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# Network analysis of scientific advisory committee integration in climate change policy: A comparison of Germany and Japan

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## Abstract

According to the literature on Environmental Policy Integration (EPI), decisionmaking in complex domains of environmental policy—of which climate change is a prime example—tend to fragment and silo into individual dimensions of a problem. Scientific Advisory Committees (SACs) have been widely used to promote more integrated decisionmaking. SACs are intended to integrate the varied, and often fragmented, dimensions of policy problems, and this integration is widely believed to enable more effective use of science in climate change policy. This paper empirically evaluates the degree of integration achieved through SACs in two national climate policy contexts: Germany and Japan. Network analysis is used to examine the myriad scientific advisory committees focused on climate change policy in these nations (N = 218), and quantify the degree of vertical integration (integration among different sectors) and horizontal integration (integration among different governmental bodies). Results show greater vertical integration among German SACs than Japanese SACs, and similar levels of horizontal integration between the two nations despite having very different structures. Such efforts to empirically connect the conceptual discussion of integration in EPI with empirical observations of integration in actual climate policy processes is an important step towards understanding the strategies that may be used to promote more integrated decisionmaking in climate change policy.

## 1. Introduction

It is widely believed that effective responses to climate change require the formation of networks that bring together diverse stakeholders and their knowledge systems [1]. Such networks are believed to enhance our collective ability to understand complex policy problems, and effectively use this understanding to develop innovative policy solutions [2, 3]. While the importance of integration in knowledge systems is widely discussed, however, there are relatively few examples of concrete and systematically-applied strategies to achieve this integration. In this paper we consider one such strategy and its effect on knowledge integration: National scientific advisory committees (SACs). SACs exist in numerous national climate

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change policy processes and bring together myriad stakeholders from science and policymaking to advise decisionmakers on climate change policy.

The importance of integrated decisionmaking in environmental policy has been long recognized, at least since the Brundtland Report, which identified integrated decisionmaking as an important requirement to adequately cope with environmental challenges. This is a central focus of the Environmental Policy Integration (EPI) literature [4], which has also been applied to climate change in the literature on Climate Policy Integration (CPI; [5]). Lafferty and Hovden's (2003) [6] definition of EPI emphasizes the importance of sectoral and environmental objectives, specifically the priority-principle of environmental issues in relation to other policy areas, justified by the fact of facing potentially irreversible damages to our life-support systems [5, 6].

Importantly, this literature provides clarity on what it means for decisionmaking to be "integrated," including communication across sectors, collaboration among agencies and other policy participants on scientific issues, and joint implementation of programs. Since integration arises from connections between disparate policy actors, the concept of networks is a useful lens through which to observe and study integration. We define integration in our research context as the communication and collaboration among actors, organizations and institutions through SACs with the focus on mainstreaming environmental issues. Moreover, we differentiate integration into two subcategories: vertical and horizontal. *Vertical integration* refers to the integration within a particular governmental sector. *Horizontal integration* which refers to the integration across the governmental sectors [6].

While EPI boasts a rich field of conceptual work, there is still no standard approach to empirically measure integration. Extant empirical research that focuses on EPI as a core concept often examines information sharing among different organizations [7, 8]. Distinct from these studies that examine the communication among actors, we focus on the institutional settings (i.e., SACs), because institutional arrangements are a key prerequisite for developing actual communication relations. Moreover, we propose a method to assess the degree of integration by utilizing membership lists of SACs which are usually publicly available in many democratic countries. Applying network analysis, we examine not only the degree of vertical and horizontal integration through SACs but also analyse the factors that result in the integration in the case of Germany and Japan.

Two research questions guide this research:

1. To what extent are SACs in Germany and Japan vertically and horizontally integrated?
2. What factors explain the variation in the degree of integration?
3. (2) How does the influence of these factors differ across the two countries studied here (Japan and Germany)?

The remainder of this paper is structured as follows: Part two outlines the theoretical concept of EPI. Part three covers a short review of the literature of the study of SACs and the background of climate policy committees in Germany and Japan. In part four, the method, a combination of network analysis and regression analysis, will be described. In part five the results are presented. Finally, we summarize the most important findings and discuss the results of the study.

## 2. Environmental policy integration (EPI) and scientific advisory committees (SACs)

### Environmental policy integration (EPI)

A policy system is *integrated* when policy issues are treated in a cross-cutting way, with actors and institutions involved in managing policy issues across boundaries of discipline, domain,

or policy venue (for an overview see [9]). EPI argues for the importance of integration [4], and more recently, the literature on CPI applied these ideas to the particular context of climate change [5, 10] (CPI is not defined consistently in the literature and it is often referred to using the more established term EPI (see [11]). Since CPI is an application of EPI, we focus here on EPI as the general concept). Originally based on the Brundtland Report "Our Common Future" [12], European Union has tried policy integration in various policy issues and has been achieved mainly in the form of environmental policy integration [13]. EPI aims to harmonize economic, social, and environmental issues in order to systematically combine the seemingly incompatible objectives of economic competitiveness, social development, and environmental protection, thus supporting sustainable development [4].

Bornemann and Weiland [14] concluded that "whenever calls for policy integration were made concerning sustainability issues, EPI was the answer." An important limitation with the EPI concept is that, although it is widely understood the importance of integration, it is often unclear how integration is to be achieved. We therefore need a better understanding of concrete strategies that may promote integration; such an understanding will help develop EPI as an actionable theory of environmental policy. One strategy to achieve integration—and the focus of this paper—is the formation of national-level SACs [15–17].

## Scientific advisory committees (SACs)

Scientific advisory committees have become widely used as a relatively stable, institutionalized place for creating a link between science and policy [18] (Glynn et al. 2003). The research on advisory committees over the last decades is broad and diverse, with several different notions existing side by side. "SAC" is a term that has emerged in several newer publications, mostly in the field of health policy [15–17], with serious efforts to reorganise the field and establish a common research line. Groux et al. [16] developed a definition and typology of SACs, which are organised either by the government or civil society organizations as follows: a) they are groups of individuals with relevant expertise, b) these experts provide their expertise to decision-makers, and c) their advice is grounded on research evidence from natural or social sciences. According to Leifeld and Schneider [19], these policy committees at the national level consist of governmental and non-governmental actors which participate in collective policy deliberation, decision-making and implementation.

Following the typologies of Groux et al. [16] and Fischer and Leifeld [20], SACs are understood to be venues where different actors from science and policy-making meet together to consult, deliberate or make recommendations for decisions for the legislative or executive purposes. Notably, climate change is a policy domain that stretches across multiple issues where various type of stakeholders have diverse views and interests. This requires synthesis of knowledge sharing and coordination in policymaking process.

