Chapter 5. Agricultural innovation systems in Japan

Innovation policy is moving beyond supply-driven approaches that focus on R&D and specific technologies to a network-based setting, in which a more inclusive, interactive, and participatory approach fosters greater innovation in response to pressing challenges facing the food and agriculture systems. This chapter describes the agricultural innovation system in Japan and outlines the recent changes it has undergone. It provides an overview of the general innovation system, presents agricultural innovation actors and governance of the innovation system, outlines changes in roles and themes of R&D, and presents the main policy instruments and monitoring efforts. It then reviews the main trends in public and private investments in R&D, the funding mechanism, as well as the means used to foster knowledge markets and networks.

The predominant model for innovation has been mostly supply-driven: scientists in the public sector create new technologies which are then disseminated by extension officers to farmers who are asked to adopt them. Many countries have reviewed their Agricultural Innovation System (AIS) in response to concerns about its low rate of adoption of innovation and the need to increase AIS performance in order to respond to emerging and pressing challenges (IO, 2012[1]). Although R&D remains important, innovation policy is moving to a more systemic approach that takes into account the many factors and actors that play a role so as to better reflect user demand and to implement more innovative solutions effectively (OECD, 2010[2]).

5.1. General characteristics of innovation systems in Japan

Japan has an economy-wide framework for science, technology, and innovation that provides incentives for all sectors. It is one of the few OECD countries where R&D expenditure exceeds 3% of GDP (OECD, 2018[3]). The intensity of private investment in R&D is one of the highest among OECD countries (Figure 5.1). However, private R&D investment concentrates on large enterprises. Enterprises with less than 250 workers accounted for only 4% of total business R&D, compared to the OECD average of 33%, in 2011 (OECD, 2013[4]).

Japan also generates a high level of human capital, with the highest proficiency in literacy and numeracy among adults in all countries participating in the OECD survey of adult education (OECD, 2016[5]). However, potential in science and technology is under threat, as indicated by a low number of students advancing to doctoral courses in these fields and a low number of papers published in leading journals. In terms of public investment in R&D, Japan ranks relatively high among OECD countries, but growth in expenditure has slowed (OECD, 2016[6]).

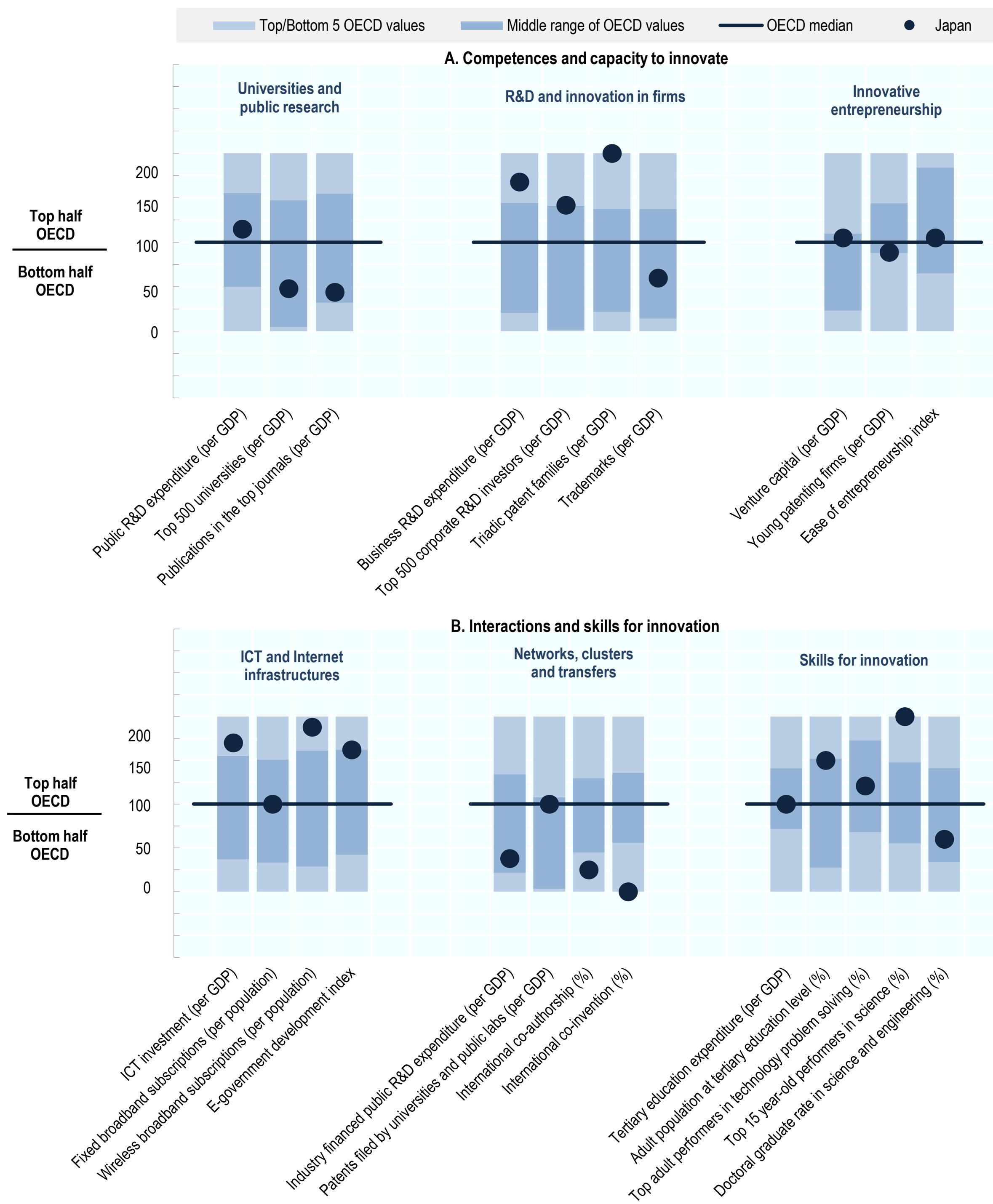
Despite strong public and private investment in R&D, collaboration between public and private actors and across sectors is relatively weak. The level of international co-authorship and co-invention are amongst the lowest in OECD countries (Figure 5.1).

The number of industry-academia collaborative activities remains small, and the mobility of personnel between organisations or across sectors is limited. Private companies prefer producing their own technology without collaborating with other private or public actors (OECD, 2016[6]). In Japan, 99% of business-financed R&D is carried out by firms, leaving little room for co-operation with universities and government research institutions. This sectoral approach, however, does not leverage the potential of the important innovations that occur between sectors.

Japan seeks to make use of its strength in information and communication technology (ICT) infrastructure. In June 2017, the government announced its "Future Investment Strategy 2017: Reforms Toward the Realization of Society 5.0". According to this strategy, the key to medium- to long-term economic growth is realising "Society 5.0", which adopts diverse ITs developed so far to "new innovation" such as IoT, Big Data, artificial intelligence (AI), robots and the sharing economy. Developing technology to analyse and formalise Big Data of meteorological information, crop development, market information, food trends, and needs is a vital tool for the sector's efficiency. New types of innovation – such as stabilising food supply, reducing food loss, and promoting food consumption – are expected to help fix major issues in agriculture.

Figure 5.1. Comparative performance of Japan's science and innovation systems, 2016

Normalised index of performance relative to median values in the OECD area (Index median=100)



Source: OECD (2016[6]), "Japan", in *OECD Science, Technology and Innovation Outlook 2016*, Paris, https://doi.org/10.1787/sti_in_outlook-2016-70-en.

StatLink http://dx.doi.org/10.1787/888933957838

National innovation policy framework

The Council for Science, Technology and Innovation (CSTI) in the Cabinet Office leads science, technology and innovation policies in Japan. It overlooks and co-ordinates all of the nation's science, technologies and innovation (STI) policies, with specific measures formulated by the relevant national ministries and agencies. CSTI is chaired by the Prime Minister and composed of the Chief Cabinet Secretary, the Minister of State for Science and Technology Policy, and other relevant ministers including from the Ministry of Internal Affairs and Communications (MIC), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Ministry of Economy, Trade and Industry (METI). The president of the Science Council of Japan and other experts from academia and industry also constitute members of CSTI. One of CSTI's principal duties is to formulate the Science and Technology (S&T) Basic Plan every five years based on the Basic Act on Science and Technology.

