

NPL REPORT IEA 26

**A SUMMARY OF SCIENCE METRIX'S BIBLIOMETRIC ASSESSMENT
OF THE NATIONAL PHYSICAL LABORATORY'S METROLOGY
RESEARCH OUTPUTS (2013-2023)**

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A Summary of Science Metrix's Bibliometric Assessment of the National Physical Laboratory's Metrology Research Outputs (2013-2023)

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ABSTRACT

Science-Metrix was commissioned by the National Physical Laboratory (NPL) to conduct a bibliometric study on NPL's publications output over 2013-2023. The analysis evaluated NPL's performance across five research fields: metrology, advanced manufacturing, data & digital, life science & health, and energy & environment, comparing it with 27 other National Metrology Institutes (NMIs). This paper focuses on the findings in metrology research. The key findings indicate that NPL ranked fourth in output volume among the 28 NMIs. Since 2021, a decline in metrology publications has been observed across most NMIs. NPL ranked second in international and public-private collaboration among NMIs and third in scientific impact, although a decline in scientific impact has been noted in recent years for both NPL and most NMIs. NPL placed in the top three among NMIs based on altmetric indicators and has shown a significant increase in citations by patents. Partnerships with NPL have enhanced global and industry engagement for its collaborators.

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Approved on behalf of NPLML by
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1 EXECUTIVE SUMMARY

The National Measurement System (NMS) serves as a cornerstone of the United Kingdom's (UK) scientific infrastructure, housing cutting-edge laboratories that champion measurement science and technology. These facilities provide the nation with standards of measurement that are both accurate and traceable, essential for driving innovation and productivity across various industries. Recognizing the pivotal role of measurement in enhancing the productivity of UK industries, the NMS plays a crucial part in bolstering the nation's prosperity.

At the forefront of the NMS, as the UK's National Measurement Institute (NMI), stands the National Physical Laboratory (NPL). Established as a government laboratory¹ in 1900, NPL is committed to delivering impactful research, products, and services to the UK. Its research contributions span diverse fields such as physical science, materials science, computing, and bioscience, with applications ranging from ship design to global positioning.

Analysts from Science-Metrix conducted a bibliometric study on NPL's publication output in five research fields: metrology, advanced manufacturing, data & digital, life science & health, and energy & environment, comparing it with 27 other NMIs². This document offers a simplified digest of the analysis, summarising the key messages from the metrology-focused bibliometric analysis.

In metrology research, NPL ranked fourth in output volume among all NMIs, demonstrating its significant contribution to the field. Since 2021, there has been a noticeable decline in metrology publications across most NMIs, including NPL. Despite this trend, NPL has excelled in fostering international and public-private collaborations, ranking second among NMIs in this area. This highlights NPL's strong network and its ability to engage with diverse stakeholders globally.

In terms of scientific impact, NPL ranked third among NMIs, indicating the high quality and influence of its research. Nevertheless, a decline in scientific impact has been observed in recent years for both NPL and many other NMIs, suggesting a broader trend that may need further analysis. NPL's performance in altmetric indicators, which measure the broader impact of research through social media and other platforms, places it in the top three among NMIs. This reflects NPL's ability to reach and engage a wide audience beyond traditional academic circles.

One of the most notable achievements for NPL is the remarkable increase in citations by patents, underscoring the practical applications and industrial relevance of its research. Partnerships with NPL have significantly enhanced the global and industry engagement of its collaborators, further extending the reach and impact of its work.

¹ Since January 2016, NPL operates as a public corporation as it is a wholly owned company of DSIT.

² Annex-1.

2 INTRODUCTION

The context:

Science-Metrix was commissioned by the National Physical Laboratory (NPL) to conduct a bibliometric study on NPL's publications output over 2013-2023. The analysis evaluated NPL's performance across five research fields: metrology, advanced manufacturing, data & digital, life science & health, and energy & environment, comparing it with 27 other National Metrology Institutes (NMIs). This comparative analysis benchmarks NPL's scientific output against the broader UK landscape and 27 other NMIs. Additionally, the assessment investigates the scientific performance of NPL's key collaborators. This comprehensive evaluation also identifies key and emerging research topics relevant to NPL, providing insights into its research landscape and collaborative efforts within the field of Metrology. This paper, specifically, summarizes the findings of Science-Metrix's work for metrology research while focusing on five NMIs, National Institute of Standards and Technology (NIST), National Metrology Institute of Germany (PTB), Korea Research Institute for Standard and Science (KRISS) and NPL, named as "selected NMIs" afterwards.

Time period:

The data used in this study covers the years 2013 to 2023, while also segmenting the period into two distinct 5-year segments, from 2013 to 2017 and 2018 to 2022 to compare two periods for an NMI. 3-year moving periods are also used to capture trends rather than relying on yearly data, which enhances the reliability of the trend analyses. However, it is important to note that the impact of scientific papers on policy and the private sector has not been computed beyond 2021 due to insufficient citation accumulation. Similarly, the analysis of the impact on patents is limited, with data not evaluated beyond 2018.

Data sources:

The primary data source utilized in this study is the Scopus³ scientific publication collection, which provides a comprehensive overview of academic research outputs. Additionally, for analysing patent-related citations and assessing the uptake of research in patents, the study employs the European Patent Office's Worldwide Patent Statistical Database (PATSTAT)⁴. To evaluate the influence of research on policy-related literature, Overton⁵ is used as a source for tracking citations in policy-relevant documents. This multi-faceted approach allows for a thorough examination of the impact of scientific research across different domains, including patents and policy.

The method for creating the data sets:

Relevant publications were retrieved using a two-step approach. First, keyword searches were conducted across titles, abstracts, keywords, affiliations, and journals to identify publications pertinent to each targeted area. In the second step, an artificial intelligence (AI) algorithm was employed to discover additional related publications by utilizing embeddings of the publications' titles and abstracts. This combination of traditional search methods and advanced AI techniques ensure a comprehensive and relevant collection of literature for the study.

Two distinct metrology sub-datasets were created, each based on different seeds. One sub-dataset was derived from publications by NMIs, while the other was formed from articles in metrology-focused journals, such as Metrologia, Journal of Research of the National Institute of Standards and Technology, and Measurement Science and Technology. To refine these seeds, the open-access Llama model from Meta⁶ was utilized to assess whether each publication's title and abstract was relevant to metrology. Subsequently, these refined seeds

³ <https://www.elsevier.com/products/scopus>

⁴ <https://data.epo.org/expert-services/index.html>

⁵ <https://www.overton.io/>

⁶ <https://ai.meta.com/blog/meta-llama-3/>

were used to identify additional publications with similar content through embeddings of titles and abstracts, which are high-dimensional numeric representations capturing the semantic meaning of the texts.

The overall dataset, referred to as "Metrology," represents the union of both sub-datasets, while the "Metrology restrict" refers to their intersection. Publications in the restricted metrology dataset focus on core concepts such as standards, quantities, measurement sciences, calibration, reference materials, and measurement uncertainty. Examples from the restricted dataset include titles like "multi-channel absolute distance measurement system with sub ppm-accuracy" and "Design considerations for stylus systems for micro-CMMs." In contrast, the broader metrology dataset features publications like "Piezoelectric stress transduction switch for VLSI and RF applications" and "Microwave study of field-effect devices based on graphene structures." Both datasets were manually assessed through random sampling to ensure relevance and quality. The findings in this study represent "restricted metrology" dataset.

3 INDICATORS

3.1 BASIC INDICATORS ON SCIENTIFIC OUTPUT

3.1.1 Publication Count

Table 1 Publication output count over 2013-2023.

Entity	Publication counts over 2013-2023	Share compared to the Worlds Metrology Research Output
World	1,039,139	100%
United Kingdom	43,919	4.2%
NPL - National Physical Laboratory	1,722	0.2%
NMI institutes excluding NPL	16,328	1.6%
NIST - National Institute of Standards and Technology	5,182	0.5%
PTB - National Metrology Institute of Germany	2,694	0.3%
KRISS - Korea Research Institute for Standard and Science	1,314	0.1%
NIMC - National Institute of Metrology of China	2,816	0.3%

Science-Metrix's analysis point-out that there were over 1 million publications in metrology research produced over 2013-2023 in the world while all 28 NMIs (including NPL) produced slightly above 18 thousand publications accounted for 1.8% of whole publications. NIST had the highest level of publications with above 16.3 thousand and NPL produced around 1.7 thousand publications, Table 1.

The relatively low percentage of metrology papers from NMIs compared to the global output can be attributed to several factors. Firstly, while metrology may not be an area of specialization for academic institutes, their research workforce does nevertheless contribute to it. Given that the academic workforce is much larger than the research workforce in NMIs, even a small contribution from universities can result in a significantly higher publication output. Secondly, NMIs, while focused on metrology, may also engage in activities beyond publishing, such as developing standards, providing calibration services, and supporting industry, which might not always result in academic publications. Thirdly, delineating metrology research has proven to be challenging. While increasing the precision of the restricted dataset could have minimized this pattern, it would have been at the expense of

the retrieval rate of NMIs' total publications, which stood at roughly 30% across the study's NMIs (weighted average). Therefore, the broader scope of metrology research and the distribution of scientific efforts across different types of institutes contribute to the observed publication patterns⁷.

