# ERAWATCH COUNTRY REPORTS 2012: Japan

ERAWATCH Network

Lee Woolgar

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# Executive Summary

Japan is an advanced economy with a population of 127,512,000 (MIC 2012) and a labour force that is roughly half of the population (65m) (NISTEP 2012: 182). Japan's economy is currently ranked as the third largest in the World with a nominal gross domestic product in purchasing power standard of €3,642b for 2011. The EU27 GDP is €12,647b for the same year. On a GDP per capita basis, for 2009 the level is €29,900 (2007), which is slightly higher than that for the EU27, which is €23,300 (2012). The unemployment rate as of 2013 is relatively stable at 4.2%, in comparison to around 12% for the Euro area.

Regarding science, technology and innovation, the level of investment and expenditure is significant. As of 2011, €130.4b (¥17.38t)[1] was spent on research and development (R&D) compared to €245b for the EU27. As a proportion of GDP, gross expenditure on R&D (GERD) accounted for 3.57% of GDP in 2010 (2.01% in the EU27 in 2009). This level has declined from a peak of 3.84% in 2009, where the financial crisis saw a large reduction in corporate expenditures towards R&D. Since 2000 R&D expenditures have tended to increase overall. There are nearly 900,000 full time equivalent researchers in Japan, compared to around 2.6m in the EU27.[2]

Following the change of government in December 2012[3] there have been a series of new initiatives towards the Japanese economy, as well as science, technology and innovation. The new Prime Minister, Shinzo Abe, launched an economic package comprising "three arrows" which will underpin efforts to strengthen the economy, under what is more informally known as "Abenomics" (Abe 2013). The first arrow is to tackle deflation through monetary easing and inflation targeting to 2%. The second arrow comprises a large supplementary budget. The third arrow comprises regulatory reforms and new strategies for growth. This third arrow was published in June 2013. Furthermore, a new comprehensive strategy for science and technology was also published in June 2013.

As a result of these first two "arrows", the Japanese yen, which had long been identified as handicapping many parts of Japanese industry which have a strong export orientation (OECD 2009), began to decline against other major currencies. This is seen as stimulating Japanese exports, thus having a positive effect on the Japanese stock exchange.[4] Levels of public support for the government, which are typically very low, have reversed (NHK 2013). The longer-term implications of these changes are as yet unclear but may make it easier for the government to implement reforms should they obtain a majority in upper house elections scheduled for summer 2013.

Both the supplementary budget and government activities towards STI have also undergone some changes. The Council for Science and Technology Policy (CSTP) the advisory body to the Prime Minister saw an influx of new members and has met more regularly than previously. The government is discussing a number of new initiatives towards science, technology and innovation that are still only in the

[1] 1 Euro = 133.26 Yen http://www.ecb.int/stats/exchange/eurofxref/html/index.en.html

[2] EUROSTAT, rd_p_persocc

[3] The result of the 16 December election was: Liberal Democratic Party 294 seats; Democratic Party of Japan 57 seats;

[4] This rose from around 9,000 to 14,000 between December 2012 and April 2013.

pipeline. Efforts to strengthen the CSTP have also been under discussion for some time and are likely to gain new momentum as they feature as part of the new comprehensive strategy where there is a section dedicated to reform of the body. On the budgetary front, the first supplementary budget unveiled by the new government saw increased allocations towards STI where around ¥1,019b yen (€7.7b) extra expenditures were allocated. This budget pushed up governmental expenditures above €35b for only the second time in recent history. The last such time was 2009 when a large supplementary budget was added following the financial crisis. On that occasion total expenditures were ¥5,046b Yen or €38.5b (Cabinet Office 2013).

Despite such large-scale expenditures by the government, it is industry that tends to dominate the Japanese research landscape, accounting for 75% of expenditures, at around €91.9b for 2009. By comparison, for the EU the share is around 50%[5], with the highest industrial expenditure found in Germany at around €49b. Amongst the high levels found in Japan, the manufacturing sector is particularly important, with only a smaller role given over to services, which are often viewed as an add-on to manufactured products (OECD 2011). Large firms are also a characteristic of the industrial R&D landscape accounting for most expenditure. Those that employ more than 10,000 people spent around 40% of total expenses as of 2011. This proportion is stable over the past decade. For other sized firms there is also stability in the proportions, but a slight decline in the proportion for the smallest sized firms (<299). Evidence appears to suggest that small scale or new firms may have only modest innovativeness (OECD 2012; Motohashi 2012: 18).The level of foreign industrial R&D expenditures in Japan is negligible, although efforts are now being implemented to attract new entrants.

The university sector, which accounts for 6% of R&D expenditures, comprises a large and diverse body of universities and graduate schools, both in the public and private sectors. The universities have been subject to large-scale changes over the past decade to increase autonomy, governance and management functions. Amongst the over 400 institutions, there are less than ten that feature prominently in international ranking exercises. These are typically the former imperial universities and a small number of other institutions. Although there is no formal grouping or recognition of the top performing universities, there is a de facto distinction, and an informal body of the best, which is based on the distribution of competitively, awarded grants and general prestige; there is increasing policy activity to further strengthen the best institutions.

There are around one hundred national laboratories that specialise in particular areas of research, both in applied and basic research fields. Similar to the universities, these institutions were granted autonomy from the government from the early part of the last decade. Many of these also perform very strongly in bibliometric assessments. There were discussions of reforming and merging some of the key institutions in this sector, but this policy appears to have dropped off the agenda since the change of government in December 2012.

Overall, Japan tends to perform reasonably well across most of the macro level assessments that exist, where it is generally among the top thirty or so countries. Over time performance on many if not all of these macro measures has tended to decline. For instance, in the *European Innovation Scoreboard*, Japan is seen to have a lead over the EU, although the EU is seen to be closing this lead over recent years

[5] Eurostat rd_e_fundgerd

(European Commission 2013:22). In the *Global Innovation Index*, Japan is a reasonably strong performer placed at 25th position. Again, performance on this index has been declining over recent years (Dutti 2012: xviii). For the *World Competitiveness Indicators*, Japan's performance has dropped from 22nd in 2008 to 27th in 2012 (IMD 2013). In specialist assessments, such as the *Global Entrepreneurship Monitor* (GEM), Japan is seen to have one of the lowest levels of performance (Xavier et al., 2012). The *Ease of Doing Business* survey from the World Bank places Japan at 24th for 2008-2012, dropping four places since 2003-7.

One of the clear weak points of the Japanese research and innovation system is the degree of internationalisation. This applies to participation in international projects, human mobility, and other factors. While there are numerous initiatives and programmes, as well as policy documents and papers that acknowledge the importance of internationalisation and international engagement the overall level of activity tends to be below that of other comparable countries. Within this overall limited level of internationalisation, where it does occur cooperation with European partners tends to be relatively strong. This can be witnessed through relatively high levels of researcher exchange over periods above three months. Joint publication trends with European partners also suggest that there have been positive upward trends. Participation in Framework programmes is still very limited but since ratification of the EU-Japan Science and Technology Agreement the number of jointly funded calls has gradually increased setting the basis for increased collaboration. Japan's participation remains small relative to the size of its research and innovation system.

### *Knowledge Triangle*

Interactions and flows between education, research and innovation are relatively weak. Efforts have been made over the past decade to enhance such flows with the introduction of a Japanese version of the Bayh-Dole act, efforts to support university ventures and incubation, as well as enhance mobility and exchange. The available data tends to suggest that these efforts have only been modestly successful. A sense of disappointment can be noted in various policy documents and new initiatives and efforts to strengthen interactions have been introduced over recent years, and have been taken up yet further in the Comprehensive Strategy for Science and Technology. Issues may be found on both sides: both by industry and university faculty.

| | **Recent policy changes** | **Assessment of strengths and weaknesses** |
|---|---|---|
| Research policy | • 2013 Action Plan<br>• Reform to the CSTP<br>• Comprehensive strategy for science and technology<br>• New members to the CSTP<br>• Strengthening research institutions<br>• New collaborative programmes with Asia<br>• Annual carry-over of funds between different fiscal years<br>• Smaller scale grants available through Grant in Aid system. | • Still uncertain direction for reform of the CSTP. The Comprehensive Strategy for Science and Technology will add greater clarity to this in due course.<br>• Improvements in the annual carry-over of budget allocations will eventually curtail wastage. This has been a long standing concern.<br>• Amongst the new members of the CSTP, industry members are mostly from established, large industries. There are no new entrepreneurs. Other members are also mostly senior and established.<br>• Efforts to strengthen research performance gaining increased traction. Need to embed the professional administrator system more deeply into institutional structures and ensure the |

| | | |
|---|---|---|
| | | sustainability of the career.<br>• The Comprehensive Strategy has added a layer of complexity to an otherwise straightforward system that would otherwise be dominated by the Basic Plan. |
| Innovation policy | • Revitalisation strategy published in summer 2013<br>• Increased carry-over possibilities for different grants<br>• Proposals for new method for national projects<br>• New industrial technology projects<br>• Centre of Innovation Project | • Poor record in implementing previous growth strategies. The comprehensive Strategy may reiterate many of previous objectives which have featured in previous plans.<br>• To increase the possibilities for expanding the flows between basic science and innovation there was a need to enhance the opportunities to carry over funding between different projects.<br>• New efforts to encourage universities to be centres of innovation and nurture innovation. There have been numerous initiatives over time that enjoyed only modest success. |
| Education policy | • Expanded number of overseas opportunities for researchers<br>• University Reform Action Plan<br>• New programmes to support university reform<br>• Efforts to strengthen university teaching<br>• Discussion of autumn calendar for university entry. | • Japan's universities perform relatively poorly across many international evaluations. The merits or seeking to chase such rankings can be questioned.<br>• Number of initiatives in place to strengthen university research and tuition. Given weak employment trends, these reforms may be necessary.<br>• Autumn entrance for universities may enhance international links, but it is likely that the changeover will have limited scope or implementation due to recruitment timetables, and school graduation times. |
| Other policies | • Three Arrows economic policy, including fiscal and monetary expansion combined with structural reform – "Abenomics programme"<br>• Inward Investment Policy<br>• Immigration policy reforms<br>• Entry into new bilateral and multilateral trade agreements. | • A bold policy agenda to rejuvenate the economy may stimulate new growth but may also be offset by population dynamics, failure to implement policy reforms, amidst increased public debt.<br>• Subsidies to support inward foreign direct investment may encourage new firms to enter Japan. These efforts may also be encouraged with the new impetus given to bilateral and multilateral trade agreements by the Japanese government. New points based system should make it easier for the highly skilled to enter Japan. Data suggest only limited take up however. |

***Main Challenges***

The main challenges for the national R&D system are coping with an aging and decreasing population with declining social and economic vitality; and a long downward trend in industrial competitiveness. Amidst this is the sustainability of public finances with debt repayment already accounting for around one-quarter of annual expenditures (Ministry of Finance 2013).

