort sharing" was considered an easier way to make respondents aware that countries are subject to an abatement obligation and not to obtain the right to emit a certain quantity of GHGs[7].

[5] Obviously there are many other existing inequalities between countries related to geographical conditions, climate, natural resource endowments, etc… The results are then contingent on our choices, i.e. on the different systems of initial allocation studied.

[6] Gross Domestic Product

[7] The objective of the TEP mechanism is not to create a right to emit GHGs, but to restrict this right which has hitherto been unlimited.

Without regulation, country *i* would emit a GHGs quantity of BE_i. However, the initial allocation system chosen by the supranational authority allocates it at a quantity equal to q_i. The country *i* must then abate its emissions by an amount $R_i = EB_i - q_i$.

Given the differences between countries in terms of BE, costs and the assumption of a difference in the marginal utility of money, the effort is expressed in terms of GDP *per capita* percentage allocated to emissions abatement.

As mentioned above, the objective of this study is to investigate which, if any individual specific country characteristics should affect the initial allocation of TEP permits, so as to correct for inequalities between countries. Bossert and Fleurbaey[8] (1996) analyse the compensation issue through two ethical principles - the compensation principle and the natural reward principle - expressed through several axioms of which we specify here the most fundamental.

- The compensation principle (or full compensation axiom): the EIER axiom

The compensation principle consists of neutralizing the influence on the individual achievements of the "relevant" characteristics whose agents are not responsible. Variables out of control should not be at the origin of inequality among individuals. This is the meaning of the EIER axiom (*Equal Income for Equal Relevant characteristics*)[9].

- The Natural reward principle (or strict compensation axiom): the ETES axiom

The principle of natural reward is an interpretation of the concept of responsibility and stipulates that society should not correct or alter the influence of variables under control on the individual achievements. Transfers should not depend on the effort profile. This is the meaning of the ETES axiom (*Equal Transfer for Equal S*)[10].

In our model, the "effort" variable is determined *ex post*, that is to say, once the initial allocation is made[11]. The effort of a country is conditioned by its initial allocation of permits

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[8] In their theoretical framework, Bossert and Fleurbaey (1996) consider that individual incomes depend on the characteristics of individuals, and suggest a characterization of several redistribution mechanisms satisfying the compensation and the responsibility principles.

[9] In a model of income redistribution, Bossert and Fleurbaey (1996) define the EIER axiom as a redistribution mechanism which requires that *"two agents with identical relevant characteristics should end up with identical post-tax incomes* (…) [and] *any income inequality between these two agents should reflect some undue influence of irrelevant characteristics"*.

[10] In a model of income redistribution, Bossert and Fleurbaey (1996) stipulate that the ETES axiom *"states that two agents i, j with identical irrelevant characteristics should end up with identical transfers"*.

[11] The effort of the countries is generally determined after the permits trade, according to their actual amount of emissions, their abatement obligation and their cost function. However, our model does not take into account the opportunity to trade permits, the initial allocation remains the actual amount of emissions.

(the smaller the initial allocation relatively to the BE level, the stronger the effort). This effort, expressed by the share of GDP allocated to emission abatement, is synonymous with individual achievement. It can be defined as the amount of expenditure to be supported by each country. It is possible to define the achievement of a country in many ways, but the sole one that allows for comparisons between countries is the one that assimilates it with the total abatement cost of the country. Because the effort of a country corresponds to its achievement, the axiom of compensation (EIER axiom) is always verified. That is why this axiom is not tested here.

In the TEP initial allocation process, the ETES axiom means that two countries with identical "relevant characteristics" should be given the same amount of permits. The "relevant" variable here defines everything that should be compensated through the TEP allocation. The various systems of initial allocation available are based on one or several variables characterizing the country. A variable is entitled to be compensated for, as far as the inequalities between countries regarding this variable are considered unfair. These inequalities should be corrected for through the allocation of emission permits in such a way that the disadvantaged country should receive a greater amount of permits than countries that are not[12].

What comes out of this discussion is that four country characteristics, namely GDP *per capita*, population, MAC and BE, are potentially entitled to compensation[13]. Subsequently, we aim to determine which of the four variables studied are eligible for compensation through the initial allocation of TEP. For that purpose, the axiom of natural reward is tested. The four variables are considered separately and for each of them, the axiom comes through a different distributive process (see Annex 1), namely: an *egalitarianist* allocation when the variable studied is the population, a *Rawlsian* allocation for GDP, a *utilitarian* allocation for the MAC, and a *grandfathering* or an allocation according to *responsibility* when the BE are analysed. When one of these allocations is considered the fairest by the majority of the subjects, it is to accept the axiom of natural reward, i.e. to consider that the inequalities should be compensated through the TEP allocation; and the studied variable acquires a status of variable entitled to compensation. Conversely, if the majority of the subjects considers that one of these allocations is not fair, the axiom is rejected. In this case, the observed inequalities should not be corrected and the studied variable is not considered

[12] The compensation of the GDP variable is made through the allocation of a larger quantity of permits to the poorest country, *ceteris paribus*.

