On the Power Distribution among the Parties of the UNFCCC

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Abstract

The voting mechanisms under which the Kyoto Protocol entered into force were probably responsible for the difficulties met during the negotiations for its ratification. Each country held a number of mandates corresponding to its greenhouse gases emissions, and as a consequence, they did not have the same influence on the collective result. The power distribution among the Parties led the negotiations to dead-end during seven years.

Studies through power indices revealed that half of the decisional power was in the hands of the United-States during the Kyoto negotiations. The Post-Kyoto agreement will integrate the whole international community, including Developing Countries. In this article, we evaluate the consequences of a similar ratification mechanism on the decisional power distribution among the Parties of the United Nations Framework Convention on Climate Change (UNFCCC). We also simulate other ratification mechanisms to estimate their impacts on the power distribution. At last, we integrate the European coalition in the model by considering the European Union (EU25) as a single player.

Three main results outlined. Firstly in terms of a priori power, the decision making process will not benefit as much to the United-States as it did in the Kyoto Protocol. Secondly, the power distribution among the countries does not substantially change if the UNFCCC considers the European Union as a single Party. Finally, the quota will probably be one of the key point of the ratification process of the future protocol.

Key words: Power indices, Environment, Post Kyoto, Empirical game theory, Weighted games.

JEL Classification: D71, Q20, C71.

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The Kyoto Protocol was implemented in November 2004 due to Russian ratification. It is a great step in favor of an international environmental strategy. It is also an important political signal for an international action against Global Warming. As the largest greenhouse gases emitters of the Annex I[1] signed it (except the United-States), Developing Countries will be encouraged to act in the same way.

But it was not easy to reach such an agreement. The decision making process adopted in Kyoto required the ratification of 55 countries including industrialized countries (so-called Annex I countries) that represented at least 55% of the total CO_2 emissions of the countries of the Annex I, taking the year 1990 as a reference point (article 25).

Measuring influence in a decision making process

The Kyoto ratification process can be considered as a simple game in which the number of mandates of a country directly depends on its emissions share. One can think that the decisional power of a country is proportional to its emissions share. But looking only at the weights of the players is quite misleading if we want to estimate the real influence of each player in a decision making process.

Let us illustrate this with an example. Suppose there are three shareholders A, B and C that respectively hold 51%, 1% and 48% of a company's capital. They decide to take a collective decision with the majority rule; the quota is thus equal to 50%. Their weights depend on their capital shares. Obviously, player A can decide alone; its influence or decisional power is 100%. The decision making power of B and C is 0%.

Assume now that the shareholders A, B and C hold respectively 49%, 2% and 49% of the company's capital. The difference between the two above configurations is very slight, but the power distribution is quite different. The approval of at least two players is necessary for a decision to be adopted. Thus, each of them have to make an alliance with another shareholder to make up a majority. Consequently, the decisional power is equally split among A, B and C.

This example shows that the a priori decisional power of a player is not proportional to its weight in the decision making process. Moreover, one can observe that small changes can have important consequences on the power distribution. Thus, the decisional power of a player depends on: Its weight, the weights of the other players and the quota to be reached for a decision to be taken. Consequently, the power of the Parties in the Kyoto Protocol did not correspond to their weights. The question is then to find a good way to evaluate the a priori decisional power of a country.

[1]The Annex I is an appendix of the Kyoto Protocol gathering the 39 industrialized countries which have emission constraints and a mandate in the decision making-process. See complete list in Table 1.

In 1954, Lord Shapley introduced the notion of *decisional power within a committee* in the economic literature[2]. To evaluate the ability of a player to influence the collective result, he proposed to count the relative number of configurations[3] in which this player is decisive (pivotal). A player is decisive if he can change the collective result by changing its vote. Banzhaf (1965) introduced another power index[4] to analyze political situations, and applied it to the US Electoral College in 1968. The *absolute Banzhaf index* reveals the relative number of coalitions in which a voter is decisive (critical).

