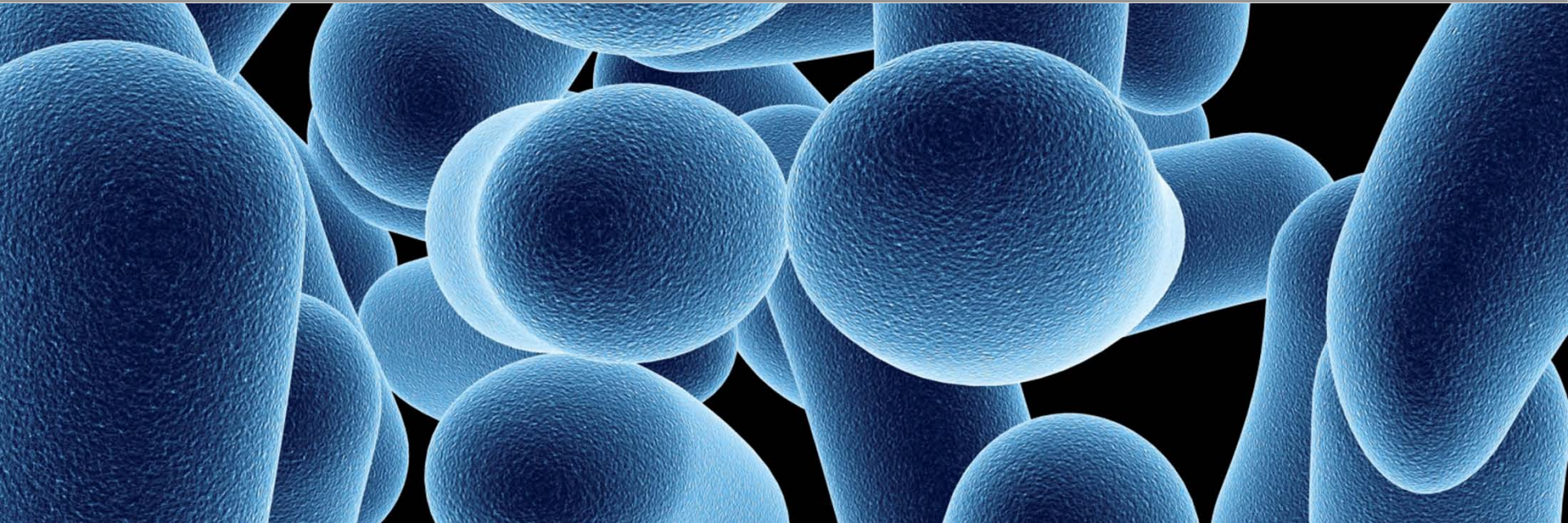




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Bibliometric Analysis of Leading Countries in Energy Research

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Energy – a central issue in human affairs

- Energy one of the greatest enabler of human development, yet may become the most important roadblock
- Roadblock is due to the finite nature of the resource but also to the environmental problem energy use creates (pollution, climate change)
- Wars are waged over access to energy
- Smarter way is to conduct research and to innovate
- In this context, it is extremely relevant to examine how to define, measure, and assess energy research and development



Contemporary definition of energy R&D

- The linked process by which an energy supply, energy end use, or carbon management technology moves from its conception in theory to its feasibility testing and small scale deployment. [...] ‘Energy R&D’ encompasses activities such as basic and applied research as well as technology development and demonstration in all aspects of production (e.g., mining, drilling, refining, exploration), power generation (i.e., nuclear fission and fusion, fossil, and renewable energy), transmission, distribution and energy storage and energy efficiency technologies.
- Dooley, J. J. (2000). A short primer on collecting and analyzing energy R&D statistics. Washington, DC: U.S. Department of Energy.



Dominant measures of energy R&D

- The most commonly used proxy measure for energy R&D are data on expenditures and investments (inputs) in R&D.
- Despite their widespread usage, researchers have questioned the utility of expenditure data, primarily because they can be difficult to interpret, but also because they are misrepresented as an indicator of output rather than of input (Dooley, 2000).
- Furthermore, there are significant gaps in existing data.
- Overall, there is currently little in the way of meaningful output measures for R&D in the field



Methods (1)

- We used the Scopus database because it contains titles, keywords and abstracts as well as full author addresses together with references
- Could have equally used the Web of Science
- Initial keywords for query were extracted from papers published by Natural Resources Canada' CANMET Energy Technology Centre
- This facilitated the identification of four comparable energy research laboratory – keywords were then extracted from their papers
 - Forschungszentrum Jülich, Institute of Energy Research (Germany); National Energy Technology Laboratory, Morgantown facility (United States); *Institut français du pétrole*, Lyon facility (France); Chinese Academy of Science, Guangzhou Institute of Energy Conversion (China); Central Research Institute of Electric Power Industry, Energy Engineering Research Laboratory, Yokosuka area facility (Japan)



Methods (2)

- Query was “de-optimized” to remove expression which were too specific to the research of any one of these research centres (and more specifically the primary seeder).
- Keywords were then tested for their precision and we examined the occurrence of the terms in the 100 or so fields used by the National Science Foundation for the Science & Engineering Indicators
- Fields where keywords seemingly produced spurious results were examined carefully
- It was determined that in health research, energy related terms could often be used in context that are not linked with energy research (e.g. ethanol used to disinfect equipment) – use of keywords tightened for these fields



Methods (3)

