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The UK-Japan relationship:

collaboration in higher education, research and innovation

Contents

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Executive summary

Strengthening collaboration with other world-leading research and innovation nations is at the heart of the UK's Research and Development (R&D) roadmap and the 2021 Integrated Review[1]. Similarly, the Japanese Government is committed to enhancing collaboration in R&D with other global leaders in science, research and innovation.

Traditionally, the UK and Japan share a strong relationship in business, diplomacy, science and technology. Undoubtedly, there is scope to build on these strong foundations to increase the scale, scope and impact of our research and innovation collaborations.

This report:

- Describes the key features of the Japanese higher education and research landscape.
- Highlights the important role of universities in the domestic R&D environment in both Japan and the UK.
- Outlines current levels of collaboration in the context of both countries' domestic R&D performance.
- Expands on the existing opportunities for collaboration in science and innovation and explores future possibilities in a bilateral and a multilateral context.

The report shows that, while UK–Japan ties in R&D are demonstrably strong, enhanced cooperation will benefit both sides. Government funding already plays an important role in the advancement of UK–Japan strategic partnerships and is expected to contribute to both countries' R&D strategies in the long term. However, existing frameworks for research collaboration could be further strengthened through increased funding for research in the fields of science, technology and innovation, in particular where there are complementary strengths and interests. Meanwhile, building a greater number of alliances between UK and Japanese higher education institutions would generate benefits for researchers from both sides, supporting the delivery of world-leading research and providing greater access to global business innovation networks.

[1] UK Research and Development Roadmap; The Integrated Review 2021 - GOV.UK (www.gov.uk)

1. Introduction

The UK and Japan have diverse, high-quality higher education systems that foster international collaboration in science and research. Both countries are global research and innovation powerhouses and share a strong bilateral relationship, developed through direct collaboration, inter-institutional partnerships and, more rarely, by consortia of institutions.

In October 2020, the UK and Japan signed the UK–Japan Comprehensive Economic Partnership Agreement[2]. As such, Japan was the first nation to sign a significant trade deal with the UK as an independent trading nation. The agreement demonstrates both countries' ambition to work closely together in trade, financial services and the creative industries.

In recent years, a key goal for UK science and innovation has been to strengthen and diversify its international partnerships. Science, research and innovation also feature at the centre of the country's post-Covid socioeconomic recovery plan and strategy for future international engagement.[3]

Meanwhile, Japan continues to diversify its academic body, attract more international students, and further develop international cooperation in science and research.[4] The current policy environment in both countries favours innovation and investment in international cooperation.

University collaboration is a driving force for sustainable and effective partnerships between nations in science, research, and innovation. This report assesses the current levels of research collaboration between the UK and Japan and suggests future opportunities for cooperation between the two countries.

The first section outlines the characteristics of the Japanese higher education system. The second assesses the research and innovation landscape in both Japan and the UK. This is then followed by a summary of Japanese cooperation in science and innovation with international partners. The last two sections present current levels of engagement in joint research between the UK and Japan and review the opportunities to enhance the level of collaboration. Case studies of programmes and funding opportunities that support UK–Japan collaboration are included at the end of this report to highlight their positive impact on research and innovation.

[2] UK-Japan Comprehensive Economic Partnership Agreement
[3] The Integrated Review 2021
[4] Porter, S., Wastl, J., Hook, D., Japanese Collaboration in the Global Research Landscape, Digital Science, 11 February 2019

2. Higher education and research in Japan: an overview

Summary:

- The Japanese higher education system is well developed, highly autonomous and a world leader in various disciplines.
- Public funding for higher education is increasing every year in Japan.
- Japan has a clear ambition to build on its world-leading position in higher education with recent policy reforms aimed at supporting its higher education sector to answer global societal, health and economic challenges.
- The internationalisation of higher education has been supported by several government initiatives; however, student mobility remains relatively low.
- Future challenges to higher education include a shrinking population limiting the potential pool of students entering higher education.

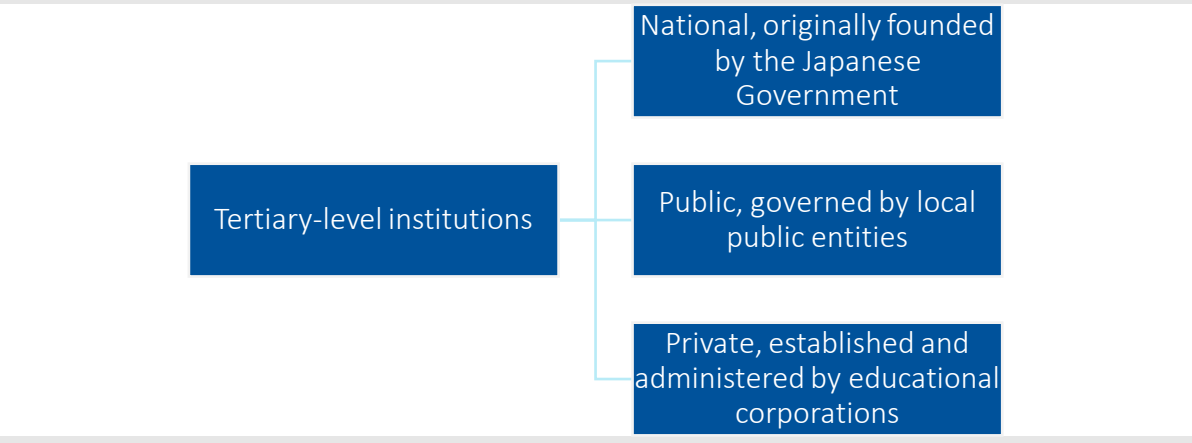
2.1 Structure of the higher education system in Japan

Japan's higher education system is well developed, academically rigorous and autonomous. Institutions offer varied courses and disciplines, and many have outstanding reputations for academic excellence. While both public and private bodies fund institutions, they retain relative independence over internal decision-making, curriculum design and awards.

Japanese tertiary-level institutions are classified into three types based on their founding principles and administration: specialist schools (senmon gakko), universities, and short-term universities or colleges of technology (kosen). In general, the Japanese education system is selective, and the admission process is relatively complex compared to other high-income countries.

As shown in Figure 1, Japan's tertiary-level institutions fall into three administrative models: national, public or private. Figure 2 sets out the various types of tertiary qualification in Japan.

FIGURE 1: TERTIARY-LEVEL INSTITUTIONS IN JAPAN



Source: World Education News and Reviews, Education in Japan, 18 February 2021

FIGURE 2: TYPES OF QUALIFICATION IN JAPAN

Associate degree	• Completion of Junior College (at least two years) or College of Technology (at least five years)
Technical associate degree	• Completion of a post-secondary course accredited by the Ministry of Education, Culture, Sports, Science and Technology (MEXT)
Bachelor's degree	• Completion of an undergraduate course
Master's degree	• Completion of a postgraduate course
Doctorate	• Completion of a doctoral programme

Source: Higher Education System in Japan

Japan has a large and high-quality higher education sector. In 2021, there were 795 universities, 80% of which are private.[5] There were 2.92 million students enrolled in universities in 2020, up slightly from 2.88 million students in 2012.[6] However, Japan's declining population means that fewer students are graduating from senior high school each year, limiting the potential pool of students entering higher education in future

[5] Number of national, public, and private universities in Japan from 2011 to 2020, accessed 10 June 2021
[6] Number of students enrolled at universities in Japan from 2011 to 2020; https://www.statista.com/statistics/647929/japan-number-university-students/

years. A decline in enrolment figures is anticipated to have significant implications for the higher education sector.

Growth in outward student mobility has been supported by the 'Tobitate! Ryugaku Japan' campaign, launched in 2013 by the Japanese Government, which aimed to double the number of Japanese students studying abroad from 60,000 in 2010 to 120,000 by 2020. However, overall outward student mobility remains relatively limited. According to the Japan Association of Overseas Studies' (JAOS) 2021 Survey on the Number of Japanese Studying Abroad,[7] the number of Japanese students studying abroad was 77,953 in 2019.[8] This represents a contraction from 2018, when an estimated 80,556 students studied abroad. The numbers saw a further unprecedented contraction due to Covid-19 in 2020, dropping to just 18,374.

The latest data from Japan's annual International Students Survey shows that in 2020 there were 279,597 international students[9] studying in Japan in all types of courses, at all levels of study.[10] This represents a 10.4% decrease from 2019, when 312,214 international students studied in Japan.[11]

2.2 Regulation of higher education

Japan's higher education sector is regulated by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). In the case of private institutions, the minister seeks advice from the Council for University Chartering and School Corporation, established within MEXT, which reviews the quality of institutions based on the 'Standards for the Establishment of Universities' and 'Standards for the Establishment of Junior Colleges' set by the Ministry. These standards include primary requirements for university management, the selection of students, staff qualifications and educational programmes.