[13] These variables are probably not the only ones that allow to claim for compensation. But, for simplicity, we limited their number and the variables selected are those most consistently present in the literature (see Brahic, 2006, chapter 2).

entitled to compensation through allocation of permits. Accepting or rejecting the natural reward axiom is therefore equivalent to judging the fairness of each allocation systems proposed, and allows us to identify the variables that can be compensated for, i.e. the inequalities to be corrected.

3. The experimental protocol

The issue of contextualizing experiments has been debated vividly (Loewenstein, 1999; Plott and Smith, 2008). Psychologists have shown that individual behaviour depends on context in which the individual finds himself. This means that each subject has his own perception of the situational context. The one who conducts the experiments therefore looses some of his control since he does not know how the individuals differ in their perception of the context. For this reason, economists, unlike psychologists, usually choose to decontextualize as much as possible the experimental protocols. However, if the study is conducted in the context of decision support, contextualizing the experiment may be desirable[14]. When the interpretation and application of general principles are influenced by the context (Konow, 2001) [15], it is necessary to clarify the nature of the problem so that the results of the experiment can be used to inform the decision maker. Insofar as we want to identify the criteria deemed most fair in the allocation of emission permits, we make explicit reference to this problem.

Furthermore, we controlled the data from our questionnaire by fixing the values of the characteristics of each country and situation and varying population, GDP *per capita*, MAC and BE one by one and two by two.

The degree of control and contextualization give our study an experimental status, and since the subjects are paying a lump-sum payment for participation, it is more appropriate to call it quasi-experiment. The motivation for paying a lump-sum as opposed to any performance index is grounded in the elicitation of ethical preferences. As such, this study is built around a questionnaire in which subjects are not personally involved in the actual distributional issues (289 students, academics, and faculty members). As the objective being to bring them into an impartial judgement, we use the fiction of “the impartial observer” (Harsanyi, 1953). Each subject must express himself in favour of the allocation he considers the fairest.

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[14] If the results of experiment aimed at enlighting the choice of a policy maker, it is certainly desirable to clarify the nature of public goods: building of a hospital, of a university, environmental project…

[15] *« One school of thought claims that justice is context-specific, that is, that there are no general equity rules and that fairness varies across contexts »* (p. 139).

The questionnaire comprises three parts: two “numerical” parts and one “verbal” part. The numerical parts are an indirect test of the natural reward axiom. They contain descriptions of several situations, each highlighting one (first part) or two (second part) characteristics of the countries, potentially eligible for compensation. The verbal part is a direct test of the natural reward axiom, the latter being translated into simple language. By comparing the numerical and verbal answers one may refine the results, allowing to investigate whether the ethical preferences of individuals are influenced by the nature of information provided.

In the numerical parts, the problem is presented as follows: In order to avoid pollution-related climate change, experts considered it necessary to abate emissions by a total of 900 units for the first part and of 1800 units for the second part[16]. The countries are characterized by four variables: population, GDP *per capita*, MAC and BE. Subjects must choose the distribution of emission abatements that they consider the most equitable given the characteristics of the countries. For this purpose, they are given information related to each allocation: the permitted emission volumes, abatement levels in each country in volume and percentage, and abatement cost in each country (expressed as a percentage of GDP).

In this part of the experiment, we first explain the subjects how the experiment will unfold and its purpose. We thereafter ask them to answer a set of questions which serve to check whether they have understood the rules of the exercise they are about to undertake. Only the subjects who correctly answered the comprehension questions are further included in the analysis. In the third part, subjects are asked to answer ten questions by choosing each time the proposal that they consider the fairest among the three that have been proposed[17].

4. Results

It is a fairly well established phenomenon that respondents’ choices are influenced by the order of the questions that they are asked to respond. We therefore test the existence of a possible “order effect” to detect any order bias. This is done by choosing two sequences’ order of situations submitted to two subgroups of respectively 145 and 144 subjects. The chi-squared (χ^2) test rejects the existence of an order effect on the responses given by the subjects (the homogeneity hypothesis is accepted with α=0,001).

The experimental protocol limits hypothetical bias for several reasons. Firstly, the questionnaires are anonymous and each proposal is justified from an ethical point of view so

[16] In the first part, the world is composed of two countries A and B. In the second part, the world consists of four countries A, B, C and D.

