Advisory Opinion

The Outlook for Science and Society in 2040

- Ten Critical Issues -

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Science Council of Japan

Young Academy of Japan

This Advisory Opinion summarizes the results of the deliberations of the Young Academy of Japan, Science Council of Japan.

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Executive Summary

1 The Rationale

The innovation landscape in Japan is reaching a critical juncture as the nation's global prominence in science and related fields declines. For a nation with limited resources, sustained innovation is crucial in order to foster new values and secure a prosperous future, materially and culturally. The Young Academy of Japan, part of the Science Council of Japan, is a unique body composed of researchers**,** under the age of 45, who conduct cutting-edge research in diverse fields that span the humanities, the social sciences, and the natural sciences. The Young Academy of Japan is preparing to carry out academic innovation over the next two decades. To this end, it has assessed the potential barriers to innovation holistically and has judiciously considered possible remedies. Based on these interdisciplinary deliberations, we have identified ten crucial issues and formulated recommendations to address them.

2 Current Status and Challenges

In order to promote scientific and academic innovation over the next 20 years, it is essential to bridge the gap between academic disciplines, strengthen collaboration with local stakeholders, and enhance international cooperation. These goals are necessary and foundational, deriving from the accumulation of knowledge and technology in the basic and traditional fields. Despite this, the foundation that supports innovation is eroding. The reasons are manifold: intense competition for research funding and positions, overreliance on quantitative metrics that are ill-suited to research such as interdisciplinary and regional collaborative studies, diminished and unstable funding such as basic expenses, insufficient technical professionals and administrative staff, and a deteriorating research environment due to overwhelming workloads. Cumulatively, this depletes the time and mental bandwidth needed to address the academic issues, and has curtailed research on important academic issues, regional challenges, and international collaborations. In addition, these debilitative factors are now precipitating an exodus of talent and reducing the number of graduate students. To be truly innovative, there is urgent need to support a diverse cohort of graduate students - the future torchbearers of innovation - and to create appropriate career paths to enable researchers to work across fields and sectors. The academic sector needs to critically assess its current state and drastically improve its research environment. Swift action on these fronts will catalyze interdisciplinary studies, international collaboration, and regional collaboration, paving the way for innovative leaps forward in the next two decades.

3 Content of the Advisory Opinion

The following desiderata comprise ten pressing issues that must be addressed immediately in order to foster innovation by envisioning academia and society in the coming two decades.

(1) Cultivating fundamental and traditional knowledge and technology

The cultivation and accumulation of knowledge and technology in fundamental fields is the seed bed of innovation.

(2) Strengthening evaluation and support for interdisciplinary research and regional collaboration together with local stakeholders

A system for evaluating academic ventures aimed at interdisciplinary research and solving regional challenges requires appropriate staffing and a budget.

(3) Enhancing core facilities with Ph.D. holders

Strengthening core facilities with skilled technical personnel with doctoral degrees: to promote innovation and expand career paths.

(4) Cultivating a cross-sector collaborative ecosystem

A collaborative system is needed for academia, industry, government, and local stakeholders to address various interdisciplinary challenges.

(5) Enhancing basic **funding and research support personnel**

A paradoxical situation exists whereby competitive funds are underutilized due to a lack of basic expenses and human resources.

(6) Establishing career paths in science diplomacy

It is important to cultivate individuals capable of spearheading science and technology diplomacy and developing their career trajectories.

(7) Overcoming the "zero-failure" bureaucratic mind in science management

To truly drive innovation, it is imperative to transcend the bureaucratic, managerial mindset and understand and accept the inherent risks of pioneering work.

(8) Reducing the burden of education on households

To stem the decline in the number of graduate students and secure human resources for the future, it is essential to substantially reduce the financial burden of education on families.

(9) Breaking free from the "Activity Trap" of Academia

It is essential to change the culture that valorizes relentless effort and align its operations with its core objectives.

(10) Promoting inter-sectoral career paths for Ph.D. holders

It is imperative to promote the use of specialized expertise across sectors, to expand job mobility~~,~~ and job-based employment.

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1 Introduction: Envisioning Science, Academia, and Society in 2040

(1) The Imperative for Innovation Creation

In a nation with limited natural resources like Japan, fostering innovation for the future is essential. Although there is an urgent need for science and academia[1] to advance this innovation, current trends indicate a decline in the state of these sectors in Japan thus compromising its international status. This suggests that the nation's potential to lead innovation is, in fact, diminishing.

Innovation creation, as defined in Article 2, Paragraph 1 of the Basic Act on Science, Technology and Innovation, is 'the creation and dissemination of new value via scientific discoveries or inventions, the development of new products or services, and other pioneering activities, resulting in substantial shifts in both the economy and society'[1]. The most important expected effect of innovation creation is undoubtedly the emergence of material wealth brought by the provision of new goods and services; the resulting price reductions would stimulate demand. According to the United Nations Statistical Division, Japan's GDP per capita ranks 33rd[2] in the world [2]. Japan is also one of the first nations in the world to experience a demographic decline. Moreover, it is projected to experience an accelerating decline in GDP in the coming years. In addition, the benefits anticipated from innovation based on science and scholarship are not limited to material prosperity. In the "6th Basic Plan for Science, Technology and Innovation," Japan's aspiration for "Society 5.0" is articulated as a society in which the diverse well-being of each individual can be realized [3]. Pursuing a future in which innovation creates and shares new values, perspectives, and knowledge, and enables citizens to thrive both physically and mentally, is the most important challenge for Japan in the midst of its prolonged phase of "decline."

(2) Five Key Domains to Propel Innovation

The Young Academy of Japan, as a branch of the Science Council of Japan (hereinafter "YAJ"), is a unique organization comprising researchers in various fields under the age of 45, ranging from the humanities and social sciences to the natural sciences, across disciplines [4] (Figure 1). YAJ embodies a strong sense of responsibility as the generation that will shoulder the responsibility of creating innovation over the next 20 years. It has held regular symposiums on the topic of creating innovation. Through these events, YAJ has elaborated on how science and academia can collaborate with government, industries, and

Figure 1 Young Academy Logo
(Source: Prepared by the Young Academy)

[1] In this Advisory Opinion, the expression "science and scholarship" is used to refer collectively to academic disciplines spanning the humanities and social sciences, the life sciences, and physical and engineering sciences.
[2] Ranking based on 2021 US dollar conversions.

even civil society to realize innovation. In addition, YAJ has vigorously pursued initiatives to address specific challenges. YAJ has sought to analyze the nuanced concept of innovation and has engaged in interdisciplinary dialogue to address the barriers that impede its realization. While certain issues have been addressed in previous reports published within and outside the Science Council of Japan (Document 1), what sets the YAJ apart is its holistic approach. YAJ has methodically assessed the complex, interconnected issues confronting science, academia, and society. It has viewed them through the lens of young researchers with an eye to 2040, and the search for viable solutions.

From the perspective of science and academia, it is essential to recognize that the cultivation and accumulation of knowledge and technology in basic and traditional fields is the bedrock of academic research[3] for the creation of innovation in a nation. Under this premise, the most critical domains required to lead initiatives can be summarized as the following:

1) Advancement of Interdisciplinary Research
2) Advancement of Regional Collaboration
3) Advancement of International Collaboration
4) Development of Human Resources and Establishment of Career Paths
5) Reconstruction of the Research Environment

These five domains are organically intertwined and require a holistic view (Figure 2). From this perspective, YAJ examines the current research environment for Japanese researchers, especially those in the early stages of their careers, in accordance with these five domains. By analyzing current conditions and envisioning science, academia, and society in 2040, YAJ has identified ten challenges and compiled the following strategies to address them.

(1) Cultivating fundamental and traditional knowledge and technology

The cultivation and accumulation of knowledge and technology in fundamental fields is the seed bed of innovation.

(2) Strengthening evaluation and support for interdisciplinary research and regional collaboration together with local stakeholders

A system for evaluating academic ventures aimed at interdisciplinary research and solving regional challenges requires appropriate staffing and a budget.

(3) Enhancing core facilities with Ph.D. holders

Strengthening core facilities with skilled technical personnel with doctoral degrees: to promote innovation and expand career paths.

(4) Cultivating a cross-sector collaborative ecosystem

A collaborative system is needed for academia, industry, government, and local stakeholders to address various interdisciplinary challenges.

[3] Basic and traditional research fields are areas of inquiry that may not immediately address specific societal challenges. However, they encompass vast, interconnected bodies of knowledge carefully organized and systematized over time. Results from these domains often pave the way for advances in other research areas. While many of these fields have a substantial and longstanding research tradition, newer fields with similar characteristics also fall under this categorization and are therefore referred to as "basic/traditional" fields.

(5) Enhancing basic **funding and research support personnel**

A paradoxical situation exists whereby competitive funds are underutilized due to a lack of basic expenses and human resources.

(6) Establishing career paths in science diplomacy

It is important to cultivate individuals capable of spearheading science and technology diplomacy and developing their career trajectories.

(7) Overcoming the "zero-failure" bureaucratic mind in science management

To truly drive innovation, it is imperative to transcend the bureaucratic, managerial mindset and understand and accept the inherent risks of pioneering work.

(8) Reducing the burden of education on households

To stem the decline in the number of graduate students and secure human resources for the future, it is essential to substantially reduce the financial burden of education on families.

(9) Breaking free from the "Activity Trap" of Academia

It is essential to change the culture that valorizes relentless effort and align its operations with its core objectives.

(10) Promoting inter-sectoral career paths for Ph.D. holders

It is imperative to promote the use of specialized expertise across sectors, to job expand mobility and job-based employment.

Interdisciplinary research among different disciplines and sectors, collaboration with regional communities, and international collaboration are the keys to innovation over the next 20 years. Moreover, the development of human resources and the improvement of the research environment remain fundamental to promoting such research. In other words, unless the research environment is reconstructed and human resource developed, and unless career paths are clearly delineated, interdisciplinary research, regional and international collaboration will not advance, and innovation creation cannot be expected in Japan for the next 20 years.

Figure 2 Five key domains to create innovation

(Source: Prepared by the Young Academy)

2 Advancement of Interdisciplinary research

(1) Interdisciplinary Research as a Field of Innovation

The advancement of innovative research, by definition, frequently comes from areas that are inherently difficult to predict. However, truly novel and innovative fields do not appear out of nowhere. They often emerge from existing high-caliber basic sciences and technologies, fusing them in unique ways or viewing them through a transformative lens. True innovation thrives when research transcends the boundaries between academia, government, industry, and civil society. This synergistic effect - analogous to unexpected chemical reactions - unleashes the potential for innovation, thereby creating an ecosystem that fosters interdisciplinary research and catalyzes cross-disciplinary efforts. This is important for breaking new ground and refining research methodologies. Innovation can only be stimulated by the unpredictable synergies that emerge from interdisciplinary research that integrates technologies and ideas and fosters collaboration among industry, government, academia, and ordinary citizens. Therefore, the robust promotion of an environment and structure that supports interdisciplinary research is of paramount importance for the exploration of new research areas and for the development of new methodologies.

For example, investments have been made in the information and telecommunications industry, and new value added from various industries; this has led to an increase in employment and domestic production value [5]. The YAJ has organized several symposiums where researchers from diverse fields propose solutions to common challenges. Through these discussions, YAJ has uncovered potential pathways into impactful new research areas. The importance of interdisciplinary research has been emphasized not only between different scientific disciplines but also among with the humanities and social sciences. In the case of online communication, which has become routine today, questions about the impact of nonverbal communication on interpersonal relationships highlight the vital need for collaborative research that bridges engineering with the humanities and social sciences [6]. While criminal trials are fundamentally about essential legal interests such as life, liberty, and property, there is a notable dearth of scientists offering perspectives from the defendant's or defense attorney's point of view. Interdisciplinary research combining criminal justice and the natural sciences is equally rare.

Again, the accumulation of knowledge and technology in the basic and traditional fields is indeed the bedrock of the country's scientific and academic research. It is extremely important to maintain and develop this foundation. Moreover, it is essential that a wide range of researchers, research styles, and approaches must coexist to promote innovation; this ranges from specialized researchers in each academic field to those engaged in interdisciplinary research. Researchers engaged in interdisciplinary research come in a variety of styles: those who integrate multiple fields and domains, those who pursue holistic knowledge, those who work with regional communities, and those who partner with industries and businesses. Such diversity fosters multidisciplinary studies and interdisciplinary collaborations, which in turn creates innovation in science and technology.

(2) Challenges and Obstacles in Interdisciplinary Research

Several inhibiting factors currently impede the promotion of interdisciplinary research as an innovation-driven field. In the following sections, we will examine these factors and outline the challenges that need to be addressed as we envision the landscape of science, academia, and society in 2040.

(i) Development of human resources and career paths for transboundary research

First and foremost, it is essential to create an evaluation system that proactively recognizes and values researchers' efforts to forge new connections and to venture into "interdisciplinary" work across fields and sectors. The current environment for (young) researchers generally involves a lack of time availability [7][8][9] as well as a constant need to pursue research funding and positions [10][11][12][13]. There is a lack of leeway to wait for long-term results, and exposure to excessive competition for authorship [14]. Furthermore, due to reductions in academic positions and research funding allocations, there is an observable tendency for research and education to concentrate in specific narrow fields and disciplines. Such a limited resource environment can fuel competition and conflict among different academic fields, making it difficult to appropriately allocate resources. As a result, universities may narrow their focus and prioritize certain disciplines in the early stages of education. Therefore, it is imperative to address the current difficulty for early career researchers to adopt an interdisciplinary perspective. Even the highly motivated in interdisciplinary research often face limited opportunities in research institutions and find it difficult to secure academic positions. For academic domains that are closely linked to societal concerns, it is imperative to develop new evaluation framework that considers different paradigms of knowledge creation, with emphasis on the promotion and accessibility of shared public knowledge. Currently, many universities in Japan incorporate interdisciplinary goals into their strategic planning and framework. In addition, several academic departments have established dedicated centers to promote interdisciplinary and cross-sector collaboration. These developments underscore a broader recognition of the importance of interdisciplinary research [15]. It is now an imperative to support these efforts by allocating appropriate positions and budgets to ensure that such researchers can reach their full potential.

To properly identify and support more than merely superficial interdisciplinary research, it is essential to have an appropriate evaluation system and the expertise to accurately assess interdisciplinary researchers and projects. Many interdisciplinary studies do not lend themselves to quantitative assessment due to their uniqueness or the lack of comparable research. In such cases, a qualitative, long-term assessment is essential to consider the nature and approach of the research, as well as the commitment of the researchers. A YAJ survey of researchers, targeting the under 45s, highlighted concerns about the current evaluation system and highlighted the gap

between the current system and the ideal evaluation framework (Document 2).

At present, there is an insufficient number of evaluators with insightful knowledge in a variety of areas. While the development of such evaluators cannot be achieved overnight, it is expected that young researchers will be the future evaluators of scientific work. Therefore, by equipping these young researchers with comprehensive knowledge and insights in various fields, they will become competent evaluators of interdisciplinary research in the future. By creating platforms for ongoing discussion among different fields of research, industry, government, academia, and civil society, and by creating frameworks that can disseminate to broader society insights based on these discussions, human resources can be nurtured to connect different research fields and sectors.

(ii) Strengthening Support for Interdisciplinary Research Initiatives

Given the limited time and resources available to researchers, the strengthening of core facilities led by Ph.D.s is critical for the advancement of interdisciplinary research[4]. Currently, compared to other nations, core facilities in Japan are under-staffed. Most of the budget has been allocated to constructing facilities and purchasing equipment, rather than investing adequately in the training and compensation of human resources for these core facilities [16]. The support provided by core facilities is particularly important for early-career researchers, who often find it difficult to establish a robust research framework. Innovation in the country will be fostered by developing adequate research environment - core facilities led by qualified Ph.D. holders.

In a situation where basic funding, such as government grants for university operations, is insufficient, it is important to support researchers not only with substantial funds, but also by expanding smaller funds that encourage the exploration of interdisciplinary research. Even in its exploratory, early stages, interdisciplinary research requires a certain level of funding, but securing such funding is challenging in the current environment. For example, the Japan Society for the Promotion of Science (JSPS) primarily allocates substantially large budgets for interdisciplinary research grants, but such grants are extremely competitive. Moreover, in recent years, there has been a significant increase in the competitiveness of challenging research that aims to bring about substantial change and redirection within the Japanese academic system. While some universities in other countries have initiatives to nurture exploratory interdisciplinary research using internal funds in their university, the proportion of Japanese universities strategically establishing mechanisms to financially support such activities remains comparatively low [15].

It is essential to establish a collaborative framework between academic researchers and the public-private sector. Innovation comes from interdisciplinary endeavors, and to achieve this, it

[4] The technical infrastructure required in cutting-edge research has become increasingly complex, making it financially and resource-wise challenging for a single laboratory to maintain and manage. The concept of a core facility involves research institutions providing an environment that ensures access to state-of-the-art technologies, where equipment and personnel are shared.

is imperative to dismantle the "silos[5]" and integrate separated various academic fields, as well as those within government, the public-private sectors, and academia. A new mechanism is needed in which researchers undertake the discovery and conceptualization of societal challenges, while the private sector focuses on business model development, allowing both parties to leverage their strengths. This setup can lead to the emergence of business opportunities from societal challenges and further advancement in research. By leveraging their respective strengths, this synergy holds the possibility of transforming societal problems into business opportunities, further driving the advancement of research. Therefore, it is essential to create opportunities for academia to connect and collaborate with the public and private sectors.