- Using this basic query, we produced a list of all journals in Scopus in which the papers were produced
- The list of Journals was carefully scan by hand and all the energy related journals were identified
- The combination of the keyword search and the inclusion of papers from energy-specific journals produced a basic dataset which is called Dataset 1
- Papers containing one keyword and at least two references made to dataset 1 or one keyword and at least two citations from Dataset 1 were added to the initial dataset which became Dataset 2

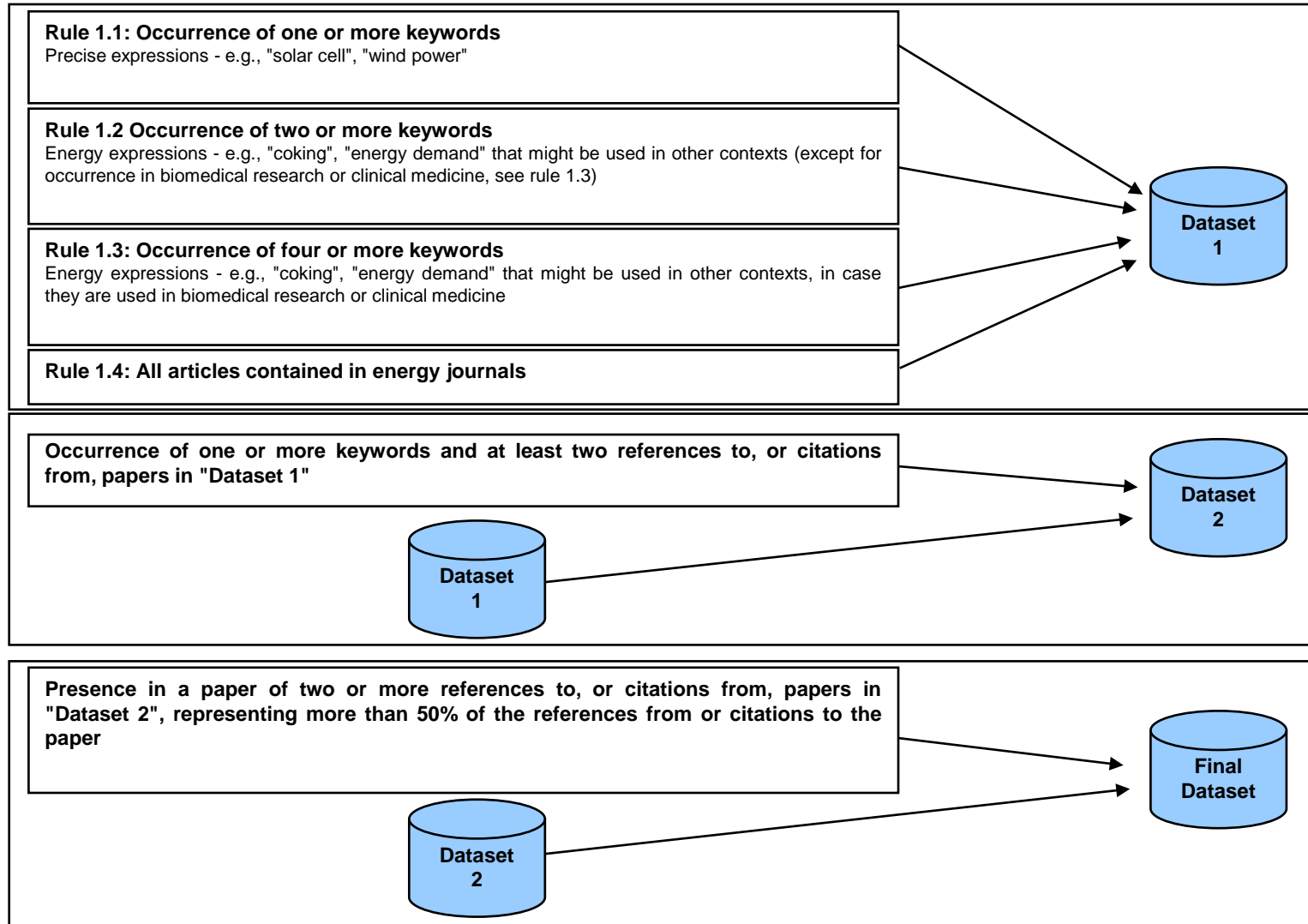


Methods (4)

- Finally, papers comprising at least two references to or at least two citations from Dataset 2 representing more than 50% of the references or citations were added to Dataset 2 – this gave us the final dataset
- Final recall for CETC was 74% of the papers (initially was 89% before de-optimization but using simple keyword search) – this is a measure of recall for a laboratory which had a substantial part of its research output in energy – not a recall rate for energy research per se
- Conversely, precision was not calculated as boundaries of a field such as energy-research is far from being consensual



Methods (5)