On the research and innovation front the main challenges are:

- Improving research and innovative performance more generally
- Strengthening the connections and opportunities for research results to lead to innovation in new products, industries, or services
- Nurturing new industrial sectors such as those identified in the health or energy sectors
- Expanding innovation into the services and other sectors beyond manufacturing
- Encouraging more small firms and entrants to reverse the birth-death ratio found amongst smaller companies
- Increasing the fluidity of interaction and movement between different actors and sectors in the innovation system
- Expanding flows and connections with other countries and regions
- Encouraging more inward investment, mobility, and ideas from overseas

The global challenges as they relate to Japan include increased competition for natural resources, energy and food; the economic rise of emerging nations, and the advance of economic globalization; as well as changes in the functioning and operation of innovation systems.

The 4th Science and Technology Basic Plan, the comprehensive strategy and the revitalisation strategy provide the major pointers on national policies and measures towards various objectives. They are too numerous to list individually but some of the general measures and orientations are presented in the box below.

**Assessment of the national policies/measures**

| | **Objectives** | **Main national policy changes over the last year** | **Assessment of strengths and weaknesses** |
|---|---|---|---|
| 1 | Labour market for researchers | - New points based system for highly skilled migrants<br>- Expanded numbers of fellowships for international mobility<br>- Greater diffusion of tenure track schemes | • Low levels of Mobility<br>• Limited opportunities for foreign researchers, but some changes<br>• Limited Female participation<br>• Aging Faculty base |
| 2 | Research infrastructures | • New emphasis on RIs following the new Comprehensive Strategy for Science and Technology | • Stronger emphasis on infrastructures is a welcome initiative.<br>• Efforts will be necessary to ensure ease of access and awareness.<br>• Linking research infrastructures with resilience and mitigation of |

| | Objectives | Main national policy changes over the last year | Assessment of strengths and weaknesses |
|---|---|---|---|
| | | | disasters fits with policy priorities.<br>• Care needs to be taken that the emphasis on regional or town revitalisation through research infrastructures does not lead to poorly located and obscure locations. |
| 3 | Strengthening research institutions | - New and expanded funds to support reform of research institutes<br>- New initiatives to increase the number of top ranked universities<br>- New efforts to improve administrative support<br>- Continuation of tenure track schemes | • Declining performance in most ranking exercises<br>• Declining performance in citation based rankings<br>• Efforts to improve institutional performance<br>• Lack of internationalisation<br>• Questionable tactic of getting a certain number of institutes into the top ranked lists. |
| 4 | Knowledge transfer | - New Centres of Innovation to be established over 2013<br>- Centre of Community programme to nurture stronger links between universities and local actors<br>- Expanded schemes to develop graduate programmes (programme for leading graduate schools) | • Disappointment with current levels of cooperation<br>• Expanded initiatives expected in the comprehensive strategy and revitalisation strategy. |
| 5 | International R&D cooperation with EU member states | - Joint calls over 2012 with the European Union; no calls expected over 2013.<br>- New BILAT programme to be established some time in 2013.<br>- EU-Japan Science and Technology Summit in 2013 | • Limited cooperation with the EU at programme and project levels<br>• Mostly limited to bilateral initiatives; less experience of multilateral, especially at the academic level<br>• Increased mobility flows to Europe for long-term stays.<br>• Increased funding to support mobility.<br>• Continued incremental expansion in institutional memorandums of understanding underlying cooperation and exchange. |
| 6 | International R&D cooperation with non-EU countries | • Fourth Basic Plan outlines expanded cooperation with Asian and other scientifically advanced countries | • Emphasis on expanded cooperation with Asia due to proximity and common issues of concern<br>• Little in the new comprehensive strategy towards international R&D cooperation |

# TABLE OF CONTENTS

# 1 INTRODUCTION

The main objective of the ERAWATCH International Analytical Country Reports 2012 is to characterize and assess the evolution of the national policy mixes of the 21 countries with which the EU has a Science and Technology Agreement. The reports focus on initiatives comparable to the ERA blocks (labor market for researchers; research infrastructures; strengthening research institutions; knowledge transfer; international cooperation). They include an analysis of national R&D investment targets, the efficiency and effectiveness of national policies and investments in R&D, the articulation between research, education and innovation as well as implementation and governance issues. Particular emphasis is given to international research cooperation in each country.

# 2 PERFORMANCE OF THE NATIONAL RESEARCH AND INNOVATION SYSTEM AND ASSESSMENT OF RECENT POLICY CHANGES

## 2.1 MAIN POLICY OBJECTIVES / PRIORITIES, SOCIAL AND GLOBAL CHALLENGES

The priorities outlined in the 4th Science and Technology Basic Plan (2011-2015) set out to address:

- The crisis that affected Japan and the direct and indirect damage caused by the Great East Japan Earthquake, including the Fukushima nuclear power station accident;
- Green Innovation
- Life Innovation
- Basic Research

This plan remains important for understanding the major policy issues in the period up to its cessation. The new government have also starting setting out a longer-term comprehensive strategy for science and technology for the period up to 2030. The finer points are still being developed at the time of writing. In the outline there are five main issues:

I. Clean & Economic Energy System

II. Health and Longevity

III. Advanced Infrastructures

IV. Economically Revitalised Regions

V. Recovery from the Great East Japan Earthquake

In part the new comprehensive strategy picks up where the Innovation 25 initiative left off. This was prompted under Abe's first term as Prime Minister between 2006- and 2007 but the implementation and follow-up to this plan was not complete due to various factors, such as the economic downturn, the change of administrations, and other factors. However, similar to the comprehensive plan, this also took a long-term perspective up to 2025. Many of the issues and topics covered in that plan look like they will now been co-opted into the comprehensive strategy (CSTP 2013).

Although the main priorities and challenges tend to stay the same, since the election of the new government of December 2012, there has been some re-ordering of the priorities for addressing key challenges. The challenges can be summarized as:

- *Economic Revitalisation: Overcoming Deflation and New Growth*

  The greatest challenge set out by the new government has been economic revitalisation and overcoming deflation. The new Prime Minister, Shinzo Abe has talked of "three arrows" to target economic growth. The first arrow is to tackle deflation through monetary easing and inflation targeting to 2%. The second arrow comprises a large supplementary budget; and the third arrow comprises regulatory reforms and new strategies for growth. This third arrow is the revitalisation strategy of which the outline points will be referred to throughout this report.

- *Responding to population change: Decline and Aging*

Japan's population declined by 259,000 between 2010 and 2011 to a total of 127,798,704 (MIC 2013). Over the longer term the population is projected to decrease to 86.74m by 2060 (IPSS 2012). Already, 23.3% of the population are over 65 years of age. By 2060 the proportion of elderly is expected to increase further, extrapolating to 39.9% by 2060 (MIC 2011).

This poses challenges in how budgets are transferred across different generations; healthcare treatment, costs and facilities; as well as the social infrastructure more generally. The types of responses seem to rest on utilising technologies to resolve the healthcare costs, increasing consumption taxes to pay for welfare and pension costs, coupled with some targeted, and limited, immigration policy changes, such as special qualifications for some types of healthcare workers and the recognition of certain professionals through a points based immigration system.

- *Increasing Participation: Realising the Potential of Women*

It has been recognised for some time that women are under-represented in many aspects of Japanese professional and working life.

Women are seen to face a number of obstacles in their careers, especially from their mid-30s when they tend to leave the labour force due to childbirth. From then on labour force participation tends to decrease dramatically in comparison to other countries. Furthermore, Japan has one of the lowest levels of women in managerial positions (Cabinet Office 2013b). Performance across international assessments tends to be amongst the lowest (WEF 2012). Amongst researchers, the proportion has increased slightly over recent years, but it continues to be lower than other advanced countries.

Recently, think-tank and other studies have suggested that increasing female labour market participation could have a positive impact on GDP as well as on Japanese business and corporate life more generally (see for instance, Keidanren 2012). In April 2013, the Prime Minister gave a speech whereby he pledged to increase the number of day care nurseries and provide longer maternity and paternity leave as part of efforts to increase female participation in the labour market. A study on the issue was also to be undertaken over 2013, but its status is now uncertain.

- *Expanding Employment Opportunities: Young People*

Unemployment amongst the 15-24 and 25-34 year old cohorts has been increasing since 2005, and there has been a marked shift towards irregular, short-term employment amongst these age groups more generally (Cabinet Office 2013b). A number of initiatives have been introduced to link these younger job-seekers with employers, particularly in the SME sector.

- *Science and Technology: Building Confidence after Fukushima*

Japan is undoubtedly a nation that places high importance on science, technology, innovation and engineering. However, recent surveys suggest that following the nuclear accident at the Fukushima reactor that trust in science and scientists has declined (MEXT 2012). Utilising science and technology results for the benefit of society and overcoming barriers to the understanding of science will be key issues going forward.

## 2.2 STRUCTURE OF THE NATIONAL RESEARCH AND INNOVATION SYSTEM AND ITS GOVERNANCE

### 2.2.1 Main actors and institutions in research governance

Japan is a large economically advanced country in Asia. As of 2011, the population is 127,512,000 (MIC 2012), accounting for around 8% for the total population of East Asia (United Nations 2011). Japan's economy is currently ranked as the third largest in the World with a nominal gross domestic product in purchasing power standard of €3,642b (2011). On a GDP per capita basis, for 2009 the level is €25,000, which is slightly higher than the EU27 (€23,600), but lower than that for the Euro zone area (€27,200). As of April 2012, the unemployment rate has remained relatively stable at 4.2% (MIC 2012). Deflation is a continued problem and in April 2013 was -0.7%. Inflation in the EU27 was 1.2% for the same period (Eurostat 2013).

Research and development (R&D) expenditure as of 2011 was €130.4b (¥17.38 trillion) (MIC 2011), or 3.67% of GDP. Government expenditure for fiscal year 2013, including local government expenditures and supplementary budgets is ¥5,152.1 (€39.5b)(Cabinet Office 2013). Despite such a large scale of expenditure, it is industry that dominates the research landscape, accounting for 75% of expenditures, at around €91.9b for 2009. By comparison, for the EU the share is around 50%[6], with the most industrial expenditure found in Germany at around €49bn. The manufacturing sector is particularly important in Japan, with only a smaller role given over to services, which are often viewed as an add-on to manufactured products (OECD 2011). Large firms are also a characteristic of the industrial R&D landscape, where those that employ more than 10,000 people spent around 40% of total expenses as of 2011. This proportion is stable over the past decade.