3 Advancement of Regional Collaboration

(1) Regional collaboration as a field of innovation

Japan's rural areas are experiencing a marked trend toward depopulation, coupled with declining birth rates and an aging population. The result is a shrinking and aging population with fewer people to address regional challenges. As communities face challenges such as population decline, aging demographics, and natural disasters, the role of universities as centers for knowledge and human resource development is increasingly important. In addition to these challenges, the traditional *satochi-satoyama* ecosystems in rural areas that were once maintained by human intervention are deteriorating. This has led to a loss of biodiversity and a decline in ecosystem services. At the same time, there is a growing trend of damage to agriculture and forestry due to wildlife incursions, and an increased risk to the lives of residents. This raises concerns about a downward spiral typified by a lack of regional problem solvers and the degradation or loss of environmental conditions that support the socio-economic aspects of the region. At the same time, wildlife is increasingly damaging agriculture and forestry, and threatening the daily lives of local people. The combined effects of the lack of regional problem solvers and the degradation and loss of the environment that sustains the local society and economy have raised concerns about a downward spiral.

These regional challenges are not unique to Japan; similar issues arise in many nations and present a global obstacle to achieving "a society where diverse well-being is realized for each individual" [3]. As a result, innovations to address these "global local challenges" are expected from science and academia. The Committee on Industrial Collaboration and Regional Support of the Ministry of Education, Culture, Sports, Science and Technology has pointed out that "it is imperative to build an innovation ecosystem[6] in each region that enables local communities and industries to autonomously address their challenges and continuously evolve, thereby strengthening

[5] A silo can also be referred to as sectionalism or Galapagos syndrome. The term "silo effect" describes the phenomenon where an organization becomes internally fragmented and trapped in narrow perspectives. This issue can arise within various organizations, including companies and public institutions, as well as between specialized fields. For more details, refer to [17].

[6] While various definitions exist, the Japan Science and Technology Agency defines it as 'a system where diverse organizations spanning industry, government, and academia collaborate and compete continuously to induce innovation'

the resilience of Japan to social challenges by diversifying risks [18]. Furthermore, it is highly anticipated that the seeds of groundbreaking interdisciplinary research can be the spillover from regional collaborations where industry, academia, government, and citizens inevitably 'cross boundaries'.

To create local innovation ecosystem, researchers must actively apply their expertise to address local challenges. By ensuring that regional stakeholders - universities, citizens, companies, and local governments - share a mutual vision and work together consistently, we can effectively address these challenges. This collective effort finds solutions, and introduces new societal values, ultimately creating a robust innovation ecosystem. This, in turn, cultivates a sustainable and self-reliant local community. Researchers are expected to play a key role in training individuals with a scientific perspective for local problem solving, as well as contributing through scientific advisory activities that use specialized knowledge to inform policy. In this context, extending knowledge production beyond the university campus and into the community is expected not only to optimize the use of university resources, but also enhance the quality of university research and education, and ultimately to contribute to its global outreach.

(2) Challenges and Obstacles for Regional Collaboration

Similar to the problems observed in interdisciplinary research, there are currently numerous obstacles to the advancement of regional collaboration as a means of creating innovation.

(i) Development of human resources and career paths for regional collaboration

First, there is an urgent need for a system that explicitly recognizes and rewards researchers who address regional challenges. At present, for many researchers, addressing such regional issues does not necessarily lead to professional recognition or achievement. Particularly in the current system, early-career researchers who have not secured tenure position inevitably have to spend much of their time obtaining competitive funding and submitting articles to peer-reviewed international journals. This structural problem hinders the development of young talent dedicated to addressing local challenges. Efforts to produce knowledge in local communities require building trust with various stakeholders. Given the need for a long-term perspective and commitment, there is a tendency to delay the publication of research outcomes. Therefore, an evaluation system that overrelies on quantitative metrics tends to undervalue initiatives that focus on knowledge production in regional communities. In addition, many of these activities may not be directly related to conventional research outputs, making it difficult to fully understand or recognize these activities. This sometimes leads to an additional burden for researchers and acts as a barrier to knowledge production within the community. As mentioned in the section on interdisciplinary research, it's important to take a broad and long-term perspective when evaluating researchers' contributions.

It is also imperative to foster an environment in which the younger generation, equipped with

scientific thinking and co-creative skills, can actively address and solve local and regional challenges. It is essential to create employment opportunities in regional areas and establish mechanisms to facilitate I-turns and U-turns, to cultivate professionals who can solve regional challenges scientifically, and build systems within local administrative bodies to utilize such experts. In the long term, it is crucial to promote career education [19] - that is, education that does not merely focus on university for a job, but cultivates the ability and attitude to make one's own path, ensuring social and professional independence after graduation. Various initiatives to promote collaboration between high schools and universities or vocational institutions have already proliferated in different regions. These include open campus events, high school students attending university lectures to receive credit, universities offering outreach lectures to high schools, and the establishment of high school-university collaboration committees. However, many of these efforts are still mostly limited to what might be called "exit guidance" or "class introductions". In contrast, we need a system that connects high school students seeking internships or professionals seeking recurrent education (reskilling[7]) with research labs that will host them.

In addition, it is desirable to collect profile information on individuals or initiatives that excel in society and involve the development of innovation talent outside the school environment, including primary and secondary education. This information can be consolidated to streamline programs to facilitate local human resources and collaboration between school education and society [20]. From the perspective of fostering talent capable of addressing interdisciplinary societal challenges, it is crucial to expand efforts such as the implementation of long-term paid internships for young researchers and continued collaboration between companies and universities to identify and support exceptional young researchers (matching). These efforts aim to foster talent in different fields and, as mentioned above, prevent the emergence of silo effects, which significantly contribute to the creation of innovation.

(ii) Improving the Environment to Support Researchers Engaged in Regional Collaboration

To maximise researchers' expertise in the regional community, there is need to create a platform where universities, citizens, companies, and local governments pool their resources (people, materials, funds, and information) to collaboratively address regional challenges. In urban planning, for example, there is a move beyond traditional administrative planning and citizen-driven urban development. Instead, various stakeholders in the region work together, with urban design professionals providing an expert perspective. As a new form of urban development organization and base, urban design centers have expanded to 23 locations nationwide from April

[7] "Reskilling" refers to learning new skills or knowledge to adapt to technological innovations or changes in business models. At the 2020 Davos meeting, the "Reskilling Revolution" initiative was announced. This initiative aims to provide one billion people with better education, skills and jobs by 2030 to acquire new skills in response to the technological changes brought about by the Fourth Industrial Revolution.

2022[21]. The expansion of such platforms is crucial.

Especially in regional collaboration, there is need for more government support. For example, researchers taking on tasks such as the internship matching mentioned above can lead to an excessive workload. It is essential to avoid such scenarios.

In addition, human resources support must be expanded from the government side, especially in regional collaboration. For example, researchers handling tasks such as the above-mentioned internship matching can lead to an excessive workload. It is important to avoid such scenarios.

4 Advancement of International Collaboration

(1) The importance of international collaboration as a field of innovation

Over the past 30 years, the number of scientific publications worldwide has grown at an average annual rate of 3.8%. Notably the increase involves international co-authorship, which has outpaced the overall growth of papers. By 2021, countries such as the UK, France, and Germany had over 60% of their scientific papers co-authored internationally; Japan lags behind at just 36.1% [22]. To drive innovation, it is critical that international collaborative research be promoted ever more vigorously [23]. In addition to international collaborative research, it is essential to vigorously promote international exchange. Encouraging the recruitment of outstanding foreign students and researchers, as well as promoting long-term exchange of Japanese students will to enhance Japan's research capabilities, including the quantity and quality of research papers. The decrease in scientific and academic talent due to the declining birthrate is a pressing concern; this will undoubtedly continue. Recruiting foreign students and researchers across borders is essential to enhance domestic research capabilities. Although Japan's geographical and cultural situation is substantially different from that of the above-mentioned European countries, it is nonetheless essential to expand international collaborative research in various forms.

From a broader perspective, international collaboration goes beyond general research partnerships. It involves engaging in equitable and constructive global dialogue on science, technology, and pressing global challenges, all with a view to fostering innovation. Ensuring fairness in the international governance of scientific and academic endeavor is of paramount importance. As the fields of science and academia exert a growing influence on global societal transformations and institutional frameworks, the importance of Ph.D.-level researchers who are well acquainted with their field and diplomacy also becomes more pronounced.

(2) Obstacles and Challenges in International Collaboration

To accelerate innovation by fostering international collaboration, we are currently facing several challenges, which are described below.

(i) Development of human resources and career paths for international collaboration

To enhance international collaborative research, it is imperative to look beyond the scientific achievements and expertise of researchers. It is essential to foster a culture of mutual trust among researchers and to develop individuals with an extensive international network to serve as a foundation for international collaborations. The recent proliferation of online communication tools has played a key role in creating opportunities for international collaboration. The importance of face-to-face meetings and physical presence has also been emphasized [24]. Increased support for activities such as participation in international conferences, the creation and maintenance of opportunities for researchers to network, and the promotion of researcher exchange are likely to enhance such face-to-face collaborations. Personal relationships based on mutual trust between foreign researchers and international students not only benefit routine international collaborative research, but also serve as an essential foundation for quickly establishing international cooperative relationships in times of crisis [25].

It is also important to develop individuals who can lead broader international collaboration beyond joint research. In concrete terms, we must prioritize the development of academics who are skilled in science diplomacy and ensure that they have clear and supportive career paths. In international diplomacy and policy-making, there is a growing demand for academic contributions in science and technology [26]. However, we are currently facing a scarcity of professionals who can fulfill this role. To develop such professionals, it is crucial for highly qualified personnel to network and collaborate both domestically and internationally. It is also imperative that government administrators with a strong understanding of science and technology, along with mid- and early-career researchers engaged in policy formulation, actively participate [27]. The acquisition of diverse experience is crucial for career advancement, especially for those who aspire to be at the forefront of science and technology diplomacy, where a broad international perspective combined with a solid understanding of science is essential. However, the prevailing employment structures in Japanese academia and government do not fully support this multifaceted career path and often place the burden of potential risk on those individuals who have the courage to undertake it. For example, the Council for the Promotion of Science and Technology Diplomacy at the Ministry of Foreign Affairs has proposed placing science and technology attachés[8] in overseas embassies [27]. While this is a commendable first step in developing talent, it is crucial to link such careers to evaluations in diplomacy and academia, and to subsequent positions. A strategy must be devised to utilize the expertise of individuals who have gained professional experience in international institutions outside of academia. This is essential for international research activities, science and technology diplomacy, and other specialized areas of international cooperation and diplomacy. It is of paramount importance to ensure that these professionals organically integrate to promote scientific and technological contributions to the global community alongside professionals from other countries.

[8] Individuals responsible for science and technology diplomacy. For more details, refer to [27].

It is also essential that the importance and details of international corporations are clearly understood by researchers, stakeholders and the citizens.

(ii) Improving the environment to support researchers and international collaborative projects

To increase the effectiveness of international collaboration initiatives, it is imperative to create an environment that is hospitable and supportive of foreign students and researchers. The declining rate at which domestic Japanese students advance to master's programs after completing their bachelor's degrees remains the same as the rate at which they advance to Ph.D. programs after earning their master's degrees [28]. Given this fact, the presence of international students plays an important role in supporting Japanese academia. The active participation of international students can drive domestic innovation, and even when these students move back overseas, the deepened ties they have established can facilitate long-term outcomes, particularly in international research partnerships. It is worth noting, however, that the acceptance rate for students planning a medium- to long-term stay (more than one month) has shifted only slightly in the two decades since 2000 [29]. Although the number of short-term international students, those who stay less than a month, has increased, the growth rate on a global scale remains modest. International student enrollment worldwide has nearly tripled in the two decades between 2000 and 2020. Countries such as China[9] and Canada are rapidly increasing their share as study destinations, challenging the dominance of the US and UK. In contrast, Japan has been unable to increase its share over the past 20 years or more [31]. Factors hindering the influx of international students and researchers include not only economic incentives and the language barrier, but also the lack of institutions prepared to host them efficiently [32]. In addition, the administrative burden of hosting international students and researchers is becoming increasingly pronounced from the perspective of researchers engaged in international collaboration. Given the existence of service providers specializing in the outsourcing of international exchange operations for universities [33], it becomes clear that support mechanisms not inherently established within research and higher education institutions are essential for the efficient handling of logistical processes, such as ensuring the smooth day-to-day life of international delegates and invitees. If measures to restrict international research collaboration and person-to-person exchange from the perspective of economic security become overly stringent, they risk undermining long-term benefits. Specifically, such measures may hinder efforts to promote international talent exchange, cultivate individuals with global perspectives, and potentially lose opportunities that contribute to innovation. Leveraging the nation's advantages, including safety and ease of living, it is imperative to create an environment conducive to the rigorous research aspirations of

[9] In 2022, China experienced a decrease in its share and dropped out of the top five study destinations [30]. This decline is thought to be influenced by policies related to the Covid-19 pandemic.

international students and researchers.

In addition, it is important to develop frameworks that facilitate study and research opportunities abroad, considering cost-of-living differences. This can provide accessible links to global institutions, creating an environment for prospective students to pursue their educational aspirations abroad. However, the number of students from Japan studying abroad is significantly lower than the number of students from other East Asian countries, such as China and South Korea, studying in various other countries [34]. Many of the educational programs introduced in Japan in recent years, while overlapping with earlier concerns, lack sufficient institutional support. These complex processes place a significant administrative burden on both domestic scholars and administrative staff, as well as their international counterparts. There is an urgent need to strengthen the support structure for international study programs and allocate additional resources to meet these administrative demands.

It is important to create a supportive environment where researchers who have honed their skills as postdocs or principal investigators abroad can return to Japan and continue their research activities smoothly and uninterruptedly. A research environment that deprives researchers of too much time for research may lead to an exodus of human resources [24]. It is necessary to maintain a quality research and human resource environment and to create an attractive place to conduct research to increase productivity [32]. This point was emphasized following a detailed study in 2000 [32], but its importance remains essentially the same today.

5 Development of Human Resources and Career Paths

(1) The importance of human resource development for innovation, interdisciplinary research, regional and international collaboration

In the quest to foster innovation, we have consistently emphasized the importance of three critical domains: advancing interdisciplinary research, fostering regional and promoting international collaboration. Within these domains, we have identified two overarching challenges that require our attention: cultivating exceptional human resources and establishing well-defined career paths. In this section, we briefly outline the importance of nurturing outstanding individuals and structuring clear career paths.

To reiterate, the cultivation of researchers who achieve outstanding research results in basic and traditional fields serves as a fertile foundation for our academic research. Neglecting this foundation is not an option. Looking ahead to 2040 and envisioning the intersection of science, academia, and society, it is of utmost importance to proactively facilitate researchers to cross boundaries, address regional challenges, and build international networks. Important also is the development of an appropriate evaluation system that effectively assesses diverse researcher profiles and the establishment of a framework that embraces career paths that differ from traditional researcher trajectories. Indeed, it is crucial to create an environment in which everyone has access to an

education that fosters individual skills, ample opportunities to use those skills in work, and the freedom to choose a lifestyle that suits them. It is also essential to create an environment in which individuals can hold multiple jobs simultaneously, in which society accepts failure, and in which it is easy to change careers along the way [3]. Concerns about the current evaluation system are indeed reflected in a large-scale survey of young researchers, as shown in Document 2, Figure k. Furthermore, the analysis of the categorization of the response patterns regarding the critical factors in the research environment for knowledge production reveals a deepening awareness among young researchers, both before and after the Ph.D., that knowledge production takes place within the interconnected framework of different research fields and activities related to research (Document 2, Figure n). An environment and a framework that takes all these dynamics into account must be forged.

Enrollment in Ph.D. programs, the most fundamental source of talented and diverse researchers, has been declining in Japan since its peak in 2003 [22]. Despite a slight increase since 2018, it is noteworthy that the increase is particularly pronounced in certain fields, such as agricultural sciences and health sciences, while other fields continue to decline. Japan's population has been declining since 2010, and is estimated to fall below 100 million around 2048 [35]. If enrollment rates and the number of working and international students remain unchanged through 2040, the number of graduate students is expected to decline significantly to about two-thirds of current levels. Without addressing the challenges facing universities as places for career development and research environments, the number of doctoral students and Ph.D. holders will undoubtedly continue to decline.

Science and academia rely on human expertise, making talent development and career paths critical components. Looking ahead to 2040, Japan must strive to create "a research environment characterized by high mobility, openness, and sustainability". It should also "nurture highly specialized professionals to strengthen the intellectual foundation". Achieving this sustainable research environment will require an ongoing commitment to nurturing a diverse pool of researchers, ensuring a steady supply of individuals to carry the torch of science and academia.

(2) Issues to be addressed now to develop human resources and career paths for researchers

(i) Reducing the household burden of education costs and closing the gender gap

Academia serves as an important institution for nurturing talent that can contribute to the growth of various industries. It is imperative for government to take measures to increase the number of students enrolled in graduate programs capable of producing high-level professionals and to ensure a robust knowledge base in all fields. Although Japan's university enrollment rate has exceeded 50 percent, it still lags behind international standards[10]. Therefore, the initial focus

[10] According to Table B4.2 in reference [36], the university enrollment rate in Japan is comparable to the OECD average and cannot be

should be on increasing the number of bachelor's degree holders. In the broad social context of a declining birthrate, expanding the pool of bachelor's degree holders is crucial. Japan has a significantly lower number of master's and doctoral degree holders per 1 million population than other countries, with a significant shortage in the humanities and social sciences [34]. This issue should be addressed to ensure that Japan remains a global partner.