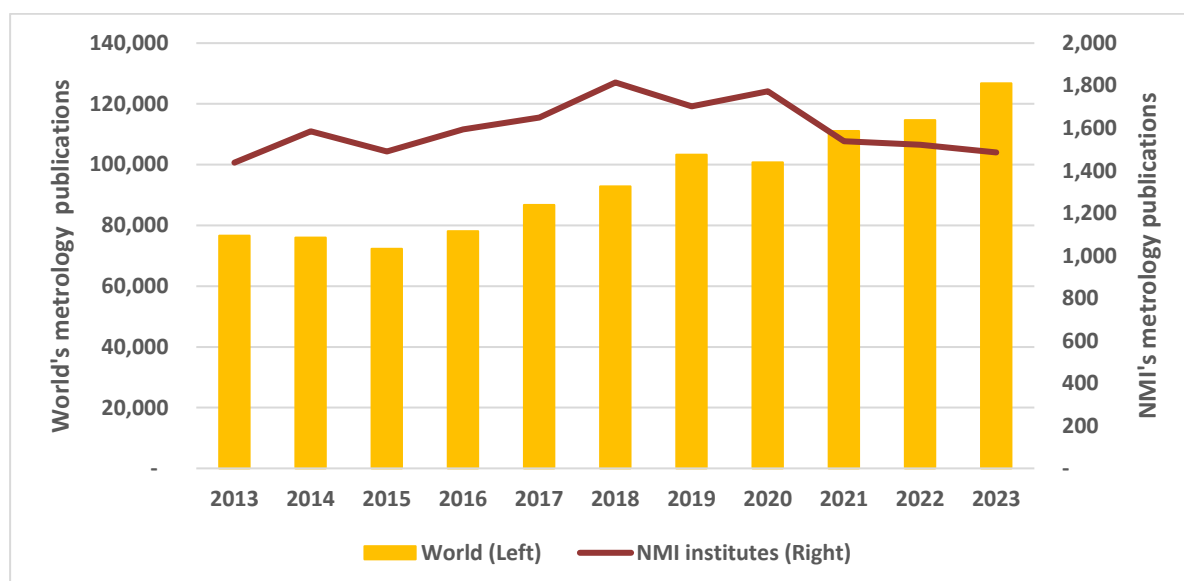


Figure 1 World's and NMIs' metrology publications over 2013-2023.

Figure 1 points out that between 2013 - 2018 total number of metrology publications produced by NMIs had an upward trend by 2018, after that year, however the trend was reversed. On the contrary, global metrology publications incrementally but constantly increased over 2015 – 2023. This phenomenon can be easily observed by looking at Figure 2 which illustrates “NMIs to World” ratio which was closer to 2% in 2014 and decreased to almost 1.2% in 2023.

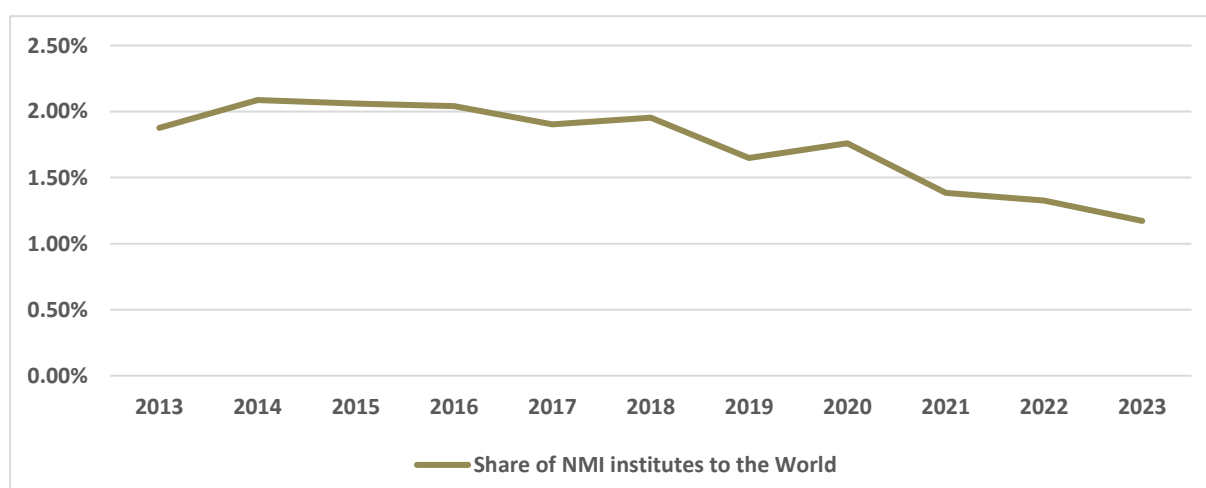


Figure 2 NMIs' metrology publications to the World's metrology publications ratio over 2013-2023.

⁷ Science-Metrix's explanation.

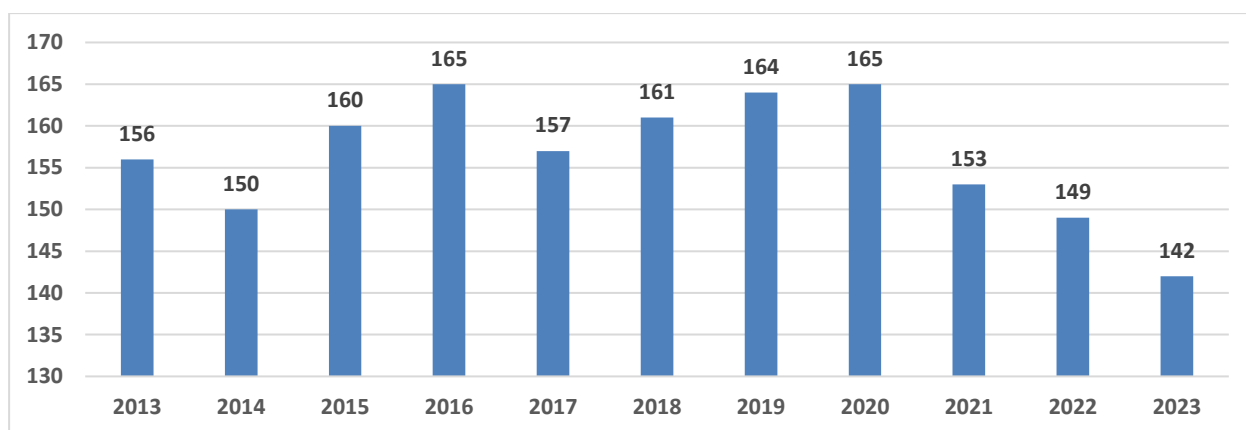


Figure 3 NPL's metrology publications over 2013-2023.

NPL's publication output in metrology research remained relatively stable over 2013 - 2023, with annual figures ranging between 142 and 165 publications. However, there is a slight downward trend in recent years, with a noticeable decrease in the number of publications from 165 in 2020 to 142 in 2023, Figure 3.

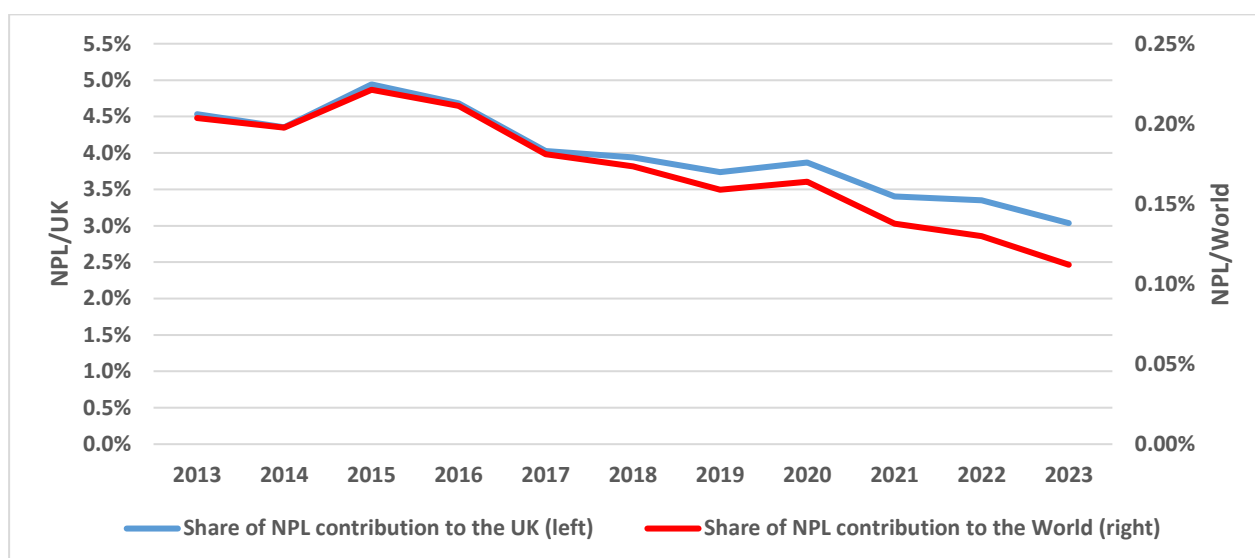


Figure 4 NPL vs. UK and the World on metrology publications over 2013-2023.