[17] Each subject may choose to allocate a similar amount of emissions to countries A and B, a higher amount to the country A, or to the country B.

that the subjects are not inclined to answer to be "well considered" by the experimenter (who is unknown from them before). Secondly, our purpose is to reveal value judgments, which do not lead to monetary reward that otherwise could potentially influence the subjects' responses.

The study of each variable is done by analysing the results of the numerical choice and the corresponding verbal question (see the tables of results in Annex 2).

The first result is that a majority of the subjects considers that the four variables studied (population, GDP *per capita*, MAC and BE) should be taken into account in the allocation of emission permits. This result is observed in the first part of the questionnaire and confirmed in the second one. The results also show some subtleties revealing how countries' differences should be compensated. In the following we present the main results.

4.1. The population variable

When countries differ on population, *ceteris paribus*, the subjects consider it fair to allocate more permits to the most populous country (table 2, proposal B: 70% of the subjects compensate the difference by granting additional permits), but not necessarily in the same proportions. Indeed, allocating twice as many permits to a country with a twice larger population is not considered fair to the majority (table 1: the proportions of subjects who choose to allocate the same amount of permits to both countries and the allocation proportional with population are not significantly different). The subjects consider that the difference in population must be taken into account in the allocation system, but not according to the egalitarianism principle.

4.2. The GDP *per capita* variable

When countries differ on GDP *per capita*, *ceteris paribus*, the subjects consider it is fairer to allocate more permits to the poorer country (table 3: 68% of the subjects choose the allocation R2; table 4: 47% of the subjects choose the proposal C). The difference in GDP *per capita* should be taken into account in the permit allocation and the additional permits granted to the poorest can be seen as an aid to development.

4.3. The marginal abatement cost variable

When countries have different MAC, *ceteris paribus*, the results indicate that the permits allocation should incorporate this fact to be considered fair. More precisely, the higher the abatement costs in a country, the larger should be its share of allocated permits (table 5: 59% of the subjects choose R2; table 6: 46% of the subjects choose the proposal B).

4.4. The baseline emissions variable

When countries differ on their BE level, the grandfathering appears as the fairest allocation system (table 7: 50% of the subjects choose R2). The BE may therefore be regarded here as legitimatising rights.

A remark must be made about the comparison of numerical distributions and verbal proposals. Distributions consistent with the grandfathering and responsibility imply a higher allowance for the largest GHGs' emitter (table 7: R2 and R3) which, results from the fact that these two principles require reasoning in abatement percentage[18] rather than in volume. However, verbal proposals are expressed in volume on an ordinal scale, so we can not distinguish the grandfathering and the responsibility principle.

To compare the numerical results and the verbal ones, we consider the following argument. Firstly, because the grandfathering considers BE as legitimating rights, we assimilate it with the proposal which implies a higher allocation to the country that emits the greatest quantity of GHGs (proposal B). Secondly, because the objective of the responsibility principle is to allocate the larger burden to the largest emitter, the proposal which consists in allocating the same amount of permits to both countries (proposal A) achieves this objective. Thirdly, the proposal which implies that the country that emits the least is the one who receives the greatest permits (proposal C) reflects a "strong" principle of responsibility. Indeed, this procedure heavily penalizes GHGs past emissions, and the abatement effort is even more important when the BE level is high and the available quantity of permits is low.

Finally, the verbal question confirms the finding that the grandfathering is considered fairer by the subjects, since 50.5% of them choose the proposal B (table 8).

4.5. When two variables are changed simultaneously

Several results obtained when two variables are changed simultaneously only confirm the ones obtained when only one variable was changed. Especially the statement that each of the four variables (population, GDP, MAC and BE) should be taken into account in the allocation system is validated by the subjects' choices. In what follows, we emphasize the results that allow a more precise analysis of the subjects' ethical preferences.

It must be noticed that the grandfathering is no longer considered fairer when countries differ simultaneously in terms of population and in terms of BE. In this case, the most equitable allocation is related to responsibility considerations and not to the grandfathering (table 9:

[18] The grandfathering requires that all countries abate their emissions in the same percentage, while the principle of responsibility is reflected by a greater abatement percentage for the largest GHGs emitter.

35.6% of the subjects choose R4). One explanation for this change can be inferred from the observation of countries' features: in the first part of the questionnaire, the differences in the *per capita* BE level vary from simple to double, when they vary in a ratio of 1 to 4 in the second part. In the first case, the subjects choose the grandfathering allocation (same reduction percentage) while in the second case, a significant majority chooses an allocation that reflects responsibility. When the emission difference is greater, the responsibility principle appears fairer, which implies more stringent abatement for countries whose *per capita* emissions are considered excessive relative to other countries.