[7] https://www.jaos.or.jp/wp-content/uploads/2021/06/JAOS-Survey2021_210611_en.pdf
[8] https://www.felca.org/jaos-2021-survey-on-the-number-of-japanese-studying-abroad/
[9] International student in this survey is defined as a foreign student who is granted the status of residence as a 'College Student' in Japan.
[10] https://www.studyinjapan.go.jp/en/statistics/zaiseki/data/2020.html
[11] Results of an Annual survey of International Students in Japan, 2020, published March 2021, available at: https://www.studyinjapan.go.jp/en/statistics/zaiseki/data/2020.html

2.3 Funding for higher education

One of the notable characteristics of Japan's higher education funding is the low level of public expenditure on higher education relative to the size of the total economy. The Japanese Government, through MEXT, contributes to the public funding of higher education institutions through several channels, including institutional and non-institutional funding. The overall share of public expenditure on higher education institutions, 1.6% in 2018, was one of the lowest in the OECD[12]. This figure as a percentage of GDP in Japan equates to 0.4%.[13]

Private expenditure is the main source of funding for the Japanese higher education sector. The share of private expenditure on higher education, reaching 68% in 2018, is among the highest in the OECD[14]. This figure as a percentage of GDP equates to 0.9%.[15] Tuition fees in public institutions in Japan are among the highest for a Bachelor's programme across OECD countries. In Japan, the average debt a student has upon graduation is JPY 3,673,684 (GBP 21,951) .[16]

While public expenditure on higher education is limited, education (at all levels) and science jointly receive one of the largest budgets of the national government's general account, with total expenditure reaching JPY6.8 trillion in 2021, representing 5.4% of total government spending.[17]

2.4 Funding agencies

The primary funding agencies for R&D in Japan are the Japan Society for Promotion of Science (JSPS), Japan Science and Technology Agency (JST), Japan Agency for Medical Research and Development (AMED) and New Energy and Industrial Technology Development Organization (NEDO).

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[12] OECD, Education at Glace 2021, available at: Education at Glance, 2021 What is the total public spending on education? | Education at a Glance 2021: OECD Indicators | OECD iLibrary (oecd-ilibrary.org)
[13] https://www.statista.com/statistics/707557/higher-education-spending-share-gdp/
[14] https://data.oecd.org/eduresource/private-spending-on-education.htm
[15] https://www.statista.com/statistics/707557/higher-education-spending-share-gdp/
[16] OECD, Education at Glance 2020, p.293, available at: OECD iLibrary | Education at a Glance 2019: OECD Indicators (oecd-ilibrary.org)
[17] This budget focuses on the promotion of culture, education and science in Japan. More details: https://www.mof.go.jp/english/policy/budget/budget/fy2021/02.pdf

While JSPS takes a bottom-up approach to funding R&D, JST, AMED and NEDO follow a top-down procedure, as illustrated in Figures 3 and 4, below.

JSPS's funding strategy focuses on grants-in-aid for scientific research and the provision of fellowships for inbound and outbound researchers to foster international collaboration. JST finances projects that implement national science and innovation policies. NEDO, in association with the Ministry of Economy, Trade and Industry, promotes R&D and the commercialisation of industrial technologies. AMED funds R&D in medicine, from basic research to clinical trials.[18]

FIGURE 3: JSPS'S BOTTOM-UP APPROACH TO R&D FUNDING

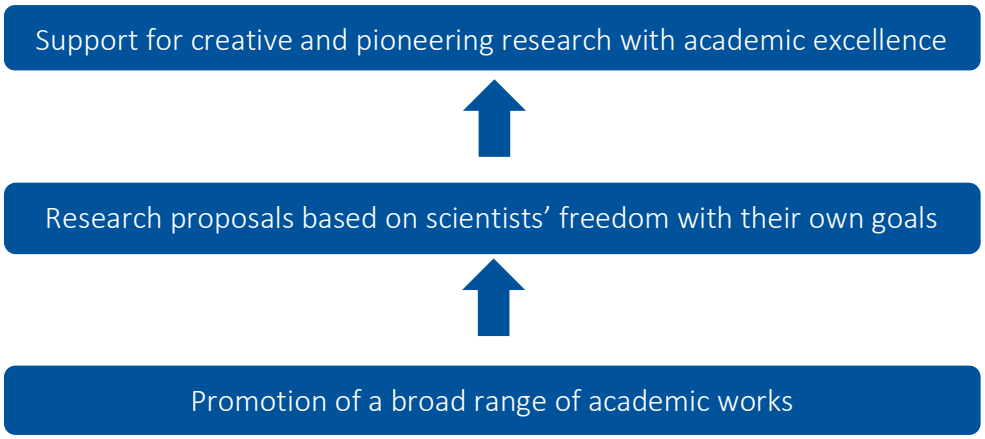
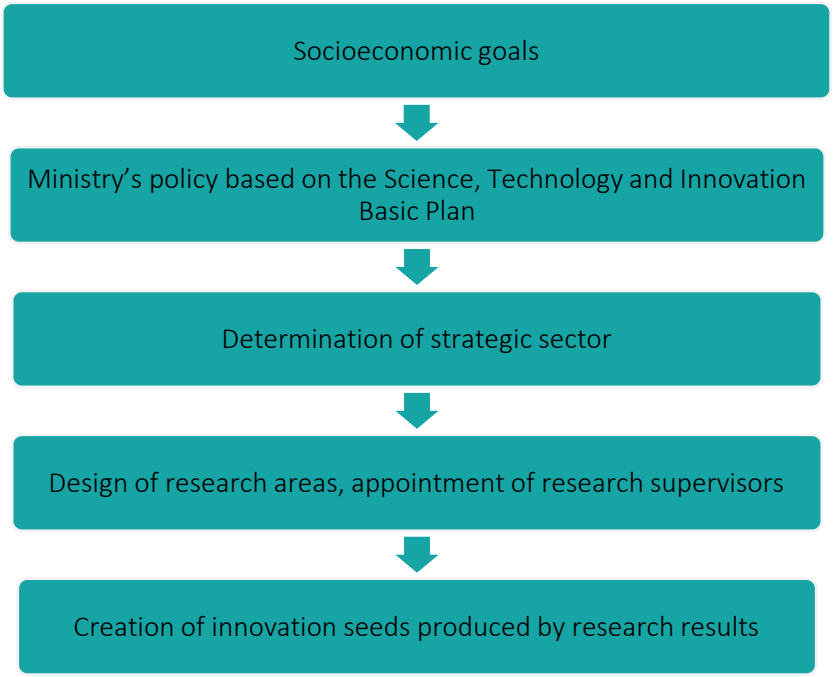


FIGURE 4: JST, AMED AND NEDO'S TOP-DOWN FUNDING APPROACH



[18] UK Science & Innovation Network Country Snapshot: Japan

2.5 Recent higher education and research policy reforms

Over the past three decades, the Japanese Government has been focussing on improving the quality, diversity, and impact of higher education through the implementation of internationalisation policies. One of the first efforts to attract international students was the '100,000 foreign students plan', launched in 1983.[19]

Policies such as the Inter-University Exchange Project (Reinventing Japan Project), the Project for Promotion of Human Resources Development, and the Global 30 Project – Establishing University Network for Internationalization, were among MEXT's internationalisation initiatives that ran in 2011 and 2012.

Since 2012, the Japanese Government has introduced a number of internationalisation policies for the higher education sector which aim to increase students' exposure to international experiences, develop international student exchange programmes, and incentivise foreign researchers and academics to join Japanese institutions.[20] Some of these are described below.

2.5.1. The Top Global University Project

The Top Global University Project[21] aims to encourage an elite group of 37 Japanese universities to advance collaboration with international partners and to rise in the global rankings. The project is set to run from 2014 to 2023, and focuses on intensifying institutional autonomy, increasing the competitiveness of Japanese institutions, and encouraging growth in strategic funding for research and development for higher education institutions.

2.5.2 'Tobitate! Study Abroad Japan'

The 2013 initiative 'Tobitate! Study Abroad Japan'[22] supported the internationalisation of the domestic higher education environment via student exchanges. Mobility at the student level is an important step in fostering internationalisation of the research environment as it provides the opportunity for future researchers to build connections and experience abroad. Its original goal was to increase the number of mobile students from 60,000 in 2010 to 120,000 by 2020; this timeframe has since been extended due

[19] Higher Education in Japan Higher Education Bureau, Ministry of Education, Culture, Sports, Science and Technology
[20] Support for Internationalization of Universities, MEXT Japan
[21] https://tgu.mext.go.jp/en/
[22] https://tobitate.mext.go.jp/about/

to disruption caused by the global pandemic. However, even before the pandemic its success has been limited, with numbers peaking at 80,556 mobile students in 2018.

2.5.3 Fifth Science and Technology Basic Plan

The Japanese Government's commitment to expanding investment in domestic technology and science was manifested in the Fifth Science and Technology Basic Plan,[23] which covered the fiscal years 2016 to 2021. It set out the following aims:

- To achieve public R&D investment of 1% of GDP, i.e., JPY 26 trillion (GBP 169 billion).[24]
- To achieve combined private and public R&D investment at 4% of GDP.
- To invest in 'Society 5.0': the integration of cyber and physical spaces using artificial intelligence, the Internet of Things, robotics and big data.

Another key objective was the construction and maintenance of infrastructure, alongside natural disaster prevention and reduction technologies.

2.5.4 Moonshot Research and Development Program

In January 2020, the Government of Japan announced its Moonshot Research and Development Program,[25] which aims to attract talent, to promote ambitious R&D projects, and to develop innovative solutions for domestic and global societal challenges by fostering cutting-edge science and technology.

