How Scientific Research Impacts Policy Cycle

Ashraf Maleki[1], Marianna Lehtisaari[2], Kim Holmberg[3]

[1]ashraf.maleki@utu.fi, [2]mkatal@utu.fi, [3]kim.j.holmberg@utu.fi
Dept of Social Research, University of Turku, Assistentinkatu 7, FI-20014 Turku (Finland)

Abstract

Scientific research is increasingly referenced in policy documents issued by international, national, and regional organizations, reflecting its role in governance and decision-making across diverse social responsibilities. However, the extent to which scientific publications contribute to different stages of policy making remain an under-researched area. This study investigates how policy sources cite scientific research across disciplines, with a particular focus on the placement and function of the citations within governmental and intergovernmental organization (IGO) policy documents. Our core dataset is drawn from UK REF2021 journal articles, while policy citation counts and a sample of policy documents were retrieved from Overton.io. A random sample of 1,000 policy documents citing scientific articles in five fields from governmental and IGO sources were analyzed to determine type of policy documents, their purposes, and the placement of the citations in them. Policy documents, based on their focus and their purpose, were assessed according to the five-stage policy chain model: agenda-setting, formulation, adoption, implementation, and evaluation. The findings indicate that governmental and IGOs are the predominant sources of policy citations. Many policy documents lack distinct sections typical of scientific articles and appear in numbered chapters (41%), while in the remaining documents citations were primarily located in the Introduction (13%), Background (9%), Methods (10%), or References without clear in-text citation (7%). With some disciplinary differences, nearly half of policy citations appear in the "policy formulation" stage of the policy making chain, while about one-fifth occur in the "policy evaluation" stage, demonstrating how policymakers rely on academic research both when shaping policy frameworks and assessing their effectiveness. Field of public health stands out as an exception, with a significantly higher proportion of scientific citations in the "policy implementation" stage (34%) compared to other fields (8%), reflecting the evidence-based nature of practical guidance and guidelines informed by research. Additionally, most policy document sources had more administrative (63%) than scientific (37%) focus and held operational (39%), advisory (26%), or executive (16.5%) roles, highlighting their action-oriented nature. The results challenge the view that policy documents merely synthesize academic research; instead, they often engage in knowledge production through commissioned studies, empirical analysis (56%), and evidence-based recommendations (34%). Policy-to-research citations should not be seen solely as indicators of research uptake but as part of a reciprocal process where policy documents both utilize and generate scientific knowledge. Policy citations can thus serve as a critical measure of the impact of science on policy research and recommendations, demonstrating how academic research informs and shapes evidence-based governance.

Introduction

Policy citations, i.e. citations to scholarly research in so-called policy documents, is an understudied area of responsible use of metrics in research impact assessment. This paper investigates how scientific findings are cited in policy documents, their placement within the text, and their broader implications for policy. Overton.io identifies and aggregates citations to academic articles from policy documents that have been openly published online by various national or international, governmental or intergovernmental organisations, thus allowing large scale analysis of policy citations for research impact assessment. The policy citations collected by

Overton.io are mostly citations in grey literature hosted on governmental, inter-governmental and institutional websites. Although policy citations offer an opportunity to investigate citation context and societal impact of research in a more diverse way than many other altmetric indicators are able to, the diversity of governmental and intergovernmental activities and responsibilities calls for more research into the context and content of policy citations before they can be reliably used for research impact assessment. The current study investigates to what degree the analysed policy documents offer policy recommendations and how the citations to research have been used in them.

Governmental and intergovernmental organizations serve far-ranging purposes in policy development, from setting international frameworks to implementing national and regional regulations. These organizations create policy documents to establish priorities, provide evidence-based and strategic guidance, enforce regulatory standards, and disseminate best practices. By investigating the context in which research is being cited in policy documents we can deduce some new understanding of how scientific evidence informs policy decisions and how research informs different stages of the policy chain of formal decision-making.

The policy chain or policy cycle refers to the sequence of processes through which policy ideas are developed, implemented, and evaluated (Jann and Wegrich, 2017). The five-stage model of policy cycle consists of several key actions based on previous studies dating back to Jones (1974):

1. **Problem Identification and Agenda Setting.** The first stage involves recognizing and defining an issue that requires governmental or intergovernmental intervention, prioritizing policy issues for discussion, and determining which problems should receive attention from policymakers.
2. **Policy Formulation and Analysis**. The second stage involves designing potential solutions, strategies, or frameworks to address the identified issues and developing policy proposals, including drafting legislation, guidelines, and recommendations.
3. **Decision-Making and Policy Adoption.** The third stage involves selecting a specific course of action, which may involve legislative approval, executive orders, or administrative rulings and formalizing the decision.
4. **Policy Implementation.** Implementation involves operationalizing the selected policies and enforcing them through regulatory measures, public programs, or institutional actions.
5. **Policy Monitoring and Evaluation**. The final evaluative stage involves assessing the impact of policy measures and making necessary modifications based on empirical findings and stakeholder input.

Each of these steps is informed by scientific research in various ways and every stage benefits from other stages as policies keep evolving. By analyzing citations from policy documents to scientific research, this study aims to clarify how and to what extent scientific research informs different stages of policymaking and thus, what kind of impact research has had beyond academia.

Research Questions

The research aims to analyze policy citations to scientific publications and their placement both in the policy documents and in the policy chain. In order to address the research goal, the following research questions are addressed in this research:

1. How frequently is scientific research cited in policy documents across different fields and policy sources?
2. Where within policy documents do citations to scientific research typically appear, and how does their placement relate to policy development?
3. How do the characteristics of citing policy sources influence how scientific research is used at different policy chain stages?
4. What types of policy documents (research, policy recommendations, review, guidance/guideline, rules/regulations) cite scientific research, and how do these types correspond to different stages of the policy chain?

Background

Policy documents have emerged as a potential source for evidence of wider societal impact of research, i.e. how research is informing policy and through that, influencing society. Both Altmetric.com and Overton.io identify and collect online policy documents and extract and aggregate citations to scientific articles from them. While the societal impact of policy citations or their applicability for research assessment remain understudied areas of altmetric research, some studies have explored and compared these new data sources (Maleki and Holmberg, 2022; 2024; Murat et al., 2023; Dorta-González et al., 2024), pointing at some differences between them and suggesting that in order to gain a more robust picture data from both should be used. Earlier research has pointed at specific affordances that may have a positive influence on the likelihood for research to be cited in policy documents. It has been shown that research that has been discussed in blogs and news is more likely to also be cited in policy documents (Dorta-González et al., 2024). This suggests that science communicators may even have an important role in influencing policy. In line with the demand from many funders to approach complex societal challenges with multi-disciplinary research approaches, disciplinary diversity has been discovered to have a positive influence on the likelihood for research to be cited in policy documents (Pinheiro et al., 2021). Co-authorship with non-academic authors also appears to increase a research article's chances of getting cited in a policy document (Ma and Cheng, 2023).

