

# 1 U.S.-China Rivalry and Scientific Nationalism in Nanotechnology

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8 nationalism; China Initiative.

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## 11 Abstract

12 Intensifying competition between the U.S. and China is recalibrating the balance between  
13 collaboration and competition in academic science among the two largest economies and global  
14 science producers. We explore the trajectory of nanotechnology research collaboration between  
15 the U.S. and China, and probe the impacts of U.S.-China decoupling on research impact. We  
16 trace changes in the frequency of U.S.-China research collaboration between 2012-2024 and  
17 investigate whether the impact of research sponsored by American and Chinese funding agencies  
18 has changed in parallel with evolving patterns of research collaboration in this period. We find a  
19 decline in U.S.-China co-authorship, which accelerates in the late 2010s. Additionally, we  
20 observe a decrease in the impact of publications funded by U.S. funding agencies – a trend not  
21 mirrored in outputs supported by Chinese funding bodies. This study contributes to the growing  
22 body of literature exploring the influence of geopolitical dynamics on scientific activity.

23

## 1 **1. Introduction**

2 The wave of neo-nationalist politics unfolding over the past decade has been well documented by  
3 higher education scholars who have analyzed its variegated implications for academic freedom,  
4 institutional autonomy, government support, and international mobility (Douglas, 2021; Brøgger  
5 & Moscovitz, 2022; Moscovitz & Sabzalieva, 2023). Others argue that while these impacts are  
6 real for specific organizations, the university as a global institution is remarkably resilient, as it is  
7 anchored in widely shared cultural norms that remain unchallenged (Frank & Meyer, 2023). We  
8 focus on how this wave of neo-nationalism is affecting global science, using the case of  
9 nanotechnology research to examine its manifestation in the relationship between the United  
10 States and China.

11 Conceptually, we frame this investigation through the persisting tension in the science policy  
12 domain between two institutional logics: Scientific Nationalism and Scientific Globalism (Sá &  
13 Sabzalieva, 2018). On one hand, Scientific Globalism logic is anchored in the widespread belief  
14 in a global, open, and collaborative “scientific community”, which is motivated by the challenge  
15 to advance knowledge. The operation of this global community as a collective enterprise is  
16 taken-for-granted in disciplinary communities as essential for scientific progress, and coherent  
17 with Mertonian norms. On the other hand, policy makers and research funders seek social,  
18 economic, and technological returns that can be appropriated domestically from national  
19 investments in science. Universities and research institutions are part of national infrastructures  
20 supporting regional development, industrial competitiveness, and technological innovation. This  
21 perspective underpins Scientific Nationalism logic, in which sovereign state’s goals and interests  
22 take precedence over norms of openness and collaboration. This framework has proven useful in  
23 analyzing how geopolitical tensions affect cross-border scientific collaboration, academic

1 exchange, and the internationalization of higher education (Lee & Haupt, 2021a; Lee & Haupt,  
2 2021b; Shih, 2024).

3 As the two largest economies and global science producers, intensifying competition between the  
4 U.S. and China is recalibrating the balance between nationalism and globalism in science policy.  
5 The relationship between the two countries in this arena has become dominated by techno-  
6 nationalist rivalry (Evans, 2020; Luo, 2022). Across several disciplines, China and the United  
7 States are often each other's main research partners, with the U.S. being China's top collaborator  
8 overall (Zhu et al, 2021). By the late 2010s, the U.S. tied science and technology (S&T) to  
9 national security in response to China's ascendancy, leading to multiple policy initiatives that  
10 promoted a decoupling in science (Tang 2024). Intelligence agencies openly frame China as a  
11 threat actor pursuing economic espionage and the illicit appropriation of U.S.-generated  
12 intellectual property (U.S. Federal Bureau of Investigation, 2024). In response, the FBI engages  
13 regularly with universities through its College and University Security Effort (CAUSE)  
14 initiative, to monitor potential threats in academia including those related to intellectual property  
15 (IP) theft, cybersecurity, sensitive research, and commercialization of technologies (US Federal  
16 Bureau of Investigation, n.d.). More broadly, a series of initiatives targeting Chinese students,  
17 visitors, and funding sources (Lee & Haupt, 2021), including from the 2018-2022 China  
18 Initiative (Thorp, 2022), contributed towards a chilling climate for U.S.-China collaboration and  
19 for Chinese and Asian Americans in U.S. academia (Lee & Xi, 2023). China's collaborative  
20 research with the U.S. has started to decline in the late 2010s (Okamura, 2023), with a noticeable  
21 impact on high-technology fields and high-impact research (Zhu et al, 2021). Early in the 2020s,  
22 the US government took forceful steps towards aligning academic science to national security  
23 with the National Security Presidential Memorandum-33 (NSPM-33) (Shih, 2023). In its early

1 days in 2025, the second Trump administration has become more aggressive in its directives to  
2 federal research funding agencies, including with new reporting requirements of links to China  
3 (Mallapaty, 2025).  
4 Nanotechnology is one of the most strategic areas of S&T for the U.S. Recently, the U.S.  
5 government has taken bold steps towards asserting scientific leadership in the sector. The Chips  
6 and Science Act passed in 2022 has been regarded as “one of the most far-reaching pieces of  
7 legislation and forms of funding in US science and technology in the postwar period”, which  
8 committed US\$50.85 billions in investments over 5 years (Peters, 2023). Recent research  
9 suggests a relative decline of commitment to international collaboration has started (Shu et al.  
10 2022), and that shifting patterns of collaboration had a qualitative impact on the research  
11 produced by scientists in China who used to co-author with American peers (Aghion et al. 2023).  
12 In this paper, we examine how the remaking of the U.S.-China relationship has influenced  
13 research collaboration in nanotechnology, and the impact of research produced in the field with  
14 U.S. sponsorship. Drawing from a bibliometric analysis, we address four research questions:  
15 (RQ1) How has the frequency of U.S.-China research collaboration evolve between 2012-2024?  
16 (RQ2) How has the frequency of research collaboration involving ethnically Chinese scientists  
17 based in the U.S. evolve in this time period? (RQ3) Has the impact of research sponsored by  
18 American funding agencies changed in concert with the evolution of research collaboration in  
19 this period? (RQ4) Has the impact of research sponsored by Chinese funding agencies changed  
20 in line with the evolution of research collaboration in this period?

