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Climate Policy and Equity Principles: Fair Burden Sharing in a Dynamic World

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Climate Policy and Equity Principles: Fair Burden Sharing in a Dynamic World

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Abstract

The paper proposes a general rule for burden sharing in international climate policy. Starting from basic equity principles and considering economic development it derives a simple equation for a fair international allocation of greenhouse emission entitlements. The fairness rule comprises both egalitarian and efficiency aspects, which appear to be crucial for political acceptance. Carbon budgets for the different countries are calculated under different parameter assumptions.

Keywords: Climate policy, carbon emissions, growth, burden sharing
JEL Classification: O10, Q52, Q54

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1 Introduction

According to the Durban climate agreement, the international distribution of the burden of climate policy has to be decided within a three-year time period. To provide useful guidelines for this process, equity principles appear to be relevant. They may be suitable for raising political acceptance and, importantly, work as focal points during negotiations. In addition, international negotiators will also have to consider fairness preferences of their voters at home. The 1987 Montreal Protocol on the Ozone layer is often seen as a successful implementation of equity principles in an international environmental issue. But climate agreements are more complex because the use of fossil fuels and its substitution are crucial issues for the economies. Moreover, international negotiations have not yet established a general concept of how to use equity principles. What is needed for climate policy is a plausible mechanism to transform abstract principles in a form, which is ready to be used in international climate negotiations. This is where the present paper aims to make a contribution.

The paper provides a brief evaluation of the most relevant equity principles. As a novel aspect, it stresses the fact that development is a dynamic process, which cannot be evaluated in a purely static framework. We argue that changes in technology and carbon efficiency must have an impact on the general policy assessment. Starting from broadly acceptable first principles the paper derives a simple equation to calculate individual and country emission budgets. By a variation of the remaining parameters, different solutions can be evaluated. For illustrative purposes and possible practical use, calculations on the country levels are given in the final part.

The contribution is related to Lange et al. (2007) putting forward the importance of equity principles in climate policy and Mattoo and Subramanian (2010) who present theory and practice of climate policy burden sharing, mainly focusing on ability to pay and efficiency principles. Konow (2003) provides a useful overview on general equity principles; Cazorla and Toman (2000), Page (2008), and Johansson-Stenman and Konow (2010) apply the principles to climate and environmental economics. A contribution stressing egalitarian principles is BASIC (2011). Other studies are mainly concerned with political constraints caused by adaptation policies and a lack of compliance and motivation, see Frankel (2008), Bosetti and Frankel (2009), Gersbach and Winkler (2011) and McKibbin et al. (2010), who present a broad calculation of economic efforts required to achieve specific climate commitments. Blanford et al. (2008) show the importance of newly emerging economies, Bretschger and Valente (2011) derive the uneven consequences of climate change, while Lange et al. (2010) remind us that in the negotiations equity principles can also be used for selfish reasons.

By agreeing on the Durban platform in 2011, the character of the international process finding a new climate agreement and related research have changed. Before, there was much consideration on how to build coalitions and how to convince (big) players to join the coalitions. Now the coalition is fixed, encompassing the whole world community. Moreover, given the confirmed target of a maximum warming of two degrees Celsius, the total budget for greenhouse gases is predetermined by scientific results. Accordingly, the current problem is to propose a distribution of a given budget across all the nations, which has the potential to be generally acceptable.

The present paper proposes a solution for burden sharing, which includes egalitarian aspects but does not impose equal sharing of resources as a first principle. Moreover, the proposed fairness rule comprises also efficiency aspects, which appear to be crucial for political acceptance, without declaring political constraints to be on the level of the principles. The provided solution is simple; it allows to eventually concentrate the debate on a single variable and two parameters.

2 Equity Principles

In the following, those equity principles are discussed and evaluated which appear to be especially relevant for climate policy and are useful for the international climate negotiation process. The latter is closely related to simplicity and intuition but also to verification, which is not given when rules depend on results from complex numerical models. The discussion is focused on the requirements of current climate policy and thus not exhaustive with regard to the principles discussed in the literature. The paper is on climate mitigation policies, adaptation is only mentioned on the side.