There is some evidence that, at least in some research topics, policy citations identified and captured by Overton are associated with research impact, as measured by the peer-review assessment of impact by the UK Research Excellence Framework (REF) 2014 (Szomszor and Adie, 2022). The authors suggest that citation analyses on policy documents may be informative for research assessment and policy review. But contradictory results have also emerged. Research excellence, as measured with more traditional bibliometric measures, may not have an influence on whether a research article is cited in policy documents or not (Mahfouz et al., 2024). Based on these findings, it would appear that other, non-academic attributes and factors, may have a more important role in determining how research influences policy. More

research is needed before more definite conclusions about the applicability of policy citations for research assessment can be made.

The citation placements in policy documents have also been studied before. It has been discovered that citations to research appear most often in policy documents that could be classified as advice documents, and not in legislative or executive records (Pinheiro et al., 2021). When it comes to the context of the citations within the policy documents, one study showed that about half of the citations appeared in what the authors called "expounding" context (Yu et al., 2023). This included contexts that explained meaning or background, such as definitions of concepts, theoretical foundations, or argumentation of ideas. The context with the second largest amount (just over 20%) of citations was discovered to be sections that could be labelled as "review" sections.

While there are some earlier studies that have analysed various aspects of policy documents and policy citations, they still remain an understudied area of altmetric research. A greater understanding of policy citation patterns would allow for more meaningful evaluation of the applicability of policy citations for research impact assessment and inform about the role of research in policy making.

Data and Methodology

Our primary dataset of scientific publications constituted about 151,712 journal articles reported to REF2021. REF2021 refers to the overarching evaluation framework used to assess the quality and impact of research conducted in UK higher education institutions. These were examined for policy citations in Overton.io. In other words, policy documents indexed by Overton were searched for citations to scientific journal articles reported to REF2012. The policy citations were retrieved through Overton API during November 2024. The regular Unit of Assessments (UoAs) from REF2021 were used for subject classification of the journal articles and sampling of the data.

A sample of policy documents that were citing scientific publications were randomly selected to analyse the policy sources and their various purposes in the policy chain. About 80% of the scientific publications reported to REF2012 had at least one government or IGO policy citation, whereas these on average constitute about 70% of all policy citations (Figure 1). In our analysis we focused on policy documents by governmental or intergovernmental sources, as these constitute the majority of all policy documents. We randomly selected a sample of 1006 policy documents (about 500 government and 500 IGO) that cite journal articles in five REF2021 subject categories (about 100 from each field per source type). The included REF2021 UoAs are Public Health, Health Services and Primary Care, Engineering, Earth Systems and Environmental Sciences, Business and Management Studies, and Art and Design publications.
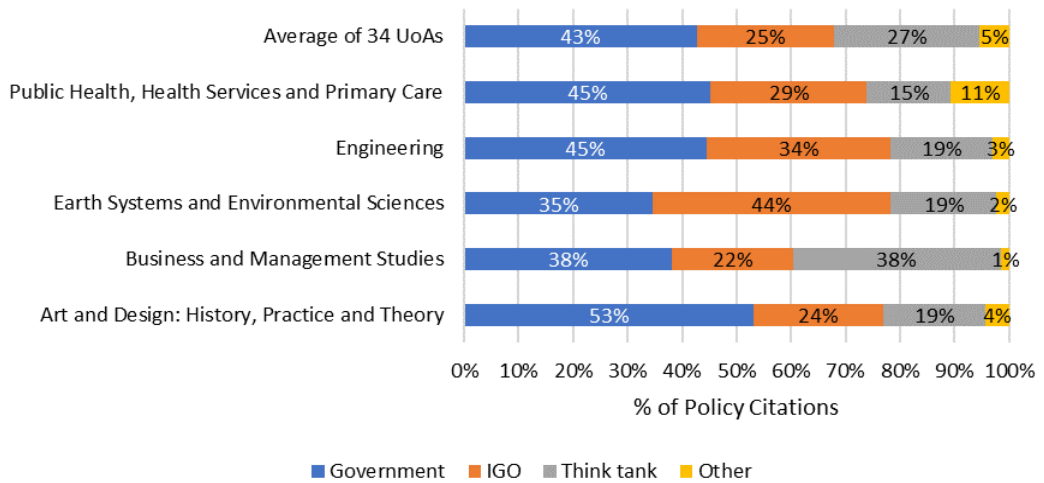
Figure 1. Cumulative Proportion of Policy Citations across source types to REF UoAs. (more in Appendix Table S2).

Appendix Table S1 gives the extent of the DOIs cited across the four Overton source types (government, IGO, think tank, and other) and appendix Table S2 gives the extent of citing policy document counts, both across the 34 UoAs.

The citation context, i.e., the sentence citing the scientific publication in the policy documents, and the placement of the citation in each document (e.g. introduction, method, findings, appendix etc.), were manually extracted from the policy documents in our sample.

While English is the majority language (851, 85%) of the sampled policy documents, the sample also contained documents in 23 other languages (155, 15%) (Table 1). The most frequent among these other languages were Spanish (47, 5%), French (30, 3%) and Swedish (18, 2%). Non-English documents were translated using Google Translate and purpose and citation contexts were extracted from the translated texts.

Our data sample had some limitations. A small proportion of the policy documents could not be reached online due to restricted access (6.3%) or because the document had been removed, while in a small number of documents the citation couldn't be located. Additionally, five documents had been withdrawn by linking to an updated or replacing document that contained the citations. Duplicate documents accounted for 1.7% of the sample. These were mostly versions of the same documents but in different versions or different drafts of the same manuscript. In some cases, some confusion was caused by the multiple PDF files that were associated with a single policy document.

Table 1. Characteristics of sampled policy documents (total n = 1006).

Characteristic	Count	percent
Language:		
English	851	84.6%
Non-English	155	15.4%
Lost sample:	66	6.6%
Online page could not be reached.	63	6.3%
Citation, wrong or not found	3	0.3%
Withdrawn	1	0.1%
Special cases:		
Withdrawn, but updated and replaced	5	0.5%
Duplicates (as different language and draft)	17	1.7%
Multi-PDF Policy documents	21	2.1%

To determine the purpose of the policy document the documents were manually searched for mentions of objectives or aims of the document. The identified texts containing a description of the purpose of the document were used to identify two aspects of documents: document type and policy chain stage. We identified document types based on possible presence of description of research, review, policy recommendation, guidance, or rules and regulations or some combinations of them. A significant effort was placed on identifying pure research from research that accompanies policy recommendation and between review studies and review studies with the main goal to advise policy (Table 2). Although policy recommendation is a potential outcome in most studies, not all studies have a similar emphasis on it and they may vary from purely academic research with potential policy advice to more focused policy advising research.

Table 2. Type of policy documents.