NPL's share of global publications in the field of metrology research (NPL/World) has remained consistently low at around 0.2% from 2013 to 2020, dropping to 0.1% in 2021 and remaining at that level through 2023. In contrast, NPL's contribution to UK publications in the field of metrology research (NPL/UK) has shown a steady decline, from 4.5% in 2013 to 3.0% by 2023, Figure 4.

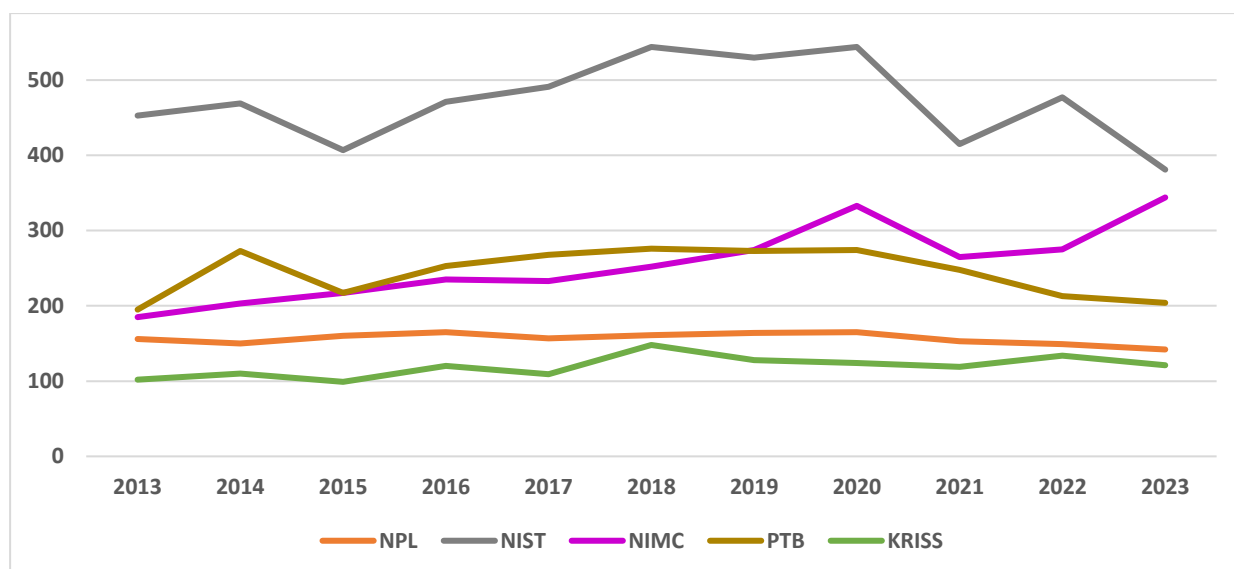


Figure 5 Selected NMIs output volumes over 2013-2023.

Figure 5 depicts the output volumes of the selected NMIs over 2013 – 2023. NIST has been the leading institute with a ten-year average of almost 450 publications. NIMC has been at the third place until 2019, after that year, it has placed at the second and from that year on it secures its second place, while producing 344 metrology papers in 2023. PTB has had a yearly average of about 250 publications. NPL has remained in the fourth place for all the years over 2013-2023, with a yearly average of around 150 metrology papers.

3.1.2 Compound Annual Growth Rate

The Compound Annual Growth Rate (CAGR) indicator measures the rate at which a given entity's production changed over a number of years, taking compounding effects into account. CAGR results in Table 2 show differing trends in publication growth. Between 2013–2017 and 2018–2022, the World and the UK saw growth, with the global CAGR increasing from 3.1% to 5.4%, while the UK's growth slowed from 3.2% to 2.1%. In contrast, NPL experienced a decline, with its growth dropping from 0.2% in 2013–2017 to -1.9% in 2018–2022. Similarly, NMI institutes saw a sharp reversal, with growth decreasing from 3.5% to -4.3% over the same periods.

Table 2 Compound Annual Growth Rate (CAGR)

Entity	Publication counts over 2013-2023	Periods	
		2013–2017	2018–2022
World	1,039,139	3.1%	5.4%
United Kingdom	43,919	3.2%	2.1%
NPL - National Physical Laboratory	1,722	0.2%	-1.9%
NMIs excluding NPL	16,328	3.5%	-4.3%
NIST - National Institute of Standards and Technology	5,182	2.0%	-3.2%
PTB - National Metrology Institute of Germany	2,694	8.3%	-6.3%
KRISS - Korea Research Institute for Standard and Science	1,314	1.7%	-2.5%
NIMC - National Institute of Metrology of China	2,816	5.9%	2.2%

3.2 COLLABORATION INDICATORS

3.2.1 International Collaboration Rate

The international collaboration rate (ICR) indicator measures the share of an entity output in international co-publications. The World ICR rate began at 16.0% for the 2013–2015 period, gradually increasing to 17.2% by 2021–2023, indicating a steady trend toward greater international collaboration in research. In contrast, the UK exhibited a significantly higher ICR, rising from 56.7% in the 2013–2015 period to a consistent 69.9% from 2021 onwards. NPL demonstrated a similar upward trajectory, with ICRs starting at 50.8% in 2013–2015 and climbing to 62.1% by 2021–2023, indicating an increasing engagement in collaborative research. However, ICRs among NMI institutes excluding NPL were notably lower, beginning at 27.3% in 2013–2015 and only reaching 30.2% by 2021–2023, Figure 6.

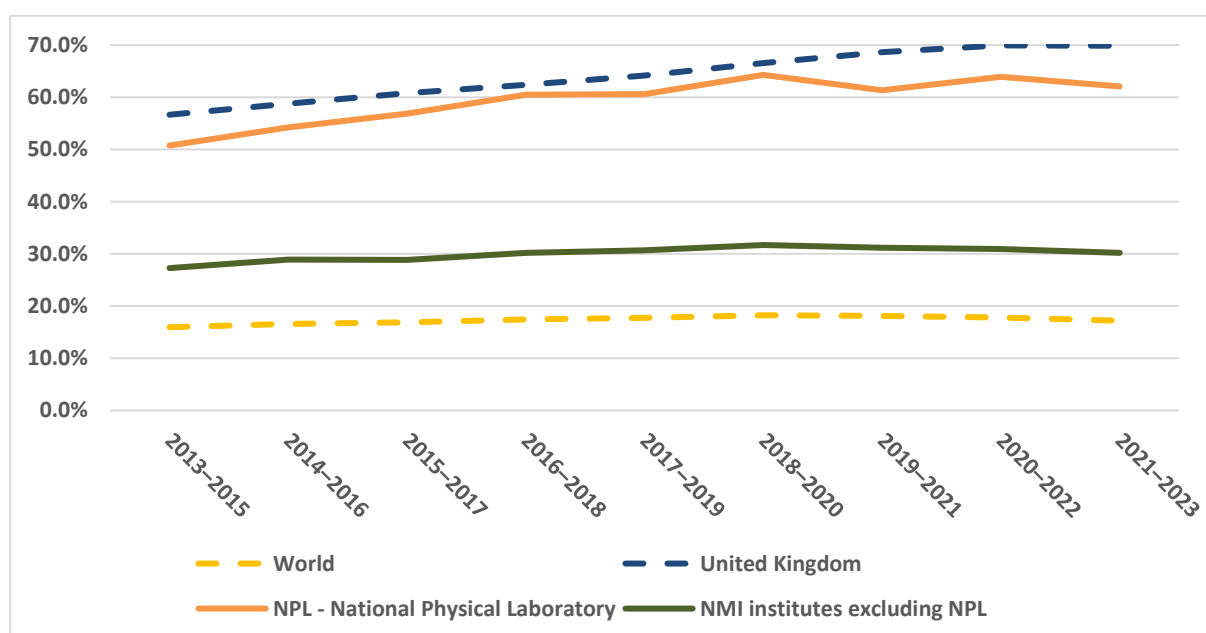


Figure 6 International collaboration rate by 3-year moving period over 2013–2023.

Figure 7 presents ICR comparison among the selected NMIs, the UK and the World. The UK leads with 64%, followed by NPL (59%), PTB (49%), NIST (36%), KRISS (31%), the World (17%) and NIMC (12%).