21

## 22 2. Methodology

1 Our bibliometric analysis draws nanotechnology publication data from the Web of Science  
2 (WoS) in the period 2012-2024. We systematically extract funding acknowledgement sources,  
3 location of authors, and types of institutions (academic or corporate) to account for the nature of  
4 scientific research in nanotechnology, in which also academic-industrial partnership is relevant  
5 (Roco, 2011; Chang, 2024). We delimit our analysis to the top 10% of publications in  
6 nanotechnology (“Percentile in Subject Area” – PSA – released by WoS, which is normalized by  
7 time of publication), seeking to investigate within the mostly impactful science. While any  
8 bibliometric indicator has its own merits and limitations (e.g. Leydesdorff, 1998), citations have  
9 been widely used as a proxy for impact in bibliometric studies for decades. We rely on PSA to  
10 select our sample of publications, seeking to capture the studies that have been most referenced  
11 by other scientists. We appreciate that delimiting our research to the most-cited publications does  
12 not mean we capture the “best” science - our purpose is to ascertain the impact of research  
13 policies in critical S&T domains like nanotechnology on the sub-set of publications that are the  
14 most noticed and referenced by other scientists. We elaborate on the procedures used to curate  
15 the dataset comprising almost 50000 articles in the Supplementary Material.  
16 We structured our analysis in four stages. First, we sought to ascertain from a time series analysis  
17 when the shifting U.S. S&T policy orientation towards a growing emphasis on national security  
18 has impacted publication patterns in nanotechnology. We trace co-authorship trends between the  
19 U.S. and China, accounting for research sponsors and for the location of scientists. We also  
20 identified ethnically Chinese scientists based in the U.S. and traced their collaboration patterns.  
21 This latter measure is relevant as the chilling climate in the U.S. towards China has particularly  
22 affected researchers of Chinese heritage and Asian Americans (Lee and Xi, 2023).

1 Second, while the literature documents an increasing share of China-based publications within  
2 top publications in terms of citations, less is known about the relationship between the source of  
3 funding and citations. Therefore, we investigated how the source of research funding affects  
4 research impact, as measured by citations. We first identified whether there have been changes  
5 between two time periods: 2012-2017 and 2018-2024, considering the source of sponsorship.  
6 These time periods were defined to capture the creeping of policy initiatives in the U.S.  
7 emphasizing national security and targeting China, which gradually affected patterns of  
8 international collaboration (Lee & Haupt, 2021; Lee & Li, 2023).

9 Third, we conducted a series of Difference-In-Difference (DiD) tests to estimate whether  
10 publications sponsored by U.S. funding agencies in the second period remain of similar impact,  
11 improved, or decreased, relative to rest of top 10% publications in the field. We also used Bell &  
12 McCaffrey bias-corrected standard errors degrees-of-freedom adjustment, and Donald & Lang  
13 aggregation method. For the latter estimate, we considered publication as grouped as “internal”  
14 (authors within the same institution), “domestic” (authors within same country, but from multiple  
15 institutions), and “international” (authors affiliated to institutions in multiple countries). In this  
16 stage we also computed parallel trend tests (pre-treatment time period), graphical diagnostic for  
17 parallel trends, and Granger causality test. We ran endogeneity tests to ascertain whether it was  
18 consistent to consider funding agencies’ acknowledgment as conducive of our dependent  
19 variable, which is an ex-post publication performance (see Supplementary Material for syntax  
20 and results).

21 Fourth, we also performed a difference-in-difference-in-differences analysis, on top of the  
22 previous step, examining five different groups of researchers in publications sponsored by U.S.

1 agencies. (The syntax used to produce the latter variable, researchers with Chinese ethnicity, is  
2 provided in the Supplementary Materials).

3

#### 4 ***2.1 Variables and descriptive statistics***

5 *PSA*. We used “percentile in subject area” to capture the impact of research. *PSA* measures the  
6 relative influence of a publication. The computation of this variable is released by Web of  
7 Science in normalized format by time of publication and field of research. This variable  
8 fluctuates between the bottom (90) and the ceiling (100) of the top 10% publications. We also  
9 used supplementary indicators of impact reported in Supplementary Material, such as top 1%,  
10 which is a subset of the top 10% in the dataset; Category Normalised Citation Indicator (CNCI),  
11 as released from Web of Science. Still computed from citations but slightly different in meaning,  
12 we refer to “highly cited papers” – the top 1% most cited papers computed by Web of Science  
13 and normalized by field and time that have a disproportionate number of citations. Whilst CNCI  
14 and top 1% are relatively similar to *PSA*, we refer to this latter indicator for a supplementary  
15 robustness check. Each indicator is not time sensitive as gross number of citations would be.  
16 These indicators which are used as alternative dependent variables are positively correlated to  
17 each other from 0.44 up to 0.68. The following variables have averages reported in Table 1.

18 *Location of Author*. WoS allows the extraction of country-level affiliations. We extracted some  
19 of the most relevant locations, namely: Mainland China (61.8%) U.S. (25.4%), South Korea  
20 (7.5%), Germany (5.1%), Australia (4.6%), Great Britain (4.3%), Japan (3.3%), India (2.6%),  
21 and France (1.9%). We also extracted Hong Kong SAR (3.9%) and Taiwan (1.8%) to analyze  
22 them separately from Mainland China, considering their distinctive governance arrangements.  
23 These latter tests yielded no supplementary findings, confirming the robustness in using

1 Mainland China. We thus compute “rest of the world” (7.2%) if a given publication’s location is  
2 not listed among the ones above. The total exceeds 100% due to international co-authorships.  
3 *Position and Location of Author* (CN\_LAST; US\_LAST). WoS allows to flag each publication  
4 located in a given country by tracing the location of the last author (country affiliation of author).  
5 Although positioning of authorship might be different by cultural and/or disciplinary traditions,  
6 we adopt the convention of the principal investigator (PI) being identified as the last author,  
7 which is followed in nanotechnology publications (Kostoff et al. 2006) – namely, the senior  
8 author/PI is the last author, and the first author is the team member who did the most work.  
9 Analytically, we found that both “First” and “corresponding” positions suffered from  
10 multicollinearity, whereas the “Last” author position held. We found that dropping “first” and  
11 “corresponding” authors was a very minor issue, as the most salient observable was the “last”  
12 author, which is proxy of PI role in the paper – which means being the grant holder for those  
13 papers that also have a funding acknowledgement. Authors located in Mainland China are in  
14 last-author position on more than a half of the publications within the top 10% publications  
15 (51.1%). For U.S. affiliated researcher, last position occurs in 18.2% of the total of top 10%  
16 publications in nanotechnology in the years under observation.  
17 *Funding Agency*. Acknowledgment of funding agency (if any reported) is coded in WoS. We  
18 extracted, within our sample, publications with acknowledgement of single funding agencies. For  
19 the U.S., sponsors parsed in this dataset are: “Air Force Office of Scientific Research” (ASOFR),  
20 “Department of Defense” (DEPTDEF), “Department of Health and Human Services”  
21 (DEPTHEALTHSERV), “Department of Energy” (DOE), “National Institutes of Health” (NIH),  
22 “National Science Foundation” (NSF), “NSF - Directorate for Engineering (ENG)” (NSFENG),  
23 “NSF - Directorate for Mathematical & Physical Sciences (MPS)” (NSFMPS), “Office of Naval