Across most measures, Japan tends to have low levels of internationalisation. In terms of internationally co-authored papers, around one-fifth is co-authored with an international partner (NISTEP 2013: 128). Most of these papers are in the fields of physics or environment/geoscience (NISTEP 2013: 129). By country, the USA is typically the main partner with 74,973 co-authored publications between 2000-2009; but the EU is closely behind (64,604) and the growth rate for joint Japan-EU publications is higher than that for joint Japan-US papers (4.9% versus 2.1%). Joint papers with Asian partners such as South Korea or China are still small (13,649 and 31,202 respectively), but are growing quickly (6.3%; 12.7%) (European Commission 2011: 291). Looking at mobility and exchanges, the overall trends may have edged up recently as government responded to concerns with increased funding to support overseas mobility. Japan's corporate R&D activities are shaped by its key technology markets, with most technological exports destined primarily to North America and Asia. By product sector these tend to be in the 'office, accounting and computing

6 EUROSTAT: rd_e_fundgerd

machinery' sector, and the 'radio, television and communication equipment' sector. There are no significant exports in aircraft or spacecraft (NISTEP 2013: 162). North America is also where most corporate R&D laboratories are located (NISTEP 2011). The 4th Science and Technology Basic Plan recognise the importance of opening up and developing new areas of cooperation with scientifically and technologically advanced countries. This concerns both general scientific collaboration, and extends to large scale projects or data infrastructures (Cabinet Office 2011: 28). In the Framework Programme, Japan as a third country is now seeing increased opportunities for participation following signature of the EU-Japan Science and Technology Agreement that came into effect in 2011. The number of jointly funded calls with the EU has expanded in a number of key areas, many of which address key challenges. Japan's policy instruments for international collaboration tend to remain at the bilateral level with only a small number of programmes that are multilateral.

Despite many reforms over the past two decades, there are still issues in the governance of science and technology, mostly relating to the coherence of design, the need to reduce overlap, and the degree of control or influence over other actors. There have also been issues surrounding the operating frameworks within which funding is distributed. The main actor for research governance is the Council for Science and Technology Policy (CSTP); an advisory body based within the Cabinet Office (see Figure 1). The membership of this body was replenished during 2013 to bring it up to capacity[7], but more substantial reforms can be expected in due course. The 4th Science and Technology Basic Plan seeks to give the body more comprehensive functions as a "watch tower", with increased coordination between ministries, more scientific advice, clearer communication, and more information aggregation and analysis. The Comprehensive Strategy talks of granting the body its own budget, the ability to set horizontal programmes that span different ministries, and greater responsibility for programme implementation.

The science and technology basic plans provide stability to policy expectations over five year periods, and although there have been frequent changes in political leadership and intense levels of party competition that can hinder legislative changes, there is a generally supportive consensus towards STI policy and its promotion. Some have suggested that this has taken on a new seriousness following the earthquake and related crisis from 2011 (Cyranoski 2013). The Comprehensive Strategy may add further stability to policy expectations due to its longer timescale up to 2030.

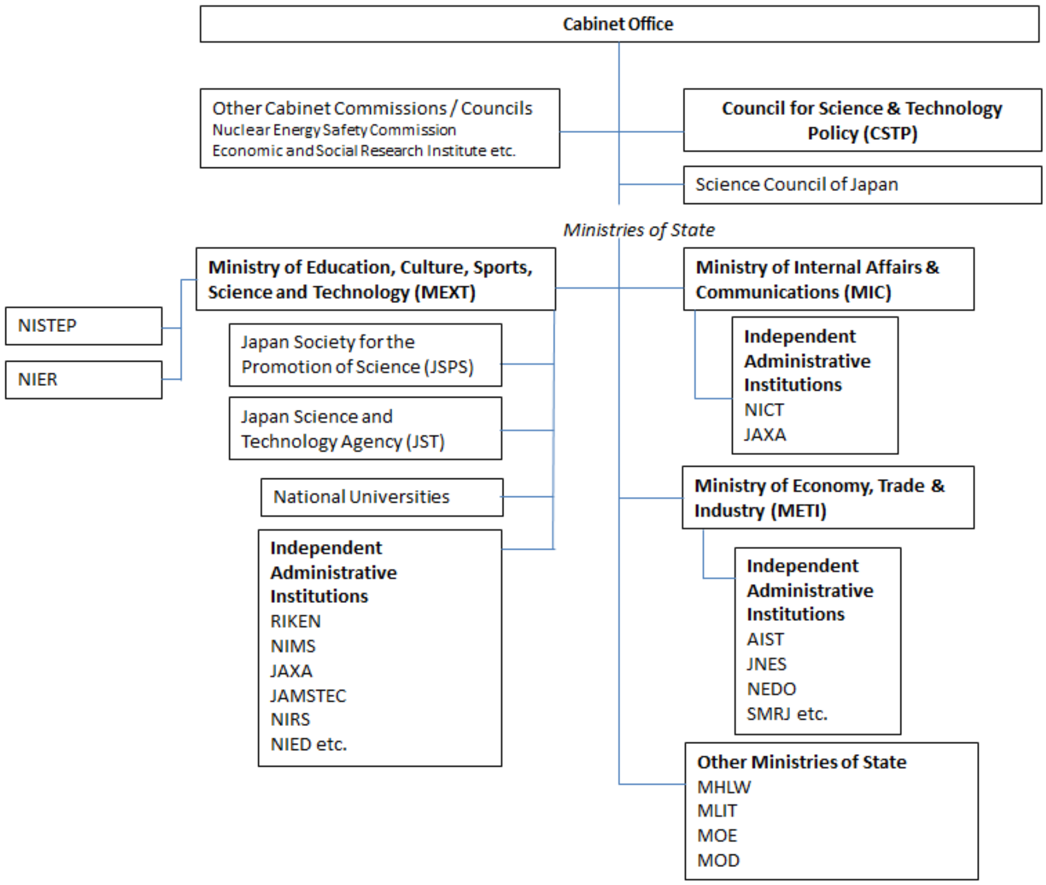
In terms of expenditures across the major ministries of state, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Ministry of Economy, Trade and Industry (METI) account for 64.8% and 14.3% of the main governmental budget.[8] MEXT provides most funding to the universities and some of the national laboratories, and provides support to basic science and technology policies. METI is mostly responsible for industrial competitiveness and industrial technologies, but also has a number of measures towards human resources particularly where training and transferable skills are concerned. The Ministry of Health, Labour and Welfare (MHLW) spends 4.6% of government R&D expenditures; the Ministry of Internal Affairs and Communications (MIC) 1.4% and has numerous

[7] Over 2012 the number of Executive members had declined to three members. The new members were appointed on 1 March 2013.

[8] Not including expenditures in supplementary budgets.

policies related to information and communications technologies (ICT); and the Ministry of Defense (4.7%) (Cabinet Office 2013). Key funding bodies are the Japan Society for the Promotion of Science (JSPS) (budget of around €3.1b (2011) (¥334.7b)), the Japan Science and Technology Agency (JST) (budget of around €1.0b (¥134b) (2013)), and the New Energy and Industrial Technology Development Organisation (NEDO) (budget of around €1.2b (2012).

**Figure 1: Simplified Overview of the Japan's research system governance structure**




Source: Adapted from Science Links Japan (2013).

### 2.2.2 The institutional role of regions in research governance

Japan is a unitary state comprising 47 prefectures. Although regional governance is seen as extremely limited (OECD 2011), there is informal recognition of eight regions.[9] The greater Tokyo region has the highest population density that is around 36.6m people or a third of the total population. This includes the cities of Tokyo (8.9m) and Yokohama (3.7m), as well as the surrounding areas of Chiba, Saitama, and Kanagawa (MIC 2012). The population density of these areas had been increasing dramatically from the 1980s, but started to decline from the latter half of

[9] These regions include: Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku, Shikoku and Kyushu.

the last decade (MLIT 2012). The second most populated region is the Kansai region (which comprises the cities of Osaka (2.6m), Kyoto (1.4m) and Kobe (1.5m)) and has a total population of 11.3m people. Third is Nagoya city (2.3m) and Aichi prefecture, lying between Tokyo and Osaka. Other prominent cities include Sapporo (1.9m) in the northern island of Hokkaido; and Fukuoka (1.4m) in the southern island, Kyushu.

Performance of science, technology and research tends to be aligned with population density: that is, found in the greater Tokyo area, Kansai area and Nagoya areas. This holds for the density of graduate students, the number of scientific papers, patents, and inventors (see NISTEP 2013: 172-185). There are also other regional clusters which have gained prominence for the strength of their research or manufacturing capabilities. These include the Kyoto and Kansai region for life science related research (see Ibata-Arens 2009); the Nagoya area for automobiles and engineering; the Tohoku and Ibaraki regions for research in materials sciences, with the Tsukuba Innovation Arena providing an example of joint initiatives in the nanotechnology field between local research institutions and industry[10]; green technologies are also beginning to gain recognition in the Kyushu area (see OECD 2013). Tokyo itself is where most headquarters for industry are located, with a concentration of universities and research laboratories. There have also been efforts to launch or build upon pre-existing clusters in Tokyo itself, such as that around the Akihabara “electric town” district (which also connects to Tsukuba via a new train link), and other initiatives.

There are additional efforts to support science and research in the Tohoku region of Japan following the earthquake and tsunami of 2011. MEXT in particular has a number of schemes targeted to that region (covered below in Section 3.4.2).

### 2.2.3 Main research performing groups

For 2009 the total expenditure on R&D was €121,357.4b.The overall distribution across the different sectors, and comparing against that for the EU27 in brackets, is as follows:

- Business Enterprise Sector: 78,2% (54.1% in the EU27)
- Government Sector: 15.6% (34.9%)
- Higher Education Sector: 5.1% (1.43%)
- Private Non-Profit Sector: 0.7% (1.6%)
- Abroad: 0.4% (8.4%)

Each sector is discussed at greater length in other places in this report.

[10] See the following website for background: http://tia-nano.jp/en/index.html.

## 2.3 RESOURCE MOBILISATION

### 2.3.1 Financial resource provision for research activities (national *and regional mechanisms)*

***Progress towards R&D Investment Targets***

In longer-term perspective, R&D expenditures have been gradually increasing over time, in a steady upward direction particularly since the 1960s. As a share of GDP the proportion stood at 3.19% in 2000, and rose throughout the decade peaking at 3.84% of GDP. Since then it declined to 3.67% of GDP (2011). In terms of actual expenditure, and in Euros in 2000 the total amount was €153.859b dropping to €121b in 2005 before declining again to a low of €110b in 2007. As of 2009, spending has recovered to €121,357.4b but is still below the 2000 level.[11] Japanese data sources for 2011 suggest that spending has increased further to around €130b (MIC 2012).