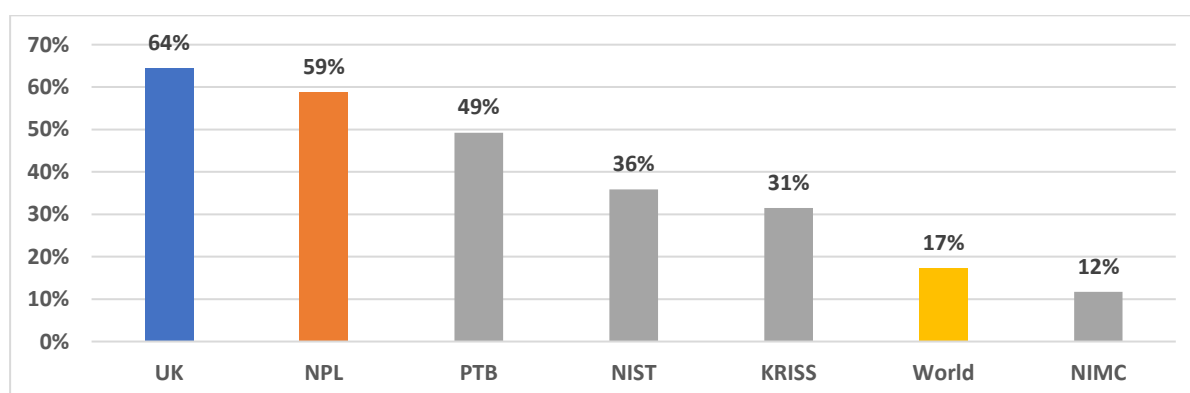


Figure 7 International collaboration rate comparison among selected NMIs, all time (2013-2023) average.

3.2.2 Public-Private Collaboration Rate

The public-private collaboration rate (PPR) indicator measures the proportion of an entity's papers that are published in collaboration between the public and private sectors. Results in Figure 8 illustrate a positive trend in PPR across various entities from 2013 to 2023. Globally, the share of public-private partnerships started at 8.3% during the 2013–2015 period and gradually increased to 9.9% by 2021–2023, indicating a modest but steady growth in such collaborations in research and innovation.

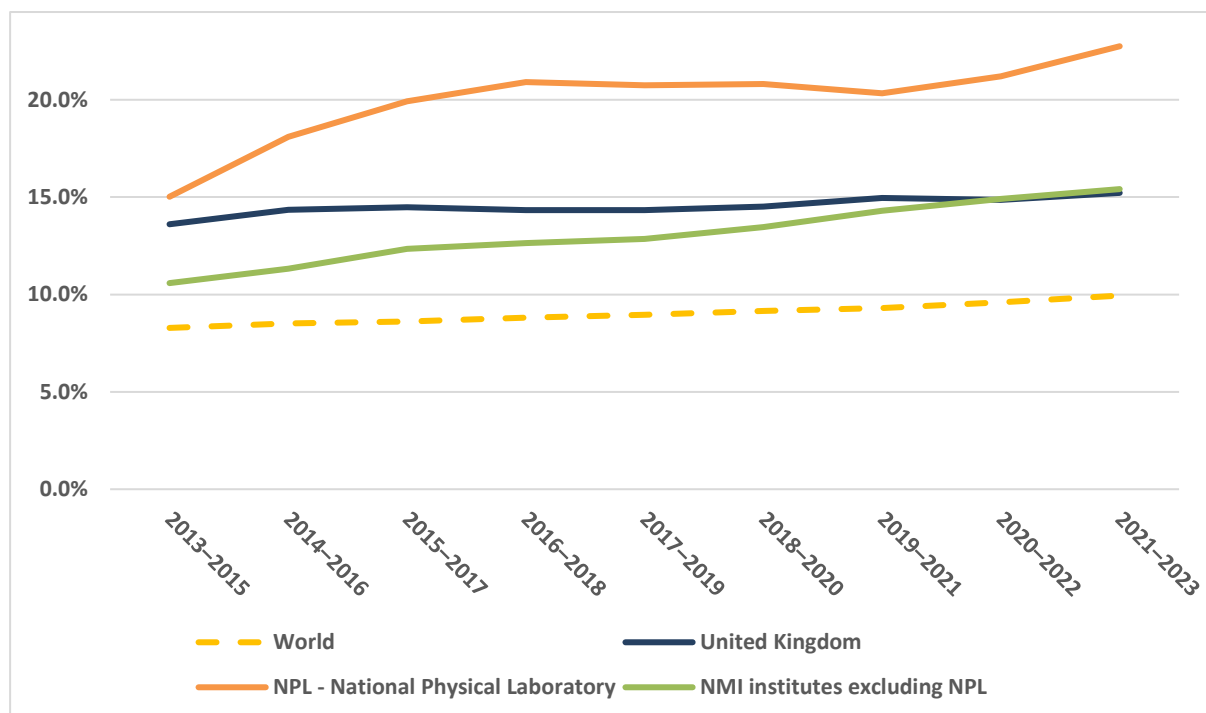


Figure 8 Public-private collaboration rate by 3-year moving period 2013–2023.

In the UK, PPR exhibited a more significant increase, rising from 13.6% in 2013–2015 to 15.2% by 2021–2023, reflecting a strong emphasis on collaborative efforts between public institutes and private sector entities. NPL's PPR increased from 15 % in 2013-2015 to 22.7% in 2021-2023. This suggests that NPL is increasingly leveraging collaborations to enhance its research impact and drive innovation, Figure 8.

3.3 CITATION INDICATORS

3.3.1 Average of Relative Citations

Average of relative citations (ARC) indicator is a citation measure normalized across fields of science and years of publication to correct for differences in the frequency and timing of citations. Figure 9 illustrates ARC scores among the selected NMIs. NPL has been above the world average (0.90) during all periods while its ARC score has been flat over 2013-2015 to 2015-2017 period, increasing over 2015-2017 to 2017-2019 period and decreasing over 2017-2019 to 2019-2021 period. In average NPL's scientific impact was 36% above the world average when all periods are concerned. Although NIST has had the highest ARC scores, it has been having a decreasing trend over 2013 - 2021.

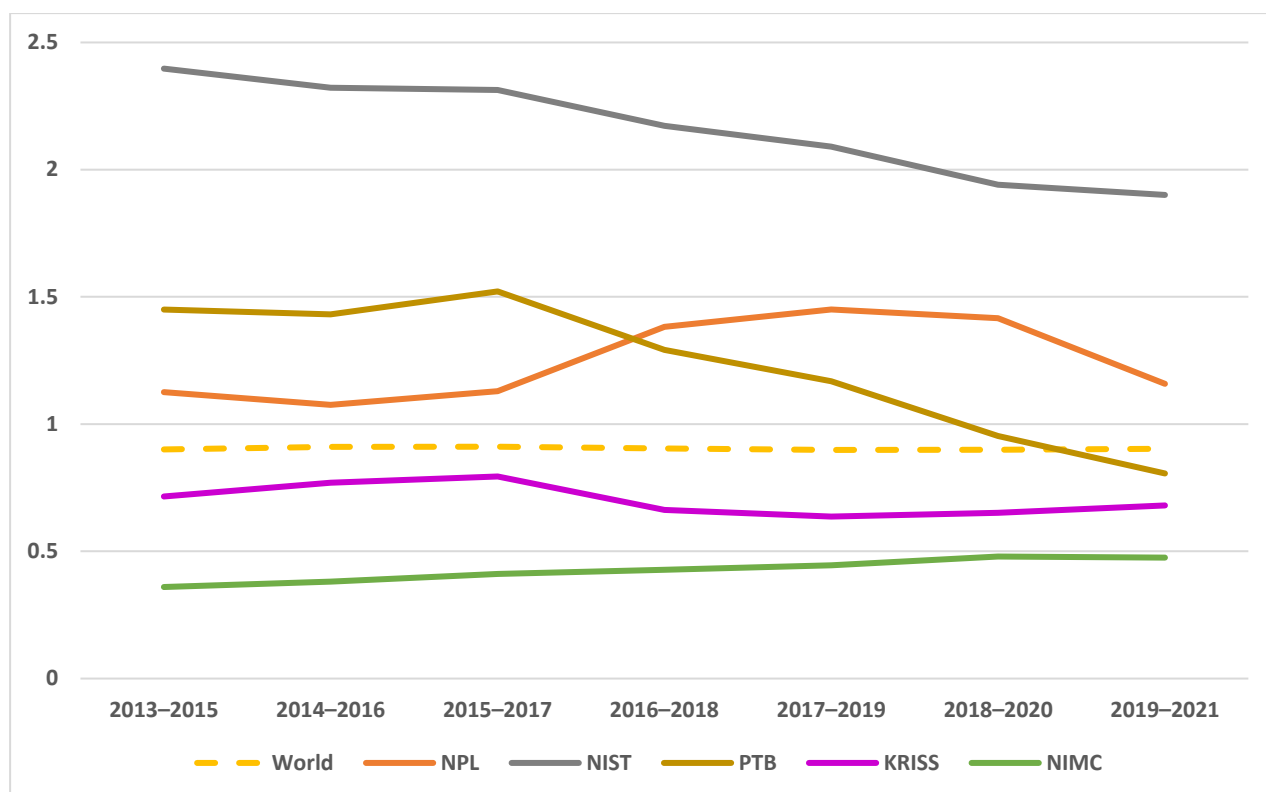


Figure 9 Avg. of relative citations (ARC) 3-year moving period over 2013–2023.

3.3.2 Field-weighted Citation Score

The Field-Weighted Citation Score (FWCS) is the ratio of the actual number of citations received by an output to date and the 'expected' number for an output with similar characteristics. 'Expected' refers to average citations over the previous three years for all the publications in Scopus' database of the same age, document type and field. FWCS shows that most NMIs reached their peak FWCS between 2016–2019, with notable declines after this period. For example, NPL's FWCS peaked at 1.27 during 2016–2018 but has since dropped to 1.05 by 2021–2023. Similarly, NIST maintained high performance, peaking at 1.77 during 2016–2018, but has also experienced a reduction, now standing at 1.58 in 2021–2023, Figure 10.