The term "carbon" is used as a short expression for all the greenhouse gases.

The *Egalitarian Principle* in the form of an equal right to atmospheric resources has recently attracted considerable interest, see BASIC (2011). However, despite its attributes of simplicity and immediate intuition, it has major drawbacks. It is conceivable to argue that, if it were applied to the atmosphere, it should also be applied to the other natural (and possibly man-made) resources, which is not a generally accepted view. Markets and policies have usually different objectives; countries allocate their own resources in a different manner. Hence, what is not the standard principle on a national level can hardly be the main guideline on an international level. Even more important, an equal use of atmospheric resources does not consider the context of the use. Notably, with the increasing availability of carbon-efficient technologies, carbon emissions become less imminent for human well-being and economic development compared to earlier periods. The often referred to *right to develop* has thus to focus on those factors which are crucial for development; among these, carbon emissions are much less imminent than for example capital, education and knowledge investments, see Bretschger, Ramer and Schwark (2011). In addition, technical progress makes resource use more productive over time, so that - under equity considerations - emissions have to be evaluated in the context of the technology level. Nevertheless, the Egalitarian Principle can be applied in the sense that the equity rules of burden sharing should be applied on a per capita level (but in an adjusted form). Hence, every individual is treated in the same way, but, and this is crucial, with consideration of the context of its actions. The principle should be interpreted to allow for an equal access to sustainable development, which crucially depends on the availability of technologies, and in particular on carbon efficient technologies, but not on absolute emission levels.

The *Ability to Pay Principle* requires the future allocation of carbon emissions to be inversely related to the ability to pay for emission reduction. It involves a redistribution of income, which is an issue in any policy context. The specific problem to consider with climate policy is that incomes are in general positively correlated not only with past but also with current carbon emissions, so that the costs to reduce carbon emissions are also related to income. Therefore, the Ability to Pay Principle may stand in contrast to the *Efficiency Principle,* which requires maximizing total surplus or, more precisely, minimizing the costs of carbon policy, see Konow (2003, p. 1205). The distribution of the costs of a global policy is not exclusively an efficiency but also an equity concern. The efficiency view is concerned with total costs becoming minimal, while the equity view argues that these costs should be distributed in a fair way. A strong focus on the distribution of cost is reflected in the often quoted *Grandfathering Rules* allocating the emission rights in proportion to current pollution. Fairness and efficiency are often considered to be at odds but an appropriate policy can alleviate the conflict, the result of the present paper may serve as an example. The Ability to Pay Principle is also related to the *Polluter Pays Principle,* which assigns the burden of the policy proportional to actual pollution. Both rules appear to be especially well suited for climate adaptation policies, in particular when defining the payments for funds used for adaptation measures.

The *Need Principle* requires distributive justice with the aim of satisfaction of the basic needs of all individuals, which may include the use of the atmosphere. The *Desert Principle* identifies factors justifying higher individual claims, in general on economic income and wealth, see Konow (2003, p.1207). From the different factors discussed in literature it emerges that differences attributable to effort are generally considered to be fair. In the context of climate policy, efforts relate to all contributions enabling a delinking of income and welfare from carbon use. It thus appears to be a desert when advancing the productivity of atmospheric resource use by developing carbon efficient technologies and letting the rest of the world benefit through international knowledge provision. Besides our focus on the general technology level this is a second dynamic ingredient which appears to be crucial for economic development. Many climate studies do not especially consider economic dynamics while the present paper argues that it is crucial to determine the "really equal" access to sustainable development. We disregard further principles mentioned in literature for the sake of clarity and briefness. Specifically, possible political constraints are not considered as first principles. Also, more complicated statements based on numerical simulation models are not included. Finally, all the countries (including the less developed economies) are included in the analysis.