Since 2013, CSTI has prepared a Comprehensive Strategy on Science, Technology and Innovation every year, which specifies and prioritises measures based on the direction of the S&T Basic Plan but tailored to annual changes in conditions. Based on this strategy, the government allocates its overall science and technology budget. In 2018 – the mid-year of the fifth S&T Basic Plan – CSTI formulated the Integrated Innovation Strategy to evaluate the progress of various measures contemplated in the Comprehensive Strategy, to examine the wide range of STI-related policies and socio-economic systems, and to ensure implementation of the policies. In this Integrated Innovation Strategy, CSTI focuses on agriculture as one of the major strategic fields of innovation.

The government's overall budget for STI policies was JPY 3.84 trillion (USD 34.2 billion) in FY2018, of which MEXT accounts for more than half. MEXT supports R&D in life sciences, materials and nanotechnology, disaster prevention, space, oceans, and nuclear energy through pubic research institutions such as RIKEN (Japan's largest research institution), and the Japan Aerospace Exploration Agency. MEXT also supports basic research by funding agencies such as the Japan Society for the Promotion of Science (JSPS) and the Japan Science & Technology Agency (JST). JSPS and JST also provide competitive research funds in agricultural science.

The Japanese government promotes industry-academia-government collaboration in R&D under CSTI's leadership. This includes, for example, implementation of the Cross-Ministerial Strategic Innovation Promotion Program (SIP) started in 2014 and the Public/Private R&D Investment Strategic Program created in 2018. CSTI allocates the budget beyond ministerial boundaries and policy areas, and oversees the entire R&D flow from basic research to application and commercialisation of STI. By taking a top-down approach, CSTI prioritises R&D agendas – including agriculture – that are expected to solve social issues, strengthen industrial competitiveness, and revitalise the economy.[1]

The country's regional innovation policies have long been characterised by cluster initiatives. Specifically, various programmes support industrial and knowledge clusters depending on the sectors and supporting ministries. MEXT promotes large-scale research collaboration among universities and companies for innovation. In addition, METI has extensive programmes to revitalise SMEs through innovation. Although initiatives by different ministries are gradually being integrated and co-ordinated, they remain rather fragmented and complex (OECD, 2016[6]).The new Program for an Open Innovation Platform with Enterprises, Research Institutes and Academia encourages industry-university partnerships, involving SMEs at the pre-competitive stage of development, and the SME Training Institute offers seminars for owners and managers of SMEs.

5.2. Main actors and governance of the agricultural innovation system

Establishing an effective AIS requires that its governance shifts towards a more collaborative and demand-driven approach. A longer-term strategy for agricultural innovation, which takes into account long-term challenges as well as consumer and societal demands, must be coordinated and clearly communicated. A greater engagement of AIS actors in the definition of objectives and funding is a common characteristic of more collaborative and demand-driven AIS.

Economy-wide processes and organisational innovation, developments in ICT, and the bio-economy increasingly drive innovation in agriculture. The integration of the agricultural system into the general innovation system should ensure better use of public funds, increased efficiency of innovation systems through the pooling of complementary expertise and resources, and higher spill-overs across sectors.

The role of AIS actors in Japan

Government

The MAFF plays a central role in the governance of Japan's AIS. Under the MAFF, the Agriculture, Forestry and Fisheries Research Council (AFFRC) is in charge of planning and implementing relevant technology R&D policies. Founded in June 1956, AFFRC formulates the Basic Plan for R&D in Agriculture, Forestry and Fisheries Research. AFFRC also co-ordinates, examines and evaluates R&D conducted by public agricultural research organisations such as NARO and the Japan International Research Center for Agricultural Sciences (JIRCAS), universities, other public R&D agencies, and some private companies. AFFRC communicates with CSTI and manages competitive research grants.

National agricultural research organisations (NARO)

NARO is an offshoot of the Agricultural Experiment Station founded in 1893 and which is the largest knowledge generator in the field of agricultural science in Japan. With 21 research centres and departments, NARO engages in wide-ranging research relating to agriculture, food and the environment. In 2001, it converted its legal status to a National Research and Development Agency. Since then, the government has reduced institutional funding for operating cost subsidies yearly; this new legal status provides NARO with more freedom to acquire external funding and manage its human resources.

NARO has five regional agricultural research centres that engage in the development of technology suitable for each regions' particular weather and climatic conditions. As a regional hub of agricultural research, the centres are mandated to reflect farmer needs in the area of technological development.

To strengthen the regional hub function, NARO implemented an organisational reform of regional agricultural research centres in 2016, including:

- creating an advisory board composed of local leading farmers
- setting up a unit specialised in planning, and proposing and co-ordinating joint research in collaboration with prefectural agricultural research organisations, extension offices and private companies;

- designating an agricultural technology communicator to engage in daily exchanges of information with prefectural agricultural extension officers
- designating an industry-academia co-ordinator to proactively engage in co-ordination that would make greater use of NARO intellectual property.

The Agri-Food Business Innovation Center (ABIC) was established by NARO in 2016 to promote industry-academy-government collaboration. ABIC matches activities with external organisations and the private sector to make use of research outcomes and intellectual property. The Bio-Oriented Technology Research Advancement Institution (BRAIN) also acts as a means of transferring knowledge to universities, technical colleges, other national research organisations and private companies

There are two additional national public research organisations in agriculture. The Japan International Research Center for Agricultural Sciences (JIRCAS) is responsible for R&D in technology relating to agriculture, forestry and fisheries in tropical, subtropical and other developing regions, with the aim of solving food and environmental problems at a global level, and to ensuring a stable supply of agricultural, forest and fisheries products. The Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries (PRIMAFF) specialises in social sciences and provides knowledge for MAFF's policy planning and proposals.

Prefectural agricultural research organisations

Prefectural governments have their own agricultural research organisations, with agricultural R&D at the local level focussing on developing technologies which are adapted to local conditions. In particular, prefectural research stations help develop cereal varieties such as rice, wheat and soybean suitable for the region.

The national and prefectural research centres complement each other. For example, national research centres collect genetic resources and develop advanced breeding technologies, as well as pioneer plant varieties and breeds, while prefectural research stations develop regional brand varieties utilising generic resources and technologies.

Recent efforts have made agricultural research more demand-oriented. For example, farmers and extension organisations are required to participate in regional agricultural R&D projects funded by the national government. Collaboration in on-site experimental research is promoted between NARO's regional agricultural research centres, prefectural research stations and extension services, and farmers knowledgeable in the field by imposing conditionality on national-level project funding.

Prefectural extension services

Farm advisory systems play an important role in the transfer and successful adoption of innovation, in particular at the early stages of development. Prefectural governments deliver public agricultural extension services as an integrated system with prefectural agricultural research organisations. The prefectural agricultural extension stations played a major role in facilitating the adoption of breeding and farming techniques developed by the prefectural agricultural research centres.

Universities

Japanese universities play an important role as agriculture-related knowledge generators. Most prefectures have a national, public or private university to carry out programmes related to agricultural science. These universities engage in education and wide-ranging research activities, including both basic and applied research.

Private companies, associations and producers

AIS actors include producers, private agri-business companies and JAs. Private agri-business companies and JAs often provide farmers with technical advice in combination with the sale of inputs. However, agricultural R&D in the private sector is limited. Contrary to public research organisations, private R&D plays a marginal role in the development of the main cereal crops; instead it concentrates on non-cereal crop research such as vegetables and flowers. Private companies also play a major role in R&D in agricultural input industries such as farm machinery and agricultural chemicals.

Governance of AIS in Japan

Policy framework and funding mechanisms

The Basic Plan for Agriculture, Forestry and Fisheries Research sets the overall direction of public agricultural R&D in Japan over a ten-year period. AFFRC has formulated the Basic Plan every five years since 2005 in parallel with preparation of the Basic Plan for Food, Agriculture and Rural Areas by MAFF.[2] The Basic Plan also takes into consideration the Integrated Innovation Strategy formulated by CSTI.