The willingness to integrate the countries' responsibility in the allocation system is observed in the responses given at the verbal question: 27% of the subjects considered the egalitarian allocation (proposal A) as the fairest (table 10). In this case, country A receives the same amount of permits as country B when it initially emits twice as much GHGs. This allocation requires country A to make considerable abatement efforts. Moreover, 18% of the subjects go even further by allocating fewer permits to country A (proposal C), pushing the concept of responsibility to the extreme. This importance of responsibility is observed through others results.

When country A has a BE level and a MAC twice as high as country B, *ceteris paribus*, the egalitarian allocation is one of the most equitable allocation (table 13), which conveys the concept of responsibility because it obliges country A to achieve greater emission reductions.

Moreover, when we study the justification of an egalitarian allocation, we observe that the differential in BE level is the only differential which is not considered to be compensated by another differential: a difference in terms of population (table 14, argument 2), in terms of GDP (table 16, argument 2), or in terms of MAC (table 17, argument 2). The BE level should be reflected in the allocation of permits in a way that integrates the countries' responsibility in terms of emissions.

Regarding the fact that certain differences may be offset, we have observed an interesting result, namely that when country A is twice as rich and supports a MAC twice the size of country B, *ceteris paribus,* the results indicate a clear preference for the egalitarian allocation (table 11: proposal A chosen by 65% of the subjects). The finding that the egalitarian allocation is considered the most equitable is observed solely for this question. This choice can be justified by the fact that the advantage of a country in terms of financial capacity can offset its disadvantage in terms of technical capabilities, and vice versa (table 15, argument 2).

Ultimately, all the results converge towards the idea that the allocation of permits should incorporate, to a greater or lesser extent, countries' responsibility based on their BE level.

5. Discussion on the responsibility concept

To refine the analysis on the concept of responsibility and explain the choice of an allocation based on responsibility rather than grandfathering, we have studied the verbal questions where countries A and B differ namely on the BE level. In these questions, the three proposals (A, B and C) integrate differently the inequality in BE levels. Since country A emits twice as much GHGs as country B, proposal B (higher permits allocation for country A) reflects the grandfathering principle, while proposal A (identical allocation for both countries) meets the expectations of the responsibility principle and proposal C (higher allocation for country B) illustrates a strong principle of responsibility. From there, one may obtain a hierarchy of proposals according to the degree of responsibility: B, A and C in ascending order.

Confronting the results and the countries' characteristics, we have thus identified a hierarchy of criteria according to the degree of responsibility that individuals attribute to them.

The question that logically follows is how to explain why subjects considered the allocation consistent with grandfathering or the strong principle of responsibility to be fairest. To answer this question, we have to consider causes potentially attributable to unequal BE levels, which may be at the origin of a greater or lesser strong importance given to the responsibility of the country. We hypothesize that the more the differential in BE level is considered out of control of countries , the lower the weight of responsibility, and vice versa. Given the respective characteristics of countries A and B, we are able to identify for each situation, some potential causes of differences in BE level.

When country A emits twice as much GHGs as country B and is twice as populous, both countries have the same level of *per capita* emissions. In that case, inequalities in BE result from different population characteristics.. The larger the country's population, the higher its energy needs, that increases its emissions level. The population being considered by the subjects as a compensable variable, the allocation of permits should not penalize the most populous country. The distribution of ethical preferences in this matter confirms this result since the grandfathering allocation is regarded here as the fairest.

When country A emits twice as much GHGs as country B *ceteris paribus*, the level of its *per capita* emissions is twice that of country B. This excess of emissions can be the result of the use of more polluting technologies or of a stronger economic development. Here, the subjects' ethical preferences are turning again towards the grandfathering allocation. In consistency with our hypothesis, the subjects seem to believe that the differential of BE is due to factors beyond the control of the countries. One may question whether this results is

at the origin of excess emissions in the use of polluting technologies, since the country may also develop more environmentally friendly alternatives.

However, if this emission surplus is the result of economic development, it seems fair to grant the country whose GDP growth is greater, more emission permits in order not to hinder its development. Because of the existence of already industrialized countries, the developing countries should not bear all the responsibility for the increase in emissions due to their development.

When the country's largest emitter of GHGs (globally and *per capita*) is also the one with the higher MAC, the question is to what extent these two factors (emissions and MAC) are linked. The existence of a high marginal cost may be due to the economy structure, factors such as geographical or climatic characteristics may affect the countries' capacity to reduce their emissions. A vast and sparsely populated country requires significant expenditure for the transportation, and a country in extreme climates requires large expenditures for heating and/or cooling, all these sectors being responsible for the emission of large quantities of GHGs. The area and the climate are certainly perceived as being outside the sphere of national responsibility, and it seems fair to take into account these features and to allocate a higher quantity of permits to countries where abatement costs are high. However, the grandfathering allocation focuses only 39% of the subjects, while 45.3% of them choose the proposal A that refers to responsibility (table 13).

