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U.S.-China Technology Decoupling and its Influence on International Academic Collaboration

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With the growing U.S.-China economic rivalry, concerns are heightening over Chinese military influence on international collaborative research, especially those research projects conducted by researchers of U.S. and Australian universities. In response, concerns are also being raised about international research collaboration itself. How are the governments of the relevant countries responding to this situation? If international collaboration in research were to be reduced in the fields of advanced science and technology, how much impact would that have? This essay summarizes the answers to these questions.

1. International research collaboration by universities, security trade control, and U.S.-China economic rivalry

China's science and technology capabilities have grown significantly over the past decade. In 2014, China's research and development spending surpassed that of EU, making it the world's second largest spender; in 2018, it became the world's largest producer of scientific articles written in English (NSF, 2020); and in 2019, it filed the largest number of international patents (international applications filed under the Patent Cooperation Treaty) in the world (WIPO, 2020). Amid this trend and in parallel with the growing U.S.-China economic rivalry, a sense of crisis concerning China's science and technology capabilities has been shared among U.S. and other developed countries. Particularly, concerns have been raised that intelligence and military agents from various countries are exploiting the open research environment of universities (refer to a nonfiction book by Golden (2017) for intelligence agencies and an article by Silver (2019) for military influence and exploitation).

2. Security trade control measures and other responses taken by respective governments to address concerns

・U.S.

In the U.S., this issue has been repeatedly raised in the Congress and countermeasures have been devised through bipartisan discussions. The National Defense Authorization Act enacted in 2018 has made it virtually impossible for universities to enter into a joint research or other agreements with companies subject to sanction. The Export Control Reform Act enacted the same year has imposed export control on emerging and foundational technologies essential to U.S. national security. Subject to this control are technologies including quantum computing and artificial intelligence pursued mainly by universities and other research institutions, leading to concerns over potential impact on university research. Although it was later explained that the control was not meant to cover academic activities intended for publication of findings, there is a growing call for tightening security trade control on universities.

For example, in May 2020, visa restrictions were introduced on Chinese graduate and post-doctoral students with ties to the People's Liberation Army. The same year, a university faculty member who did not disclose his connection with China was arrested.

However, there are arguments within the U.S. government urging respect to be given to the special characteristics of universities. One good example is the report issued by the U.S. Government Accountability Office (GAO) in May 2020. The report can be interpreted as calling on universities to prioritize appropriate management within the framework of conflict of interest, while recognizing the value of academic freedom.

In response to these moves, U.S. universities are developing appropriate frameworks for risk assessment of their export compliance as part of their conflict of interest management framework mainly in line with the suggestions of the GAO Report (Policy Alternatives Research Institute, 2019). Under this framework, universities require researchers to disclose their relationship with foreign governments, and in turn, the administrative department of the university reviews any security trade control issues that relationship may have and imposes restriction as necessary on activities that could be affected by the foreign government(s) in question.

・Australia

In Australia, Guidelines to Counter Foreign Interference in the Australian University Sector was established by the Department of Education, Skills and Employment in 2019 to address concerns over foreign military influence on the country's scientific research, particularly

the risk of joint research with Chinese research institutions being influenced by the People's Liberation Army. These guidelines call on universities to perform appropriate risk assessment on the possibility of foreign interference when engaging in international collaboration, to ensure the integrity of academic research. According to a Nature report, this is a pioneering example of guidelines of this sort (Lewis, 2020).

- **Japan**

In Japan, there are no specific systems to regulate the influences of foreign governments other than the security trade control framework. In light of the policies upheld by the academic community, however, it seems necessary for universities and other institutions to take measures such as risk assessments to address concerns over foreign military influence on international collaborative research.

Specifically, Report on Research for Military Security, a 2017 report by the Science Council of Japan's (hereafter "the Report") sets forth "Universities and research institutions are responsible for the management of their facilities, information, intellectual properties, and other resources, and for the preservation of unrestricted research and educational environments. Accordingly, it is desirable for each university or research institution to create a system to review research proposals that might be used for military security research for their appropriateness, both technologically and ethically, based on the validity of their research objectives, methods, and potential applications." Needless to say, it is not the Statement's intention to discourage international collaboration in research, as evidenced by 4 (4) of the Report which clearly points to the need for considering the following concerns: "concerns about hindering international collaboration with foreign researchers and students in universities and other institutions, maintaining open and unrestricted research and educational environments, and limiting the career paths of students and young researchers." The starting point of this discussion was concerns about ensuring academic integrity, that is about government interference on science through research associated with military purposes. In this context, risks of foreign military interference as assumed in Australia's guidelines cannot be ignored.