The programme sets out seven goals:

- To create a society in which everyone can participate in various activities.
- To prevent diseases.
- To build a society in which humans and robots coexist.
- To support a cool Earth and a clean Earth.
- To ensure sustainable food supply without food loss or environmental loading.
- To establish a universal quantum computer that will dramatically revolutionise society.
- To establish a sustainable care system that enables everyone to enjoy life until the age of 100.

The government committed to investing JPY 115 billion into these projects over the next ten years from 2021.

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[23] https://www8.cao.go.jp/cstp/kihonkeikaku/5basicplan_en.pdf
[24] Currency conversions here and below as of 6 May 2022.
[25] https://www8.cao.go.jp/cstp/english/moonshot/basicapproach_en.pdf

2.5.5 Sixth Science and Technology Basic Plan

In March 2021, the Sixth Science and Technology Basic Plan[26] came into force. This plan centred around commitments to domestic reform and responding to global challenges. It set out the ambition for Japan to strengthen its position as a regional and global leader by providing solutions to global and domestic challenges based on science, technology and innovation.

The two pillars of the plan are supplemented by the government's commitment to increase public funding for R&D to JPY 30 trillion (GBP 186 billion) by the end of 2025, signifying a total of JPY 120 trillion in public and private investment. Over the course of the Sixth Basic Plan, the Japanese Government will concentrate its efforts on:

- Transitioning to a sustainable and resilient society.
- The production of knowledge that is a source of value creation.
- The cultivation of human resources to support the changing society.

Strengthening the country's R&D capacity is a cornerstone for the realisation of Society 5.0. The plan focuses on strategic and targeted investment into R&D, diversification of the human resources of the domestic research and academic body and promoting multidisciplinary research and innovation. Furthermore, the government commits to transforming its policy-making process by increasing the contributions made by science regarding data and knowledge in the evaluation, formulation and implementation of policy.

2.5.6 Other science and innovation initiatives

The World Premier International Research Center Initiative (WPI),[27] launched in 2007 by MEXT, aims to establish globally recognised research centres in Japan to produce excellent research using high-quality equipment, attracting international frontline researchers to collaborate and develop science in Japan. Hosted by universities and national research institutes across the country, there are currently 13 centres, each receiving annual funding of JPY 700 million to JPY 1.4 billion for 10–15 years. The working language at the WPI Centers is English and around 40% of researchers who work there are from overseas.

MEXT supports domestic researchers' autonomy through the competitive Grants-in-Aid for Scientific Research (KAKENHI).[28] These grants aim to develop all areas of scientific research in Japan and are awarded to pioneering and unconventional research projects that support social development. The funds have been available since

[26] https://www8.cao.go.jp/cstp/english/sti_basic_plan.pdf
[27] http://www.mext.go.jp/en/policy/science_technology/researchpromotion/title01/detail01/1374076.htm
[28] https://www.mext.go.jp/content/20201201-mxt_gakjokik-000004681_01.pdf

1999 and are awarded to researchers working in all fields, ranging from the humanities and social sciences to the natural sciences.

The Topic-Setting Program to Advance Cutting-Edge Humanities and Social Sciences Research,[29] initiated in 2012, supports research that contributes to social development, enables interdisciplinary discoveries, and fosters international joint research in the humanities and social sciences.

Developing a reliable infrastructure for data sharing between governments is a major goal of the Japanese Government and is supported by the Programme for Constructing Data Infrastructure for the Humanities and Social Sciences,[30] which promotes joint research both domestically and internationally and advances research in the humanities and social sciences.

The Japan Science and Technology Agency's JPY 10 trillion (GBP 62 billion) University Fund,[31] launched in April 2022, aims to increase public financing for scientific research and support globally competitive research, by investing in shared facilities and equipment in institutions, establishing advanced R&D infrastructure in universities, and developing a national innovation ecosystem. In addition, the fund aims to increase financial support for doctoral students in R&D disciplines.

[29] https://www.jsps.go.jp/english/e-kadai/
[30] http://www.jsps.go.jp/english/e-di/index.html
[31] https://www.universityworldnews.com/post.php?story=20210203130630432

3. Research and innovation in Japan and the UK: a comparative overview

Summary:

- Investment in R&D is a priority for both the UK and Japanese governments in the long-term.
- Higher education institutions in both countries are leaders in innovation, scientific discovery and technological advancement.
- Both countries produce high-quality and influential research.
- The UK and Japanese R&D sectors have specific strengths in complementary fields.

3.1 Total expenditure on Research and Development

TABLE 1: COMPARATIVE VIEW OF JAPAN AND UK RESEARCH LANDSCAPE: EXPENDITURE ON R&D (2019)

	Japan	UK
Gross expenditure on R&D (GERD)	GBP 122 billion/ JPY 19.6 trillion	GBP 38.5 billion/ JPY 6.2 trillion
Domestic GERD (as % of GDP)	3.24	1.76
Business GERD (as % of GDP)	2.59	0.95
Government GERD (as % of GDP)	0.48	0.45

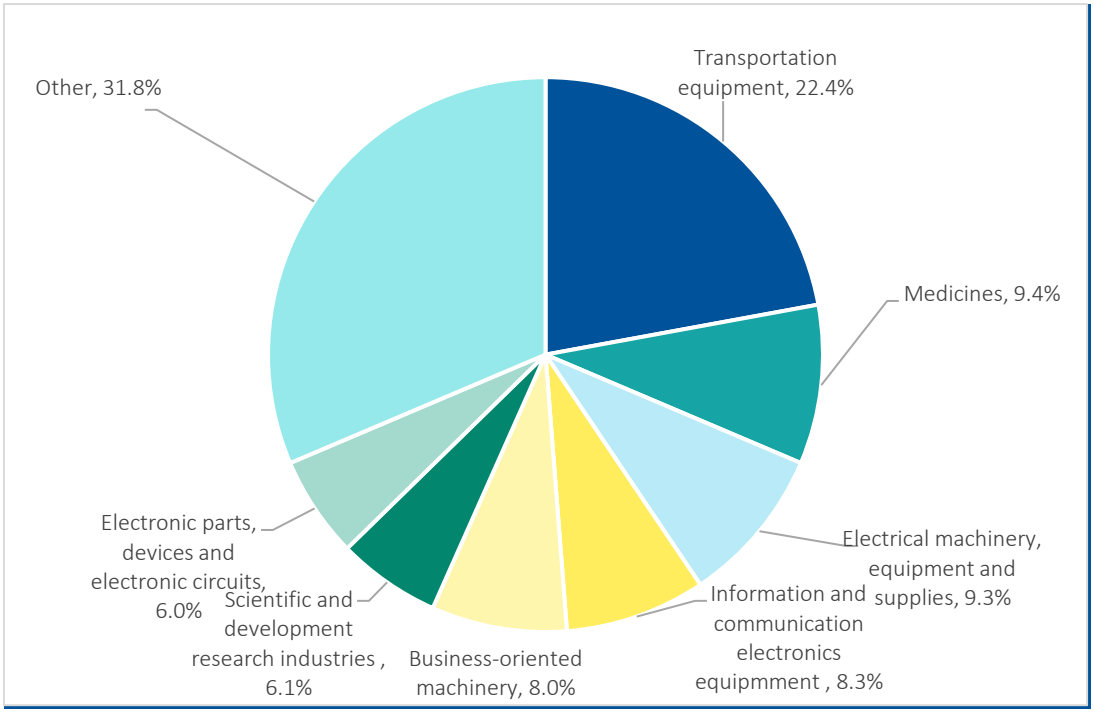
Source: OECD Main Science and Technology Indicators, vol. 2020, issue 2, available at: https://www.oecd.org/sti/msti.htm

R&D is a priority area for public funding for both the UK and Japan. According to the Japan Statistics Bureau, in FY [32]2020 the total expenditure on R&D was JPY 19.2 trillion (GBP 11.5 bn) or 3.6% of GDP, down 1.7% from the previous year.[33]

However, with the Sixth Science and Technology Basic Plan, the Japanese Government committed to increase government funding for R&D to JPY 30 trillion (GBP 18.6 bn) by the end of 2023.

The highest share of R&D expenditure goes on transportation equipment, which received 22.4% of the funding in FY 2019[34], followed by medicines (9.4%) and electrical machinery, equipment and supplies (9.3%) (Figure 5).