To increase the percentage of students who advance to bachelor's, master's, and doctoral programs, the most important issue is to reduce the household burden of educational expenses. In recent years, in addition to the existing Japan Society for the Promotion of Science (JSPS) Special Researchers Program, scholarship programs, especially for doctoral students, have been strengthened. Programs such as the University Fellowship Establishment Project and the Next-Generation Researchers Challenging Research Program have enriched the available opportunities. Nevertheless, the rising direct cost associated with undergraduate and graduate education have been identified as a barrier to higher education. A policy mix is needed to further reduce the financial burden associated with pursuing undergraduate and postgraduate studies, including bachelor's and master's degrees [37]. To ensure that all students who aspire to higher education can do so without financial hardship and can focus on their studies and research, it is crucial to create an environment that supports them. Specific measures to achieve this include expanding scholarships with stipends, increasing the availability of low-interest student loans, expanding the scope of tuition fee waivers, providing interest subsidies for private education loans, and implementing policies to ensure university enrollment opportunities in regional areas. In addition, it is essential to reduce inequalities resulting from differences in young people's upbringing, regional disparities, and family income disparities. Further efforts to promote the development of student housing can also contribute to ensuring equal and equitable educational opportunities up to the doctoral level.

In addition, as outlined in the “Integrated Innovation Strategy 2022”, it is essential to address and close the gender gap in STEM (Science, Technology, Engineering and Mathematics) education. This is critical to ensuring diversity in the talent pool - the foundation of innovation. [20].

(ii) Improving the research environment for training the next generation of researchers

Researchers and university faculty members play the central role in training the next generation of researchers. Therefore, to cultivate exceptional talent and diverse research capabilities, it is essential to have sufficient high-quality professionals who are leaders in their respective fields. The presence of high-caliber researchers in different fields ensures that knowledge from different fields is passed on to the next generation, allowing a continuous flow of research output into the future.

In addressing these challenges, it is crucial to first improve the research environment, which is

considered to be at a high level.

often characterized by excessive competitiveness and demanding working conditions. The current dissatisfaction of many researchers with their research environment is detrimental to the attractiveness of the profession. In a context where the country's young population continues to decline, the number of graduate school applicants and those aspiring to research careers may continue to decline, potentially exacerbating the decline in the researcher population through means other than retirement, such as early retirement. In non-English-speaking countries such as Japan, graduate schools also serve as training grounds for professional English literacy. The ability of highly qualified individuals to circulate and network within academia, industry, government, and both domestically and internationally can contribute to strengthening the nation's scientific and technological base [27], as well as enhancing science and technology diplomacy. In other words, the decline in graduate students is a cause for concern because it may lead to a decline in the country's international standing.

It is also important to encourage more active collaboration and resource sharing through inter-university collaboration and sharing, as is already being done in some cases. This would help to balance the number of researchers in different fields and maintain the diversity of disciplines [38]. Encouraging Ph.D.s from other sectors to visit university research environments and participate in graduate education could create new forms of research and educational environments.

In addition, it is important to recognize that improving the research environment is not only essential to addressing the decline in research capacity, but also critical to improving the quality of education. If researchers, who play a central role in training the next generation of researchers, are unable to fully engage in their own research activities or devote adequate time to teaching, this may result in insufficient resources being allocated to the training of students as future researchers. For university faculty to provide high quality "research education" to graduate students, they must continuously update their knowledge through ongoing research activities, which requires time. Although the time devoted to teaching by university teachers has increased by 4.8 percentage points since 2002, the time devoted to research activities has decreased by 13.6 percentage points. This is particularly noticeable in private universities, where the proportion of time devoted to research is less than 30%, making it difficult to consider research as a primary focus (Document 3).

To solve this problem, especially to improve the research environment associated with graduate education, it is crucial to allocate sufficient funding for research education to educational institutions, rather than relying solely on funding for individual researchers. For example, in the case of national universities, the operation of research laboratories where undergraduate training is provided relies on both institutional operating subsidies from the university and external funding sources, such as competitive research grants such as scientific research grants. As operational funding grant to universities have been progressively reduced, research laboratories without external funding are often unable to adequately conduct educational activities. In addition, competitive funding programs have high application costs. The uncertainty

of whether they will be awarded until the last moment complicates the planning of activities such as staffing and laboratory operations. Because educational outcomes require a medium- to long-term perspective, there is a mismatch between the short-term focus often associated with competitive funding and the need for sustained educational effectiveness.

(iii) Increasing the use of highly skilled personnel in various sectors and enhancing the attractiveness of research careers

As noted above, the working-age population is expected to continue to decline in the future, leading to increased competition for talent. Enhancing the attractiveness and competitiveness of research careers compared to other professions is crucial to developing a diverse, highly skilled professional talent pool capable of creating innovation. To achieve this, it is critical to effectively evaluate Pd.D. holders, taking into account not only their specialized knowledge, but also their multi-faceted skills such as problem solving, logical thinking, and intellectual curiosity. As the labor force shrinks and AI increasingly takes over routine tasks, specialized expertise is expected to become even more valuable. In an era of increased unpredictability and complexity, often referred to as the "post-VUCA" era (characterized by volatility, uncertainty, complexity, and ambiguity), the development of specialized expertise and intellectual resilience through academic exploration in graduate programs will be essential for a country to maintain flexible growth.

In particular, it is essential to provide opportunities for Ph.D. holders to be recognized and to excel in various sectors including industry, government, politics, and international organizations, not only within universities or research institutions. This includes the need for universities and research institutions to objectively evaluate the skills of Ph.D. holders. It also requires the development of job roles in other sectors that can utilize their expertise, as well as detailed definitions of the competencies required for effective job performance. Collaborative efforts between both parties to establish and share these new mechanisms will be crucial.

At present, we have seen the successful application of specialized technical expertise in industry, particularly in certain fields such as engineering and information technology. This has led to increased mobility between academia and the private sector, making it easier for individuals with Ph.D.s to be recognized for their significant contribution to society. To build on this trend, it is essential to expand the number of organizations that value and recognize Ph.D.s, not only in research and development roles, but also across sectors. In the current landscape, the percentage of Ph.D.s employed as researchers in individual companies is relatively low, typically around 3-4%. In the United States, on the other hand, more than 40% of managerial positions are occupied by Ph.D. holders. In Japan, on the other hand, the figure is only 12% [39]. This difference can be attributed in part to Japan's dominant employment model, which relies on lifetime employment within a single organization. To foster innovation and adapt to changing workforce dynamics, it is essential for Japan to promote a job-based employment approach similar to that used in Western countries. In this approach, organizations hire individuals based

on their specialized skills and expertise, allowing them to effectively utilize their external knowledge. In the foreseeable future, there will be fewer companies capable of providing comprehensive in-house training. As a result, there will be a growing need to recruit and effectively utilize individuals who already possess specialized knowledge. Failure to do so could impede the achievement of the required high levels of productivity, potentially undermining the viability of various companies. It is critical for business leaders in diverse industries to strategically assess how they can leverage specialized talent from different disciplines within their companies to sustain growth. This approach will enable highly skilled individuals who have pursued advanced education at the Ph.D. level to make valuable contributions across industries, even if they choose career paths other than research. It is imperative to create an environment that facilitates such developments in the future.

6 Reconstructing the Research Environment

(1) The importance of improving the research environment for Interdisciplinary research, regional and international collaboration, and human resource development

Throughout this discussion, we have emphasized the importance of fostering interdisciplinary research, regional and international collaboration, and human resource development as essential components for driving innovation. These areas are interrelated and share common challenges that need to be addressed.

First and foremost, a recurring theme in all four domains is the need to secure time and resources for researchers and university faculty to engage in interdisciplinary research, regional and international collaboration, and human resource development. This includes the importance of improving organizational, financial, and administrative support to facilitate these efforts. Furthermore, it has been emphasized that, while it is essential to recognize and reward researchers who achieve outstanding research results, it is equally important to evaluate the activities of young researchers with a discerning eye, employing a variety of evaluation criteria. Finally, the establishment of platforms for co-creation across academic fields and sectors has been acknowledged as a common and necessary means of improving the research environment.

(2) Challenges in Improving the Research Environment

(i) Breaking Free From the "Activity Trap" in Academia

In the current state of academia, a recurring and significant issue that cannot be overlooked is the difficulty in securing time and resources for researchers and university faculty to engage in cross-border research, regional collaboration, international collaboration, and talent development [40]. This problem has also been identified by the Cabinet Office Council for Science, Technology and Innovation as a particularly challenging issue, especially in the context of strengthening research capacity and supporting young researchers [41]. The structure of

academia, where excessive workload has become a chronic problem, hampers the allocation of research time, resulting in a degradation of research capacity. This problem stems from an “overwhelming workload” that leads to a lack of work-life balance. In today's world of academia, the pursuit of cutting-edge research, the acquisition of research funding, and the participation in recruitment processes to secure positions are all highly competitive tasks. While the pursuit of excellence is a normal and essential aspect of self-improvement, the pursuit of excellence knows no bounds. The pressure to excel can expose individuals to anxiety, lead to longer working hours, and result in excessive workloads. Many researchers have faced relentless competition from their undergraduate days to securing research positions, fostering a survivorship bias that tends to accept competition as an inherent aspect of this environment. In addition, there is a deep-rooted belief in academia that hard work is a virtue, and this prevailing sentiment has contributed to a reluctance to streamline work processes. The structure of academia, in which chronic overwork has become a significant deterrent, affects various segments of the academic community, including women facing the potential challenges of menstruation or pregnancy; students and young researchers facing uncertain career prospects; individuals responsible for caring for minors, patients, or elderly relatives; and researchers dealing with their own physical and mental health issues - all of whom face vulnerabilities in their personal lives. This situation has led many talented individuals to avoid or abandon academic pursuits [42]. Thus, academia is currently caught in a downward spiral of increasing individual strain and a shrinking pool of professionals.

In addition, it is crucial to recognize that the impact of life-related factors on research activities varies according to the life stage and family circumstances of researchers. Large-scale surveys of early-career researchers have shown that factors such as aging, marriage, childbirth and childcare have a significant impact on knowledge production activities (Document 2). This trend is particularly pronounced in the responses of female researchers, highlighting the importance of addressing structural issues affecting female researchers (although this is also a broader societal concern in Japan).

To address this problem, it is crucial first to work across sectors to expand core facilities, improve administrative support systems, and reduce the excessively high rates of competition for research budgets, as mentioned above. It is suggested, however, that especially among young academics, the academy itself should simultaneously engage in improving its "structure of academia". Academia, founded on public trust and endowed with significant resources and autonomy, has the capacity to address these issues. While it may be challenging to change this deeply ingrained "structure of academia" characterized by excessive workload, incremental efforts to address specific issues can lead to the establishment of a healthier culture over time. To achieve this, it is necessary to maintain the attitude required for research, which includes "thoroughly examining the essence without being constrained by formalities, using appropriate methods, and diligently dealing with the subject," not only in research but also in other practices

in academia.

a. Efficient Research Effort Allocation in Universities and Research Institutions

Over the past two decades, the time devoted to research by university faculty has declined. This trend can be attributed to the increasing proportion of time devoted to other responsibilities, including teaching, community service, and various other duties [43]. Researchers today, burdened with a variety of responsibilities, find themselves in a situation where they can only devote the remaining effort to their research activities.

Universities and research institutions should ensure a dedicated research effort while allowing faculty members to fulfill other responsibilities. To allocate research effort effectively, one possible approach is to explicitly define the expected research effort for each faculty member. Careful consideration should then be given to other responsibilities and, if necessary, delegation of tasks to non-faculty personnel or external organizations should be considered if these responsibilities interfere with research effort. Recognizing that it may be difficult to ensure research effort within a single fiscal year, it is advisable to implement institutional policies for multi-year allocation of research effort. In addition, encouraging role specialization among faculty members, especially those who excel in teaching, as often advocated by research experts with international experience, holds promise [24]. Indeed, surveys of young researchers indicate a desire for support systems and task streamlining in order to increase the proportion of time spent directly on research and knowledge production by about 50%, while reducing other responsibilities by about half [11] (Document 2).

In addition, committees and admissions examinations play an important role in the non-research activities of university faculty [41]. The use of lessons learned during the COVID-19 pandemic, such as the use of chat tools and online conferencing systems to streamline internal processes, should be further encouraged and institutionalized. Regarding admissions, which are considered a major university undertaking, it is crucial to carefully reassess whether the increased workload and costs associated with the diversification of admissions in recent years are justified by the results achieved.

b. Reviewing and Streamlining Academic Association Activities

Academic associations play a vital role in supporting their respective scientific and academic fields through activities such as publishing academic journals and organizing academic conferences. However, the administrative tasks associated with their operation, including membership management and fee collection, as well as the review processes related to papers and research grants, often place a significant burden on researchers. It may be

[11] It would be premature to interpret these results as young researchers avoiding responsibilities other than activity directly related to research and knowledge production. The goal should be the appropriate allocation of tasks, recognizing the necessity of responsibilities beyond research and knowledge production within their work.

counterproductive for the efforts aimed at sustaining and expanding academic societies to consume the resources and efforts that should be directed towards scientific and academic activities themselves.

In today's academic landscape, where academia as a whole is struggling with excessive workloads, it is imperative to examine the burden of writing requested manuscripts. One must assess whether the burden of writing requested manuscripts is acceptable in an era of academic overload, and whether it results in publications that are sufficiently meaningful. This examination should be particularly relevant for senior researchers and those in leadership positions who solicit. Moreover, in today's academic landscape, where academia as a whole is struggling with excessive workloads, it is imperative to examine the burden of writing requested manuscripts. We must assess whether the burden of writing requested manuscripts, and the publications themselves, are sufficiently meaningful. This is particularly relevant for senior researchers and those in leadership positions who are often in the position of soliciting. Senior researchers should work to foster a culture in which limited effort is used most effectively.

c. Excessive Review Costs and Streamlining of Committees

In the midst of the shift in science and technology policy from basic funding to competitive funding, proposers and reviewers invest considerable effort in submitting and evaluating proposals, leading to what can be termed "evaluation exhaustion" with excessive costs for both parties [40]. In particular, discriminating between proposals close to the funding threshold can be very challenging, and it may be inherently impossible to draw a clear line through peer review. One proposed solution is to implement approaches such as "screening and random selection," in which proposals that are clearly ineligible (or exceptionally outstanding) are screened out through peer review, and the remaining proposals are then randomly selected for funding. As noted above, it is essential to continue to expand small-scale budgets to support exploratory research and long-term evaluations. Such an approach may prove particularly effective in selecting exploratory research topics where success is difficult to predict. In addition, there are concerns about increasing the burden of evaluation beyond current levels if the goal is to evaluate young researchers on multiple criteria in the context of interdisciplinary research and regional collaboration. The implementation of approaches such as those described above may alleviate some of the evaluation burden.

To facilitate innovation, the process of creating something entirely new, it is critical to establish a budgetary and operational framework that allows for trial and error. The nation that is committed to fostering innovation must break free from an over-reliance on a bureaucratic approach to resource allocation, a culture that rigidly adheres to past practices and shuns failure, and a mindset that is bound by traditional norms. Moreover, while research funding has increased, the introduction of numerous new funding mechanisms has needlessly complicated

the system, resulting in ever-increasing evaluation costs. This counterproductive situation threatens essential research resources and demands immediate improvement.

In addition, it is imperative to explore systemic change as a means to reduce this burdensome workload. Researchers play a crucial role in society by serving as experts on committees and advisory boards established by national and local governments (as social services). Many of the issues under consideration have similarities, making it desirable to share knowledge, foster unified discussions, and address workload reduction, effective incorporation of academic insights into policy, and feedback from these deliberations. For example, rather than seeking arbitrary individuality and distinctiveness in each local jurisdiction, it is essential to engage in discussions between academic expert groups, such as academic societies, and governmental bodies to efficiently and effectively restructure these committees and advisory boards.

(ii) Expansion of Organizational, Budgetary, and Administrative Support for Research Environment Improvement

Academia must proactively address the prevailing "self-structural issues in academia" It is equally imperative to strengthen organizational, financial, and administrative support for improving the research environment. The following priorities, as outlined above, require immediate attention in order to create innovation: Expanding core facilities to strengthen research capabilities, facilitating collaborative platforms and spaces that engage participants from different sectors to foster innovation, and increasing human resource support to reduce the administrative burden on researchers and university faculty. In addition, it is critical to address the time constraints associated with international research collaborations, which often require extensive arrangements in advance compared to domestic exchanges. Failure to do so can perpetuate a negative cycle in which a lack of international connections hinders engagement in global research collaborations. Breaking this cycle is imperative.

Furthermore, in addition to the aforementioned increases in time spent on evaluations and meetings, academia is experiencing an increasing trend in workload, including activities such as outreach and student advising, which are becoming integral parts of researchers' responsibilities. For example, there is a growing need to provide reasonable accommodations and appropriate support for students and staff with special needs. However, in the current situation, faculty members without specialized knowledge and skills often spend considerable time providing "amateur" individualized support [40]. To address this problem, it is imperative to re-evaluate traditional university management, where education, including the full range of student support, falls primarily on the shoulders of faculty members alone. Instead, a new approach is called for in which multidisciplinary experts from within and outside the university work as a team to provide comprehensive education. These experts would have specialized knowledge in areas such as psychology, mental health, law, and education, thereby reshaping the way universities

are administered.