In the case of Japan, risk assessment on potential foreign military influence on international collaborative research is required as part of the academic community's policies rather than as a request from the Japanese government.

- **China**

In China, Export Control Law (ECL) was enacted in October 2020 to tighten its security

trade control system. ECL stipulates “national interests” as the interest to be protected by the law. Industrial policy intentions are also reflected in ECL as evidenced by its restrictions on overseas transfer of data, for example. Related systems are currently in development. While there are many aspects to be clarified, ECL may have an impact on international collaboration in science and technology research by Chinese universities.

・Section summary

As seen above, some major countries, being aware of the context of U.S.-China economic rivalry, are starting to impose restrictions on international research collaboration in a way that could affect science and technology research pursued by universities. However, at least the U.S. and Australia are both calling for appropriate risk assessments to be undertaken within the conflict of interest management framework, with an aim to prevent interference by foreign military and governments detrimental to the integrity of academic research, rather than imposing restrictions on joint research with certain countries by highlighting national security issues. Therefore, while it is unlikely that research collaboration between U.S. and China, for example, will be immediately restricted, it can be inferred that restraints on international research collaboration in dual-use domains of advanced science and technology fields will be demanded or voluntarily imposed.

3. Potential impact of decoupling: case study

・Study method

If such restraints are to affect international research collaborations conducted by universities in the fields of advanced science and technology, to what extent will the impact be? This essay will provide a descriptive analysis, taking deep learning in the artificial intelligence domain and quantum computing among quantum information science as case examples. The two examples are positioned as critical and emerging technologies in the U.S. security trade control framework.

Here, I will use co-authorship of research papers as a proxy indicator for research collaboration by universities. Although analysis of bibliographic information of research papers is a widely used method for social science studies on scientific research, bibliographic information has limitations as an indicator of scientific capabilities, as suggested by Hicks et al. (2015). For example, the positioning of a paper differs by the science field. The unit of a paper

and positioning of the author vary as well. Bibliographic information, however, provides an effective indicator when handling papers of a somewhat common field and if research papers are the primary means of publishing research findings in the field.

In this regard, deep learning and quantum computing respectively belong to a certain limited field in which research papers are deemed as the primary output, and therefore analysis of bibliographic information can appropriately be used as a study method. It needs to be noted, however, that deep learning is a versatile technology applied to a wide range of fields, which implies a certain level of inappropriateness.

Analysis was conducted using bibliographic information of research papers[1] published during 2015 to 2019 in academic journals (mostly English journals) listed in the Web of Science and included the term "deep learning", "quantum computing" or "quantum computer" in the title, abstract, or author keywords. Data processing was performed using the R bibliometrix package (version 3.03).[2] Research papers were linked to the country/region where the corresponding author is based.

The following two points need to be noted in defining co-authorship.

First, when a temporary or honorary position (such as a guest professor or visiting professor from a country different from the country of a corresponding author) is indicated as an author's affiliation, the authorship will be automatically categorized as international co-authorship. Exclusion of such cases requires complete name identification of all authors, but I haven't been able to do that as it was too much work.