Type of policy documents	Description
Research	Original research in a journal or conference publications hosted on government websites. Do not necessarily offer policy recommendations.
Research & Policy Recommendation	Original research or analysis either in a scientific paper or organizational report with clear policy recommendations. Includes policy research papers.
Review	Systematic review/synthesis of original research and/or policies in a scientific paper or report meant for improving understanding of a subject or current literature. May contain a call for discussion or present various solutions, but do not offer any policy recommendation.
Review & Policy Recommendation	Systematic review/synthesis of original research and/or policies in a scientific paper or report meant for both improving understanding of a subject or current literature and offering a policy recommendation.
Guidance or Guideline	Guidance or guidelines, handbooks and evidence-based recommendations.
Rules and Regulations	Formal rules and regulatory documents.

Based on the identified purpose of the policy documents the documents were assigned to the five policy chain stages (Table 3). For this both manual coding and ChatGPT-4o were used (examples of texts used to identify different policy chain stages are in Appendix 1).

Table 3. Stages of the policy chain.

Policy chain stages	Description
1. Agenda-setting	Identifying issues that require government intervention.
2. Formulation	Developing possible policy solutions.
3. Adoption	Deciding which policies to implement.
4. Implementation	Putting policies into action.
5. Evaluation	Assessing the effectiveness of policies.

Because of the large number of sentences that were identified to contain evidence of either the purpose of the document or of its type, large language models (LLMs) were used for automated analysis of the textual content. An organizational premium access to ChatGPT was used to send a command prompt asking for ChatGPT to determine the policy document type and policy chain stages of the uploaded sentences containing policy document purposes. Several tests were conducted before the optimal command prompt was chosen.

To examine the reproducibility of the ChatGPT results, the prompts were repeated three times and any inconsistencies in the results were investigated. Documents for which the results changed were cross-checked manually by the first author to identify

potential reasons for changes in the classification results. Of the 1006 policy documents the classification of 81 documents changed between repeated tests with ChatGPT. ChatGPT was asked to assign the documents to only one of the given policy chain stages and to assign a policy document type to each document. The policy document types were manually coded by two humans and then using ChatGPT, while the policy chain stages were coded manually by one human and with the help of ChatGPT. Despite taking measures to try to secure reproducibility, it is unclear if the results can be reproduced if using ChatGPT. Updates in the LLM, users' previous interaction with the LLM, and certain level of disambiguation in the policy texts may influence the results at a later stage.

The sources of analysed policy documents were classified as governmental or intergovernmental; international, national or regional; administrative or scientific; and according to their function as advisory, research, executive, operational, legislative, regulatory, or information (Table 4).

Table 4. Policy source types with examples.

Source types	Examples
Governmental	*Government of Ireland (GOV.IE), County Administrative Boards (Sweden)*
Intergovernmental	Asian Development Bank, Arctic Council
International	*European Commission, International Monetary Fund (IMF)*
National	*Government of Singapore, NHS England*
Regional	*Government of Flanders, Public Health Wales*
Administrative	*European Parliament Committees, German Environment Agency (UBA)*
Scientific	*Joint Research Centre (European Commission), Eurostat*
Advisory	*Intergovernmental Science-Policy Platform on Biodiversity (IPBES), Internet Governance Forum, European Economic and Social Committee*
Research	*National Renewable Energy Laboratory (NREL), European Forest Institute (EFI)*
Executive	*New Zealand Treasury, Northern Ireland Executive*
Operational	*European Investment Bank, Food and Agriculture Organization of the United Nations, NHS Trusts*
Legislative	*European Parliament Plenary, Parliament of Denmark*
Regulatory	*Organisation for the Prohibition of Chemical Weapons, Bank of Italy*
Information	*Community Research and Development Information Service (CORDIS), Official State Gazette (Spain)*

Findings and Discussion

The findings show that of the 151,712 REF 2021 journal articles included in this study a total of 26% (n = 39,226) received a policy citation from the Overton data (Appendix Table S1), with 69% of them coming from government-sourced policy

documents, 46% from documents published by think tanks, 33% from documents by IGOs and 20% coming from other sources. The cumulative number of policy citations were 275,028 (Appendix Table S1) constituting 41% government policy citations, 28% IGOs, 27% think tanks and 6% other policy sources. This demonstrates that governmental documents are the most significant source of policy citations to journal articles. Although think tanks tend to cite a higher number of academic research (46% vs. 33% IGOs), IGOs produce almost similar extent of policy documents that are supported by research (28% vs. 27% think tank).

Policy Citations to REF2021 Articles

In answer to the first research question, Figure 2 indicates proportion of REF2021 journal articles with positive policy citations across the four Overton.io policy source types in 34 REF UoAs. In most fields, the government cites a significantly higher proportion of journal articles compared to other source types, with the highest coverage being in *Public Health, Health Services and Primary Care* (54%). The exceptions are *Economics and Econometrics*, and *Politics and International Studies* where think tanks (62% and 37%, respectively) cite a significantly higher proportion of scientific publications than government (42% vs. 20%).