In this context of increasing workloads, the use of IT should not be used as a reason to reduce the number of faculty members, but rather as a means to secure budgets for the necessary equipment and to promote the relaxation of laws and regulations that impede such a shift. Particularly since the individual burden of facilities maintenance and upkeep tends to be greater at smaller and mid-sized universities, where it can be relatively difficult to find staff with facilities management skills, it is critical to provide targeted support to these universities.

The shortage of research support personnel in highly specialized positions related to administrative and educational support and research leads to the problem of long working hours for researchers. In particular, even if research funding increases to some extent, there is a structural problem in that the burden of accountability and clarification of the use of such funds results in an enormous increase in administrative work and various demands not taken into account. In fact, the ratio of the number of staff to the number of researchers is very low in Japan, and the system for supporting research is thin (Document 4).

As mentioned earlier, the amount of operational grants allocated as research funding for individual researchers is very limited in Japan. Therefore, securing competitive funding has become a necessity for research and education. However, due to insufficient funding for basic infrastructure to employ research support staff and maintain the research environment, even when competitive funding is obtained, researchers are unable to fully utilize it. This is a highly critical situation. To address this problem, improvements in the treatment of research support personnel, including technical staff and other specialized professionals, and the establishment of stable and consistent funding for infrastructure are essential. Considering that an increase in infrastructure funding is expected in various countries, it is important to allocate additional resources for this purpose as well.

The insufficient number of research support personnel in Japan is influenced by broader international factors. In some countries, there is a higher degree of job mobility outside of academia, especially among highly skilled individuals, who often change positions as a matter of course. While various employment arrangements, including fixed-term contracts, are common worldwide, fixed-term employment is often perceived as a disadvantage for employees, regardless of their salary level in Japan. Therefore, it is imperative to promote a Job-type employment model that addresses these challenges.

7 Conclusion

In summary, we have examined the current situation of researchers in Japan, especially young researchers, and highlighted the interconnectedness of five key domains (Figure 3). To foster innovation, it is essential to create a robust research and education environment that is attractive to graduate students and where Ph.D. holders can play an active role in research institutions and companies with high professional appeal. Academia must strive to improve the research environment

so that researchers have sufficient time to address truly important scientific and social challenges and provide high quality, relevant education. This should be carried out while fostering an academic culture in which individuals can thrive and lead fulfilling lives. We should also envision science, academia and society in 2040, and strive to build a nation where innovation is seamlessly created, and where the boundaries between industry, academia, government and the private sector are transcended to create a forward-looking, academic environment full of quality learning and exploration.

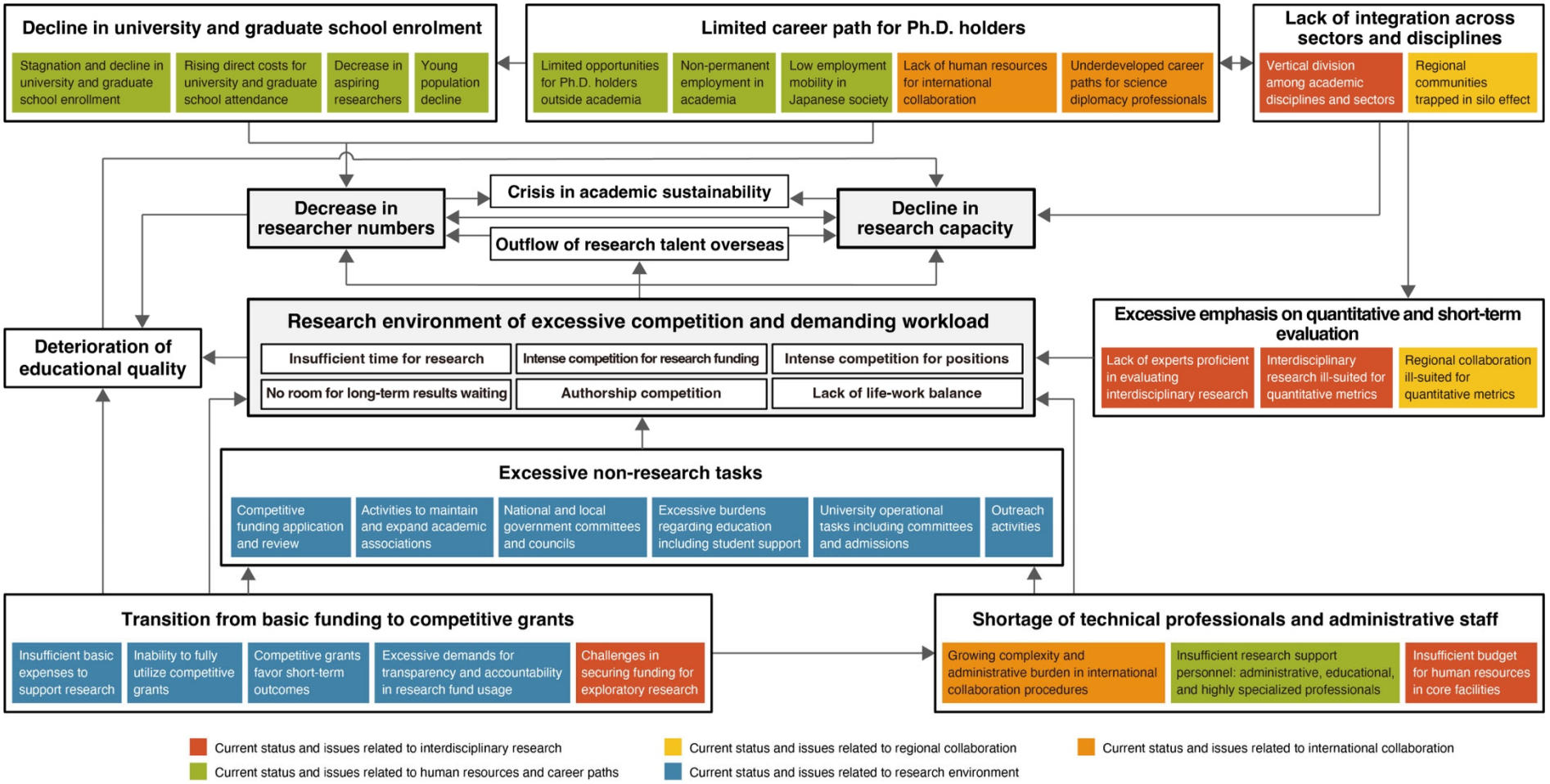

Figure 3 Structural problems that hinder innovation creation

(Source: Prepared by the Young Academy of Japan)

The following desiderata comprise ten pressing issues that must be addressed immediately in order to foster innovation by reenvisioning academia and society in the coming two decades (Figure 4, Document 5).

(1) Cultivating fundamental and traditional knowledge and technology
(2) Strengthening evaluation and support for interdisciplinary research and regional collaboration together with local stakeholders
(3) Enhancing core facilities with Ph.D. holders
(4) Cultivating a cross-sector collaborative ecosystem
(5) Enhancing basic funding and research support personnel
(6) Establishing career paths in science diplomacy
(7) Overcoming the "zero-failure" bureaucratic mind in science management
(8) Reducing the burden of education on households
(9) Breaking free from the "Activity Trap" of Academia
(10) Promoting inter-sectoral career paths for Ph.D. holders

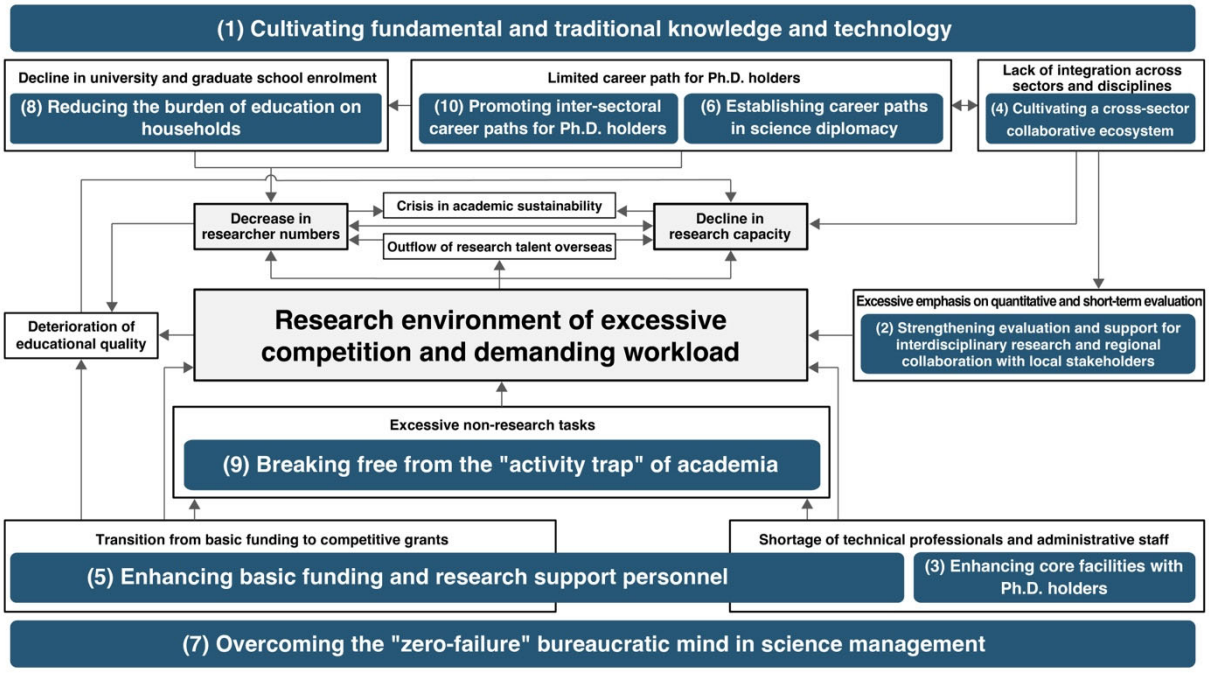

Figure 4 Ten pressing issues to address the creation of innovation

(Source: Prepared by the Young Academy of Japan)

(Note: Recommendations for addressing the 10 issues are presented in Document 5.)

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Document 1 Documents of the Science Council of Japan related to this Opinion

The main documents concerning this Opinion, issued by the Science Council of Japan since 2010, are summarized below. The main statements related to the content of this Opinion are excerpted for each of the following keywords: young researchers (young researchers), science, academia, innovation, interdisciplinary (ten pressing interdisciplinary issues that must be addressed in the domain of research), regional (regional collaboration), international (international collaboration), human resources (human resource development and career path), and environment (research environment and industry structure).

issuing entity	type	Title.	Date of issue
The Science Council of Japan	proposal	Prospects for Japan - Proposals from Academia 2010	April 2010
Young: "It is important to create opportunities for young researchers to tackle academic issues from a bird's-eye view and to develop the human resources that will be responsible for the near future of academia." Science and Academia: "Japan's Vision: Proposals from Academia 2010" is a proposal from academia on how academia, which encompasses all the sciences including the humanities, social sciences, life sciences, science, and engineering, should demonstrate its collective strength with a view to building a sustainable society, an urgent issue for human society and Japanese society in the 21st century. Border-crossing: "Liberal arts and liberal arts education for modern citizens must be conceived from three perspectives: i) respect for individual independence and autonomy; ii) understanding and recognition of human interdependence, symbiosis, and collaboration based on respect for individual dignity and individuality and their diversity; iii) integrated intelligence that transcends individual fields of specialization and the formation of practical intelligence to solve problems and work together. The concept must be conceived from three perspectives: i) the formation of an integrated intellect that transcends individual disciplines and the formation of a practical intellect that works collaboratively to solve problems. Innovation: "In the 21st century, when the fruits of scientific and technological knowledge creation are deeply embedded in society and the world, and further progress is expected in the future, 'scholarship and innovation' are inextricably linked."			
The Science Council of Japan, Committee on the Young Academy, Subcommittee for Review of Young Academy Activities	proposal	Establishment of the Young Academy	September 2011
Young Scientists: "The Science Council of Japan, through the Young Scientists Academy, will foster young scientists with a bird's eye view through international activities and exchange with other disciplines, and will enable such young scientists to develop original activities that actively address solutions to various problems in society by means of their new ideas." Academia: "The establishment of the Young Scientists Academy will encourage the next generation of young scientists to participate in the activities of the Science Council of Japan, providing a forum for the examination of academic and social issues from a broad perspective and opportunities for diverse exchanges, and fostering the development of young scientists as future leaders in academia." Crossing Borders: "The Young Scientists Academy can create opportunities for young scientists to freely and actively interact and collaborate across disciplines and national borders, and can be a part of a borderless intellectual community that aims to create new academic disciplines and integrated studies." International: "In 2010, the Global Young Academy was established with members from various countries (124 members from 58 countries in 2011), and the members of the Subcommittee for Review of Young Academy Activities participate in its international activities."			
The Science Council of Japan, Committee to Study the "Evaluation System" for Research	proposal	The state of Japan's research evaluation system: Transformation to an evaluation system that fosters and supports researchers.	October 2012
Younger faculty: "There is concern that the current method of individual evaluation may lead young faculty members and researchers in particular toward short-term research, and for postdoctoral fellows, the relationship between evaluation and career development,			

such as tenure renewal or employment, is not clear." Environment: "Researchers are forced to spend a great deal of time and energy to respond to evaluations, which some say leads to a lack of time for research, a skeleton evaluation process, and a feeling of exhaustion for those involved in the evaluation process." International: "The national government and funding agencies ... will be mindful of conflicts of interest, international evaluation, etc., and will actively recruit foreign evaluators."			
The Science Council of Japan, Committee for the Study of Fostering Future Generations of Science and Technology	proposal	Measures to nurture the future generation of science and technology leaders - Recommendations for the integrated promotion of education and scientific and technological innovation	February 2013
Young researchers: "Young researchers in academia are also under pressure to produce research results in a short period of time, as the majority of positions are tenured, and there is a growing tendency to avoid medium- to long-term perspectives, research in unexplored fields, and collaborative research overseas." Science: "In terms of the inheritance and development of science and technology, there are especially great expectations for the training of young people who will lead the next generation and the education of children, students, and young people." Human resources: "In order to improve the capacity for sustainable science and technology innovation generation, it is essential to go beyond short-term human resource development to link up with consistent education and science and technology policies that can promote the improvement and enhancement of overall education from primary education to higher education and adult education." International: "Graduate students with research-based problem-solving skills and the ability to make decisions backed by a high level of expertise are essential for leadership and international competition." Innovation: "The Fourth Science and Technology Basic Plan (approved by the Cabinet on August 19, 2011) defines 'science and technology innovation' as 'the creation of intellectual and cultural value based on new knowledge through scientific discoveries and inventions, and innovation that leads to the creation of economic, social and public value through the development of such knowledge. The company aims to achieve this goal."			
Subcommittee on Education and Human Resource Development for Sustainable Development, Committee on the Promotion of Future Earth, Science Council of Japan	proposal	Toward the Promotion of Education and Human Resource Development for a Sustainable Future	September 2014
Region: "Promotion of community-based capacity building through the use of science museums, museums, etc."			
The Science Council of Japan Part I: Subcommittee on Science and Society after the Fukushima Nuclear Disaster	proposal	Toward a Better Relationship between Science and Society: In Light of the Loss of Trust after the Fukushima Nuclear Disaster	September 2014
Science: "The division of labor between 'science' and 'society' is not always possible, with science providing 'objective truth' and society making some political response or decision based on that truth; the line between the two is increasingly difficult to draw.			
The Science Council of Japan, Committee on Young Academy, Subcommittee to Study the Future of Academia *Not an expression of intent as defined in Article 2 of the Constitution of the Science Council of Japan	record	The New Role of Academia: Young People's Perspectives, Perspectives from Outside	September 2014
Younger researchers: "Younger researchers shared the perception that it is difficult to establish a stable research career unless an individual is single, healthy, and able to devote most of his or her life to work, or has sufficient support for housework and childcare from a spouse or other family member."			
The Science Council of Japan Committee on Employment System for Research Personnel that Contributes to Strengthening Japan's Research Capability	proposal	Employment System for Young Researchers Contributing to Strengthening Japan's Research Capabilities	September 2014
Young researchers: "In particular, clarifying how young researchers and post-doctoral researchers can improve themselves and their abilities, and how they can create a lifelong plan, is a core issue for strengthening Japan's research capabilities." Human resources: "Based on a portfolio of postdoctoral researcher employment created with a bird's-eye view, a system that enables stable employment and continuous human resource development is needed so that postdoctoral researchers can fully demonstrate their			