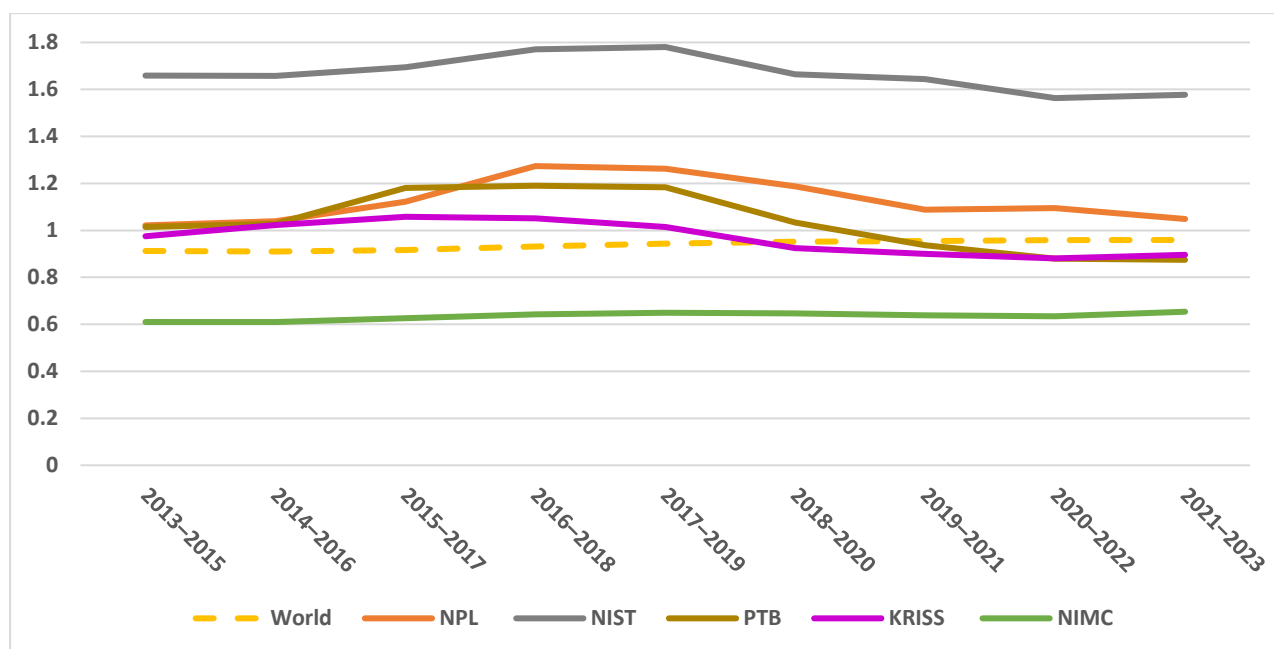


Figure 10 Field-weighted Cite Score for selected NMIs by 3-year moving period over 2013–2023.

In comparison, the UK has maintained a strong FWCS score of around 1.29 throughout, indicating consistently high research quality. PTB showed similar trends, reaching high scores around 2017–2019 but experiencing subsequent declines. NIMC's FWCS remains the lowest at 0.65, although it has shown some marginal improvement in recent years. Overall, the trend reflects a broad decline in metrology research impact post-2019, Figure 10.

3.4 ALTERNATIVE INDICATORS (ALTMETRICS)

3.4.1 Normalised Share of Publications Cited by Patents

Share of publications cited by patents (PCP) is calculated for a specific publication, by normalizing the patent citation count by publication year, subfield, and document type. Between 2013–2018, NPL's citations in patents increased significantly, reflecting growing relevance of its research to technological innovation. Initially, NPL's normalized share was negative, with -0.39 percentage points (p.p.) in 2013–2015, indicating fewer patent citations compared to global trends. However, by 2016–2018, NPL's normalized share surged to 2.43 p.p., surpassing both the UK and other NMIs excluding NPL, signalling a notable improvement in the impact of NPL research on patents, Figure 11.

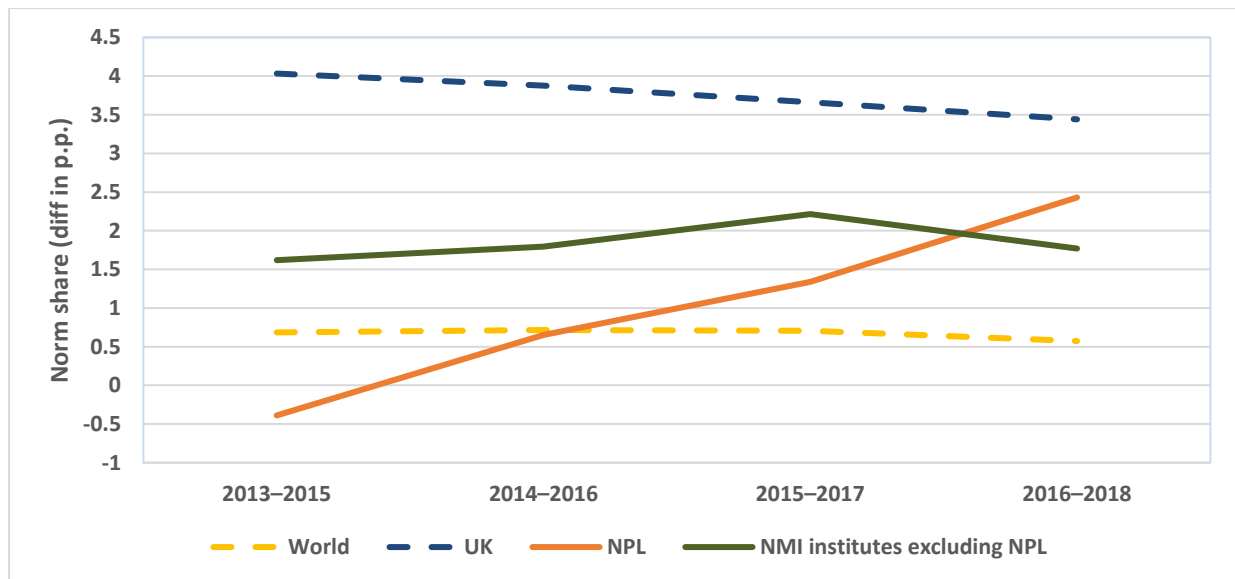


Figure 11 Norm share (diff in p.p.) cited in Patents, 3-year moving period over 2013–2023.

Figure 12 highlights PCP scores from 2013 to 2018. NPL ranks second with a PCP score of 1.046, indicating that its research is highly relevant to patent citations, just behind NIST. NIST leads with a significant share of 8.5, showing its publications are the most frequently referenced in patents.

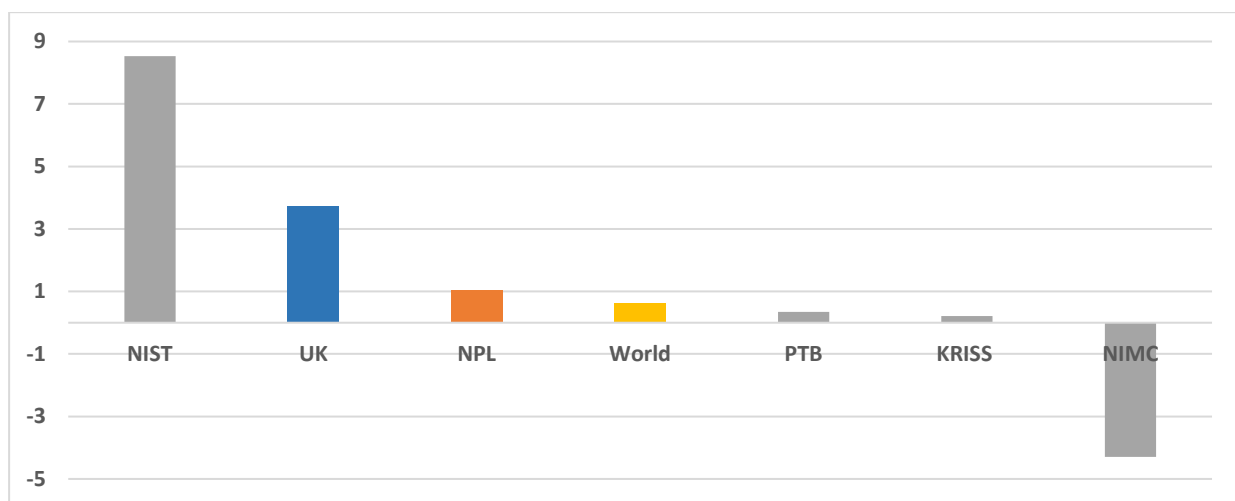


Figure 12 Normalized share of publications cited by patents among selected NMIs, all time (2013-2023) average.