Since 2010 there has been a target of increasing the level of expenditure to 4% of GDP by 2020. [12] This was first mentioned in the *New Growth Strategy* decided by the Cabinet Office in June 2010. This would increase the proportion by the business enterprise sector to 3% and the governmental sector to 1% of GDP. The 4th Science and Technology Basic Plan also included this provision (Cabinet Office 2011: 48).

Business efforts towards this expenditure target are discussed in Section 2.3.3. For the government sector there may be difficulties in attaining the 1% target. The overall share has tended to increase slightly over recent years, from 0.27% to 0.31% between 2007 and 2009. However, since 2002 the level as a proportion is flat (0.3% in 2002). In terms of real expenditures, the level has actually declined in the longer term from €12,563.197m in 2002, to €11,182.584m in 2009. Within the science and technology basic plans, the objective has been to spend €250b (¥25 trillion) over the course of each five year period. Under previous plans, however, expenditure targets have mostly not been met. Under the 1st Plan, the government exceeded its expenditure target (spending 17.6 trillion yen against the target of 17 trillion); under the 2nd and 3rd plans it only attained around 86% of its specified targets[13]. Since the implementation of the 4th Basic Plan in 2011 the past two total budgets have been ¥4,695b for fiscal year 2011, and ¥5,152b for fiscal year 2012 (Cabinet Office 2013). If the government is able to maintain expenditures above €35b then it will be on course to reach the target set in the plan. This will still be some way below the 1% of GDP target however, depending of course upon how GDP itself fluctuates over time.

The factors that will shape these expenditure targets are the ability to exploit new sources of R&D from industry (discussed in Section 2.3 below), as well as the ability of government to either raise new sources of income[14], or redirect expenditure away from other areas. This will be difficult given that most current expenditures are financed via bond issuance. Tax has only paid for around 45% of expenditures over recent years.

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[11] Some degree of caution is necessary as Japanese data shows slight increases in overall expenditures: from 162,893b yen in 2000 to 171,099b yen in 2010 (MEXT 2012: 106)

[12] A similar trend can be observed in yen (see MEXT 2012: 106)

[13] Under the 2nd Plan the target was 24 trillion yen, but actual expenditure was 21.1 trillion. Under the 3rd Plan the target was to spend 25 trillion yen. Actual expenditure was 21.7 trillion (CSTP 2012: 6)

[14] The government is set to increase the consumption tax to 8% in 2014, and 10% by 2015.

As of 2013, the total value of outstanding bonds is 750 trillion yen (around €6 trillion) and over 200% of GDP. Debt servicing as expenditure has increased to 24% for 2013, and is likely to double by 2020 (OECD 2013: 111). There are also significant other spending requirements, with social security increasing from just below 20% of expenditures to more than 30% between 2000 and 2013. This is placing pressures on other areas of expenditure (see MoF 2013) suggesting overall that there may be limited scope to redirect financing from other areas.

### 2.3.2 Providing qualified human resources

Since the passage of the Science and Technology Basic Law in 1995, there have been four science and technology basic plans that have implemented the provisions within the Law.[15] The 4th Basic Plan was introduced in 2011, and will run until the end of fiscal year 2015 (March 2016).[16] While the 1st plan was more concerned with strengthening basic research, the 2nd and 3rd plans prioritized four primary fields (life sciences, information technologies, nanotechnologies/materials, and the environment) and four secondary priority fields (energy, manufacturing technologies, social infrastructure, and frontier sciences). For the budget distribution of these research areas, on an annual basis around 46% has been towards basic research and human resource programmes; 8% to the life sciences; 13% to energy; 2% to nanotechnology; 3.4% to the environment; and 3.3% to information and communications technologies (Cabinet Office 2013). The prioritisation has thus been for around 50% of funds with the remainder bottom-up and basic oriented research programmes and support.

For the 4th Plan emphasis came to be placed on using science, technology and research to address societal challenges. This change reflected concern both over the issues facing Japan, and the need to strengthen how investments in science and technology diffuse towards innovative development (see CSTP 2010). Although there have thus been some changes in the priorities for government funding, the funding situation has itself been extremely stable. There has been no real growth in the main government budget over time, and it has tended to be through the use of supplementary budgets that extra financing for R&D has been allocated. This is particularly the case following the economic downturn from 2008, where the 2009 supplementary budget added €8.4b to the total amount. The change of government in December 2012 witnessed a second large supplementary budget of €7.8b (Cabinet Office 2013; for information on the supplementary budget see Ministry of Finance 2013).

The main funding instruments are institutional grants for the national and public universities. These account for around 50% of university income and are in the region of €8.45b (2013) (1,127b yen) (MEXT 2013). Competitively awarded research grants have increased considerably over the past two decades, rising from 800m (824oku) in 1994 to €2.5b (256.6b yen). The main programme for the distribution of these programmes is the Grants-in-Aid programme operated by MEXT and the Japan Society for the Promotion of Science (JSPS). These are bottom-up grants evaluated

[15] The First Basic Plan was from1996-2000; Second Basic Plan: 2001-2005; Third Basic Plan: 2006-10,

[16] The first three reports are available in English at the Cabinet Office homepage. An overview of the 4th Basic Plan is available in English from MEXT (see MEXT 2012b).

through peer review and allocated on a competitive basis. Between 2011 and 2012 the budget declined -2.5% (MEXT 2012b). The JSPS and JST also provide a range of other competitively allocated schemes through their budgets.

Subsidies are in place to support R&D, but for the business enterprise sector these are of minimal importance. In fact, government supported business R&D is one of the lowest in the OECD. In 2009, 1.17% of BERD was financed by government. This has changed little over time (in 1999 the proportion was 1.76% (OECD 2011a)). Nonetheless, there are numerous collaborative initiatives supported by the ministries of state and via the New Energy and Industrial Technology Development Organisation (NEDO). NEDO supports projects and demonstrations that companies would find difficult to finance by themselves but which may be close to practical application (NEDO 2011). These projects include stakeholders from different sectors, such as industry, academia and other organisations.

Tax incentives exist to support R&D activities. According to the OECD indirect support through R&D tax incentives tend to outweigh direct funding of BERD. For data from 2008, 0.02% of BERD (as a per cent of GDP) is through direct funding; 0.06% is from indirect measures such as tax incentives (OECD 2011). Overall, Japan is towards the lower end of the scale in how government supports business investments in R&D (OECD 2011).

METI have introduced the Subsidy Programme for Project Promoting Asian Site Location in Japan, comprising a mixture of tax exemptions and reductions, as well as some easing of requirements for entrant firms. This is budgeted at €4m and has seen support given to a number of inward investing firms (see METI 2013a).

### Recent Policy Changes Affecting Research Funding

The Ministry of Finance suggest that there are a number of changes affecting research funding for fiscal year 2013. It should be noted that the Comprehensive Strategy and Revitalisation Strategy are likely to add further reforms and proposals above and beyond the following. For 2012-13, the reforms proposed thus far include:

- Programmes to support the strengthening of research institutes

  This includes provision of support to specialist human resources, in the form of university research administrators, who will be placed at research institutes and universities and undertake evaluations and outline areas where performance can be improved. There are a range of complementary programmes being introduced to provide funding to particularly Japan’s top institutions as efforts are made to improve international prominence and research performance.

- Expansion of long term funding schemes

  There had been calls from the research community to provide longer-term stability to research programmes. For instance, Shinya Yamanaka, the 2012 Nobel laureate in medicine gave a presentation to the Cabinet noting the uncertainties in the funding environment. Particularly in the iPS field funding will be provided for 10 years. Under CREST schemes there will also be new opportunities for extension.

- Reform to the requirements of research grants

It has long been noted that the inability to carry over budgets between different fiscal years leads to a waste of resources. Reforms have been introduced now to enable the possibility of carryover.

### Building Mutual Trust between Science and Society

All of the Science and Technology Basic Plans implemented so far have featured provisions for the social understanding and mutual trust between science and society. The 1st Plan (1996-2000) included provisions to encourage university professors to give ta ks at schools; create and enrich museums of science and technology as well as broader activities to disseminate and provide information on science and technology (see CSTP 1996: 41-44).The 2nd Plan followed this by outlining measures for promoting learning of science and technology in society, as well the communication channels (Government of Japan 2001:40).The 3rd Plan outlined measures for resolving ethical issues, accountability and the improvement of information provision, increasing public awareness and measures to stimulate participation of the public in science and technology (Government of Japan 2006:60-2). Some prominent examples include the support of science museums, the museum of emerging science and innovation, and provision of support for web related contents regarding science and technology. Efforts have also been outlined to strengthen interest in science amongst children through the super science teacher programme, science partnership project between schools and researchers and scientists.

In the 4th Basic Plan, efforts to strengthen public perceptions of science are grounded in the experiences of the earthquake, tsunami and nuclear crisis. Japan's risk and crisis management is acknowledged to have been deficient, increasing distrust and uncertainty towards science and necessitating the need for new cooperation and openness in how scientific issues are related. To strengthen the relationship between science and society, the plan proposes to encourage public participation in policy planning and promotion, address ethical, legal and social issues, develop human resources to link STI policy with society; as well as promote communication activities (Cabinet Office 2011: 40-42).

Trust in science has declined following the series of events from March 2011. According to the White Paper on Science and Technology by MEXT (2012), for pre-crisis and post-crisis periods the number of people who report that they can trust science has declined from 59.1% to 19.5% (2012: 44).

### *Main Societal Challenges*

Governmental Budgetary Appropriations on R&D (GBAORD) as reported to EUROSTAT are €32,815m for 2011 rising to €35,803.61m for 2012. Of this, 97.1% of this is towards civilian R&D, with 2.7% towards defence. For the civilian oriented component, general advancement of knowledge through general university funds accounts for 36.8% of GBAORD. Other important areas include energy 11.5%, industrial production and technology (6.4%), exploration and exploitation of space 6.6%, transport, and telecommunications and other infrastructures 2.9%, health 4.7%, and agriculture 2.9% (EUROSTAT 2012).

Although these clearly relate to the major societal challenges as discussed above, in terms of the distribution according the 2013 Action Plan, from the total governmental expenditure on R&D of €36.8b (3,669.5m yen) for 2013, the Action Plan component is €2b (2,625b yen) for the main and supplementary budget, the prioritized project package accounts for €1.7b (2,195b yen), Within the Action Plan component, there are 36 projects which are oriented to revival and regeneration €344m; 57 projects in the green innovation field (€1.3b); 30 projects in the life innovation field (€391m). Within the prioritized project package (€220m) which comprise the bottom-up requests from ministries, there are projects on strengthening industrial competitiveness and quality of life initiatives. This package funding has more than doubled on 2012.