research capabilities."			
The Science Council of Japan, Committee on Scientists, Subcommittee on Gender Equality	proposal	Strategies to increase the participation of women in the scientific community	August 2015
Environment: "Building a 'Mechanism of Choice' to Improve Researchers' Work-Life Balance"			
The Science Council of Japan Committee on Promotion of Future Earth	proposal	Toward the realization of a sustainable global society - Promotion of Future Earth	April 2016
Science: "In addition to interdisciplinary research in the natural sciences and the humanities and social sciences, this FE (Future Earth) emphasizes "transdisciplinary" research through collaboration and cooperation between the scientific community and society." International: "Japan, with its advanced science and technology and extensive experience in environmental and development research, must take an international leadership role in FE (Future Earth) and communicate it to the international community through collaboration and partnership in Asia."			
The Science Council of Japan, Part I, Subcommittee on the Role and Promotion of the Humanities and Social Sciences	proposal	Toward the Comprehensive Development of Science: Proposals from the Humanities and Social Sciences	June 2017
Young researchers: "The conversion of full-time posts to fixed-term posts and the reduction of part-time posts are serious problems that threaten young researchers. ...Efforts must be made to secure full-time posts and improve the treatment of part-time lecturers." Science: "The humanities and social sciences have the unique quality of combining time and space perspectives and using diverse approaches to critically examine various values." Human Resources: "What is indispensable in the development of human resources is the knowledge provided by the humanities and social sciences, including an understanding of Japanese and foreign societies, cultures, and histories, as well as English and other foreign languages, and the ability to make judgments and think critically based on these." Crossing Borders: "Even in the humanities and social sciences, there is an ever-increasing need to learn about research trends and results in adjacent fields and to gain a perspective on research as a whole from a interdisciplinary perspective." Region: "The role expected of researchers in the humanities and social sciences at regional national universities is extremely important, not only for the preservation of local cultural assets and traditional performing arts and the development of local history research, but also for the revitalization of the local economy and the enhancement of regional brand power."			
The Science Council of Japan Committee on Education and Research at National Universities from the Perspective of Academic Advancement and the Support by the State	proposal	Education and Research Reforms at National Universities and Government Support: From the Perspective of Forming the Foundation for Academic Advancement	June 2017
Human resources: "It is important to overcome the stagnation in academic research and the deterioration in the development of young human resources, which is triggered by the decline in basic expenses at universities." Environment: "The critical situation, which could be called a 'negative spiral,' is particularly evident in the following three points. ...The third is the decline in research capacity due to decreased research time." International: "It is important to increase openness, mobility, diversity, and internationalism in the faculty personnel system." Regional: "According to a survey of experts, local governments, and residents in four prefectures across Japan, ... the roles of regional national universities that were rated "very important" or "somewhat important" were "revitalization of the region through cooperation between industry, government, and academia" (92%), "development of human resources who can lead society" (91%), and "promotion of advanced, cutting-edge research" (87%), indicating that national universities are expected to contribute very strongly to regional revitalization based on advanced education and research. (87%), indicating that national universities are highly expected to contribute to regional revitalization based on advanced education and research.			
The Science Council of Japan, Committee for the Study of the Research Funding System for the Promotion of Academic Research	proposal	Proposal for a research funding system that contributes to the comprehensive development of academia and innovation in society	August 2017
Environment: "The government should create conditions that allow for adequate comprehensiveness, an appropriate ST ratio (number of students per faculty member), and adequate research hours through the stable provision of operating grants." Innovation: "One area that should be expanded in the future for universities and other institutions to fully play a leading role in social innovation is closer collaboration with businesses in research."			

The Science Council of Japan, Committee on Science and Society, Subcommittee on Government-Industry Collaboration	proposal	The University from the Perspective of Industry-Academia Co-Creation: Achieving a Knowledge Intensive Society by 2025	November 2018
Young people: "In order to promote new strategies and measures, it is essential to have human resources who can put them into practice. Particularly important for venture start-ups are the young researchers and students who will lead the charge." Human Resources: "There is a growing demand for universities to develop human resources to drive innovation in order to increase the international competitiveness of industry." International: "International Development and International Platforms with a Focus on Promoting the Diverse Experiences of Young People" Region: "Accumulation and utilization of information and data based on universities in each region" Innovation: "For example, a system in which a company's R&D center can be established at a university to promote consistent innovation activities from basic research to social implementation would also be useful, and expanding this system would be effective."			
The Science Council of Japan, Committee of Scientists, Subcommittee on Academic System	proposal	Recommendations for the Sixth Science and Technology Basic Plan	October 2019
Young researchers: "For young researchers, support is needed in the areas of salary, career path, and research funding, but from the perspective of international brain circulation, it is also essential to level the playing field of social security, along with measures to support the expansion of international cross-appointments that allow researchers to return home with peace of mind." Academic: "This proposal reorganizes the problem and the effects of existing policies from the perspective of the academic research field, and recommends measures that should be taken in a way that goes into concrete form." Human resources: "Some attempts have begun to foster doctoral human resources through university-industry partnerships." Environment: "The problem of researchers' "deterioration of research time" is also serious. As a result of the shift in funding allocations to top-down competitive research funds, researchers are not only forced to produce short-term research results and achievements, but also to devote much of their time and effort to paperwork for applications, reports, and other documentation." Region: "Each university has deep ties to the region in which it is located and is expected to play an increasingly significant role as the nucleus of a regional industrial cluster and as a center for human resource development in the region."			
The Science Council of Japan, Committee of Scientists, Subcommittee on Research Evaluation	proposal	Toward Research Evaluation that Contributes to the Promotion of Academia: Challenges and Prospects for Desirable Research Evaluation	November 2021
Young researchers: "In the evaluation of research by young researchers, we should pay sufficient attention to new research methods and methods of disseminating results in order to evaluate them in a way that supports their growth." Region: "Because young researchers are often in fixed-term positions and are expected to be fluid, it is difficult for regional contribution activities in which young researchers are involved to receive proper recognition beyond the university or region."			
The Science Council of Japan	Answer.	Deliberations on Strengthening Research Capability - Especially from the Perspective of Improving the Research Environment at Universities, etc.	August 2022
Young researchers: "(of 10 proposals) [Proposal 6] Enhancement of start-up support for young researchers" Academia: "Public understanding of academia is the foundation for the effective promotion of various measures, without which national initiatives will have no viability." Environment: "The government should evaluate and promote self-help efforts by each institution, department, faculty member, and adjunct instructor that reduce the teaching burden while maintaining educational effectiveness as an effective measure for securing research time, rather than as an excuse to reduce the number of faculty members." The measures should be considered on the premise that individual researchers are now making decisions that emphasize and manage both work and family, which is called work-life management." International: "[Proposal 7] International Human Resource Mobility and International Network Building for Young Researchers"			

Document 2: Summary of results of Survey of Perceptions of Evaluation in Young Researcher Environments

The following is a summary of the " Survey of Perceptions of Evaluation in Young Researcher Environments " conducted by the Young Academy of Japan in 2022.

[Summary of the survey]

The research and knowledge production environment for young researchers faces many challenges, including global competition, evaluation issues, and issues related to career paths. Especially in Japan, evaluation issues are becoming more apparent with the shift from basic funding to competitive funding. The purpose of this survey is to contribute to the creation of a better ecosystem for knowledge production by analyzing the gap between current perceptions and ideal images of evaluation for young researchers.

Survey Summary

Survey period	June 7 - July 5, 2022
Subject of an investigation	Young researchers (including graduate students and young professionals) under the age of 45
Questionnaire	https://www.scj.go.jp/ja/scj/wakate/pdf25/chosa2206-07.pdf
Method of investigation	Web-based survey (outsourced to Rakuten Insight to build a response site and collect data) Note that the respondents are young researchers and are likely to have a relatively high level of interest in career paths, etc., due to the nature of the web survey.
Methods used to advertise and collect surveys	URLs distributed through academic societies and universities at the request of the Science Council of Japan and the Ministry of Education, Culture, Sports, Science and Technology
Number of valid responses	7849 respondents (excluding those not surveyed from the total of 8629 responses)
Financial assistance	The Koji Harada Fund of the Japan Science Cooperation Foundation

[Summary of Survey Results]

■ Basic characteristics of Respondents

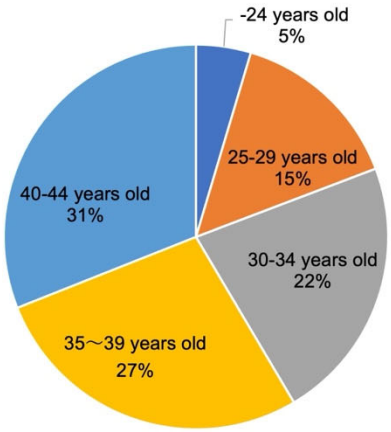


Figure a. Age

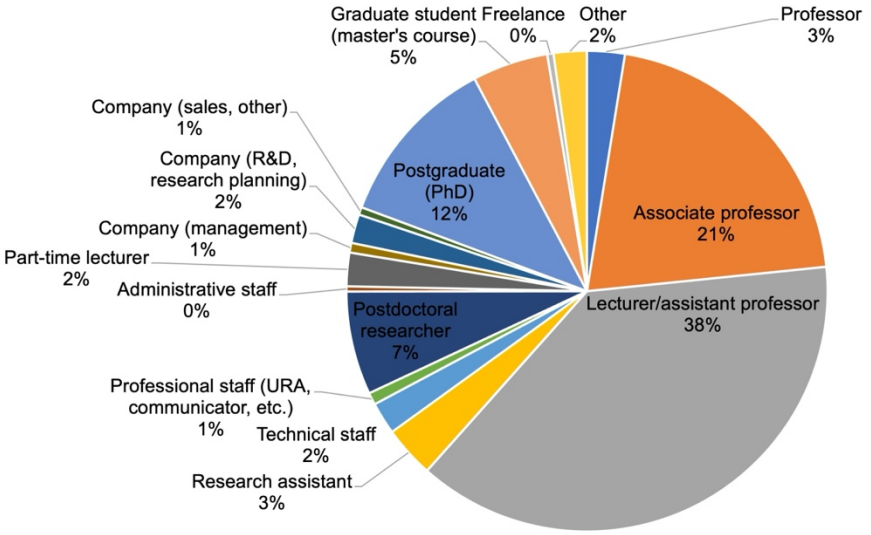


Figure b. Position

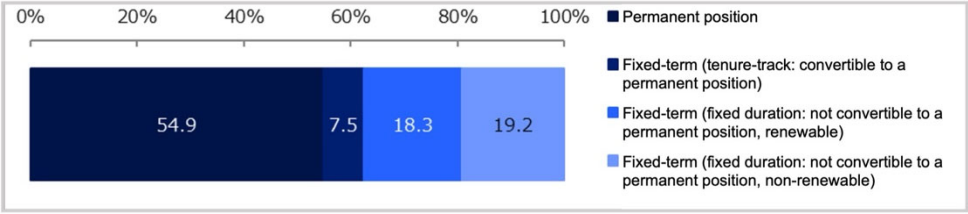


Figure c. Employment status

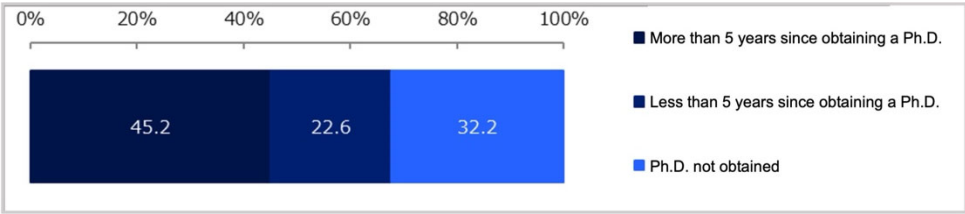


Figure d. Time from Ph.D. degree completion

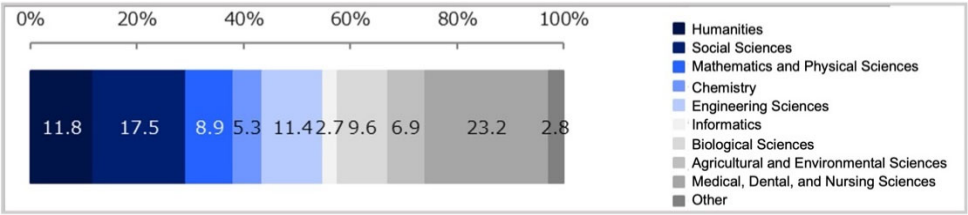


Figure e. Areas of Expertise

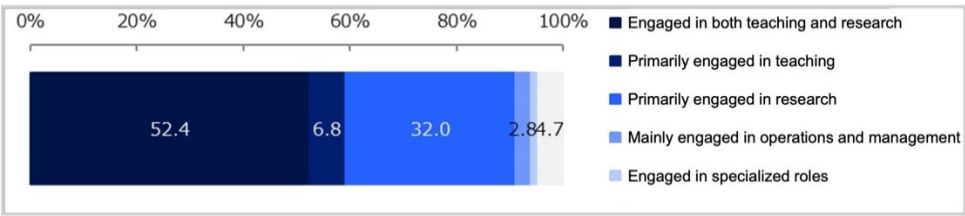


Figure f. Duties

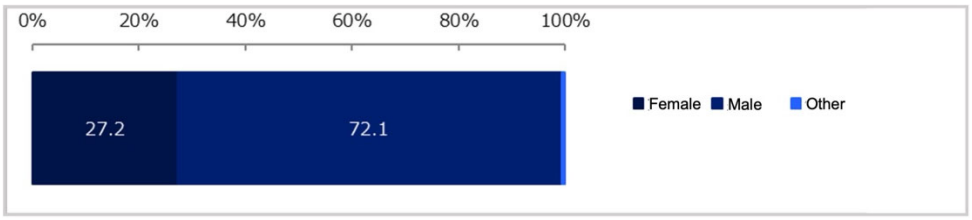


Figure g. Gender

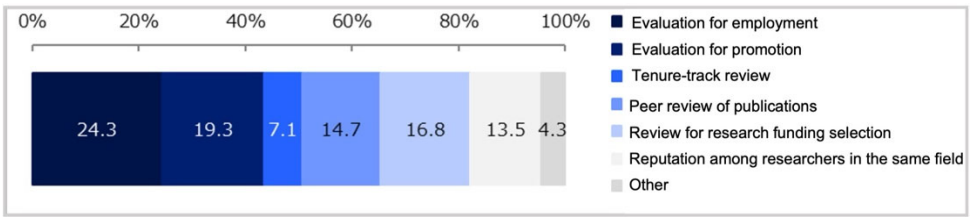


Figure h. Evaluations of particular interest

- Age: Early 20s to early 40s (Figure a)
- Position: "Associate Professor and Lecturer/Assistant Professor together account for approximately 60%. Other positions include graduate students (master's and doctoral), postdoctoral researchers, assistant professors, adjunct faculty, and technical staff (Figure b).
- Tenure: "No term of office" accounts for 55%, with the remainder "with term of office" (Figure c).
- Ph.D. Status: 45% "more than 5 years since Ph.D.", 23% "less than 5 years since Ph.D.", 32% "not obtained" (Figure d).
- Specialties: A wide range of specialties, from the humanities and social sciences to the natural sciences (Figure e).
- Job description: "Engaged in both teaching and research" was the most common response (52%), followed by "Primarily engaged in research" (32%). Fewer respondents are primarily engaged in teaching, administration, or specific specialized work (Figure f).
- Gender: 72% "male" and 27% "female" (Figure g).
- Evaluation of interests: "Evaluation in employment," "Evaluation in promotion," "Tenure-track review," "Peer review of papers," "Review related to acceptance of research funding such as Grant-in-Aid for Scientific Research," "Reputation among researchers in the same field," and other broad concerns (Figure h).
- Affiliation: 97% affiliated with domestic universities and research institutes
- Children: 41% of respondents have children.
- Caregiver status: 3% of respondents are "caregivers" for a family member.

■ Time allocation in daily life

Respondents were asked to indicate how much time they spend or would like to spend on work and private life, and their "current" and "ideal" percentage of time allocation in their daily lives (Figures i and j).