FIGURE 5: LEADING INDUSTRIES FOR R&D EXPENDITURE IN JAPAN IN FY2019 (1 APRIL 2019-31 MARCH 2020)



Source: Japan Statistics Bureau, accessed 30 June 2021

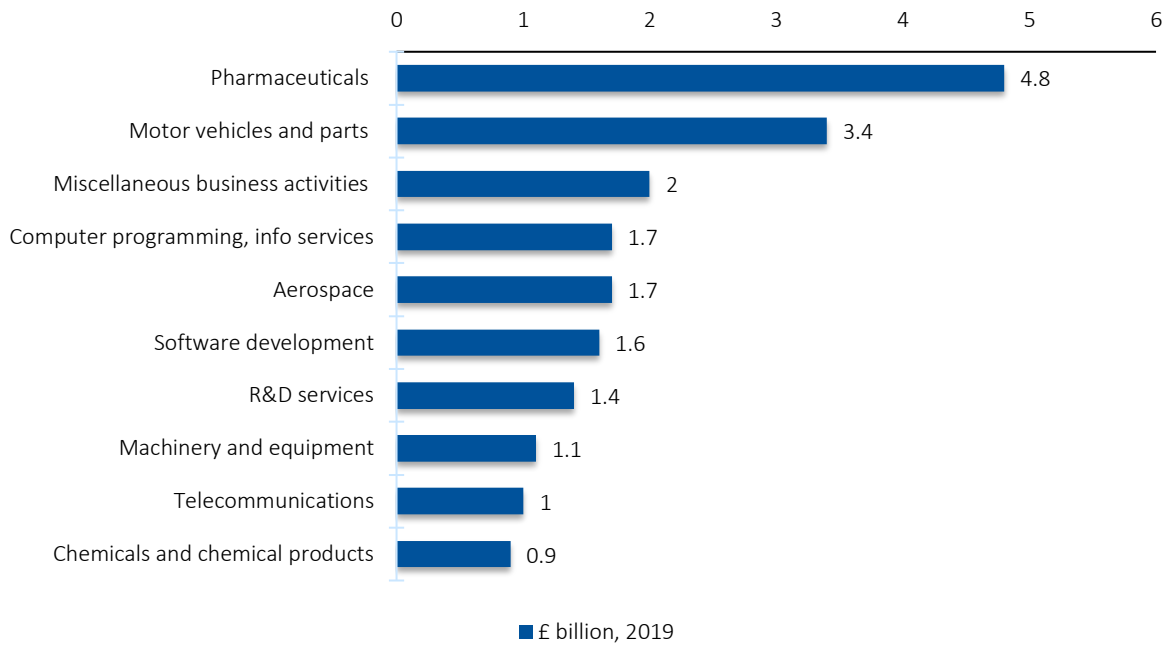
By way of comparison, the total expenditure on R&D in the UK in 2020 was GBP 15.3 billion in 2020 (the equivalent of 0.7% of GDP). This represented an increase of £1.7 billion since 2019, and there is a commitment to invest 2.4% of GDP by 2027. [35] Public investment into R&D for 2019 reached GBP 13.1 billion (JPY 2.1 trillion). The two industries that undertook the most R&D in the UK in 2019 were the pharmaceutical

[32] In Japan, the government's financial year is from 1 April to 31 March and therefore all statistics produced on government spending will relate to this period.
[33] Statistics Bureau Statistics Bureau Home Page/Survey of Research and Development/Summary of Results (2021)
[34] Financial year 2019 encompasses the period between 1 April 2019 and 31 March 2020
[35] Research and development expenditure by the UK government - Office for National Statistics (ons.gov.uk)

industry and the automotive manufacturing industry, spending GBP 4.8 billion (JPY 771 billion) and GBP 3.4 billion (JPY 547 billion), respectively (Figure 6).[36]

In March 2022, the Department of Business, Energy and Industrial Strategy (BEIS) in the UK announced the largest ever research and development budget, worth GBP 39.5 billion over the period 2022-2025. It aims to support the government's ambitions as a science superpower, and delivery of the Innovation Strategy. [37]

FIGURE 6: TOP 10 BUSINESS SECTORS IN TERMS OF R&D EXPENDITURE IN THE UK, 2019

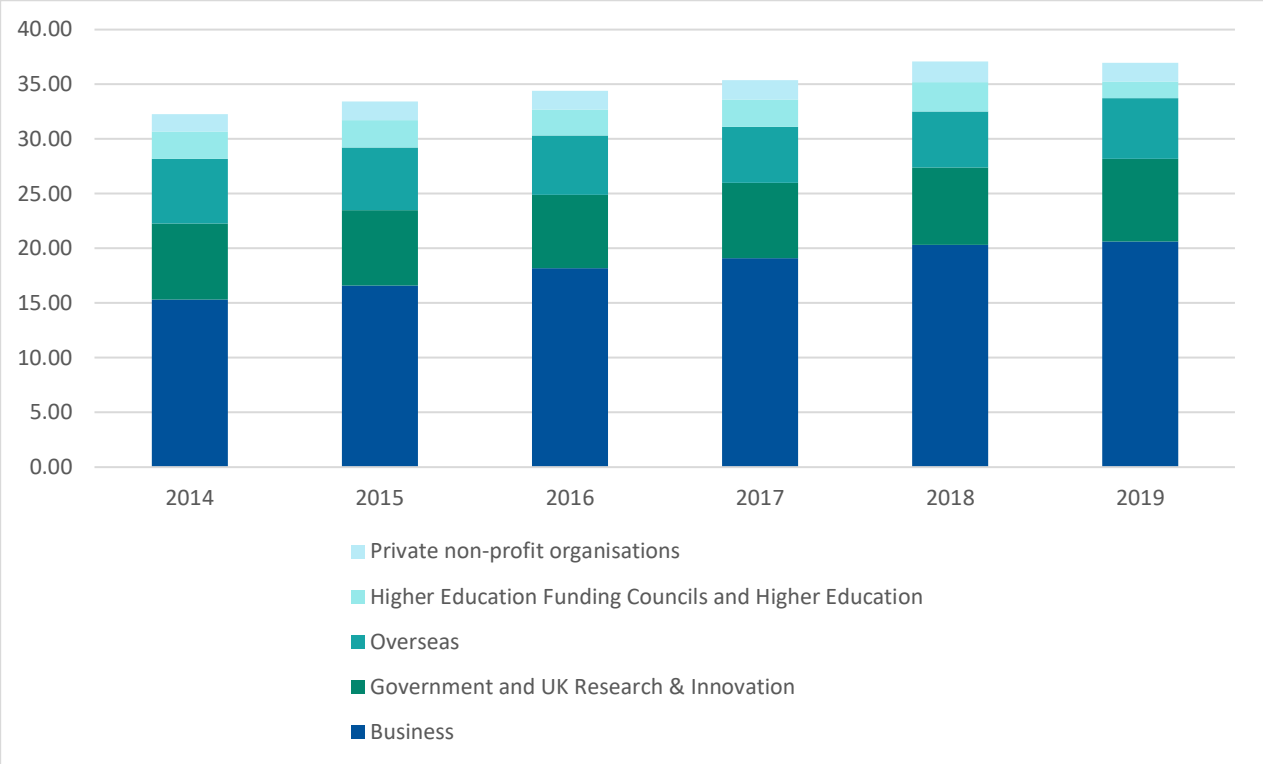


Source: Research & Development Spending, Briefing Paper, UK House of Commons, 16 March 2021

Gross domestic expenditure on R&D by government and businesses has increased year-on-year in cash terms since 2015; however, there has been an overall contraction in spending from overseas sources and by higher education funding councils and institutions (Figure 7).

[36] Research and development spending, House of Commons, 16 March 2021
[37] https://www.gov.uk/government/news/government-announces-plans-for-largest-ever-rd-budget#:~:text=The%20%C2%A339.8%20billion%20R%26D,ambitions%20as%20a%20science%20superpower.

FIGURE 7: UK DOMESTIC GROSS EXPENDITURE ON R&D BY FUNDING SECTOR IN CONSTANT PRICES, 2014–2019



Source: Office for National Statistics, Gross Domestic Expenditure on research and development, UK, 2018, accessed 7 June 2021.

3.2 Numbers of researchers

TABLE 2: Number of researchers in Japan and UK, 2019

	Japan	UK
Number of researchers full-time equivalent	681,821	317,472
Researchers per 1,000 of population	9.8	9.7

Source: OECD Main Science and Technology Indicators, vol. 2020, issue 2

According to the OECD, there were 689,889 full-time researchers (in academia and industry) in Japan in 2020, up from 678,134 in 2018.[38]

While the vast majority academics and researchers in tertiary-level institutions are Japanese, efforts to internationalise the academic and research body are increasing. According to MEXT's Overview of International Research Exchanges, 13,280 foreign researchers came to Japan for medium- to long-term research in 2019.[39]If short-term researchers are added, then there was a total of 34,678 inbound researchers that year, down 4,646 from the previous year, due to the impact of the Covid-19 pandemic at the end of the 2019 fiscal year (early 2020).[40]

In the UK, international academic staff and researchers have traditionally formed a large proportion of the total numbers of researchers. In 2019 there were 316,295 full-time researchers, up from an estimated 305,795 in 2018.[41] In the 2019–20 academic year, 35.6% of all academic staff at UK institutions were carrying out research functions, and 36.6% of all academic research staff were international.[42]

3.3 Output and publication quality

TABLE 3: RESEARCH OUTPUTS AND PERFORMANCE METRICS IN JAPAN AND UK

	Japan	UK
Total research outputs, 2016-2021*	831,994	1,357,720
Share of research outputs among most highly cited, 2016–2021 (%)*	8.1	16.5
Share of research outputs with international co-author, 2016–2021 (%)*	29.6	54.9
Field-Weighted Citation Index, 2016–2021*	0.93	1.56
Institutions in global top 100, 2022**	5	17

Sources: *SciVal, 2016–21; **QS World university rankings, 2022

[38] OECD Main Science and Technology Indicators, Volume 2021, available at: https://www.oecd.org/sti/msti.htm
[39] MEXT, 2019 Survey of Researcher Exchanges
[40] Fiscal 2019 Data Shows Japan's International Research Exchange Mainly Inbound | Nippon.com
[41] OECD Main Science and Technology Indicators, Volume 2021, available at: https://www.oecd.org/sti/msti.htm
[42] HESA Student Records, accessed June 2021.

