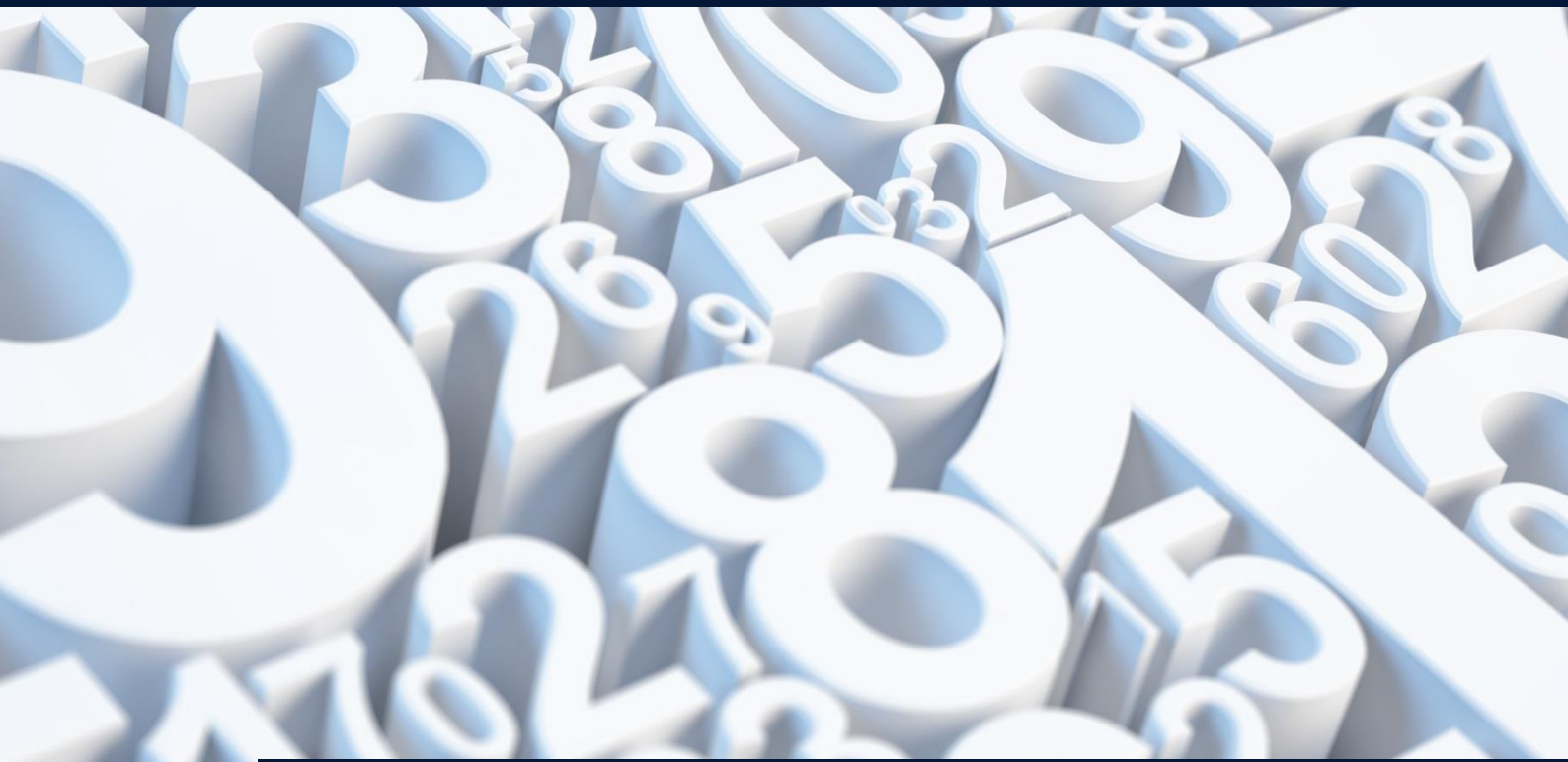

# 2014 ICCG Climate Think Tank Ranking



*Methodological Report*

L. Farnia, A. Silvestri

# 2014 ICCG Climate Think Tank Ranking.

## *Methodological Report*

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*Disclaimer: The results of this ranking were based on data collected through a survey, and through research on the websites of the most renowned think tanks and Climate Change Organizations. We apologize for not having included all think tanks in the field of climate economics and policy. Of course, we would be glad to consider additional think tanks for the next edition of the ICCG Climate Think Tank Ranking.*

**Acknowledgments**

A special thanks to all the previous coauthors I. Alloisio, S. Bertolin, Prof. A. Giacometti, Prof. S. Giove, M. Khoroshiltseva, J. Trevisan for their past contribution in building up the main structure of this report.

**About ICCG**

The International Center for Climate Governance (ICCG) was founded in 2009 as a joint initiative of Fondazione Eni Enrico Mattei (FEEM) and Fondazione Giorgio Cini. The ICCG is now an internationally renowned center whose research activities focus on the design of climate policy and governance. Located on the Island of San Giorgio Maggiore, right in front of Saint Mark's Square in Venice, and directed by Professor Carlo Carraro, ICCG works with economics and political sciences researchers who explore the interdependencies between economic, social, cultural, ethical, and political aspects of climate governance. ICCG's mission is to disseminate science-based and socio-economic research in the field of climate change mitigation and adaptation to policymakers and the general public. It seeks to achieve this at the local, national and international level through interdisciplinary activities as well as producing climate and energy policy analyzes and defining optimal governance models to manage climate change.

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## Executive Summary

Every year the International Center for Climate Governance (ICCG) releases a ranking of the top 100 think tanks active in the field of climate sciences, economics and politics. Launched the first time in 2013, and now at its third edition, the ICCG's composite index aims to fill the huge gap between think tank rankings yearly released and based on a consensus survey (McGann, Prospect Magazine), and those –related to universities- based mainly on bibliometric indicators (ARWU, HEEACT, Scimago).

The scope of the ICCG composite index is hence to provide an objective measurement –derived from available public data- of a think tank's performance, not only on the basis of its research but also on its ability to popularize it and involve stakeholders through its channels. For this reason the evaluation comprises 15 indicators carefully selected according to the feedback provided by experts within the field and structured into three main pillars: *Activities*, *Publications* and *Dissemination*.

The data search has been conducted in a composite manner: through questionnaires sent in January 2015 to the 244 non-university-affiliated think tanks included in the ICCG Think Tank Map, as well as through available data on the official think tank website, on the websites of the International events selected and of the International Organizations responsible for climate economics and policy (i.e. IPCC, UNFCCC).

Different from many rankings existing in the literature where equal importance is imposed on various criteria and indicators, the weights attached to the ICCG index structure were elicited from an expert's panel. Moreover the application of fuzzy measures - which can capture potential interactions (synergies or redundancies) existing among criteria- instead of the traditional weight to be associated to each indicator, substantially increases the model capability both in effectively eliciting experts' preferences and in the data aggregation phase.

Two rankings are released yearly: a *Standardized* one, where, in order to make different-sized think tanks comparable, each indicator is divided by the number of researchers working in the institution, yielding a measurement of that think tank's efficiency. An *Absolute* one where the think tank's performance is measured in absolute terms, regardless of its size.

Every year the award is given to the most efficient climate think tank, hence on the basis of the standardized ranking. For the second year in a row, the best climate think tank is *Woods Hole Research Center* (WHRC)[1], a private, non-profit research organization focusing on environmental sciences, founded in 1985 and located in Falmouth (MA), USA.

[1] See it at http://www.thinktankmap.org and http://www.whrc.org/

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# 1. Introduction

The role of think tanks in shaping climate policies and raising awareness among the general public has become increasingly important in the last decades. The ability of a given think tank to have policy outreach is usually dependent on a variety of factors that can be divided into internal conditions (the level of technical expertise required to understand the issue, the number and the leverage of partners involved), as well as external conditions (economic interests that act as a strong driver for policy changes or pressures from the international community).

Therefore, evaluating their role in "bridging knowledge and power" is now a crucial issue. This, however, would only be possible if the direct correlation between a specific think tank's activity and a change in policy can be proved. Assessing the impact of certain ideas on a precise policy measurement is often a difficult task, since the policy-making process is the result of the collective activity of different political actors and organizations. In this context, it is only possible to evaluate the ways in which think tanks are trying to influence the policy-making process, and not the influence itself. It is reasonable that an assessment of a think tank's influence on the different public circles can be seen as a proxy of its potential impact on the final policy-making process.

Regardless of the ability required to promote a particular issue, the result of a think tank's activity is also heavily dependent on the type of policy changes sought, the balance of strength among the relevant actors, and different institutional capacities.[2] This clarifies that the success of a think tank depends on internal as well as external conditions. While the internal conditions are dependent on the way every think tank is funded and managed, the external conditions that may deeply influence its activity cannot always be thoroughly assessed.

In this framework, the ICCG Climate Think Tank Ranking was first launched in 2012. It was the first ranking of think tanks working in the field of climate change economics and policy, and it included the most world-renowned think tanks that specialize in climate change economics and policy.

The remainder of the report is organized as follows. Section 2 provides a definition of think tank. Section 3 presents our analysis regarding the think tanks active in the field of climate change economics and policy. Section 4 provides an overview of the literature regarding the most important think tank and university rankings. Section 5 explains 2014 ICCG Climate Think Tank Ranking in terms of its data sources, the aim of the study, the criteria and the methodology used. Section 6 underlines further conditions for making assessments. Section 7 describes the

[2] N. Jones, et All., *Think Tanks in post-conflict contexts: Towards evidence-informed governance reform*, Oslo Governance Centre Discussion Papers 16, September 2009.

methodology. Section 8 examines the indicators selected to analyze climate think tanks, and in Section 9 we briefly comment on the results of ICCG 2014 Climate Change Ranking.

## 2. Think Tank: a definition

Although there is already a general consensus of what a "Think Tank" is, defining a set of objective criteria that an organization has to comply with in order to be described as a "Think Tank" is not an easy task. This exercise leads to the definition of a loose set of features that describe the goals of a think tank, as well as the activities that it may carry out in order to reach them. However, this does not result in a unique and self-sufficient definition applicable to all existing "Think Tanks".

Defining a think tank is difficult for three reasons. The first one is that "Think Tanks" are considerably different in dimension, composition, structure and internal assets. Organizations with consistent funds, that employ many well-trained researchers and produce hundreds of articles and other publications every year can be described as "Think Tanks", as well as small organizations that have smaller resources and involve students or businessmen in a limited set of activities every year.

The second reason is that a wide variety of organizations can be described as "Think Tanks": this definition has been applied to private research centers, governments' bodies or political parties, consulting companies. As long as these groups conduct their research activities autonomously such as ONGs, industrial R&D laboratories, university-affiliated centers, and even private networks, they can be referred to as think tanks. Nevertheless, a definition of an independent "Think Tank" may apply to those that are not affiliated with academic institutions, political parties or interest groups (McGann, 2005).[3]

The third reason is the fact that think tanks engage in a large variety of activities such as: publishing papers in journals or books, organizing events open to a selected group of experts or public campaigns that involve common people and civil society organizations, developing very specific research strands, and organizing lobbying activities or public protests.

Due to these reasons, it is not an easy task to identify a clear-cut boundary between "Think Tanks" and other entities. Several studies have also tried to set some common criteria in order to define them (Stone, 2004)[4].

Although the genesis of what are now commonly called "Think Tanks" is very heterogeneous across countries and political cultures, there is a general consensus in peer-reviewed literature that, despite these differences, all these organizations have one thing in common, which is the fact that "Think Tanks" are actively interested in influencing the policy makers and pushing the issues they

[3] James G. McGann, *Think Tanks and policy Advice in the US,* Foreign Policy Research Institute, August 2005, p. 3.