The Basic Plan for Agriculture, Forestry and Fisheries Research defines a specific R&D target by both research area and commodity, and it prioritises research to quickly solve problems faced by producers. It also sets the direction of the medium- to long-term research agenda, including on global warming. The current basic plan sets 32 priority targets related to industry-academia-government collaborative research. The examples include seed development in collaboration with ICT and robotic technology, and the development of value chains for agricultural, forestry and fisheries products.

NARO is a central player in public R&D projects based on the Basic Plan for Agriculture, Forestry and Fisheries Research. Based on five-year operational objectives set by MAFF, NARO formulates a medium- to long-term plan as well as annual operation plans. NARO set four priorities for the current medium-term operational plan (2016-20), namely: 1) strengthening the capability and management of production sites; 2) developing new plant cultivars and agricultural products through genomic and agri-biological research and new industrial innovation; 3) producing high-quality agricultural products and food while ensuring safety and reliability; and 4) solving environmental problems and using local resources sustainably.

The research projects in the Basic Plan are funded mainly from the government budget allocated to MAFF. In FY2017, JPY 98.4 billion (USD 877.2 million) was allocated for research, or 7.5% of the overall government budget allocated to science and technology promotion.

The budget of NARO and other agriculture-related national public research institutions is comprised of operational cost subsidies and research funds. Operational cost subsidies are institutional funding that cover the expenses of public research institutions to perform tasks commissioned by the government. This subsidy accounts for around 90% of science and technology promotion expenditure allocated to MAFF. The government also allocates its budget to project funding through a research fund. There are two research fund schemes; namely, project research contracts and competitive research grants. The topic of project research contracts is pre-determined by MAFF, but applicants can propose research topics for the competitive research grants. In both cases, AFFRC is responsible for all operations, such as setting research subjects, allocation of budgets and selecting projects.

In FY2017, the project research contract and competitive research grant received JPY 4.1 billion (USD 36.5 million) and JPY 5.1 billion (USD 45.5 million) of budget, respectively, or 4% and 5% of science and technology promotion expenditure allocated to MAFF in 2017. A series of OECD country reviews on innovation, agricultural productivity and sustainability indicate that despite an increase in the project research contracts and competitive research grants, Japan's share of project-based funding in total funding for agricultural R&D remains one of the lowest (Table 5.1).

Table 5.1. Share of project-based funding in total funding for agricultural R&D

0-20%	Argentina, Brazil, China, Korea, Japan
20-40%	Canada, Latvia, Turkey
40-60%	Australia, Sweden
60-80%	Columbia, Estonia, United States
80-100%	Netherlands

Source: OECD (2019[7]).

NARO and other public research organisations in agriculture are eligible for the external competitive research grant. For example, 66% of the competitive research grants NARO received in 2017 were from MEXT, while grants from MAFF accounted for 29% (MAFF, 2018[8]). However, competitive research grants account for only around 3% of NARO's total budget. Moreover, funding from the private sector to public agricultural research institutions such as NARO is negligible. In FY2017, NARO financed 88% of its budget from institutional funding from MAFF.

As public funding in agricultural R&D declines, prioritising research targets within public research and enhancing private investment in agricultural R&D has become an important point of the policy agenda. AFFRC and other national agencies have started new schemes for government-funded R&D projects and competitive research grants to increase incentives for the private sector to participate in R&D activities with universities or public research organisations, as well as to commercialise technologies and expertise acquired through R&D.

In 2018, MAFF introduced new selection criteria for project funding contracts, designated as for need-based R&D projects. First, inquiries were organised to ascertain the needs of farmers. Specifically, MAFF staff visited farmers and conducted hearings, inviting 300 participants to regional meetings. It also conducted opinion surveys to understand research needs. Second, funding was given only to a consortia of farmers, private companies, universities, research institutions, and other related organisations. Finally, the research agenda for project funding contracts is based on the opinions of 12 experts. In FY2018 and the supplementary budget of FY2017, 23 need-based research projects were selected.

Another type of project funding is available for projects that develop pioneering technology and solve medium- to long-term issues. Unlike the need-based project funding, this contract does not require a research consortium. In FY2018, three research topics were selected and included research on food distribution and smart breeding system using AI.

The experience of other OECD countries shows that demand-oriented agricultural research requires strong partnership with stakeholders. In some countries, farmers contribute to funding agricultural R&D through statutory or voluntary levies. This helps ensure that research adapts to their needs and will be widely adopted, and to channel public R&D expenditure into more pre-competitive R&D agendas. The Australian Research and Development Corporation (RDC) model, based on 50-50 co-funding by farmers and the government, channels a large part of agricultural R&D funding (Box 5.1). While organised by commodity sectors, some RDCs have wide coverage, including small and emerging industries (OECD, 2015[9]). The Federation of Swedish Farmers (LRF) created the Swedish Farmers' Foundation for Agricultural Research in 1996 as an independent legal organisation, receiving funding from both the LRF and the government. Every year it distributes about SEK 57 million (USD 6.7 million) to support agricultural-needs-driven research, of which about two-thirds goes to private sources.

Box 5.1. Co-financing model of agricultural R&D

Top Sector policy in the Netherlands

The Top Sector policy limits the granting of public funds to public-private partnerships within top sectors and gives industry a leading role in setting innovation agendas. One original objective of the Top Sector policy was to leverage business-sector R&D and increase the applicability of public research. The policy was also expected to promote closer co-operation between knowledge institutes, public authorities and business.

Public funds have to be matched with an equivalent contribution from the private sector (50-50), which can be in kind (access to facilities) or financial, in which case it can benefit from public support (investment or tax rebates). In the Top Sector policy, the business community sets the agenda for R&D investments in its field together with the government and scientists. The government invites businesses and scientists to draw up action plans, which serve as a base for developing concrete lines of action. Each top sector created one or more Top Consortia for knowledge and innovation, where entrepreneurs and researchers work together in innovative products and concepts. The government is an observer on the board.

Australian Rural Research and Development Corporation model

The RDC model of co-financing rural R&D activities was established in 1989. It places interaction between public R&D and agricultural industries at the heart of rural innovation systems, and channelled a significant share of Australian government spending on rural R&D in recent years.

Under the RDC model, the Australian government matches dollar for dollar industry R&D funds collected from primary producers via statutory or voluntary levies, with maximum matching contribution per year of 0.5% of an industry's gross value of production.

This co-investment model generates greater spending capacity, ensures that producers who benefit from research contribute to its costs, ensures that research is of practical value, and facilitates greater and faster uptake of research outputs.

Originally competitive and market-driven, the model became more collaborative and inclusive. However, it does not directly integrate agri-business processing and retailing stakeholders in funding decisions, potentially limiting capacity to respond to demand for product and process development along the food chain. Similarly, its design is more adapted to marginal improvements than fundamental changes in production systems and resource management. Past evaluations questioned the complex arrangements and unclear funding flows, making evaluation difficult.

Source: OECD (2015[10]), OECD (2015[9]).

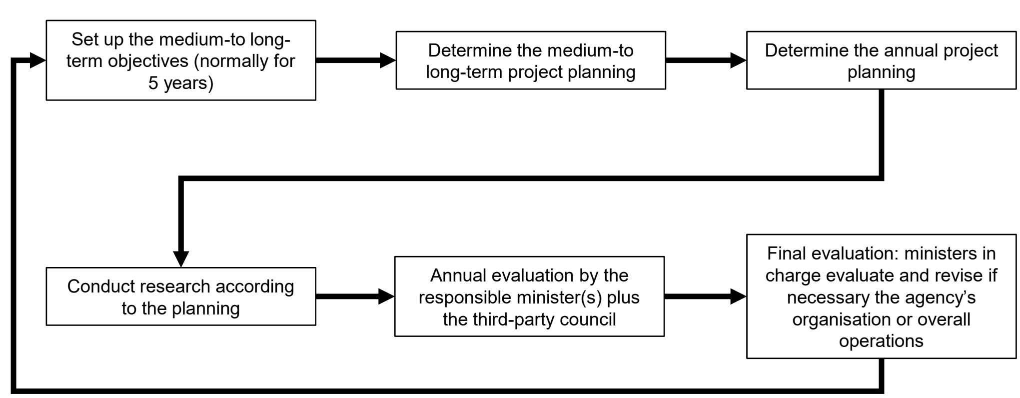
Monitoring and evaluation

Agricultural R&D projects with public funding or in government research organisations are evaluated at four stages in accordance with the General Guidelines for R&D Evaluation: 1) preliminary evaluation at the planning and proposal stage; 2) interim evaluation at the middle stage for improvement or revision; 3) final evaluation of the extent to which the project was achieved, the significance of the outcome obtained, the outcome's practical application and commercialisation, and the efforts required for such purposes; and 4) follow-up evaluation after completion of the project to see what has been achieved. An external evaluation committee composed of farmers, members of the private sector, and other relevant actors is in charge of the evaluation.[3]

Follow-up investigations on how farmers adopted new agricultural technologies, their impact, and feedback to developers are important to the process of innovation. Since 2007, AFFRC conducts an annual selection of new technologies and crop varieties among the research outcomes achieved, as well as follow-up surveys after two or five years of development through prefectural extension services.