Figure 13 shows PCP scores from 2013 to 2018, highlighting trends for various NMIs. NIST experienced a decline in patent uptake while dropping from 10.46 in 2015–2017 to 8.11 in 2016–2018. In contrast, NPL saw significant growth, rising from -0.39 in 2013–2015 to 2.43 in 2016–2018, closing the gap with NIST. The UK's patent uptake stands at 3.7, reflecting NPL's increasing impact.

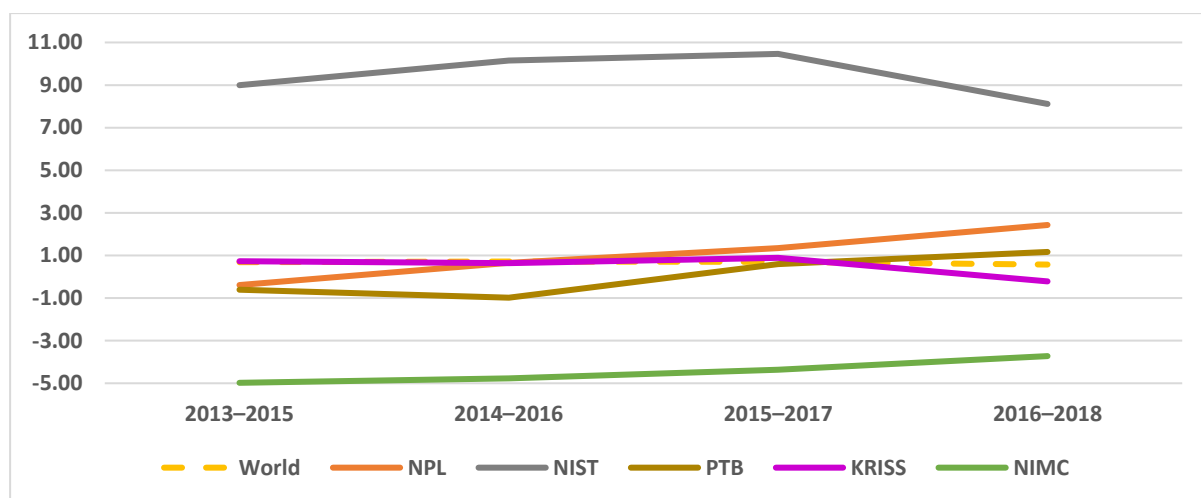


Figure 13 Normalized share of publications cited by patents for the selected NMIs over 2013–2018.

3.4.2 Normalised Share of Publications Cited by the Private Sector

Share of publications cited by the private sector (PCI) is calculated for a specific publication, by normalising the industry citations by publication year, subfield, and document type. NPL's research uptake by the private sector has remained significantly higher than the global average but has shown a steady decline over time. From 2013–2015, NPL's normalized share cited in the industry was 17.6 p.p. above the global average, demonstrating strong engagement with industry. However, by 2019–2021, this figure had decreased to 13.6 p.p., indicating a gradual reduction in private-sector citations of NPL research, Figure 14.

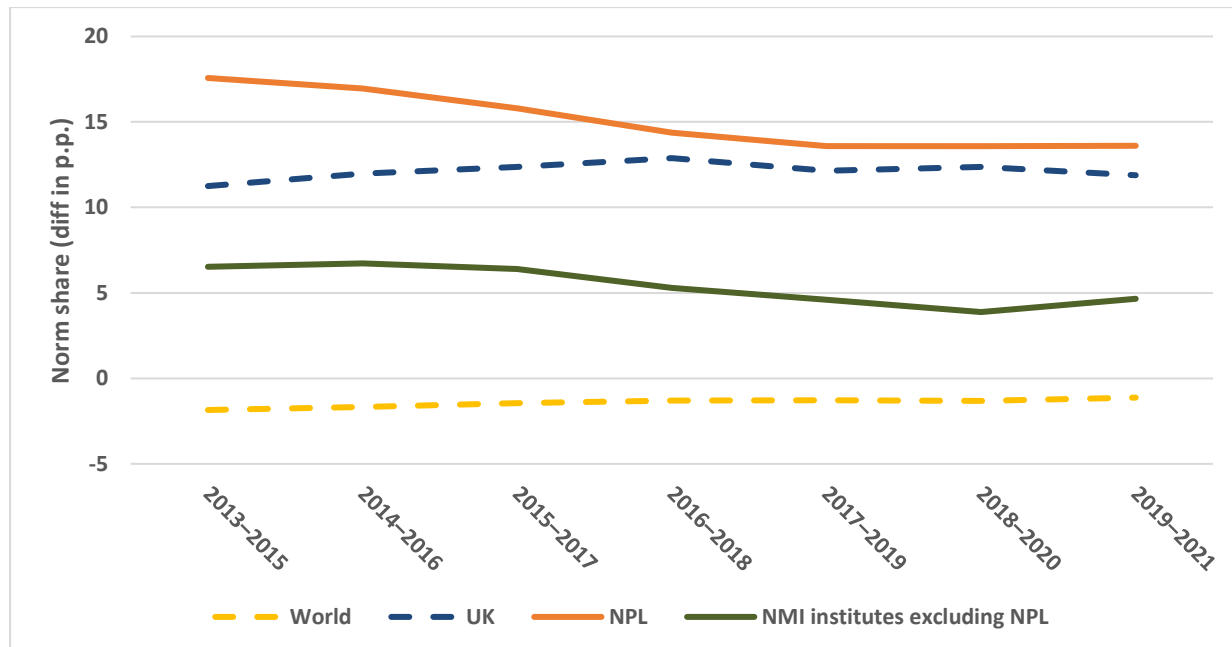


Figure 14 Norm share (diff in p.p.) cited in Private sector, 3-year moving period over 2013–2023.

Despite this decline, NPL's impact still far exceeds the global average, which remained negative throughout the period, at around -1.1 to -1.8 p.p. The UK and other NMIs excluding NPL also showed consistent engagement with the private sector, with the UK maintaining a share between 11.2 to 12.9 p.p. and other NMIs experiencing a slight decline, from 6.5 p.p. in 2013–2015 to 4.6 p.p. in 2019–2021, Figure 14.

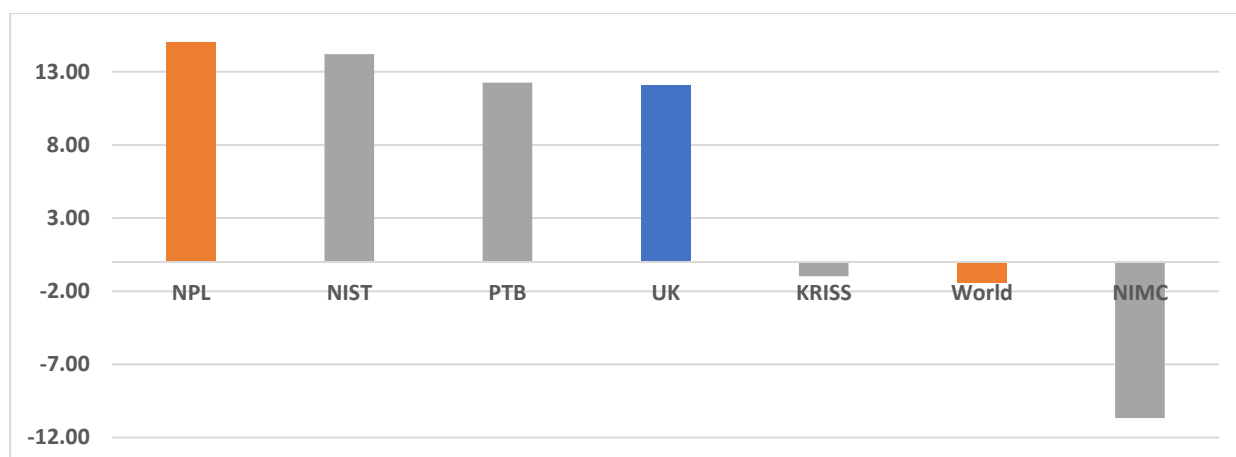


Figure 15 Normalized share of publications cited by the private sector among selected NMIs, all time (2013-2023) average.

Figure 15 highlights PCI scores from 2013 to 2021. NPL leads with a share of 15.2, showing the highest uptake of its research by private companies, followed closely by NIST (14.2). PTB (12.3) also performed strongly, scoring above the World average of -1.4.