Figure 3 indicates the geometric mean of policy citations across source types. While reflecting a similar trend as in the proportions of cited documents, the highest geometric mean policy citations were made by think tanks citing Economics and Econometrics journal articles (2.4), followed by government citations to P*ublic Health, Health Services and Primary Care* (1.3).
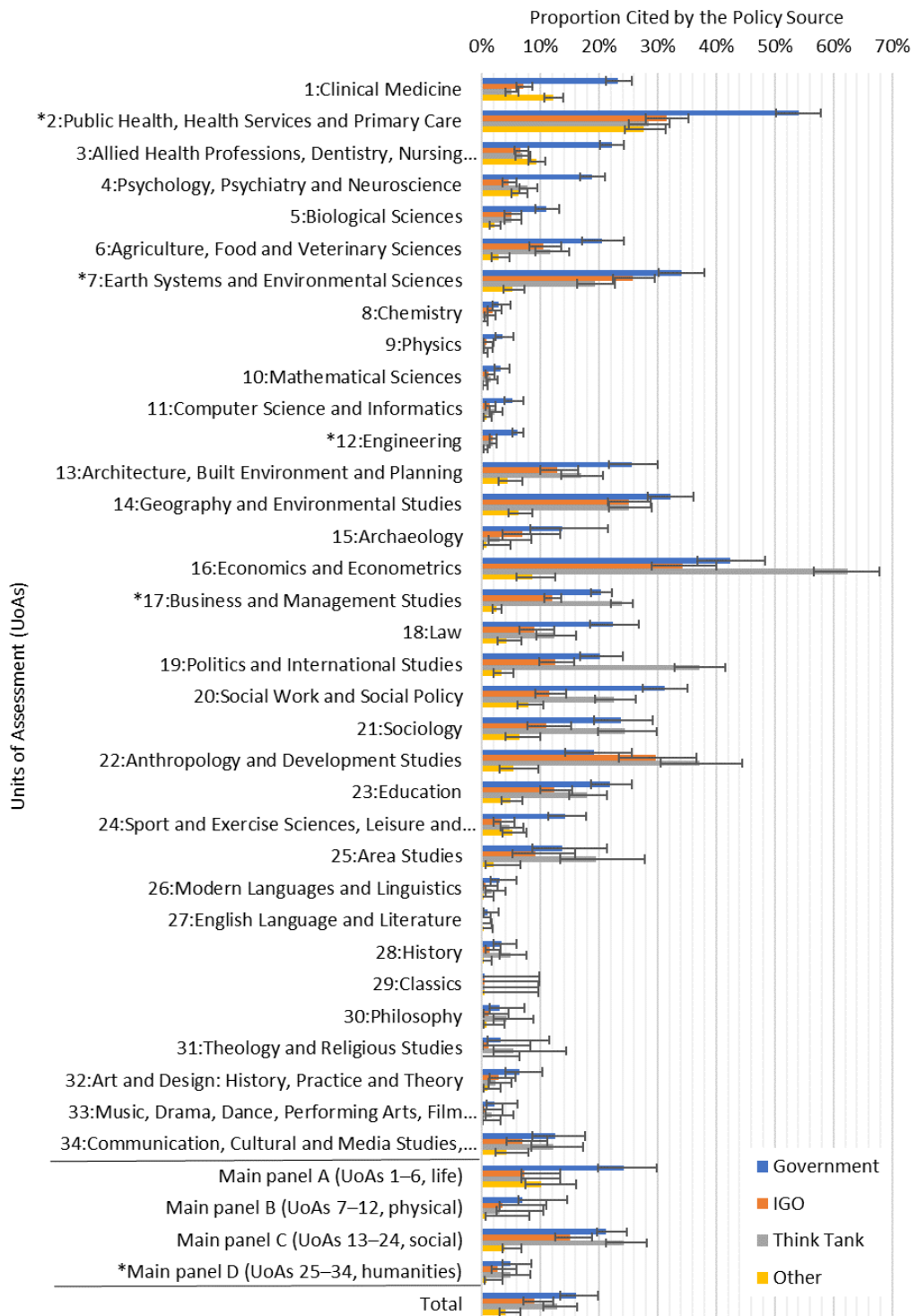
Figure 2. Proportion non-zero policy citations of REF journal articles (2014-2020) across UoAs across source types (government, IGO, think tank, and other). (Detailed in Appendix Table S1).

Geometric Mean Policy Citations by Source

Figure 3. Average Geometric mean policy citations of REF 2021 journal articles (2014-2020) across UoAs in terms of citing source types (government, IGO, think tank, and other). * Fields used in the sampling.

Citation Placements in Policy Documents

In answer to the second research question, Figure 4 shows where in the analysed documents the citations to scientific articles were discovered. The policy documents often had several citations occurring in different parts of the document. Several policy documents in our sample contained numbered chapters rather than a structure that would have been similar to that of scientific journal articles (i.e. sections for executive summary, introduction, methodology, findings, discussion, conclusion, references and appendices). Thus, 41% of the citations were located simply in chapters, rather than some specific sections typical for a scientific article. Our categorization thus differs somewhat from that of Yu et al. (2023) in terms of citation locations in text. Of the citations that were found in specific sections most were discovered in Introduction (13%), Background (9%), Method (10%) and in References (7%). Figure 4 gives a breakdown of in which sections or parts of the policy documents the citations were found and the chapter numbers where the policy citations to research were found. Many of the policy documents had significantly more chapters than the ten reported here, but because the statistics dropped significantly after chapter 7 we decided to not report all the chapters. The results showed how the first chapters of the policy documents had most of the citations, resembling the structure of scientific articles where the earlier parts of the articles and reports alike, review and present earlier scientific evidence.
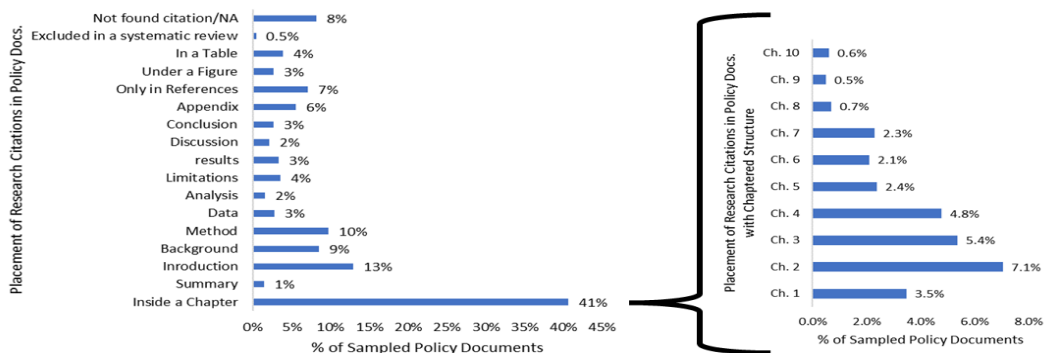

Figure 4. Proportion of sampled policy documents (total n = 1006) containing the REF2021 journal paper citations in terms of placement of citations in different headings of policy documents. The percentages are shown only for the first 10 chapters for brevity. Ch.: Chapter.

Characteristics of Policy Documents

Figure 5 gives a breakdown of specific characteristics of the policy documents. The proportion of documents from IGOs (66%) were almost double that of governmental documents (34%). There reasons for this contrast from the initial sample is that EU organizations have already been identified as governmental source types in Overton, contributing our sample from the government and making it sound larger than actually it was. But now that we applied our source type categorization, EU-level organizations migrated categorically to the Intergovernmental category, causing the

government sample to shrink. With an almost two thirds majority (65%) the policy documents came from international organizations, while only under a third came from national sources and regional sources contributed to only 7% of the documents. Majority of the policy citations came from organizations with administrative (63%) focus rather than scientific (37%), while their functions were mainly classified as operational (39%), advisory (36%) and executive (17%). Only 10% of policy sources held research functions, while only 5% were regulatory and 2% were legislative.
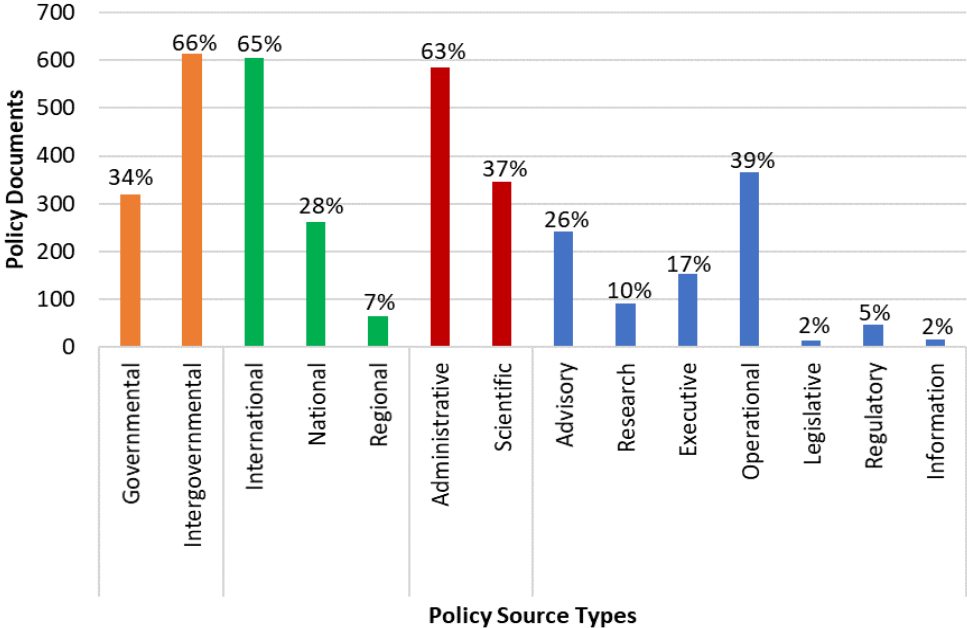

Figure 5. Count and proportion of sampled policy documents in terms of policy source type. (total n = 932).