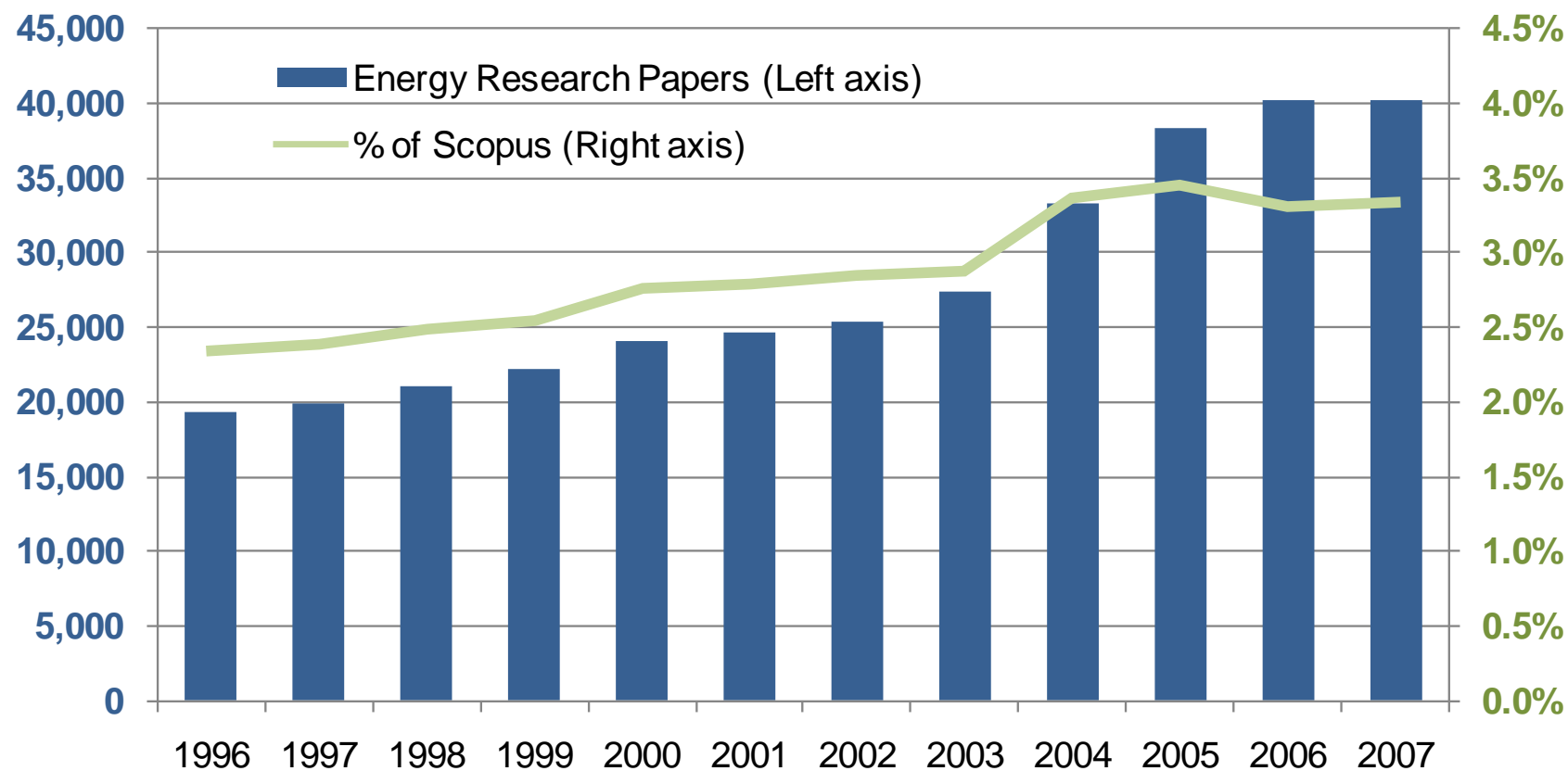




- **Number of papers**
- **Papers per capita**
- **Growth:** papers published between 2002 and 2007 divided by those published between 1996 and 2001
- **Specialization index (SI)**
- **Average of relative citations (ARC)**
- **Average relative impact factor (ARIF)**
- **Positional analysis:** number of papers, SI, and ARC