[4] Stone, Diane and Denham, Andrew, Think Tank traditions: policy research and the politics of ideas, Manchester University Press, Manchester (UK), 2004. See also: Steven Boucher, Europe and its Think Tanks: a promise to be fulfilled, Notre Europe, Paris, Studies and Research, no. 35, October 2004.

address on the policy agenda.[5] However, as a direct correlation between a specific activity and a relevant policy, change is extremely hard to trace. It is difficult to assess the role that think tanks play in influencing the national and international policy debate (Stone, 2004).

Such an analysis is made even more difficult due to the fact, outlined above, that think tanks engage in a number of completely different activities, and that policy makers do indeed have different levels of permeability to the ideas that are pushed towards them. Logically, the ability of a think tank to bring an idea to the table of the relevant policy maker depends also on the type of government (democratic or not), on the other actors in the field (furthermore, the recent rise of multi-level governance systems has resulted in a growth of the number of the cores where policies are developed), and on the timeliness of the issue.

Lastly, looking at their evolution over time, think tanks tend to specialize as the growing competition for limited funds requires more sectorial competencies (Missiroli et al. 2012)[6]. For example, since 1980 in the United States the vast majority of think tanks that have been established are specialized. This means that these "specialty" or "boutique" think tanks focus their activities on a single issue[7], such as is the case of the ICCG Climate Think Tank Ranking, whose focus is on think tanks that specialize in climate change economics and policy.

[5] The UNDP defines Think Tanks as "organisations engaged on a regular basis in research and advocacy on any matter related to public policy. They are the bridge between knowledge and power in modern democracies" (UNDP, 2003), while McGann refers to the term "Think Tank" as any organisation undertaking technical and scientific research to support policy-related analysis (McGann, 2005).

[6] Antonio, Missiroli and Isabelle, Ioannides, European Think Tanks and the EU, Berlaymont Paper, Issue 2, 2012.

[7] James G. McGann, Think Tanks and policy Advice in the US, Foreign Policy Research Institute, August 2005, p. 3.

# 3. Think Tanks active in the field of climate change

Since 2011, the International Center for Climate Governance has been working on the think tank Map, an observatory on think tanks active in the field of climate economics and policy.
In this analysis, only the think tanks working in the field of climate economics and policy have been considered. Even in this narrow field, there are many kinds of organizations, which have different objectives, structure and scope.
The preliminary study behind the ICCG Think Tank Map has defined a set of five criteria that a research organization working in the field of climate change economics and policy should respect in order to be included in the Map:

- it must conduct both research and dissemination activities;
- the final objective of its activities must be a practical solution, not the simple definition of a problem;
- policy makers and experts must be its main targets. The general public must be involved only as a means to influence policy makers;
- its projects and partners list must be updated and well defined;
- its activities must be focused on climate change economics and policy.[8]

These points remark that a think tank must develop a series of projects that produce solid and reliable scientific research, which is essential in order to exert a powerful influence on the policy discourse through argument and analysis, and disseminate its result through various channels in order to reach the relevant stakeholders. An organization that conducts lobbying activities, or that involves only the general public acting as an advocacy group, cannot be considered as a think tank, unless it is supported by its own scientific research.
This set of criteria is supported by a definition of climate think tank, which stresses the important role they play, acting as links between research and policy through analysis and outreach: *A Think Tank is a research organization engaged on a regular basis in studying a particular issue of climate science in order to develop a broad range of policy solutions for the global warming, actively seeking to educate, advise or to influence relevant policy makers at both governmental and non-governmental (business) levels.*

[8] The 9 research areas of the Climate Change in which the Climate Think Tank is operating had been identified through the preliminary study: Impacts, Adaptation, Renewable energy & Energy efficiency, Policy & Institutions, Carbon finance, Climate & Development, Sustainable cities, Forestry & Land use, Water.

This definition does not prevent research organizations that work on climate change as well as on many other fields from being considered as "climate think tanks". Indeed, thinks tanks working in the field of climate change economics and policy are very heterogeneous, and they span from university-affiliated centers to others at the edge of consultancy companies.

# 4. Literature on existing Think Tanks and university rankings

A consensus on a common methodology for assessing think tanks among the scientific community does not exist at the present time. The assessment exercises that have been made so far, rely heavily on the role of opinion surveys and experts, who only take into account limited features characterizing think tanks for their evaluation.

## 4.1 Think Tanks rankings

The first and most widespread ranking of global think tanks is based on this method. It is produced by the Think Tanks and Civil Societies Program (TTCSP) at the University of Pennsylvania's International Relations Program, led by Dr. James G. McGann. It consists of an annual report, which has been published since 2007, that ranks the world's leading think tanks. This method takes into account the opinions of a wide, carefully selected group of "experts" (including scholars, policymakers, journalists, researchers and civil society representatives) to nominate the most influential think tanks in geographic areas or in thematic fields. The number of nominations that a think tank receives determines its position in the final ranking. This ranking usually receives great coverage from the media and is well-known among researchers; however, every year it draws some criticism concerning mainly its lack of scientific method, lack of control of the institutions, and generally the ranking can be considered as a "popularity" contest more than a list of organizations based on the quality of their research output.

The Prospect Think Tank of the Year Awards, founded in 2001 by the British Prospect Magazine, uses a similar method to rank think tanks. Every year they run a contest for think tanks judged by a panel of experts. The awards are judged by a cross-party panel looking for evidence of influence both on public policy and on public discourse. The judges also consider the quality of research and the potential of younger and smaller organizations. However, in this case, for each think tank they evaluate only a single outcome, such as a publication, a project or an initiative. Although this method is simpler, since it requires less data, it is clear that assessing an entire institution over a single outcome is insufficient to obtain a clear understanding of its true potential.

The existing think tank rankings based only on opinion surveys among a group of experts, albeit wide and various, are considered faulty due to their subjectivity. They also receive a lot of criticism for not taking into account the effective quality of the research of a think tank and its role in influencing policy.[9] Therefore, an assessment methodology that can be as objective as possible is needed, which explains the purpose of the 2014 ICCG Climate Think Tank Ranking.

[9] Jan Trevisan, "2011 Global Go To Think Tank Rankings": an analysis, ICCG Reflections, February 2012; Enrique Mendizabal, *And the winner is: Brookings … but, once again, the loser: critical analysis*, blog post, January 2012;

To be mention, although as policy paper and not yearly released, the ranking made by J. Clark and D. Roodman[10] (2013); even though less ambitious than the ICCG composite index it follows the same idea, hence a ranking not based on consensus survey but on public available data and standardized by the institution funding in order to measure the institution's efficiency.

## 4.2 University rankings

The main rankings of the best global universities face a major criticism: international rankings only cover a very small percentage of the world's 17,000 universities, between 1% and 3% (corresponding to 200-500 universities). This means that the ranking cannot be considered an assessment of the quality of the academic institution, but simply a ranking producing global league tables. Such a ranking cannot be considered comprehensive and cannot produce stable results for more than around 300 universities in rankings specialized in a specific subject area.[11]

Moreover, the most international rankings predominantly focus on indicators related to the research function of universities. Measuring the quality of teaching and learning generally undertakes the use of proxies, often with a very indirect link to the teaching process, with the result that these rankings are rarely effective. The link to external stakeholders and environments, such as the participation in international exchange programs is largely ignored, whereas reputational factors tend to have disproportional importance in many cases. The ratio between the number of students per professor is one of the few reliable indicators used by some university rankings.

There are four renowned global university rankings. The first and the oldest is the *Shanghai Academic Ranking of World Universities (ARWU)* which was first established in 2003, and has been updated annually ever since, under the Chinese original project to benchmark the top Chinese universities with US research universities. This ranking was conducted with the aim to reverse the Chinese students' brain drain in response to a statement made by the then President of the People's Republic of China, Jiang Zemin, that China must have a significant number of top, world class universities[12]. Today, ARWU's main purpose is to produce league tables of the top universities (it only considers around 1000 universities of which the first 500 are ranked in the league table of the world's top universities), it only concerns research performance, and it is based on bibliometric indicators. ARWU compares the overall strength of a university; indeed all but one indicator (i.e., per capita performance) are based on absolute numbers (e.g. the number of alumni and staff

[10] J. Clark and D. Roodman, 2013, Measuring Think Tank Performance, CGD Policy Paper 025.

[11] Andrejs Rauhvargers, *Global University rankings and their impact, European University Association Report on Rankings 2011, p. 7 and 13.*

[12] Nian Cai Liu, *The story of academic rankings. International Higher Education, No. 54, 2-3 Winter 2009.*

winning Nobel prizes, the number of staff included in the lists of most highly cited researchers, number of papers published in Nature and Science), thus favoring large universities.

The second most popular ranking is the *Times Higher Education World Universities Rankings (THE)*, initially conceived as a response to the Shanghai ARWU ranking; it was at first conducted in cooperation with Quacquarelli Symands (tHE-QS), and since 2010 in cooperation with *Thomson Reuters (THE-TR).* The latter is based on both bibliometric (having the greatest share of the overall weight: 37%) and non-bibliometric indicators (still reputation surveys on research and teaching account for more than one third of the overall score: 34.5%; income indicators 10.75%; importance of PhD studies 8.25%; internationalization indicators 5%; and student to staff ratio accounting for 4.5%). THE-TR can be considered a research oriented ranking. It should also be noted that since all output indicators are standardized (for the number of staff, of publications, etc.), the ranking score is not size-dependent. The main purpose of THE-Thomson Reuters Ranking is also to produce league tables of top universities, excluding graduate schools, and those that have not provided data.

The third most popular ranking is the *Taiwan Higher Education Accreditation and Evaluation Council University Ranking (HEAACT), which* concentrates on research performance and whose output is also a league table based on a composite score, but concentrating on bibliometric indicators only. Although HEEACT does not rank all universities in the world, it does consider the 700 top universities for its overall university ranking and around 500 top universities for each subject field. HEEACT attempts to compensate for the size of a university, unlike ARWU, and indeed 50% of the indicators are standardized for the number of researchers.

The fourth most popular ranking is the *World's Best University Ranking - US News and World Report* in cooperation with *Quacquarelli Symonds (tHE-QS),* which was founded in 1990. Its main mission is to produce university league tables and thus can be considered a global provider of higher education and independent research. Its activities focus on over 2,000 international universities and business schools. It is similar to THE-TR not only because it uses similar methodology, but also because it is based on both bibliometric and non-bibliometric indicators.

Other than these four most famous rankings of academic institutions, there are other university rankings or classifications not aimed at producing league tables, such as *Webometrics, which is* based on the degree of visibility on the web; *U-Map* is based on a number of indicators with no intention of producing league tables, but only comparing universities that have similar profiles; *EU U-Multirank*, an EU-funded project which aims to respond to the main criticism moved towards the international rankings. According to the EU objectives, this ranking should be multi-dimensional covering the missions of all universities such as education, research, innovation, internationalization, outreach, and independence, thus not to be run by universities themselves.

Finally, it is worth mentioning the *Spanish Scimago Institutions Rankings* (SIR) which also does not produce a league table, rather it aims at being acknowledged as the most comprehensive ranking of worldwide research institutions and is based on bibliometric indicators. It embraces all institutions that have significant scientific output, spanning from universities to national research laboratories and even health research centers according to five Institutional Sectors.[13] With the aim to assess their research performance, SIR uses several indicators, the most relevant being the "Normalized Impact – NI." For instance, NI values relate the citations that an institution receives by comparing them to the world average, which is equal to one. That is, an institution having an NI of two can be considered as having twice the scientific impact as the world average. Other quantitative indicators used by SIR are the Q1 indicator - assessing the institution's ability to put its scientific production within the best scholarly and most influential journals as ranked by the Scimago Journal Rank indicator, the Excellence Rate and the Specialization Index.[14]

[13] Higher Education, Health System, Government Agencies, Corporations and Others.