#### Providing qualified human resources

As of 2011, there are roughly 660,000 researchers in Japan (or using headcount data, 890,000) (NISTEP 2013: 63). The distribution amongst the different actors is as follows, with the EU27 comparison in brackets:

- 74.9% of researchers are in the business enterprise sector (45.1% for the EU27)
- 19% are in universities and colleges (41.1%)
- 4.9% in public organisations (12.5%)
- 1.2% in non-profit institutions (1.3%)

On a Headcount (HC) basis, there has been a slight gradual increase in the number of researchers over time, from around 670,000 to 730,000 between 1996 and 2001. For the Full time equivalent (FTE) the trend is gently upward over the past decade from 792,000 to 894,000 between 2002 and 2011. On a per-capita basis Japan tends to perform well, both on HC and FTE measures on the number of researchers per 10,000. For 2010, it is 69.4 researchers per 10,000; this compares against 31.3 for the EU27.

Looking then at the different sectors, the following observations can be made.

For the business enterprise sector, the number of researchers has been increasing both on HC and FTE metrics. For FTE the number has increased from 430,688 in 2002 to just over 490,000 in 2011. Nearly 90% of all researchers in industry are working in the manufacturing sector. This includes the telecom device sector (around 90,000 researchers (20%)) and the transport related sector (around 70,000 researchers (15%). There are only a small number (60,000) of researchers in non-manufacturing industries such as scientific research services or other professional and technological services. This is quite different from the USA (see NISTEP 2012). Employment of doctoral graduates is minimal in industry, at around 4.2% of the number of researchers; the level has been fairly flat over the past decade increasing from 16,000 to 22,000 between 2002 and 2011.

For the other main stakeholders, in the university sector there is a downward trend in FTE (from 135,000 to 124,000 between 2002 and 2011), but an increase in HC (from 281,000 to 312,000 over the same period). Amongst such faculty, in-breeding is tending to decline. In 2010, the number of faculty working at universities they graduated from stood at 32% but has been decreasing overall from just over 40% in

1980 (NISTEP 2013: 92). One issue that is increasingly being recognised is the aging of faculty. The number of faculty over 60 years old has gradually crept up since the mid-1980s, where they now account for around 20% of faculty. At the same time, the proportion of younger faculty in the 25-39 age bracket has tended to decline (NISTEP 2013: 93; Fuyuno 2012).

For the public research sector, HC and FTE are flat over the 2002 to 2011 period at around 35,000 researchers. The private, non-profit sector also shows declines both across FTE and HC counts.

There are two further points worthy of mention regarding researchers.

Firstly, women are poorly represented in the Japanese research landscape, accounting for only 13.8% of researchers in 2011. There is an upward trend in the ratio overall, increasing from 8.2% in 1992 but it is still lower than for many other countries (see NISTEP 2012: 63). The employment ratio for women is lowest in the business enterprise sector (<10%) and highest in universities and colleges. The comprehensive strategy aims to increase the proportion of women to 30% by 2016 (Cabinet Office 2013a: 44). As noted above, raising female participation in the labour force more generally has also featured as a speech by the Prime Minister in April 2013).

Secondly, the number of foreign researchers is also a small component of the labour force, at around 3.9%. Numerous policy papers have talked of Japan being an attractive location for foreign researchers for a number of years. However, progress has been modest. This may now be changing with reforms introduced to immigration policy and the introduction of a point system intended to make it easier for professionals and other skilled people to move to Japan. Applications under this scheme began in May 2012, with foreign nationals classified into three categories: academic research activities; advanced specialized/technical activities; business management activities (see Immigration Bureau of Japan 2012). The comprehensive strategy for science and technology talks of expanding the proportion to 20% by 2020 and 30% by 2030 (Cabinet Office 2013a: 44).

### *Articulation of Education Policies within the Knowledge Triangle*

Although there is no concept of the “knowledge triangle” employed in Japan, there are a number of initiatives to enhance the educational curricula at tertiary levels, and enhance vocational training.

Programmes towards entrepreneurship training and curricula are promoted chiefly by METI which has a number of programmes in this area. In their 2013 budgetary statement they include a fund to support internships amongst science and engineering doctoral students (METI 2013). Universities also have their own schemes, with 250 universities implementing courses that seek to nurture entrepreneurship. Such programmes include internships, business plan contests, and visiting lectures by businesspeople (METI 2009).

For many young people there has been a growth in non-regular employment and labour market dualism (OECD 2011) over recent years. There are now significant concerns about employment prospects for many graduates, compounded by concerns over the suitability of educational provision from universities. In a survey referred to by the OECD economic survey of Japan, nearly half of Japanese university graduates report that they make little use of knowledge gained in school, more than double that for European graduates (OECD 2011:133). For 2013 MEXT have introduced a number of programmes to enhance university education and research.

The *New Growth Strategy* aimed to create full employment for science and technology doctoral graduates. For a number of years there has been concern about post-doctoral employment with statistics suggesting low rates of employment. There is now some recognition that the timing of the survey instrument to assess this situation may explain some of the low employment levels due to the varied entry timescales of doctoral candidates (NISTEP 2012). Nonetheless, a number of schemes both at the national and institutional levels have been introduced to enhance doctoral training to broaden career opportunities beyond graduation. MEXT introduced a university reform action plan to strengthen engagement with the local community, increase globalisation, and enhance research strengths through governance reforms and more accreditation in 2012 (MEXT 2012).

### 2.3.3 Evolution towards the national R&D&I targets

***Evolution of Business Enterprise Expenditure on Research and Development***

BERD, which is the main component of R&D expenditure in Japan, declined in the post economic crisis (2008 onwards) period. It has since started to recover. The overall sectoral composition has not changed, nor has the proportion given over to the type of research. Surveys do suggest, however, that there is an increasingly short term focus towards R&D.

BERD as a proportion of GERD has increased from around 65% in the mid-1980s to 78.2% in 2008. This compares against 54.1% for the EU27 in 2009 (Eurostat 2012c). As a proportion of GDP this was 2.7% in 2008, in comparison to 1.23% in 2010 for the EU27 (Eurostat 2012). As Eurostat data does not yet cover the post-economic crisis period from 2008, it is worthwhile observing national statistical data to ascertain how BERD has evolved in the subsequent period.

According to MIC data, and as noted above in Section 2.3.1, GERD has declined from 3.84% of GDP (2008) to 3.57% of GDP (2010), for BERD the overall level has declined from €154b in 2008 to €138b (MIC 2012: 5). Many top firms in automobiles, IT and pharmaceuticals sectors decreased their R&D expenditure. For example, Takeda Pharmaceutical (-34.6%), NEC (-20.4%), Toyota (-19.8%), Honda (-17.7%), Nissan (-15.4%) (European Commission 2011). However, the 2012 Industrial R&D Scoreboard which suggests overall that industrial expenditures rebound after 2009, observes that that for Japanese companies the large reductions in expenditure in 2010 recovered and moved into positive territory in 2011, from -10% to around 5%. Toyota is still classed as the company with the largest expenditures on R&D at nearly €8b. Panasonic and Honda also spend considerable amounts on R&D at around €5b (European Commission 2012). In all, an estimate based on the Scoreboard data suggests that the top 12 companies in Japan account for around one third of total BERD. It is also noticeable that these top 12 companies have a lot lower profitability than counterparts from Germany, France, the UK or the USA[17]; perhaps explained by the high numbers of employees found in Japanese companies.[18]

In terms of progress to the 3% of GDP target expressed in the Fourth Science and Technology Basic Plan, there will be some challenges in meeting this objective. The proportion of expenditure by industry increased up to 2008, but then declined. It rose as a percentage of GDP from 2.32% to 2.72% between 2002 and 2008 but in 2009 it dropped to 2.54%. However, in terms of actual expenditure, since 2000 there has actually been a decline in expenditures. In 2000 the overall level was €109b, which then bottomed at €85b in 2007 from whence it began to increase, hitting €91,942.949m in 2009. It is thus back at and now exceeding pre-crisis levels but is still below the level of 2000. The percentage of GDP does not adequately reflect these changes and the overall long term decline may be difficult to reverse.[19] These points are also addressed, as well as possible countermeasures, further below.

Government funded business R&D continues to play only a small role. In 1995, 98.2% of BERD was financed by industry; by 2007 the proportion was 98.5%. In terms of the sectoral composition of R&D expenditure, around 90% of this is from the manufacturing sectors, with the automobile, information and communications industries, and medical device industries accounting for the largest share. In comparison to five years earlier, the proportion performed by this broadly defined manufacturing sector has not changed (MIC 2005: a201). Just over 60% of expenditures are directed towards developmental activities, 14.7% to basic research, and 23.1% to applied research. This ratio also changed little over the course of the 2000s. What has been noted however is that around 40% of all Japanese companies have reoriented some of their R&D activities towards short term objectives; this is particularly in the electronics sector where 55% of companies have now increased their focus on short term challenges (METI 2012).

For other sized firms there is also stability in the proportions, but a slight decline in the proportion for the smallest sized firms (<299). Evidence appears to suggest that small scale or new firms may have only modest innovativeness (OECD 2012; Motohashi 2012: 18). These trends might be in contrast to those observed in the US innovation system where smaller scale specialist firms are playing an increasingly important role in the innovation system (Mowery 2009).

### *Policy Mixes towards Increased Private R&D Investment*

*Route 1. Stimulating greater R&D investment in R&D performing firms*

In Japan the business enterprise sector already apportions more than 2% of GDP to R&D, but the overall rates of expenditure are relatively stable over time, and not expanding sufficiently to meet expenditure targets. Amongst small scale firms R&D expenditures appear to be decreasing.

As noted in this report last year, stimulating greater R&D from R&D performing firms will come from increasing investments by new firm growth, attracting greater levels of

[17] The average profitability is 5.2% for the top 12 Japanese companies. It is 21.6% for USA companies, 15.2% for UK companies, 10.4% for French companies, and 12.6% for German companies (simple calculation derived from the data sheet accompanying the study).

[18] The average number of employees for the top 12 companies is 204,000. It is 166k in Germany, 104k in France, 104k in the UK and 145k in the USA (derived from the data sheet accompanying the study).

[19] A similar situation was mentioned by John Marburger III regarding expenditure patterns towards basic research in the United States (AAAS 2004).

inward investment to Japan, or motivating new expenditures amongst existing firms.

Possible policy routes would include lowering corporate tax rates. The issues surround the ability of the Japanese government to enhance the incentives in Japan through lowering corporate tax rates or enhancing other tax incentives (METI 2010). On this latter point, surveys already suggest that there is limited awareness of current R&D tax incentives which are poorly utilised, and not well known (NISTEP 2011).