In addition to the evaluation of R&D projects, national research and development agencies such as NARO are evaluated as an institution by the ministers in charge (Figure 5.2). NARO introduced a new evaluation system to reinforce the Plan-Do-Check-Act cycle since the latest medium- to long-term objective period (FY2016-FY2020). NARO set up the Office of Evaluation to handle performance evaluations and organise the evaluation committee by research pillar. More specifically, NARO set up an evaluation strategy council and an evaluation committee that includes external members to evaluate NARO's operation from diverse, multiple viewpoints. NARO modifies research subjects, research budget allocations, and human resource allocations based on the result of its evaluation. Additionally, overseas experts review the research subjects that involve international aspects. However, there is a potential risk that such strict research management may impede creation of knowledge from a long-term perspective.

Figure 5.2. Evaluation system for national R&D agencies in Japan



Source: MIC (2018[11]), *Evaluation System of Independent Administrative Corporations*, http://www.soumu.go.jp/main_sosiki/hyouka/dokuritu_n/index.html.

5.3. Investment and outcomes in agriculture and food R&D

Trends in public and private R&D investment

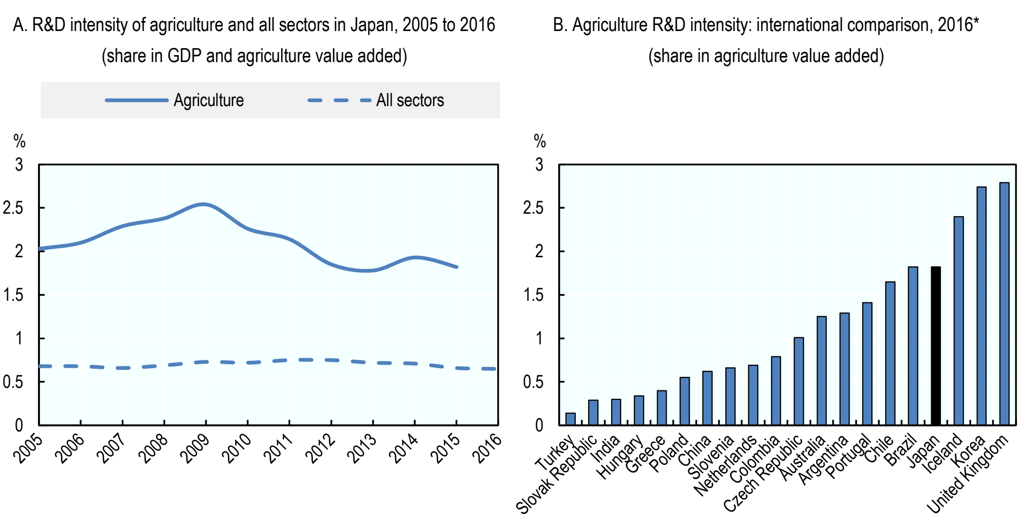
Japan maintains a relatively high level of R&D investment, with the ratio of Gross Domestic Expenditure on R&D (GERD) to GDP staying in the upper 3% in 2007-16. While GERD is the sum of public and private R&D investments, private investment accounts for around 70% of GERD during the last ten years, followed by universities (20%) and public institutions (7%). Around 70% of private R&D investment is concentrated on large enterprises with capital of JPY 10 billion (USD 82.6 million) or more, and 98.3% of private R&D expenditure was self-financed in 2015.

In comparison, the public sector accounts for the majority of agricultural R&D investment in Japan. The intensity of public R&D investment is higher than that of other sectors, but private investment was only 0.03% of agricultural value added, much lower than for most OECD countries (Figure 5.3). In the food and beverage industry, while the intensity of private R&D investment is lower than other sectors, it is higher than in other OECD countries (Figure 5.4). The ratio of government appropriations or outlays for agricultural R&D to gross agricultural output peaked in 2009 at 2.54%, and then continued to decline until 2013. The intensity of public investment in agricultural R&D nevertheless remains higher than in most other OECD countries.

To date, agricultural R&D is mainly conducted by public research organisations such as NARO. Researchers in agriculture tend to be less conscious of commercialising their research outcomes than other sectors. A limited collaboration of universities and public research organisations with industry results in the situation that a majority of agricultural R&D projects targets improvement or modification of existing technologies and the extension of outcomes to producers.

Figure 5.3. Intensity of public agricultural R&D investment

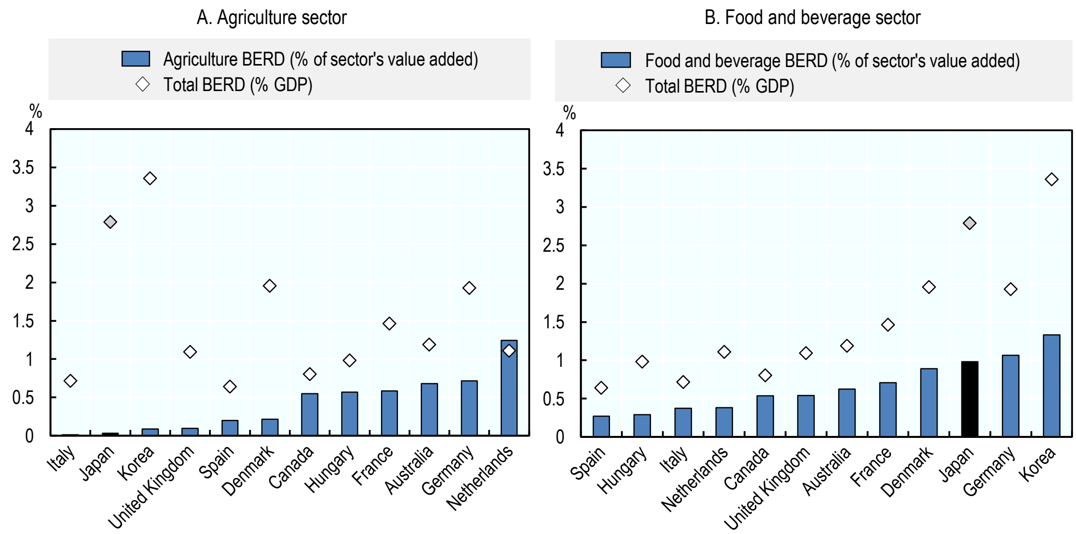
Government budget appropriations or outlays for R&D as a share of value-added



Note: * or latest available year
Source: OECD (2016[12]), *OECD Science, Technology and R&D Statistics* (database), https://doi.org/10.1787/48768e54-en; OECD (2017[13]), *OECD.Stat* (database), https://stats.oecd.org; ASTI (2017[14]), *Agricultural Science and Technology Indicators 2017* (database), https://www.asti.cgiar.org/data.

StatLink http://dx.doi.org/10.1787/888933957857

Figure 5.4. Business Expenditures on R&D (BERD) in the agriculture and food and beverage sectors



Note: The figures are based on data for the latest available year for each country: 2013 and 2014 for the agriculture sector (panel A), except 2010 for Canada; 2010 for the food and beverage sector (panel B), except 2009 for Korea and 2006 for Australia.
Source: OECD (2016[12]), *OECD Science, Technology and R&D Statistics* (database), https://doi.org/10.1787/48768e54-en; OECD (2017[13]), *OECD.Stat* (database), https://stats.oecd.org.