This result can be explained if the subjects follow the reasoning of Gosseries (2006), which states that "*environmental factors that increase the need to emit GHGs* (...) *can be considered in the short run as mere circumstances*"[19]. However, in the long run, these factors can "*become the expression of a choice" because "so as the essential need to reduce GHGs emissions is better perceived and the cost factors are better identified* (...), *the States should adapt their planning and policy accordingly: reduce fragmentation of habitat, encourage people to populate in priority the more temperate regions* (...). *If they do not, this should be considered the result of extravangant tastes that other states would not be to finance through the granting of additional GHGs emission permits*" [20].

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[19] Les *« facteurs environnementaux qui augmentent la nécessité d'émettre des GES (…) peuvent être considérés à court terme comme de pures circonstances »* (p. 34).

[20] These factors can « *devenir l'expression d'un choix* » because « *à mesure que s'impose la nécessité de réduire les émissions de GES et que sont mieux identifiés les facteurs de coût* (…), *les Etats devront adapter leur politique d'aménagement du territoire en conséquence : réduire la dispersion de l'habitat, inciter à peupler d'abord les régions les plus tempérées* (…). *S'ils ne le font pas, cela devra être considéré comme le fruit de goûts dispendieux qu'il n'appartiendrait pas aux autres Etats de financer via l'octroi de droits d'émission de GES supplémentaires* » (p. 35).

When the country's largest emitter of GHGs is also the richest, 37% of the subjects consider the strong principle of responsibility (Proposal C) as the fairest (table 12). Why, in this case, does it seem fairer to allocate fewer permits to countries that pollute more (country A)? If the aim is to impute to the country A the responsibility of its emissions, it is enough to allocate it the same amount of permits as to country B (proposal A). However, subjects go further with the idea of responsibility and they choose to allocate fewer permits. Following our hypothesis, this result can be explained by the fact that the subjects consider the country's GDP as a result of its emissions level. Industrialization is a source of emissions so as it is the origin of the economic wealth, it is considered as being under the responsibility of the country, especially as it derives all the benefits (the living conditions are by far better in industrialized than in developing countries).

Ultimately, the degree of responsibility is judged by the respective countries' characteristics and by the reasons assumed to be behind the emissions.

6. Conclusion

What criteria are relevant in terms of fairness for the TEP allocation? Through the revelation of ethical preferences, experiment allowed us to provide some answers to this question. Although the establishment of a TEP allocation system is not the result of decisions taken at the micro level, but from the concerted action of governments (Parties to the Convention), the sense of justice that prevails among individuals may be an indicator for decision support that political and institutional systems are more or less able to integrate.

The results of this study show that the subjects attribute to the allocation of permits a re-distributive role: it should help to correct the inequalities in initial endowments. The results of the first part of the questionnaire indicate that the differential in terms of population, GDP, MAC and BE are considered inequalities that justify compensation. Each of these four variables is judged relevant criteria in terms of fairness and must be incorporated into the TEP allocation. Moreover, a more precise analysis of the perception by the subjects of the national responsibility *vis-à-vis* their BE led to establish a hierarchy of criteria.

Considering that the criteria that are not under the countries' responsibility should be compensated through the TEP allocation, the weight given to each of these criteria in the building of the allocation system should reflect the degree of responsibility attached to it. If we rank the four criteria in order of increasing weight in the allocation system, we obtain the following order: the GDP, the MAC, the BE and the population. In other words, a fair allocation should reflect mainly the differential in terms of population and of BE, and to a lesser extent, of the MAC and of a country's GDP.

Finally, this experiment points us towards a definition of what might be a fair TEP allocation. Testing however, does not allow to assert that this view should be adopted by the Parties during climate negotiations. Insofar as there is no supranational organization which has authority over decisions, and the representations of agents preferences, even in democratic systems, are very imperfect, the problem of conflicts of interest remains on the forefront (Bohm, 2008). Furthermore, the concrete negotiation processes are so complex that the actual weighting of fairness criteria in the burden sharing will probably never be made explicit.

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Annex 1

1. The population criterion: an *Egalitarianist* allocation

Egalitarianism, or principle of equality of rights, refers to the Universal Declaration of Human Rights that all men are equal in rights. By extension, men would then have an equal right to emit GHGs into the atmosphere, which would give all individuals an equal right to use the resources of the atmosphere. Under this principle, the initial allocation consists in allocating permits in direct proportion to the population, i.e. in distributing them so that *per capita* emissions were equalized (Agarwal, 1991, 1998, Bertram, 1992; Grubb, 1990). In practice, the system comes to determine the acceptable overall level of emissions and divide it by the number of human beings, the calculated amount corresponding to the amount of GHGs emissions attributed to each individual. Applying this principle, however, is approximate because the recipients are states and not individuals, how the permits will be allocated within the territory is then being defined by each country.