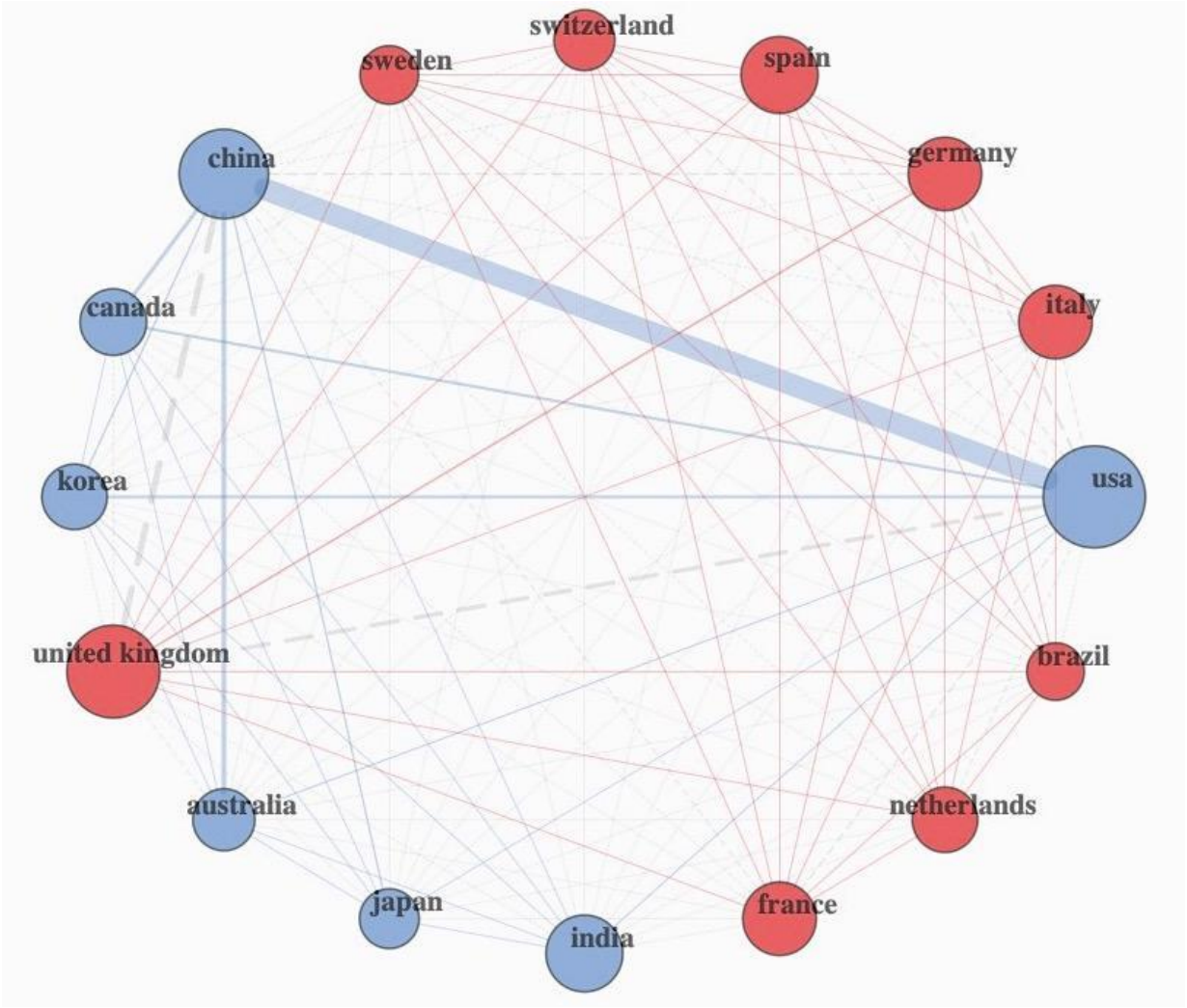
Second, there are cases that have been identified as international co-authorship based on the affiliation of the authors, because participating graduate students returned to their home country or found a job overseas after completing their graduate program. Graduate students make significant contributions in the production of research papers (Larivière, 2012). Although this is not much of a problem since such cases can also be deemed as a channel of knowledge transfer, it may be questionable to call them international collaborative research.

- **Deep learning**

Figure 1 shows international co-authorship relations of recent research papers in the field of deep learning. It indicates that China occupies a central position in the international co-

[1] I excluded Proceedings and some other forms of research outputs. This may not have been appropriate in consideration of the nature of the field.
[2] The said package automatically categorizes Taiwan as part of China. I must say this is crude since Hong Kong and Taiwan seem to have different conditions for international co-authorship relations from those of mainland China. However, the analysis was carried out while recognizing its limitations.

authorship relations among leading countries. In addition to producing a large number of co-authored papers with the U.S., China is also the largest co-authorship partner for U.K. and Australia. Likewise, the U.S. is also producing numerous internationally co-authored papers. On the other hand, Japan has little connection with other countries in general, except for some co-authorship relation with the U.S. and China. This tendency is common with Canada and Korea.