[14] Scimago Institutions Rankings, SIR World Report 2011: Global Ranking, Scimago Research Group, 2011. The SIR 2011 edition includes more than 3,000 institutions that together are responsible for the 80% of worldwide scientific output during the term 2005-09 as indexed in Elsevier's Scopus database.

# 5. 2014 ICCG Climate Think Tank Ranking

Launched the first time in 2013, and now at its third edition, the ICCG composite index aims to fill the huge gap between think tank rankings yearly released and based on consensus survey (McGann, Prospect Magazine) and those –related to universities- based mainly on bibliometric indicators (ARWU, HEEACT, Scimago).

The scope of the ICCG composite index is hence to provide an objective measurement –derived from available public data- of a think tank's performance, not only on the basis of its practical research but also on its ability to popularize its research and involve stakeholders through its channels. For this reason the evaluation comprises15 indicators carefully selected according to the feedback provided by experts within the field and structured into three main pillars: *Activities*, *Publications* and *Dissemination*. As further illustrated in section 8, the dissemination pillar represents a proxy for the think tank's ability in disseminating its studies by means of international events and web channels; the publication pillar measures the research output of a think tank in terms of peer-review publications (quantity and quality) and working paper/policy brief; the activities pillar measures the influence of research findings on policy, managerial and professional practices, social behavior or public discourse.

Different from many rankings existing in literature where equal importance is imposed on criteria, the measures attached to the ICCG index structure were elicited from an expert's panel. Moreover the application of *fuzzy measures*[15] - which can capture potential interactions (synergies or redundancies) existing among criteria- instead of the traditional weight to be associated to each indicator, substantially increases the model capability both in effectively eliciting experts' preferences and in the data aggregation phase.

The indicators used for the 2014 ICCG Climate Think Tank Ranking –as in the first edition- are based on *per capita* think tank productivity. For this reason criteria are standardized with respect to the think tank size -according to the number of its researchers- making different-sized/funded think tanks comparable. However for a complementary picture, the same criteria are used to measure the think tank performance in absolute term, hence regardless of its size. Bearing this in mind, every year we release two rankings: the first is referred to *Standardized ranking*, which is based on per capita productivity; the other is referred to as *Absolute ranking.* Our methodology aims, therefore, at highlighting the most efficient in terms of per capita productivity and not just the "best" think tank.

[15] See appendix (sect.12.1) for detailed explanation

The data collection has been conducted in a composite manner: through a survey sent on January 2015 to the 244 *not University affiliated* think tanks included in the ICCG Think Tank Map, as well as available data on the official think tank website, on the websites of the International events selected and of the International Organizations responsible for climate economics and policy (i.e. IPCC, UNFCCC). It is worth to underline that think tanks that display information on their activities and internal structure in clear, well-organized websites as well as in annual reports are, of course, privileged with respect to those whose information are incomplete or not publicly available and may therefore not be taken into consideration; as a consequence, the resulting ranking may therefore be affected by the availability of data.

## 6. Conditions for assessment

The ranking needs to be based upon objective indicators comparing think tanks on the basis of features that are common to all. Since think tanks greatly differ in scope, scale and resources, finding common parameters to evaluate and rank all climate Think tanks in the world is a difficult task. In order to make the assessment on the same grounds for all the entities considered, further conditions have to be defined.

*Only Think Tanks working at the international level will be assessed*

Comparing influence on domestic policy makers poses great challenges, as interaction between think tanks and policy makers in each country is subject to a host of context-specific variables. Secondly, think tanks active in different countries of the world use different channels to disseminate the results of their research and to influence the public. In addition, there are considerable linguistic barriers to accessing information regarding domestic policy-making and related research, as these documents are written in many different languages.
In this connection, the comparative assessment of climate think tanks around the globe is possible only narrowing down the selection to the think tanks that use a common set of channels to disseminate the results of their research, share information and connect with policy makers. The adopted solution is to consider only the think tanks that work at the international level, participating in international climate change research and advocacy activity (in addition to the local one). In this case, only common channels for disseminating knowledge will be considered, making it possible to build a ranking among think tanks working in many different parts of the world.

*The ranking must be based upon coherent and checkable data*

The ranking must be built around comparable features and should take into account concerns regarding data availability (i.e. whether it will be possible to get the required information for every think tank). To avoid criticism, the ranking also needs to be transparent and based upon reliable data. So as it was already observed, if on the one side think tanks have been asked to provide information for the ranking through a survey, on the other hand when the survey had not been filled in, the relevant information were found by the Think Tank Map team through a web search. It is imperative that this information be verifiable whatever is the source of data collection. This verification may be carried out by making reference to public sources, such as reports and web pages. As we have already observed, the reference period for the data search is year 2014.

# 7. Methodology

Different from many rankings existing in literature where equal importance is imposed on criteria, the measures attached to the ICCG index structure were elicited from an expert's panel. Moreover the application of *fuzzy measures*[16]- which can capture potential interactions (synergies or redundancies) existing among criteria- instead of the traditional weight to be associated to each indicator, substantially increases the model capability both in effectively eliciting experts' preferences and in the data aggregation phase.

The following sections describe all the necessary steps used for the ranking.

## 7.1 Normalization

In order to measure the efficiency of a think tank in per capita terms, leading to the *Standardized Ranking* (sect. 9.1), data – before being normalized- are divided over the number of researchers[17] as climate specialist, in the reference year (2014). Respect the 2013 edition, the criteria "*Other Publications*" and "*Social Network*" are not standardized respect the number of researchers, inasmuch large size think are unfairly heavily penalized given the binary nature (Yes/No) of the indicator and its easy fulfillment.

The Absolute Ranking (sect. 9.2), since it measures the performance of a think tank regardless its dimension, does not require this step.

In order to aggregate the indicators into a single number, they need to be previously normalized to guarantee a common scale, in such a way that every indicator lies on a $[0,1]$ scale.

Different methods could be used for normalization; one often used is the *max-min* method:

$$I(x) = \frac{x - \min(X)}{\max(X) - \min(X)}$$

However, this approach is not immune to the scale of $X$, strongly depending on the sampled data distribution. Thus it can happen that even if the sampled values are very close together (very narrow distribution), the data are stretched, artificially forced to vary in between zero and one.

A more suitable normalization is the following max-normalization that fixes the minimum value of the sampled data to zero:

$$I(x) = \frac{x}{\max(X)}$$

[16] See appendix (sect.12.1) for detailed explanation

[17] In the case of *Sites Traffic Ranking* indicator (sect. 8.1.2) the normalization applied is: $1/(n° * r)$ where $n°$ is the total number of researchers and $r$ the Site Traffic Ranking value.

This method does not suffer from the min-max drawback, since the original data spread is respected: the higher/lower the difference between two values in $X$, the higher/lower the difference in their normalized value.

However, both methods, like all those based on data set, suffer from the so-called *rank reversal* problem: the ranking position of two alternatives could get reversed when a new alternative enters, or an existing one exits from the alternatives set.

Even if this phenomenon is not observed frequently, it could render the procedure suspicious. The reason for rank reversal relies on the *data dependent* normalization, and characterizes all the approaches based on similar normalization techniques, even if some of them are more or less sensitive to outliers – the max-normalization is less sensitive than the max-min normalization. A formal way to avoid this problem is to define a Value Function for each indicator, one that transforms the original data into a common scale in order to enable all the indicators to be comparable to each other; since Value Function is defined a priori and consequently does not depend on the sampled data, the rank reversal cannot appear. Nevertheless, the elicitation of a suitable Value Function is not an easy task, and can be too subjective and/or normative.

The *max*-normalization can be intended as a *measurement* of how closely a target is reached, meaning that if a high value – let us suppose – is reached in the data set (the target), it means that at least this level could be reached by other think tanks. This method can be a suitable compromise between formal correctness and practical application, and, for these reasons, it will be adopted in our case. In fact, roughly speaking, it is consistent with and similar to the concept of piecewise linear *Value Function* in *Multi Criteria Decision Analysis*; it is consistent in that, as the sample number of think tanks participating in the price increases, the maximum in each criteria converges to the true value of *excellence*, allowing us to obtain sufficiently robust results.

## 7.2 Aggregation

In order to create an aggregated index, suitable weight needs to be assigned to each indicator expressing its importance with respect to the final composite index. Once weights are defined, different techniques can be used to combine the weighted indicators into one single measurement. A broadly used aggregation technique is the Equally Weighted Average (EWA), which, as its name suggests, relies on a simple mathematical operation in which all indicators are given the same weight. In real world applications, EWA may be functional in the cases where no interactions exist among different criteria; however, this is an infrequent situation. For this reason, many methods have been proposed in the Multi Attribute Value Theory (MAVT) context, such as the multiplicative approach, the compensation operator (Von Altrock, 1995) or the Ordered Weighted Averaging (OWA) operator (Yager, 1993). Nowadays, it is widely recognized that *the non-additive measures* (NAM) approach satisfies many theoretical requirements, in that it is able to model

potential interaction (synergies, redundancies) existing among criteria; as a consequence it is sufficiently general to cover many preference structures of the Decision Maker (DM).

The price to pay is an exponentially increasing numerical complexity, given the number of criteria (indicators) involved. In fact, if $n$ is the number of the criteria, NAM requires the specification of $2^n$ parameters, i.e. the number of all the subsets of the $n$ criteria, while the Weighted Average WA approach requires $n$ parameters only.

Subsequently, the so-called *Choquet Integral*[18] (De Waegenaere and Wakker, 2001; and Murofushi et al., 1994) computes a weighted average of the values of all the subsets. Naturally, if the measure of a coalition is simply the sum of the measures of the singletons belonging to it, NAM collapses into WA.

The required measure have been were elicited by means of the *Least Square*[19] elicitation algorithm, by means of an ad hoc web-questionnaire (sect. 7.2.1).

### *7.2.1 Experts opinion elicitation*

A panel of nine think tank presidents were interviewed by means of an ad hoc web-questionnaire implemented in *Qualtrics* platform.

The questionnaire was made up of a set of alternatives, i.e. *what ... if...* questions, representing hypothetical think tank performance, by means of the criteria used in the decision tree. Experts' preferences were elicited by means of the *Least Square* optimization algorithm that minimizes the sum of squared distance between an expert's answers and the solution to the problem. The procedure was applied to each node of the decision tree. In order to reduce the number of questions to be asked. the *second order model*[20] was chosen.

#### *Ad-hoc questionnaire for experts opinion elicitation.*

Each expert was asked to evaluate some hypothetical think tanks on the basis of the joint performance of certain criteria. Given the structure of the decision tree, whose nodes are formed by different sets of criteria, this process was performed for all nodes. Table 1 shows the qualitative scale used in the questionnaire and its equivalent numerical scale for the elicitation process. Table 2 is an example of the think tank main node questionnaire, where 5 hypothetical think tanks with different performances in *activities*, *publications* and *dissemination,* were jointly evaluated by each decision-maker (DM) interviewed.