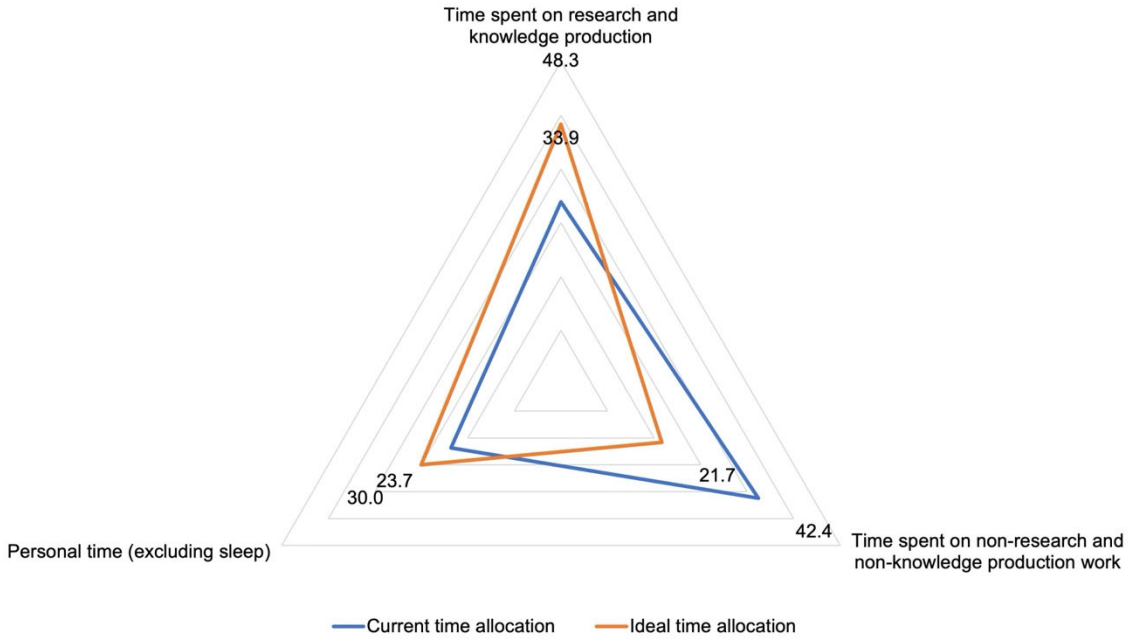


Figure i. Current and ideal time allocation ratio

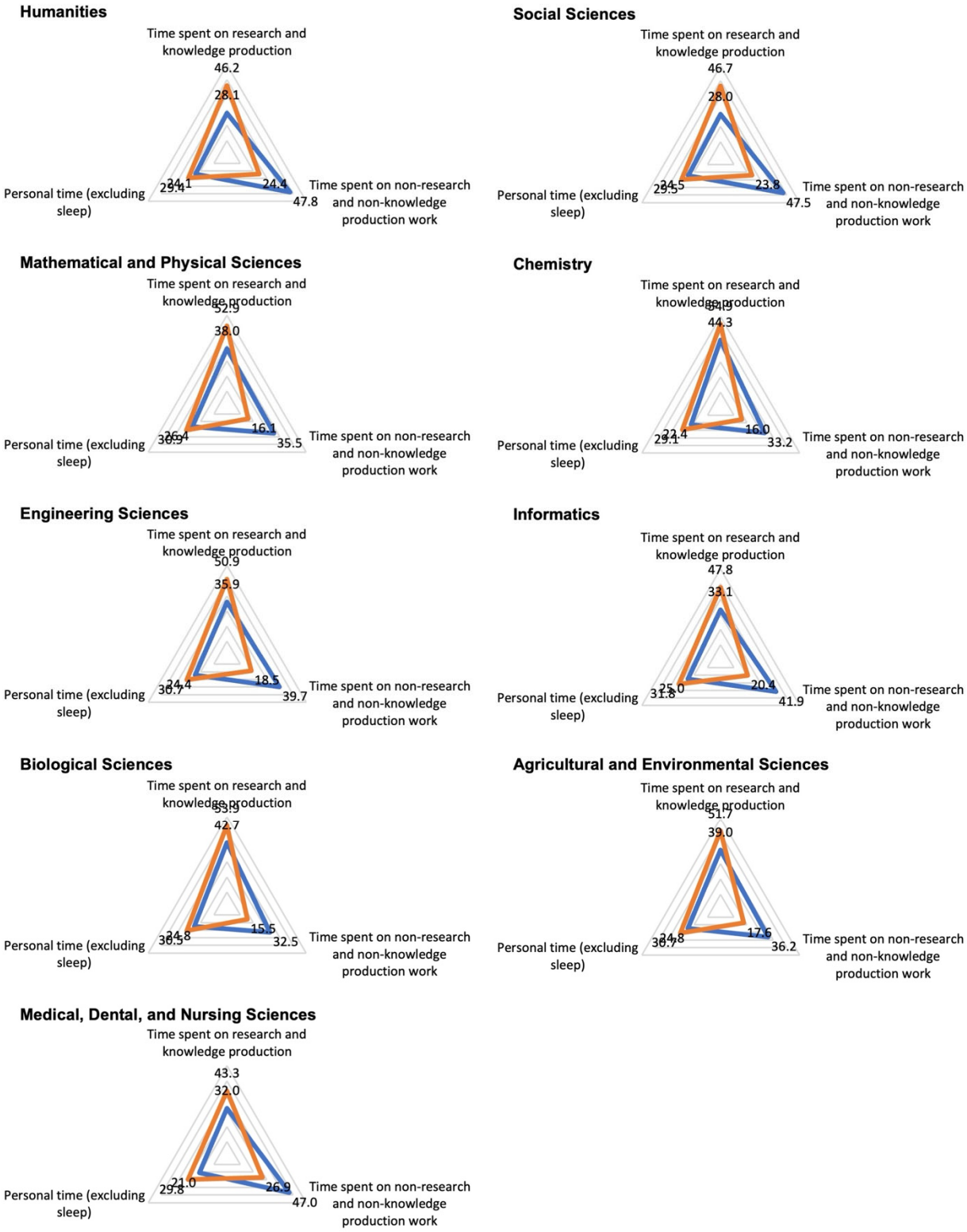


Figure j. Percentage of time allocated for current situation and ideal situation in different fields

- Currently, "time spent on work other than research and knowledge production" is the most common (42%), followed by "time spent on research and knowledge production" (34%), and "time spent on personal life" (24%).

- Ideally, I would like to reduce my "time spent on work other than research and knowledge production" by half from its current level, and divide that amount between "time spent on research and knowledge production" and "personal time".
- The above trends are common to all fields.
- It is possible to interpret that "time spent on work other than research and knowledge production" is acceptable as long as it is about 20% of total time.
  → A guideline could be to limit "time spent on work other than research and knowledge production" to about 20% of total time.
- Time spent "on work other than research and knowledge production" includes various elements such as teaching, academic work and practical work, and varies from field to field.
  →Differences in work portfolios and personalities between disciplines and universities must be taken into account.

■ How you currently feel valued and how you would ideally like to be valued

Respondents were asked to indicate the extent to which they "currently" feel valued for various activities related to research and knowledge production, and the extent to which they "ideally" would like to be valued (Figure k).

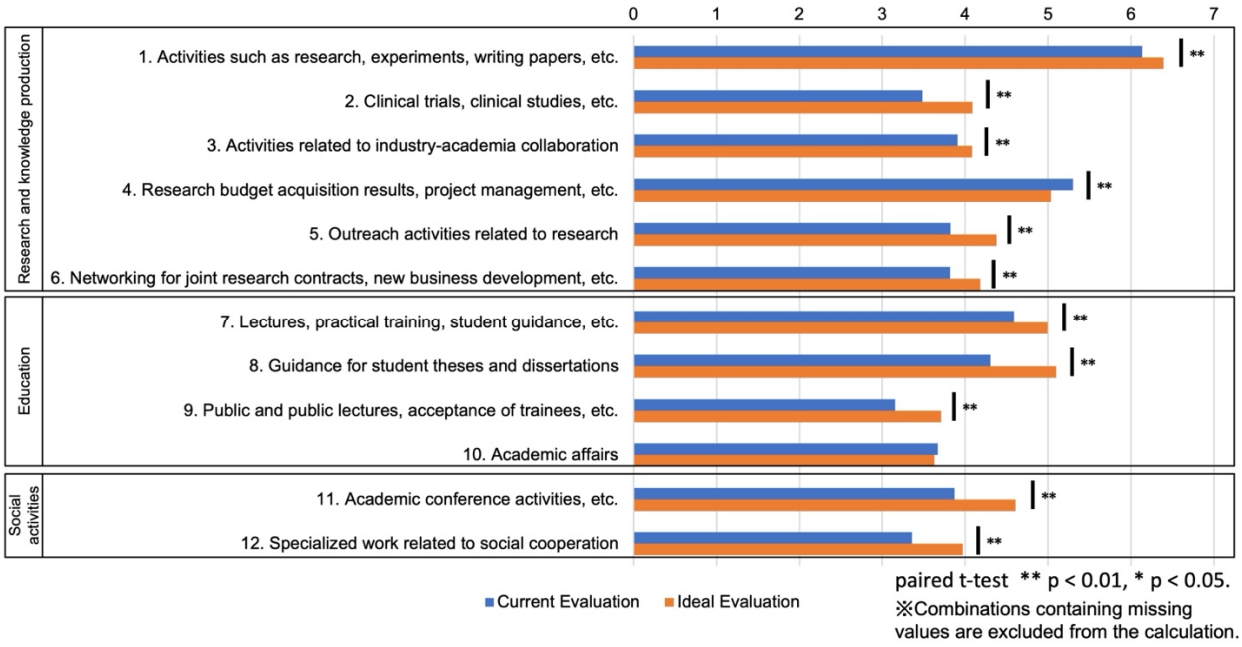


Figure k. Perceived importance of current and ideal evaluation

- Concerns and dissatisfaction that the various activities related to research and knowledge production are not sufficiently valued, and a desire for greater recognition.
  → Can also be interpreted as a manifestation of burden
- Activities such as "research, experimentation, and writing papers" are the most valued, both in the present and in the ideal. In other words, they feel they are most valued (present) and want to be most valued (ideal).
  →It can be said that there is a common agreement that valuing "activities such as research, experiments, and writing papers" is important.
- The difference between actual and ideal is particularly large for "supervision related to students' theses/academic papers", "academic conference activities, etc.", and "professional work related to social cooperation". It is possible that they feel that they should be evaluated more or that they should be evaluated more.
  →Need to consider differences in work portfolios and personalities across disciplines and universities
- Only in the areas of "research budget acquisition results, project management, etc." is the current ideal level higher than the current ideal level, and respondents feel that they are over evaluated.
  →Suggests concern among young researchers that competition for budgets may be excessive.

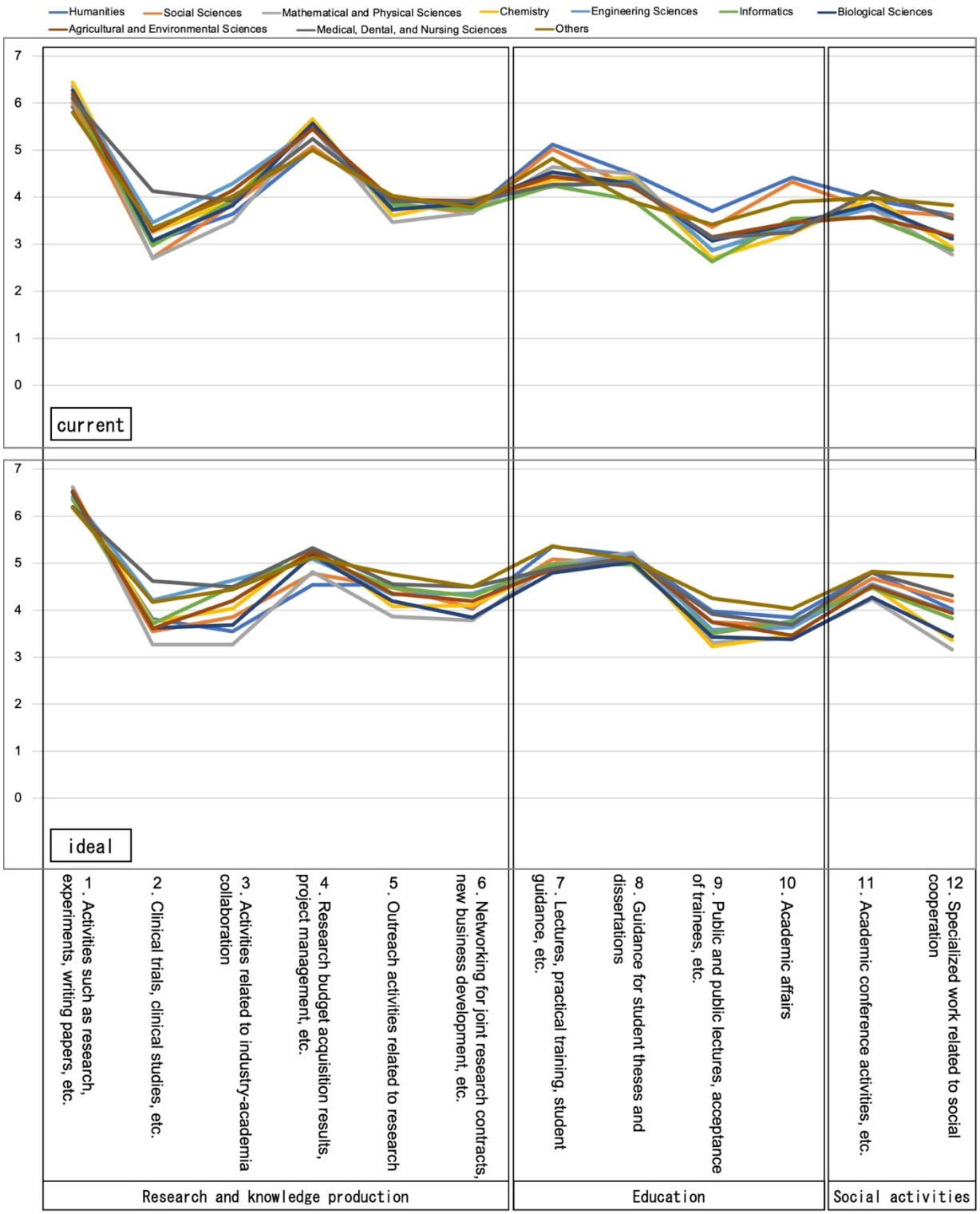


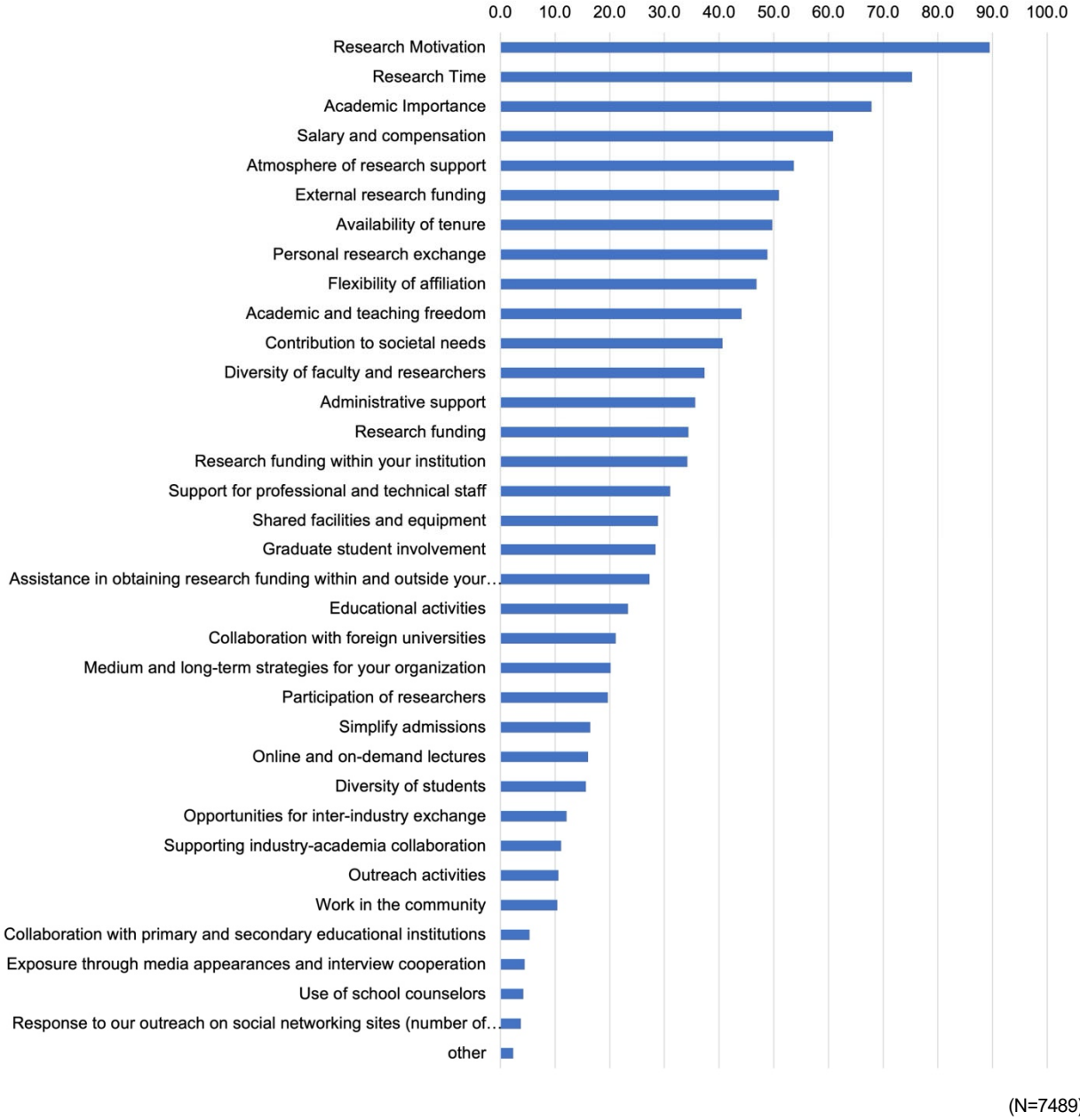
Figure l. Perceived importance of current and ideal evaluation, by sector

- In general, all fields exhibit the same trend.
- In all areas, "activities such as research, experiments, and writing papers" are perceived as the most important, both currently and ideally.
- With the exception of "acquiring results from research budgets, project management, etc.", the scores were generally lower than the current ideal (more evaluation), but the scores were higher

than the current ideal (lower evaluation or excessive evaluation) for "Activities related to industry-university cooperation" in Mathematical and Physical Sciences, Biological Sciences and Engineering, and for "Academic Affairs" in Humanities and Social Sciences. (would like to be rated less highly, is rated highly).
→Suggests that excessive pressure is placed on young researchers by the field.

■ Environmental factors that you consider important in relation to knowledge production activities

Respondents were asked to select all applicable factors that influence their research and knowledge production activities (Figure M).