Over the last ten years, research output from Japanese authors has grown steadily,[43] reaching 831,994 publications in the 2016–2021 period, with a field-weighted citation impact of 0.93.[44] In 2020, Japanese authors produced 139,098 scientific papers, a 4.5% increase from 2016.[45]

Japanese authors are increasingly collaborating with international researchers: in 2017, 37,442 publications were produced with an international co-author; by 2020 this number had grown to 44,374.[46]

Through a regional lens, the percentage of global publications produced in Japan is decreasing, although the volume of scientific output remains significant, positioning Japan fifth globally. Although Japanese scientists produce relatively fewer publications, their output provides high-quality contributions to science, with 8.1% of those published in the 2017–2020 period counted among the top 10% most-cited publications in the world by SciVal.[47]

Over 10,000 patents cited Japanese publications between 2017 and 2021

TABLE 4: SCHOLARLY OUTPUT CITED IN PATENTS 2017-2021

Publication year of output	Citing-Patents Count[48]
2017	5,981
2018	3,451
2019	1,268
2020	433
2021	130
Total	10,389

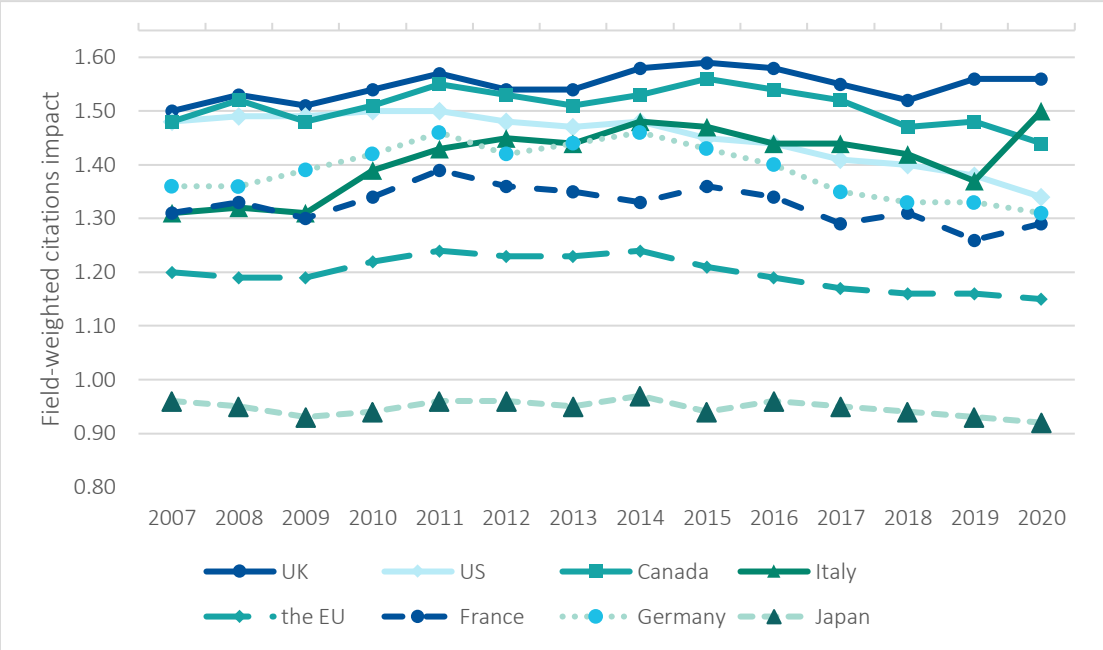
Source: SciVal® database, accessed 05 August 2022

[43] Porter, S., Wastl, J., Hook, D., Japanese Collaboration in the Global Research Landscape, Digital Science, 11 February 2019
[44] SciVal® database, accessed 07 June 2022.
[45] SciVal® database, accessed 07 June 2022.
[46] SciVal® database, accessed 07 June 2022.
[47] SciVal® database, accessed 09 June 2022.
[48] The count of patents citing the scholarly output published by Japanese authors

The domestic workforce is highly educated and includes a substantial proportion of researchers, ranking ninth globally.[49] Japanese research has a noticeable impact on the economy and industry, with over 10,000 patents citing scholarly output published in Japan between 2017 and 2021.

The UK's citation impact has been ranked first in the G7 every year since 2007

FIGURE 8: Country comparison by citation impact (FWCI) 2007-2020



The UK produces world-leading research, known for its high quality, integrity and diverse impact. The UK's field-weighted citation impact has been ranked first in the G7 every year since 2007, varying between 1.2 and 1.6. Of the world's most highly cited publications in 2020, 16.2% were produced in the UK.[50]

A substantial and increasing proportion of the UK's output is delivered jointly with an international partner, reaching 58% in 2019–20. This makes the UK the second most internationally collaborative country in the G7, after France, and is significantly higher than the OECD average.[51] The UK's research influences strategic domestic and international sectors and industries and affects social and economic development.

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[49] OECD Library: Changing skill needs in the Japanese labour market

[50] SciVal® database, accessed 07 June 2022.

[51] Department for Business, Energy and Industrial Strategy, 2019, INTERNATIONAL COMPARISON OF THE UK RESEARCH BASE, 2019: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/815400/International_comparison_of_the_UK_research_base_2019._Accompanying_note.pdf

4. Japan's international research collaborations

- Japan's primary international research partners are the US, China, Germany, the UK and France.
- Japanese researchers are increasingly collaborating with counterparts from overseas institutions.
- More international researchers engage in mobility and exchange programmes in Japan every year.
- The primary countries with which mobility exchanges take place are the US, Taiwan, China, South Korea, the UK and Germany.

4.1 Top 10 research partners by output

While historically a less global higher education system than that found in the UK, Japan has made significant advances towards internationalisation over the last decade. For example, in 2018, 566 of Japan's 842 universities and research institutes had established research agreements with overseas partners.[52]

As illustrated in Table 5, Japan collaborates most actively with the US, jointly publishing over 50,000 papers in the 2016–21 period. Japan's second most important global partner is China, and among European countries it is Germany, closely followed by the UK.

TABLE 5: JAPAN'S TOP 10 GLOBAL RESEARCH PARTNERS BY PUBLICATION OUTPUT AND FIELD-WEIGHTED CITATION IMPACT (FWCI) 2016-21

Country	Co-authored publications	FWCI
United States	54,093	2.39
China	38,692	2.05
Germany	20,725	3.14
United Kingdom	20,342	3.31
France	15,358	3.45

[52] MEXT, Survey of Researcher Exchanges, 2019. Available at: https://www.mext.go.jp/content/20200117-mxt_kagkoku-000004191_02.pdf

Australia	12,888	3.78
South Korea	11,608	2.85
Italy	11,055	4.22
Canada	10,860	4.05
Spain	8,345	4.81

Source: SciVal® database, accessed 09 June 2022

4.2 Research mobility

MEXT's 2019 Survey of Researcher Exchanges[53] provides data on incoming and outbound mobile academic researchers in Japan between 1997 and 2017. It demonstrates that over the past 30 years, Japanese researchers have been increasingly active internationally.

4.2.1 Outbound mobility

The total number of outbound mobile Japanese researchers in 2017 was 174,602, up 24.1% from 140,731 in 2010.

Under JSPS's Institutional Program for Young Researcher Overseas Visits,[54] there has been a temporary rise in the number of outbound mobile scholars. However, overall numbers of mid- to long-term mobile researchers going to North America and Asia have declined slightly over the past five years.

Where do Japanese researchers go?

Since 2002, the most popular destinations for Japanese researchers have been the US, Taiwan, China, South Korea, the UK and Germany (although not always in this order).