[18] See Appendix (sect. 12.1.1) for detailed explanation

[19] See Appendix (sect. 12.3) for detailed explanation

[20] See Appendix (sect.12.4) for detailed explanation

| Qualitative Scale | | Numerical Scale |
|---|---|---|
| *Criteria Performance* | *DM Evaluation* | |
| Very bad | Very Dissatisfied | 0 |
| Bad | Dissatisfied | 0.25 |
| Fair | Nor Diss./ Sat. | 0.5 |
| Good | Satisfied | 0.75 |
| Excellent | Very Satisfied | 1 |

**Table 1:** Evaluation scheme

| *Think Tank* | *Criteria* | | | DM Overall Evaluation |
|---|---|---|---|---|
| | *Dissemination* | *Publications* | *Activities* | |
| *1* | Excellent | Good | Bad | - |
| *2* | Excellent | Bad | Good | - |
| *3* | Good | Excellent | Bad | - |
| *4* | Bad | Excellent | Good | - |
| *5* | Bad | Good | Excellent | - |

**Table 2:** Think Tank (main node) questionnaire example

### *7.2.2 Aggregation of experts' opinions*

The approach used[21] makes it possible to weigh in the Choquet dimension- expert's preference according to his/her overall consistency in judging the alternatives; this is hence an important tool, especially when a survey is conducted without having any direct, immediate control over an expert's evaluation.
As a result, the fuzzy weights used for each node of the decision tree are the result of a weighted average of experts' preferences.

#### *Main results*

Table 3 shows the result of the aggregation of the experts' preferences[22]; more specifically it returns the *Shapley values*[23] for each node of the decision tree. The Shapley can be interpreted in the traditional way, that is as the relative importance of a criterion.

We limit ourselves to commenting as an example the results for the main node of the decision tree: on average experts believe that *publication* is the most important task for a think tank (42%) followed by *dissemination* (33%) and *activities* (25%).

[21] See Appendix (sect. 12.4) for detailed explanation and Table 5for the main node results.

[22] Table 6 in Appendix shows Shapley values elicited for each DM

[23] See Appendix (sect. 12.2.1) for detailed explanation

| Pillar | Node | Criteria | Shapley Value |
|---|---|---|---|
| **Main** | **Think Tank** | Activities | 0.25 |
| | | Publications | 0.42 |
| | | Dissemination | 0.33 |
| **Activities Pillar** | Activities | Organized Events | 0.28 |
| | | Policy Involvement | 0.72 |
| | Policy Involvement | IPCC Reports | 0.47 |
| | | UNFCCC Submission | 0.22 |
| | | UNFCCC Side Events | 0.31 |
| **Publications Pillar** | Publications | Peer-Review Journals | 0.68 |
| | | Other Publications | 0.32 |
| **Dissemination Pillar** | Dissemination | Social Network | 0.15 |
| | | Web Performance | 0.48 |
| | | International events | 0.37 |
| | Web Performance | Sites Traffic Ranking | 0.54 |
| | | Site Linking in | 0.46 |
| | International Events | Climate Events | 0.49 |
| | | Energy Events | 0.51 |
| | Climate Events | Climate Summit | 0.36 |
| | | G.G.G.Forum | 0.32 |
| | | W.S.R for Climate | 0.32 |
| | Energy Events | W.F.E.Summit | 0.37 |
| | | I.E.Workshop | 0.33 |
| | | W.S.E.Forum | 0.30 |

**Table 3:** Aggregated Shapley Values

Table 4 returns the *Interaction indices*[24], which on a $[-1,1]$ scale reveal the degree of interaction existing between couples of criteria; a positive value discloses synergy between two criteria while a negative one redundancy; a zero value represents independence.

We limit ourselves to commenting as an example the results for the main node of the decision tree[25]; in this node experts on average believe that a slight degree of synergy should exist between *publication* and *dissemination*, meaning that a think tank should slightly satisfy both dimensions contemporaneously; on the contrary, they argue that a good performance in *activities* could be slightly substituted by a good performance in *dissemination*.

[24] See Appendix (sect. 12.2.2) for detailed explanation

[25] Table 7 in Appendix shows Interaction Indices elicited for each DM

| Pillar | Node | Criteria | Interaction |
|---|---|---|---|
| **Main** | **Think Tank** | Activities & Publications | 0.005 |
| | | Activities & Dissemination | -0.028 |
| | | Publications & Dissemination | 0.105 |
| **Activities Pillar** | Activities | Organized Events & Policy Involvement | -0.086 |
| | Policy Involvement | IPCC Reports & UNFCCC Submission | -0.103 |
| | | IPCC Reports & UNFCCC Side Events | -0.137 |
| | | UNFCCC Submissions & Side Events | -0.032 |
| **Publications Pillar** | Publications | Peer-Review Journals & Other Publications | 0.011 |
| **Dissemination Pillar** | Dissemination | Social Network & Web Performance | 0.038 |
| | | Social Network & International events | 0.138 |
| | | Web Performance & International events | 0.100 |
| | Web Performance | Sites Traffic Ranking & Site Linking in | 0.043 |
| | International Events | Climate Events & Energy Events | -0.056 |
| | Climate Events | C.S. & G.G.G.F | 0.02 |
| | | C.S. & W.S.R.C | -0.63 |
| | | G.G.G.F & W.S.R.C | 0.00 |
| | Energy Events | W.F.E.S & I.E.W | 0.05 |
| | | W.F.E.S & W.S.E.F | 0.00 |
| | | I.E.W & W.S.E.F | 0.00 |

**Table 4:** Aggregated Interaction Indices

# 8. 2014 ICCG Think Tank Composite Index Structure

ICCG composite index evaluates a think tank's performance working in the field of climate/environmental economics and policy. Think tanks were assessed on a set of 15 indicators structured into a decision tree with three main pillars: *Activities*, *Publications* and *Dissemination* (see Figure 1).

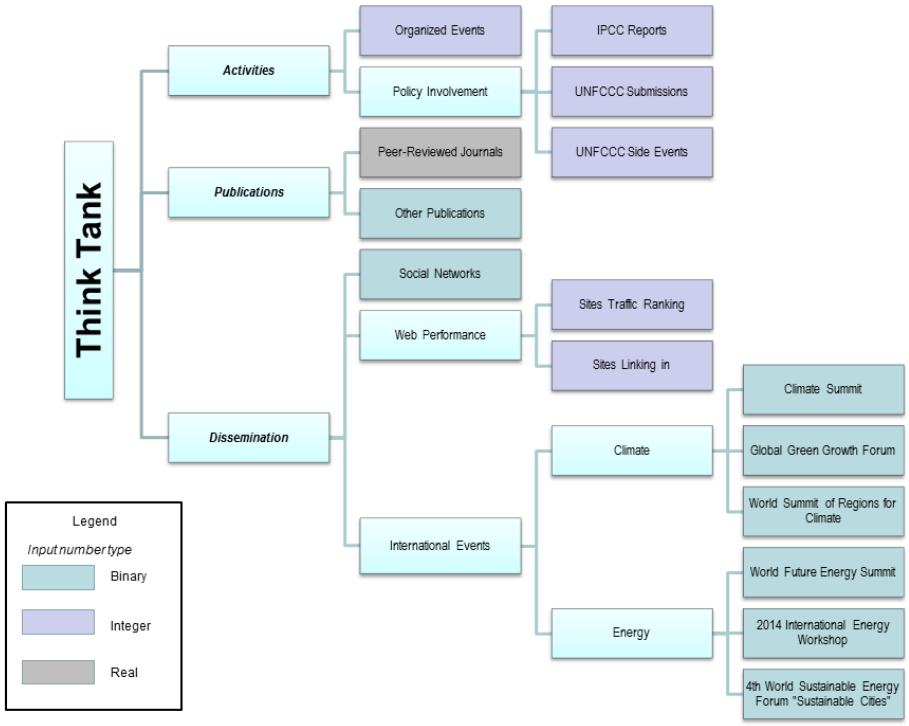


**Figure 1: 2014 ICCG composite index structure**

All the indicators listed below refer exclusively to climate/environmental-related activities[26]. Albeit general, this definition includes all the sectors in which climate think tanks are active (agriculture, development, energy, transport, etc.) and excludes automatically some non-relevant fields (non-climate related policy, security and military analyses, gender issues, and so on).

## 8.1 Dissemination

Dissemination is acknowledged as an important component of the research process; it involves the communication of innovation, this being either a planned, systematic process, or a passive, unplanned diffusion process. Effective communication is an important aspect of dissemination.

[26] http://www.thinktankmap.org/

Enhancing dialogue between researchers and users, developing new contacts and networks, and developing effective dissemination strategies can bridge the communication gap.

Effective dissemination requires an active, systematic approach which is adequately resourced throughout. Formal publication of research results most commonly takes place in refereed academic *journals or books*, but this is not always the case. This section applies to other forms of dissemination of research findings, in any medium of communication, including social networks, web channels, conferences and public exhibitions, analyzing the ability of a think tank to use different channels of communication.

This pillar is structured into three main indicators: *international events, web performance and social networks.*

### *8.1.1 International Events*

Public presentation of research findings on specialized international events is an important channel of the active systematic process of dissemination. The aim of these indicators is to analyze how active a think tank is in participating in international conferences and workshops.

We chose some of the most important international events held in 2014, split into two main groups: *climate* and *energy events*. The *binary* indicator used considers whether a think tank took part as *speaker* in the specific event.

#### *Energy Events*

**World Future Energy Summit** - *Abu Dhabi, 20-22 January 2014*

**Data transparency:** information about speakers is available on the conference website[27].

**2014 International Energy Workshop** - *Beijing, 04–06 June, 2014*

**Data transparency:** information about speakers is available on the conference website[28].

**4th World Sustainable Energy Forum "Sustainable Cities"** - *Vienna, 20 - 21 November 2014*

**Data transparency:** information about speakers is available on the conference website[29].

#### *Climate Events*

**Climate Summit 2014** - *New York, 23 September 2014*

**Data transparency:** information about speakers is available on the conference website[30].

[27] http://www.worldfutureenergysummit.com/

[28] http://www.internationalenergyworkshop.org/meetings-7.html

[29] http://www.world-sustainable-energy.com/wsef/wsef-2014/

**Global Green Growth Forum (3GF)** - *Copenhagen, Denmark, 20-21 October 2014*

**Data transparency:** information about speakers is available on the conference website[31].

**World Summit of Regions for Climate (R20)** - *Paris, 10-11 October 2014*

**Data transparency:** information about speakers is available on the conference website[32].

### *8.1.2 Web Performance*

Think tank websites are powerful tools for divulgating ideas, projects and research.

Two indicators were considered for measuring a think tank's web performance: *site traffic ranking* and *sites linking in*.

#### *Sites Linking in*

This indicator reports the number of sites that link to the think tank's website.

**Data transparency**: information can be found in http://www.alexa.com

#### *Site Traffic Ranking*

This indicator is a rough estimate of a site's popularity. The rank is calculated by using a combination of average daily visitors to the think tank's website and page views on this site over the past 3 months. The site with the highest combination of visitors and page views is ranked #1.

**Data transparency**: information was found in the same time window for each think tank, in http://www.alexa.com

### *8.1.3 Social Network*

Social networking sites such as Facebook, Twitter, LinkedIn have become powerful communication tools.

The *binary* indicator used reflects whether the think tank uses social media as communication channels to enhance its research activities.

**Data transparency**: the information is available on the think tank's website.

[30] http://www.un.org/climatechange/summit/

[31] http://3gf.dk/en/

[32] http://regions-climate.org/en/

## 8.2 Activities

### *8.2.1 Organized Events*

This indicator represents the ability of a think tank to attract all the sectors of society. At the bottom level, think tanks are able to make their ideas available to a broad public: by doing so, their aim is to raise awareness on certain subjects and advance their views with the people who will, in turn, play an important role in pressing policy-makers to reshape their policy agendas or to plan concrete actions. Thus, through directly influencing the general public, think tanks are able to exert indirect influence on policy-makers.

By involving the upper levels of society in their events, think tanks are able to disseminate their vision and the results of their research among people directly involved in the policy process by providing the scientific basis to guide their decisions.

Events have primary importance for think tanks, since through events think tanks can disseminate their research and ideas, make themselves known among a relevant audience, and attract visibility from the general public and the media.