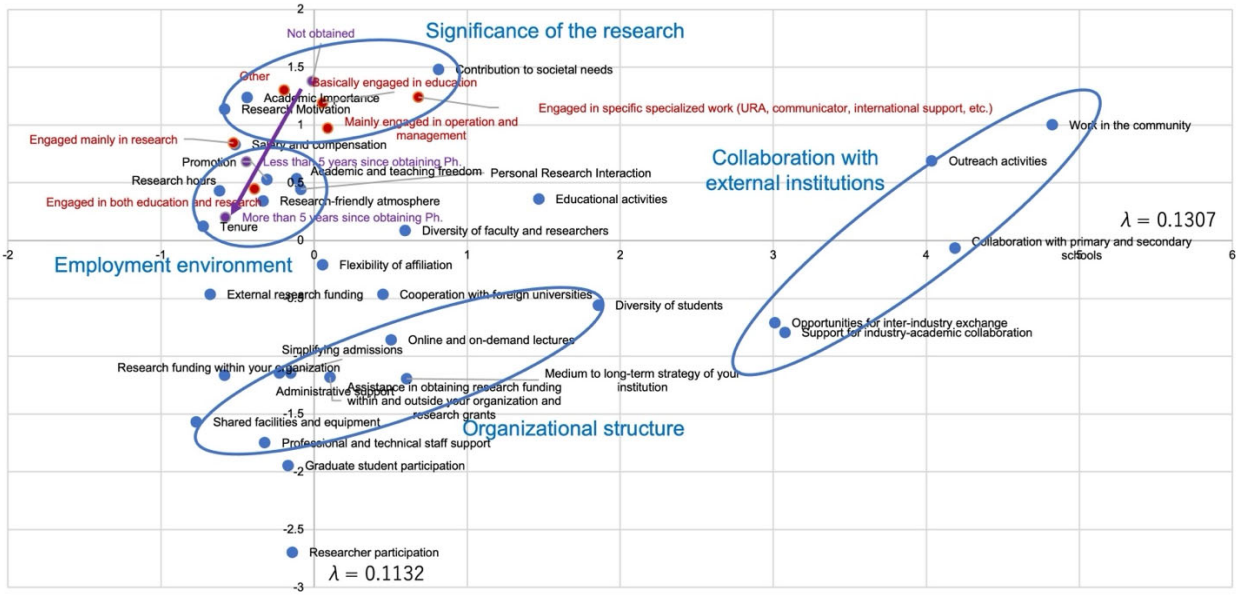


(N=7489)

Figure m. Factors considered important in relation to knowledge production activities

- Research motivation, academic significance, and an atmosphere conducive to research were the most important motivational factors, while research time was recognized as an important factor influencing research and knowledge production activities. "Salary and remuneration" and "availability of tenure" were followed by items related to professional stability.
- Similar trends are observed across all age groups and job classifications.

To determine which environmental factors were more likely to be selected together, a Quantification III analysis was used to classify response patterns (Figure n).



(Excluding those with less than 5% of selections, N=7842)

Figure n. Classification of response patterns based on quantification III analysis of life factors considered important in relation to knowledge production activities

- Items related to "importance of research", "employment environment", "organizational structure", and "collaboration with external parties" tended to be selected together.
- Factors of interest related to research and knowledge production change from "significance of research" to "employment environment" depending on the time elapsed before and after the Ph.D.
  →As one's career progresses, one is forced to consider the employment environment and so on.
- Similarly, interest in "organizational structure" increases with the passage of time after the Ph.D.
  →The research ecosystem and the infrastructure of research activities are seen to gain more perspective and interest as one's career progresses.
- There are few differences in response trends based on gender, age, discipline, or location of institutional affiliation.
- Compared to respondents from other occupations, respondents from professional occupations (URAs, communicators, etc.) and from companies (managers) were, in relative terms, slightly more likely to select "collaboration with outside the university".

■ Lifestyle factors that you consider important in relation to knowledge production activities

Respondents were asked to select all applicable lifestyle factors that influence their research and knowledge production activities (Figure o).

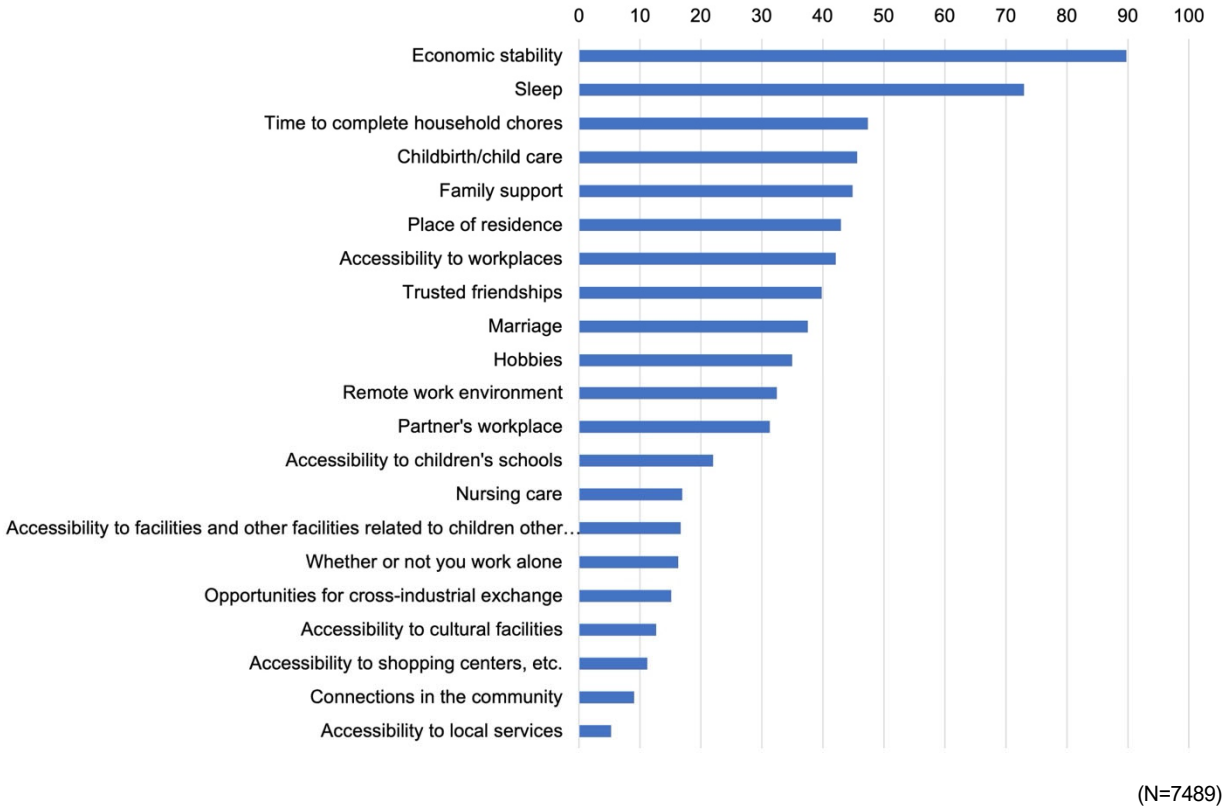
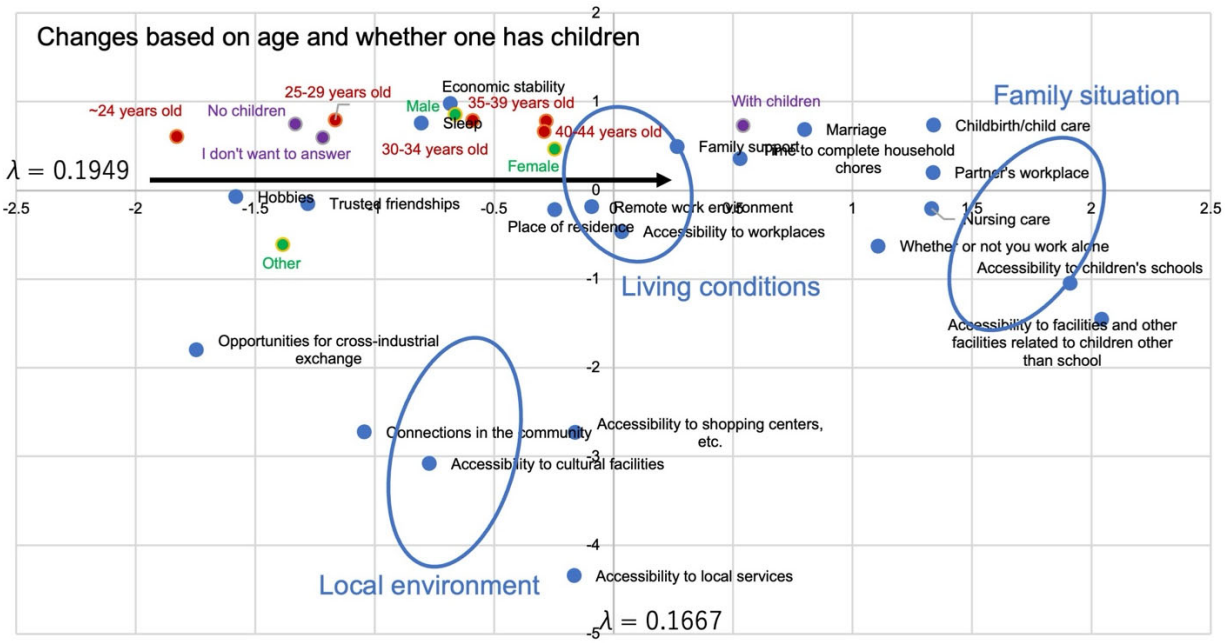


Figure o. Lifestyle factors considered important in relation to knowledge production activities

- Economic stability and sleep are recognized as important life factors that influence research and knowledge production activities.
- Items related to family and daily life, such as "time to complete household chores," "childbirth/child care," and "family support," followed by items related to where they live and work, such as "place of residence" and "accessibility to work.

To determine which life factors were more likely to be selected together, a Quantification III analysis was used to classify the response patterns (Figure p).



(Excluding those with less than 5% of selections, N=7842)

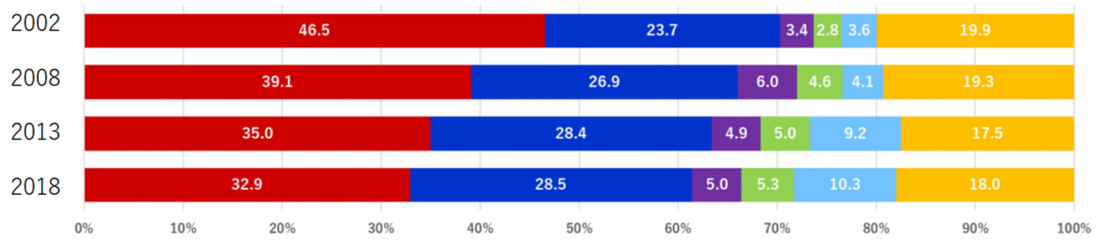
Figure p. Classification of response patterns based on quantification III analysis of life factors considered important in relation to knowledge production activities.

- Interrelationship of factors: There is a clustering tendency among items related to "living situation," "family situation," and "local environment." They are often selected together, suggesting that these factors may have interrelated effects on a researcher's professional life.
- Shift with age: As researchers age, their concerns shift from personal factors to those related to family. This suggests that personal priorities evolve over time, influencing the areas of interest or focus in their academic work.
- Influence of parenthood: Having children significantly influences a researcher's priorities. Researchers with children are more concerned about the "family situation" than their counterparts without children, indicating the profound impact of parenthood on professional interests and concerns.
- Gender differences: There is a notable gender difference when considering the "family situation" factor. Women are more likely than men to select this factor, highlighting the unique challenges and considerations that female researchers may face, particularly in balancing family and work.
- Holistic Consideration: The increasing interest in children and family with age suggests that it becomes difficult to separate personal and family factors from professional pursuits. These factors are deeply intertwined and influence each other.
- Career evolution: Changes in personal and family situations, such as the birth of a child, can influence career paths and decisions. It's important to recognize and support these evolving needs

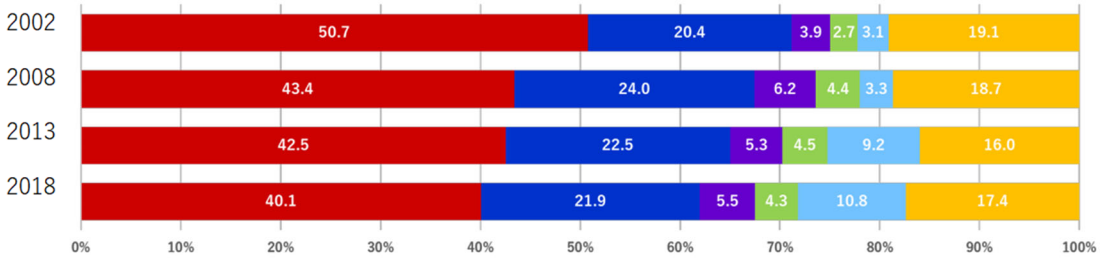
and priorities.

- Support Systems: Given the significant impact of personal and family factors on career decisions, there is an urgent need for natural support mechanisms to help researchers balance their life plans with their careers.
- Gender-sensitive approaches: The particular challenges faced by women researchers, especially with regard to family considerations, require gender-sensitive policies and support systems in academia and research institutions.

Document 3: Percentage of time spent on professional activities by faculty members at universities and other institutions



Percentage of time spent on professional activities by university and other faculty members



Percentage of time spent on professional activities by national university faculty

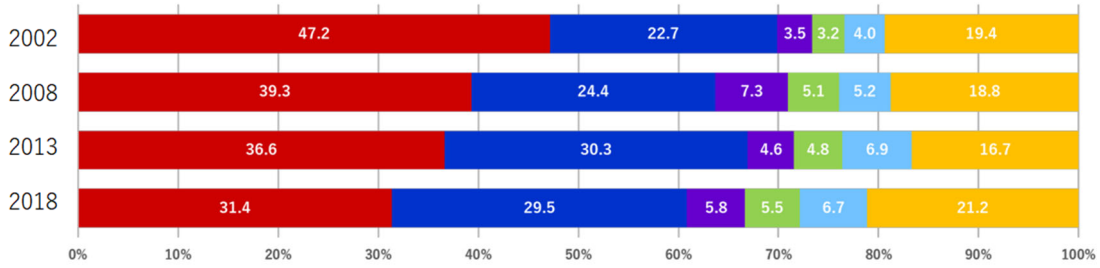


Figure: Percentage of time spent on professional activities by public university faculty

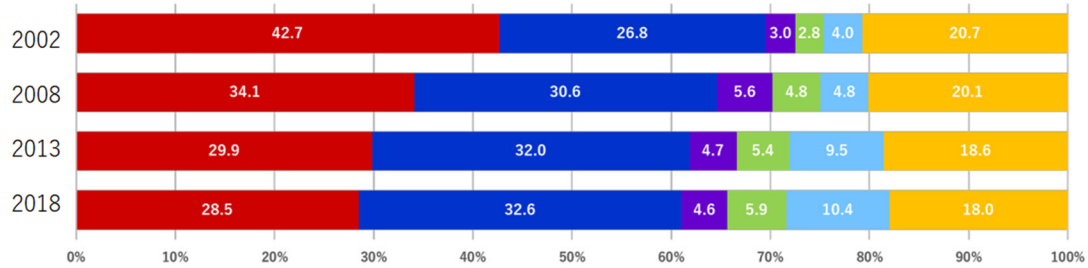
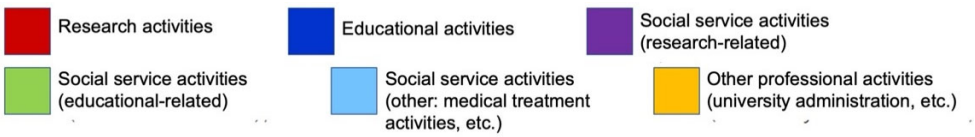


Figure: Percentage of time spent on professional activities by private university faculty



Retrieved from Ministry of Education, Culture, Sports, Science and Technology, "Survey on Full-Time Equivalent Data at Universities, etc. in Academic Year 2018," Summary (2019), available at https://www.mext.go.jp/b_menu/houdou/31/06/__icsFiles/afieldfile/2019/06/26/ 1418365_01_3_1.pdf)

Document 4: Comparison of University Faculty and Staff Ratios

Leading universities in Japan have fewer staff members compared to their counterparts at top-tier universities overseas.

[Student and Staff Numbers at Top Universities in the TIMES World Top 200 Rankings]

TIMES Ranking	University Name	Number of Students per Faculty	Number of Students per Staff	Number of Faculty per Staff
1	Harvard University (USA)	4.36	1.39	0.32
2	Yale University (USA)	3.74	1.13	0.30
3	University of Cambridge (UK)	4.66	4.22	0.91
4	University of Oxford (UK)	4.45	4.08	0.92
5	California Institute of Technology (USA)	5.56	0.79	0.14
	Average of the 5 Universities	4.37	2.01	0.46

TIMES Ranking	University Name	Number of Students per Faculty	Number of Students per Staff	Number of Faculty per Staff
19	University of Tokyo	5.17	7.39	1.43
25	Kyoto University	7.81	8.86	1.13
44	Osaka University	6.43	10.49	1.63
	Average of the 3 Universities	6.19	8.66	1.40

Source: Survey Report on Internationalization Trends of Leading Universities Worldwide (2007), International Cooperation Office, International Strategy Division, University of Tokyo.

Note: Student and faculty numbers are based on the top 15 universities listed in the *Times Higher Education* University Rankings. Staff numbers are sourced from figures published on the official websites of each university.

Quoted from "Trends in Internationalization of the World's Leading Universities," Research Report (2007) (modified by Cabinet Office), International Planning Department, International Cooperation Division, The University of Tokyo (https://www.u-tokyo.ac.jp/content/400009827.pdf).

Document 5: Improvement measures for 10 issues

Organize remedies for the 10 issues, key stakeholders, and five related areas.