When applying these principles to international carbon policy, several side conditions have to be settled. First, especially with international trade, one has to determine whether producers or consumers are liable for the consequences of resource use. The standards of income accounting and international law suggest that producers are responsible, but economics shows that, also in this case, consumers carry a (part of the) burden of climate policy through (higher) prices of (imported) goods. Another issue is whether we should apply the same principles for distributing the burden in mitigation and adaptation policies. The discussion suggests that with adaptation we should refer more to the ability to pay and the polluter pays approach but the present paper is concerned with mitigation policy. As regards timing, we consider the period starting with *Historic Responsibility* (where the period of "excusable ignorance" stops) and ending in the middle of the 21st century, because climate sciences have calculated feasible world carbon budgets up to this point in time, see Meinshausen et al. (2009). We will calculate country carbon budgets and not time paths, because these can be better optimized on the country level. Also, in order to optimize costs, countries should be allowed to internationally trade their initial emission entitlements. Additional services in landscape and forest management may be included in calculating the entitlements, but this is not a focus here. We argue that responsibility also includes sharing resources among a country's population so that we count population of a country at the beginning of the "responsibility" period.

3 Application to Climate Policy

3.1 Choosing the Principles

The main equity principles are now combined to yield a simple allocation rule for international carbon budgets. The Egalitarian Principles is used in the way that we calculate per capita carbon claims throughout, that is we choose the individual as a unit of analysis. The Ability to Pay Principle is included to derive the budgets as a measure of purchasing power, mainly for carbon efficient technologies. The Efficiency

Principle is employed to reflect the different abatement costs. The Desert Principle is used for the provision of carbon-saving technical progress. Another determinant pointing at economic dynamics is the development of technical progress. The Polluter Pays Principle is included in the sense that past emissions are deducted from the overall carbon budget, possibly with a discount, depending on the valuation of historic responsibility. In the long-run steady state, one can assume that every individual will obtain an equal share of atmospheric resources according to the Need Principle, but this has no impact on our derivation, because we look at the transition of the economy towards sustainable development. As given conditions we take that by the agreement on the Durban platform all the countries are included in the analysis. In addition, by the Cancun agreements, we assume that the two degrees Celsius target is confirmed so that the world carbon budget is predetermined (by natural science results).

3.2 Fairness Index

The different principles are used to build a fairness index F, which is the main ingredient to determine the carbon budgets; a higher F will yield a higher budget in the following. F depends on four variables: the (inverse of the) Ability to Pay A, the Abatement Cost parameter C, the (individual or country) Technology Contribution x, and the general Technology Development X. All variables are measured for an individual i at the *beginning* of the considered time period. An important methodological issue is how to combine these four factors mathematically, which ultimately determines their weight in the index. A broadly used technique is the weighted average, which relies on the (simple) arithmetic weighted average of the (normalized) variables. When the weights are the same for all the variables we get the so-called "equally weighted averages." The procedure is simple but the linearity implies constant substitutability among the different criteria, which is a strong assumption for international climate policy. It implies that a country can compensate (even extreme) deviations from the mean in one variable in exchange with other variables at a constant ratio. A more suitable procedure is to use the multiplicative form between the variables and define the weights in the exponents. In the present case, this leads to:

$$F_i = A_i^{\alpha} \cdot C_i^{\beta} \cdot {x_i}^{\gamma} \cdot X_i^{\delta} \tag{1}$$

where $0 < \alpha, \beta, \gamma, \delta < 1$ determine how the index F increases when a variable on the right hand side grows. Because the exponents are below unity, the index grows less than proportional with the single variables. For concrete application, we measure A by the inverse of income Y per capita L, the mitigation cost burden by emissions E per capita L, the contribution to technology development by output Y per emission E and the context of general technology development by emissions E per capita L. This last measure is meaningful when we assume that technical efficiency of carbon use is improving steadily, as it has been the case in the past. Then, a country with high pollution in the beginning and a deacreasing carbon profile is different from a country with low pollution in the beginning and rising emissions. With regard to carbon use, the first country has unambiguously less technical opportunities than the second. The measurement of the variables is represented in the following Table 1.