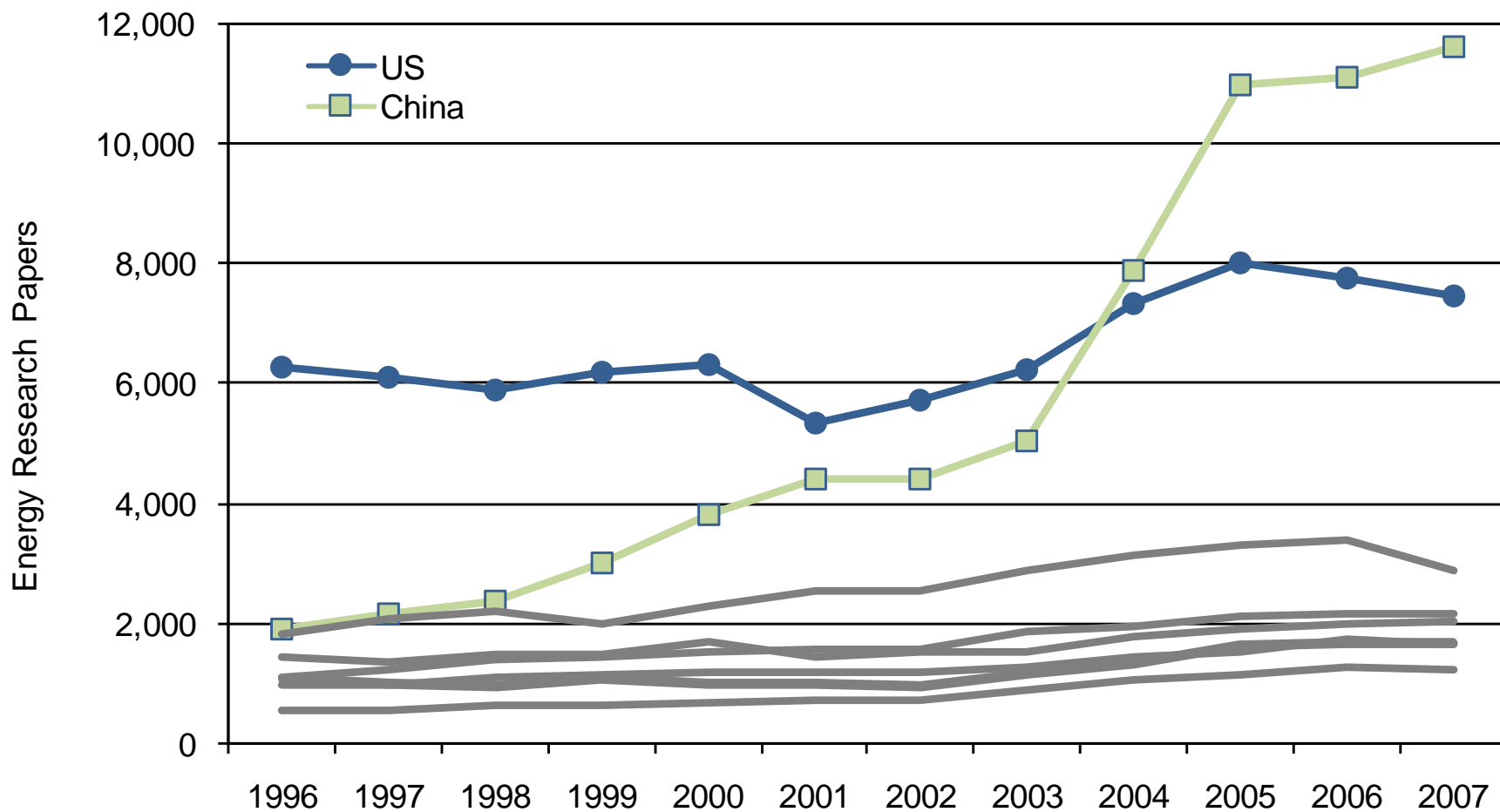
Results (1)



Number of papers in energy research in Scopus, 1996-2007



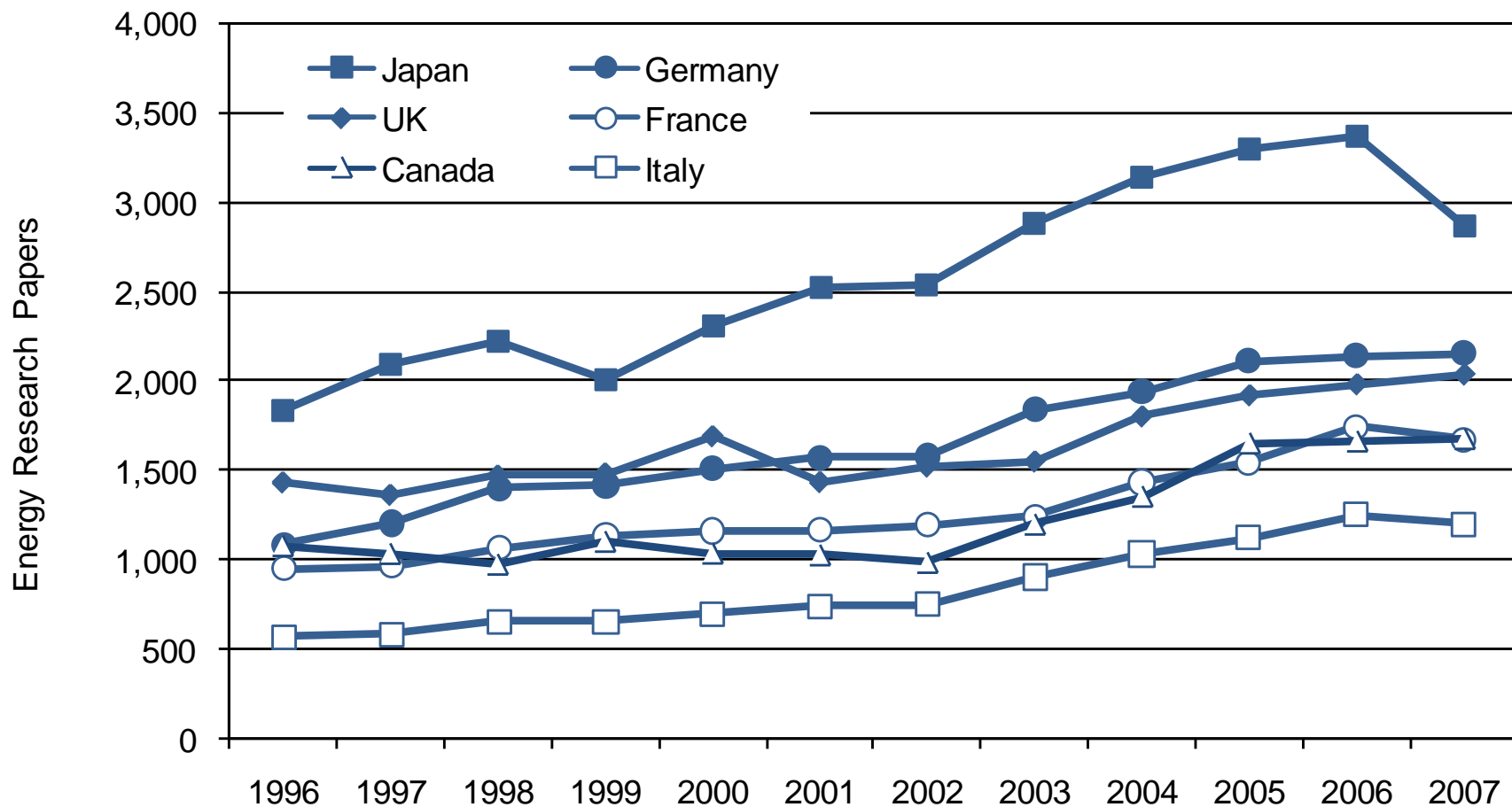
Results (2)