*Route 2: Promoting the establishment of new indigenous R&D performing firms*

The stimulation of new indigenous R&D performing firms has been a priority since the mid-1990s, when various venture start-up funds and support schemes began to be put in place. These were accompanied by other measures such as the Small Business and Innovation Research (SBIR) scheme. More recently, in an attempt to link research projects with firm and product development the A-Seed scheme has been put in place by the Japan Science and Technology Agency (JST) to provide the opportunity for seamless support between different stages of the research and product development stages.

The rate of new firm entry has tended to be below exit levels over the past two decades, meaning that the closure of new industries has been more common than their establishment. At the sectoral level, entry of new firms in ICT or medical, health and welfare is apparent and similar to the US case, but the number of exits still exceeds entries (JSBRI 2012: 180). Given this long-standing trend, it may be difficult for breakthroughs in new firm establishment. Despite this, VC firms have begun to be launched again following the economic crisis from 2008 and are strongly focused on the ICT sector (JVR 2012a); the number of Initial public offerings has also began to recover with 22 Japanese VC backed firms making IPOs in 2011 (JVR 2012b). Between 2009 and 2010 the number of new ventures dropped from 74 to 47. In total, 2,074 ventures from universities have now been established (MEXT 2012: 16).

The Global Entrepreneurship Monitor studies have regularly suggested that there is a high fear of failure in Japan, and a relatively low status accorded to entrepreneurs (Kelley et al. 2012: 8). OECD data suggests that there are very low levels of financing for venture companies, which is one of the lowest levels in the OECD (OECD 2012).

*Route 3: Stimulating firms that do not perform R&D yet*

Various policies are seeking to stimulate the agriculture, fisheries and forestry industries, as well as the health care industries. The “other non-manufacturing sectors” as well as the service sectors tend to only have low levels of R&D expenditures. The need to shift beyond the manufacturing sector is therefore essential. Overall expenditures in these non-manufacturing sectors tend to be stagnant over the past decade (NISTEP 2013: 40).

The Revitilisation Strategy aims to speed up the restructuring of industries, promote greater use of information technology, and strengthen SMEs through innovation, accompanied by strategic market creation plans that cover health and energy. To propel these changes there will be a number of structural reforms to employment and labour regulations, greater use of big data and other IT related measures. There will also be new funds for the cross ministerial R&D projects to develop innovation and new markets in these areas (Cabinet Office 2013a).

*Route 4: Attracting R&D-performing firms from abroad*

As noted above, the proportion of R&D from abroad is very low accounting for around 0.4% of gross expenditure on R&D (Eurostat 2013). To put this in perspective, in Europe 8.9% of such expenditures derived from overseas in 2010, and were as high as 40% in countries such as Bulgaria or 28% in Lithuania. In Austria, Germany, Sweden or the UK it is 15.9%, 3.9%, 10.9% and 17% respectively (Eurostat 2013). There is thus certainly scope to increase the level of R&D undertaken by foreign firms in Japan.

Seeking such firms has indeed already become a priority. The Invest Japan office in Cabinet Office is now aiming to increase FDI to Japan with the target of attracting €350b (35 trillion yen) by 2020, with five year exemptions of corporate taxation (Cabinet Office 2012) and new subsidy programmes in place to try to attract firms (see Section .

*Route 5: Increasing extramural R&D carried out in cooperation with the public sector*

Although the proportion of extramural R&D has tended to increase, the levels of interaction are seen to be comparatively low. The OECD suggest that industry financed public R&D expenditures are at the lower end of the OECD average. The overall level as a proportion is flat over the past decade, at 2.5% (OECD 2011).

As shown in Section 2.6.1 below the number of collaborative relationships between industries and universities and public research institutes have increased consistently since the late 1990s, but there are still noted gaps in the flows between the sectors and a need to strengthen interactions (Cabinet Office 2013b).

*Route 6: Increasing R&D in the public sector*

Funding to support R&D in the public sector is stable and relatively secure, added to via supplementary budgets as discussed in Section 2.3.1.

***Ease of Access to Public Funding***

There are a broad range of public support programmes for innovation both by ministries and NEDO. These programmes are clearly signposted, and advertised through the relevant call announcement channels. Application guidelines are clear and explanatory, with most applications managed online through the E-Rad system for individuals and institutions.

## 2.4 KNOWLEDGE DEMAND

***Business Driven Knowledge Demand***

Business driven knowledge demand is characterised by relative stability in terms of the main actors, but an increasingly recognised role of Japanese companies in specialised componentry that are a key part of global value chains. The structure of demand is shaped by highly autarkic innovative activities within the firm that may lead to duplication of effort, with limited use of open innovation principles.

The R&D active sectors in Japan have been largely quite stable over time, dominated by the automobile sector (17.7% of BERD), the information and communications devices sector (14.4%) the medical device sector (10.6%) and the electronic device sector (8.3%) which account for just over half total business enterprise expenditures (MIC 2012a). These sectors tend to be dominated by large firms. For instance, 78%

of the expenditure by the transportation sector is by those companies with over 10,000 employees. The proportion in the electronic device sector is lower at 43%, and the proportion for medical device sector is 70%. According to MIC data for each of these major sectors, funds received are less than 5% (MIC 2012: Table 2).

Despite the dominance of these industrial sectors it also becoming increasingly recognised that there are unique sectors of the Japanese industrial structure which play an important role in global technological componentry and materials markets. According to analysis by Shaede (2011) many of these companies have relatively high levels of profitability, operate in specialist fields, but are largely unknown and not active in consumer good production but instead business-to-business intermediate products in the global value chain (see also de Backer and Yamano 2012).

Robert Kneller has described the manner in which many Japanese companies tend to perform their R&D, which is described as autarkic, undertaking their own research and seeking to control over as much of the value chain as possible (2007). Although there are increased linkages on an intertemporal basis between industries and other organisations (Motohashi 2008), surveys also suggest that many companies are reluctant to employ the principles of open innovation. Companies that responded to a survey by METI expressed a preference for developing technologies within their company (METI 2011: 94) and levels of collaboration with organisations tend to be lower than in other countries (METI 2012: 11). Collaboration with international partners is likewise very low (METI 2012: 34). This self-sufficiency in R&D has led to fears that there are inefficiencies in R&D investments with duplication and replication of effort (METI 2012: 10-11). Others have suggested that the lack of international participation and perspective may further undermine the strategic orientation of technological exploitation, leading to a focus on the domestic market (Fasol 2012).

Where external technologies are to be brought in, then merger or acquisition is one option that is most likely to be considered, especially if the firm is within the same sector (METI 2011: 98). Merger and acquisition (M&A) activity by Japanese companies has been increasing to acquire or develop new technologies or access new markets (NISTEP 2011: 121). The appreciation of the yen following the economic crisis in 2008 may have also prompted such transactions. The volume of M&A has increased to around 9% of all cross border transactions, an increase from 2-3% throughout the past decade (Pilling 2012). Aside from such benefits, the appreciation of the Yen (World Bank 2012) has also posed risks to the structure of knowledge demand. At the height of the yen’s appreciation against other currencies, many companies reported that they are considering the opportunities for undertaking R&D as well as other activities in overseas markets, thereby ultimately hollowing out the domestic industrial base (METI 2012: 12).

The 4$^{th}$ Basic Plan talks of enhancing networks between industry and universities, developing centres for open innovation, building of regional innovation systems, and utilizing regulations and institutions to promote innovation. As noted above he comprehensive strategy and the revitalisation strategy both aim to improve the linkages between universities and industries.

## 2.5 KNOWLEDGE PRODUCTION

### 2.5.1 Quality and excellence of knowledge production

Undoubtedly there are some areas of excellence in the Japanese research system. There are also, however, many weaknesses. Against other countries most data is suggestive of a relative decline of performance over time. Many new efforts are being introduced to reverse these trends.

According to a macro assessment by the OECD, Japan is at the lower end of OECD performance for the number of top 500 universities per GDP and for the number of publications in top-quartile journals (OECD 2012). Other macro assessments paint a picture of relatively strong performance, but there is some disquiet over the direction of some of the indicators.

For instance, in the *European Innovation Scoreboard*, Japan is seen to have a lead over the EU, although the EU is seen to be closing this lead over recent years (European Commission 2013:22). In the *Global Innovation Index*, Japan is a reasonably strong performer placed at 25$^{th}$ position. Again, performance on this index has been declining over recent years (Dutta 2012: xviii). For the *World Competitiveness Indicators*, Japan's performance has dropped from 22$^{nd}$ in 2008 to 27$^{th}$ in 2012 (IMD 2013). In specialist assessments, such as the *Global Entrepreneurship Monitor* (GEM), Japan is seen to have one of the lowest levels of performance (Xaxier et al. 2012). The *Ease of Doing Business* survey from the World Bank places Japan at 24$^{th}$ for 2008-2012, dropping four places since 2003-7 (World Bank 2012).

Japan is major producer of publications, but it has ceded its high position to other countries over recent years. During the 1988-1990 period Japan was third in the world with the production of 42,566 whole count papers (Japan was fourth for top 10% highly cited papers for this period (3,548 papers; behind the US, UK and Germany). Over time, Japan's position has declined. For the 2008-2010 period Japan was fifth with 70,576 whole papers (behind the US, China, UK, and Germany). For top 10% highly cited papers for the same period, Japan was seventh (5,051 papers; behind the US, UK, Germany, China, France, and Canada) (see NISTEP 2012: 123). Japan's papers are mostly in basic life sciences (around 27%), clinical medicine around 25%), chemistry (around 15%) and physics (NISTEP 2012: 126). Japan's share of citations in key areas of science and technology research have tended to decline across two time periods (2000-4; 2005-9) more significantly than those of the USA according to National Science Indicators data. This is particularly so in physics, materials and chemicals (see METI 2012: 21).

### 2.5.2 Policy aiming at improving the quality and excellence of knowledge production

Policies aimed at improving the quality and excellence of knowledge production is gaining increasing traction. Concerns over declining shares of top 10% citations, as well as performance on ranking exercises is prompting a number of new initiatives. In particular the Comprehensive Strategy includes a number of new policies in this area.

In the 2013 budgetary statement by MEXT, there are number of schemes which aim to increase research institute performance. The specific details, however, are not available at the time of writing (MEXT 2013).