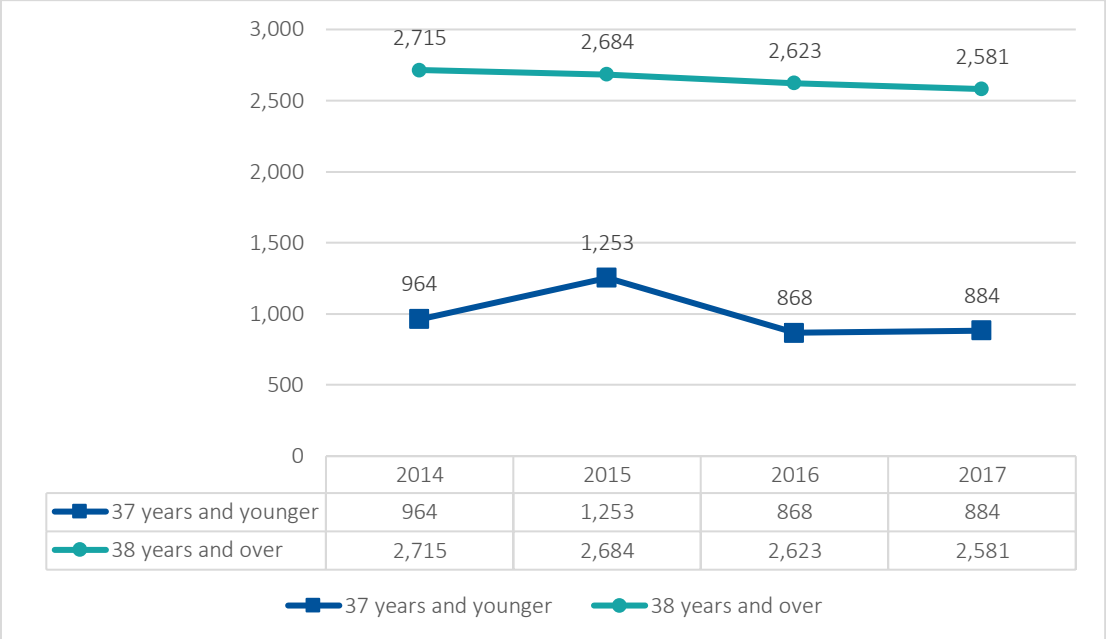
[53] MEXT, Survey of Researcher Exchanges, 2019.
[54] https://www.jsps.go.jp/english/e-daikokai/index.html

What are the demographic features of mobile researchers?

Age, gender and academic level are all influential factors in researchers' ability to participate in an overseas mobility programme. As illustrated in Figure 8, 'young' researchers (aged 37 or less) are less likely to engage in mid- to long-term mobility abroad compared to those in the next age group up, indicating that researchers with higher academic credentials are more likely to engage in this type of mobility.

There are more male mobile researchers than female (Figure 9). This may be attributable to gender disparities in employment and career opportunities.

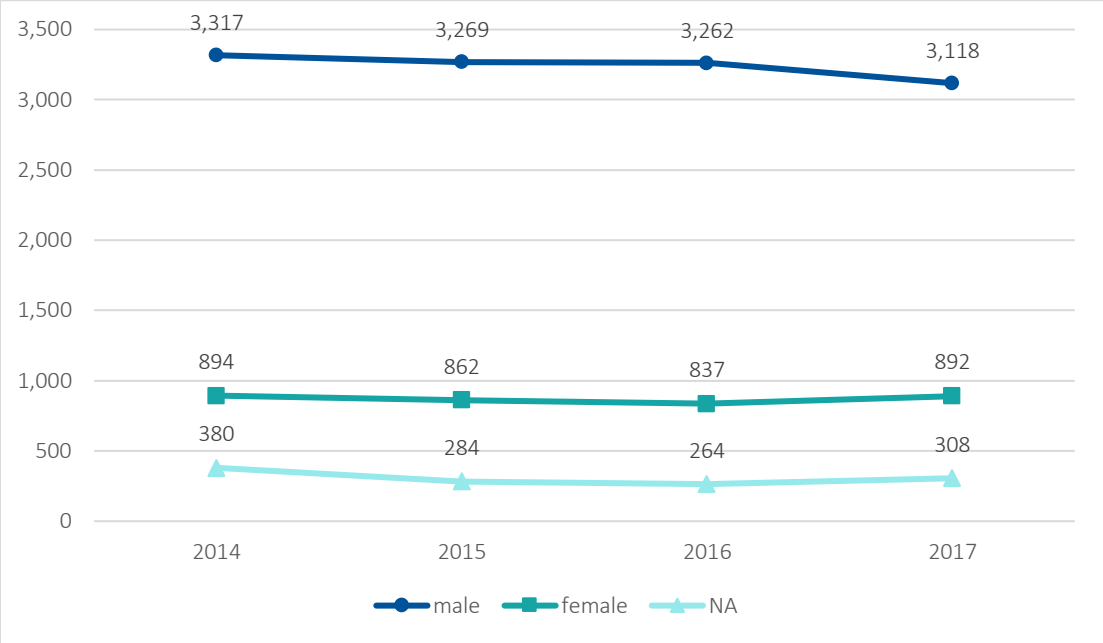
FIGURE 9: MOBILE JAPANESE RESEARCHERS BY AGE 2014–2017



	2014	2015	2016	2017
37 years and younger	964	1,253	868	884
38 years and over	2,715	2,684	2,623	2,581

Source: MEXT, 2019 Survey of Researcher Exchanges

FIGURE 10: NUMBERS OF OUTBOUND MOBILE RESEARCHERS BY GENDER (MEDIUM- AND LONG-TERM MOBILE RESEARCHERS), 2014-2017



Source: MEXT, 2019 Survey of Researcher Exchanges

4.2.2 Inbound mobility

In 2017, the total number of inbound mobile international researchers was 39,473, up 5.4% from 37,453 in 2010.

Where do international researchers come from?

The largest cohorts of inbound mobile researchers come from the USA, China, South Korea, UK, France and Taiwan.

5. Collaboration between the UK and Japan

- UK–Japanese joint research outputs have been growing since 2010.
- Collaboration in research remains the primary domain for higher education engagement between the two countries.
- The number of full-time Japanese students in the UK is relatively low and has been declining each year since 2007–08.
- The overall number of Japanese researchers in the UK has been growing; however, the number of young Japanese researchers has been declining.

Japan is one of several countries identified by UK Research and Innovation (UKRI) and the Department for Business, Energy & Industrial Strategy (BEIS) as priorities within their international strategies. Its favourable socioeconomic and political environment, advanced research, innovation capacity in science and technology, and high quality of higher education all position Japan as a preferred partner of the UK.

At the same time, Japan is aiming to internationalise its science and research bodies and is working on strengthening cooperation with world-leading institutions with complementary expertise in technology and innovation.

5.1 Research collaboration

Research collaboration is an important area of higher education engagement between the UK and Japan, with scientific collaboration taking place in bilateral and multilateral contexts. Institutions in both countries work together via programmes such as RENKEI, Horizon Europe, and the Human Frontier and Science Programme, and participate in joint calls for the various UK Research Councils.

At present, 585 UK organisations and institutions[55] are collaborating with 620 Japanese counterparts, illustrating a well-developed and diverse inter-institutional infrastructure that can evolve further in the future.[56]

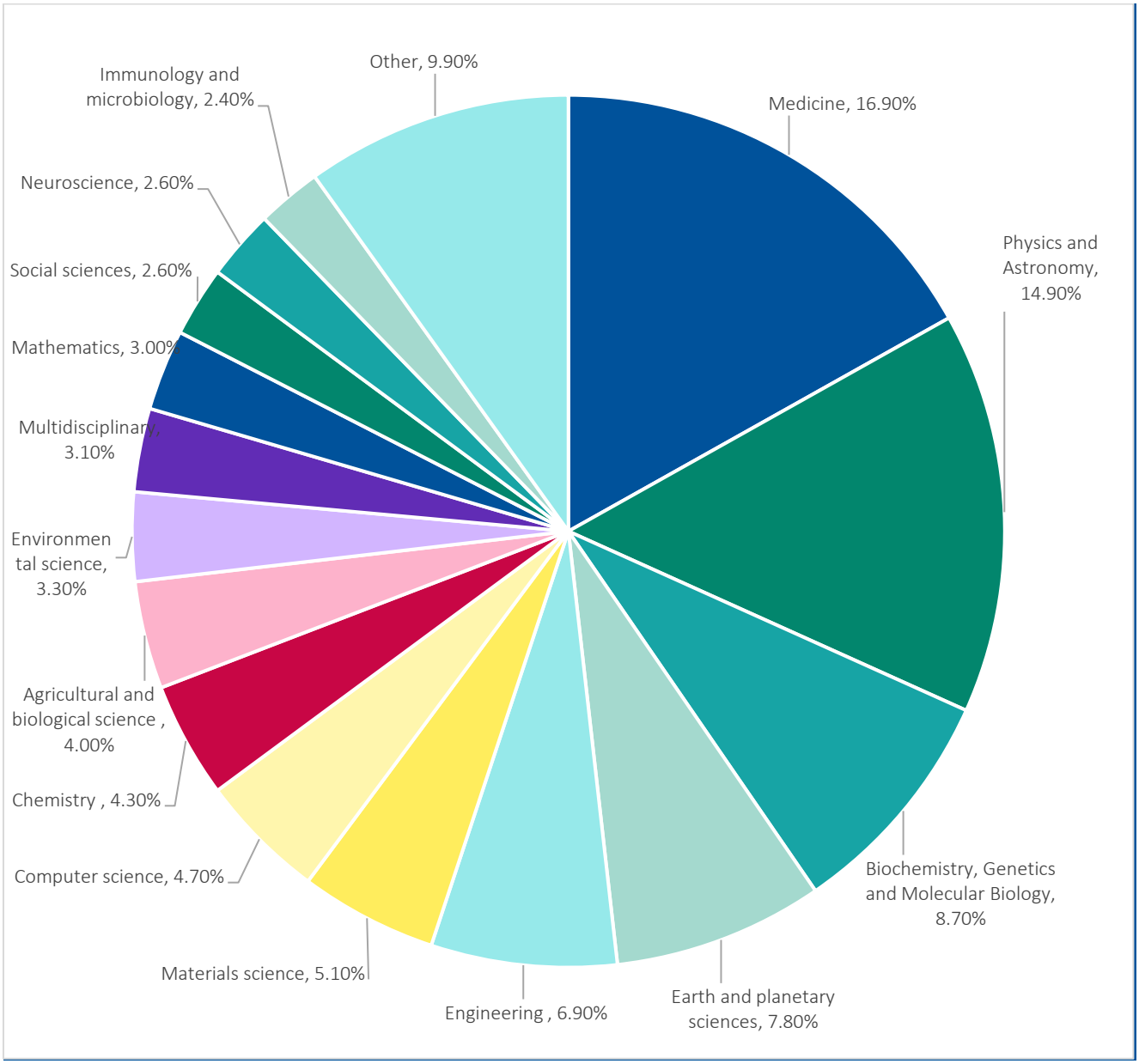
Figure 10 demonstrates the primary disciplines for collaborative research between the UK and Japan. Medicine is the top area of collaboration, followed by physics and

[55] Institutions refers to universities, corporations, NGOs and all other types of organisations, according to SciVal's definition

[56] SciVal® database, accessed 09 June 2021.

astronomy; however, materials science and computer science are both emerging spheres of interest for both countries.