Papers in energy research produced by the US and China, 1996-2007



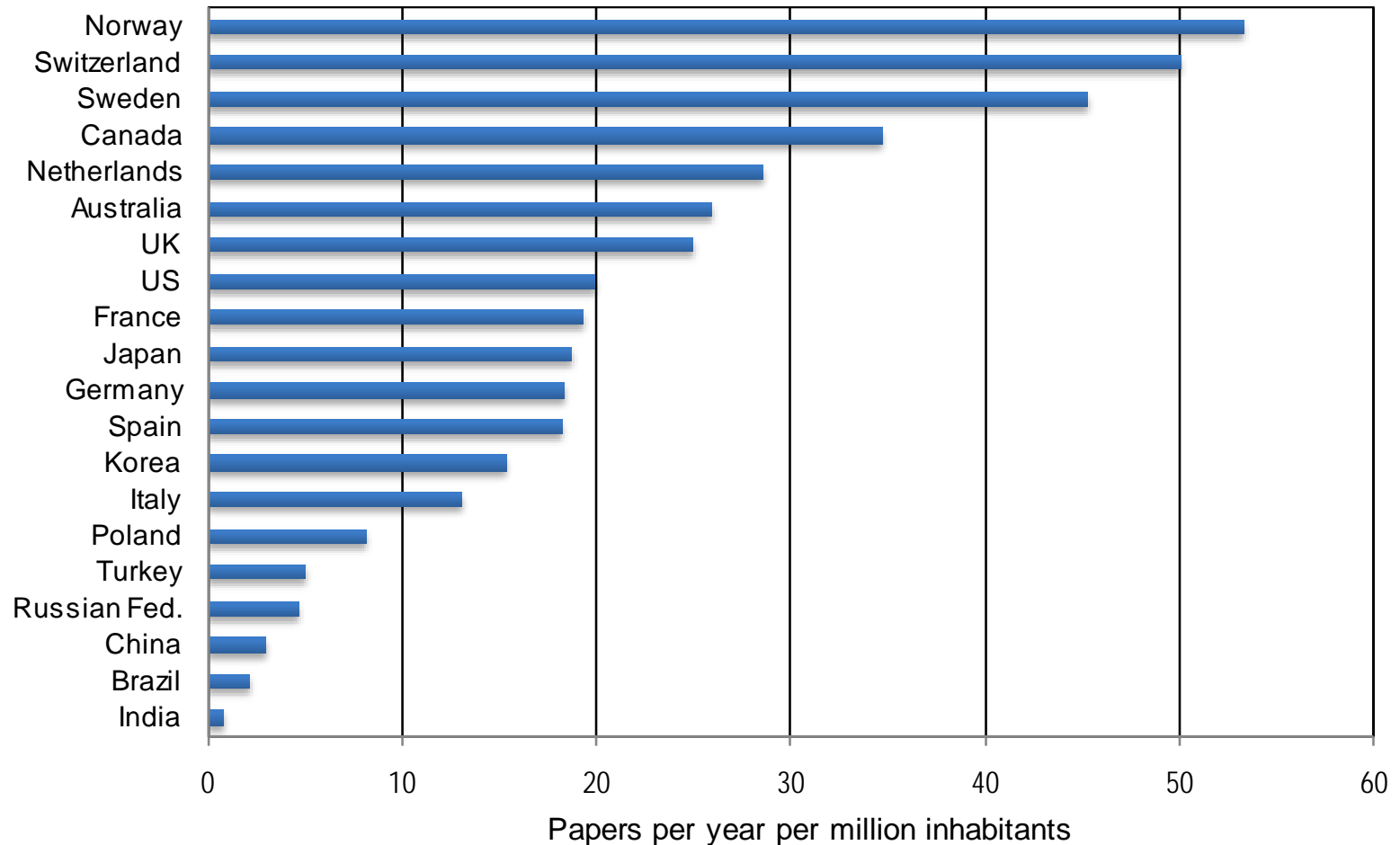
Results (3)