Improvement plan	Main Stake holder				Five areas of relevance	Falling under page
	Academia	Industry	Government	Citizens		
(1) Cultivating fundamental and traditional knowledge and technology	X				Interdisciplinary research / Regional collaboration	2
(2) Strengthening evaluation and support for interdisciplinary research and regional collaboration together with local stakeholders						
• Establishment of methods for the evaluation of research on the basis of different types of knowledge production	X				Interdisciplinary research / Regional collaboration / Human resources	5,6,7,8, 10,. 12,18
• Mechanisms and personnel to accurately evaluate interdisciplinary researchers and projects	X	X	X		Interdisciplinary research / Human resources	5
• Distribution of sufficient posts and budgets to organizations and initiatives aimed at interdisciplinary research	X				Interdisciplinary research / Human resources	5
• Expansion of smaller budgets to support exploratory research (e.g., intramural funds)	X		X		Interdisciplinary research / Research environment	6
(3) Enhancing core facilities with Ph.D. holders	X		X		Interdisciplinary research / Research environment	6
(4) Cultivating a cross-sector collaborative ecosystem						
• Creation of opportunities for matching and exchange between researchers in academia and industry/government/private sector	X	X	X	X	Interdisciplinary research / Research environment	6
• A system to develop professional human resources that are scientifically engaged in solving regional problems and who can be utilized for local government agencies.	X		X		Regional collaboration / Human resources	8
• Career education to foster the ability and attitude to independently determine career paths (e.g., establishing a system to match high school students who wish to take internships and professionals who wish to pursue recurrent education with academic laboratories).	X				Regional collaboration / Human resources	8
• Streamlining schemes for collaboration between school education and society by utilizing local human resources, etc.	X			X	Regional collaboration / Human resources	8
• Support for human resources to solve interdisciplinary social issues (long-term paid internships for young researchers, identification of outstanding young researchers by companies and universities, etc.)	X	X	X		Regional collaboration / Human resources	8
• Establishment of a platform for industry, government, academia, and the private sector to work together to solve regional issues	X	X	X	X	Regional collaboration / Research environment	8
• Expansion of human support from the government side in regional cooperation, etc.			X		Regional collaboration / Research environment	9
(5) Enhancing basic funding and research support personnel						
• Improvement of compensation for research support personnel, including administrative, educational, and technical staff, and basic expenses to ensure stable employment.	X		X		Research environment	19,20
• Review of increasingly complex research funding systems			X		Human resources / Research environment	19
• Secure budgets for equipment necessary for IT utilization, and relax laws and regulations that hinder IT utilization.	X		X		Research environment	19,20
• Fostering human resources for researchers with international networks (participation in international conferences, networking opportunities among researchers, personnel exchange, etc.)	X		X		International collaboration / Human resources	9,10

• Establishment of an environment conducive to accepting international students and foreign researchers (e.g., resolution of issues related to economic treatment and the environment for accepting them, establishment of a support system for administrative procedures, etc.)	X		X		International collaboration / Research environment	11
• Establishment of a system that facilitates overseas study and overseas research (e.g., strengthening the system to support study abroad, improving the support system for administrative procedures, etc.)	X		X		International collaboration / Research environment	11
• Maintain an internationally high-quality research environment and human resources so that personnel who have been active in overseas research institutions can develop their research activities in Japan.	X		X		International collaboration / Research environment	11
• Institutions distribute sufficient research and education budgets to laboratories to ensure that graduate students receive adequate quality research and education.	X		X		Human resources	14
• Establishment of a new type of university management in which education in the broadest sense is conducted by considering as a team professional personnel from inside and outside the university who have specialized knowledge required in the areas of psychology, psychiatry, law, education, and other areas of on-campus support.	X	X	X		Research environment	19
(6) Establishing career paths in science diplomacy						
• Fostering human resources in academia who can play a role in science and technology diplomacy and developing career paths	X		X		International collaboration / Human resources	10
• Communicate the significance and content of international collaboration to researchers, stakeholders, the public, etc.	X			X	International collaboration / Human resources	10
(7) Overcoming the "zero-failure" bureaucratic mind in science management	X		X		Research environment	18,19
(8) Reducing the burden of education on households						
• Policy mix to reduce the burden of direct costs associated with college and graduate school (salary scholarships, expansion of low-interest loan scholarships, expansion of tuition waiver quotas, interest supplements for private education loans, measures to ensure college opportunities in rural areas, etc.)	X	X	X		Human resources	13
• Maintenance of student housing, etc.	X				Human resources	13
• Bridging the Gender Gap for Learning Science and Mathematics	X			X	Human resources	13
(9) Breaking free from the "activity trap" of academia						
• Substantiation of research effort assurance in universities and research institutions	X				Research environment	17
• Promotion of division of roles among faculty members (e.g., assignment of faculty members who are active in educational aspects)	X				Research environment	17
• Improving the efficiency of campus operations through the use of chat tools and online conferencing systems, etc.	X				Research environment	17
• Review of Admissions Diversification	X				Research environment	17
• Review and organize academic association activities	X				Research environment	18
• Reduce excessive review costs for competitive funding and researcher evaluations (e.g., by adopting a "screen and random" approach).	X		X		Interdisciplinary research / Regional collaboration / Research environmental	18
• Reduce the burden on national and local government committees and councils (e.g., restructure efficient and effective committees and councils through consultation between academic associations and government)	X		X		Research environment	19
(10) Promoting inter-sectoral career paths for Ph.D. holders						

• Collaboration among universities in securing researchers and university faculty involved in education	X				Human resources	14
• Development of a research and education environment in which doctoral students scattered in sectors other than academia can engage in graduate education	X	X	X			14
• Raising the superiority of research positions (e.g., appropriate evaluation of versatile abilities such as problem-solving skills, logical thinking, and intellectual curiosity as advanced human resources, in addition to the expertise of PhD holders).	X				Human resources	14
• Establish a situation in which doctoral degree holders can utilize their expertise to play an active role in various sectors (objectification of doctoral degree holders' abilities by universities and research institutions, establishment of job descriptions that can utilize their expertise by other sectors, detailed definition of abilities required for job performance, etc.).	X	X	X		Human resources	15
• Promotion of job-based employment	X	X	X		Human resources / Research environment	15,20

<The Organizational Framework of the 25th Young Academy>

Young Academy of Japan

Mission 1. Recommendations based on the perspectives of young scientists
2. Management of the Young Scientists Network
3. Collection of opinions and issues raised by young scientists
4. International exchange of young scientists
5. Collaboration with industry, government, NPOs, etc.
6. Promotion of science education
7. Other activities necessary to achieve the objectives of the Young Academy

Steering Subcommittee

Mission 1. Matters related to the daily activities of the Young Academy

Subcommittee on Human Resource Development for the Future of Academia

Theme 1. Multifaceted evaluation of the social value of liberal arts and professional education
2. Support for the mental and financial environment of young researchers

Subcommittee on Improving the Industry Structure of Academia

Theme 1. Promoting Life-Work Balance in Academia
2. Reduction of time and financial burden of academic activities

Interdisciplinary Young Scientists Subcommittee

Theme 1. Integration of scientific disciplines
2. New ways of expressing academic results

International Subcommittee

Theme 1: The role that Japanese academia should play in the global community and guidelines for domestic activities considering that role
2. Promotion of international activities of the Young Academy and liaison and coordination related to international activities of the Young Academy
3. Other international activities of the Young Academy

Subcommittee on Social Collaboration for Regional Revitalization

Theme 1. Visualization and evaluation of the role of scientists in the community
2. Public/private/academic partnerships that contribute to regional revitalization
3. Developmental research activities in rural areas

Social Collaboration for Innovation Subcommittee

Theme 1. Issues related to the relation between academia and society in science and technology innovation, and solutions to these issues

GYA General Assembly National Organizing Subcommittee (*The Global Young Academy)

Theme 1. Planning and management of the GYA General Assembly considering the role that Japanese academia should play in the global community.

2. Liaison and coordination related to the GYA General Assembly

3. other deliberations related to the holding of the GYA General Assembly

Information Dissemination Subcommittee

Theme 1. The Young Academy's website

2. Dissemination of information on the Young Academy

<Deliberation Process>

25th period

2020

November 30: Young Academy Meeting (1st)

Explanation of the purpose of the Young Academy and introduction of the activities of the previous year, election of representatives, discussion of the activities of the subcommittees and establishment and future of the subcommittees, future management of the Young Academy, etc.

Dec. 16: Young Academy Management Subcommittee Meeting (1st meeting)

Establishment of the Young Academy Subcommittee and selection of its members, etc.

2021

January 21: Young Academy Management Subcommittee Meeting (2nd)

Addition of Young Academy Members, Selection of Additional Members for the Subcommittee on Social Collaboration for Innovation, etc.

February 22: Young Academy Management Subcommittee Meeting (3rd)

Establishment of Information Dissemination Subcommittee, etc.

September 1: Young Academy Management Subcommittee Meeting (4th)

Subcommittee projects, YAJ website, etc.

Dec. 10 Young Academy Meeting (2nd)

Previous activities and future plans of the Young Academy, etc.

2022

January 7: Young Academy Management Subcommittee Meeting (5th) *Deliberation via e-mail

Public Symposium organized by the Young Scientists Academy and the Interdisciplinary Young Scientists Subcommittee

March 23: Young Academy Management Subcommittee Meeting (6th)

Exchange of opinions on Nascon Valley activities, future activities of subcommittees, future activities of the Young Academy, etc.

June 21: Young Academy Management Subcommittee Meeting (7th) *Deliberation via e-mail

Public Symposium hosted by the Young Academy, Social Collaboration Subcommittee for Innovation and Social Collaboration Subcommittee for Regional Revitalization

August 19: Young Academy Management Subcommittee Meeting (8th) *Deliberation by e-mail

Public Symposium hosted by the Young Academy and the Subcommittee on Social Collaboration for Regional Revitalization, regarding the creation of an

expression of intent

August 29: Young Academy Management Subcommittee Meeting (9th) *Deliberation by e-mail

About the Public Symposium hosted by the Young Academy

September 6: Young Academy Meeting (3rd)

Past activities of the Young Academy, Vision for the 25th Young Academy, Future activities of the Young Academy, Nascon Valley and NHK Citizen Lab (topics to be discussed), etc.

November 28, Young Academy Management Subcommittee Meeting (10th)

Discussions on the management of the Young Academy, discussions on the expression of will, etc.

2023

Feb. 28, Young Academy Management Subcommittee Meeting (11th)

Approval of the draft of the draft opinion "Issues to be addressed with a view to science, science and society in 2040: innovation, Interdisciplinary research, regional cooperation, international cooperation, human resource development, and research environment"; Academic Forum; the 4th Young Academy Meeting; etc.

June 29: Young Academy Management Subcommittee Meeting (12th) *Deliberation by e-mail

Approval of the draft opinion "Medium- and Long-Term Remodeling Strategies to Promote the Development of Innovative Human Resources".

July 2: Young Academy Meeting (4th)

Draft Opinion "Issues to be addressed for Science, Academia and Society in 2040 - Innovation, Interdisciplinary Research, Regional Collaboration, International Collaboration, Human Resource Development, and Research Environment", Draft Opinion "Medium- and Long-term Remodeling Strategy to Promote the Development of Innovative Human Resources", Academic Forum, Activities of Subcommittees About the 5th Young Academy Conference, etc.

<Symposiums>

In compiling this opinion, we have exchanged views with related parties and organizations by holding symposiums and other events as described below.

March 1, 2021 Public Workshop "Young Scientists Pioneer the Relationship between Community and Science" hosted by the Academy for Young Scientists
Summary: https://www.scj.go.jp/ja/event/2021/307-s-0301.html
Report: https://www.scj.go.jp/ja/scj/wakate/pdf25/307-s-0301-houkoku.pdf

June 18, 2021 Session "Open Science with Young Academy of Science Council" planned by Young Academy members at Japan Open Science Summit 2021
Summary: https://joss.rcos.nii.ac.jp/2021/session/overview/?id=se_118
Report: https://www.scj.go.jp/ja/scj/wakate/pdf25/joss2021.pdf

September 27, 2021 Young Academy members will participate in the Tsukuba Conference as members of the planning committee, and will hold a Future Shapers Session "Inclusive Innovation for the New Normal" by young researchers, a dialogue session with Nobel laureates, and a concurrent session "Open Science and Ethical Issues Concerning Conventional Knowledge". and a concurrent session on "Open Science and Ethical Issues Concerning Conventional Knowledge", etc.
Summary: https://tsukuba-conference.com/
Report: https://www.scj.go.jp/ja/scj/wakate/pdf25/210921-30huokoku.pdf

February 23, 2022 the Science Council of Japan in Fukuoka Academic Lecture Meeting on "Regional Development and the Future of Academia by Young Researchers" planned by the Social Collaboration Subcommittee for Regional Revitalization of the Young Academy
Summary: https://www.scj.go.jp/ja/event/2022/318-s-0223.html
Report: https://www.scj.go.jp/ja/scj/wakate/pdf25/220223huokoku.pdf

March 1, 2022 Public symposium organized by the Young Academy and six related subcommittees, "In the age of contraction, think about town and society 20 years from now: space x city x genes x ecology".
Summary: https://www.scj.go.jp/ja/event/2022/321-s-0301.html
Report: https://www.scj.go.jp/ja/scj/wakate/pdf25/321-s-0301-houkoku.pdf
Video: https://www.youtube.com/watch?v=OQb27Vh37Ag

June 12-17, 2022 12th Annual Meeting and Conference of the Global Young Academy hosted by the

Young Academy and the Global Young Academy
Summary: https://gya2022.com/index.html
Report: https://www.scj.go.jp/ja/scj/wakate/pdf25/220701huokoku-1.pdf

June 22-July 30, 2022 Academic internship for local high school students conducted by the Young Academy's Social Collaboration Subcommittee for Regional Revitalization exhibited at the Osaka Residential Information Center as a panel display entitled "Initiatives for Financial Education by High School Students for High School Students".
Summary: https://www.osaka-angenet.jp/event/185

September 5, 2022 Public Symposium "Japanese Society in 20 Years from Now: Innovation Creation in Co-domain and Local Development" hosted by the Young Academy
Summary: https://www.scj.go.jp/ja/event/2022/327-s-0905.html
Report: https://www.scj.go.jp/ja/scj/wakate/pdf25/327-s-0905-houkoku.pdf

October 6, 2022 Public Symposium "Evaluation Surrounding Young Researchers - Report on Survey Results and Discussion Points -" organized by the Academy for Young Researchers
Summary: https://www.scj.go.jp/ja/event/2022/330-s-1006.html
Report: https://www.scj.go.jp/ja/scj/wakate/pdf25/330-s-1006-houkoku.pdf
Video: https://www.youtube.com/watch?v=K-1LopyVwQ0

October 21, 2022 Public Symposium "Science Agora 2022 Session 'World Science Forum in Cape Town: Social Justice and Science for the Future'" co-sponsored by the Academy for Young Scientists and the National Institute of Science and Technology (JST)
Summary: https://www.scj.go.jp/ja/event/2022/330-s-1021.html
Report: https://www.jst.go.jp/sis/scienceagora/2022/online/21-b16.html
Video: https://www.youtube.com/watch?v=LCa-ueDBAa4

December 8, 2022 The Young Academy of Japan and the Japan Science and Technology Agency (JST) will co-host the session "Ecosystem to enhance global public good with science: distributive justice and well-being as key concepts 'back to Programme lister'" at the World Science Forum (WSF) 2022. justice and well-being as key concepts ' back to Programme lister
Abstract: https://worldscienceforum.org/programme/2022-12-08-thematic-session-iiia-ecosystem-to-enhance-global-public-good-with-science- distributive-justice-and-well-being-as-key-concepts-211
Report: https://www.jst.go.jp/report/2022/221227.html

July 2, 2023 Academic Forum " Remodeling science and society for the next 20 years: Innovation,

Interdisciplinary Research, Regional Collaboration, International Collaboration, Human Resource Development, and Research Environment" organized by Young Academy of Japan, Science Council of Japan
Summary: https://www.scj.go.jp/ja/event/2023/340-s-0702.html

<Trends in the Sciences>

The June 2022 issue of " Trends in the Science " published a special feature on the Young Academy, "Remodeling science and society for the next 20 years". It introduces a summary of the activities of the 24th Young Academy and the vision and initiatives of the 25th Young Academy.

http://jssf86.org/doukou315.html

The purpose of this Special Issue."
Wataru Iwasaki
https://www.jstage.jst.go.jp/article/tits/27/6/27_6_45/_article/-char/ja/

Review of the Activities of the 24th Young Academy: Making the Organization Ready for the Future
Akihiro Kishimura
https://www.jstage.jst.go.jp/article/tits/27/6/27_6_46/_article/-char/ja/

Rebalancing Sensitivity and Reason: Toward the Global Young Academy Annual Meeting and Conference in Japan
Yoko Shimpuku
https://www.jstage.jst.go.jp/article/tits/27/6/27_6_53/_article/-char/ja/

From the Public Symposium "In the Age of Contraction, Think about Town and Ssociety 20 years from Now: Space x City x Genes x Ecology."
Asano Ishikawa
https://www.jstage.jst.go.jp/article/tits/27/6/27_6_59/_article/-char/ja/

Public Workshop "Young Scientists Developing Relationships between the Community and Science"
Haruka Ono
https://www.jstage.jst.go.jp/article/tits/27/6/27_6_65/_article/-char/ja/