FIGURE 11: RESEARCH DISCIPLINES FOR JOINT PUBLICATIONS BY UK AND JAPANESE AUTHORS, 2017–2021



Source: SciVal® database, accessed 04 August 2022

5.2 UK-Japan research output

The UK–Japanese partnership produces high-quality scientific outputs. Although in terms of quantity Japan is an occasional collaborator, ranking 14th in terms of the number of co-authored publications globally, the capacity for enhanced partnerships between the two countries is continuously expanding, as evidenced by a 29.2% growth in the number of co-authored UK–Japan publications between 2017 and 2021.[57]

As seen in table 6, the field-weighted citations impact (FWCI) of joint publications in the 2017–2021 period was 3.48, more than three times higher than the world average (1.00), clearly demonstrating the high quality of collaboration between the UK and Japan. In the area of medicine, the output produced is highly influential, with an FWCI of 5.85. Collaborative research papers in the field of biochemistry, genetics and molecular biology are also impactful with an FWCI of 3.16.

TABLE 6: CO-AUTHORED PUBLICATIONS BY SUBJECT AREA AND FIELD-WEIGHTED CITATIONS IMPACT 2017-2021

Subject area	Scholarly output	FWCI
Medicine	7,117	5.85
Physics and astronomy	6,291	2.58
Biochemistry, genetics and molecular biology	3,698	3.16
Earth and planetary sciences	3,292	2.86
Engineering	2,895	1.92
Materials science	2,123	1.81
Computer science	1,959	1.98
Chemistry	1,801	1.87
Agricultural and biological sciences	1,710	2.29
Mathematics	1,254	1.92

Source: SciVal® database, accessed 04 August 2022

[57] SciVal® database, accessed 04 August 2022

5.3 Japan-UK mobility

5.3.1 Japanese students in UK institutions

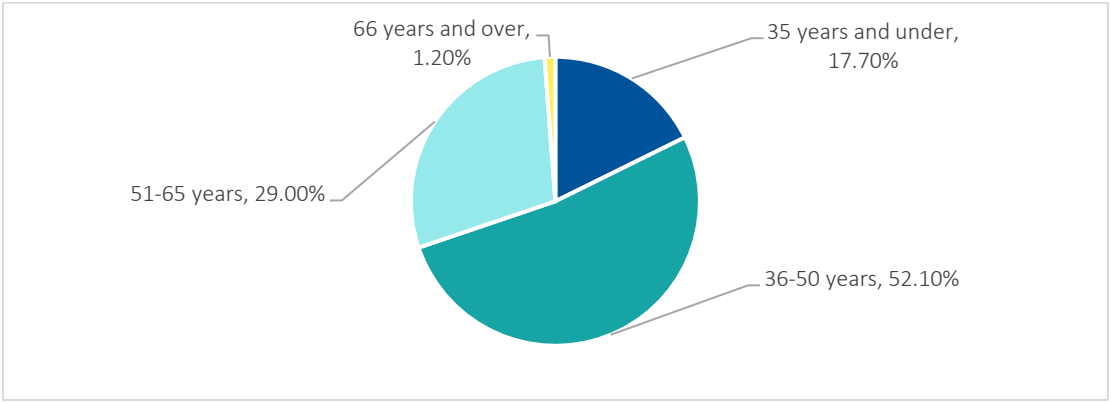
The presence of Japanese full-time students in the UK is limited, particularly when compared to student numbers from other countries. The number of Japanese full-time students enrolled on courses in the UK in 2020–21 has dropped by over a third since 2007–08 from 4,470 to 2,795.

In 2019, the UK ranked third (behind the US and Australia) among preferred international study destinations for Japanese students.[58] However, there were still only 2,684 full-time equivalent Japanese students studying in the UK,[59] compared to 14,730 students (almost six times more) enrolled on courses in the US.[60]

5.3.2 Japanese staff in UK institutions

The number of Japanese academic and research staff working in UK universities has almost doubled, from 470 in 2004–05 to 770 in 2020-21, equivalent to 0.2% of all international staff. Of these staff, 29.5% carry out teaching duties only, 25.6% concentrate on research, and 28.8% combine both functions. However, the reverse is true of young academic and research staff (aged 35 or under), 56% of whom are involved in research-only activities. As shown in figure 12, in 2020-21, 52.1% of all Japanese staff in UK universities were aged 36–50; the next most populous group was individuals aged 51–65.[61]

Figure 12: Japanese staff in UK universities per age group 2020-21



[58] UIS.stat data, last accessed June 2022
[59] HESA Student Records, accessed June 2022
[60] UIS.stat data, last accessed June 2022
[61] HESA Staff Records, accessed June 2022.

6. The future of UK-Japan collaboration

- UK–Japan ties in research and development are strong, but enhanced cooperation will benefit both sides.
- Government-subsidised funding has played an important role in the advancement of strategic partnerships on both sides and will contribute to both countries' R&D strategies in the long term.
- The existing frameworks for collaboration in research could be enhanced through increased funding for research in strategic fields of science, technology and innovation.
- Supporting student and staff mobility between Japan and the UK brings many benefits to institutions and can contribute to world-leading research and scientific discoveries.

The UK and Japan already have a strong partnership in research and innovation. There are ties between industries, institutions, faculties, and individual researchers. However, a broader range of partnerships and collaborations would add value and enhance each country's science, research and innovation capabilities and support their individual and collective strategic priorities.

Building strategic alliances between higher education institutions will allow researchers from both sides to realise significant benefits, deliver world-leading research and improve access to global business innovation networks.

In March 2021, the UK Government published an Integrated Review of Security, Defence, Development and Foreign Policy.[62] A crucial aspect of the review is the aspiration for closer engagement with Japan and countries in the Indo-Pacific region. Science and technology are recognised as important factors in the UK's future international strategy, and collaboration with mature developed partners such as Japan is at the forefront of the UK's plans to further grow its global reputation as a leader in science, research and innovation.

Alongside the review, the 2021 G7 Summit saw the publication of a research compact[63] which highlighted the importance of open science and the shared collective ambition of G7 governments to develop a set of principles to underpin international

[62] https://commonslibrary.parliament.uk/research-briefings/cbp-9171/
[63] https://www.gov.uk/government/publications/g7-2021-research-compact

collaboration. The COP-26 UN Climate Change Conference in November 2021[64] represented another major opportunity to foster new research collaborations focussed on addressing global challenges.

These developments highlight the opportunities to strengthen the cooperation between the UK and Japan and to encourage more, and more diverse, collaborations in R&D between the two countries.

Japan's Sixth Science and Technology Basic Plan, which will invest JPY120 trillion public and private investment into R&D between 2021 and 2025, represents further opportunities for collaboration. Among the strategic aims of the programme are building diplomatic relations with other governments, boosting joint research opportunities, and establishing collaborations with foreign funding agencies.

6.1 Research collaboration

The UK and Japanese governments could benefit from working together to boost collaboration between their higher education sectors. There are many possibilities for enhancing collaboration on R&D in science, academia and industry via the existing bilateral and multilateral frameworks for cooperation.

Through a strengthened partnership with strategic goals and long-term commitments, British and Japanese universities could use these frameworks to greater effect, complementing their institutional strengths, and building strong research teams capable of responding to global societal challenges.

One area ripe for improvement relates to publications. As discussed above, Japan–UK research output is high in quality and impact, but low in quantity. Building on the number of international research collaborations will bring benefits both to the international research standing of both countries, and to the overall quality of internationally published literature.

6.2 Mobility

Existing mobility and exchange schemes between the UK and Japan have demonstrated their many benefits for institutions and the higher education sector, and their ability to support the production of high-quality scientific discoveries.

However, the number of young researchers from Japan has steadily declined over recent years. Enhanced financial support focused on young and female researchers,

[64] https://ukcop26.org/uk-presidency/

combined with greater opportunities for mobility and exchange between institutions, would be welcome. Furthermore, a proactive regional diversification campaign would ensure that researchers do not end up concentrated in London institutions.