1 Research” (OFFNAVAL), “United States Navy” (USNAVY). Chinese funding agencies are:  
2 “National Science Foundation” (NSFC), “Fundamental Research Funds for the Central  
3 Universities” (FRCENTRAL), “National Basic Research Program” (NBRPC), “China  
4 Postdoctoral Science Foundation” (CPSF), “Chinese Academy of Science” (CAS). Other  
5 relevant sponsors we identified from the dataset were: “National Research Foundation of Korea”  
6 (NRFK), “European Union” (EU), “Spanish Government” (ESGOV), “European Research  
7 Council” (ERC), “UK Research and Innovation” (UKRI). It is possible that acknowledgement of  
8 funding agencies is dictated by different policies and practices internationally, although since  
9 around 2012 WoS consistently reports this information. Table 1 provides the percentage of  
10 presence of each funding agency in our dataset – the total exceeding 100% because each  
11 publication might be sponsored by multiple agencies at the same time. Mainland Chinese  
12 funding agencies are present in 53% of the cases; U.S. ones in 16.6%. In less than 1 in 10  
13 publications the funding agency is from a third country. Notably, publications sponsored by  
14 Chinese funding agencies have increased in the time series, whereas those funded by U.S.  
15 funding agencies declined somewhat, especially after 2020.

16 *Nocoaut*. The number of co-authors in a given publication is generally associated to citations, in  
17 the literature. We discover an average of 7.86 authors per article, with a positive skewness as  
18 expected.

19 *Industry*. WoS InCite Clarivate allows to trace whether a single publication is out of partnership  
20 with authors affiliated to non-academic and non-public research institutes. University-industry  
21 linkages are key in nanotechnology (Chang 2024), and almost 2% of top 10% publications  
22 appear to have industry participation.

1 *International*. Each publication is coded as either “domestic” or “international” according to the  
2 location of authors’ affiliations. International publications are therefore necessarily co-authored.  
3 This variable also captures collaborations involving large numbers of co-authors (Rüland, 2023).  
4 As shown in Table1, around 35% of publications are internationally co-authored.

5 *Agglo*. This variable detects the extent to which there are multiple funding agencies  
6 acknowledged in a given publication. Agglomeration is relevant as coexistence of multiple  
7 sponsors, especially if based on different countries or being transnational entities (e.g., the  
8 European Union), is a cornerstone of scientific globalism. The average is 1.2%. Roughly one  
9 quarter of publications (25.8%) reports no funding agencies in Table 1 (agglo=0). Less than 5%  
10 of publications have four or more different funding agencies reported. The combination of  
11 Chinese and U.S. funding agencies acknowledged in the same publication is around 3% of the  
12 sample – these latter publications are excluded in the estimates reported since Table 3 and  
13 beyond.

14 *CNAUTHOR*. Chinese ethnicity is imputed by a list of the most common Chinese last names  
15 (See Supplementary Material). This variable may not capture all ethnic Chinese authors, and it is  
16 subject to a minor percentage of non-Chinese last names corresponding to that of other nationals  
17 (e.g., Koreans). We are confident that outside Mainland China, and excluding Hong Kong SAR  
18 and Taiwan where last names are written in a slightly different way, we were able to accurately  
19 categorize ethnic Chinese authors in other countries in a relatively reliable and efficient way.

20 Chinese-Americans whose antecessors immigrated several decades ago are likely to have  
21 different transliteration of last names – for instance "Lee" instead of "Li [李]". Among the  
22 publications with authors located in China (variable ‘CN’), 99.2% have the most common  
23 Chinese last names – a share which is consistent with expectations. Following this procedure, the

1 top 10% publications in nanotechnology are remarkably authored 78.5% of the times by at least  
 2 one person who is of Chinese heritage. We also compute CN\_ETH which includes only those  
 3 ethnic Chinese authors who are not affiliated in the Mainland (42.6%), and with CN\_ETHus  
 4 those of Chinese heritage who are affiliated in the US (9.2%).

6 **Table 1. Descriptive statistics**

Location of at least one Author in publication	N	Mean	Funding Agencies	N	Mean
CN	49,061	0.6183323	FUND_ASOFR	49,061	0.0161228
CN_LAST	49,061	0.5108946	FUND_DEPTDEF	49,061	0.0427427
US	49,061	0.2544587	FUND_DEPTH~V	49,061	0.0288416
US_LAST	49,061	0.1823648	FUND_DOE	49,061	0.0730723
HK	49,061	0.0396038	FUND_NIH	49,061	0.0296162
TW	49,061	0.0183037	FUND_NSF	49,061	0.0863211
AU	49,061	0.0459836	FUND_NSFENG	49,061	0.0196490
DE	49,061	0.0508958	FUND_NSFMP	49,061	0.0219115
FR	49,061	0.0190171	FUND_OFFNA~L	49,061	0.0157763
GB	49,061	0.0430281	FUND_USNAVY	49,061	0.0163062
IN	49,061	0.0258250	fund_USd (funded by any of the mentioned U.S. F.A.)	49,061	0.1664866
JP	49,061	0.0330813	FUND_NSFC	49,061	0.5126475
KR	49,061	0.0746622	FUND_FRCEN~L	49,061	0.0930270
restWORLD	49,061	0.0718697	FUND_NBRPC	49,061	0.0612910
Ethnic Chinese authors (CNAUTHOR)	49,061	0.7853285	FUND_CPSF	49,061	0.0550947
Of which outside China* (CN_ETH)	49,061	0.4260615	FUND_CAS	49,061	0.0363425

Of which affiliated in the US (CN_ETHus)	49,061	0.0921709	fund_CNd (funded by any of the mentioned Mainland F.A.)	49,061	0.5300952
<b>Other confounding variable</b>	<b>N</b>	<b>Mean</b>	FUND_NRFK	49,061	0.0335501
Nocoau	49,061	7.8608060	FUND_EU	49,061	0.0224415
Industry	49,061	0.0199140	FUND_ESGOV	49,061	0.0220134
International	49,061	0.3500540	FUND_ERC	49,061	0.0234198
Agglo	49,061	1.2319150	FUND_UKRI	49,061	0.0217281
			fund_WORLDd (funded by any of the main rest of the world F.A.)	49,061	0.0970832
<b>Other dependent variables (Table S1; Figures S1, S2, S3)</b>				<b>N</b>	<b>Mean</b>
CNCI				49,061	4.8634050
Top1				49,061	0.1026681
Highly Cited Papers				49,061	0.1463688

1 Source: Authors' extraction. Dataset accessible at: <https://zenodo.org/records/15470162>

2 \* This count excludes not only Mainland China, but also Hong Kong SAR and Taiwan. Macau is  
3 overlooked.