	Ability to Pay	Cost Distrib.	Techn. Contrib.	Techn. Develop.
Variable	A_i	C_i	x_i	X_i
Measure	$\frac{L_i}{Y_i}$	$\frac{E_i}{L_i}$	$\frac{Y_i}{E_i}$	$\frac{E_i}{L_i}$

Table 1: Measuring the Variables

Using this specification we get

$$F_i = \left(\frac{L_i}{Y_i}\right)^{\alpha} \left(\frac{E_i}{L_i}\right)^{\beta+\delta} \left(\frac{Y_i}{E_i}\right)^{\gamma}$$

$$= {L_i}^{\alpha-\beta-\delta} E_i^{\beta+\delta-\gamma} Y_i^{\gamma-\alpha}. \tag{2}$$

In a non-growing (static) economy, the technology development parameter is zero, i.e. $\delta = 0$. Then, applying the equal weight method to the parameters in the exponent, we set $\alpha = \beta = \gamma$. Interestingly, this yields $F_i = 1$, which is exactly the egalitarian solution with equal weights for every individual, like in BASIC (2011). But note that the result is not using equal carbon space as something like a first princinple, the outcome emerges due to the exactly balancing effects of three (real) first principles, namely ability to pay, abatement costs, and technology contribution.

However, we argue that the considered economies are inherently dynamic, mainly driven by technical progress. Hence, taking $\delta > 0$ and applying the equal weight rule to all the four variables, we have $\alpha = \beta = \gamma = \delta$ in order to obtain

$$F_i = \left(\frac{E_i}{L_i}\right)^{\alpha}. \tag{3}$$

This expression has many interesting aspects. It reduces the highly complex problem of burden sharing in international climate policy to one single variable (E_i/L_i) and a unique parameter (α, with $\alpha = \beta = \gamma = \delta$). It offers a close link to natural sciences and, moreover, an easy calculation method for the emission budgets. Importantly, with the link to (initial) emissions it opens the door to (possible) political acceptance, much like the *grandfathering rules* used with past carbon policy, without using political constraints as first principle. The derived relationship is nonlinear, so that the impact of emissions on the index fades with increasing emissions. Nonlinearity is even high, because with the obvious restriction $\alpha + \beta + \gamma + \delta = 1$, we have $\alpha = 0.25$. The index is very robust with respect to ordering of individuals and countries.

3.3 Budget Calculation

Individual allocation Each individual i receives an emission budget B_i according to the individual fairness index F_i and the total amount of entitlements Z available, according to

$$B_i = \frac{F_i}{\sum_{i=1}^{L} F_i} \cdot Z. \tag{4}$$

Country allocation Let us define the population share of country j as $m_j(t) = L_j(t)/L(t)$ and use M for the number of countries. Each country receives an emission budget Q_j according to the weighting index F_j (reflecting the country fairness average), the country share m_j, and the total amount of entitlements Z available, so that

$$Q_j = \frac{m_j \cdot F_j}{\sum_{j=1}^{M} m_j \cdot F_j} \cdot Z. \tag{5}$$

3.4 Historic Responsibility

So far we have not distinguished between different time periods. The whole period to consider starts with historic responsibility and is assumed to end in 2050, because current budget calculations provided by natural sciences end at that point in time. Because of natural decay of greenhouse gases and the absence of legal obligations in the past we might value past carbon use differently from future use. For practical reasons, we will distinguish between a *first period*, starting with the date of historic responsibility up to the point where the most recent statistics are available, and a *second period,* from that point in time until 2050. For the budget calculation, we assume the countries to receive entitlements according to the fairness index as derived above but now posit that actually used emissions in the first period may be discounted with a factor $0 < \theta < 1$. In the concrete calcuations, we will compare carbon budgets for the responsibility values $\theta = 1.0$; 0.8; 0.5; and 0.0.

4 Country results

4.1 Assumptions

To provide concrete information about the derived fairness equation, this section calculates country carbon budgets, using the fairness index F and based on the following assumptions:

- Start of (historic) responsibility: 1990
- First ("responsibility") period; 1990-2008 (1990 is the starting date of international climate policy; for 2008 the last international data on carbon use are available)
- Second ("carbon budget") period: 2008-2050 (feasible world carbon budgets were calculated up to 2050)

- Total carbon budget Z for 1990-2050: Carbon emissions corresponding to a probability of 50% of exceeding 2°C, according to Meinshausen et al. (2009) who cover 2000-2050, plus carbon emissions 1990-2000, yielding 1640 Gigatons in total.