Decisional power distribution within the UNFCCC

Two studies (Wagner and Höhne (2001) and Le Tensorer, Larrach and Merlin (2004)) dealt with the a priori power distribution among the Parties of the Kyoto Protocol. They both only took into account the emissions quota because the protocol was quickly ratified by more than 55 countries (Developing countries had no emission constraint). The objective of the present study is to evaluate the power distribution that could emerge from the different voting mechanisms that could be used in the Post Kyoto agreement. In order to compare our results to previous ones we use Banzhaf index throughout this analysis.

The algorithm proposed by Banzhaf enumerates all the possible coalitions of the set of players. There are more than 180 Parties within the UNFCCC. It is consequently impossible to compute exactly the Banzhaf index for such a large set of player due to computing time. Thus, we used an approximation method to calculate the power distribution. Dennis Leech (2003) proposed the *Modified Multilinear Extension Approximation* (MMEA) technique to evaluate the power distribution, when the set of players is large and when the majority of the weights is concentrated in the hands of a minority of players. These assumptions are fulfilled in the UNFCCC. Consequently, we can compute the Banzhaf indices with the MMEA.

In the Kyoto Protocol, the reference point for the emissions is 1990. In our study, the reference point for the emissions is 1995[5] and the greenhouses gases considered are those of the Kyoto Protocol[6]. We also consider that the emissions quota was the only relevant one. Consequently, in our model, the weights of the countries are equal to their emissions share and a quota is fixed for the agreement to be adopted.

[2]Penrose (1946) had suggested ways to measure power and influence several years before. Unfortunately, his contributions were ignored for a long time by the game theory community.

[3]For Shapley, the number of configurations is equal to the number of permutations of a player.

[4]For a complete review of the power indices, see Felsenthal and Machover (1998).

[5]We choose 1995 as reference point because complete emissions databases are difficult to obtain (especially emissions of China). Studies with more recent databases will give us a more precise point of view.

[6]The Annex A of the Kyoto Protocol stipulates that the concerning greenhouse gases are CO_2, CH_4, N_2, HFC, PFC and SF_6 (in CO_2 equivalent).

Thus, the aim of this paper is the evaluation of the power distribution among the Parties of the Kyoto Protocol with different quotas, q. We tested $q = 50\%$, $q = 55\%$, $q = 60\%$ and $q = 65\%$. The method used is the Banzhaf index computation through the Modified Multilinear Extension Approximations technique developed by Leech[7].

Results

In the first scenario, the countries vote alone; the UNFCCC does not consider the European Union as a single Party. The first observation concerns the heterogeneity of the weights' distribution (see Table 2): United-States holds 19.22% of the votes, China 14.04%, the Russian Federation 6.45% and India only 5.40%. When the quota is equal to 55%, the normalized Banzhaf index distribution is more heterogeneous: USA catches 22.68% of the power while China holds 13.68% and Russia 6.14%. Furthermore, we remark that, as it was in the Kyoto Protocol, the power of the United-States is bigger than its weight. This collective decision rule benefits to the countries with the highest weights. But the most striking result is that, compared to the Kyoto Protocol, the US influence is divided by 2.5. They held 50.84% of the decisional power in the Kyoto Protocol.

Let us consider two other quota levels: 60% and 65%. With these hypothesis (see Table 4), the US power decreases respectively to 22.26% and 17.34% while the power of China becomes 17.66% and 16.36%. In the same time Russia's influence (measured with the normalized Banzhaf index) jumps respectively to 5.40% and 6.67%. Thus, increasing the quota makes the decisional power distribution more homogeneous. The reason is that the more the quota increases, the more the game tends to an unanimity game. In such a game, the power is equally distributed among the players because each country has the power to block any agreement[8].

In the second scenario, the UNFCCC considers the European Union (EU25) as a single Party. Since the beginning of the Convention, the European countries acted in a cooperative way by convening before each Conference how to combine their bargaining strategy. This approach modified the Kyoto voting game and had consequences on the a priori power distribution. For example, it made the US influence decreased from 50.84% to 41.44% (see Le Tensorer, Larrach and Merlin (2004)).