From an organizational and procedural perspective, SACs represent an institutionalized venue with the aim of connecting different sectoral views through the scientific exchange in these respective committees. SACs produce diverse and scientifically-grounded knowledge about a policy issue, which in turn is a necessary condition for optimal decision-making in complex policy fields where various sectors and bodies are involved in governance [21, 22].

In the governmental organizational context, the integration concept is more fruitfully discussed by differentiating between vertical and horizontal integration. Vertical integration is manifest when SACs promote the exchange of different sectoral views, and where the discussion becomes input for the governmental body served by the SAC. Lafferty and Hovden [6] refer to this as vertical integration in reference to the integration in the state-society relationship. By contrast, horizontal integration is Integration among different governmental bodies.

The horizonal integration is necessary to achieve the integration across different issues, because SACs are typically organized within each distinct policy issue.

## Measurement of vertical and horizontal integration

How can vertical and horizontal integration through SACs be analysed empirically? In this paper, we focus on the formal membership in SACs. SAC members are expected to bring in their expertise, and therefore integration occurs through the communications among those SAC members. By connecting the aforementioned distinction between vertical and horizontal integration, two aspects of the membership are examined.

Vertical integration is measured by asking whether SAC members are recruited from diverse sectors. It is repeatedly observed that in the climate policy domain the interests and worldviews are particularly different between economic sectors and environmental groups [23, 24], but also between national and local governments [25], and scientists and non-scientists [8]. Securing the chances for actors from various sectors to speak out and listen to others in the SACs is a necessary condition for enhancing EPI.

Horizontal integration is measured by asking whether membership in SACs is constructed in a way it crosses boundaries of governmental bodies. Bureaucratic systems are generally developed such that each ministry and its subdivisions are responsible for a particular issue [26]. Committee membership therefore tend to correspond to the governmental body's boundary of substantive focus. In reality, governmental bodies will sometimes be responsible for the same or inter-related issues. This leads to conflicts among governmental bodies (among ministries in particular) (A typical example is the Ministry for the Environment and the Ministry for the Economy). and is a common issue in climate change politics, because environmental, economic, agricultural, and transportation issues are involved. Importantly, these conflicts tend to occur along with the fact that each governmental body has completely different members in their SACs [27, 28]. If there is no exchange of information between the SACs, proposals under discussion will not be optimally coordinated and will therefore not result in an integrated climate policy output. Accordingly, for the integration of expertise across governmental bodies, a certain degree of membership overlaps between the ministries is required, as members can transmit the information from one committee to another. There are certainly many other channels of communication between SACs leading to policy integration, such as personal contacts between members in different committees, or sending the policy recommendation to other committees. However, such subtle evidence is hard to compare in different countries. We argue that membership overlap is a systematic, observable matric of stable and institutionalized communication among different SACs.

## Case selection

Our data come from SACs in two different national contexts: Japan and Germany. They are the largest Western industrial nations after the US, sharing a similar size of GDP and population. Japan and Germany are the fifth and seventh largest emitter of the greenhouse gas in the world, respectively [29]. Moreover, they share some institutional commonalities [28, 30, 31]. Both countries are classified as consensus democracies [32], and advisory committees play a significant role in the phase of policy formulation [28].

Now we turn to the question of how we selected the SACs for both countries and define the object of investigation based on existing literature and document research. To begin, we included the following "main committees"("Wesentliche Gremien") (In the sense of Art. 3.2 of the Federal Law on Appointment of Executive Bodies ("Bundesgremienbesetzungsgesetz")) into the data set. In Germany, those committees that are responsible for the government and

the parliament were included. In Japan, the corresponding counterpart of these main committees are "shingikai", and "iinkai" in some cases. By contrast, we excluded the following bodies because their main consultant target is neither the state nor the parliament, but private or third sector organizations (It should, however, be noted that it seems that in Germany the difference between those committees targeted for states and those for private/third sectors are not as strictly differentiated as in Japan. For example, it is quite common that both types of committees to be listed under the same list "Gremien", whereas in Japan the latter body is completely separated and the latter is regarded as a third body (Gaikaku Dantai). Because of this institutional difference, it is rather difficult to identify the "Aufsichtsrat" equivalent of the third sector organization in Japan). Those excluded bodies are supervisory boards ("Aufsichtsgremien") (As defined in Art. 3.1 Bundesgremienbesetzungsgesetz), foundations ("Stiftungen"in German, "Zaidan" in Japanese), foundation boards ("Stiftungsrat"in German, "Kansa"in Japanese), supervisory board for private companies such as interest groups or NGOs (e.g. "Supervisory board German energy agency Inc.", "Aufsichtsrat Deutsche Energie-Agentur GmbH", or"Gaibu-iinkai"since in Japanese but there is no fixed term for this type of committee), and Committees of the Bundesrat or the Bundestag (as long as they are comprised only by party members).

In Japan, the purpose of the SACs is first and foremost to gather expertise. This is in accordance with the country's advisory committee law. Many scientists and academics are involved in the committees. These committees consist of private actors who are reappointed every two years. As several reappointments are possible, some members have been appointed to these committees for more than ten years. Regular committees ("shingikai") are central committees that consist of sections, often also subsections and working groups, and in some cases there are even sub-working groups. Additionally, there are ad-hoc discussion committees ("kentokai" or "kondankai") that are not formally affiliated with these regular committees. Until the ministerial reform in 2001, advisory committees were often criticized because of their lack of transparency. However, since 2001, almost all membership lists and minutes are publicly available. Still, some criticize that this transparency actually prevents effective discussion, as most members only represent their position to justify their efforts to their fellow groups, which is sometimes referred to as "position talk" (simply arguing the organizational official stance without considering the flow of discussion) [26]. The appointments are made exclusively by administrative staff, which is why these committees are often said to form an inner circle [33].

In Germany, the purpose of the SACs is, in contrast to Japan, mainly to gather expertise, coordinate efforts, and legitimize action rather than gathering scientific information. Regarding the membership of German committees, ministry employees and politicians can also be formal members of such a committee. It is also more common than in Japan for a ministry employee to be an official member of a committee organized by another ministry. The organizational structure of German committees is very flat and there are committees with specific working groups. With regard to transparency, we discovered that in Germany information on these committees is less transparent than in the Japanese case. However, in most cases, a final report is publicly available. If we consider the nomination of the members, we notice that political parties are actively involved in the appointment process. There are both ministerial and parliamentary committees. A recent famous example of the latter is the "Ethics Commission" for nuclear energy policy set up after the Fukushima nuclear accident which had the purpose to give advice and consult on how to deal with nuclear hazards.

Systematic evaluations of SACs are rare (but see [34–36]), therefore our research question in this context is exploratory and is intended to further develop the field. Even though SACs are key forum for discussing and formulating policy proposals in both Germany and Japan [7, 27], there are cultural and institutional differences in terms of the network structure and the

organization of SACs. Our research questions (stated in the introduction, above) are based on these considerations.