Think tanks organize different kinds of events that vary according to the type of public (general or specialized public) addressed, the number of speakers, the possibility for external researchers to give presentations, as well as content. In general, there is no consensus among think tanks on the term "events", as it is used to identify activities with different formats and involving diverse sectors of the public. For the sake of Climate Think Tank Ranking, the ICCG drafted the following definitions, in order to avoid any possible misunderstandings:

- *Lecture: e*vent in which a single keynote speaker presents a certain topic to a broad public. Might be followed by a Q&A session or a press conference.
- *Conference:* prearranged meeting for consultation or exchange of information or discussion, usually with a formal agenda. It features keynote speakers and speakers chosen through a call for papers, and is usually attended by specialists.
- *Seminar:* educational event that features one or more experts delivering information to a selected public (academics, business and other stakeholders).
- *Workshop:* may have various speakers, who can be selected through a call for papers. It is open to a selected audience, and is usually followed by a plenary discussion or a debate among work groups.
- *Forum:* meeting attended by high-level stakeholders, focused on presentations and discussions. It generally covers a particular issue, is organized periodically (usually, once a year) and may take place over of period of days.

- *Non-academic event*: any event that does not imply the dissemination of scientific research. Its aim is to mobilize the general public, convey a message or an idea, and generally is targeted to a broad public (e.g. film screenings, training courses, public demonstrations, volunteering campaigns).

The analysis of events is important because such circumstances represent the most concrete occasions for think tanks to enter in contact with the public they want to reach. Organizing an extensive number of events can be seen as a proxy of the ability of a think tank to present its ideas to the audience it is trying to influence.

The indicator used measures the aggregated number of events targeted to specialized public sectors and events targeted to the general public organized by a think tank in the reference year (2014).

**Data transparency**: in order to attract a broad public, think tanks make full use of all the channels available for disseminating information about the events being organized. Usually, the number of events can be found on the think tank's website.

### *8.2.2 Policy Involvement*

Indicators in this section consider think tanks' involvement in the most authoritative organizations dealing with climate change, the IPCC and the UNFCCC treaty bodies.

An indicator included in this section considers also the direct involvement of a think tank in the EU policy making process through taking part in public consultations at the EU level.

The fact that a think tank is involved in outstanding international events and discussion forums is considered a sign of its ability to play an active role among the most authoritative actors in the field of climate change economics and policy. It is a sign of international recognition, of the capacity to build relevant links and connections, and to directly address policy-makers at the highest possible level. The indicators considered are, *IPCC reports, UNFCCC submissions, and UNFCCC side events*.

#### *IPCC Reports*

Engagement with the IPCC (Intergovernmental Panel on Climate Change) is regarded as a proxy for assessing the visibility of think tank members in the most authoritative scientific body dealing with climate change. It is also a sign of the ability of a think tank to attract the most authoritative scholars in the field.

The indicator measures the number of fellows of a think tank who are leading authors and/or editors of AR5 IPCC reports.

**Data transparency**: the list of people involved in writing the IPCC reports can be found on the IPCC website[33].

### *UNFCCC Submission*

Submissions are texts that any think tank may provide to the UNFCCC (The United Nations Framework Convention on Climate Change) treaty bodies, containing inputs and contributions on various issues. Through this procedure, think tanks have the effective possibility of bringing their demands and recommendations directly to the attention of the negotiators. The number of submissions to the UNFCCC treaty bodies is regarded as a proxy for a think tank's attempts to influence the most important global climate policy-making forum.

The indicator measures the number of submissions to UNFCCC treaty bodies in the reference year (2014).

**Data transparency:** submissions are public, and the updated list of submissions is available on the UNFCCC website[34].

### *UNFCCC Side Events*

Side events were established as a platform for observer organizations to highlight diverse climate change issues at UNFCCC conferences. Side events are a vital component of the UNFCCC sessions, as they provide opportunities for information dissemination, capacity building, policy discussions and a way to legitimize global governance[35].

The indicator measures the number of side events organized by think tanks within The 19th session of the Conference of the Parties, COP 19 - Warsaw, 11-22 November 2014.

**Data transparency:** the information about events is public and available on the UNFCCC website in the section *Side events/exhibits archive*[36].

[33] WG1: http://www.climatechange2013.org/contributors/chapter/chapter-1
WG2: http://ipcc-wg2.gov/AR5/contributors/chapter/chapter-1
WG3: http://www.ipcc-wg3.de/assessment-reports/fifth-assessment-report/Authors/chapter-1

[34] http://unfccc.int/documentation/submissions_from_observers/items/7478.php

[35] http://unfccc.int/meetings/bonn_jun_2014/meeting/8031/php/view/seors.php

[36] https://seors.unfccc.int/seors/reports/archive.html

## 8.3 Publications

### *8.3.1 Peer-reviewed articles*

Think tanks use different kinds of publications to spread their ideas, such as newsletters, books, journal articles, reports, and policy briefings. All of these are important channels for disseminating research, and one of the main outputs of a think tank's activity.

Every type of publication is targeted to a different group: for example, newsletters and newspaper articles are targeted at both experts and the general public, and are usually used to inform them about the think tank's activities and to raise awareness by highlighting the most important issues. On the other hand, policy briefings aim at assessing specific in-depth issues, while giving practical advice to policy makers on the need to consider a particular policy alternative or course of action. Policy briefs aim directly at influencing the target audience, convincing them of the need to act in a specific way.

Academic audiences are reached by working papers and journal articles. Journal articles are papers published in peer-reviewed journals. Consequently, the fact that a text produced by a think tank is published in such print media is both a sign of high-level expertise of the authors and recognition of the quality of the research undertaken by the think tank.

An analysis of publications can assess a think tank's ability to produce timely, authoritative research. Evaluating a think tank's research is important, because research excellence ideally leads to higher involvement in dissemination, participation in national and international projects, better funding by external actors, a higher rate of consultancies, etc. In general, there are two possible ways to assess these printed outputs: qualitatively, by assessing the overall quality of the publications of a single think tank, or quantitatively, by relying on existing analytics. For the sake of building ICCG's Climate Think Tank Ranking, the qualitative analysis of publications is not recommended, for two reasons:

*A qualitative assessment would take a lot of time and effort.*

A think tank's production is usually very ample. It would take too long to read all the publications and assess them. Furthermore, the persons conducting the assessment would need to have proven knowledge of the issues in the various fields where think tanks work.

*A qualitative assessment would be inevitably biased.*

The persons leading the assessment would inevitably allow some degree of bias to creep into their analysis, with the result that it would not achieve the level of objectivity required for such an exercise.

The only possible option is to analyze the publications of a think tank quantitatively, by using the existing analytics and bibliometric indicators to assess their publications. Consequently, the analysis of a think tank's publications would need to take into account only the publications to which such metrics can be applied.

Lubrano et al. (2003)[37] suggests that "*the main difficulty is that it seems difficult to say on a priori grounds if a book is good or not, while it seems easier to say that an article is published in a good or in a bad journal*", and moreover it is also quite hard to quantify factors such as publications in conference proceedings in different fields, the academic influence of a project, and consultancies provided by a think tank. Therefore, in order to build the ranking, research outputs are measured by analyzing the publications of individual researchers in peer reviewed journals, since the publications in distinguished journals, which undergo a certain level of quality control based on anonymous reference, can be seen as a proxy of the overall quality of a think tank's research .

Furthermore, peer-reviewed journals are included in the major citation databases, e.g., Web of Knowledge (Thomson Reuters), Scopus (Elsevier), and all the widely-used bibliometrics are referred to them. Books were excluded from this analysis, since they are only partially included in the above-mentioned databases: probably, in the future, an analysis of books will be possible, as the biggest databases are gradually considering more and more of them. Other publications, such as newsletters, reports or newspaper articles, have not been assessed. Work papers and Policy Briefs, however, have been assessed in the second indicator of this section.

The following indicators were used to evaluate publications:

To assess the quality of a journal, two approaches have been used in the literature: the analysis of the *direct impact* of an article, and the *indirect impact*, which uses journal weights as a proxy for the future accumulation of citations. The direct impact of a paper can be assessed by counting the number of citations that it accumulated over time[38]. An alternative to direct impact is to evaluate the possible impact of an article being published by analyzing the prestige of the journal where the research has been published. In order to assess the relative importance of peer-reviewed journal articles, the analysis proposed here relied upon bibliometric indicators.

Bibliometric indicators are needed for various reasons. First, using the above-mentioned *direct impact* method, which implies just counting the citations, would not be a good method: given the fact that the issue of climate change is interdisciplinary, researchers publish their works in journals

37 Lubrano, Michael et al., Ranking Economics Departments in Europe: a statistical approach, Journal of the European Economic Association, 1(6), 2003.

38 Likewise, the H-index, in measuring the papers published by a researcher, received an h level of citations, the total citations accumulated by a researcher.

catering to different fields of research that have different citation traditions[39]. Moreover, the trend of citations, not only among different fields but also within each field, varies extensively[40]: counting citations of publications would favour some publications in the field of natural sciences against those published in the field of social sciences, since some research fields accumulate citations in shorter horizons as compared to others[41]. Therefore, counting direct citations of researchers' work within a specific period would give biased results, depending on the concentration of the publications in different fields that a think tank produces. Given the limitations and shortcomings of the direct citations in the period of evaluation as discussed above, the excellence of the research produced by a think tank is evaluated with the use of weights given to each journal, depending on that journal's impact.

Various researchers have studied methods for assigning weights to journals with respect to their prestige, focusing especially on the most respected journals. (e.g., Burton and Phimister, 1995; Kalaitzidakis et al. 2003; Kalaitzidakis et al. 2011). The most common measurement used till now has been the *impact factor*, linked closely to the number of citations that a paper accumulates over a specific timeframe.[42] The impact factor of a journal is considered to be a good proxy for the number of citations that a paper published in that journal will accumulate in the near future. However, there has been major criticism for various reasons about the use of the impact factors as journal weights: first, impact factors do not account for citation patterns in different fields; second, they do not specify from which journal the citations come (i.e., all citations from any sources are accounted evenly); and third, they cover a limited window for citations, in which some fields have higher immediate citation traditions, whereas in some other fields citations take place after a longer

[39] Centre for Science and Technology Studies (2007) suggested that in the social sciences and the humanities, the number of citations is generally an order of magnitude lower than in the natural and medical sciences. For some social sciences and most fields in the humanities it may be desirable to use a considerably longer citation window (e.g. 5-6 years) than in the natural sciences and medical fields (3-4 years), since the flow of citations in the social sciences from its publication date is more gradual.

[40] Centre for Science and Technology Studies (2007) also finds differences in orientation within the social sciences and humanities, and publication and citation characteristics may vary widely among the different fields.

[41] For example, on average, citations accumulated by a publication in the field of biological sciences within the year of its publication is 3-4 times higher than a publication in the field of economics would accumulate in the same period. Furthermore, the average time that it takes for an article in a journal to receive half of its citations also varies extensively among different fields; see the Thomson Reuters Science and Social Sciences Citation Index.

[42] The two-year and five-year impact factor of a journal is calculated by counting the citations that a journal received for its publications in the last 2 years and in the last 5 years, divided by the number of papers published by that journal in the last 2 and 5 years, respectively.

period greater than the window itself[43]. For this reason, this analysis has not considered *impact factor* as the values used to weigh the indicators. Instead, the metrics used is the SCImago Journal Rank (SJR) bibliometric indicator provided by the Scopus database (Elsevier). *Methodologically, the SRJ indicator establishes different values for citations according to the scientific influence of the journals that generate them. It uses a three-year citation window – long enough to cover the citation peak of a significant number of journals, and short enough to be able to reflect the dynamics of the scholarly communication process. It restricts a journal's self-citation to a maximum of 33% of its issued references, so that excessive self-citation will not artificially inflate a journal's value, but without touching on the normal process of self-citation.*

*Methodology*

The methodology for producing the final value for the indicator based on peer-reviewed journals was a Scoring Rule approach (Marchant 2009)[44] that, by taking into account the number of articles and their respective *SJR* score, returns for each think tank the overall quality and productivity of a think tank's publications (measured as the sum of all *SJR*'s journals in which they published in the last year).