When the quota is equal to 55%, the power distribution is slightly modified (see Table 3): The US' influence decreases to 21.34%. The normalized Banzhaf index of the EU25 is 13.93%, just above the sum of the power of its members alone (13.31%). Moreover, the decisional power of China jumps to 14.03%. There is also a small gain for Russia in this scheme: Its power rises to 6.36%. Therefore, the formation of

[7]See Dennis Leech web site for computing program: http://www.warwick.ac.uk/ ecaae/

[8]Coleman (1971) distinguished two forms of power: The *power to initiate action* and the *power to prevent action*. When the quota is higher than 65%, the power to prevent action of the United-States and China are too high for a proposal to be collectively accepted without their consent (see Table 5).

an European coalition especially benefits to China and Russia in terms of decisional power.

Results of simulations with higher quotas (60% and 65%) are close to those of the first scenario (without the EU25). US' influence decreases respectively to 19.61% and 19.23%. The influence of China, EU25 and Russia are enlarged (see Table 5 for complete results).

Conclusion

This analysis shows how complex is the choice of a ratification process. A Banzhaf analysis can enlighten about the influence of national governments on a collective decision in an international institution such as the UNFCCC. Our results reveal that the decisional power will probably be more homogeneously distributed than in the Kyoto Protocol. This is mainly due to the participation of the Developing Countries and especially China. They also show that one way to share the power more equally, in the ratification process of the next protocol, is to rise the emissions quota from 55% to 60% or 65%. Nevertheless, according to Coleman's predictions, this must be done carefully in order to prevent the largest greenhouse gases emitters to build locking majorities.

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Table 1: The decisional power distribution between countries of the Annex I (Kyoto Protocol).

Country	Emissions in 1990*	% CO_2	Normalized Banzhaf	$\frac{Bz.norm.}{\%\ CO_2}$
USA	4 998 516	35.02%	50.84%	1.45
Russia	2 372 300	16.62%	9.24%	0.56
Japan	1 119 319	7.84%	6.51%	0.83
Germany	1 014 501	7.11%	5.87%	0.83
Ukraine	703 792	4.93%	4.05%	0.82
UK	583 705	4.09%	3.38%	0.83
Poland	476 625	3.34%	2.75%	0.82
Canada	471 563	3.30%	2.72%	0.82
Italy	439 478	3.08%	2.54%	0.82
France	394 067	2.76%	2.28%	0.82
Australia	277 867	1.95%	1.61%	0.83
Spain	227 233	1.59%	1.31%	0.82
Romania	194 826	1.37%	1.13%	0.82
Belgium	117 966	0.83%	0.68%	0.83
Bulgaria	103 856	0.73%	0.60%	0.83
Greece	84 336	0.59%	0.49%	0.83
Hungary	83 676	0.59%	0.48%	0.83
Finland	62 466	0.44%	0.36%	0.83
Austria	62 297	0.44%	0.36%	0.83
Slovakia	59 746	0.42%	0.35%	0.83
Sweden	56 065	0.39%	0.32%	0.83
Denmark	52 635	0.37%	0.30%	0.83
Portugal	44 109	0.31%	0.26%	0.83
Lithuania	39 535	0.28%	0.23%	0.83
Estonia	38 107	0.27%	0.22%	0.83
Norway	35 163	0.25%	0.20%	0.83
Ireland	31 599	0.22%	0.18%	0.83
New Zealand	25 267	0.18%	0.15%	0.83
Latvia	23 527	0.16%	0.14%	0.83
Croatia	23 305	0.16%	0.13%	0.83
Czech Rep.	16 399	0.11%	0.09%	0.83
Netherlands	15 963	0.11%	0.09%	0.83
Slovenia	13 935	0.10%	0.08%	0.83
Switzerland	4 442	0.03%	0.02%	0.83
Iceland	2 065	0.01%	0.01%	0.82
Luxembourg	1 275	0.01%	0.01%	0.83
Liechtenstein	195	ε	0.00%	0.81
Monaco	98	ε	0.00%	0.87
Belarus	N.A.	-	-	-

* See UNFCCC web site GHG data base: http://ghg.unfccc.int/
CO_2 emissions in Gigagrams.
N.A: Data Non Available

Table 2: The power distribution among major countries, considering the whole international community when the quota is equal to 55%.