StatLink http://dx.doi.org/10.1787/888933957876

R&D outcomes

The outcome and impact of innovation can be examined via proxy data such as the number of patents issued, and the number of scientific papers published and cited (OECD, 2015[15]). The number of patents in the agri-food sector in Japan is the second highest, after the United States (Table 5.2). However, the number of patents issued is not necessarily a comprehensive indicator of the performance of innovation systems (OECD, 2018[16]) because not all technological components of innovation systems hold patents, and those that do are not always used effectively.

The number of scientific papers on agricultural subjects published by research institutions in Japan has decreased in the last decade, while it increased in the People's Republic of China (hereafter "China") and Korea over the same period. However, Japan's share in global publications on agriculture remains higher than the average of OECD and EU15 countries.

Table 5.2. Japan's agriculture and food R&D outcomes in international comparison, 2007-12

	Japan	Korea	China	United States	Netherlands	BRIICS average	OECD average	EU15 average
Specialisation: agri-food science outputs as a share of country's total, %								
Patents	**3.5**	4.3	2.8	6.8	8.8	3.8	5.6	6.6
Publications	**6.8**	6.1	5.1	6.7	6.9	12.3	9.4	8.1
Citations	**6.9**	5.8	6.8	6.3	6.4	12.0	11.9	10.8
Contribution to world agri-food science output, %								
Patents	**3.7**	1.2	1.0	10.8	1.0	0.3	0.7	0.6
Publications	**4.3**	1.8	8.3	18.3	1.6	3.1	2.0	1.8
Citations	**4.2**	1.4	6.7	27.2	2.8	1.8	2.4	2.4

Source: SCImago (SJR) (2018[17]), (2014).

Clarivate Analytics, a data analysis firm, defines Essential Science Indicators (ESI) as the number of outstanding papers ranked among the top 1% internationally based on the number of citations in pertinent fields. The ESI database classifies the entire field of science into 22 categories. Japan ranks eighth worldwide in the fields of botany and zoology, which are closely related to agriculture (2007-17). Within Japan, public research organisations (i.e. national research and development agencies) rank high in botany and zoology compared with other fields. NARO and JIRCAS ranked third and seventh respectively among institutions in Japan.

5.4. Creating knowledge markets and networks

Public-private collaboration in agricultural R&D

Innovation in agriculture today is more dependent on the technologies developed outside agriculture such as genetics and digital technologies, requiring collaboration between public and private actors across the sectors. OECD countries apply a variety of institutional and funding mechanisms: public funding to foundations, institutions, and research projects requiring public and private participation and co-funding.

For example, USDA's Agricultural Research Service engages in R&D partnerships to address major challenges in agriculture. An agriculture-specific institution, the Foundation for Food and Agricultural Research, was created in 2014 as an independent, board-driven, non-profit organisation, to foster collaboration between government, university, industry, and non-profit researchers (OECD, 2016[18]). Public-private partnerships (PPPs) are based on Co-operative Research and Development Agreements, which allow both parties to keep research results confidential for up to five years under the Freedom of Information Act, shared patents, patent licenses and permits where one partner can retain exclusive rights to a patent or patent license. The Netherlands goes furthest in placing PPPs at the heart of R&D strategy. However, by giving industry a leading role in setting innovation agendas, this approach risks focusing public funds on low-risk and short-term R&D activities, away from research with more fundamental public goods aspects that need to be addressed for long-term challenges.

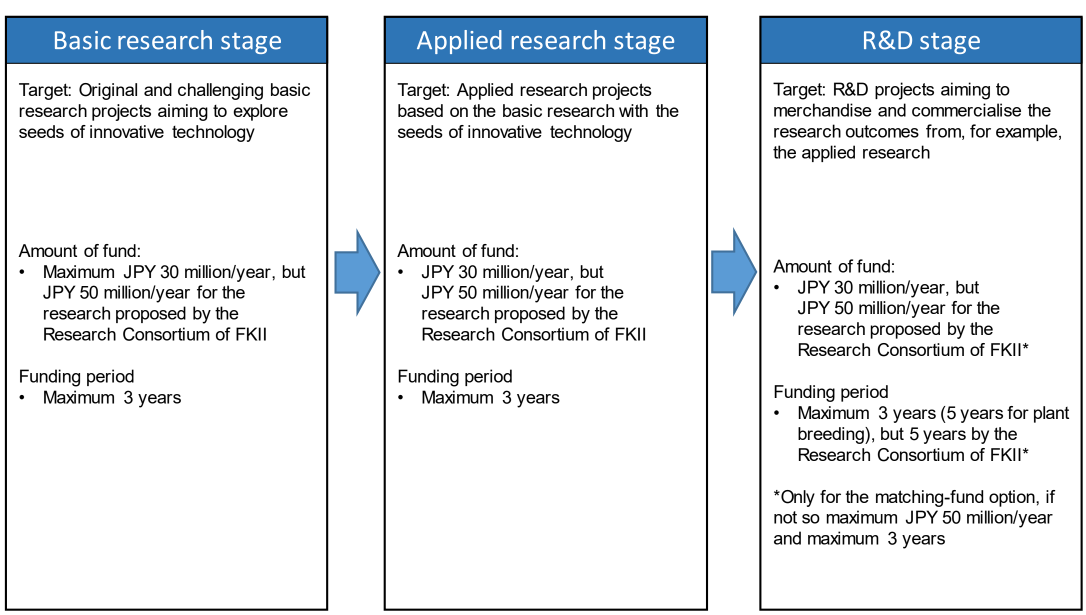
There is significant room to strengthen the links between public and private AIS actors in Japan. In 2016, MAFF launched the Council of Industry-Academia-Government Collaboration in the Field for Knowledge Integration and Innovation (FKII). The Council consists of private companies, universities, and research institutions from non-agricultural sectors, and it serves as a platform for exchanging information (Box 5.2). The seminars and workshops organised in different regions assist Council members with shared challenges to form a cross-sectoral R&D platform and conduct joint research.

In 2018, MAFF introduced a new competitive research grant to give preference to research proposed by the Research Consortium formed by FKII (Figure 5.5). To promote collaboration of R&D across sectors, research groups eligible for this competitive grant must comprise organisations from at least two of the following categories of actors in case they conduct research at either the applied or adaptive research stage:

- *Category I:* Prefectures, municipalities, prefectural research organisations, independent regional administrative agencies.
- *Category II:* Universities, Inter-University Research Institute Corporations.
- *Category III*: Incorporated administrative agencies, government-affiliated special corporations, government-authorised corporations.
- *Category IV*: Private companies, non-profit organisations, co-operatives, farmers, fishermen and foresters.

Proposals from the Research Consortium of FKII have advantages, such as higher upper grant limits, extension of research periods, and additional consideration given during selection. Furthermore, to encourage private-sector investment and promote the commercialisation of research outcomes, a matching funds scheme is used in the adaptive research stage, in which private business finances at least half the research expense.

Figure 5.5. Scheme for new competitive research grants in Japan



Source: MAFF (2016[19]), *Field for Knowledge Integration and Innovation: Organization and Evolution Since Fiscal Year 2016.*

Box 5.2. Platform for open innovation in agriculture

The Council of Industry-Academia-Government Collaboration of the Field for Knowledge Integration and Innovation (FKII) aims to be a cross-sectoral platform of people, information, and funds for agricultural research. It is composed of three levels:

- *The Council of Industry-Academia-Government Collaboration* that exchanges information among member,s such as producers, private companies, universities, and research organisations.
- *A R&D Platform* that engages in collaborative research led by a designated research director.
- *A Research Consortium* that performs joint research.

As of May 2018, FKII included 1 751 organisations and 690 individual members in the council, and launched 118 R&D platforms.

Cross-sectoral collaboration through FKII is expected to promote the commercialisation of new technology and enhance incentives for private investment in agricultural R&D. Most private companies engaged in R&D are interested only to the merchandising or commercialisation of their own products or services. Universities and public research organisations have played a central role in basic and applied research, which requires a long term horizon before results can be commercialised.

FKII is intended to connect each R&D stage with diverse actors of the Agricultural Innovation System. Financial support through FKII focuses on the commercialisation of research output from basic to applied over a three- to five-year period.

BRAIN, the institution managed by NARO, provides support for R&D via a matching fund method that is designed to encourage collaboration with private-sector companies. A total of 17 agricultural, forestry and fisheries projects were adopted in model projects selected from public proposals in 2016-17. These include, "development of a model plant factory system for the Asian monsoon region" and "development of an AI robot-operated greenhouse."