## 3. Data and method

Our data set consist of the national governmental SACs existing between 2010–2015 in Germany and Japan, with a topical relationship to climate change. There is no list of specifically climate-related advisory bodies in both countries, so we visited the websites of individual ministries and government agencies and manually identified the relevant SACs and their members.

When compiling the dataset, we encountered a few issues in terms of comparison. As previously described, the Japanese SACs are institutionally more nested. Hence, it could be problematic to simply compare the degree of integration by including all single committees, because by doing so, we could overestimate the degree of integration in the Japanese case. Therefore, we decided to exclude those sub-committees whose members are completely included in the set of parent committee members (Formally, this was tested if Szymkiewicz-Simpson overlap coefficient is 1 or not. The Shimpson overlap coefficient is defined as $\frac{|C_m \cap C_n|}{\min(|C_m|,|C_n|)}$, where $|C_m|$ and $|C_n|$ is the set of members of advisory committee $C_m$ and $C_n$, respectively). As a consequence, we were able to identify 174 different SACs for the Japanese case. Concerning the availability of data, there is a lower transparency for the German SACs. In Germany, membership lists are typically available in the supporting information of the committees' final reports. However, membership information was available online only for 44 out of the 49 committees which we identified (Even after several attempts (telephone calls, e-mails, internet searches) to gather all of these data, it was not possible to collect all).

### Measuring vertical integration through membership sectoral diversity

Vertical integration is measured through the diversity of sectors participating in SACs. To describe the sector an actor belongs to, each member is coded according to the following categories: government, science, business, non-governmental organizations (NGOs), media, local governments (i.e., states in Germany and prefecture in Japan as well as cities in both countries), individual university researchers, and political parties (for details see S1 Text).

As an indicator of the sectoral diversity of SAC members, we utilize the inverted version of Herfindahl-Hirschman Index (HHI) (Formally, HHI is defined as $\sum_{i=1}^{k} P_i^2$, where $P_i$ is the proportion of each sector and k is number of categories of sectors). HHI is widely used for measuring the degree of market monopoly. The inversed version of this index (i.e., $\frac{1}{HHI}$) is used for calculating the diversity (e.g., [37, 38]). The diversity index takes the minimum value 1 when all members in a SAC are from the same sector. On the other hand, the diversity index takes the maximum value when the proportions of each sectors member belong to are even.

### Measuring horizontal integration through memberships overlap

Horizontal integration is measured through membership overlap across SACs. As a concrete indicator of membership overlap, we use the *Dice coefficient of the members in the pair of committees* (Formally, let $|C_m|$ and $|C_n|$ be a set of membership of the committee $C_m$ and $C_n$, respectively. Then, the Dice coefficient of the two committee is, $Dice_{(C_m,C_m)} = \frac{2*(|C_m| \cap |C_n|)}{|C_m|+|C_n|}$) that ranges from zero (no overlap) to one (complete overlap). A high Dice coefficient means that there is a high degree of overlap of members between two committees. Accordingly, we conceptualize that a high degree of overlap among committees can be viewed as a high level of

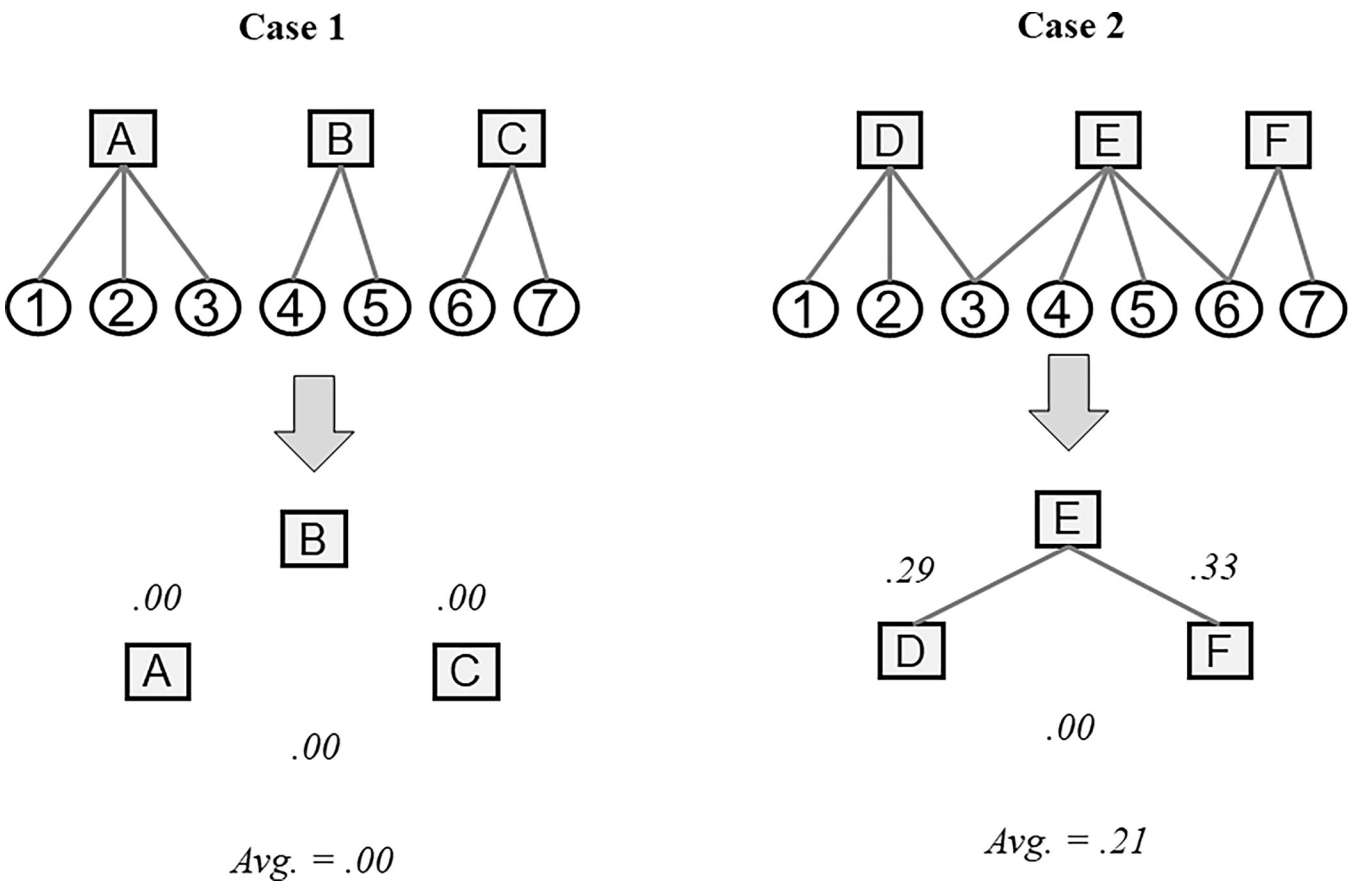


**Fig 1. Illustration of overlap of committee members.** Note: A-F indicates SACs and 1–7 indicates actors. The edges in the upper figures show that the actor is a member of the committees. The number in the bottom figures indicates the Dice coefficient of membership overlaps between committees. Avg. is the average Dice coefficient in each case.