Let:

- P, be the world population
- Pi, the population of the country *i*
- Q, the total quantity of permits to be allocated
- Qi, the quantity of permits allocated to country *i*
- Q, the quantity of permits allocated *per capita*

The amount of permits for each individual is the same, it is the ratio between the global acceptable quantity of permits and the world population $q = \frac{Q}{P}$. This then determines the amount of permits allocated to each country. The allocation is carried out in proportion to the population, simply multiplying the quantity *q* by the population of the country, so: $Qi = q * Pi$

2. The GDP *per capita* criterion: a *Rawlsian* allocation

In accordance with the Rawlsian perspective on fairness, this allocation system aims at maximizing the position of the most disadvantaged. Then we consider as a criterion for allocating emissions permits the states' capacity to pay (Claussen & McNeilly, 1998), the principle being that the greatest burden falls on rich countries, traditionally characterized by a high GDP *per capita*. Although this allocation procedure does not result strictly from Rawlsian Theory of justice (Rawls, 1971), it may be regarded as one of possible rendering. Also, since the outset of negotiations, countries formed coalitions partly based upon their income in order to discuss who should bear the emissions reductions, we considered income as an acceptable proxy of the ability of the country to support abatement efforts. We then translate

this allocation system into an effort to abate emissions which is an increasing function of GDP *per capita*.

The abatement function is defined as follows: $Ai = h * Ei^0 * \left(\frac{R_i}{R_{\max}} \right)$

With:

- Ai, the abatement to be supported by country *i*
- H, an exogenous coefficient that allows to satisfy the constraint $\sum_i Qi = Q$
- Ri, the GDP *per capita* of country *i*
- R_{max}, the highest GDP *per capita*, in other words the GDP *per capita* of the richest country
- E_i^0, the quantity of GHGs emitted by the country *i* with *laisser-faire* (BE)

The abatement depends positively on the amount of GHGs emitted in case of *laissez-faire*, because it is assumed that there is a positive correlation between the GDP of a country and its emissions level. If a country is rich today, this is thanks in part to emissions of GHGs it emits, or has emitted in the past. Industrialised countries are usually characterized by higher emissions.

The allocated quantity of permits is then calculated as follows $Qi = Ei^0 - Ai$, or $Q_i = E_i^0 * \left[1 - h * \frac{R_i}{R_{\max}} \right]$.

3. The emissions criterion: an allocation according to *Responsibility*

According to the principle of equalization of extended resource (Dworkin, 1981), every individual is responsible for his preferences, his conception of the good life and the use of his resources. We can then consider that every country is responsible for the amount of GHGs it emits, since this amount allows it to implement a part of its vision of the "good life". Moreover, the principle of responsibility aims at incorporating externalities in the economy by charging the externality to whoever is behind (Pigou, 1920). Under the initial allocation of TEP, these principles support the idea that countries should be given responsibility commensurate with their level of emissions, pollution source and externalities. This is then to allocate them a quantity of permits in decreasing function of the emission level. The effort for each depends positively on the *per capita* emissions level.

The relative abatement supported by country *i* is then $\frac{A_i}{E_i^0} = \frac{E_i^0 - Q_i}{E_i^0}$

Since the abatement effort depends on the *per capita* emissions, it can also be interpreted as follows $\frac{A_i}{E_i^0} = k * \frac{E_i^0}{P_i}$

With:

- Ei^0/Pi, the BE *per capita*
- k, an exogenous coefficient that allows to satisfy the constraint $\sum_i Qi = Q$

Equalizing the right members of the two equations above, it is then possible to determine the function of permit allocation which is $Qi = Ei^0 * \left[1 - k * \frac{E_i^0}{P_i}\right]$

4. The emissions criterion: the *Grandfathering* allocation

The grandfathering allocation is ethically justified by the libertarian theory of Nozick (1974), libertarianism being based primarily on the classical liberal thought of Locke (1690). In a libertarian perspective, existing and/or past emissions can be regarded as legitimate rights of the countries (clean air is not regarded as a common resource but as likely to be appropriated by the first comer). The United Nations Framework Convention has implicitly accepted this principle by providing a stabilization of GHGs emissions at 1990 levels. The grandfathering suggests to allocate the TEP in proportion to these rights, the criterion used is that of historical level of emissions ("inherited" rights or "grandfathering"). In practice, this leads to reduce emissions proportionately for all countries, which comes to maintain relative emission levels among them. Knowing the overall emission target and the overall level of BE, we can determine the overall percentage reduction (R), this percentage is then applied to each country.

The initial allocation function (suggested by Rose et al., 1998) of permits is formalized as follows: $Qi = (1 - R) * Ei^0$.