Country	% CO_2 in 1995*	Normalized Banzhaf	$\frac{Bz.norm.}{\% CO_2}$	Coleman's Power to	
				Prevent Action	Initiate Action
USA	19.22%	22.68%	1.18	0.8979	0.4589
China	14.04%	13.68%	0.97	0.5419	0.2769
Russia	6.45%	6.14%	0.95	0.2433	0.1243
India	5.40%	5.15%	0.95	0.2040	0.1042
Japan	3.73%	3.56%	0.95	0.1411	0.0721
Brazil	3.41%	3.26%	0.95	0.1289	0.0659
Germany	3.15%	3.01%	0.95	0.1190	0.0608
Indonesia	2.03%	1.94%	0.95	0.0767	0.0392
UK	1.95%	1.86%	0.95	0.0737	0.0377
Canada	1.95%	1.86%	0.95	0.0736	0.0376
Ukraine	1.54%	1.47%	0.95	0.0581	0.0297
Mexico	1.52%	1.45%	0.95	0.0573	0.0293
France	1.50%	1.43%	0.95	0.0566	0.0289
Italy	1.48%	1.41%	0.95	0.0560	0.0286
Australia	1.40%	1.34%	0.95	0.0530	0.0271
Poland	1.32%	1.26%	0.95	0.0498	0.0254
South Korea	1.26%	1.20%	0.95	0.0477	0.0244
Iran	1.17%	1.12%	0.95	0.0442	0.0226
South Africa	1.06%	1.01%	0.95	0.0399	0.0204
Spain	0.94%	0.89%	0.95	0.0354	0.0181

* Source: IEA greenhouse gases emissions database

Table 3: Distribution of the theoretical decisional power with the European coalition (EU25) when the quota is equal to 55%.

Country	% CO_2 in 1995*	Normalized Banzhaf	$\frac{Bz.norm.}{\% CO_2}$	Coleman's Power to Prevent Action	Coleman's Power to Initiate Action
USA	19.22%	21.34%	1.11	0.9638	0.3738
China	14.04%	14.03%	1.00	0.6336	0.2457
EU25	13.95%	13.93%	1.00	0.6293	0.2440
Russia	6.45%	6.36%	0.99	0.2874	0.1115
India	5.40%	5.26%	0.97	0.2378	0.0922
Japan	3.73%	3.58%	0.96	0.1616	0.0627
Brazil	3.41%	3.27%	0.96	0.1475	0.0572
Indonesia	2.03%	1.94%	0.96	0.0876	0.0340
Canada	1.95%	1.86%	0.96	0.0840	0.0326
Ukraine	1.54%	1.47%	0.95	0.0663	0.0257
Mexico	1.52%	1.45%	0.95	0.0654	0.0254
Australia	1.40%	1.34%	0.95	0.0605	0.0235
South Korea	1.26%	1.20%	0.95	0.0544	0.0211
Iran	1.17%	1.12%	0.95	0.0505	0.0196
South Africa	1.06%	1.01%	0.95	0.0455	0.0177
Saoudite Arabia	0.86%	0.82%	0.95	0.0370	0.0144
Argentina	0.84%	0.80%	0.95	0.0360	0.0140
Thailand	0.82%	0.78%	0.95	0.0354	0.0137
Venezuela	0.75%	0.78%	0.95	0.0353	0.0137
Pakistan	0.78%	0.74%	0.95	0.0335	0.0130

Table 4: The power distribution among major countries, considering the whole international community.