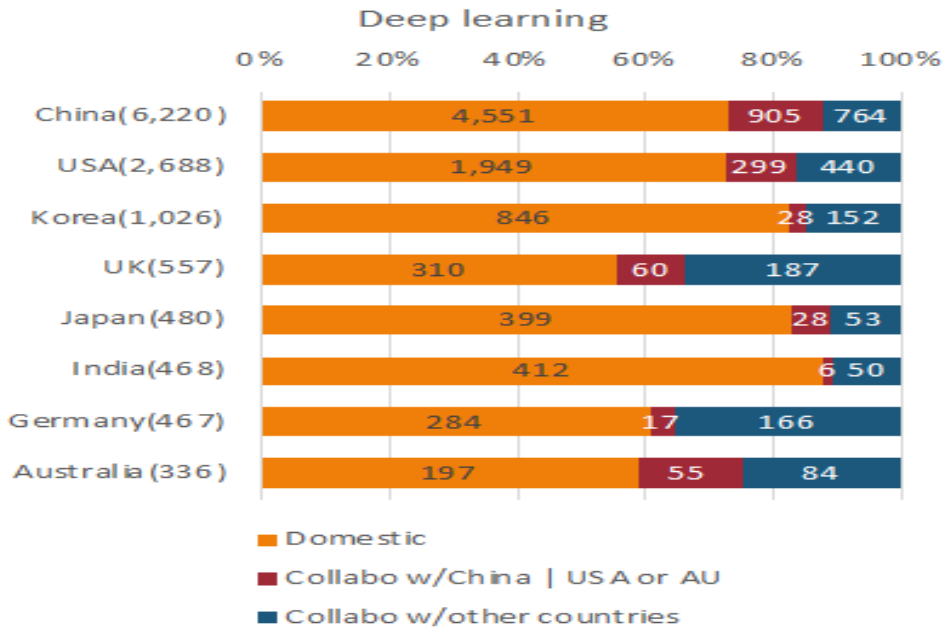
(Note) The colors, line thickness, dotted lines, and the size of the circles indicate loose groups based on co-authorship relations, the number of co-authored papers, co-authorship relations outside the groups, and the number of partner countries/regions, respectively. Co-authorship between authors other than the corresponding author is also included.

Figure 1 International co-authorship relations of research papers in the field of deep learning (2015-2019) (includes only leading countries)

Figure 2 shows the ratio of research papers attributable to international co-authorship against the total number of research papers produced by each country. During the period of 2015-2019, China produced not only the largest number of internationally co-authored papers, but also

4,551 research papers exclusively authored by researchers affiliated to its own institutions, which is more than twice as that of the U.S. Papers co-authored between China and the U.S. accounted for 14% and 11% of the total number of research papers produced by China and the U.S., respectively. Along with Korea and India, the percentage of international co-authorship is relatively low in Japan. In particular, co-authorship with China accounts for a mere 6% of the total output of Japan. Although Australia has a relatively high level of co-authorship with China, the ratio remains at 16%.

In light of this situation, if U.S.-China and Australia-China research collaboration is hindered in the field of deep learning, it is estimated that at least in China and Australia, up to nearly 15% of the total research activity will be impacted. On the other hand, it may not have a significant impact on Japan's international collaborative research activities.



(Note) The figure in parenthesis next to the country name indicates the number of research papers with a corresponding author based in that country. The region colored in dark red indicates co-authorship with the U.S. or Australia in the case of China and co-authorship with China in the case of other countries.