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horizontal integration. We calculated the Dice coefficient for every pair of SACs in each country.

As an illustration, consider the constellation of SACs in case 1 in *Fig 1*. Case 1 is the one with no membership overlaps at all among committees, hence no horizontal integration. In Case 2, it is more integrated than case 1 because there are some membership overlaps (actor 3 and 6).

Concerning membership, we coded the members of each committee at the organizational level, not the individual (person) level. Two committees are therefore regarded to be sharing members if the members have the same organizational affiliation (even if the individual people are different). The reasoning behind this procedure is that most of the committee members are selected based on their organization affiliation. It is only for the university that we cannot apply the above reasoning, since each researcher may be selected independent of his or her university affiliation. In this special case, therefore, university researchers are treated as individual. Those who do not have any organizational affiliation are also treated as individuals.

## Issue of the advisory committee

Horizontal and vertical integration may vary across SACs that deal with different issues. The issues dealt with by a SAC are coded by the authors according to the following categories, recognizing that a SAC may have several issues (see S1 Text for the detail) (To ensure the

comparability, one author of this paper who reads both Japanese and German cross-checked the adequacy of the coding in both country data): target (e.g., emission reduction target) (Target means in this context there are specific *targets* that are defined, e.g., a percentage for the reduction of emissions by a certain date), energy, nuclear, science, technology and development, business and product regulation, local (e.g. local government climate policy) (*Local* refers to the fact that the committees are concerned with national policy programs that relate specifically to the local level of implementation. This is a specific feature of the German federalism), ethics, and transportation.

## Understanding drivers of integration

To identify the factors that result in horizontal integration, we utilize the multiple regression quadratic assignment procedures (MRQAP) tests [39, 40]. MRQAP tests are permutation tests (Among the various permutation methods, we used "double semi-partialling" following the recommendation by Dekker et al. (2007) [39]). for multiple linear regression model coefficients for data organized in square matrices of relatedness among objects. In our case, the observation organized in the matrices is the relation between the committees.

Our *dependent variable* ***Y*** is the degree of horizontal integration measured by the Dice coefficients of membership overlap between advisory committees (Formally, the dependent variable is k×k Dice coefficient matrix ***Y***, which consists of k advisory committees and an entry $y_{nm}$ in ***Y*** is a dice coefficient between the advisory committee n and m). Each entry in the matrix indicates the Dice coefficient between a pair of SACs; namely, how the members in two SACs are overlapped.

For the independent variable, we enter several possible driving forces that can cause membership overlap as listed below. As our dependent variable is a matrix, we also need to create a matrix for each independent variable ***X***, meaning that our unit of observation is the pair of committees. However, for some independent variables, the dependent variable comes from the attribute of each SAC, not a pair of SACs. In those cases, we use the *sum method*, which is a sum of the relevant attributes of two SACs. Let us take the size of the committee matrix (i.e., ***X2*** in the explanation below) as an example. If number of members in committee A and B is 3 and 5, respectively, the entry for A-B (i.e., $x2_{AB}$) of this matrix is 8, meaning that the sum of the number of committee members in A and in B is 8. If this *sum method* is used, it is specifically indicated.

In the description below, **X1** indicates the matrix of the first independent variable. The same logic applies for X2, X3, . . ., X7 (see S2 Text for detail).

- ***X1*. Same Ministries:** Whether two committees belong to the same ministry (coded as 1) or not (coded as 0).
- ***X2*. Size of the committee** (*sum method*): Sum of the number of members in two committees.
- ***X3*. Sectoral diversity of the committee** (*sum method*): Sum of the sectoral diversity index of two committees. Note that the sectoral diversity is the one for measuring the degree of vertical integration in a SAC, as discussed above.
- ***X4*. Same issue**: Whether two committees handle the same topic (coded as 1) or not (coded as 0).
- *X5*. **Organizational category** *(sum method)*: Sum of the coefficient of the specialization of each organizational category of two committees. In brief, this coefficient indicates how much a particular organizational type is present in a SAC given the country's average.

- ***X6*. Prominent actor** (*sum method*): Sum of the prominence actor scores in two committees. The prominence of an actor is calculated as the number of committees this actor belongs to. A committee level prominence score is the average of the prominence of committee members.
- ***X7*. Multi-issue actor** (*sum method*). Sum of the multi-issue actor score in two committees. In essence, multi-issue score of an actor is calculated by how wide range of committees in terms of their issues this actor simultaneously belongs to, which indirectly indicates the range of issues this actor can speaks of. A committee level multi-issue actor score is the average of the multi-issue actor score of committee members.

In the calculation, **model 1** conducts the regression against the whole set of committees in Japan and Germany. By contrast, **model 2** limits the observations to the entries of the matrix that indicates the membership overlap between committees belonging to different ministries. This allows us to specify the factors that result in horizontal integration among ministries. In a similar vein, **model 3** limits the observation to the entries of the matrix that correspond to membership overlaps between committees that handle different issues. This allows us to specify the factors that result in the horizontal integration across different issues. The calculation was done by *R* [41] and *R* package *sna* [42].

## 4. Results

### Results of vertical integration: Sector diversity

As described above, we identified 174 climate change-related committees in Japan and 44 committees in Germany. **Table 1** shows the number of committees by ministry. For better readability, we use the simplified names of the individual ministries in both countries (see S1 Table for the formal names).

In Japan, more than half of the climate change-related committees belong to the Ministry of the Economy. In Germany, by contrast, almost half of the committees are organized by the Ministry of the Environment. This result indicates the difference of the issue ownership of the relevant ministries in Japan and Germany, which also influences the frames of the discussion on climate policy. Judging from the result, climate change in Germany is dealt with more from an environmental point of view, while in Japan the economic issues are more salient.