5. The marginal abatement cost criterion: a *Utilitarist* allocation

The utilitarian objective is to achieve the greatest happiness for the greatest number (Bentham, 1781), i.e. to maximize the sum of utilities (here, the well-being provided through the allocation system).

Under this perspective, a fair allocation system should be based on the marginal abatement costs of emissions. The fair solution in the allocation of permits would be one that maximizes global economic wealth, as an indicator of well-being. Equalizing the marginal abatement costs can achieve this result: when the total abatement cost is minimal the wealth is at its maximum (in raw estimate). A utilitarian allocation of permits is achieved when the countries whose marginal abatement costs are the lowest are performing most of the abatement efforts.

The amount of permits *Qi* to be allocated to each country *i* is then determined so that: $Cm_i = Cm_j$ ($\forall$ i, j), Cm_i being the marginal abatement cost of the country *i*.

Annex 2: Tables of results

Here are presented the results of the numerical parts and the verbal parts of the experiment.

• The population variable

The country A is twice as populous as the country B, *ceteris paribus*.

TABLE 1: RESULTS OF THE NUMERICAL PART

	Allocation principle	Number of subjects	%
R1	$Q_A = Q_B$	157	54.3
R2	Egalitarianism ($Q_A > Q_B$)	132	45.7
Σ		289	100

TABLE 2: RESULTS OF THE VERBAL PART

	Allocation principle	Number of subjects	%
A	$Q_A = Q_B$	53	18.3
B	$Q_A > Q_B$	203	70.2
C	$Q_A < Q_B$	33	11.4
Σ		289	100

• The GDP *per capita* variable

The country A is twice as rich as the country B, *ceteris paribus*.

TABLE 3: RESULTS OF THE NUMERICAL PART

	Allocation principle	Number of subjects	%
R1	$Q_A = Q_B$	92	31.8
R2	Maximin ($Q_A < Q_B$)	197	68.2
Σ		289	100

TABLE 4: RESULTS OF THE VERBAL PART

	Allocation principle	Number of subjects	%
A	$Q_A = Q_B$	73	25.3
B	$Q_A > Q_B$	80	27.7
C	$Q_A < Q_B$	136	47.1
Σ		289	100

• The marginal abatement cost variable

The country A abatement costs are twice higher as those of the country B, *ceteris paribus*.

TABLE 5: RESULTS OF THE NUMERICAL PART

	Allocation principle	Number of subjects	%
R1	$Q_A = Q_B$	119	41.2
R2	Utilitarism ($Q_A > Q_B$)	170	58.8
Σ		289	100

TABLE 6: RESULTS OF THE VERBAL PART

	Allocation principle	Number of subjects	%
A	$Q_A = Q_B$	82	28.4
B	$Q_A > Q_B$	134	46.4
C	$Q_A < Q_B$	73	25.3
Σ		289	100

• The baseline emissions variable

The country A *baseline* emissions are twice higher as those of the country B, *ceteris paribus*.

TABLE 7: RESULTS OF THE NUMERICAL PART

	Allocation principle	Number of subjects	%
R1	$Q_A = Q_B$	53	18.3
R2	Grandfathering ($Q_A > Q_B$)	144	49.8
R3	Responsibility ($Q_A > Q_B$)	92	31.8
Σ		289	100

TABLE 8: RESULTS OF THE VERBAL PART

	Allocation principle	Number of subjects	%
A	$Q_A = Q_B$	77	26.6
B	$Q_A > Q_B$	146	50.5
C	$Q_A < Q_B$	66	22.8
Σ		289	100

• The population and baseline emissions variables

The country A is twice as populous and has a baseline emissions level twice the level of country B, *ceteris paribus*.

TABLE 9: RESULTS OF THE NUMERICAL PART

	Allocation principle	Number of subjects	%
R1	$Q_A = Q_B$	14	4.8
R2	Egalitarianism ($Q_A > Q_B$)	55	19.0
R3	Grandfathering ($Q_A > Q_B$)	74	25.6
R4	Responsibility ($Q_A > Q_B$)	103	35.6
R5	Equalization of abatement costs ($Q_A > Q_B$)	43	14.9
Σ		289	100

TABLE 10: RESULTS OF THE VERBAL PART

	Allocation principle	Number of subjects	%
A	$Q_A = Q_B$	78	27.0
B	$Q_A > Q_B$	159	55.0
C	$Q_A < Q_B$	52	18.0
Σ		289	100

• The GDP *per capita* and marginal abatement cost variables

The country A is twice as rich and supports a marginal abatement cost twice the size of country B, *ceteris paribus*.