4

### 5 3. Results

#### 6 3.1 Shifting Patterns of Research Collaboration in Nanotechnology

7 Addressing our first two research questions, Table 2 provides the time series of Chinese location  
8 of author (*a*), last-name Chinese location of author (*b*), and Chinese ethnicity as per the  
9 definitions above (*c*). For each of these three definitions, we show how many are co-authored by  
10 location of author (affiliation of co-author, second and third columns), and how many by location

1 of funding agency (fourth, fifth and sixth columns). More specifically, we reconstruct the time  
2 series by also including the following categories of publications: co-authored by anyone located  
3 in the U.S. (second columns); located in any other part of the world (Hong Kong and Taiwan  
4 included), with the exclusion of both China Mainland and U.S. (third columns); funded by  
5 Chinese Mainland agencies (fourth columns); funded by U.S. funding agencies (fifth columns);  
6 or funded by any other funding agencies (sixth columns). Table 2 indicates that Authors based in  
7 Mainland China increased consistently their presence among the top 10% articles in the field,  
8 with a peak in 2022. Those located in China co-author frequently with colleagues based in the  
9 U.S. However, such combination started to decline sharply from 2020 onwards. In 2023, this  
10 form of collaboration was almost a third of 2019 (from 626 down to 260). Such trend is not  
11 visible for co-authorship between scientists in China and their peers in the rest of the world  
12 (excluding the U.S.).

13 When checking how often Mainland China-affiliated scholars publish articles with sponsorship  
14 from U.S. funding agencies, we observe an even more marked decline (from 291 in 2018 down  
15 to 61 in 2023). The trend is not so clear for publications funded by the rest of the world”, but an  
16 emerging pattern seems to point to a slight decline for publications authored in the Mainland  
17 under non-U.S. foreign funding – a pattern which is nevertheless consistently different from that  
18 observable for U.S. funded research. Looking specifically at papers produced by PIs based in  
19 China (sub-table *b* – author in last position being located in China), there is a clear and similar  
20 decline in co-authorship with U.S.-based scientists, and also in participation in publications  
21 sponsored by U.S. funding agencies. When looking at Chinese PIs co-authoring with peers in the  
22 rest of the world, the trend seems relatively flat, if not on the rise.

1 Last, when looking at authors of Chinese ethnicity (last part of Table 2 – *c*), we equally see a  
 2 decline of co-authorships between scientists with U.S.-based affiliation (excluding those located  
 3 in Mainland China, Hong Kong SAR, and Taiwan) roughly in late 2010s, and certainly from  
 4 2021 onward. Co-authorships with ethnic Chinese authors based abroad, but not in the U.S., start  
 5 declining in 2022. Ethnic Chinese scientists affiliated abroad publish less often with sponsorship  
 6 from U.S. funding agencies starting in 2016, eventually declining steadily.  
 7 It seems sufficiently clear that the shift in U.S. policy had a visible impact on collaborations with  
 8 Mainland China, which is not seen in China’s collaborations with the rest of the world. Roughly,  
 9 2019 appears to represent a turning point, which is consistent with the anti-China sentiment  
 10 ostensibly propagated by the 2018 launch of the China Initiative (Lewis, 2022; Lee and Haupt,  
 11 2021). We proceed our analysis considering the period 2018-2023 as the one under the influence  
 12 of a series of policy initiatives emphasizing Scientific Nationalism – an emphasis on national  
 13 security in S&T and targeting China as a source security threats to the U.S. The following  
 14 analysis omits 2024, for which data is partial and too recent for capturing impact.

15  
 16 **Table 2. Count of Mainland China-affiliated publications (first column); of which count of co-**  
 17 **authorships with US (second column) or rest of the world (third column); Count of articles funded**  
 18 **by agencies located in China Mainland (fourth column), U.S. (fifth column), or rest of the world**  
 19 **(sixth column). Time series. Sub-tables (b) and (c) providing same statistics, but limited respectively**  
 20 **to Chinese affiliated as last author, and authors of Chinese ethnicity affiliated abroad.**

<i>a</i>	Tot	co-authoring with location:		funding location		
	Chinese affiliated author	US	rest of world	CN	US	rest of world

	(CN)					
2012	779	193	95	642	151	20
2013	1027	227	93	854	159	23
2014	1261	278	153	1033	195	41
2015	1582	350	174	1343	195	46
2016	1910	425	224	1620	220	64
2017	2304	551	292	1971	290	66
2018	2730	569	337	2387	291	84
2019	3174	626	416	2748	259	65
2020	3337	539	501	2786	240	111
2021	3752	481	497	3206	163	81
2022	4033	388	522	3486	111	95
2023	3890	260	475	3391	61	87
2024	557	26	79	458	10	11
	tot	co-authoring with location:		funding location		
<i>b</i>	Chinese last-author (CN_last)	US	rest of world	CN	US	rest of world
2012	559	68	38	523	46	8
2013	790	91	42	727	60	6
2014	969	117	75	887	70	18
2015	1239	180	90	1143	65	23
2016	1479	206	107	1381	77	30

2017	1831	276	156	1704	92	34
2018	2187	293	182	2067	100	42
2019	2564	323	221	2388	88	25
2020	2699	273	277	2437	87	57
2021	3166	257	316	2876	62	28
2022	3553	243	335	3225	48	40
2023	3527	180	307	3188	39	29
2024	502	19	50	424	4	5
	tot	co-authoring with location:		funding location		
<i>c</i>	Chinese ethnicity (CN_ETH)	US	rest of world	CN	US	rest of world
2012	770	418	304	4	351	105
2013	1018	464	352	2	389	127
2014	1251	495	376	3	411	113
2015	1570	474	445	2	402	118
2016	1892	463	398	2	372	105
2017	2285	383	380	4	303	120
2018	2713	362	378	4	278	107
2019	3157	295	341	3	219	86
2020	3289	316	346	2	232	117
2021	3721	246	301	5	185	122
2022	4011	202	258	1	159	126

2023	3865	192	275	5	140	138
2024	551	29	62	0	21	39

1 2024 year is partial

2

3 Table 3 provides some averages of the impact of publication. Since we draw from the top 10%  
 4 (PSA ranging 90-100; 100 being top 1%) publications, expectation is that the average is 95. The  
 5 first column includes all publications, mostly located in Mainland China, either as location of  
 6 author or in terms of funding. We see an increase in terms of PSA, especially when PI of  
 7 publication is affiliated in China (CN\_LAST). The fact that publications of Chinese overseas  
 8 (CN\_ETH) have a decrease in impact seems consistent with previous findings (Aghion et al,  
 9 2023). However, it is notable that PSA, when collaborating with authors affiliated in the U.S.,  
 10 decreased, especially for the subset of publications co-authored by ethnic Chinese authors  
 11 affiliated outside China (CN\_ETH: from 95.33 down to 94.87). Also publications funded by the  
 12 main U.S. research agencies in the field experience a drop of average impact when involving  
 13 collaboration with Chinese scientists, again with a wider delta when considering those of  
 14 Chinese heritage working abroad (CN\_ETH). It is worth noting that PSA goes up in all  
 15 categories when considering Chinese funding (last column), which gives room to the possibility  
 16 that China has become able to excel using domestic research capacity.