**Table 1. Number of climate-policy-related committees by ministries in Japan and Germany.**

| | | Japan | Germany |
|---|---|---|---|
| Cabinet | | 2 | 3 |
| Parliament | | 0 | 1 |
| Ministry of | Agriculture | 3 | 4 |
| | Economy | 105 | 6 |
| | Environment | 37 | 22 |
| | Finance | 1 | 0 |
| | Internal | 4 | 0 |
| | Land | 3 | 1 |
| | Meteorology | 1 | 0 |
| | Development | 0 | 1 |
| | Science | 17 | 6 |
| | Welfare | 1 | 0 |
| Total | | 174 | 44 |

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**Table 2. Prominent actors in committees.**

| | Japan | | Germany | |
|---|---|---|---|---|
| **Rank** | **Name** | **n** | **Name** | **n** |
| 1 | Japan Consumer Affairs Advisor-Consultant Association | 43 | Independent State Bayern | 13 |
| 2 | Japan Institute of Energy Economics | 39 | State Nordrhein-Westfalen | 13 |
| 3 | National Institute for Environmental Studies | 36 | Federal Environmental Agency | 11 |
| 4 | Research Institute of Innovative Technology for the Earth | 36 | BUND | 11 |
| 5 | Residential Environment Planning fugure Laboratory | 34 | State Baden-Württemberg | 9 |
| 6 | Institute of Industrial Science, University of Tokyo | 30 | Fraunhofer-Gesellschaft | 8 |
| 7 | Federation of Electric Power Companies | 29 | Independent State Sachsen | 8 |
| 8 | Toshihiro Muramatsu | 27 | Öko-Institute | 7 |
| 9 | National Institute of Advanced Industrial Science and Technology | 25 | Federal Institute for Materials Research and Testing | 7 |
| 10 | Takao Kashiwagi | 21 | Federal Ministry of Economics and Energy | 7 |

Note: n indicates the number of times the organization was a member of SACs in 2010–2015 (including reappointments to the same committees).

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This interpretation can be also supported from the list of prominent actors, i.e., organizations and individuals which are members of many committees (***Table 2***). In Japan, only one research institute, the *National Institute for Environmental Studies*, which is affiliated with the *Ministry of the Environment*, is in the top 10. There are, however, no other organizations which clearly represent environmental policy issues within the top 10 actors. By contrast, three research institutes (*Japan Institute of Energy Economics; Research Institute of Innovative Technology for the Earth;* and *National Institute of Advanced Industrial Science and Technology*), and one third-sector organization (*Japan Consumer Affairs Advisor-Consultant Association*) are affiliated with the *Ministry of the Economy*. In addition, the Federation of Electric Power Companies that is the industrial association of electricity companies is ranked in the top 10.

In Germany, the *Federal Institute for Materials Research and Testing* and the *Federal Ministry of Economics and Energy*, which both represent economic issues, feature in the top 10 list (in the last two positions). The *Federal Environmental Agency* comes in third place, which is Germany's main agency for environmental protection. This institution is characterized by its scientific and technocratic expertise in environmental protection. Contrary to the Japanese case, NGOs advocating for the promotion of environmental policy are more strongly represented, namely *Öko-Institute* and *BUND*. Another remarkable actor type is the local governments, reflecting Germany's strong federalism. The independent research institute *Fraunhofer Gesellschaft* also plays an important role (As for the research institutes, we coded the actors' affiliations in accordance with their representation at the committees, namely, either the particular sub-institute or the whole institute. As for the Max-Planck-Gesellschaft, for example, many members tend to represent a particular sub-institute, whereas members of the Fraunhofer-Gesellschaft tend to represent the whole institute. Accordingly, in Table 1, the Max-Planck-Gesellschaft may be underrepresented as compared to the Fraunhofer-Gesellschaft). with their expertise in the field of energy transformation and climate research. Note, however, that we do not consider how politically important individual committees are, as this is difficult to quantify. It is also possible that some of the prominent actors participate in relatively unimportant committees.

**Table 3** presents the degree of vertical integration measured by actor type diversity score. Overall, the German diversity score is 1.5 to two times as high as the Japanese one. In other words, organizations from more diverse sectors participate in German SACs than in Japanese ones. If we consider each category, individual university researchers are the most frequent

**Table 3. Degree of vertical integration in Japanese and German SACs.**

| | | Diversity index | Actors | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sectors (%) | | | | | | |
| | | | n[1)] | GOV | SCI | BIZ | NGO | MED | LCL | UNI | POL |
| **Japan** | ***Overall*** | 3.7 | | 4.5 | 17.4 | 24.7 | 5.3 | 1.6 | 5.3 | 41.2 | 0.0 |
| | ***By issue*** | | | | | | | | | | |
| | Target | 3.8 | 347 | 2.9 | 20.2 | 20.2 | 8.1 | 3.5 | 3.5 | 41.8 | 0.0 |
| | Energy | 3.4 | 736 | 3.8 | 14.0 | 41.7 | 6.3 | 1.1 | 2.2 | 31.0 | 0.0 |
| | Nuclear | 4.0 | 262 | 4.2 | 18.3 | 25.2 | 9.2 | 1.9 | 3.4 | 37.8 | 0.0 |
| | Science | 3.3 | 450 | 8.2 | 24.4 | 14.2 | 2.4 | 2.4 | 2.0 | 46.2 | 0.0 |
| | Technology development | 3.7 | 344 | 4.7 | 22.1 | 28.2 | 3.2 | 1.5 | 3.2 | 37.2 | 0.0 |
| | Business and product regulation | 3.8 | 885 | 5.6 | 16.9 | 30.1 | 6.7 | 1.2 | 2.7 | 36.7 | 0.0 |
| | Agriculture | 3.4 | 65 | 1.5 | 10.8 | 41.5 | 4.6 | 0.0 | 10.8 | 30.8 | 0.0 |
| | Local | 3.2 | 76 | 9.2 | 7.9 | 9.2 | 3.9 | 0.0 | 19.7 | 50.0 | 0.0 |
| | Adaptation and Riskmanagement | 2.4 | 67 | 0.0 | 22.4 | 11.9 | 3.0 | 3.0 | 0.0 | 59.7 | 0.0 |
| | Development | – | 0 | – | – | – | – | – | – | – | – |
| | Ethics | – | 0 | – | – | – | – | – | – | – | – |
| | Transportation | 3.4 | 125 | 0.0 | 23.2 | 14.4 | 9.6 | 0.0 | 7.2 | 45.6 | 0.0 |
| **Germany** | ***Overall*** | 6.1 | | 13.1 | 10.5 | 16.9 | 14.8 | 0.0 | 12.8 | 25.6 | 6.3 |
| | ***By issue*** | | | | | | | | | | |
| | Target | 6.1 | 323 | 14.2 | 9.0 | 22.3 | 16.4 | 0.0 | 16.7 | 16.7 | 4.6 |
| | Energy | 6.3 | 256 | 14.8 | 10.9 | 19.1 | 16.0 | 0.0 | 14.8 | 19.5 | 4.7 |
| | Nuclear | 5.5 | 167 | 14.4 | 8.4 | 28.1 | 17.4 | 0.0 | 13.8 | 16.2 | 1.8 |
| | Science | 4.3 | 355 | 9.9 | 11.8 | 11.5 | 7.9 | 0.0 | 16.6 | 40.3 | 2.0 |
| | Technology development | 6.1 | 143 | 17.5 | 10.5 | 18.2 | 12.6 | 0.0 | 18.9 | 19.6 | 2.8 |
| | Business and product regulation | 5.9 | 201 | 17.4 | 9.0 | 19.9 | 14.4 | 0.0 | 23.4 | 11.4 | 4.5 |
| | Agriculture | 4.3 | 199 | 12.1 | 11.1 | 11.1 | 11.1 | 0.0 | 11.6 | 40.7 | 2.0 |
| | Local | 5.1 | 85 | 15.3 | 11.8 | 9.4 | 14.1 | 0.0 | 10.6 | 34.1 | 4.7 |
| | Adaptation and Riskmanagement | 4.8 | 103 | 9.7 | 11.7 | 9.7 | 12.6 | 0.0 | 6.8 | 37.9 | 11.7 |
| | Development | 4.9 | 47 | 8.5 | 4.3 | 19.1 | 25.5 | 0.0 | 2.1 | 12.8 | 27.7 |
| | Ethics | 5.7 | 180 | 11.7 | 12.2 | 15.6 | 15.0 | 0.0 | 11.1 | 28.9 | 5.6 |
| | Transportation | 5.4 | 128 | 11.7 | 15.6 | 18.8 | 14.8 | 0.0 | 7.0 | 28.9 | 3.1 |