Policy Source Functions and Policy Chain Stages

Table 5 shows how the functions of the policy documents align with the policy chain stages. The results demonstrate how almost half of the policy documents appear in the formulation stage of the policy chain and about one fifth appear in the evaluation stage, together accounting for 63% of policy citations (of total = 1006). These results reflect the importance of research in policy formulation on one hand and for the evaluation of the policy on the other hand. In other words, the results demonstrate that policy-makers often use academic research in the policy formulation and when developing indicators to assess effectiveness of policy approaches. It is also noteworthy that the majority of the policy documents appear to be operational (39%), advisory (26%) or executive (16.5%) in their function. This may reflect an action-oriented approach of the policy documents.

Table 5. Policy source structures mapped on policy chain stages of sample policy documents (total n = 932).

Source function	1. Agenda-Setting	2. Formulation	3. Adoption	4. Implementation	5. Evaluation	Total
Advisory	42 (4.5%)	**94 (10%)**	37 (4%)	18 (2%)	51 (5.5%)	**242 (26%)**
Research	9 (1%)	32 (3%)	4 (0.4%)	8 (0.9%)	**38 (4%)**	91 (10%)
Legislative	2 (0.2%)	6 (0.6%)	3 (0.3%)	1 (0.1%)	3 (0.3%)	15 (1.6%)
Regulatory	7 (0.8%)	**25 (3%)**	2 (0.2%)	1 (0.1%)	14 (1.5%)	49 (5%)
Executive	11 (1.2%)	**66 (7%)**	15 (2%)	24 (3%)	38 (4%)	**154 (16.5%)**
Operational	52 (6%)	**217 (23%)**	44 (5%)	22 (2%)	31 (3%)	**366 (39%)**
Information		**11 (1.2%)**			4 (0.4%)	15 (1.6%)
Total	123 (13%)	451 (48%)	105 (11%)	74 (8%)	179 (19%)	932 (100%)

Types of Policy Documents and Stages of the Policy Chain

The content of the citing policy documents is identified for policy document type analysis. One of the most important findings in this analysis is the identification of a high proportion of research-based policy documents (44%, 438), as they are hosted on government and intergovernmental organization (IGO) websites and cite journal articles. This is significant because policy documents are generally not associated with original research in the academic sense (i.e., primary research involving novel experiments, data collection, or theoretical development). However, our findings indicate that research is abundant as a type of policy document. This is likely because some organizations commission research studies specifically for policy-making, which can be considered gray literature rather than peer-reviewed original research. For instance, a World Bank report on economic development might include empirical analysis but is not peer-reviewed like journal articles. Additionally, our data suggest that the majority of policy sources conduct and publish original research as policy reports, which may contain surveys, statistical and cost-effectiveness analyses, or case studies. For example, some OECD (Organization for Economic Co-operation and Development) reports include novel data analysis on global education trends or World Bank reports published as research and policy brief quantifies the cost-effectiveness of various interventions to avert per death in a pandemic.

Policy documents are typically known for relying on and synthesizing existing research to inform policy recommendations. In our dataset, we found that Review & Policy Recommendation documents were the second most common type (23%, 232). Additionally, Research & Policy Recommendation (12%, 119) and Guidance and Guidelines (11%, 109) were also prevalent. These types of policy documents are often high-quality and evidence-based, meaning they integrate data and insights from academic research, stakeholder consultations, and case studies (e.g., health policy briefs and white papers). Only a minor proportion of policy documents (3%, 28) were identified as review papers only.

The policy document types were also examined against the policy chain stages (Figure 6). The results showed that *research* is the most common type of document, appearing mainly in policy formulation (21%), evaluation (13%) or agenda-setting (7%) policy chain stages. *Review and policy recommendation* is the second most common document type and they mainly contribute to policy formulation (10%) and policy adoption (6%). *Research and policy recommendation* are the third common document type, mainly appearing in the formulation (8%) stage of the policy chain. *Guidance and guidelines* are much less frequent overall but they make up a significant share of policy documents in the implementation stage (4%). Only a few *Rules and regulation* documents appeared in the policy adoption and the implementation stages (both 0.3%).
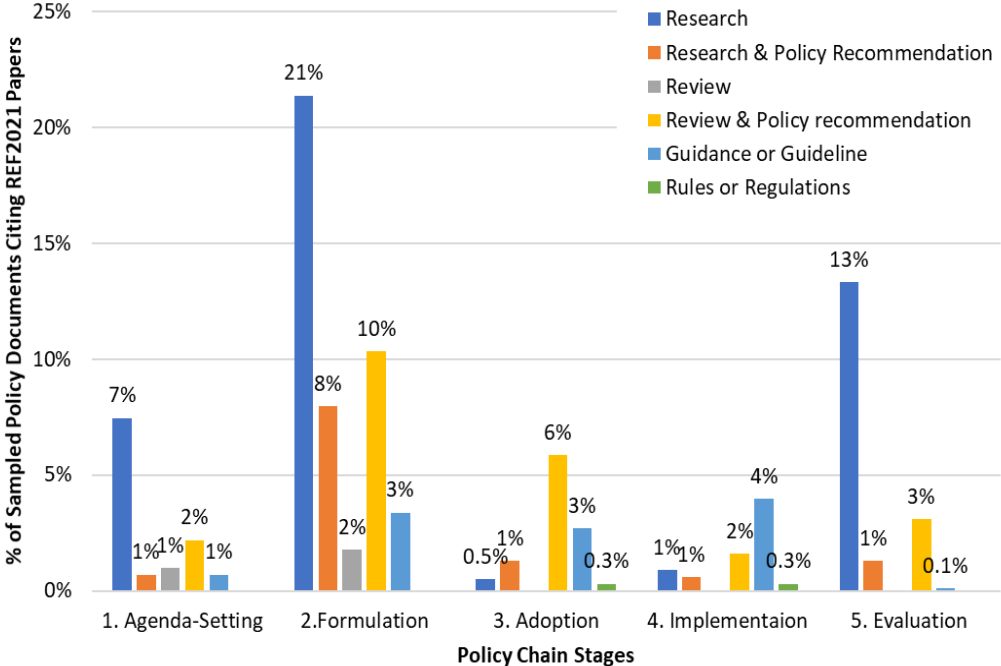

Figure 6. Proportion of all sampled policy documents (total n = 1006) across policy chain stages and policy document purposes.