Source: MAFF (2016[19]), *Field for Knowledge Integration and Innovation: Organization and Evolution Since Fiscal Year 2016*.

Intellectual property protection

Because of the fragmented structure of agricultural production, comprising relatively small operations producing multiple, homogeneous products, few farms are willing to invest in private R&D. Furthermore, because of the biological nature of agriculture, improved crop seed and animal breeds are self-replicating. This complicates the ability of innovators to protect intellectual property. In addition, many agricultural technologies tend to be geographically specific, meaning they do not transfer easily to other locations with different soil types, weather patterns, or topography. These features imply that unique policies to foster innovation in agriculture are required (OECD, 2016[18]).

Japan maintains a high level of intellectual property protection (Figure 5.6, Panel C). Patent protection increased rapidly in the 1980-90s, leading to a level of protection equivalent to that in the Netherlands or France from around the 1990s to 2000s (Figure 5.6, Panel A). According to the Plant Variety Protection Index created by Campi and Nuvolari (2013[20]), Japan's score now stands at the same level as France, though lower than that of the Netherlands or the United States (Figure 5.6, Panel B).

Japan developed a comprehensive framework of Intellectual Property Rights (IPRs), including patent, trademark, plant variety, and GI protection systems (Table 5.3). While MAFF is in charge of plant variety and GI protection systems for agricultural goods, the National Tax Agency protects GI for Japanese liquor. Japan's Patent Office administers patents, trademarks, designs and utility models, and the Agency of Cultural Affairs protects copyrights.

In 1999, Japan introduced the Bayh-Dole system to its Industrial Technology Enhancement Act, drawing on the US Bayh-Dole Act, to allow private companies which receive project funding to own 100% of the intellectual property rights. The application of this measure is conditional on: 1) notifying the government when the research outcome is achieved; 2) licensing such IPR to the government for free in case when the latter needs it for public interest; and 3) licensing the IPR to a third party at the request of the government if the contractor has not used it within a reasonable time.

Table 5.3. Japan's legal framework for intellectual property protection in agriculture

Types of rights protected	Details	Protection period
GI Protection system	Protection of the names of agricultural, forestry or fisheries products or foods whose quality, reputation or other established characteristics is attributable to their place of production	Unlimited
Registration of plant variety	Right to exclusively utilise a new variety of plant	25 years
Trademark right	Right to exclusive use of names and marks for a product or service	10 years
Regional collective trademark	Right to exclusive use of a trademark consisting of a regional name and common (customary) name of goods and services	10 years
Patent right	Right to the exclusive use of an invention	20 years
Utility model right	Right to exclusive use of a device relating to the shape, structure or combination of goods	10 years
Design right	Right to exclusive use of a design consisting of shape, pattern or colours of goods that have a creative, aesthetic appearance	20 years

Source: MAFF (2014[21]), *Manual for Strategic Use of Intellectual Property Rights* (in Japanese).

In 2007, MAFF announced an integrated Intellectual Property Strategy with the aim to prevent technology outflow, promote brand management, and accelerate the use of intellectual property. The strategy was renewed in 2010 and 2015. The current strategy adds a new element to promote intellectual property management in ICT-related businesses, and in the seed and seedling industry.

While NARO and other public agricultural R&D institutions under MAFF hold a number of IPRs, these have not necessarily been well utilised by private companies or local governments. AFFRC recently strengthened IPR management within NARO by appointing full-time co-ordinators at regional agricultural research centres. They are expected to engage in: 1) promoting the use of intellectual property, including license grants; 2) collaboration with external experts in technology, business models and intellectual property management; and 3) promoting joint research with the private sector, including venture capital firms that undertake commercialisation of intellectual property.

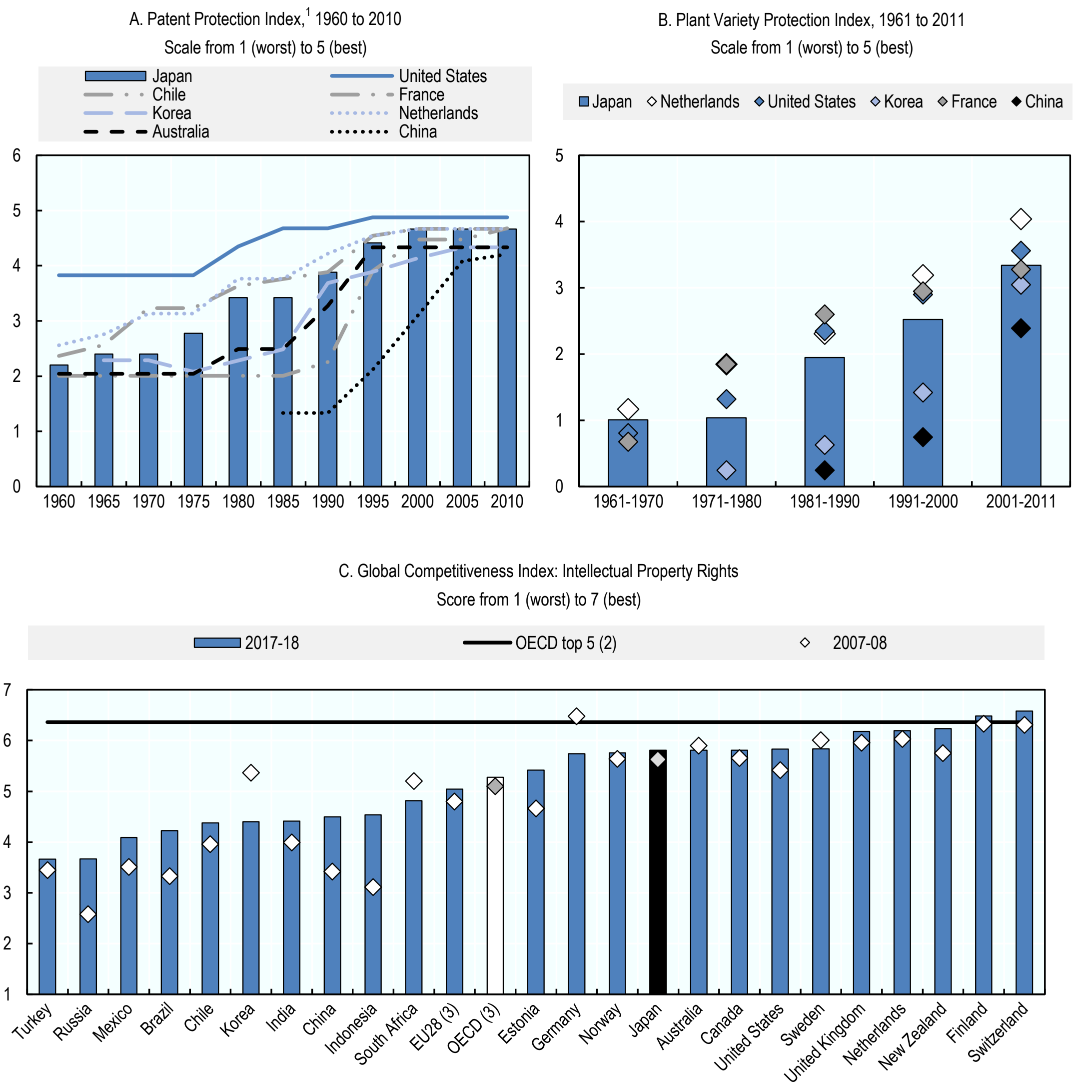
Japan is a member of major international treaties on intellectual property. These include the Paris Convention for the Protection of Industrial Property (1899), the Berne Convention for the Protection of Literary and Artistic Works (1899), the Patent Co-operation Treaty (1978), the Protocol Relating to the Madrid Agreement Concerning the International Registration of Marks (2000), the Patent Law Treaty (2016), and the Agreement on Trade-related Aspects of Intellectual Property Rights (1995).

The International Convention for the Protection of New Varieties of Plants (UPOV Convention) was adopted in 1961 and amended in 1978 and 1991. The 1991 Act took effect in April 1998. Japan acceded the 1979 Act in 1982 and the 1991 Act in 1998. The International Union for the Protection of New Varieties of Plants (UPOV) aims to promote an effective system of plant variety protection with a view to encourage the development of new plant varieties. The UPOV Convention provides basis for member countries to encourage plant breeding by granting breeders an intellectual property right for the new plant varieties.