17

18 **Table 3. Averages of PSA in two periods (2012-2017; 2018-2023). Row: Chinese location of author;**  
 19 **Chinese last position of author; and Chinese ethnicity affiliated abroad. Columns: all top10%**  
 20 **publications in the field; subset of co-authorship with affiliated in the U.S.; subset of**  
 21 **acknowledgement of U.S. funding; subset of acknowledgement of Mainland China funding**

		All	co-authored with US	Funded by U.S. (fund_USd)	Funded by Mainland China (fund_CNd)
2012-2017	CN	95.14182	95.50636	95.63245	95.12363
2018-2023		95.20780	95.41331	95.45507	95.28149
2012-2017	CN_last	95.06656	95.56525	95.86960	95.06976
2018-2023		95.18143	95.43600	95.59225	95.26330
2012-2017	CN_ETH	95.18578	95.33076	95.34336	95.11600
2018-2023		94.80824	94.87021	94.81978	95.21945

1

### 2 **3.2 Source of Funding, Collaboration, and Research Impact**

3 Turning to our third and fourth research questions, we examine the relationship between shifting  
4 patterns of collaboration, source of funding, and research impact. Table 4 shows coefficients in  
5 predicting, from OLS regressions, research impact. We proceed with the analysis of the two time  
6 periods separately for first and second models. In the third model we assess the effect of U.S.  
7 funding on publication impact; and in the fourth model assessing the effect of Chinese funding  
8 agencies on this outcome. Between 2012-2017, whether a publication was funded by any U.S.  
9 funding agency or not was not significantly related to impact, and this remains so between 2018-  
10 2023. In relation to China-supported research, in the 2018-2023 period, acknowledgement of  
11 Chinese Mainland funding starts predicting more influential research (coefficient = 0.381),  
12 which is consistent with an overall pattern of growth of Chinese research also in impact.

1 **Table 4. OLS regressions predicting PSA. 2012-2017 time period (Model1); 2018-2023 time period**  
 2 **(Model2); estimation of DiD effects for U.S. funding agency (Model3), and for Mainland Chinese**  
 3 **funding agency (Model4).**

	m1 (2012- 2017)	m2 (2018- 2023)	m3 (DiD; U.S. funding agency)	m4 (DiD; Chinese funding agency)
	b/se	b/se	b/se	b/se
fund_USd	-0.041 (0.10)	-0.164 (0.11)		-0.091 (0.07)
fund_CNd	0.163 (0.10)	0.381*** (0.07)	0.302*** (0.06)	
FUND_WORLDd	0.041 (0.08)	-0.273** (0.09)	-0.114 (0.06)	-0.127* (0.06)
US_LAST	0.244** (0.08)	0.196* (0.09)	0.214*** (0.06)	0.207*** (0.06)
CN_last	0.096 (0.09)	0.203** (0.07)	0.160** (0.05)	0.183*** (0.05)
CN_ETH	0.276*** (0.06)	0.202** (0.06)	0.255*** (0.04)	0.251*** (0.04)
agglo	0.083** (0.03)	0.039 (0.03)	0.056** (0.02)	0.068*** (0.02)
nocoau	0.040*** (0.01)	0.028*** (0.01)	0.032*** (0.00)	0.031*** (0.00)
INTERNATIONAL	0.143** (0.05)	0.244*** (0.04)	0.198*** (0.03)	0.211*** (0.03)
INDUSTRY	0.076 (0.13)	-0.106 (0.15)	0.003 (0.10)	-0.004 (0.10)
List of other Countries	YES	YES	YES	YES
Years	YES	YES	YES	YES
fund_USd * period (2012-17/18- 23)			-0.413*** (0.08)	
fund_CNd * period (2012-17/18- 23)				0.367*** (0.06)

_cons	94.423***	94.301***	94.433***	94.548***
	(0.09)	(0.08)	(0.07)	(0.07)
N	18,988	27,757	46,745	46,745
R-sqr	0.013	0.013	0.012	0.013
dfres	18963	27732	46713	46713
BIC	94195.7	137375.5	231465.2	231450.8

1 Note: 2024 publications are excluded. All models exclude publications funded at the same time by any  
2 U.S. funding agency and Mainland Chinese funding agency  
3 legend: \*  $p < .05$ ; \*\*  $p < .01$ ; \*\*\*  $p < .001$   
4  
5 To test the effect of publishing with sponsorship from U.S./Chinese funding agencies as having  
6 been “treated” in the 2018-2023 period, we used the following covariates: number of authors per  
7 publication (nocoau), whether a publication is internationally co-authored or not  
8 (INTERNATIONAL), whether a publication is co-authored with corporations (INDUSTRY),  
9 number of multiple funding agencies per paper (agglo). We kept years as time unit in  
10 observables and grouping of publications (institutional; domestic; international). We find  
11 positive coefficients in number or authors per publication, and less consistently agglomeration of  
12 multiple funding agencies, which are all expected (see Supplementary Material for VIFs values).  
13 These tests excluded those publications that might have been funded at the same time by U.S.  
14 and Mainland Chinese funding agencies. We treat the data as cross-sectional as publications are  
15 considered the outcomes of different stimuli, including funding agency regulations and the  
16 broader S&T policy environment. The change of such stimuli represents a “treatment”.  
17 Results from Table 5 show averages treatment effect on the treated (ATET) (see Supplementary  
18 Material for syntax). This calculation can be read as the effect of funding source on the impact of  
19 publications, considering its effects on patterns of domestic/international collaboration. Looking  
20 at PSA within the top 10% publications between 2012 and 2023, and assuming that scientists

1 sponsored by U.S. funding agencies experienced a change in incentives/disincentives for  
 2 collaboration with China, we see that U.S.-based scientists’ new restricting regulations produced  
 3 a negative effect. Namely, since the late 2010s there was a reduction between half a percentile (-  
 4 0.495) up to three quarters of a percentile (-0.767), depending on the technique to estimate ATET  
 5 (Table 4). This is a relevant difference within our sample representing the top 10% of  
 6 publications in the field. This reduction can be expressed as a percentage drop varying from  
 7 almost 5% to nearly 8% – both notable changes in magnitude.