TABLE 11: RESULTS OF THE VERBAL PART

	Allocation principle	Number of subjects	%
A	$Q_A = Q_B$	187	64.7
B	$Q_A > Q_B$	53	18.3
C	$Q_A < Q_B$	49	17.0
Σ		289	100

• The GDP *per capita* and baseline emissions variables

The country A is twice as rich and has a baseline emissions level twice higher than country B, *ceteris paribus*.

TABLE 12: RESULTS OF THE VERBAL PART

	Allocation principle	Number of subjects	%
A	$Q_A = Q_B$	84	29.1
B	$Q_A > Q_B$	98	33.9
C	$Q_A < Q_B$	107	37.0
Σ		289	100

• The baseline emissions and marginal abatement cost variables

The country A has a baseline emissions level and a marginal abatement cost twice as high as the country B, *ceteris paribus*.

TABLE 13: RESULTS OF THE VERBAL PART

	Allocation principle	Number of subjects	%
A	$Q_A = Q_B$	131	45.3
B	$Q_A > Q_B$	114	39.4
C	$Q_A < Q_B$	44	15.2
Σ		289	100

• Justification of an egalitarian allocation

When inequalities are related to two variables, the egalitarian choice can be justified by three arguments.

The first argument relates to the fact that the inequalities are not entitled to compensation because they are not considered unfair. The variables on which inequalities are related appear therefore not eligible for compensation through additional permits.

The second argument involves a notion of compensation, that is, a neutralization of the effects. Here, the individual believes that each variable related to inequalities should be compensated *via* additional permits. Conversely, since these variables come simultaneously and play in opposite directions from each other[21], their effects may counteract, making any compensation unjustified.

[21] The fact that two variables counteract means that the inequality associated with one of these variables implies a larger allocation of permits for one country and, at the same time, the inequality covered by the other variable involves a lower allocation of permits for this country.

Finally, when neither of the above behaviour is observed, it may be argued that the criteria considered important (variables that should be compensated) are not differentiated, meaning that the countries involved in the allocation process are identical in terms of these variables. As such, the equality related to these variables makes any compensation unjustified.

By crossing certain responses made by subjects, we can support several assumptions about the reasons that led them to opt for an egalitarian allocation:

- Argument 1: the differentiated criteria are not compensable;
- Argument 2: the effects of the differentiated criteria counteract;
- Argument 3: the non differentiated criteria are compensable;
- Other: This category is related to subjects whose egalitarian choice remains unexplained because it can not be attached to any of the three arguments. It might be related to a change of opinion within the questionnaire or a misunderstanding of certain questions.

TABLE 14: COUNTRIES DIFFER ON POPULATION AND BASELINE EMISSIONS

	Crossed results	Number of subjects	%
Argument 1	Q_1(pop) = A *and* Q_4(BE) = A	9	11.5
Argument 2	Q_1(pop) = B *and* Q_4(BE) = B *or* Q_1(pop) = C *and* Q_4(BE) = C	18 3	23.1 3.8
Argument 3	Q_2(GDP) = C *or* Q_3(MAC) = B	30	38.5
Other		18	23.1
Total		78	100

TABLE 15: COUNTRIES DIFFER ON GDP *PER CAPITA* AND MARGINAL ABATEMENT COST

	Crossed results	Number of subjects	%
Argument 1	Q_2(GDP) = A *and* Q_3(MAC) = A	25	13.4
Argument 2	Q_2(GDP) = C *and* Q_3(MAC) = B *or* Q_2(GDP) = B *and* Q_3(MAC) = C	63 19	33.7 10.2
Argument 3	Q_1(pop) = B *or* Q_4(BE) = B	73	39.0
Other		7	3.7
Total		187	100

TABLE 16: COUNTRIES DIFFER ON GDP *PER CAPITA* AND BASELINE EMISSIONS

	Crossed results	Number of subjects	%
Argument 1	Q_2(GDP) = A *and* Q_4(BE) = A	17	20.2
Argument 2	Q_2(GDP) = C *and* Q_4(BE) = B *or* Q_2(GDP) = B *and* Q_4(BE) = C	20 2	23.8 2.4
Argument 3	Q_1(pop) = B *or* Q_3(MAC) = B	40	47.6
Other		5	6.0
Total		84	100

TABLE 17: COUNTRIES DIFFER ON BASELINE EMISSIONS AND MARGINAL ABATEMENT COSTS

	Crossed results	Number of subjects	%
Argument 1	Q_4(BE) = A *and* Q_3(MAC) = A	23	17.6
Argument 2	Q_4(BE) = B *and* Q_3(MAC) = B *or* Q_4(BE) = C *and* Q_3(MAC) = C	19 5	14.5 3.8
Argument 3	Q_1(pop) = B *ou* Q_2(GDP) = C	70	53.4
Other		14	10.7
Total		131	100