Papers in energy research produced by G7 countries (excluding the US), 1996-2007



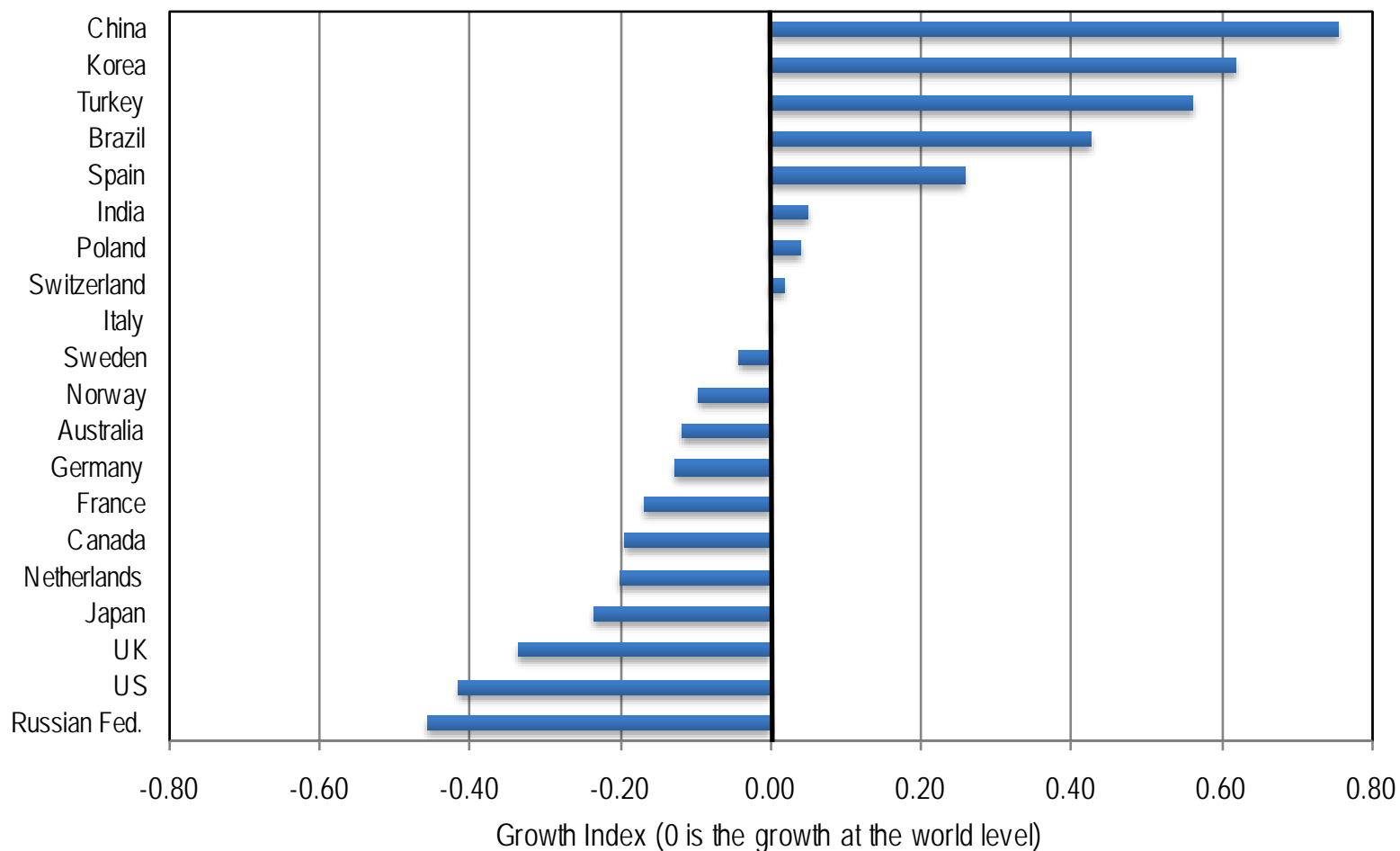
Results (4)



Papers in energy research per capita (20 most active countries), 1996-2007



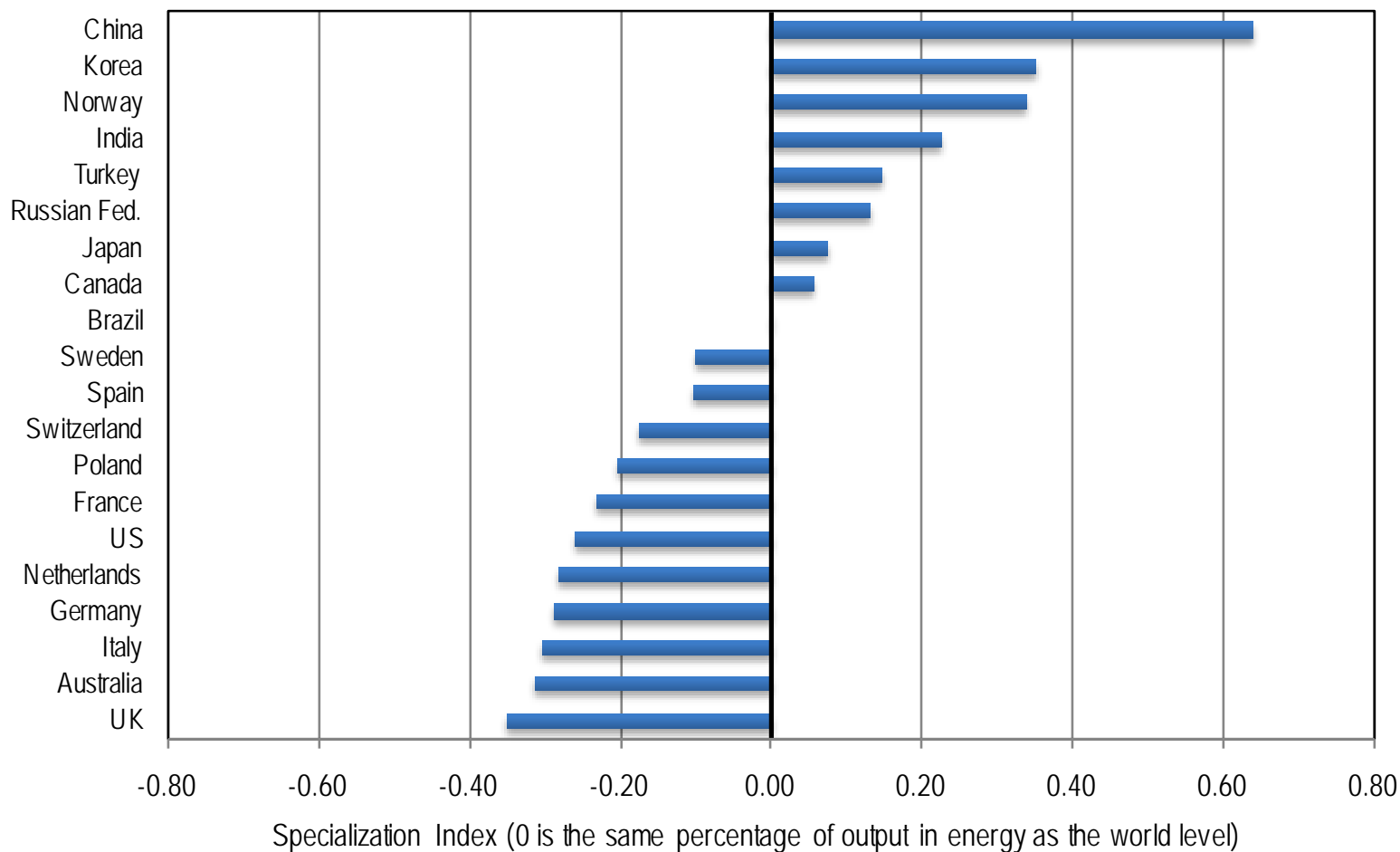
Results (5)