Japan provides plant variety protection system based on the Plant Variety Protection and Seed Act. Plant breeding is encouraged under the Act as it contributes to the development of agriculture. Around 800 new plant varieties are registered per year in Japan – the fifth largest number among UPOV members after the European Union, China, the United States and Ukraine in 2017 (UPOV, 2018[22]). Of those who hold plant breeder's right, 50% is seed companies, 25% is individuals and 15% is public sectors. This shows that various sectors engage in breeding activities in Japan.

Japan took the initiative to establish the East Asia Plant Variety Protection Forum (EAPVP Forum) in 2007. It is composed of ASEAN Member States, China, Korea, and Japan. Japan has been supporting EAPVP Forum activities in collaboration with the UPOV and UPOV members. The 11th EAPVP Forum Annual Meeting in August 2018 adopted the Common Direction of the 10-Year Strategic Plan; it aims to achieve that all Forum members which are also members of UPOV will serve as the basis for further harmonization and co-operation of plant variety protection in the region.

Figure 5.6. Intellectual property protection indicators



1. Overall index is the sum of indices for duration, enforcement, loss of rights, membership and coverage.
2. OECD top 5 refers to the average of the scores for the top 5 performers among OECD countries in 2017-18 (Switzerland, Finland, Luxembourg, New Zealand and Netherlands).
3. Indices for EU28 and OECD are the simple average of member-country indices.
Source: (Panel A) Adapted from Park (2008[23]), "International Patent Protection: 1960-2005", *Research Policy*, No. 37. (Panel B) Campi and Nuvolari (2013[20]), *IP Protection in Plant Varieties: A New Worldwide Index (1961-2011)*, http://hdl.handle.net/10419/89567. (Panel C) WEF (2017[24]), *The Global Competitiveness Report 2017-2018: Full-data Edition*, http://reports.weforum.org/global-competitiveness-index-2017-2018/.

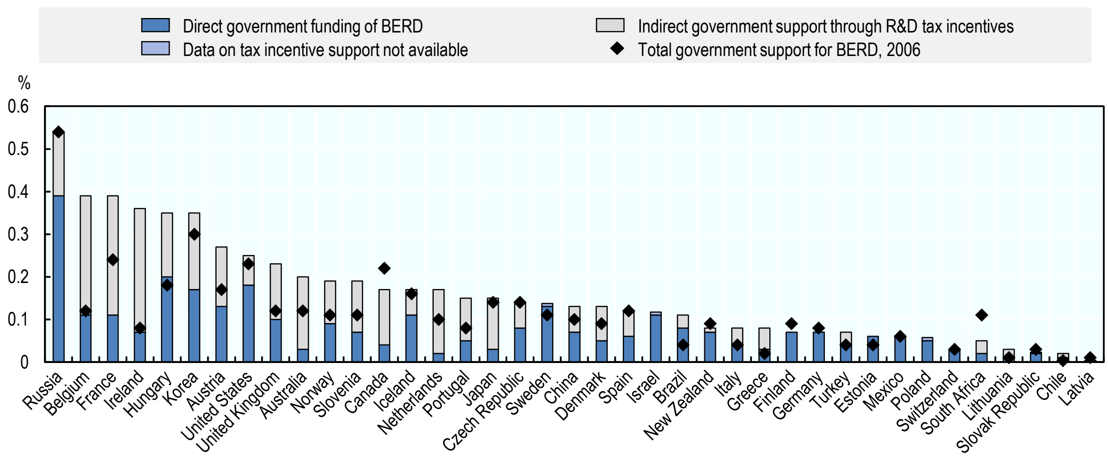
StatLink http://dx.doi.org/10.1787/888933957895

Preferential taxation and R&D

Japan has developed a tax credit system to allow enterprises to deduct certain R&D-related expenditures, and thus reduce the amount of corporate taxes. The total tax credit, when all available tax credits are applied, is capped at 40% of applicable corporate income taxes. As of April 2017, in addition to R&D in manufacturing, ICT-related service development became eligible for tax credit. Developing agriculture support services using ICTs, such as agricultural data collection and analysis, is one form of R&D eligible for tax credit. Overall, indirect support through preferential taxes accounts for most government support to private R&D in Japan (Figure 5.7).

Figure 5.7. Direct government funding and tax support for business R&D, 2015

As a percentage of GDP



Note: The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.
Source: OECD (2017[25]), *Innovation in Firms*, https://doi.org/10.1787/sti_scoreboard-2017-graph135-en.

StatLink http://dx.doi.org/10.1787/888933957914

R&D tax credits apply to all companies irrespective of its size, but grant higher tax incentives, such as a higher percentage of R&D expenditure deduction, to SMEs with a capital of JPY 100 million (USD 891 000) or less. Moreover, the R&D tax system provides additional incentives to increase R&D expenditure, or to maintain high levels of R&D expenditure in addition to performing collaborative R&D. For example, 30% of collaborative R&D expenditure with national research institutions and universities (20% in the case of other research partners) is deductible from taxable corporate income.

Besides preferential tax treatment, the Small Business Innovation Research programme supports R&D and the commercialisation of its outcomes by SMEs. An SME that receives certain grants from the government is eligible for preferential loans from JFC to cover capital spending or the working capital required to commercialise the technology developed; they are also eligible for reduced patent fees.

5.5. International R&D collaboration

The benefits of international R&D collaboration for national innovation systems stem from the specialisation it allows and from international spill-overs. International collaboration in agricultural R&D is particularly effective in cases where a large initial investment is required to finance R&D that produces solutions for global issues (e.g. climate change) or transboundary issues (e.g. spread of animal diseases).

Promoting international joint research

Despite a higher number of patents in the agri-food sector, the share of patents jointly owned with foreign researchers is only 5.2% of the total Japanese-owned patents. Similarly, the share of internationally co-authored papers in the field of agriculture and food in Japan is lower than the OECD average (Table 5.4). Low levels of international co-operation in R&D are not limited to the agri-food sector. Japan ranked 16th out of 24 OECD countries in a 2008-10 study on the share of external knowledge sources for innovation (OECD, 2013[4]). Only 0.5% of the R&D carried out in Japan in 2013 was financed from abroad.

Table 5.4. Japan's agri-food R&D co-operation, 2006-11

Agri-food R&D outputs with foreign co-authors, as a share of economies' total agri-food R&D outputs, %

	Japan	Korea	China	United States	Netherlands	BRIICS average	OECD average	EU15 average
Agricultural science collaboration								
Patents	5.2	5.8	21.8	14.3	27.1	23.7	11.8	36.2
Publications	31.5	31.4	23.6	36.4	65.1	38.9	50.8	57.7

Source: OECD (2014[26]), *OECD Patent Database* https://doi.org/10.1787/patent-data-en; SCImago (SJR) (2018[17]), *SCImago Journal & Country Rank*, http://www.scimagojr.com.

To accelerate international co-operation in agricultural research, MAFF has been assisting Japanese research agencies since 2014 in signing Memorandums of Understanding (MoUs) with foreign or international research organisations. As a result, JIRCAS and NARO have so far concluded 121 MoUs and 72 MoUs, respectively, with more than 40 countries. In 2017, AFFRC entered into a Memorandum of Cooperation on joint research with the Russian Science Foundation and the Ministry of Agriculture and Rural Development of Israel. In 2018, NARO dispatched a liaison scientist to Wageningen University and Research in the Netherlands in an effort to develop networks with the university as well as other EU research institutions.

Technology in developing countries and responses to global issues

To achieve the Sustainable Development Goals set by the United Nations General Assembly, MAFF makes financial contributions to international research organisations as well as research projects by domestic research organisations that address global issues such as climate change.

JIRCAS is the only Japanese national research organisation explicitly mandated by law to engage in technological experiments and research related to agriculture, forestry and fisheries in tropical, subtropical or other developing regions overseas. At present, JIRCAS engages in 14 international joint research projects in four programmes. These cover the development of agricultural technologies for sustainable environment and natural resource management in developing regions, technology development for stable production of agricultural products in the tropics and other adverse environments, the development of high-value adding technologies and utilisation of local resources in developing regions, and the collection, analysis and dissemination of information to grasp international trends in agriculture, forestry and fisheries.