Abbreviations: GOV = government, SCI = science, BIZ = business, MED = media, LCL = local, UNI = university researcher, POL = political party.

Total number of actors being a member of those advisory committee that handle the relevant issue.

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participants in the committees in each country. However, the composition of each sector differs for both countries. In Japan, scientific organizations, business groups, and university researchers on average account for almost 85% of all participants. By contrast, the percentage of these sectors is much lower in Germany (around 50%). Moreover, in Germany NGOs and local governments (i.e., *Länder* and cities) on average account for around 30% of all participants, while in Japan only approximately 10%.

## Results of horizontal integration: Membership overlap

Now, we turn to the horizontal integration measured by the degree of membership overlap between the different committees through the Dice coefficient (***Table 4***). The average Dice coefficient in Japan and in Germany is 0.07, meaning that both countries are equally well integrated in terms of their membership overlap. However, if we limit our observation to the Dice coefficient between the ministries, the average Dice coefficient is lower in Japan (0.02) than in

**Table 4. Degree of horizontal integration in Japanese and German SACs.**

| | | Committee | | |
|---|---|---|---|---|
| | | | Dice coef | |
| | | n[1)] | Overall | Inter Min.[2)] |
| **Japan** | ***Overall*** | | 0.07 | 0.02 |
| | ***By issue*** | | | |
| | Target | 19 | 0.10 | 0.02 |
| | Energy | 56 | 0.09 | 0.00 |
| | Nuclear | 19 | 0.08 | 0.04 |
| | Science | 22 | 0.12 | 0.04 |
| | Technology development | 25 | 0.05 | 0.01 |
| | Business and product regulation | 72 | 0.05 | 0.02 |
| | Agriculture | 4 | 0.02 | 0.01 |
| | Local | 9 | 0.03 | 0.02 |
| | Adaptation and Riskmanagement | 4 | 0.07 | 0.04 |
| | Development | 0 | – | – |
| | Ethics | 0 | – | – |
| | Transportation | 12 | 0.10 | 0.04 |
| **Germany** | ***Overall*** | | 0.07 | 0.04 |
| | ***By issue*** | | | |
| | Target | 19 | 0.06 | 0.03 |
| | Energy | 17 | 0.04 | 0.03 |
| | Nuclear | 13 | 0.12 | 0.00 |
| | Science | 20 | 0.03 | 0.02 |
| | Technology development | 10 | 0.06 | 0.02 |
| | Business and product regulation | 12 | 0.07 | 0.04 |
| | Agriculture | 12 | 0.03 | 0.02 |
| | Local | 6 | 0.03 | 0.01 |
| | Adaptation and Riskmanagement | 7 | 0.07 | 0.05 |
| | Development | 3 | 0.23 | 0.23 |
| | Ethics | 9 | 0.04 | 0.03 |
| | Transportation | 9 | 0.03 | 0.02 |

Dice coef = Dice coefficient. Inter Min. = Inter-Ministries (see note 2)

1) Total number of committees that handle the relevant topic.

2) Dice coefficient between the committees that belong to the different ministries.

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Germany (0.04). In other words, Japanese integration especially occurs between committees that fall under the same ministries, as compared to the German case.

There are also some differences in the degree of overlap among the different issues. In both countries, the Dice coefficient is relatively high in the SACs which handle the topic of nuclear energy (0.08 and 0.12), even more so for Germany than for Japan. The biggest overlap in Japan (0.12) is seen for science. Furthermore, we can derive from the analysis that integration occurs in Japan through explicit target setting (0.10) and energy issues (0.09). In Germany, technology and development (0.23) is an especially strong factor for the integration of different committees. Business and product regulations and adaptation (0.07) and risk management (0.07) are further topics with high horizontal integration in Germany.

The different structure of horizontal integration in both countries can also be visually examined. Fig 2 shows how the degree of membership overlaps across the different