8 **Table 5. Average Treatment Effect on the Treated (ATET) on impact of publication from**  
 9 **difference-in-differences tests accounting for covariates, groups, and single years (U.S. funding**  
 10 **agencies).**

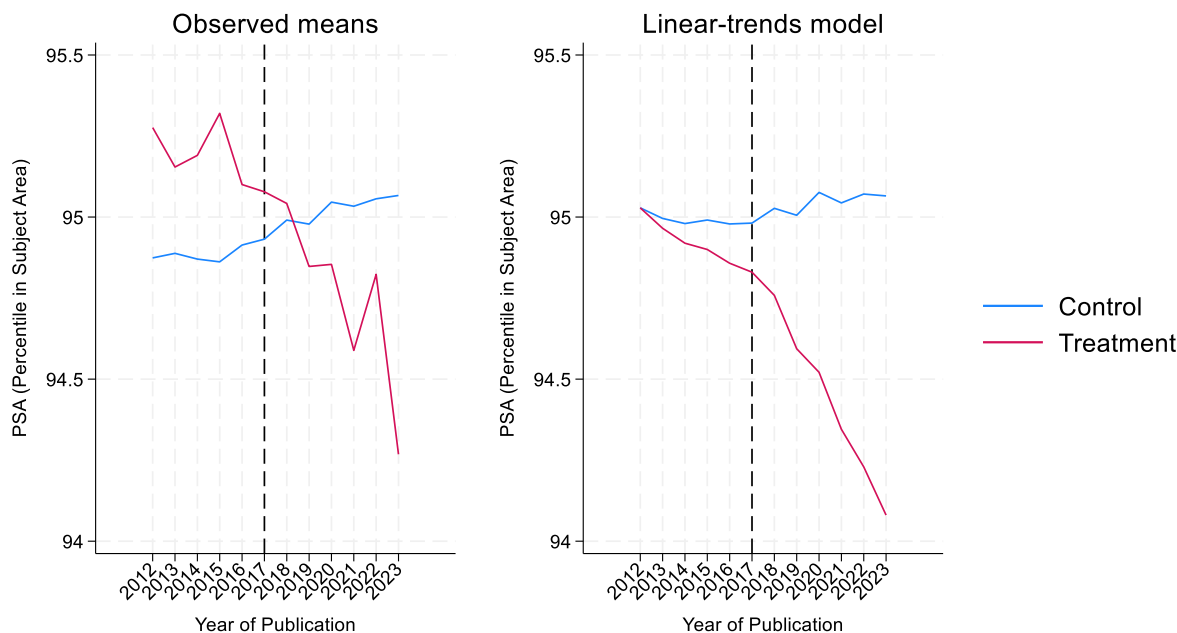
	Simple	Bell & McCaffrey bias-corrected standard errors degrees-of- freedom adjustment	Donald & Lang aggregation method	Donald & Lang aggregation method with varying coefficients
ATET	-0.4876	-0.488	-0.557	-0.917
<i>P</i>	0.000	0.005	0.000	0.000
<i>Parallel-trends test (Prob &gt; F =)</i>	0.6446	0.6671	0.5246	<i>n.a.</i>
<i>Granger causality test (Prob &gt; F =)</i>	0.0000	0.0000	0.9132	<i>n.a.</i>

11 Note: 2024 publications and those funded at the same time by Chinese and U.S. funding agencies are  
 12 excluded.

1  
2 Graphical results and  $p$  values for parallel test assumption confirm that the DiD approach is  
3 consistent (Figure 1). The parallel tests indicate that there was not a parallel trajectory between  
4 U.S. funded research and non-U.S. funded studies. In fact, Chinese funding agencies have  
5 shaped science to a greater extent than their U.S. counterparts in recent years. However, the  
6 Granger causality tests for each test provided on Table 5 suggest that publications funded by  
7 U.S. agencies between 2012-2017 and 2018-2024 (when adversarial policy shifts towards China  
8 presumably engendered tangible effects), show a change of trend. This change is depicted in  
9 Figure 1, indicating that despite the absence of a parallel trend, there is evidence that the  
10 changing policy context in the U.S. significantly shaped the ongoing pattern up to 2017. In other  
11 words, the ATET estimates indicates that the reduction in international collaboration of U.S.  
12 funded research in nanotechnology lessened the impact of such research more than it would have  
13 occurred anyway. This, in turn, accelerates the already increasing delta between U.S. funded  
14 research and the Chinese-funded publications – which results predominantly from the increase of  
15 Chinese nanotechnology research.  
16 Put differently, we cannot reject the null hypothesis that the impact of U.S. funded research has  
17 not changed a pattern related to impact. Nonetheless, it is possible that this relative decline is  
18 attributable also to an on-going surge of China’s research impact, which might have influenced  
19 the relative decline in citations of US-sponsored publications within our data extraction.

20  
21 **Figure 1. Parallel trend diagnosis and Granger test for change of pattern after treatment (U.S.**  
22 **funding agencies considered as “treated”)**

### Graphical diagnostics for parallel trends



1  
 2  
 3 Seeking robustness confirmations, we obtained similar results by running supplementary tests  
 4 predicting top 1% out of the top 10% publications, Category Normalized Citation Impact, and  
 5 also “Highly Cited Papers” as a dependent variable, which is still not time sensitive, but highly  
 6 skewed distributed (see Supplementary Material).  
 7  
 8 **Table 6. Average Treatment Effect on the Treated (ATET) on impact of publication from**  
 9 **difference-in-differences tests accounting for covariates, groups, and single years (Chinese funding**  
 10 **agencies).**

	Simple	Bell & McCaffrey bias-corrected standard errors	Donald & Lang aggregation method	Donald & Lang aggregation method with
--	--------	-------------------------------------------------------	----------------------------------------	---------------------------------------------