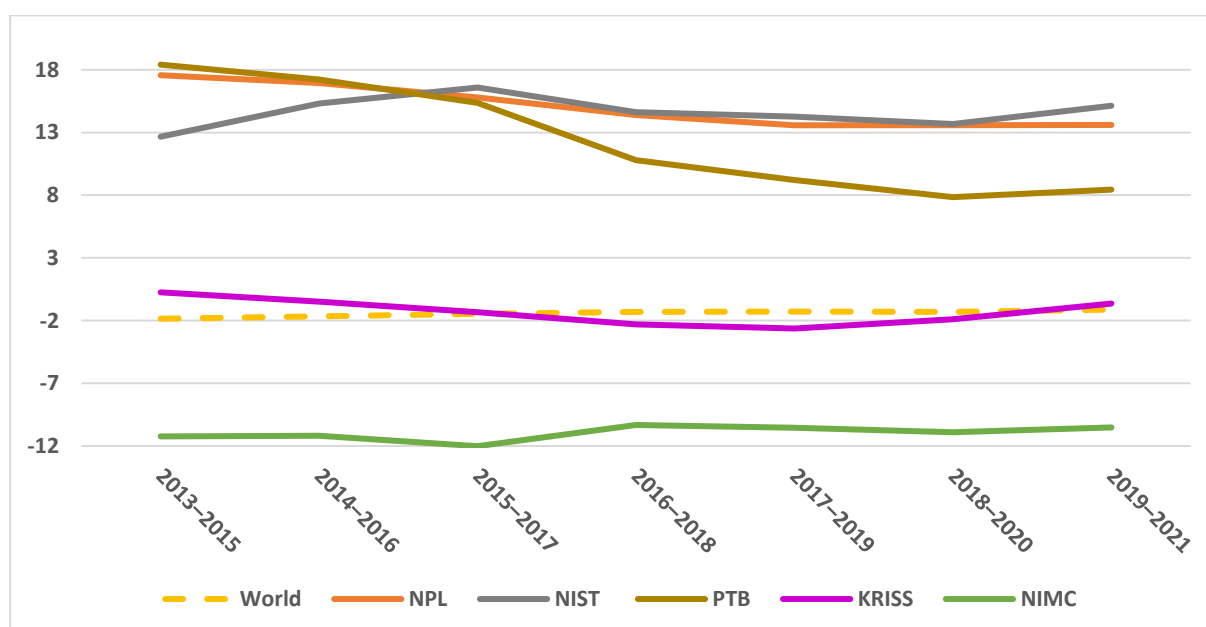


Figure 16 Normalized share of publications cited by the private sector over 2013–2021.

Figure 16 illustrates the trends in PCI scores from 2013 to 2021. NPL consistently led in earlier periods, dropping from 17.6 in 2013–2015 to 13.6 in 2019–2021, with NIST surpassing NPL in the final period at 15.1. PTB fell from 18.4 to 8.5. KRISS showed negative trend while rebounding slightly.

3.4.3 Normalized Share of Publications Cited in Policy-relevant Literature.

Share of publications cited in policy-relevant literature (PCPL) is calculated for a specific publication, by normalising the policy documents citations by publication year, subfield, and document type. NPL's research has demonstrated a strong and consistent uptake in PCPL over time, significantly outperforming both the global average and other NMIs. From 2013–2015, NPL's PCPL was 3.8 p.p. above the global average, and this increased to a peak of 6.0 p.p. during 2017–2019, reflecting its growing influence in policy-related discussions. However, by 2019–2021, this figure declined to 3.9 p.p., showing some decrease in policy

citations. In contrast, the global average remained negative throughout the period, fluctuating between -0.7 p.p. and -0.4 p.p.. The UK maintained a steady increase, reaching a peak of 1.7 p.p. in 2016–2018 before slightly declining Figure 17.

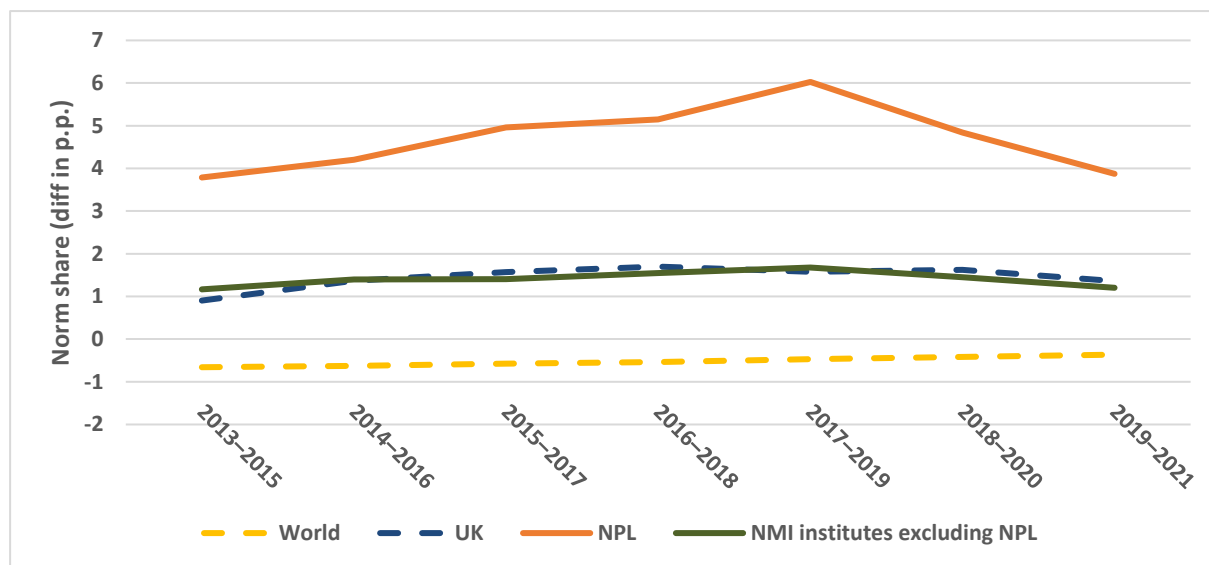


Figure 17 Norm share (diff in p.p.) cited in Policy literature, 3-year moving period over 2013–2023.

Figure 18 shows PCPL scores from 2013 to 2021. Among the selected NMIs, NPL ranks first with a score of 4.3. PTB and NIST follow with 2.5 and 2.3, respectively.

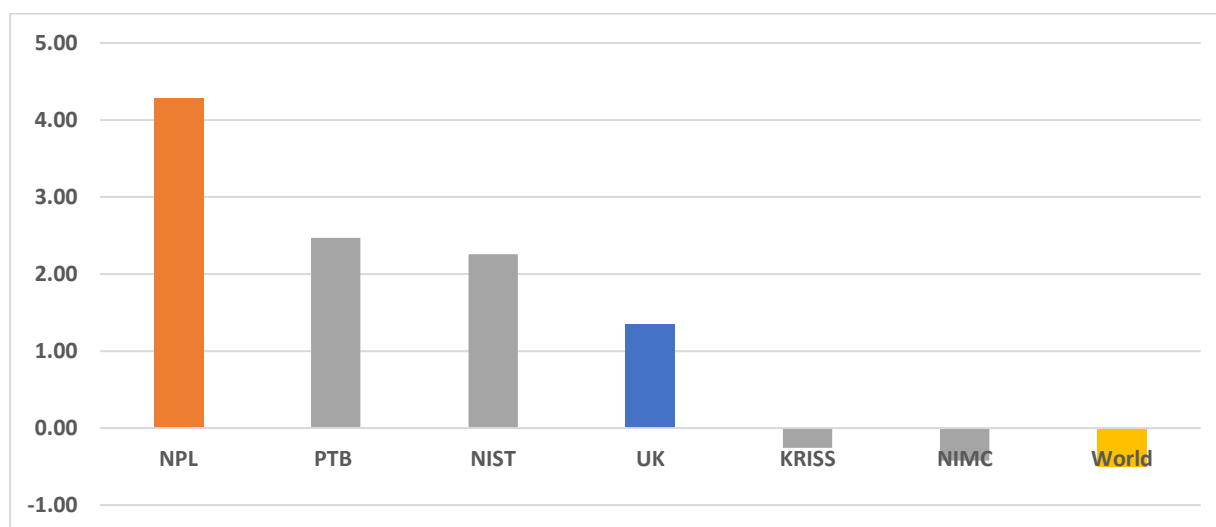


Figure 18 Normalized share of publications cited by policy literature among selected NMIs, all time (2013–2023) average.

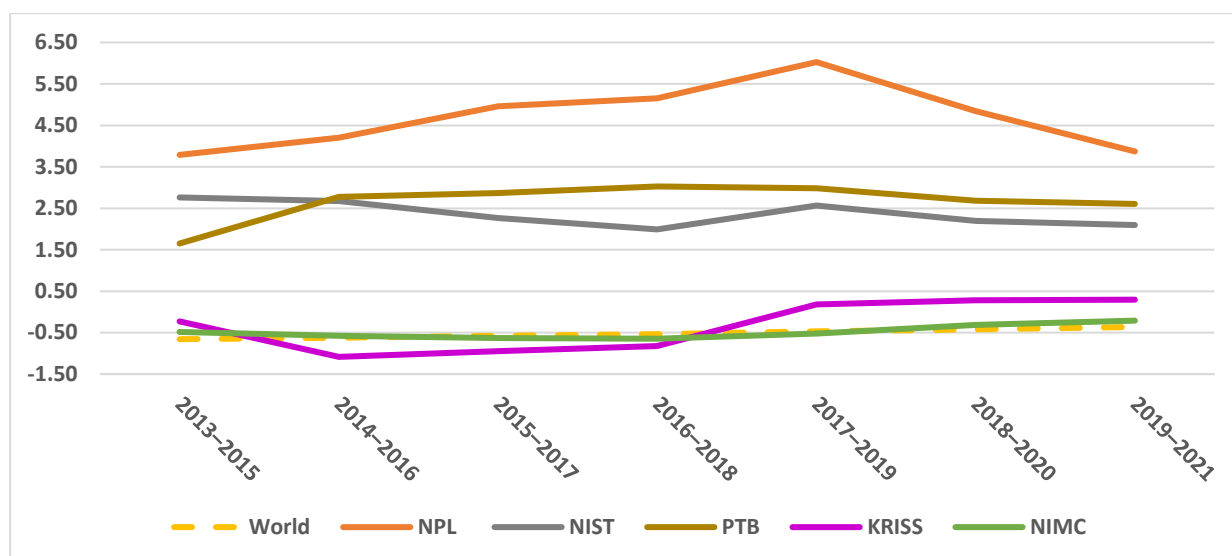


Figure 19 Normalized share of publications cited by policy literature for selected NMIs over 2013–2021 – trends.