### *8.3.2 Other publications*

The aim of this indicator is to include in the ranking all the publications that cannot be evaluated through bibliometric indicators. For a think tank publishing its material autonomously in working papers or policy briefs is a clear sign of the will to disseminate its research and ideas. Working papers are published by think tanks to inform about the latest results of their research and their most recent findings. They can circulate in paper or digital versions, usually downloadable cost-free on the think tanks' websites. The choice of making working papers available cost-free greatly expands the audience that can be reached.

The *binary* indicator used measures whether a think tank publishes working paper or policy brief series.

**Data transparency:** this information can be easily confirmed, as it is clearly presented on every think tank's website.

[43] See Amin and Mabe (2000) for a detailed discussion.

[44] Tierry Marchant, Score-based bibliometric rankings of authors, 2009. This article outlines the theoretical framework for building bibliometric indicators.

# 9. 2014 Top 100 Climate Think Tanks

As explained in section 5, two different rankings are yearly released; the first one - *Standardized Ranking*- measures the most efficient think tanks in per capita/researcher terms, while the *Absolute Ranking* measures the best think tanks in absolute terms, regardless of their efficiency and hence size. Since absolute ranking would favor large size institutions making it unfair to compare different think tank performances, the highest rated ICCG Climate Think Tank is based on the standardized ranking.

For the second year in a row the best 2014 ICCG Climate Think Tank is the *Woods Hole Research Center (WHRC)*, founded in 1985 and situated in Falmouth (MA), USA.

Section 9.1 and 9.2 show the best 100 not university affiliated think tanks (among 244 mapped[45] in the ICCG Think Tank Map), in standardized and absolute terms respectively.

[45] Adelphi Research decided not to participate in the 2014 edition.

## 9.1 Standardized Ranking

| Rank | Think-Tank | Score |
|---|---|---|
| 1 | Woods Hole Research Center (WHRC) | 0.418 |
| 2 | Mercator Research Institute on Global Commons and Climate Change (MCC) | 0.400 |
| 3 | Resources for the Future (RFF) | 0.365 |
| 4 | Basque Centre for Climate Change (BC3) | 0.355 |
| 5 | Potsdam Institute for Climate Impact Research (PIK) | 0.336 |
| 6 | Plymouth Marine Laboratory (PML) | 0.332 |
| 7 | Center for Global Development* | 0.313 |
| 8 | Worldwatch Institute | 0.313 |
| 9 | International Institute for Applied Systems Analysis (IIASA) | 0.307 |
| 10 | Union of Concerned Scientists (UCS) | 0.296 |
| 11 | Centre for International Forestry Research (CIFOR) | 0.295 |
| 12 | Institute for Ecological Economy Research (IÖW) | 0.293 |
| 13 | Fondazione Eni Enrico Mattei (FEEM) | 0.288 |
| 14 | Centre for Policy Research (CPR) * | 0.282 |
| 15 | Centre for European Economic Research (ZEW) * | 0.280 |
| 16 | Rainforest Alliance (RA) | 0.279 |
| 17 | Wetlands International | 0.271 |
| 18 | International Centre for Climate Change and Development (ICCCAD) | 0.268 |
| 19 | Motu Economic and Public Policy Research* | 0.267 |
| 20 | Environmental Defense Fund (EDF) | 0.266 |
| 21 | James Hutton Institute | 0.266 |
| 22 | Brighter Green | 0.261 |
| 23 | National Institute for Water & Atmospheric Research (NIWA) | 0.261 |
| 24 | Centre for European Policy Studies (CEPS) * | 0.258 |
| 25 | Climate Interactive | 0.251 |
| 26 | Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) | 0.250 |
| 27 | Helmholtz Centre for Environmental Research (UFZ) | 0.248 |
| 28 | Fundacion Bariloche* | 0.244 |
| 29 | Institute of International and European Affairs (IIEA) * | 0.240 |
| 30 | Red Cross / Red Crescent Climate Centre (RCCC) | 0.230 |
| 31 | Global Footprint Network | 0.229 |
| 32 | START International, Inc. | 0.224 |
| 33 | The Climate Group (TCG) | 0.223 |
| 34 | Sustainable Europe Research Institute (SERI) | 0.219 |
| 35 | Kiel Institute for the World Economy* | 0.215 |
| 36 | Climate Analytics | 0.213 |
| 37 | International Institute for Environment and Development (IIED) | 0.212 |
| 38 | Institute for Sustainable Development and International Relations (IDDRI) | 0.211 |
| 39 | Energy Research Centre of the Netherlands | 0.210 |
| 40 | The Nature Conservancy (TNC) | 0.209 |
| 41 | Germanwatch | 0.209 |
| 42 | Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) | 0.206 |
| 43 | Green Belt Movement (GBM) | 0.205 |
| 44 | Centre for Sustainability and Excellence (CSE) | 0.203 |
| 45 | Global Green Growth Institute (GGGI) | 0.202 |
| 46 | World Business Council for Sustainable Development (WBCSD) | 0.200 |

*only climate/environmental department considered

| Rank | Think-Tank | Score |
|---|---|---|
| 47 | Stockholm Environment Institute (SEI) | 0.200 |
| 48 | Chatham House* | 0.200 |
| 49 | International Centre for Trade and Sustainable Development (ICTSD) | 0.199 |
| 50 | RAND Corporation* | 0.199 |
| 51 | Centre International de Recherche sur l'Environnement et le Développement (CIRED) | 0.197 |
| 52 | Center for Climate and Energy Solutions (C2ES) | 0.196 |
| 53 | Global Environment Centre (GEC) | 0.196 |
| 54 | Amazon Environmental Research Institute (IPAM) | 0.195 |
| 55 | International Institute for Sustainable Development (IISD) | 0.193 |
| 56 | CDP Driving sustainable economies | 0.191 |
| 57 | Tyndall Centre for Climate Change Research | 0.191 |
| 58 | German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) | 0.190 |
| 59 | The Manila Observatory (MO) | 0.189 |
| 60 | Integrated Research and Action for Development (IRADe) | 0.189 |
| 61 | Global CCS Institute | 0.186 |
| 62 | Research Institute of Innovative Technology for the Earth (RITE) | 0.184 |
| 63 | Ecologic Institute | 0.180 |
| 64 | Ashoka Trust for Research in Ecology and the Environment (ATREE) | 0.180 |
| 65 | Deltares | 0.180 |
| 66 | Imazon | 0.180 |
| 67 | Centro Mexicano de Derecho Ambiental (CEMDA) | 0.179 |
| 68 | Institute for Global Environmental Strategies (IGES) | 0.179 |
| 69 | Overseas Development Institute (ODI) | 0.179 |
| 70 | Austrian Institute of Economic Research (WIFO)* | 0.179 |
| 71 | Global Climate Adaptation Partnership | 0.179 |
| 72 | The Center for Climate Strategies (CCS) | 0.178 |
| 73 | Conservation International | 0.173 |
| 74 | Sustainable Development Policy Institute (SDPI) | 0.173 |
| 75 | Fridtjof Nansen Institute (FNI) | 0.172 |
| 76 | Centre on Sustainable Consumption and Production (CSCP) | 0.169 |
| 77 | World Resources Institute (WRI) | 0.169 |
| 78 | International Center for Tropical Agriculture (CIAT)* | 0.169 |
| 79 | Michael Succow Foundation (MSF) | 0.169 |
| 80 | Global Canopy Programme (GCP) | 0.169 |
| 81 | Instituto Socioambiental (ISA) | 0.167 |
| 82 | Natural Resources Defense Council (NRDC) | 0.167 |
| 83 | African Centre for Technology Studies (ACTS) | 0.165 |
| 84 | Buildings Performance Institute Europe (BPIE) | 0.164 |
| 85 | Oeko Institut | 0.164 |
| 86 | Council on Energy, Environement and Water (CEEW) | 0.163 |
| 87 | CDC Climat | 0.162 |
| 88 | Climate Policy Initiative (CPI) | 0.161 |
| 89 | The Energy and Resources Institute (TERI) | 0.160 |
| 90 | Institute for European Environmental Policy (IEEP) | 0.160 |
| 91 | HuMa | 0.159 |
| 92 | Sandbag Climate Campaign | 0.158 |
| 93 | Institute of Policy Studies (IPS) | 0.157 |
| 94 | Civic Exchange | 0.157 |
| 95 | Center for International Environmental Law (CIEL) | 0.157 |
| 96 | The Center for People and Forests (RECOFTC) | 0.156 |
| 97 | Fung Global Institute | 0.156 |
| 98 | Zoï Environment Network | 0.155 |
| 99 | Centro Mario Molina | 0.154 |
| 100 | ISET-International | 0.153 |

*only climate/environmental department considered

## 9.2 Absolute Ranking

| Rank | Think-Tank | Score |
|---|---|---|
| 1 | The Nature Conservancy (TNC) | 0.545 |
| 2 | Helmholtz Centre for Environmental Research (UFZ) | 0.483 |
| 3 | International Institute for Applied Systems Analysis (IIASA) | 0.461 |
| 4 | Environmental Defense Fund (EDF) | 0.453 |
| 5 | Potsdam Institute for Climate Impact Research (PIK) | 0.401 |
| 6 | Natural Resources Defense Council (NRDC) | 0.398 |
| 7 | World Resources Institute (WRI) | 0.369 |
| 8 | James Hutton Institute | 0.351 |
| 9 | Conservation International | 0.348 |
| 10 | Union of Concerned Scientists (UCS) | 0.332 |
| 11 | Overseas Development Institute (ODI) | 0.327 |
| 12 | The Energy and Resources Institute (TERI) | 0.317 |
| 13 | Energy Research Centre of the Netherlands | 0.305 |
| 14 | International Institute for Sustainable Development (IISD) | 0.305 |
| 15 | Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) | 0.303 |
| 16 | Stockholm Environment Institute (SEI) | 0.300 |
| 17 | Centre for International Forestry Research (CIFOR) | 0.299 |
| 18 | Global Green Growth Institute (GGGI) | 0.297 |
| 19 | International Center for Tropical Agriculture (CIAT) * | 0.294 |
| 20 | Rainforest Alliance (RA) | 0.294 |
| 21 | RAND Corporation * | 0.292 |
| 22 | Institute for Global Environmental Strategies (IGES) | 0.291 |
| 23 | Centre for European Economic Research (ZEW) * | 0.289 |
| 24 | The Climate Group (TCG) | 0.287 |
| 25 | National Institute for Water & Atmospheric Research (NIWA) | 0.285 |
| 26 | Fondazione Eni Enrico Mattei (FEEM) | 0.284 |
| 27 | International Institute for Environment and Development (IIED) | 0.283 |
| 28 | Chatham House * | 0.269 |
| 29 | Woods Hole Research Center (WHRC) | 0.266 |
| 30 | International Centre for Trade and Sustainable Development (ICTSD) | 0.263 |
| 31 | Center for Global Development * | 0.261 |
| 32 | Ecologic Institute | 0.260 |
| 33 | Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) | 0.259 |
| 34 | German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE) | 0.258 |
| 35 | Centre for European Policy Studies (CEPS) * | 0.252 |
| 36 | Sustainable Development Policy Institute (SDPI) | 0.249 |
| 37 | Centre International de Recherche sur l'Environnement et le Développement (CIRED) | 0.248 |
| 38 | Germanwatch | 0.246 |
| 39 | Resources for the Future (RFF) | 0.243 |
| 40 | Center for International Environmental Law (CIEL) | 0.237 |
| 41 | Centro Mexicano de Derecho Ambiental (CEMDA) | 0.236 |
| 42 | Plymouth Marine Laboratory (PML) | 0.235 |
| 43 | Brighter Green | 0.234 |
| 44 | Oeko Institut | 0.234 |
| 45 | Wuppertal Institute for Climate, Environment and Energy | 0.232 |
| 46 | CDP Driving sustainable economies | 0.232 |