Comparing Sampled Units of Assessment Across Policy Source Types and Policy Chain stages

Figure 7 shows that approximately 90% of all sampled policy documents could be traced for their role in the policy cycle. When comparing the cited research disciplines by the citing policy source types (governmental and intergovernmental) and policy chain stages, the results indicate that overall IGOs have a higher share of citing documents than governmental documents in both agenda-setting and in formulation stages, i.e. the early stages of the policy chain (Figure 7). The difference is the largest in Public Health, Health Services, and Primary Care, with governmental documents accounting for 5% of the agenda-setting documents, 17% of the formulation documents and a substantial 34% of implementation guidelines, while

942

policy documents by IGOs account for 7%, 46%, and only 10%, respectively. The results also demonstrate that depending on the UoAs between 5% and 18% of the policy documents were not accessible at the time of the analysis and thus, resulting in missing data in the analyses.
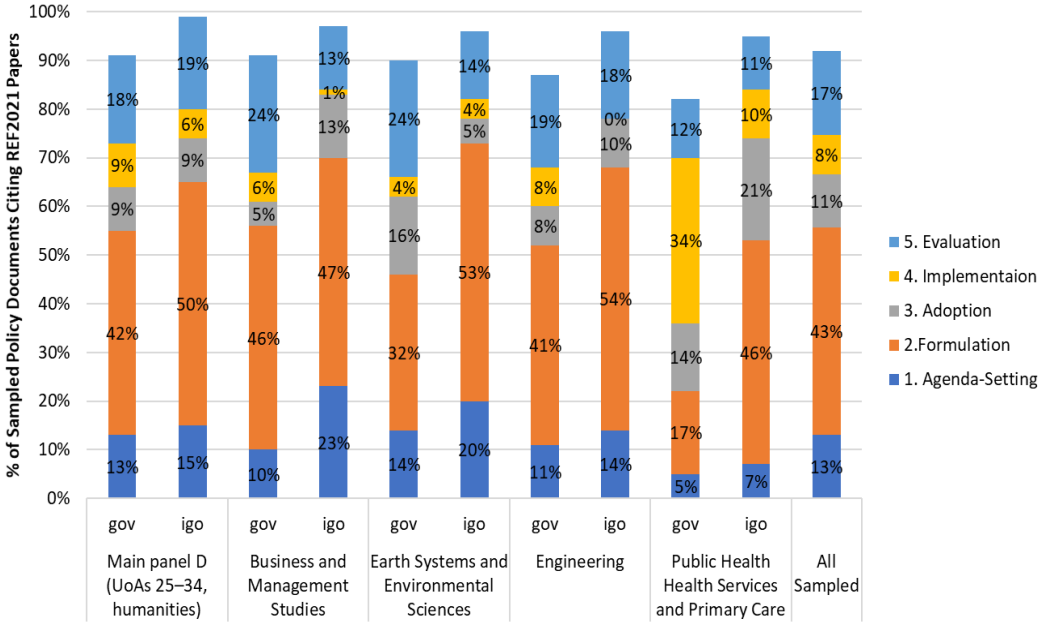

Figure 7. The proportions of policy documents by governmental and IGO sources across policy chain stages compared across five subject fields.

Conclusion

This research investigated the role of policy citations in understanding the broader societal impact of academic research. By analyzing how policy documents cite scientific publications, the results of this research offer insights into the placement of the citations within the policy documents, the purpose of the policy documents, and how they are placed within the policy-making process. Our findings confirm that governmental and intergovernmental organizations (IGOs) are the predominant sources of policy citations, with governmental policy documents containing the majority of the citations to policy-relevant research. Policy citations offer a promising data source for assessing research impact beyond traditional academic metrics, although the interpretation of the policy citations require careful consideration of the policy context in which they appear.

Our analysis reveals notable patterns in how citations appear within policy documents. Unlike scientific journal articles, which follow a standardized structure, many policy documents are organized into numbered chapters without distinct sections typical for scientific articles. As a result, 41% of the policy citations were found in chapters, while the remainder were primarily located in sections such as Introduction (13%), Background (9%), Methods (10%), and only in References without clear in-text citation (7%). In both cases, chapters and sections alike, policy

citations appeared mainly in the earlier parts of the policy documents, resembling the structure of academic papers where prior research is reviewed before new contributions are presented.

Our findings contribute to our understanding of the role research has in informing different stages of the policy making process. Almost half of the policy citations appear in the formulation stage of the policy chain, while about one-fifth are in the evaluation stage, suggesting that policymakers frequently rely on academic research when in the beginning shaping policy frameworks and when in the end assessing their effectiveness. It was also discovered that the source of most policy documents was operational (39%), advisory (26%), or executive (16.5%) functions, reflecting their action-oriented nature.

Policy-to-research citations should be interpreted with nuance, as policy documents are not merely consumers of existing research but, in many cases, also producers of original research. The high proportion of research-based policy documents (44%) suggests that policy documents often engage in empirical work, even if they are not traditionally considered as academic research. This challenges the simplistic interpretations of policy citations as one-way knowledge transfer and instead highlights a more dynamic and interactive relationship where policy documents contribute to, synthesize, and sometimes generate research. The prominence of Review & Policy Recommendation documents (23%) further indicates that policy documents often rely on academic work while framing it within broader policy contexts. Therefore, when analyzing policy citations, it is important to account for the diverse roles of policy documents - not just as passive users of research but as active participants in knowledge production and dissemination.

The findings from our research offer an original perspective that investigates policy documents through their placement in different policy chain stages and the role of policy citations in research impact assessment. The diversity in the placement of policy citations and the different document types points to the need to reconsider and to refine methodologies for interpreting policy citations. Future studies could explore qualitative aspects of citation use, assess disciplinary differences, and further investigate the mechanisms by which research informs policy decisions. By deepening our understanding of how policy citations function within the broader policy making landscape, we can improve their reliability as indicators of societal impact in research assessment frameworks.

References

Dorta-González, P., Rodríguez-Caro, A., & Dorta-González, M. I. (2024). Societal and scientific impact of policy research: A large-scale empirical study of some explanatory factors using Altmetric and Overton. Journal of Informetrics, 18(3), 101530. https://doi.org/10.1016/j.joi.2024.101530

Jones, C. O. (1974). Doing before knowing: concept development in political research. *American Journal of Political Science*, *18*(1), 215-228. https://www.jstor.org/stable/pdf/2110663.pdf

Jann, W., & Wegrich, K. (2017). Theories of the policy cycle. In *Handbook of public policy analysis* (pp. 69-88). Routledge.