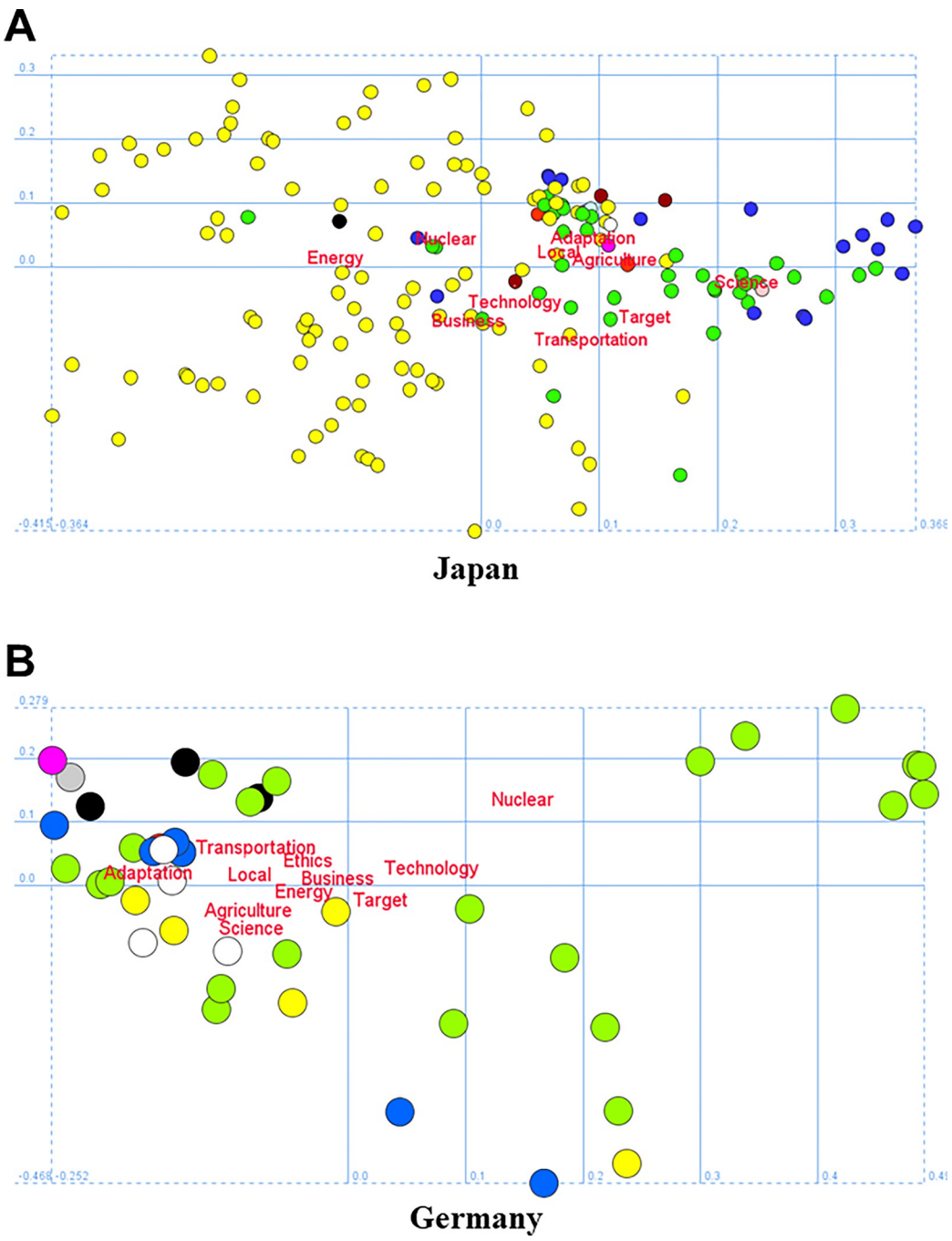


**Fig 2. Overlap of memberships among committees.** Note: Each node represents a SAC. The colour of the node represents the ministries the SAC belongs to (white = agriculture; blue = science; yellow = economy; green = environment; red = land; black = cabinet; grey = development; purple = parliament). The distance between the committees represents the Dice coefficient. The closer two nodes are, the more similar are the members in those committees.

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committees, where the Dice coefficient was treated as distance (A high Dice coefficient indicates a higher degree of overlap. We converged it into distance by subtracting the Dice coefficient from 1 (namely, 1 minus Dice coefficient)). and plotted based on multidimensional scaling. The closer two nodes (committees) are in the plot, the higher the degree of

membership overlap was observed between them. The issue label was superimposed by calculating the average of the positions of the SACs that handle the relevant issue.

In Japan (Fig 2A), the clear structure of horizontal integration is readable from the plot. Memberships overlaps in particular between the committees organised by the Ministry of the Economy, the Ministry of the Environment and the Ministry of Education. On the other hand, there is a clear division of committees among the ministries, especially between the ministries of the Economy and the Environment. There are some issues in which this ministerial segregation does not seem to apply, however, including adaptation, local policy and agriculture.

In Germany (Fig 2B), committees are more dispersed, so that there is very little membership overlap overall. Notably, we do observe some similar patterns to the Japanese case as the committees which are organized by the same ministries tend to be placed together. Despite this, even the committees organized by the same ministries are scattered. For example, committees organized by the Ministry of the Environment are clustered in top-right, top-left, and in the middle of ***Fig 2***, suggesting that at least three different clusters of members exist under the committees organized by the Ministry of the Environment. In addition, some SACs, which belong to the different ministries, are in many cases placed close to each other. It suggests that the overlap occurs more for specifically defined topics, regardless of their parent ministries.

## Factors leading to membership overlap

Despite these structural differences in the way of integration in two countries' SACs, we can observe some common factors leading to horizontal integration. In this last subsection, we analyse these factors by applying MRQAP regression by setting the membership overlap among SACs (i.e., Dice coefficient) as dependent variable and the possible factors as independent variables (see method and measurement section).

This analysis reveals some common factors leading to membership overlap (**Table 5**). Firstly, it is more common for the membership to overlap between committees that belong to the same ministries. This result reveals the existence of actors who have a persistent relationship with a particular Ministry. From the perspective of nominators (e.g., bureaucrats within the ministries), there is a pool of "favourite" members to name.

Secondly, the larger the committee, the greater the chances of the committee membership to overlap with other committees. This is a natural consequence of the first finding.

Thirdly, the nuclear issue leads to a higher overlap of members in both countries. Apparently, this reflects the time of data collection where the nuclear phase-out and its policy integration was intensively discussed in both countries. This is not significant in the German case (possibly because of the smaller number of observations), but still has a positive coefficient. Local policy is also a common factor for integration.

Fourthly, multi-issue actors (i.e., those with knowledge of several issues) seem to lead to higher overlap among committees. This effect is not significant in the German case, but it is still positive. Moreover, this variable is interesting because the effect is larger in the model where the integration between ministries is concerned (model 2 and model 5). In other words, multi-issue and prominent actors serve as policy brokers, especially between the different committees under different ministries.

In addition to these common features, there are interesting differences between the two countries. It is particularly interesting to observe that, in Japanese committees, handling the same issues results in integration among them. However, this effect is not positive in many of the issues in Germany (except for the issue of nuclear, adaptation and development). Seemingly, German committees define the issues in more detail and more generally defined issues do not cause the membership to overlap. The fact that the German committee seemingly