- Population size: 1990 values

- $\alpha = 0.25$ $(= \beta = \gamma = \delta)$

- Valuation of emissions in the "responsibility" period: scenarios for different levels of θ ranging from $\theta = 1$ (full responsibility) to $\theta \to 0$ (no responsibility).

4.2 Budgets

The following tables show the carbon budgets for 2008 to 2050 for *selected countries* and four levels of historic responsibility. The first table contains the total budget, the second the budget per capita (using 2008 population values), and the third the average budget per capita per year. As can be seen from the tables, historic responsibility matters especially for the United States, but is also an issue for other countries like Russia or Japan.

Table 1

Total budget left (from 2008 - 2050) in Gigatons				
Country Name	**$\theta = 1$**	**$\theta = 0.8$**	**$\theta = 0.5$**	**$\theta \to 0$**
China	294.36	287.08	277.96	266.21
India	195.84	185.50	172.55	155.86
European Union	114.52	120.34	127.62	137.02
United States	26.20	43.12	64.31	91.62
Indonesia	43.12	40.92	38.15	34.58
Russian Federation	32.33	36.07	40.74	46.77
Brazil	36.76	35.14	33.11	30.50
Japan	29.18	31.24	33.81	37.13
Nigeria	19.93	18.71	17.18	15.21
Bangladesh	17.61	16.42	14.93	13.02
Colombia	8.03	7.66	7.19	6.58
Peru	4.98	4.72	4.39	3.96
Congo, Dem. Rep.	4.45	4.13	3.73	3.22
Kenya	4.13	3.86	3.51	3.07
Nepal	2.68	2.50	2.26	1.96
Cote d'Ivoire	2.42	2.27	2.07	1.83
Uganda	2.28	2.12	1.92	1.66
Bolivia	1.55	1.47	1.37	1.24
Cambodia	1.54	1.44	1.30	1.14
Senegal	1.42	1.33	1.22	1.08

Table 2

Budget left per capita (from 2008 - 2050) in tons				
Country Name	**θ = 1**	**θ = 0.8**	**θ = 0.5**	**θ → 0**
China	219.95	214.51	207.70	198.92
India	167.25	158.42	147.36	133.11
European Union	228.08	239.67	254.19	272.90
United States	84.78	139.51	208.07	296.46
Indonesia	179.78	170.57	159.04	144.18
Russian Federation	228.09	254.43	287.42	329.96
Brazil	188.54	180.24	169.85	156.45
Japan	228.98	245.10	265.30	291.34
Nigeria	125.79	118.10	108.46	96.03
Bangladesh	118.40	110.42	100.43	87.54
Colombia	173.46	165.36	155.21	142.13
Peru	171.41	162.31	150.91	136.22
Congo, Dem. Rep.	67.41	62.61	56.61	48.87
Kenya	101.95	95.20	86.74	75.83
Nepal	89.61	83.34	75.49	65.37
Cote d'Ivoire	122.66	114.88	105.13	92.55
Uganda	68.19	63.36	57.32	49.53
Bolivia	155.95	147.86	137.73	124.67
Cambodia	108.98	101.56	92.28	80.30
Senegal	114.40	107.20	98.19	86.58

Table 3

Budget left per capita per year (from 2008 - 2050) in tons				
Country Name	**θ = 1**	**θ = 0.8**	**θ = 0.5**	**θ → 0**
China	5.24	5.11	4.95	4.74
India	3.98	3.77	3.51	3.17
European Union	5.43	5.71	6.05	6.50
United States	2.02	3.32	4.95	7.06
Indonesia	4.28	4.06	3.79	3.43
Russian Federation	5.43	6.06	6.84	7.86
Brazil	4.49	4.29	4.04	3.73
Japan	5.45	5.84	6.32	6.94
Nigeria	3.00	2.81	2.58	2.29
Bangladesh	2.82	2.63	2.39	2.08
Colombia	4.13	3.94	3.70	3.38
Peru	4.08	3.86	3.59	3.24
Congo, Dem. Rep.	1.60	1.49	1.35	1.16
Kenya	2.43	2.27	2.07	1.81
Nepal	2.13	1.98	1.80	1.56
Cote d'Ivoire	2.92	2.74	2.50	2.20
Uganda	1.62	1.51	1.36	1.18
Bolivia	3.71	3.52	3.28	2.97
Cambodia	2.59	2.42	2.20	1.91
Senegal	2.72	2.55	2.34	2.06