Ma, J., & Cheng, Y. (2024). Why do some academic articles receive more citations from policy communities?. *Public Administration Review*. 1-23. https://doi.org/10.1111/puar.13857

Mahfouz, B., Capra, L., & Mulgan, G. (2024). Assessing the influence of research quality on policy citations: Quantitative analysis finds non- academic factors more likely to influence how papers get cited in SDG policy. *Sustainable Development*. https://doi.org/10.1002/sd.3214

Maleki, A., & Holmberg, K. (2022). Comparing coverage of policy citations to scientific publications in Overton and Altmetric. com: Case study of Finnish research organizations in Social Science. *Informaatiotutkimus*, *41*(2–3), 92-96. https://doi.org/10.23978/inf.122592

Maleki, A., & Holmberg, K. (2024). Policy Citations tracked by Overton. io versus Altmetric. com: Case Study of Finnish Research Organizations in Social Sciences. *Informaatiotutkimus*, *43*(3-4), 4-28. https://doi.org/10.23978/inf.145570

Murat, B., Noyons, E., & Costas, R. (2023, April). Exploratory analysis of policy document sources in Altmetric. com and Overton. In 27th International Conference on Science, Technology and Innovation Indicators (STI 2023). International Conference on Science, Technology and Innovation Indicators.

Pinheiro, H., Vignola-Gagné, E., & Campbell, D. (2021). A large-scale validation of the relationship between cross-disciplinary research and its uptake in policy-related documents, using the novel Overton altmetrics database. Quantitative Science Studies, 2(2), 616-642. https://doi.org/10.1162/qss_a_00137

Szomszor, M., & Adie, E. (2022). Overton: A bibliometric database of policy document citations. *Quantitative science studies*, *3*(3), 624-650. https://doi.org/10.1162/qss_a_00204

Tattersall, A., & Carroll, C. (2018). What can Altmetric. com tell us about policy citations of research? An analysis of Altmetric. com data for research articles from the University of Sheffield. *Frontiers in research metrics and analytics*, *2*, 9. https://doi.org/10.3389/frma.2017.00009

Yu, H., Murat, B., Li, J., & Li, L. (2023). How can policy document mentions to scholarly papers be interpreted? An analysis of the underlying mentioning process. Scientometrics, 128(11), 6247-6266. https://doi.org/10.1007/s11192-023-04826-y

Appendix

Examples of texts used to identify different policy chain stages:

1. Agenda-setting and Policy Problem Identification.

Example 1:

"The report presents scientific and technical background intended to stimulate debate and serves as a basis for further work to achieve a harmonized European view on the design and verification of such structures."

Example 2:

"This consultation paper is an initial consultation that sets out Central Bank proposals and seeks views on the introduction of a tiered regulatory approach for credit unions."

2. Policy Formulation and Analysis.

Example 1:

"This paper therefore provides empirical evidence in support of theoretical work stressing the importance of domestic variables in determining sudden stop episodes complementing the recent empirical literature which found a predominant role for global factors."

Example 2:

"The work presented in this report attempts to explore other realms about the future(s) of work beyond the strongly driven narrative of digital transformation. We have addressed one particular grassroots community, the Maker Movement, which is de facto enabling new models of education, collaborative work, and manufacture."

3. Policy Adoption and Decision-Making.

Example 1:

"In our discussions we shared five main goals: • secure and guarantee the necessary extra investment; • make practical changes to help solve the big challenges facing general practice, not least workforce and workload; • deliver the expansion in services and improvements in care quality and outcomes set out in The NHS Long Term Plan, phased over a realistic timeframe; • ensure and show value for money for taxpayers and the rest of the NHS, bearing in mind the scale of investment; • get better at developing, testing and costing future potential changes before rolling them out nationwide."

Example 2:

"This paper provides decision-makers with a framework for prioritising different economic, social and environmental goals and analysing the options available to achieve them. To this end, it develops three stylised COVID-19 recovery pathways ("Rebound", "Decoupling" and "Wider well-being") that differ in the extent to which they encompass greenhouse gas (GHG) emission reductions and the integration of mitigation and wider well-being outcomes or, broadly equivalently, SDGs."

4. **Policy Implementation.**

Example 1:

> *"This guideline covers identifying and managing familial hypercholesterolaemia (FH), a specific type of high cholesterol that runs in the family, in children, young people and adults. It aims to help identify people at increased risk of coronary heart disease as a result of having FH."*

Example 2:

> *"This handbook aims at helping its users to effectively co-create the powerful policies we need today. It combines an entrepreneurial way of thinking and a concrete process for developing breakthrough ideas that stand a high chance of producing real-world impact. It presents a practitioner-oriented narrative for the design and implementation of innovative participatory processes and workshops to address societal challenges – coordinated by policymakers and with the active engagement of key stakeholders."*

5. **Policy Evaluation and Monitoring.**

Example 1:

> *"To evaluate effectiveness and harms of opioids compared to nonopioid analgesics as treatment of moderate to severe acute pain in the prehospital setting."*

Example 2:

> *"The Assessment Report on Land Degradation and Restoration by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) provides a critical analysis of the state of knowledge regarding the importance, drivers, status, and trends of terrestrial ecosystems."*

Appendix Table S1. Frequency and percentage of journal articles in REF2021 with Overton.io policy citations across policy source types.

REF2021 Subjects	DOIs	Policy Cited	by government	by IGO	by think tank	by other
Agriculture, Food and Veterinary Sciences	3421	1022 (30%)	706 (69%)	368 (36%)	407 (40%)	100 (10%)
Allied Health Professions, Dentistry, Nursing and Pharmacy	11,547	3372 (29%)	2649 (79%)	800 (24%)	830 (25%)	1145 (34%)
Anthropology and Development Studies	1270	599 (47%)	236 (39%)	372 (62%)	465 (78%)	66 (11%)
Archaeology	790	152 (19%)	112 (74%)	53 (35%)	23 (15%)	6 (4%)
Architecture, Built Environment and Planning	3060	1100 (36%)	792 (72%)	397 (36%)	511 (46%)	139 (13%)
Area Studies	818	231 (28%)	112 (48%)	74 (32%)	162 (70%)	17 (7%)
Art and Design: History, Practice and Theory	1764	165 (9%)	115 (70%)	51 (31%)	41 (25%)	17 (10%)
Biological Sciences	7097	1096 (15%)	808 (74%)	376 (34%)	390 (36%)	162 (15%)
*Business and Management Studies	15,488	5708 (37%)	3200 (56%)	1866 (33%)	3735 (65%)	385 (7%)
Chemistry	3688	155 (4%)	114 (74%)	64 (41%)	36 (23%)	4 (3%)
Classics	244	7 (3%)	4 (57%)	2 (29%)	1 (14%)	1 (14%)
Clinical Medicine	11,971	3823 (32%)	3031 (79%)	913 (24%)	664 (17%)	1676 (44%)
Communication, Cultural and Media Studies, Library and Information Management	1542	369 (24%)	190 (51%)	112 (30%)	190 (51%)	69 (19%)
Computer Science and Informatics	5510	391 (7%)	294 (75%)	73 (19%)	116 (30%)	45 (12%)
*Earth Systems and Environmental Sciences	4365	1913 (44%)	1545 (81%)	1183 (62%)	901 (47%)	244 (13%)
Economics and Econometrics	2121	1473 (69%)	913 (62%)	737 (50%)	1339 (91%)	190 (13%)
Education	4133	1475 (36%)	934 (63%)	519 (35%)	751 (51%)	199 (13%)
*Engineering	17,963	1422 (8%)	1144 (80%)	350 (25%)	361 (25%)	100 (7%)
English Language and Literature	1962	31 (2%)	20 (65%)	2 (6%)	4 (13%)	7 (23%)
Geography and Environmental Studies	4162	1951 (47%)	1367 (70%)	1071 (55%)	1055 (54%)	275 (14%)
History	2633	210 (8%)	93 (44%)	41 (20%)	135 (64%)	10 (5%)
Law	2817	904 (32%)	620 (69%)	247 (27%)	338 (37%)	123 (14%)
Mathematical Sciences	5783	253 (4%)	197 (78%)	65 (26%)	88 (35%)	17 (7%)
Modern Languages and Linguistics	1821	83 (5%)	57 (69%)	13 (16%)	30 (36%)	6 (7%)