Growth Index in energy research (20 most active countries), 1996-2007



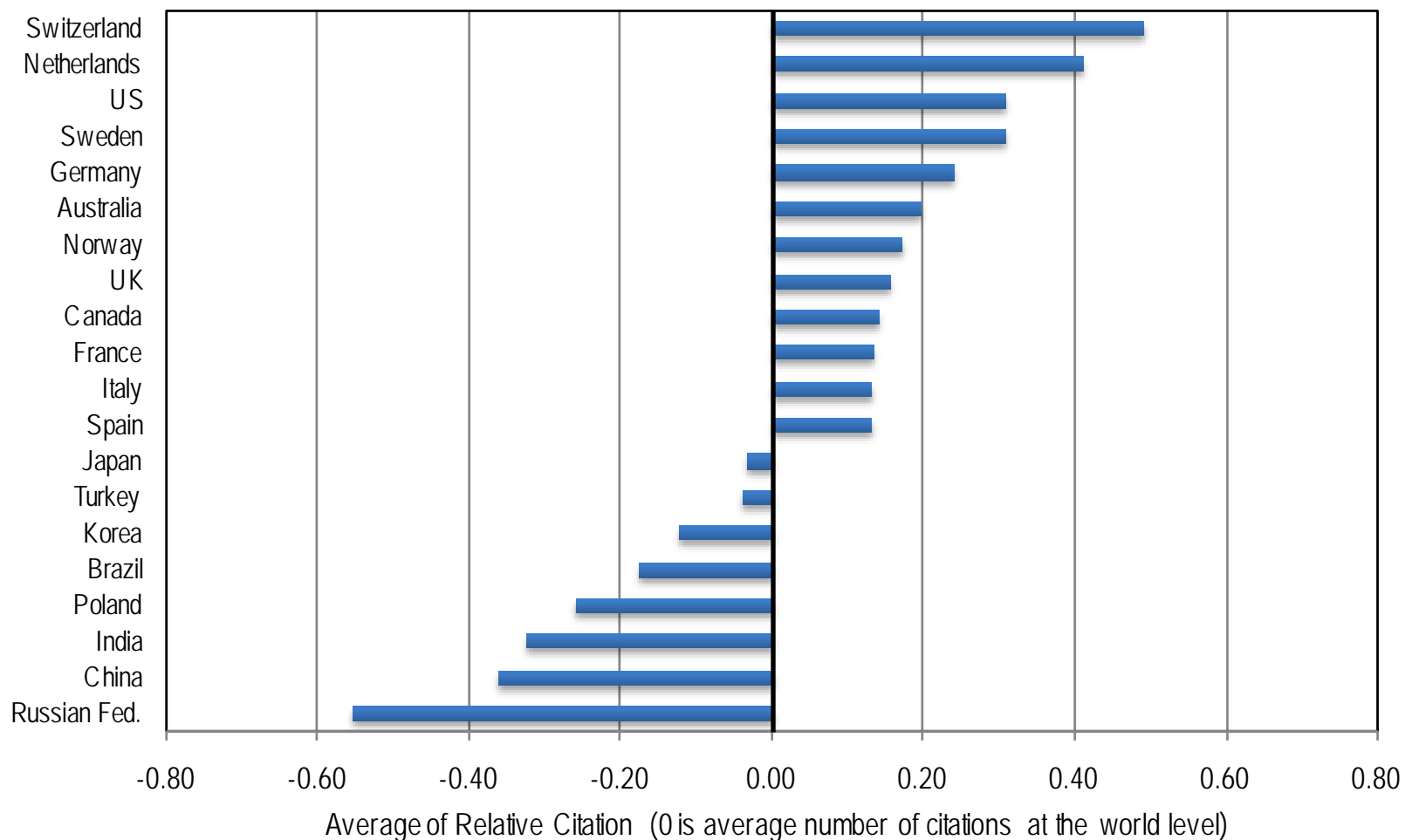
Results (6)