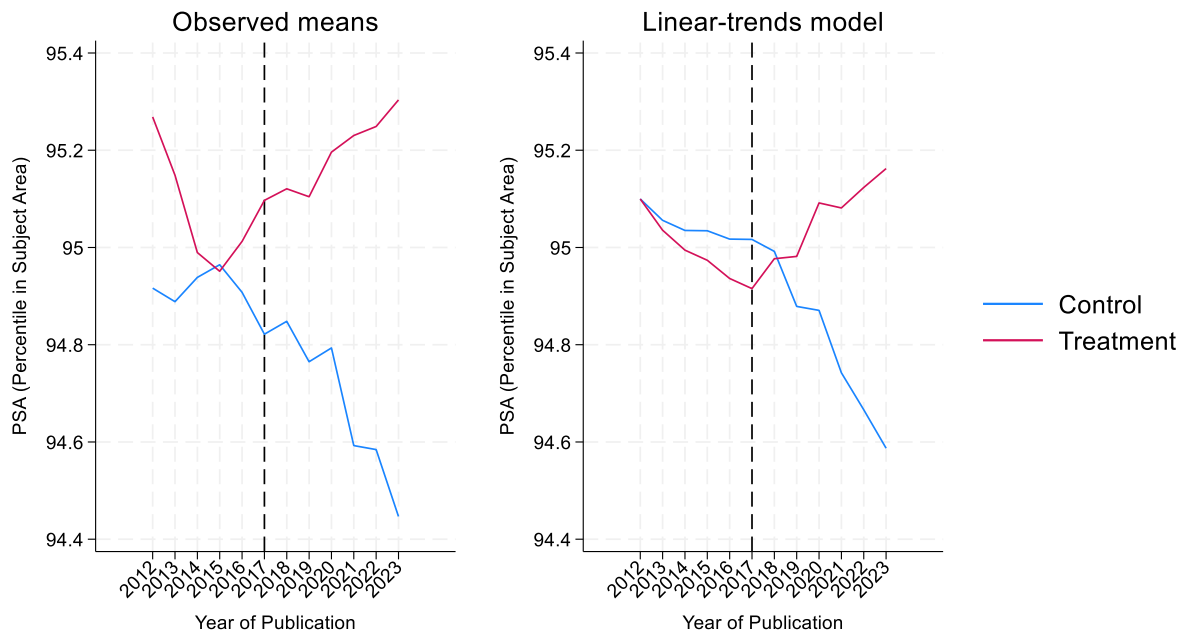
		degrees-of-freedom adjustment		varying coefficients
ATET	0.3414	0.3414	0.3297	0.5214
<i>P</i>	0.000	0.001	0.000	0.007
<i>Parallel-trends test (Prob &gt; F =)</i>	0.3430	0.3646	0.1009	<i>n.a.</i>
<i>Granger causality test (Prob &gt; F =)</i>	0.000	0.000	0.2466	<i>n.a.</i>

1 Note: 2024 publications and those funded at the same time by Chinese and U.S. funding agencies are  
 2 excluded.

3  
 4  
 5  
 6  
 7

**Figure 2. Parallel trend diagnosis and Granger test for change of pattern after treatment (Chinese funding agencies considered as “treated”)**

### Graphical diagnostics for parallel trends



1  
2 Difference-in-difference-in-difference tests (DDD) add insights to these findings, drawing from a  
3 focus on U.S. funding agencies considered as “under treatment” – namely testing whether the  
4 U.S. policy stance towards China has impacted the output of Chinese located and/or by  
5 researchers with Chinese heritage, building on previous studies (e.g. Lee & Xi, 2023). Table 6  
6 provides coefficients about the possible effects in considering a further interaction variable on  
7 top of the OSL equation in the third model in Table 4. The purpose of these tests is to check  
8 whether the U.S. policy climate might have affected specific groups of scientists, for instance by  
9 ethnicity. We used the following additional variables: 1) Researchers affiliated in Mainland  
10 China (Model 1); 2) ethnic Chinese scientists affiliated abroad (Model 2); 3) any ethnic Chinese  
11 scientists over only those affiliated abroad (Model 3); 4) U.S.-affiliated authors of Chinese  
12 heritage over all publications authored in the U.S. (Model 4); 5) either a publication has as a last  
13 author a researcher based in Mainland China or not (Model 5).

1 The first test did not have a statistically significant result. For the second Model in Table 6 we  
2 note that there is negative effect linked to sponsorship by U.S. funding agencies on publications  
3 with participation of authors of Chinese heritage. This suggests that the shifting U.S. policy  
4 context has had an effect specifically on those scientists of Chinese ethnicity. However, when we  
5 restrict the observations on the set of ethnic Chinese authors affiliated outside the Mainland only  
6 (Model 3 Table 6), we find that there are no statistically significant effects. Model 4 in Table 6  
7 further tests a possible effect of U.S. funding on ethnic Chinese scientists working in the U.S.  
8 relative to non-Chinese authors. In this fourth case, like for Model 3, there are no indications of a  
9 relationship altogether between U.S. funding and the impact of publications co-authored by  
10 ethnic Chinese scientists with U.S. scientific affiliation. The following model instead shows that  
11 there is a negative, high, and statistically significant slope if the last author is ethnic Chinese and  
12 located in Mainland China. This last test let suggest that U.S. funding agencies may effectively  
13 disincentivize research to happen when the project is led by a researcher located in Mainland  
14 China (or, alternatively, researchers in China do not wish to lead as PI projects funded by U.S.  
15 agencies).

16 Overall, the DDD tests indicate a significant change in the impact of U.S. funded publications  
17 with ethnic Chinese co-authors (Model 2). However, this effect is not observed among  
18 researchers working in the U.S., or among those of Chinese ethnicity working outside of  
19 Mainland China. Nor is it observed among those scientists who work in Mainland China. Yet, an  
20 effect is found when the project is led from the Mainland (Model 5). This suggests that the  
21 impact of U.S. policy changes is felt differently based on where researchers are based and what  
22 role they may have in a grant. As shown in Table 2, this does influence the make up of the  
23 researchers publishing in the top 10% as measured by PSA.

1  
 2 **Table 6. Difference-in-Difference-in-Differences (DDD) as per Table 4 Model 3, adding five**  
 3 **additional variables: either a paper is co-authored by anyone affiliated in Mainland China (M1 –**  
 4 **CN); either a paper is co-authored with any ethnic Chinese author (M2 – CNAUTHOR); either a**  
 5 **paper is co-authored with any ethnic Chinese author affiliated abroad or not (M3 – CN\_ETH);**  
 6 **either papers authored in the US are authored with any ethnic Chinese author or not (M4 –**  
 7 **CN\_ETHus); either a paper has as a last author anyone affiliated in Mainland China or not (M5 –**  
 8 **CN\_last).**

	b/(s.e.)	b/(s.e.)	b/(s.e.)	b/(s.e.)	b/(s.e.)
Models specify which is third variable on Table 4 Model 3	M1 – * any paper with at least one affiliated in Mainland China (CN)	M2 – * any paper with at least one ethnic Chinese author (CNAUTHOR)	M3 – * any paper with at least one ethnic Chinese author affiliated abroad (CN_ETH)	M4 - * any paper with at least one ethnic Chinese author affiliated in the US (CN_ETHus)	M5 - * any paper with at least one Mainland China affiliated last author (CN_last)
Fund_USd * period * third var	-0.3088	-0.4589**	-0.1890	-0.8683	-1.3727*
	(0.22)	(0.18)	(0.20)	(0.88)	(0.57)
Other vars as per Table 4	YES	YES	YES	YES	YES
N	46,745	46,745	18,423	8,325	46,745