5 Conclusions

By reducing the complexity of fundamental equity principles the paper proposes a general rule for burden sharing in international climate policy. The fair allocation of carbon budgets comprises both egalitarian and efficiency aspects, which appear to be crucial for political acceptance. The calculated carbon budgets for the different countries show the absolute values and the sensitivity of the results with respect to the assumption on historic responsibility.

One can extend the discussion to more complex combinations of the different principles and their valuation. The coming political debare might find reasons to do so. But the simplicity of burden sharing rules have their own merits, they can provide clear guidelines. The present paper finds a rule that respects the issue of sharing climate abatement costs, but includes the other basic principles like the ability to pay in an equal way. The nonlinear impact of initial emissions per capita on the fairness index smoothens the carbon budget differences between the countries, which guides the way towards a long-term future with sustainable and equal sharing of atmospheric resources.

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6 Appendix

The following figures show the distribution of the carbon budget on the country level graphically.

Figure 1

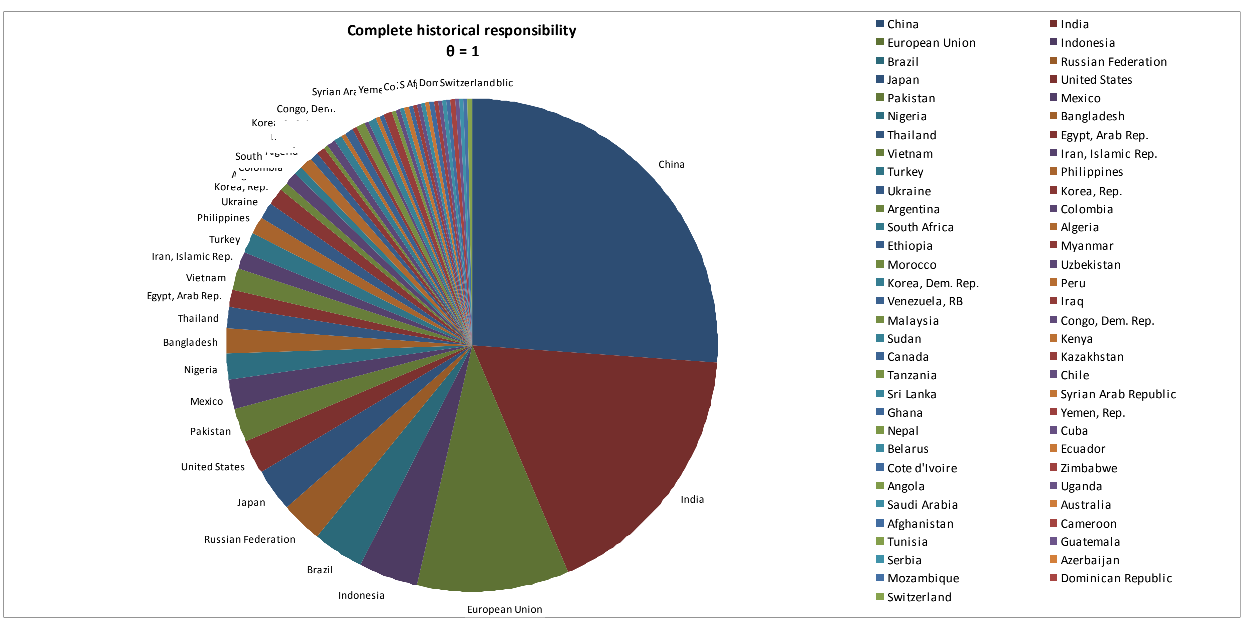


Figure 2

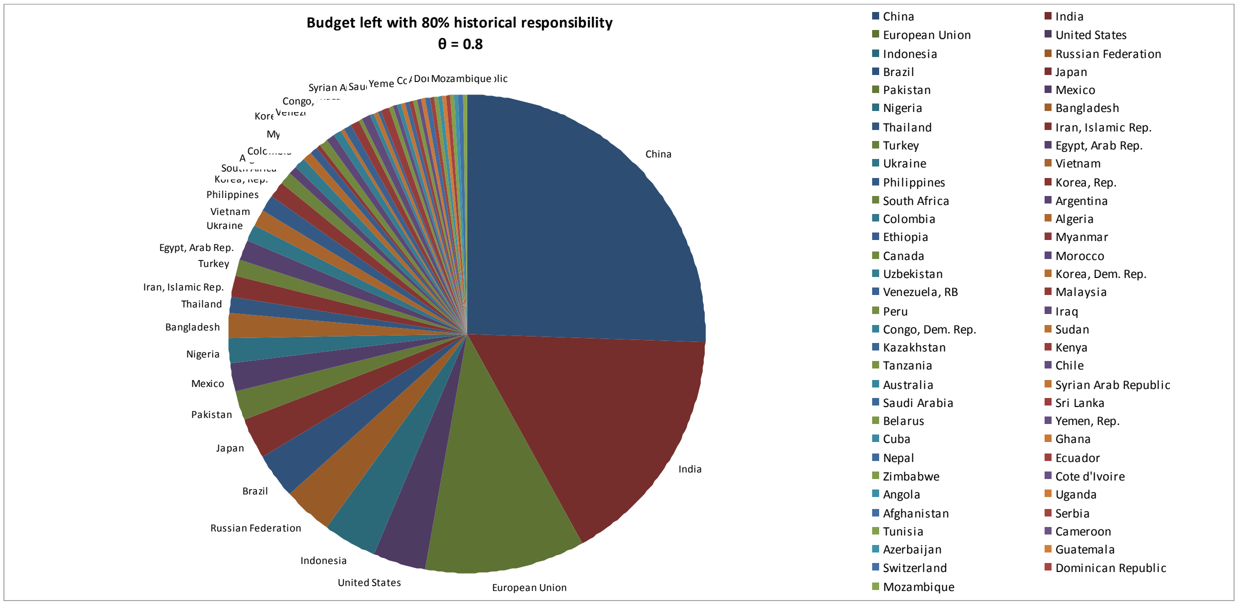


Figure 3

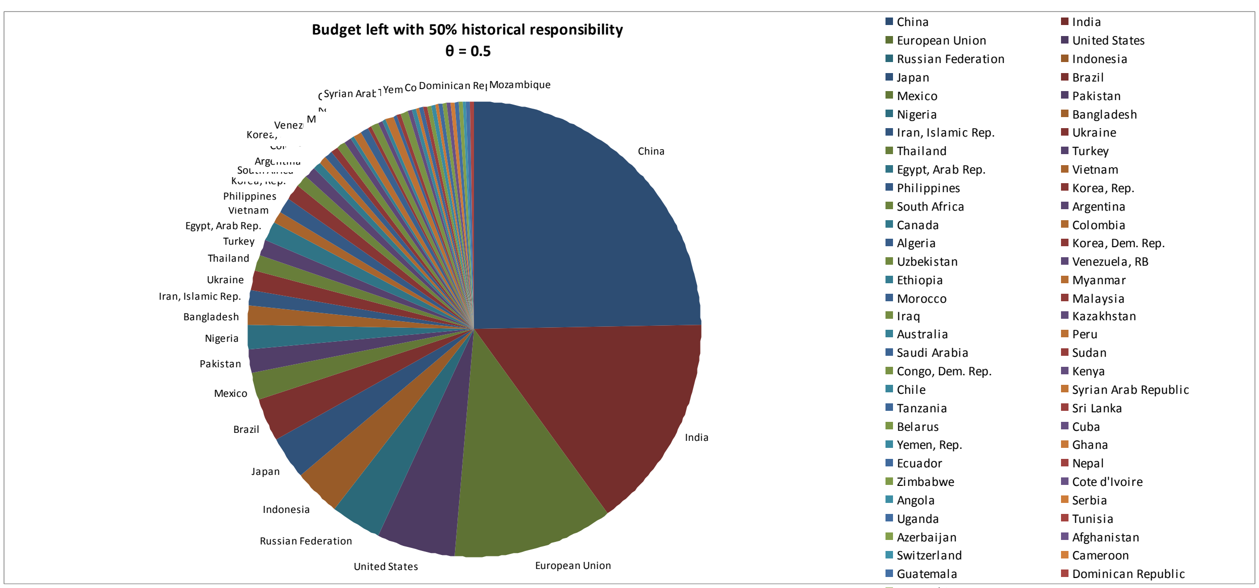