	Policy Citations	Government	IGO	Think tank	Other
Music, Drama, Dance, Performing Arts, Film and Screen Studies	1071	40 (4%)	26 (65%)	6 (15%)	19 (48%)	4 (10%)
Philosophy	1126	69 (6%)	36 (52%)	13 (19%)	48 (70%)	11 (16%)
Physics	5480	280 (5%)	248 (89%)	39 (14%)	38 (14%)	10 (4%)
Politics and International Studies	3509	1668 (48%)	719 (43%)	445 (27%)	1331 (80%)	122 (7%)
Psychology, Psychiatry and Neuroscience	9718	2425 (25%)	1925 (79%)	476 (20%)	800 (33%)	679 (28%)
*Public Health, Health Services and Primary Care	4898	3553 (73%)	2765 (78%)	1591 (45%)	1444 (41%)	1472 (41%)
Social Work and Social Policy	4102	1843 (45%)	1286 (70%)	476 (26%)	930 (50%)	333 (18%)
Sociology	1975	783 (40%)	472 (60%)	218 (28%)	489 (62%)	126 (16%)
Sport and Exercise Sciences, Leisure and Tourism	3447	630 (18%)	467 (74%)	116 (18%)	158 (25%)	174 (28%)
Theology and Religious Studies	416	30 (7%)	13 (43%)	5 (17%)	21 (70%)	(0%)
Grand Total	151,712	39,226 (26%)	27,210 (69%)	13134 (33%)	17,851 (46%)	7934 (20%)

Appendix Table S2. Frequency and percentage of Overton.io-indexed policy documents citing REF2021 journal articles across policy source types.

REF2021 Subjects	Policy Citations	Government	IGO	Think tank	Other
Agriculture, Food and Veterinary Sciences	5351	2372 (44%)	1806 (34%)	1038 (19%)	148 (3%)
Allied Health Professions, Dentistry, Nursing and Pharmacy	16,791	9343 (56%)	3303 (20%)	1987 (12%)	2186 (13%)
Anthropology and Development Studies	5942	669 (11%)	2627 (44%)	2562 (43%)	84 (1%)
Archaeology	412	206 (50%)	144 (35%)	56 (14%)	6 (1%)
Architecture, Built Environment and Planning	6664	2537 (38%)	2000 (30%)	1925 (29%)	251 (4%)
Area Studies	1051	291 (28%)	254 (24%)	483 (46%)	23 (2%)
Art and Design: History, Practice and Theory	538	286 (53%)	128 (24%)	101 (19%)	23 (4%)
Biological Sciences	8253	3686 (45%)	2726 (33%)	1609 (19%)	263 (3%)
*Business and Management Studies	34,000	13,054 (38%)	7547 (22%)	13,061 (38%)	510 (2%)
Chemistry	725	366 (50%)	252 (35%)	102 (14%)	4 (1%)
Classics	10	4 (40%)	4 (40%)	1 (10%)	1 (10%)
Clinical Medicine	24,380	14,560 (60%)	5039 (21%)	1907 (8%)	3827 (16%)
Communication, Cultural and Media Studies, Library and Information Management	1279	462 (36%)	351 (27%)	376 (29%)	92 (7%)

949

Computer Science and Informatics	1417	741 (52%)	251 (18%)	348 (25%)	77 (5%)
*Earth Systems and Environmental Sciences	21,311	7507 (35%)	9484 (45%)	4223 (20%)	489 (2%)
Economics and Econometrics	32,567	7700 (24%)	7516 (23%)	17,494 (54%)	333 (1%)
Education	7877	2662 (34%)	2690 (34%)	2237 (28%)	336 (4%)
*Engineering	7046	3620 (51%)	2731 (39%)	1532 (22%)	243 (3%)
English Language and Literature	43	26 (60%)	4 (9%)	4 (9%)	9 (21%)
Geography and Environmental Studies	19,674	6195 (31%)	8578 (44%)	4703 (24%)	463 (2%)
History	477	147 (31%)	80 (17%)	239 (50%)	11 (2%)
Law	3395	1808 (53%)	623 (18%)	759 (22%)	240 (7%)
Mathematical Sciences	1574	865 (55%)	422 (27%)	360 (23%)	53 (3%)
Modern Languages and Linguistics	158	94 (59%)	19 (12%)	40 (25%)	6 (4%)
Music, Drama, Dance, Performing Arts, Film and Screen Studies	96	47 (49%)	13 (14%)	29 (30%)	7 (7%)
Philosophy	308	100 (32%)	52 (17%)	129 (42%)	27 (9%)
Physics	579	378 (65%)	115 (20%)	75 (13%)	11 (2%)
Politics and International Studies	7348	1798 (24%)	1366 (19%)	4057 (55%)	147 (2%)
Psychology, Psychiatry and Neuroscience	12,860	7412 (58%)	2134 (17%)	2407 (19%)	1327 (10%)
*Public Health, Health Services and Primary Care	37,375	17,689 (47%)	11,215 (30%)	6018 (16%)	4165 (11%)
Social Work and Social Policy	8843	3976 (45%)	2014 (23%)	2796 (32%)	547 (6%)
Sociology	4174	1446 (35%)	1175 (28%)	1343 (32%)	210 (5%)
Sport and Exercise Sciences, Leisure and Tourism	2428	1266 (52%)	561 (23%)	312 (13%)	289 (12%)
Theology and Religious Studies	82	26 (32%)	6 (7%)	50 (61%)	(0%)
Grand Total	275,028	113,339 (41%)	77,230 (28%)	74,363 (27%)	16,408 (6%)