International benchmarking is undertaken by NISTEP through their Science and Technology Indicators (2012) published bi-annually. These provide a comprehensive assessment of both inputs and outputs of Japanese performance against key comparator countries, which typically includes the US, European countries such as the UK, France and Germany, as well as China and Korea. Indeed, NISTEP undertake a number of studies and assessments that are used and referred to throughout government policy documentation. These include assessments of corporate R&D trends (NISTEP 2011), human resources, scientific performance, and other topics

The monitoring of projects is undertaken by the CSTP through the e-Rad system. This is not primarily concerned with the monitoring of excellence. Instead it is used to reduce overlap in research funding between different organisations, and a tool for the management of research managers to mitigate the administrative burdens placed on researchers

Institutional evaluations are generally concerned with performance against set criteria, such as educational provision, student entry, facilities, teaching support, and administration. An evaluation at least once every seven years of each institution is performed by a certified evaluation organization. The National Institution for Academic Degree and University Evaluation (NIAD-UE) is one such body. These evaluations are for the most part a domestic exercise and are relayed to the university that has been evaluated and can feed into discussions at the University Evaluation Committee within the Ministry of Education.

There are some exceptions to this system. With the World Premier International Research Center (WPI) centres supported by the JSPS, these centres are now submitting detailed annual reports on their performance in terms of faculty, publications, external visitors and events that are organised. These centres are also subject to annual follow-up reviews where the evaluating Working Group comprises at least half of its members from overseas (see the JSPS WPI Programme for further information).

National competitive funding (such as Grants-in-Aid which are bottom-up grants decided by the researcher) is evaluated through the peer review process. Mostly, the evaluators are from Japanese institutes, with proceedings performed in Japanese. There are generally no call openings for international evaluators and experts to participate in such schemes.

## 2.6 KNOWLEDGE CIRCULATION

### 2.6.1 Knowledge circulation between the universities, PROs and business sectors

There have been substantial revisions to the structures through which public-private collaboration is performed since the late-1990s. At the policy level there is still concern of the intensity of interactions and a perceived need to foster closer relations between universities and industry.

A series of legal mechanisms, policy guidelines and organisational reforms were introduced to formalise the process of university-industry cooperation, supported by subsidies by METI and MEXT to develop the range of linkages between firms and universities. Indicators suggest that there are increased, but still modest, flows between the different actors[20]. In terms of industrial financing of higher education expenditure on R&D, this has gradually increased from 2.5% in 1995 to 2.5% in 2009 (OECD 2010). This is still low in comparison to the EU27, which has witnessed an increase from 6.0% to 6.4% up to 2009. Japan's level is similar to that of the Slovak Republic (2.3% (2010)) or Poland (2.9%) (OECD 2011).

There are currently 38 Technology Licensing Offices (TLOs) in Japan (JPO 2013). Although there are a small number of successful TLOs, the number of organisations that are ceasing operations or running deficits has been increasing. Those with deficits have increased from 7 in 2005 to 15 in 2008 (Cabinet Office 2012a: 7).

Research projects with private companies have been increasing. In 2005 there were 11,054 joint projects and by 2011 the number had risen to 16,302. Most relationships tend to be with large companies, but the number with SMEs has been gradually increasing. That with foreign companies has also slowly increased from a low base, from 51 collaborative projects in 2005 to 214 in 2011. By field for all types of partners, collaborative relationships are mostly in the life sciences (29.1%), nanotechnology and materials (16.4%), or ICT (8.5%); other fields account for 39.0%. Contracted research projects with private companies have remained broadly stable with 6,292 in 2005, declining to 5,760 in 2011.[21] Again there are small increases in the number of projects with SMEs (from 1,647 in 2005 to 1,839 in 2011) and with foreign enterprises (41 in 2005 to 82 in 2010).

University patenting activities are broadly at around 9,000 per year. Foreign patent applications also tend to be increasing. Although Japan has about a twenty year lag on the Bayh-Dole Act in the US, licensing revenues are only a fraction of those for the US when comparing against similar time points in the policy cycle (Cabinet Office 2012: 5)

According to analysis by NISTEP, patents are also increasingly citing academic papers. The science linkage from 1997-1999 to 2007-2009 saw an increase from 2.0 to 3.4 in the number of citations to the scientific literature. In particular, medical and chemical manufacturing fields have the highest science linkages; it has also been increasing in petroleum/coal production over recent years (NISTEP 2011: 133).

One of the main actors for facilitating joint projects between the different sectors is NEDO. NEDO is currently operating numerous research programmes addressing topic of technological development on energy, environmental technologies, information and communications, new manufacturing technologies, nanotechnology and materials, life sciences, and cross-over peripheral fields. The annual budget by NEDO specifically for national projects is €820m (1093b yen), €12m (1.6b yen) for supporting technological seeds and €24m (3.2b yen) for supporting application development (NEDO 2012).

[20] See section 3.3.2 for discussion of the management and expertise limitations in Japanese universities.
[21] Ibid and ERAWATCH Research Inventory Report for Japan.

Japan's cluster policies have undergone reform and in 2011 MEXT inaugurated a Regional Innovation Strategy Support Program. This aims to support and build upon the achievements from earlier cluster initiatives (see MEXT 2011). A new call was announced in 2013 to support Centres of Innovation. The results and exact constituents were unavailable at the time of writing this report.

## 2.7 OVERALL ASSESSMENT

To sum up the preceding discussion, the following can be seen as the most salient points:

- STI is well funded and accorded a high priority by government and industry. However, overall trends are suggestive of decreases in the longer term.
- The future will pose significant challenges in how R&D is financed without substantial efforts to attract new entrants from overseas or nurture new firms from within the national innovation system.
- Business dominates the Japanese STI landscape and for the most part is vertically integrated in how it approaches innovation. Connections between different STI actors across most main metrics are modest. Inter-sectorial mobility and research collaboration are all relatively low.
- Japan's industrial structure is largely unchanged on previous years and there has not been a growth in small science based industries similar to that observed in the US innovation system. However, key manufacturers of high end componentry are increasingly being acknowledged. Many of these were established prior to when many of the reform efforts began and have not been well studied thus far.
- Japan has high level stocks of human resources especially in quantitative and scientific skills. Transferable and other softer skills may be given less attention, although they are increasingly being emphasised in curricula and other educational programmes at tertiary levels.
- There is a lack of diversity in the researcher stocks available, with low numbers of female researchers and virtually no foreign researchers, especially in industry.
- Likewise, internationalisation of the innovation system is limited across most indicators. Assessment and evaluation of national programmes and institutions are for the most part national exercises, which may deprive these programmes of an international perspective.

# 3 NATIONAL POLICIES FOR R&D&I

## 3.1 LABOUR MARKET FOR RESEARCHERS

### 3.1.1 Stocks of researchers

Japan is relatively well stocked in terms of researchers. However, there are few intersectoral mobility flows, and there is a lack of diversity due to limited employment of women or foreigners. Efforts are being made to redress these issues. There is also a significant push towards enhancing The 4th Plan talks of placing stronger emphasis on nurturing and creating diverse career structures for researchers and the environment where they work (2011: 4). The revitalisation strategy adds further to this by emphasising the role that women or high skilled foreigners can play (Cabinet Office 2013).

Firstly, overall Japan has relatively high levels of researcher stocks on a full 55 equivalent (FTE) and per capita basis. Performance is higher than a macro level EU comparator but lower than many individual European countries. According to OECD data, on a per capita basis there are 10.4 FTE researchers per thousand. This has increased from 4.9 in 1995 (OECD 2012). This is above the OECD averages and also for the EU, which for the same time points is 4.8 and 6.6. As with other indicators, Japan's performance is below that of the leading EU Member States or associated countries, and is below Finland (16.2), Iceland (12.9), and on a par with Denmark (10.5).

75.1% of Japan's researchers are employed in the business enterprise sector (2009), with 18.8% in universities and colleges, 4.9% in public organisations, and 1.3% in non-profit institutions. This compares against 48.5% for the EU15 and 45.9% for the EU27 for business enterprises in 2007.

There were approximately 74,000 doctoral candidates in Japan in 2012. Entry to doctoral school has recently been in a horizontal trend, having initially declined from 2003. In 2012, around 15,600 entered doctoral schools (NISTEP 2012: 4). Survey data from NISTEP has suggested that there is little financial support for doctoral students, with most relying on personal savings or their families (NISTEP 2012a). To expand the support structure, MEXT have expanded competitive grants that include funding for teaching or research assistants. These compliment other types of support provided by the JSPS (MEXT 2012: 230).

### 3.1.2 Providing attractive employment and working conditions

For those pursing an academic career there has been a substantial growth in the number of part-time teaching positions at universities, and few full time openings. Further compounding the lack of opportunities for younger researchers has been the aging of faculty (Fuyuno 2012). To redress this situation there has been a steady expansion in the number of tenure track schemes. These are intended to provide greater career stability to researchers at the early stage of their career when they are seen to be most productive and original. An over reliance on short term contracts is seen to diminish the opportunities and stability for developing a research portfolio. Tenure track schemes are thus intended to provide a more stable environment for researchers (Inomata 2012).

Research has also suggested that the overall time given over to research has declined over time for Japanese university faculty. Policies have been introduced to redress this situation and are discussed further in Section 3.3.2.

Salary levels for researchers are roughly €34,895 (¥3,725,000 per annum). This is above the average salary in Japan, which in 2010 is €27,803 (¥2,968,000) (MHLW 2011). Since the national university incorporation law, legal determination for setting salaries has been at the institutional level. Despite this, the exercise of such autonomy in determining salaries has been somewhat limited and tends to vary by institution (Newby et al. 2009). It also depends of the amount of discretionary finance in universities which in some cases has been limited (Nikkei 2012a).

Survey data on brain drain is limited. However, in surveys of overseas diaspora of researchers, Japan is seen to have the one of the smallest proportions of national researchers based in overseas countries (Franzoni et al. 2012). Brain gain is also small scale with only a small proportion of foreign researchers in Japan. Brain circulation is covered in Section 4.

### 3.1.3 Open recruitment and portability of grants

Recruitment in Japan is increasingly open. There are few nationality restrictions on employment opportunities, but most positions are only advertised in Japanese. This may pose problems as Japan seeks to move towards a more international research system. With grants, there are only limited opportunities for research portability.

There are generally no nationality restrictions in competitions for permanent and academic positions. However, most employment positions in Japan are advertised only in Japanese. According to NISTEP data (2009), 74.4% of positions at Japan's national universities are only advertised in Japanese with only 3.5% of universities advertising all positions in English. The National Laboratories tend to place more positions in English and 23.2% of institutions advertising all positions in English. There are some schemes where nationality restrictions do apply, but they are in the minority or at a small number of national laboratories. Typically with research grants, there are no limitations on nationality, but having a position at a Japanese research institute is necessary.

Recruitment procedures differ by institution and faculty. As typically advertised they would require the applicant to complete a standard form outlining their school, academic and employment history. Some institutions or faculty evaluate potential faculty on the basis of their best paper; others look at more than one paper. This would then be supported by references. Employment positions are generally publicly advertised. According to the NISTEP research referred to above, 66.3% of all university positions are now advertised on the Internet.