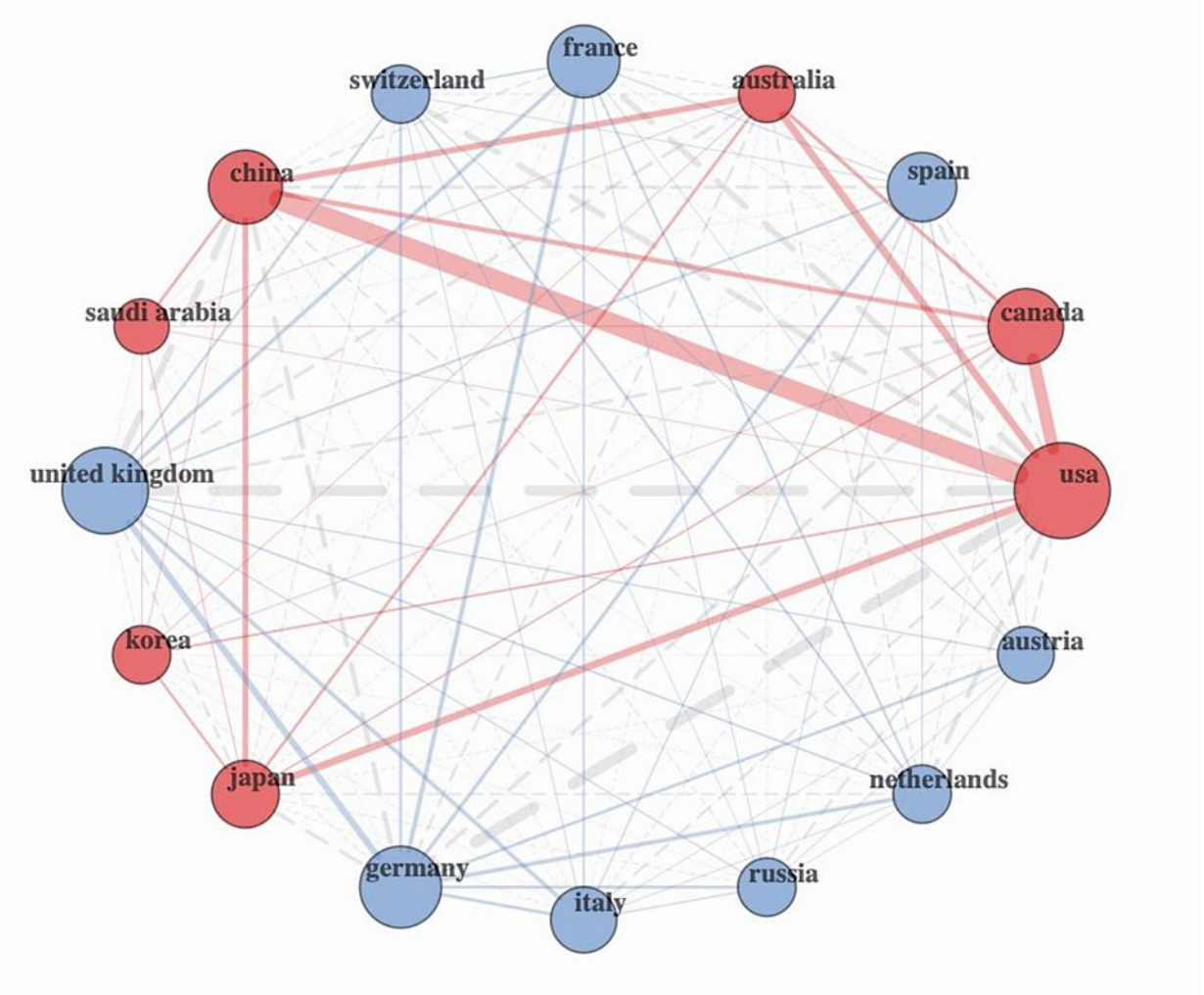
Figure 2 Ratio of international authorship among research papers published in the field of deep learning (2015-2019)

- **Quantum computing**[3]

Figure 3 shows international co-authorship relations of recent research papers in the field of quantum computing. The figure shows that the U.S. occupies a central position in the

[3] Refer to Yoshioka-Kobayashi, T. (2020) for more detailed information related to this section, especially analysis of chronological change.

international co-authorship relations. The U.S. has produced many papers co-authored with Chinese researchers as well as with U.K., Germany, and Canada. China too has strong co-authorship relations with multiple countries. Japan has relatively strong co-authorship relations with the U.S., China and Germany, showing a similar pattern as Australia.