Student mobility can be a driver of future research partnerships. Existing schemes, such as the UK's Turing Scheme[65] and Japan's Tobitate! Study Abroad[66] initiative, can be deployed to encourage increased student mobility in both directions.

In addition, the various research funding platforms, such as RENKEI and the DAIWA Foundation Grants, can support the development of international research partnerships, providing opportunities for international mobility among early-career researchers. For a fuller list of such resources, see Annexe 8.2.

[65] https://www.turing-scheme.org.uk/
[66] https://tobitate.mext.go.jp/about/english.html

7. Conclusion

The UK and Japan share long-standing traditions in international cooperation, strong leadership positions in the G7, and a deep commitment to science, technology and innovation. The UK's focus on boosting existing engagement with resilient and advanced research economies makes Japan a priority partner for collaboration in the sphere of R&D, science and innovation. Japan's domestic R&D policy, high-quality education system and aspirations for internationalisation provide a favourable climate for increasing cooperation among researchers on both sides.

The commitment to deepen and develop institutional partnerships represents a long-term endeavour for both sides. It involves significant reciprocal financial investment to strengthen and institutionalise relationships, capitalise on complementary strengths, and define shared goals.

It is crucial to enhance and bolster exchange programmes and provide greater mobility opportunities for PhD, post-doctorate and early-career researchers from Japan and the UK. Existing programmes have demonstrated that exchanges are essential for building strong inter-institutional relationships and developing collaborations. An opportunity for long-term partnerships based on complementary strengths and investment in talent will not only raise the profile of institutions, but it will also allow individual researchers to realise their potential and contribute to international scientific discoveries.

8. Annexe

8.1 Case studies

8.1.1 MEXT Scholarships

MEXT Scholarships are funding opportunities for UK graduates to pursue independent research or enrol on a taught course in a Japanese higher education institution.[67] The aim is to internationalise the domestic higher education sector and provide opportunities for talented international researchers to collaborate with Japanese researchers, use Japanese facilities, and learn about the Japanese language, culture and lifestyle. The scholarships cover living expenses, university fees and return airfares.

Testimonials from programme alumni highlight this scholarship's impact on UK–Japan cooperation across a diverse range of disciplines, showing that it provides a foundation for a sustainable relationship between individuals and institutions.

8.1.2 JSPS short- and long-term invitation fellowships (Japan Society for the Promotion of Science with the Royal Society)

The JSPS International Fellowships for Research in Japan aim to develop collaboration between Japanese and UK institutions via short- and long-term fellowships for senior members of UK universities in their Japanese counterparts, as well as early-career researchers.[68] There are two programmes: Post-doctoral Fellowships for Research in Japan, aimed at young researchers, and Invitational Fellowships for Research in Japan for mid-career and senior researchers.

Alumni testimonials show this programme's effectiveness in strengthening institutional links and cooperation in research and science. Collaboration between institutions is typically established during the course of the project and continues after the end of the fellowship. For instance, Dr Kevin Critchley, University of Leeds, joined Dr Tanaka's group in the Tokyo Institute of Technology. They worked on four joint papers together from 2018 to 2020, both within the programme and beyond. These papers are now published, and more are due to follow. He and his colleagues are now seeking other funding to continue the collaboration.

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[67] https://www.mext.go.jp/en/policy/education/highered/title02/detail02/sdetail02/1373897.htm
[68] https://www.jsps.go.jp/english/e-inv/index.html

Dr Mohammed Ismail from the University of Sheffield collaborated with Dr Stephen Lyth from Kyushu University under the JSPS and the Royal Society International Exchanges Scheme. After carrying out workshops in both institutions as part of the JSPS programme, both researchers applied for Horizon 2020 funding to continue the collaboration with nine European and two Japanese institutions known as world leaders in carbon capture. They also plan to reapply for the next International Exchanges Scheme to intensify the partnership on an institutional level.

8.1.3 EPSRC–JSPS Core-to-Core Collaboration in Advanced Functional Materials

The Core-to-Core programme was set up by JSPS in 2003 to build a platform for international cooperation in primary fields of science among universities and research institutes in Japan and the Western world.[69] Since 2012, the framework's focus has been on creating world-class research hubs in innovative research fields in Japan, and high-potential hubs with specific importance to Asia and Africa.[70]

In 2018, the EPSRC opened a call for expressions of interest in participation in the Core-to-Core programme on Advanced Functional Materials.[71] JSPS is the primary sponsor for the programme, and the EPSRC supplied match funding.

As Dr John Errington, Reader in Metalorganic Chemistry from Newcastle University describes:

'Within Europe, the tremendous benefit of network funding was amply demonstrated by our successful COST network, which ended in 2016. The EPSRC–JSPS Core-to-Core programme was an opportunity to extend this type of support to institutions in Japan while including research groups from other regions to maintain resilient overseas interactions. About half of the funding received must be spent on networking activities, including research exchange visits, and it is a tremendous opportunity to develop research collaboration

The EPSRC funding also enabled us to appoint some post-doctoral research assistants in Newcastle that contribute massively to the research and helping to arrange the networking activities. Professor Masahiro Sadakani from Hiroshima University has assembled a talented team from across Japan, involving prominent researchers in several areas. The INPOMS Core-to-Core network includes a considerable proportion of early-career researchers, and we have had very enthusiastic engagement from several Japanese companies, while the contributions of partners from China, France and Germany serve to further strengthen the network.

[69] https://www.jsps.go.jp/english/e-core_to_core/index.html
[70] Core-to-Core Program, FY2021
[71] EPSRC-JSPS Core-to-Core Collaboration in Advanced Functional Materials

The network has already been successful in establishing a new research collaboration between Newcastle University and a leading Japanese chemical company, which we hope will grow over the coming years.'

8.1.4 Addressing Covid-19 challenges with Japanese researchers

The ESRC and AHRC, co-funded by JSPS, have set up a call for collaborative UK–Japan research projects in the social sciences, arts and humanities that address challenges and opportunities associated with the Covid-19 pandemic.[72] Proposals could focus on developing a more science-informed policy design post-Covid; speeding up recovery and mitigating long-term negative impacts; or influencing policy towards more resilient, sustainable, inclusive and fair practices.[73]

8.2 Resources

Japan:

8.2.1 National Research Institutions

- RIKEN The Institute of Physical and Chemical Research
- NIMS National Institute for Materials Science
- QST National Institutes for Quantum and Radiological Science and Technology
- JAMSTEC Japan Agency for Marine-Earth Science and Technology
- JAEA Japan Atomic Energy Agency
- JAXA Japan Aerospace Exploration Agency
- NIED National Research Institute for Earth Science and Disaster Prevention
- AIST National Institute of Advanced Industrial Science and Technology

8.2.2 Funding agencies

- JSPS Japan Society for the Promotion of Science
- JST Japan Science and Technology Agency
- AMED Japan Agency for Medical Research and Development
- NEDO New Energy and Industrial Technology Development Organisation

[72] https://www.ukri.org/opportunity/addressing-covid-19-challenges-with-japanese-researchers/
[73] Addressing COVID-19 challenges with Japanese researchers

United Kingdom:

8.2.3 Funding agencies

- UKRI UK Research and Innovation
- AHRC Arts and Humanities Research Council
- BBSRC Biotechnology and Biological Sciences Research Council
- ESRC Economic and Social Research Council
- EPSRC Engineering and Physical Sciences Research Council
- Innovate UK
- MRC Medical Research Council
- NERC Natural Environment Research Council
- RE Research England
- STFC Science and Technology Facilities Council

8.2.4 Collaboration opportunities

Scholarships and fellowships

- Harasawa Fellowship
- MEXT Undergraduate and Postgraduate Scholarships
- Student Exchange Support Program Scholarship for Short-term Study in Japan
- John Crump Studentship (Final-stage PhD scholarship)
- Conference Attendance Support for Postgraduate Students
- Japanese Studies Event Top-up Funding
- DAIWA Scholarships for Japanese Studies
- DAIWA grants and awards to institutions and individuals
- The Ivan Morris Memorial Prize
- Butterfield Awards
- Sasakawa Japanese Studies Postgraduate Studentship Program
- Royal Society Wolfson Visiting Fellowship

Study exchanges

- Tobitate! (Leap for Tomorrow) Study Abroad Initiative
- Japan Exchange and Teaching Program
- Japan Experience Study Tour
- International Fellowships
- Leverhulme Trust Study Abroad Studentships
- Leverhulme Trust Visiting Professorships
- Turing Scheme
- Royal Society International Exchanges Scheme

- Wellcome Trust Master's Studentships in Humanities and Social Sciences
- Japan Foundation (London)'s Japanese Studies and Intellectual Exchanges

8.2.5 Platforms for international research engagement

- DAIWA Foundation Awards for collaborative projects enabling institutional partnership
- European Cooperation in Science and Technology (COST)
- Horizon Europe
- JSPS's KAKENHI – Grants-in-Aid for Scientific Research
- JSPS Programs
- Royal Society Newton Fellowships
- Novartis Research Grants
- The Belmont Forum
- The Human Frontier Science Program
- UKRI funding
- RENKEI – the Japan–UK Research and Education Network for Knowledge Economy Initiatives

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