NARO also focuses on the resolution of environmental issues and the sustainable use of local resources in developing countries. For instance, in co-operation with the International Rice Research Institute and other Philippine, Thai, Vietnamese and Indonesian research institutions, NARO engages in research on water-saving cultivation technology to reduce greenhouse gas emissions from paddy fields in various parts of Asia (Greenhouse Gas Mitigation in Irrigated Rice Paddies in Southeast Asia). NARO also contributes to the development of agricultural technology and capacity development in developing countries by sending experts and researchers.

In addition to the activities mentioned above, the Science and Technology Research Partnership for Sustainable Development programme has promoted since 2008 a large-scale programme to promote joint research between Japan and developing countries. This is co-managed by JST and the Japan International Co-operation Agency (JICA). The budget is approximately JPY 100 million (USD 891 000) per project per year. To date, 133 projects have been implemented in 50 countries.

Participation in international frameworks for agricultural research

Participation in international frameworks for agricultural research will help Japan develop an international network of researchers and to introduce outside expertise in domestic agricultural research. The country's participation in the G20 Meeting(s) of Agricultural Chief Scientists (MACS) is one such initiative. Chief scientists and high-level research administrative officials of G20 countries and international research organisations discuss research priorities, thereby strengthening collaboration between countries and international research organisations. Representatives from AFFRC and JIRCAS participate in all MACS meetings, and Japan hosted the eighth meeting held in Tokyo in April 2019. Japan also participates in the OECD Co-operative Research Programme to promote personnel exchanges between Japanese and overseas researchers by supporting conferences held in Japan, as well as dispatching Japanese researchers overseas and accepting foreign researchers to Japanese research organisations.

In 2017-18, Japan chaired the Global Research Alliance on agricultural greenhouse gases, an international network of 50 countries focused on reducing greenhouse gas emissions in agriculture. Japan assigned funded projects to the Consultative Group on International Agricultural Research (CGIAR) to promote international research in agriculture, forestry and fisheries to resolve global issues. JIRCAS engages in joint research with the International Rice Research Institute (IRRI), the International Maize and Wheat Improvement Center, the International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA), World Agroforestry Centre and the Africa Rice Center, all of which are research organisations of CGIAR. One JIRCAS researcher is part of the CGIAR System Management Office.

Japan and CGIAR actively collaborate in Public-Private Partnerships (PPPs) in an effort to link private-sector capabilities to the development, extension and improvement of technology. For example, the Nutrition Japan Public Private Platform is a government and private-sector collaboration that promotes food supply businesses and improves nutrition in developing and emerging countries by taking advantage of Japanese technologies and knowledge. Other examples of PPPs include: collaboration between Bioversity International's Kenya office and Nissin Food Products Co. Ltd. for the development of instant noodles; IITA and Taiyo-Industry Co. Ltd. for the development of technology to produce fishing feed; IITA and Honda Motor Co. Ltd. for the introduction of small agricultural machinery; and CIAT and Ajinomoto Co. Inc. for the supply of disease-resistant cassava.

As a member of the executive committee of the Coalition for African Rice Development and the Initiative for Food and Nutrition Security in Africa, JIRCAS has built international research networks for rice blast and soybean rust diseases, and collaborates with international organisations and African countries to solve food and nutritional problems in Africa. NARO also participates in the Global Strategic Alliances for the Co-ordination of Research on the Major Infectious Diseases of Animals and Zoonoses International Research Consortium.

The Japan Intellectual Support Network in Agricultural Sciences (JISNAS) was created in 2009 to promote collaboration among young researchers at universities that participate in international co-operation in the field of agronomy and to increase their partnerships with JIRCAS and JICA. Currently, JISNAS has 49 members composed of domestic universities and associations. MEXT and MAFF also participate in JISNAS as observers.

5.6. Key points

- Innovation policy is moving beyond supply-driven approaches focused on R&D and specific technologies towards a network-based setting, in which a more inclusive, interactive, and participatory approach fosters greater innovation in response to emerging and pressing challenges facing the food and agriculture systems. This means that farmers and their organisations, extension services, research institutions and universities, vocational education centres, agri-business companies, and the government interact and participate in the innovation process, jointly generating, learning and using knowledge.
- Despite efforts to engage the private sector, public research institutions continue to play a major role at every stage of agricultural R&D in Japan, with the exception of certain farm inputs such as machinery and chemicals. In principle, public agricultural research should concentrate on pre-competitive research areas with medium- to long-term perspectives that are not specifically tied to commercial production. Further clarification of the role of public agricultural R&D would harness the participation of a wider range of actors in the innovation process and increase private investment in agricultural R&D.
- While project-based funding increased, institutional funding to NARO and other public research institutions accounts for a large part of the agricultural R&D budget. NARO finances around 90% of its budget through institutional funding from MAFF. The share of institutional funding in the public agricultural R&D budget remains particularly high in Japan.
- Across OECD countries, efforts to improve the governance of the agricultural innovation system focus on developing more coherent and longer term strategies for innovation in food and agriculture, involving stakeholders more formally and at earlier stages, and strengthening evaluation frameworks. Efforts to integrate farmers in the innovation process are growing in some countries.
- Japan strengthened the engagement of farmers and other stakeholders in R&D planning, implementation and evaluation. Going forward, developing co-financing schemes for agricultural R&D investment with producers would allow the agricultural R&D system to be more demand driven. Co-financing schemes also allow the government to channel more funds to medium- and long-term research while boosting overall spending capacity for agricultural R&D. However, individual producers are not able to finance R&D projects and have little incentive to do so as the benefits of R&D accrue to other farmers in the same sector. Building

co-funding schemes with producers requires a legal and fiscal system that encourages producers to form industry groups to fund R&D projects.

- Japan has strengthened the planning and evaluation systems of public research institutions, including the preparation of annual project plans and annual evaluations by the relevant ministries and third-party council. While strict research management is needed to monitor project progress, the annual process of evaluation could impede the long-term research agenda and discourage other AIS actors from collaborating with public research institutions.
- As NARO's regional centres are mandated to perform demand-oriented research in collaboration with regional producer groups, their role and the role of prefectural agricultural research stations converge with Japan's AIS. National and subnational regional agricultural research organisations could consolidate their efforts by improving co-ordination between national and regional research organisations and clarifying the role of each.
- Innovation in agriculture in agriculture today is more dependent on the technologies developed outside agriculture, such as genetics and digital technologies. This requires collaboration between public and private actors across sectors, and Japan needs to further strengthen the interconnections between AIS actors across sectors. While FKII and tax incentives for research collaboration are useful initiatives in this direction, Japan should remove the remaining impediments to cross-sectoral collaboration and further integrate agricultural R&D system with the economy wide innovation system.
- International research collaboration in agriculture strengthens Japan's own innovation system as it allows specialisation and gains from international spill-overs. It is also important to address global challenges such as climate change and transboundary issues. However, the degree of international co-authorship in agri-food R&D outputs in Japan is lower than the OECD average.

Notes

[1] The first SIP in 2014-18 selected 11 projects, one of which was to develop technologies for creating next-generation agriculture, forestry and fisheries. The second SIP, 2018-22, selected 12 projects, including technology for smart bio-industry, expected to promote innovation in the field of agriculture. The project aims to develop a smart food chain that will enable efficiency by using AI, ICT or other means.

[2] The latest Basic Plan for Agriculture, Forestry and Fisheries Research covers the 2015-25 period. The process of preparation began in February 2014 with seven regular AFFRC board members and three special members selected from consumers and mass media. AFFRC organised more than 150 workshops, conducted opinion surveys and interviews with private companies and universities. The information collected was discussed in the final version of the basic research plan, published on 31 March 2015.

[3] National R&D agencies including NARO are evaluated by the responsible ministers in accordance with the uniform governmental guidelines established by MIC. In the case of NARO, the Ministers of MAFF and MOF are in charge of evaluation. AFFRC takes the opinions of the external evaluation committee into consideration and gives guidance on revisions if necessary. At the end of a medium- to long-term objective period, the ministers in charge evaluate and revise the R&D agency's organisation and overall operations.

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