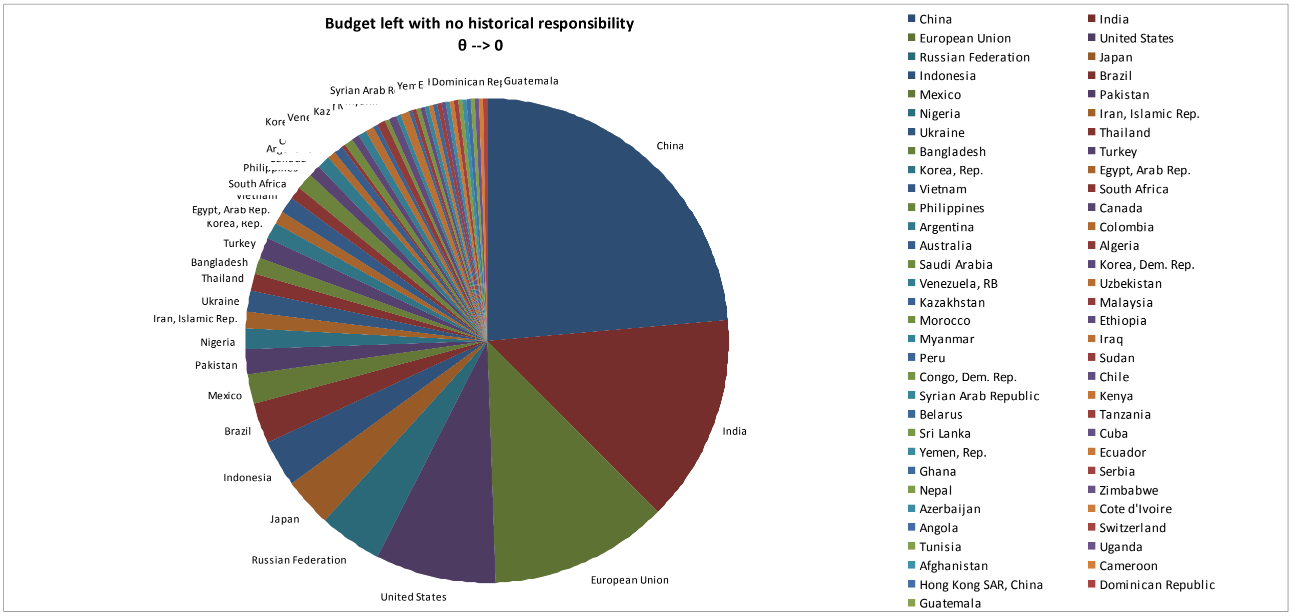


Figure 4



Budget left with no historical responsibility
θ --> 0
China
India
European Union
United States
Russian Federation
Japan
Indonesia
Brazil
Mexico
Pakistan
Nigeria
Iran, Islamic Rep.
Ukraine
Thailand
Bangladesh
Turkey
Korea, Rep.
Egypt, Arab Rep.
Vietnam
South Africa
Philippines
Canada
Argentina
Colombia
Australia
Algeria
Saudi Arabia
Korea, Dem. Rep.
Venezuela, RB
Uzbekistan
Kazakhstan
Malaysia
Morocco
Ethiopia
Myanmar
Iraq
Peru
Sudan
Congo, Dem. Rep.
Chile
Syrian Arab Republic
Kenya
Belarus
Tanzania
Sri Lanka
Cuba
Yemen, Rep.
Ecuador
Ghana
Serbia
Nepal
Zimbabwe
Azerbaijan
Cote d'Ivoire
Angola
Switzerland
Tunisia
Uganda
Afghanistan
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