**Table 5. MRQAP regression on membership overlap among advisory committees.**

| | Japan | | | | | | Germany | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | model 1 | | model 2 | | model 3 | | model 4 | | model 5 | | model 6 | |
| DV = | (Whole) | | (between ministries) | | (between topics) | | (Whole) | | (between ministries) | | (between topics) | |
| (Intercept) | -0.25 | *** | 0.01 | | -0.06 | * | -0.23 | *** | -0.04 | | -0.10 | |
| Same ministry (dummy) | 0.31 | *** | | | 0.32 | *** | 0.28 | *** | | | 0.32 | ** |
| Size | 0.14 | *** | 0.13 | *** | 0.16 | *** | 0.16 | *** | 0.13 | ** | 0.21 | *** |
| Actor type diversity | 0.03 | | 0.06 | * | 0.03 | | -0.02 | | 0.03 | | -0.09 | |
| SameTopic (Target) | 0.57 | *** | 0.05 | | | | 0.05 | | 0.15 | | | |
| (Energy) | 0.42 | *** | -0.05 | | | | 0.15 | | 0.18 | | | |
| (Nuclear) | 0.79 | *** | 0.94 | *** | | | 0.75 | *** | 0.03 | | | |
| (Science) | 1.13 | *** | 0.70 | *** | | | 0.12 | | 0.02 | | | |
| (Technology) | 0.22 | | -0.01 | | | | -0.16 | | -0.35 | † | | |
| (Business) | 0.20 | *** | 0.22 | *** | | | 0.14 | | 0.00 | | | |
| (Agriculture) | 0.32 | | 0.26 | | | | 0.15 | | 0.19 | | | |
| (Local) | 0.49 | * | 0.43 | * | | | -0.29 | | -0.39 | | | |
| (Adaptation) | 0.74 | | 1.41 | ** | | | 0.54 | * | 0.54 | * | | |
| (Development) | | | | | | | 2.29 | *** | 3.12 | *** | | |
| (Ethic) | | | | | | | | | -0.12 | | | |
| (Transportation) | 0.66 | *** | 0.79 | ** | | | 0.04 | | 0.31 | | | |
| Science | 0.03 | | 0.12 | * | 0.10 | * | 0.01 | | -0.09 | | -0.06 | |
| Business | 0.00 | | 0.06 | | 0.10 | | -0.09 | | -0.30 | ** | -0.10 | |
| NGO | -0.02 | | -0.04 | | 0.00 | | 0.05 | | -0.19 | * | | |
| Media | -0.01 | | 0.01 | | 0.00 | | | | | | -0.01 | |
| Local | 0.04 | * | 0.04 | | 0.07 | *** | 0.04 | | 0.05 | | 0.13 | |
| University researcher | 0.02 | | 0.06 | | 0.08 | | -0.07 | | -0.44 | ** | -0.24 | |
| Political party | | | | | | | -0.06 | | -0.23 | * | -0.18 | |
| Prominent actor | 0.38 | *** | 0.36 | *** | 0.40 | *** | 0.41 | *** | 0.06 | | 0.16 | |
| Multi-issue actor | -0.02 | | 0.04 | * | 0.07 | *** | 0.00 | | 0.10 | | 0.14 | |
| $R^2$ | 0.27 | | 0.21 | | 0.25 | | 0.33 | | 0.27 | | 0.33 | |
| Adj. $R^2$ | 0.27 | | 0.21 | | 0.25 | | 0.32 | | 0.25 | | 0.32 | |
| Observations | 15051 | | 8776 | | 10129 | | 903 | | 638 | | 397 | |

***p < .001

**p < .01

*p < .05

†p < .10.

Note: Significant level was calculated against 1,000 randomly permuted graphs.

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define the issues in a narrow way is further supported by the result that individual university researchers have a negative coefficient. Given the general tendency that the university researchers' expertise is highly specialized, the German researchers appear to attend only committees that fall within their own domain of expertise.

## 5. Discussion and conclusions

The EPI literature argues that communication and collaboration across various sectors and public agencies, and coordinating decisionmaking, are key for the effective management of sustainability issues [4, 13, 43]. SACs are one of the important institutionalized venues that can

promote integration [20]. Using this as motivation, we have empirically investigated the degree of vertical and horizontal integration of SACs in Japan and Germany.

Regarding vertical integration (i.e., sectoral diversity in SAC membership), the vertical integration of German SACs is almost twice that of Japanese SACs. Japanese SACs are dominated by three sectors, namely, scientific organizations, business groups, and university researchers. By contrast, in German SACs, NGOs and local governments are more present than in Japan. In addition to the difference in diversity, it is worth noting that in Japan the prominent actors (i.e., those actors being in many SACs) are dominated by those organizations affiliated with the Ministry of the Economy. In Germany, environmental NGOs and local governments are listed in the top 10 prominent actors.

Regarding horizontal integration (i.e., membership overlaps across SACs), the degree of integration is almost the same in Japan and Germany. Nevertheless, the way the horizontal integration is achieved is different. The membership overlaps in Japanese SACs predominantly occurs among SACs that belong to the same ministries. The result suggests that relatively similar information is distributed among SACs under the same ministries, leading to the integration within a ministry. The flip side is that it results in a segregation of information; information may not circulate well between ministries whose policy orientation is different, which is a finding that is consistent with the existing literature [7].

In Germany, the committees are more dispersed and there is less membership overlap, but there is also less segregation of the SACs under the different ministries. This appears to result in a similar level of horizontal integration between two countries. Together with another result —that SACs handling the same issues does not lead to the membership overlaps in German SACs (Table 5)—the finding suggests that German committees define issues in a narrow way. In line with this interpretation, the literature argues that committees in Germany tend to be very technical and expert-based and solutions to environmental problems have been favoured on the basis of technological innovations [44, 45]. Because of the high issue-ownership of each committee, it can be interpreted that each of them has an unchallenged decision-making competence. In addition, each committee includes actors from different areas (such as NGOs, scientists, business organizations). One study [44] argues that this combination of high issue-ownership and high vertical integration contribute to the deliberation of the discussion from different political stances.

Despite the different characteristics of horizontal integration in Japan and Germany, we find the common underlying factors that leads to the membership overlaps among committees. Those factors include committees belonging to the same ministry, having a larger number of members, having many prominent actors and multi-issue actors (i.e., actors who can speak about multiple issues). In addition, in our cases the nuclear issue caused a higher overlap of members in both countries. This may be an artifact of the timing of data collection (2010 to 2015).

Methodologically, we have demonstrated the utility of membership lists of SACs for the empirical assessment of vertical and horizontal integration. Membership lists are usually publicly available and we can set a common criterion for comparing the integration in different countries.

There are also several limitations in our study, and we point out three important avenue for further investigation. First, this research addresses the empirical question of the extent to which learning occurs among members of SACs. While we have argued that being in a same committee in SACs is a necessary condition for communication among participants, it may be not always sufficient for environmental policy integration (EPI). One study [46] found that participants in committees tend to obtain policy advice from those whose views are similar to their own, suggesting SACs are not always enabling policy learning. But more research in this regard needs to be done.

Second, while we considered scientific knowledge integration among different sectors and governmental bodies, there is also a growing interest on how indigenous knowledge alongside scientific knowledge is integrated in the governance [47]. We believe our operationalization would also be extensible for empirical studies that investigate the science and indigenous knowledge integration for EPI.

Third, whether and how the vertical and horizontal integration in SACs enhances the effective policy implementations requires empirical investigation. As reviewed, this is the widely discussed proposition in the extant literature. However, the actual investigation is rather rare. We believe that our results can thus provide a starting point for further empirical research.

## Supporting information

**S1 Table. List of the formal names of the Ministries in Germany and Japan.**
(DOCX)

**S1 Text. Coding scheme organizational types and topic of the advisory committee.**
(DOCX)

**S2 Text. List of possible driving forces that can cause integration.**
(DOCX)

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