*only climate/environmental department considered

| Rank | Think-Tank | Score |
|---|---|---|
| 47 | Global Environment Centre (GEC) | 0.232 |
| 48 | Deltares | 0.232 |
| 49 | Amazon Environmental Research Institute (IPAM) | 0.231 |
| 50 | Zoï Environment Network | 0.230 |
| 51 | Climate Policy Initiative (CPI) | 0.229 |
| 52 | The Center for Climate Strategies (CCS) | 0.226 |
| 53 | Imazon | 0.225 |
| 54 | The Center for People and Forests (RECOFTC) | 0.224 |
| 55 | Centre for International Sustainable Development Law (CISDL) | 0.223 |
| 56 | Global Canopy Programme (GCP) | 0.223 |
| 57 | World Business Council for Sustainable Development (WBCSD) | 0.222 |
| 58 | Climate Strategies | 0.221 |
| 59 | HELIO International | 0.221 |
| 60 | Tyndall Centre for Climate Change Research | 0.212 |
| 61 | Climate Analytics | 0.205 |
| 62 | Global Climate Foundation | 0.198 |
| 63 | Munich Climate Insurance Initiative (MCII) | 0.195 |
| 64 | Kiel Institute for the World Economy * | 0.195 |
| 65 | Worldwatch Institute | 0.195 |
| 66 | Basque Centre for Climate Change (BC3) | 0.193 |
| 67 | Wetlands International | 0.183 |
| 68 | Mercator Research Institute on Global Commons and Climate Change (MCC) | 0.181 |
| 69 | Green Belt Movement (GBM) | 0.178 |
| 70 | Global Footprint Network | 0.177 |
| 71 | Global CCS Institute | 0.176 |
| 72 | Centre for Sustainability and Excellence (CSE) | 0.174 |
| 73 | START International, Inc. | 0.173 |
| 74 | Centre for Policy Research (CPR) * | 0.172 |
| 75 | Institute for Sustainable Development and International Relations (IDDRI) | 0.171 |
| 76 | Centre on Sustainable Consumption and Production (CSCP) | 0.170 |
| 77 | Research Institute of Innovative Technology for the Earth (RITE) | 0.170 |
| 78 | Institute for Ecological Economy Research (IÖW) | 0.170 |
| 79 | Centro Mario Molina | 0.169 |
| 80 | The Manila Observatory (MO) | 0.168 |
| 81 | Instituto Socioambiental (ISA) | 0.168 |
| 82 | Ashoka Trust for Research in Ecology and the Environment (ATREE) | 0.167 |
| 83 | Center for Climate and Energy Solutions (C2ES) | 0.162 |
| 84 | Climate Interactive | 0.161 |
| 85 | Motu Economic and Public Policy Research * | 0.160 |
| 86 | African Centre for Technology Studies (ACTS) | 0.159 |
| 87 | Red Cross / Red Crescent Climate Centre (RCCC) | 0.156 |
| 88 | CDC Climat | 0.156 |
| 89 | Council on Energy, Environement and Water (CEEW) | 0.155 |
| 90 | HuMa | 0.155 |
| 91 | ISET-International | 0.155 |
| 92 | Sustainable Europe Research Institute (SERI) | 0.155 |
| 93 | Institute of International and European Affairs (IIEA) * | 0.155 |
| 94 | International Centre for Climate Change and Development (ICCCAD) | 0.154 |
| 95 | Global Climate Adaptation Partnership | 0.152 |
| 96 | Environment for Development (EfD) | 0.152 |
| 97 | Fridtjof Nansen Institute (FNI) | 0.151 |
| 98 | Institute for European Environmental Policy (IEEP) | 0.149 |
| 99 | Institute of Policy Studies (IPS) | 0.149 |
| 100 | Institute for Industrial Productivity (IIP) | 0.148 |

*only climate/environmental department considered

# 10. The Think Tank Map

The Think Tank Map[46], a project developed by the International Center for Climate Governance (ICCG), was launched in 2011 as an instrument to provide a complete overview of active Think Tanks in the field of climate change economics and policy. The Think Tank Map is at present composed of 309 think tanks worldwide (independent and University affiliated).

The Think Tank Map is not only a showcase for every organization working on Climate change economics and policy, but it is also a catalyst for new cooperation opportunities, allowing stakeholders, researchers, institutions, and the media to be informed on all the relevant activities, to find new contacts, and to engage in mutually beneficial partnerships.

By collecting both scientific and statistic data about many different entities, the Think Tank Map observatory is the starting point for a series of in-depth studies about the Think Tanks working in the field of climate change and their influence on policy makers.

[46] http://www.thinktankmap.org/Default.aspx

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# 12. Appendix

## 12.1 Non-Additive Measures and Aggregation Operators

This document briefly describes the methodological aspects necessary for implementing the computation of ICCG 2014 Climate Think Tank Ranking. The methodological framework employs the innovative, general Multi Attribute Value Theory (MAVT) approach. In real-world applications, the commonly used aggregation method is the Weighted Averaging (WA) approach, which simply computes the weighted average of the numerical score of each criterion. WA is a very simple approach implying no interaction among the criteria; hence, it requires the satisfaction of the Preferential Independent axiom, which is hard to verify in human decision processes. For the purpose of bypassing such limitations, many other methods were proposed, such as Geometric Averaging (GA), Ordered Weighted Averaging (OWA) operators (Yager, 1993), and the compensation operator (Von Altrock, 1995). In this section, we do not address the theoretical framework required by these operators (see Klement et al. (2000)) for detailed explanation. However, we take note of the usefulness of dealing with the general operators. This requirement avoids falling into traps which can considerably damage the results of the final computation. Nowadays, it is widely recognized that the non-additive measures (NAM) approaches satisfy these theoretical requirements, and at the same time, they are sufficiently general to cover many preference structures. Moreover, the required parameters can be easily obtained by means of a simple questionnaire. However, we need to point out that the number of required questionnaires increases exponentially with the number of criteria. Nevertheless, in the current application this is not a disadvantage, since the number of criteria for each node is at most three. A method based on a NAM is nothing but an extension of the WA approach, in such a way that NAM not only assigns a weight to every (single) element of the attribute set, but also a weight to every possible subset of the criteria (i.e. any possible coalition of the indicators at a given node); hence synergic and redundant interactions among criteria can be explicitly considered.

**Definition 1**. Let $N = \{1,2,\dots,n\}$ be the set of attributes for a given node in the tree. A non additive (monotonic) measure (NAM) is a set function $\mu$: $2^n \rightarrow [0,1]$, so that:

$$\mu\{\emptyset\} = 0, \qquad \mu\{N\} = 1$$

$$\mu\{S\} \leq m\{T\}, \qquad \forall\, S \subseteq T$$

It is remarkable that the set function assigns a weight to every subset of the criteria and not only to a single criterion, as in the case of the WA algorithm. Besides the natural border conditions (the empty and the full set ones), the second constraint implies the monotonicity property, a very

intuitive constraint, even if, in rare cases, non monotonic measures could be applied (see De Waegenaere and Wakker, 2001; and Murofushi et al., 1994). NAM is *additive* if $\mu\{S \cup T\} = \mu\{S\} + \mu\{T\}$ whenever $(S \cap T) = \emptyset$, and this case corresponds to the WA operator. On the other hand, if the "joint effect" is lower than the sum of the two effects considered separately $\mu\{S \cup T\} \leq \mu\{S\} + \mu\{T\}$ whenever $(S \cap T) = \emptyset$, the measure is called *sub-additive*, and represents a redundancy effect. While if the contrary holds, $\mu\{S \cup T\} \geq \mu\{S\} + \mu\{T\}$ whenever $(S \cap T) = \emptyset$, the measure is *super-additive*, representing a synergic effect. If $n$ is the number of the criteria (indicator), despite the WA approach, which needs only $n$ parameters (weights), a NAM requires the specification of $(2^n - 2)$ parameters, i.e. the number of all the subsets of the $n$ criteria, minus 2 (the border conditions already have measures for the empty and universal sets).

As soon as the NAM values are assigned, the (normalized) values of the criteria can be aggregated by using a suitable extension of the WA approach, namely the so-called Choquet integral or other methods derived from it, the multi-linear approach (Grabisch, 1995 and 1996). Varying the values of the measure, the Choquet integral aggregator generalizes the WA, obtaining as sub-cases the Ordered Weighted Averaging (OWA) (Yager, 1993), the Min and the Max operators, the $k$-order statistics, and others.

For practical applications, an initial problem is the assignment of the measures via the preference structure of one or more DM(s); this approach is often used in social and economic sciences, since the computation of an aggregated index strongly depends on the subjective relative importance of one coalition with respect to another. First of all, we recall a theoretical implementation. To every set of NAMs, an alternative representation exists, based on the Möbius transform (Grabisch et al., 2003). This transformation assigns to every subset a value directly connected to the measures. If this value is null, no interaction exists among the elements of the subset, as in the WA case; if it is positive there could be a synergy; if negative, a redundancy. The Choquet integral can be directly calculated by using the Möbius values (see section 2). Moreover, in using these values some possible extensions of the Choquet integral can easily be obtained, such as the multi-linear algorithm, a smoother modification of the Choquet integral.

To avoid heavy notation, the cardinality of subsets $N, S, T, \ldots$ will be denoted by the lower-case letters $n, s, t$.

### *12.1.1 Aggregation by the Choquet Integral*

Given the values of the criteria, in the first step they are normalized in a common scale by means of a transform function which filters the sampled data, as is usually done in MAVT methods, employed as benchmark for practical purposes. The most common shape of such transform functions is piecewise linear, but also bell, quadratic, polynomial or spline can be used. We do not

consider here the problem of the determination of the analytical form of such functions, usually obtained from statistical considerations, or, more correctly in the multi-criteria case, from expertise. Let $(x_1,\dots,x_n)$ be the values of the normalized criteria, obtained from the benchmark filtering. The next step includes the ordering phase, the vector $(x_1,\dots,x_n)$ is transformed to a vector of $\left(x_{(i)},\dots,x_{(n)}\right)$ in such a way that $x_{(1)} \leq \cdots \leq x_{(n)}$.

Let us consider the computation of the *Choquet integral* defined as follows:

$$C_m(x_1,\dots,x_n) = \sum_{i=1}^{n} (x_{(i)} - x_{(i-1)}) \cdot \mu\left(A_{(i)}\right)$$

where $x_{(0)} \equiv 0$ and $\mu\left(A_{(i)}\right) \equiv \mu\left(x_{(i)}, x_{(i+1)}, \cdots, x_{(n)}\right)$.

As written above, the Choquet integral generalizes the WA approach, enabling the computation of many possible aggregation operators by varying the value of the corresponding NAM, which includes some logical combinations of the criteria values. It is remarkable that this cannot be done in the WA approach, the most widely used aggregation operator applied in sustainable indicator computation. The Choquet integral is mathematically characterized by a set of properties and requirements that need to be satisfied by the preference structure of the DM, we limit to quote[47]:

a) the Preferential Independence for *comonotonic* acts;
b) idempotency: $C_m(x,\dots,x) = x$;
c) monotonicity: $C_m(x_1,\dots,x_n) \geq C_m(y_1,\dots,y_n)\ \ iif\ x_j \geq y_j\ \ \forall j = (1,2,\cdots,n)$;
d) border conditions: $C_m(0,\dots,0) = 0,\ C_m(1,\dots,1) = 1$.