SI of energy research (20 most active countries), 1996-2007



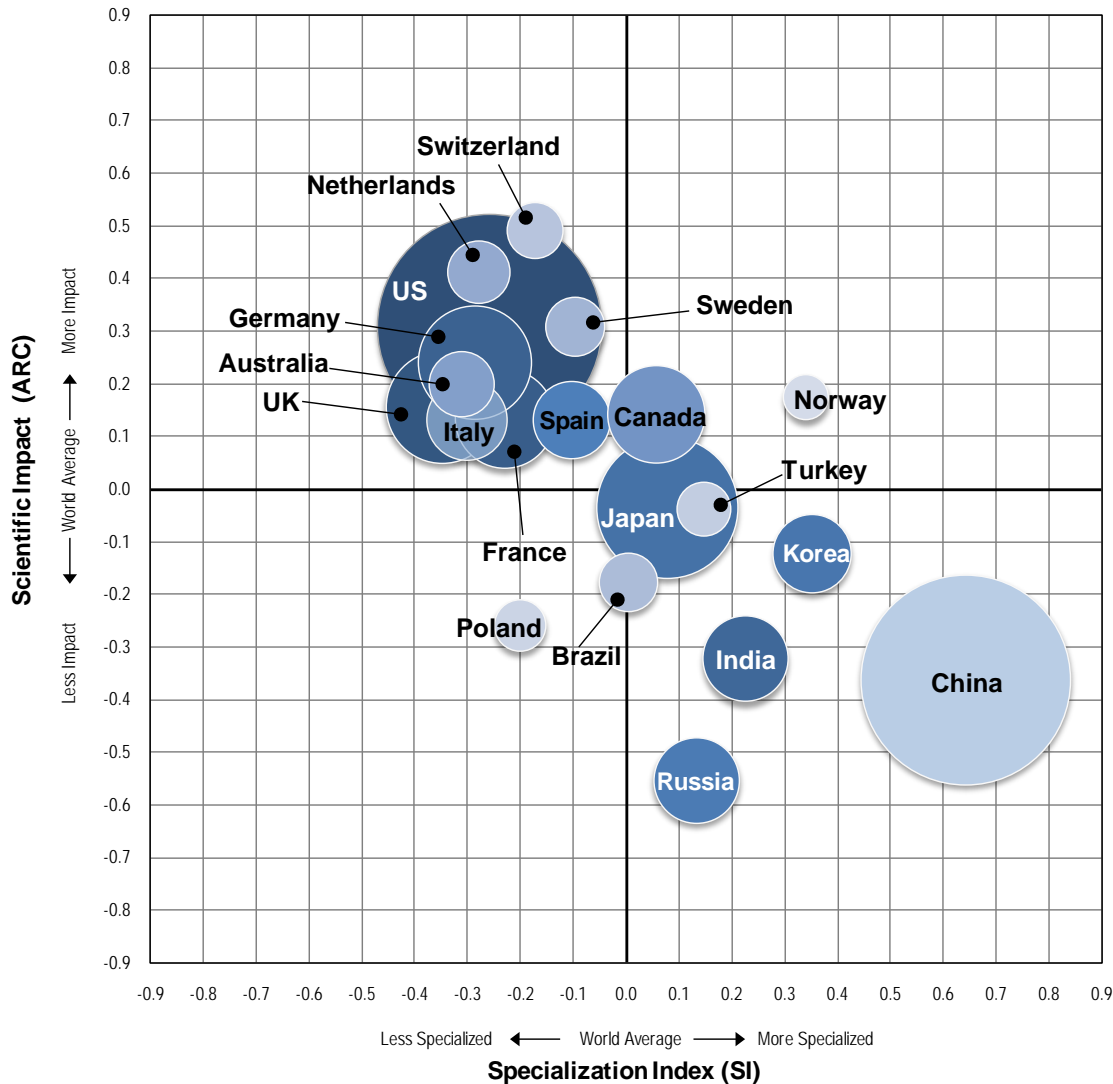
Results (7)



ARC of energy research (20 most active countries), 1996-2007



Results (8)



Positional analysis of energy research using number of papers, SI and ARC (20 most active countries), 1996-2007



Discussion & ...

- Method presented here presents incremental innovations over existing methods: keywords, journal set, citations, and references
- Needs fine-tuning for each parameter and for each project
- Somewhat labour and computational intensive
- Provides a relatively robust method for fields with semi-open boundaries where keywords used are not necessarily specific, where there is not necessarily a large body of specialized journals



... Conclusion

- There is one country to watch in energy research: China
- China has a stupendous growth rate, specialization in the field, and immense scientific output. It falls behind only in measures of citedness.
- Norway, Sweden, the Netherlands and Switzerland also demonstrate a good level of performance including a high quality output.
- In contrast, English-speaking and G7 countries, perhaps with the exception of Canada, are not performing very well, especially when one considers relative measures such as the specialization index and the number of papers per capita.



Thank you for your time!



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