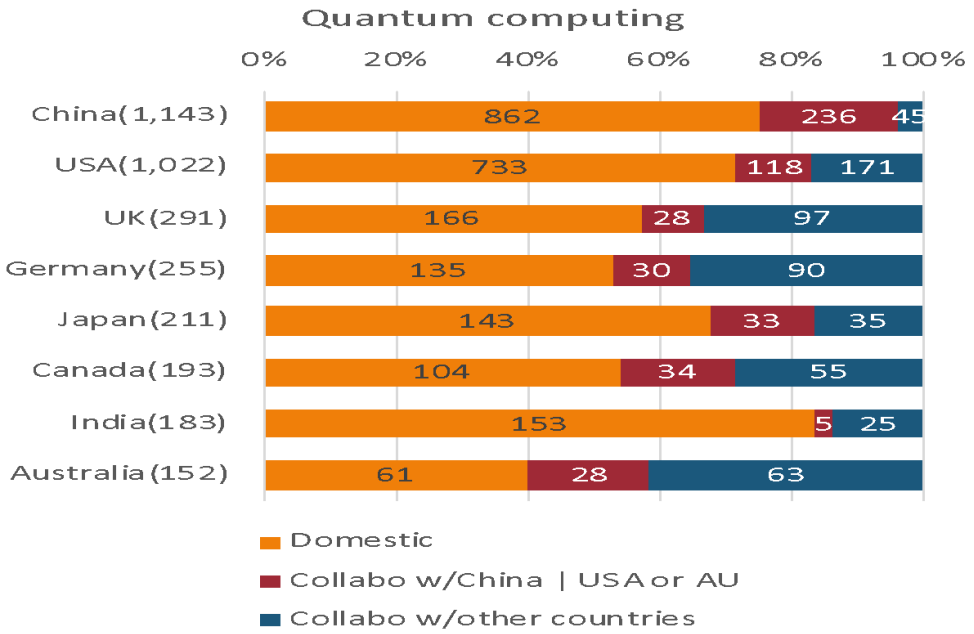


(Note) The colors, line thickness, dotted lines, and the size of the circles indicate loose groups based on co-authorship relations, the number of co-authored papers, co-authorship relations outside the groups, and the number of partner countries/regions, respectively. Co-authorship between authors other than the corresponding author is also included.

Figure 3 International co-authorship relations of research papers in the field of quantum computing (2015-2019) (includes only leading countries)

Figure 4 shows the ratio of research papers attributable to international co-authorship against the total number of research papers produced by each country. During the period of 2015-2019, both China and U.S. produced not only a large number of internationally co-authored papers, but also numerous research papers exclusively authored by researchers affiliated to their own institutions. The difference between the two lies in the distribution of partner countries of

international authorship. 84% of China's internationally co-authored papers were co-authored with U.S. researchers, showing an extreme concentration on the U.S. The ratio of papers co-authored with U.S. researchers to the total number of research papers was also quite high at 21%. On the other hand, U.S. researchers have been partnering with researchers of a variety of countries, and countries other than China account for the majority of internationally co-authored papers. The ratio of co-authorship with China was 12% for the U.S., 16% for Japan, and 18% for Australia, indicating that Japan and Australia have been producing a relatively large number of co-authored papers with Chinese researchers. Based on the above facts, it can be inferred that should there be any change in international collaborative research relations, it may have a particularly large impact on China and Australia.



(Note) The figure in parenthesis next to the country name indicates the number of research papers with a corresponding author based in that country. The region colored in dark red indicates co-authorship with the U.S. or Australia in the case of China and co-authorship with China in the case of other countries.

Figure 4 Ratio of international authorship among research papers published in the field of quantum computing (2015-2019)

- **Implications of the case study findings**

The analysis suggests the following findings. The U.S. and China both play a central role in academic research in the above two fields identified as emerging and foundational technologies in the U.S. export control framework. If there is a change in international collaborative research relations, the impact will vary by country, with China and Australia suffering a relatively large impact in the two fields. Meanwhile, impact on Japan will vary

depending on the research field. It is anticipated that impact on Japan will be large in the field of quantum computing. It also became evident that Japan showed a relatively low level of international co-authorship in the first place.

4. Conclusion

It has been econometrically verified that international co-authorship relations affect productivity of research papers (e.g., Guan, 2016). The attempt of this essay is to verify the influence of U.S.-China decoupling on international co-authorship. It seems that the decoupling will have an impact on the production of science and technology knowledge by countries around the world. At the same time, based on the current situation, it was also suggested that in the two fields studied in this essay, decoupling will not lead to a significant reduction of the production of science and technology knowledge in either one or both of China and the U.S. The results suggested that both countries already have the necessary base for creating advanced knowledge in the two fields within their own country.

Japan is placed in a difficult position amid this situation, but it seems that the best way for Japan is to promote international research collaboration while maintaining research integrity taking its historical background into consideration. Japan can be characterized as having relatively weak international relations, which may be hindering its opportunities for absorbing emerging knowledge. If the additional workload for conducting risk assessment of international research collaboration is imposed solely on the researchers, that may discourage researchers from engaging in international research collaboration. That, in turn, would narrow Japan's information channel for science and technology, which would be the last thing we want to do.

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