9 Note: 2024 year publications are omitted

10 legend: \* p<.05; \*\* p<.01; \*\*\* p<.001

### 11 **3.3 Limitations**

12 We acknowledge some limitations to this study. First, we rely only on top 10% publications.

13 Whilst this follows from the idea of focusing on the research with the most impact in the field,

14 further investigation across the whole spectrum of publications would provide a more wide-

15 ranging examination of collaboration patterns. Second, the link between the shifting policy

16 environment outlined in the introduction and micro-level decisions regarding research

1 communication and publications is still understudied. Third, the implications of our findings for  
2 the “impact” of nanotechnology research sponsored by US agencies cannot be over-interpreted;  
3 citation-derived metrics such as the ones we used are imperfect proxies for impact, since they  
4 embed the multiple biases inherent to citation practices. Impacts beyond the scientific  
5 literature—such as as input to technological advance—offer another lens on publication value  
6 and warrant studies that trace such effects. Finally, U.S. policy changes, in concert with other  
7 countries’ policies, influence—without determining—the decisions scientists make about project  
8 sponsorship, collaboration, and co-authorship in national and global contexts. We rely on the  
9 awareness of these limitations to interpret our findings with caution.

10

#### 11 **4. Conclusion**

12 In general, our analyses point towards two conclusions about the U.S.-China relationship in the  
13 production of the highest impact publications in nanotechnology. First, the escalating policy  
14 efforts from the U.S. federal government towards a more nationalistic science policy stance has  
15 had a visible effect on patterns of collaboration and publication impacts. A disengagement from  
16 China is visible from the late 2010s to the present, with a reduction of research collaboration in  
17 nanotechnology as measured by co-authorship. Publications involving U.S. and China-based  
18 scientists funded by U.S. funding agencies declined precipitously, while the publication output of  
19 Chinese scientists, also sponsored domestically, has increased steadily. Our analysis provides  
20 granular evidence of shifting patterns of knowledge production and the impact of publications at  
21 the field level, which complements broader analyses of aggregate scientific decoupling between  
22 the two countries (Zhu et al, 2021; Okamura, 2023; Tang, 2024).

1 As science becomes ever more global and collaborative (Aksnes & Sivertsen, 2023; Baker &  
2 Powell 2024), stronger state orientation towards Scientific Nationalism raises questions about its  
3 effects on the direction and nature of research. This leads to the second main conclusion from  
4 our study: the shift away from collaboration with China is associated with a negative effect on  
5 the impact of U.S.-sponsored research. As shown above (Figure 1), a relative decline in  
6 comparison to research funded by China was already taking place during the 2010s, but it  
7 appears to have accelerated towards the end of the decade.

8 Whilst U.S. S&T policy efforts such as the Chips and Science Act have aimed at securing U.S.  
9 scientific leadership in strategic S&T areas and at containing China's advancement (Peters,  
10 2023), our analysis points in a different direction when it comes to research in nanotechnology.  
11 Not only has the impact of U.S. funded publications slipped, but China, via its own funding  
12 agencies, was able to increase its high-impact output in the field. Yet, the most visible impact is  
13 on U.S. sponsored research under projects led by Mainland China-affiliated authors (not  
14 necessarily Chinese nationals). The evolving U.S. and Chinese research systems—together with  
15 the limits of citation-based metrics as proxies for impactful science—counsel caution about  
16 causal claims, particularly those attributed to policy. The nexus between research impact and  
17 research policy change remains underexplored; these facets are unlikely to stand in a simple,  
18 one-way causal relationship. Further work is needed to clarify how citation-based measures of  
19 impact relate to technological advance, the outcome of central concern to funding agencies. Our  
20 findings also raise other questions for further research and policy analysis. For instance: are the  
21 declining rates of research collaboration the result of a temporary re-adjustment towards a new  
22 plateau, or the sign of a much broader and comprehensive decoupling affecting S&T fields

1 across the board? Future bibliometric analyses will likely continue to monitor these  
2 developments.

3 Yet, at the micro-level, researchers might explore decision-making by investigating scientists'  
4 formation of their authorship networks, and their perceptions of, and responses to, shifting policy  
5 incentives and disincentives to international partnerships. For scientists and policy-makers alike,  
6 the overarching question our study raises is: in the context of techno-nationalist rivalry, do the  
7 costs of decoupling U.S. nanotechnology research from China outweigh its benefits? Our results  
8 suggest that the costs borne by the U.S. in terms of research impact are not negligible.

9 Interpreting these results from the canonical perspective in the scientific community regarding  
10 the desirability of open and unrestricted collaboration as a key driver of knowledge advancement  
11 – the perspective encapsulated in the concept of Scientific Globalism logic – our results suggest  
12 negative impacts for academic science.

13 As already mentioned, it is arguably possible that this cost-benefit analysis is far from  
14 straightforward if one approaches it from a broader perspective considering the capacity of  
15 different countries to translate nanotechnology discoveries into technological and commercial  
16 outcomes (Rambaran & Schirhagl, 2022). An idealized joint scientific effort by multiple  
17 countries to push the techno-scientific frontier might disproportionately benefit the ones with  
18 stronger technological infrastructures and innovation capabilities. Hence, in some countries, a  
19 comparative disadvantage in the ability to turn cutting-edge science into innovations might lead  
20 to domestic inventions being systematically commercialized abroad (Sá, Kretz & Sigurdson,  
21 2013). Considering the strength of the U.S. innovation economy, the benefits of a nationalistic  
22 retrenchment from collaboration with China would hardly relate to a relative disadvantage in this  
23 area.

1 Framed within the U.S.-China rivalry, foreign policy analysts may weigh the cost to research  
2 impact against the strategic advantage of hindering a direct competitor’s scientific progress.  
3 Indeed, for U.S. foreign policy hardliners pushing a “Second Cold War”, the disengagement  
4 from collaboration with China in nanotechnology is consistent with the U.S.’ strategy of  
5 containing China’s advance in several strategic science-based technologies, including  
6 semiconductors (Schindler et al, 2023). Some argue that such a containment strategy is bound to  
7 fail (Allen 2023; Muller, 2023). Whether that remains a viable and realistic strategy remains to  
8 be seen, considering China’s own growing contributions to the knowledge frontier in the field.

9  
10

## 11 **AUTHOR CONTRIBUTIONS**

12 Giulio Marini: Conceptualization, Formal analysis, Methodology, Data curation, Visualization,  
13 Validation, , Resources Writing—original draft, Writing—review & editing. Creso Sá:  
14 Conceptualization, Writing—original draft, Writing—review & editing.

15

## 16 **COMPETING INTERESTS**

17 The authors have no competing interests.

## 18 **FUNDING INFORMATION**

19 This research received no external funding.

20

21

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