Country	% CO_2 in 1995*	Quota = 60%			Quota = 65%		
		Norm. Banzhaf	$\frac{Bz.norm.}{\% CO_2}$	Power to Prevent	Norm. Banzhaf	$\frac{Bz.norm.}{\% CO_2}$	Power to Prevent
USA	19.22%	22.26%	1.16	0.9697	17.34%	0.90	0.9977
China	14.04%	17.66%	1.26	0.7693	16.36%	1.16	0.9410
Russia	6.45%	5.40%	0.84	0.2351	6.67%	1.03	0.3840
India	5.40%	4.73%	0.88	0.2062	5.42%	1.00	0.3121
Japan	3.73%	3.35%	0.90	0.1460	3.70%	0.99	0.2131
Brazil	3.41%	3.07%	0.90	0.1339	3.38%	0.99	0.1945
Germany	3.15%	2.84%	0.90	0.1239	3.12%	0.99	0.1794
Indonesia	2.03%	1.85%	0.91	0.0804	2.01%	0.99	0.1154
UK	1.95%	1.78%	0.91	0.0773	1.93%	0.99	0.1109
Canada	1.95%	1.77%	0.91	0.0772	1.92%	0.99	0.1107
Ukraine	1.54%	1.40%	0.91	0.0611	1.52%	0.99	0.0874
Mexico	1.52%	1.38%	0.91	0.0602	1.50%	0.99	0.0862
France	1.50%	1.37%	0.91	0.0595	1.48%	0.99	0.0851
Italy	1.48%	1.35%	0.91	0.0589	1.46%	0.99	0.0842
Australia	1.40%	1.28%	0.91	0.0557	1.39%	0.99	0.0797
Poland	1.32%	1.20%	0.91	0.0523	1.30%	0.99	0.0748
South Korea	1.26%	1.15%	0.91	0.0501	1.25%	0.99	0.0717
Iran	1.17%	1.07%	0.91	0.0465	1.16%	0.99	0.0665
South Africa	1.06%	0.96%	0.91	0.0420	1.04%	0.99	0.0600
Spain	0.94%	0.85%	0.91	0.0372	0.92%	0.99	0.0531

Table 5: Distribution of the theoretical decisional power with the European coalition (EU25).

Country	% CO_2 in 1995*	Quota = 60%			Quota = 65%		
		Norm. Banzhaf	$\frac{Bz.norm.}{\%\ CO_2}$	Power to Prevent	Norm. Banzhaf	$\frac{Bz.norm.}{\%\ CO_2}$	Power to Prevent
USA	19.22%	19.61%	1.02	0.9999*	19.23%	1.00	0.9999*
China	14.04%	12.87%	0.92	0.7033	14.73%	1.05	0.8220
EU25	13.95%	12.74%	0.91	0.6959	14.60%	1.05	0.8149
Russia	6.45%	7.15%	1.11	0.3905	5.90%	0.91	0.3293
India	5.40%	5.73%	1.06	0.3132	5.20%	0.96	0.2900
Japan	3.73%	3.87%	1.04	0.2114	3.64%	0.98	0.2033
Brazil	3.41%	3.51%	1.03	0.1918	3.34%	0.98	0.1862
Indonesia	2.03%	2.08%	1.03	0.1138	2.00%	0.99	0.1118
Canada	1.95%	2.00%	1.03	0.1091	1.92%	0.99	0.1073
Ukraine	1.54%	1.57%	1.02	0.0860	1.52%	0.99	0.0848
Mexico	1.52%	1.55%	1.02	0.0848	1.50%	0.99	0.0836
Australia	1.40%	1.44%	1.02	0.0784	1.39%	0.99	0.0774
South Korea	1.26%	1.29%	1.02	0.0705	1.25%	0.99	0.0696
Iran	1.17%	1.20%	1.02	0.0654	1.16%	0.99	0.0646
South Africa	1.06%	1.08%	1.02	0.0590	1.04%	0.99	0.0583
Saoudite Arabia	0.86%	0.88%	1.02	0.0479	0.85%	0.99	0.0474
Argentina	0.84%	0.85%	1.02	0.0467	0.83%	0.99	0.0461
Thailand	0.82%	0.84%	1.02	0.0458	0.81%	0.99	0.0453
Venezuela	0.75%	0.84%	1.02	0.0458	0.81%	0.99	0.0452
Pakistan	0.78%	0.79%	1.02	0.0434	0.77%	0.99	0.0429

* The MMEA's result being larger than 1, we fix it at 0.9999.