### *12.1.2 The Möbius Transform*

The Möbius transforms $m(T),\ T \subseteq N$ is a transformation of fuzzy measures $\mu(T)$; in many cases they are used to simplify some computation and to allow the $k$-additive model. In terms of fuzzy measures, they are defined as:

$m(S) = \sum_{T\subseteq S}(-1)^{s-t}\mu(T)$ with $S \subseteq N$

The boundary conditions are:

$m(\emptyset) = 0\ ,\ \sum_{S\subseteq N} m(S) = 1$

And the monotonicity condition is:

$$\sum_{T\subseteq S, T\ni i} m(T) \geq 0, \quad \forall S \subseteq N, \forall i \in S$$

Using the Möbius coefficients the Choquet integral is given by:

[47] See Grabisch, 1995 and 1996; and Grabisch et al., 2003 for further properties that the Choquet integral satisfies.

$$C_m(x_1,\dots,x_n) = \sum_{T\subseteq N} m(T) \bigwedge_{i\in T} x_i$$

where ∧ is the minimum operator.

### *12.1.3 The Concept of k-additivity*

From the previous results it can be seen that a capacity m is completely defined by the knowledge of $(2^n - 2)$ coefficients; such a complexity can be prohibitive in certain situations, especially where we must elicit all the necessary information by means of a survey; moreover, too complex a mechanism and hence excessively high interaction dimensions, are difficult to capture by the human brain.

A capacity $\mu$ on $N$ is said to be $k$-additive if its Möbius representation satisfies $m(T) = 0\ \forall T \subseteq N$ such that $t > k$, and there exists at least one subset $T$ with $card(T) = k$ such that $m(T) \neq 0$. In this way a $k$-additive capacity with $k \in \{1,2,\dots,n\}$ is completely defined by the identification of $\sum_{j=1}^{k}\binom{n}{j}$ parameters. Let $k \in \{1,2,\dots,n\}$, the fuzzy measures $\mu$ in function of Möbius representation are given by:

$$\mu(S) = \sum_{\substack{\emptyset\neq T\subseteq S \\ t\leq k}} m(T),\ \ \forall\, S \subseteq N$$

## 12.2 Behavioral Analysis

### *12.2.1 Shapley Value*

The Shapley value characterizes the "relative importance" of each criterion and can be derived directly by the NAM values. The Shapley value can be computed for each criterion at every node of the hierarchy tree. It is obtained by averaging all the marginal gains obtained by adding the criterion to every coalition not including itself (Grabisch, 1995 and 1996). This value generalized the concept of "weight", since, if it is null, it means that adding the criterion to any coalition does not change the score, and thus it can be excluded since it does not implement any importance. Conversely, if it equals 1 (the maximum value), every coalition excluding itself scores as zero, while every coalition including itself scores 1, and, in this extreme case, it is the only important criterion.

For the *i-th* criterion, its Shapley value (with respect to the fuzzy measure $m$) $\varphi_{\{x_i\}}(\mu)$ is calculated as follows:

$$\varphi_{\{x_i\}}(\mu) = \sum_{T\subseteq N\setminus\{x_i\}} \frac{(n-t-1)!\,t!}{n!}\left[\mu(T\cup\{x_i\}) - \mu(T)\right]$$

These values have the property that $\sum_i \varphi_{\{x_i\}}(\mu) = 1$. It is possible to verify that the Shapley values vary between 0 and 1, the higher value representing the higher importance of that criterion. It is also convenient to scale these values by a factor $n$, therefore, a value greater than 1 indicates an attribute that is more important than the average.

This value can be written alternatively in terms Möbius transform of as:

$$\varphi_{\{x_i\}}(m) = \sum_{T \ni \{x_i\}} \frac{1}{t} m(T) \;\; \forall \;\; T \subseteq N$$

### *12.2.2 Interaction Indices*

The interaction indices summarize the degree of interaction among any coalitions of criteria belonging to the decision set $N$. This index always varies between $[-1,1]$ for any coalitions; the more its value is close to 1, the more the two criteria under consideration are *complementary*, meaning that the satisfaction of only one criterion produces a very weak effect compared with the satisfaction of both. On the contrary, a value close to $-1$ reveals that the two criteria under consideration are *substitutes* or, in other words, the satisfaction of only one criterion produces almost the same effect as the satisfaction of both.

In terms of Möbius transform, the interaction index of $S$ $(s \geq 2)$ is given by:

$$I_S(m) = \sum_{T \supseteq S} \frac{1}{t - s + 1} m(T) \;\; \forall \;\; S \subseteq N$$

For example, in a 2-additive model, the interaction of any couples of criteria is given by:

$I_{\{i,j\}}(m) = m\{i,j\}$.

## 12.3 Expert's opinion elicitation

Many approaches have been developed in the literature to elicit an expert's preferences; we limit ourselves to recalling the Least Square (LS) and the Heuristic Least Square (HLS) [Grabisch, 1995], the approach of Marichal and Roubens (MR) [Marichal, 2000-1], the Minimum Variance (MV) [Kojadinovic, 2007] and Minimum Distance (MD) [Kojadinovic, 2000].

The LS minimizes the sum of squared distances between the values set by a DM and those returned by the algorithm, under the constraint that the boundary and monotonicity conditions are not violated.

**LS**: $MIN_{m(T)} \sum_{a=1}^{v} \left(C_m(a) - y(a)\right)^2$

$s.t.$

$$\left\{ \begin{array}{l} \sum_{T \subseteq S} m(T) \geq 0 \;\; \forall \, S \subseteq N, \forall \, i \in S \\ \sum_{\substack{T \ni i \\ T \subseteq N}} m(T) = 1 \end{array} \right\} \quad Monotonicity\ and\ boundary\ conditions$$

Where $y(a)$ is the value set by DM for alternative $a$; $C_m(a)$ is the value returned by the algorithm for alternative $a$ as function of Mobius representation.

## 12.4 Experts' opinion aggregation

Given that the NAM approach is sufficiently general to cover many preference structures, the expert's preference was weighted according to his/her overall consistency in judging the alternatives proposed. This is indeed an important step, especially when a survey is conducted without having direct, immediate control over an expert's evaluation. We measure an expert's consistency as a function of the sum of squared distances in problem 8), in such a way that the greater (smaller) this sum, the smaller (greater) the contribution of the relative expert. The above conditions can be formalized as follows. Given $v$ alternatives to be judged, let us define the vector $\boldsymbol{\varepsilon}_j$ $(1 \times v)$ whose elements represent the differences between the overall utilities values set by the *j*-th expert and the respective Choquet values of the Lest Square algorithm.

The sum of squared residuals for the *j*-th DM is given by:

$g_j = \boldsymbol{\varepsilon}_j{}' \boldsymbol{\varepsilon}_j$.

The sum of squared distance normalization is given by:

$h_j = e^{-\rho g_j}$ with $\rho > 0$ a penalization factor[48].

The relative weight to be associated to *j*-th DM on a total of $D$ interviewed is given by:

$w_j = \frac{h_j}{\sum_{j=1}^{D} h_j}$.

The final "representative" Möbius representation given by:

$$m^*\{T\} = \sum_{j=1}^{D} w_j m_j\{T\} \quad \forall\, T \subseteq N \; and \; t \leq k$$

is hence a weighted average of each expert's preference, where the higher the sum of squared distances for a particular DM, the lower the weight to be associated to his/her evaluation.

[48] A penalization factor $\rho = 3$ has been used in the aggregation phase.

## 12.5 Example - Main Node Results

We limit ourselves to showing in Table 5, Table 6 and Table 7 the results of the experts' opinion elicitation for the main node of the decision tree where the three main pillars of a think tank (*activities*, *publications* and *dissemination* ) must be jointly considered:

| Mobius of sets | | Agg. value | DM_1 | DM_2 | DM_3 | DM_4 | DM_5 | DM_6 | DM_7 | DM_8 | DM_9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Activities | m{1} | **0.26** | 0.77 | 0.50 | 0.25 | 0.00 | 0.12 | 0.00 | 0.44 | 0.00 | 0.00 |
| Publications | m{2} | **0.36** | 0.52 | 0.50 | 0.25 | 0.73 | 0.27 | 0.45 | 0.00 | 0.00 | 0.65 |
| Dissemination | m{3} | **0.30** | 0.13 | 0.50 | 0.25 | 0.00 | 0.71 | 0.04 | 0.36 | 0.52 | 0.00 |
| | | | | | | | | | | | |
| Activ. &Publ. | m{1,2} | **0.01** | -0.42 | -0.17 | 0.08 | 0.27 | -0.12 | 0.00 | 0.00 | 0.36 | 0.35 |
| Activ. &Diss. | m{1,3} | **-0.03** | -0.03 | -0.17 | -0.25 | 0.00 | 0.16 | 0.26 | -0.23 | 0.03 | 0.00 |
| Publ.&Diss. | m{2,3} | **0.11** | 0.02 | -0.17 | 0.42 | 0.00 | -0.15 | 0.25 | 0.43 | 0.09 | 0.00 |
| | | | | | | | | | | | |
| **ESS** | $g_j$ | --- | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.02 | 0.07 | 0.37 |
| **ESS Norm.** | $h_j$ | --- | 1.00 | 1.00 | 1.00 | 0.98 | 0.96 | 0.94 | 0.93 | 0.81 | 0.33 |
| **Weights** | $w_j$ | --- | ***0.13*** | ***0.13*** | ***0.13*** | ***0.12*** | ***0.12*** | ***0.12*** | ***0.12*** | ***0.10*** | ***0.04*** |

**Table 5:** Panel Experts Mobius Elicitation (see sect. 12.4)

| Shapley Value | Agg. value | DM_1 | DM_2 | DM_3 | DM_4 | DM_5 | DM_6 | DM_7 | DM_8 | DM_9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Activities | **0.25** | 0.55 | 0.33 | 0.17 | 0.13 | 0.14 | 0.13 | 0.33 | 0.20 | 0.17 |
| Publications | **0.42** | 0.33 | 0.33 | 0.50 | 0.87 | 0.14 | 0.58 | 0.21 | 0.23 | 0.83 |
| Dissemination | **0.33** | 0.13 | 0.33 | 0.33 | 0.00 | 0.72 | 0.29 | 0.46 | 0.58 | 0.00 |
| **Weights** | --- | ***0.13*** | ***0.13*** | ***0.13*** | ***0.12*** | ***0.12*** | ***0.12*** | ***0.12*** | ***0.10*** | ***0.04*** |

**Table 6:** Shapley Values

| Interaction | Agg. value | DM_1 | DM_2 | DM_3 | DM_4 | DM_5 | DM_6 | DM_7 | DM_8 | DM_9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Activ. &Publ. | **0.01** | -0.42 | -0.17 | 0.08 | 0.27 | -0.12 | 0.00 | 0.00 | 0.36 | 0.35 |
| Activ. &Diss. | **-0.03** | -0.03 | -0.17 | -0.25 | 0.00 | 0.16 | 0.26 | -0.23 | 0.03 | 0.00 |
| Publ.&Diss. | **0.11** | 0.02 | -0.17 | 0.42 | 0.00 | -0.15 | 0.25 | 0.43 | 0.09 | 0.00 |
| **Weights** | --- | ***0.13*** | ***0.13*** | ***0.13*** | ***0.12*** | ***0.12*** | ***0.12*** | ***0.12*** | ***0.10*** | ***0.04*** |

**Table 7:** Interaction Indices