Between 2013 and 2021, NPL consistently led in PCPL, peaking at 6.03 during 2017–2019 before declining to 3.87 by 2019–2021. NIST's share decreased from 2.76 in 2013–2015 to 2.09 in 2019–2021. PTB saw an increase, peaking at 3.03 in 2016–2018, then slightly declining to 2.60 by 2019–2021. KRISS improved from negative values, reaching 0.29 by 2019–2021. NIMC's share remained negative throughout, though it improved from -0.66 in 2013–2015 to -0.21 by 2019–2021. The global average also showed a steady increase, moving from -0.66 to -0.36 over the same period, Figure 19.

3.5 TOPIC CLUSTERS

Topic-clusters are Scopus aggregators of publications with similar research topics, were utilized to identify research niches. These clusters are named using three specific terms found among their publications, providing insight into the content of each cluster (e.g., Photonics; Optical Resonator; Nonlinear Optics). The study identified key and emerging research topics in metrology for both NPL and all NMIs grouped together, based on two criteria: the number of metrology publications (key topic-clusters) and their growth trends (emerging topic-clusters). A positional chart combining information on scientific impact, specialization, output size, and growth rate was used to identify the strengths and potential future strengths of NPL and all NMIs grouped.

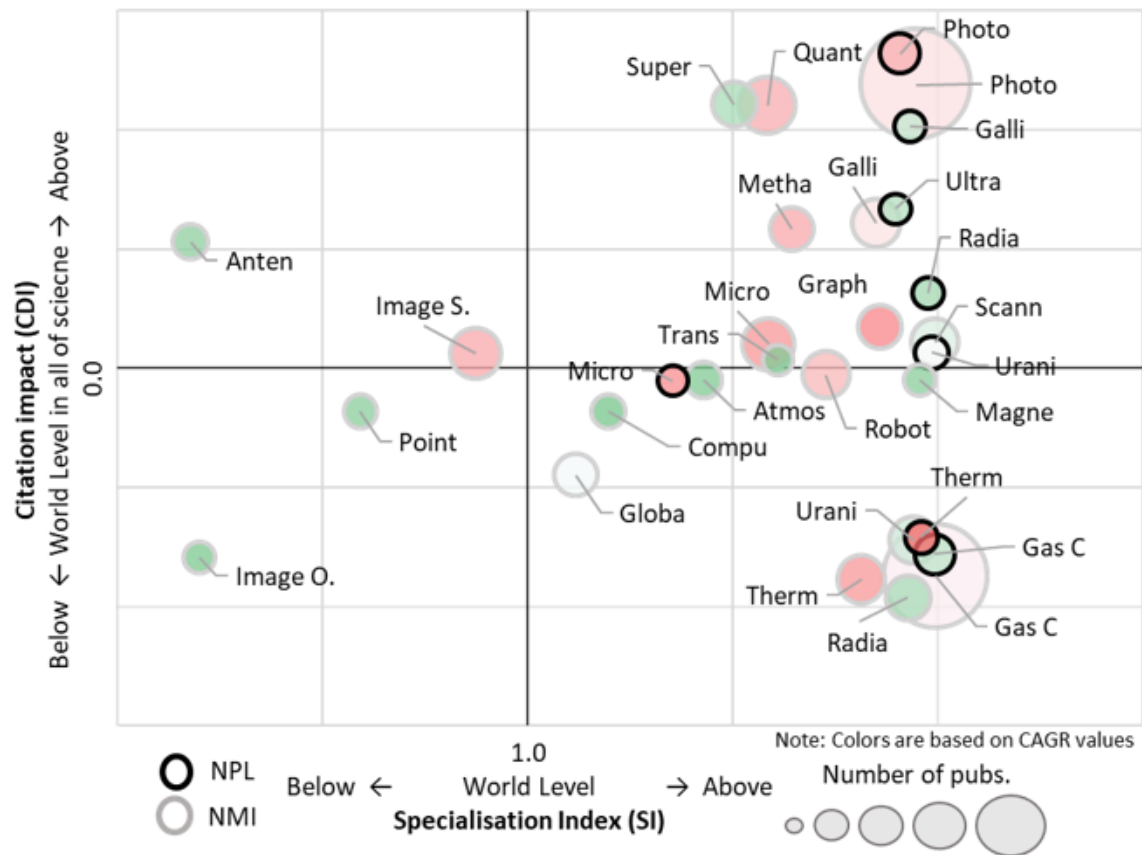


Figure 20 Key & Emerging Topic-Clusters in Metrology, NPL and all NMIs grouped over 2013–2023.

NPL and other NMIs share the same top two key topic-clusters by publication volume: "Photonics; Optical Resonator; Nonlinear Optics" and "Gas Chromatography; Tandem Mass Spectrometry; Ultrasonics." In terms of emerging topic-clusters, NPL's top area of growth is "Radiation Therapy Planning; Computed Tomography; Imaging Phantom," which has a CAGR of 10.3%. This highlights both the current strengths and the rapidly developing areas of research within NPL and the broader metrology community, Figure 20.

4 CONCLUSION

From 2013 to 2023, NPL's metrology publication output remained stable, ranging from 142 to 165 annually. However, its global publication share dropped to 0.1% in 2021, and its UK share declined from 4.5% to 3.0%. NPL's CAGR fell from 0.2% to -1.9%, and it ranked fourth in output volume among five major institutes, peaking at 165 publications but declining to 142 by 2023.

During the same period, NPL's ICR score increased from 50.8% to 62.1%, highlighting its growing engagement in collaborative research. This trend underscores NPL's prominent role in fostering global research partnerships, with a ten-year average ICR score of 59%. NPL also demonstrated the highest engagement in public-private partnerships, with its PPR score rising from 15.0% to 22.7%, emphasizing its efforts to enhance research impact and drive innovation.

The results from FWCS analysis show that most NMIs peaked in scientific impact between 2016 and 2019, with declines afterward. NPL's FWCS peaked at 1.27 in 2016–2018 but dropped to 1.05 by 2021–2023. Between 2013 and 2018, NPL's citations in patents (PCP) increased significantly, rising from -0.39 p.p. to 2.43 p.p., highlighting its growing impact on technological innovation. From 2013 to 2021, NPL's research uptake by the private sector (PCI) remained significantly higher than the global average, though it showed a steady decline. NPL's normalized share cited in the private sector dropped from 17.57 p.p. above the global average in 2013–2015 to 13.61 p.p. in 2019–2021.

NPL's research consistently showed strong uptake in policy literature, significantly outperforming the global average and other NMIs. Its PCPL score peaked at 6.0 p.p. above the global average during 2017–2019, before declining to 3.9 p.p. by 2019–2021. NPL and other NMIs share the top two key topic-clusters: "Photonics; Optical Resonator; Nonlinear Optics" and "Gas Chromatography; Tandem Mass Spectrometry; Ultrasonics." NPL's top emerging topic-cluster is "Radiation Therapy Planning; Computed Tomography; Imaging Phantom," with a CAGR of 10.3%.

ANNEX: NATIONAL METROLOGY INSTITUTES

Acronym	Entity
BEV	Federal Office of Metrology and Surveying of Austria
CEM	Spanish Metrology Centre
CMI	Czech Metrology Institute
DFM	Danish National Metrology Institute
GUM	Central Office of Measures
IMBiH	Institute of Metrology of Bosnia and Herzegovina
INM	Romanian National Institute of Metrology
INRIM	National Institute of Metrological Research of Italy
IPQ	Portuguese Quality Institute
Justervesenet	Norwegian Metrology Service
KRISS	Korea Research Institute for Standard and Science
LNE	National Metrology and Testing Laboratory of France
METAS	Swiss Federal Institute of Metrology
Metrosert	Metrosert AS
MIKES	Centre for Metrology and Accreditation of Finland
MIRS	Metrology Institute of the Republic of Slovenia
NIMC	National Institute of Metrology of China
NMIJ	National Metrology Institute of Japan
NIST	National Institute of Standards and Technology
NPL	National Physical Laboratory
OMH	National Metrology Institute of Hungary
PTB	National Metrology Institute of Germany
RISE	Research Institutes of Sweden
SMD	FPS Economy, SMEs, Middle Classes, and Energy
SMU	Slovak Institute of Metrology
SP	Technical Research Institute of Sweden
TUBITAK UME	Turkish National Institute of Metrology
VSL	Dutch Metrology Institute