Research positions in Japan are mostly advertised in the website of the Japan Research career Information Network (JREC-IN) which is operated by the Japan Science and Technology Agency, a research funding organisation. On a monthly basis the site advertises over one thousand jobs in Japanese, and around 100 jobs in

English. In 2010, JREC-IN also started advertising jobs for foreign institutes. International advertising of positions occurs, especially in centres with a distinctly international dimension, such as the WPI centres. Although there is no statistical data on the proportion of such advertisements it is assumed to be very small given the tendencies outlined above.

Research grants have limited portability in Japan. Under Grant-in-Aid for instance, portability is permitted if the Principal Researcher or Investigator moves to a different institution. Prior approval from the JSPS is required (JSPS 2010).

### 3.1.4 Enhancing the training, skills and experience of researchers

Policy initiatives have recently emerged to enhance research careers. These take on two dimensions; on the one hand through expanding tenure track and other postdoctoral schemes, and on the other through expanding transferable skills training. Following on from trial initiatives implemented by a small group of institutions between 2006 and 2010, an expanded programme of tenure track programmes has now been introduced with 48 universities receiving support from MEXT for such schemes (Inomata 2012), with some universities also implementing their own programmes.

For early stage researchers or those in doctoral education in Japan is mostly undertaken at the research group level and is largely shaped by the research supervisor. Research by NISTEP suggests that it is large amounts of latitude in how doctoral courses are delivered throughout Japan, dependent upon the discipline and the institution. Some universities require students to sit on lectures; other universities have larger course work requirements. The report found that universities are in the process of developing particular courses and curriculums at the doctoral level (NISTEP 2009).

It is possible to study and write a masters or doctoral thesis in English, but there is no data available on the overall number or proportion of such cases.

Japanese universities are expanding their cooperative relationships with overseas institutions, typically through memorandums of understanding on a bilateral basis. Many of these bilateral exchanges include student or researcher exchange. At the programme level, there are both double-degree or joint degree programmes that apply at undergraduate or doctoral levels. These are to be encouraged through the 4th Basic Plan. There is close monitoring and assessment of overseas doctoral practices, but no concerted efforts to align or standardize doctoral education with that found in other countries.

Between 1995 and 2008 there has been a 71% increase in the number of graduate schools in Japan. There has also been a substantial increase in professional graduate schools, increasing to 140 by 2006. Despite the increase in such schools, the ratio of undergraduates is still lower than other countries (OECD 2011: 116). What is also of note according to OECD assessments are the importance of enhancing the vocational training role of universities requires enhancement (OECD 2011).

## 3.2 RESEARCH INFRASTRUCTURES

Japan does not have a national roadmap for research infrastructures. However, research infrastructures have featured the throughout the basic plans, including the 4th Plan (Cabinet Office 2012: 38). The Comprehensive Strategy also now includes provisions towards research infrastructures.

MEXT has been supporting research infrastructures and there are now 30 such infrastructures distributed throughout Japan. These infrastructures are either based at national laboratories or universities (See MEXT 2011a) and are open to external usage with details on how to apply to use such facilities presented in English on each site. The research fields for these infrastructures encompass chemistry, bio, manufacturing technologies and nanotechnology. Prominent joint use facilities include the Spring-8 facility, and the Japan Proton Accelerator Research Complex (J-PARC).[22]

A second aspect of research infrastructures regards information systems (Cabinet Office 2011: 39), such as online information systems, repositories and open access sources. These are also being promoted.

## 3.3 STRENGTHENING RESEARCH INSTITUTIONS

### 3.3.1 Quality of National Higher Education System

*Size and Composition of the Higher Education Sector*

There are a total of 783 universities in Japan, with three main categories:

- National University Corporations (86 Institutions)

- Public Universities (92 Institutions)

- Private Universities (605 Institutions) (MIC 2012)

The percentage of higher education expenditure on R&D as a percentage of GDP is 0.75% as of 2011. This is higher than that of the EU as a per cent of GDP (0.49%) (2010).

There are approximately 2.6m undergraduate students in Japan, of which 811,000 are in the field of natural science and engineering. Roughly 50% of 18 year olds advance to a tertiary level qualification in Japan. This is both above the OECD average (28%) and above that of the EU19 (25%) (NISTEP 2012: 96). The European country which comes closest to the Japanese level is Finland (37%) (OECD 2011: 36). For graduates of undergraduate degrees, 60% of these enter employment with 40% going on to postgraduate study. Around one-third of natural science and engineering graduates enter the manufacturing sector, and one-third enters service industries.

The number of master's programme students is 174,000 including 109,000 in the natural science and engineering fields. There were 82,000 enrolments in 2010, an

[22] J-PARC: http://is.j-parc.jp/uo/index_e.html; Spring-8: http://www.spring8.or.jp/en/users/

increase of 5.4% on the previous year. 50% of new enrolments are in science and engineering (NISTEP 2012: 99-100). At the doctoral level there are 74,000 students, 48,000 are in the natural science and engineering field (NISTEP 2012: 95). By comparison the EU27 had 19.8m ISCED level 5 and 6 students in 2010. The European country with similar levels to that of Japan is Germany (2.5m) (Eurostat 2012e). Employment of doctorates by industry is very low, with less than 4% of industrial researchers possessing a doctoral degree. In other OECD countries such as Belgium, Norway, or Ireland the ratio is above 12% (MEXT 2012: 217).

*Mission of Higher Education Institutions*

There is no official or publicly stated distinction of the roles of different types of universities in Japan. Their role is chiefly that of teaching and research. However, there are some *de facto* differences in the division of labour by institution type; there is also a high degree of academic credentialism associated with the institution one attended (OECD 2011).

The National Universities tend to be the major performers of science and technology in Japan, with a higher number of researchers engaged in the physical sciences, engineering, agriculture and health. Most medical schools, for instance, are based at the national universities. It is also the case that the national universities tend to see higher application / acceptance ratios than public universities due to their perceived prestige. The private universities, by contrast, are more heavily involved in the humanities and social sciences and more engaged in undergraduate education, where they educate 77.6 per cent of students. At postgraduate levels by contrast, the private universities educate 37.4 per cent of Master degrees students and 24.6 per cent of doctoral candidates (MEXT 2011). Public universities are by the local prefectural government and are similar to private universities in terms of activities. Each university in Japan requires accreditation from MEXT.

The national universities introduced six-year medium term plans following their incorporation from 2004. These plans cover such topics as the performance of teaching, research, contribution to society; administrative objectives, financial affairs and administration. These plans require approval from MEXT and are also evaluated against their objectives. In addition, many universities have additional strategic or policy statements beyond that of the medium term plan. For instance, the University of Tokyo has an action plan scenario that aims to build on the results of the medium term plan (University of Tokyo 2012). Other policies, strategies and missions also apply for different aspects of the university's function, for instance, relations with industry (see for example University of Tokyo 2011).

*Research performance*

Japan has a large higher education sector but it is mostly domestically oriented with low international prominence. The proportion of foreign students is less than 5%[23], with a similarly low proportion of foreign faculty. These poor international aspects tend to be the weak point in ranking exercises.

According to the Academic Ranking of World Universities (ARWU 2012), Japan has one institution in the top 20 ranking, four institutions are in the top 100 rankings, and five institutions are in the top 101-200 institutions, with 12 institutions in the 201-500

[23] For the EU27, 7.89% of students at tertiary levels 5 and 6 are foreign (2009). Countries with particularly high levels of foreign students at this level include Austria (19%), Cyprus (34%), France (11%), and the UK (20%) (Eurostat – educ_mofo_gen).

rankings. By contrast, there are 34 European institutions in the top 100. The top universities in Japan are typically associated with the former Imperial universities established during the Meiji Restoration from 1868. The top institution is typically recognised as the University of Tokyo, followed by Kyoto University, and then a group of other universities such as Tohoku University, Osaka University, Hokkaido University, Kyushu University, and Nagoya University. Tokyo Institute of Technology, while not a former imperial university, is also part of this select group. All these universities are national universities, and tend to perform strongest in the various ranking exercises performed. Amongst the private universities, Keio University and Waseda University are widely seen as the strongest performers. As shown in Section 4 below, participation in European programmes is also limited.

Macro-level bibliometric indicators are used in NISTEP assessments (see NISTEP 2012) and in 2012 a detailed bibliometric study at the institutional level was published. This was to support the planning and management of universities, and provided insights according to disciplinary field, level of collaboration with overseas partners and other trends (Saka and Kuwahara 2012). This exercise is part of the data generation programme accompanying the science of science, technology and innovation policy programme.[24]

According to citation analysis performed by Thomson Reuters, Tokyo University obtains the most citations, followed by Kyoto University, Osaka University, and the JST. Also in the top ten are national laboratories such as RIKEN and the National Institute of Advanced Industrial Science and Technology (AIST). The national universities tend to dominate the citation rankings (Thomson Reuters 2013). By field, some Japanese universities have very strong performance. The National Institute of Materials Science (NIMS) is ranked 3$^{rd}$ in the World for materials science citations; the University of Tokyo is 3$^{rd}$ for physics citations; Kyoto University is 3rd for chemistry citations; the University of Tokyo is 3$^{rd}$ for biology and biochemistry citations (Thomson Reuters 2013).

### 3.3.2 **Academic autonomy**

Changes over the past ten years have increased the autonomy of Japan's universities. Government is still, however, seen as playing a supervisory role.

The Constitution of Japan stipulates the independence and autonomy of educational entities. Each of the three types of university in Japan is governed to differing degrees by MEXT which lays down basic policies, and authorises institutions. The National Universities became national university corporations in 2004. This granted new independence to the national universities, in terms of personnel affairs, budgetary matters, and gave the university responsibility for its own performance. To that end, the governance of universities was also reformed with the introduction of (1) a *board of directors*, which is the highest deliberative body before the final decision by the president; (2) an *administrative council*, which deliberates on important matters concerning the administration of the national university corporation; and (3) an *education and research council*, to deliberate on important matters concerning education and research (Oba 2006).

[24] See: http://scirex.mext.go.jp or http://www.nistep.go.jp/research/scisip

A 2009 review undertaken by the OECD suggested that what the 2004 reforms had achieved was 'not so much the introduction of total autonomy as a shift from control to supervision' (2009:18). University autonomy is seen to be particularly limited regarding the establishment of new departments or faculties, changes in student numbers, student tuition fees and the appointment of the President and the auditors (OECD 2009).Universities themselves have been limited in how to develop their own initiatives due to a lack of managerial and financial expertise due to their longstanding dependence upon the Ministry of Education. To address this, MEXT have launched a University Researcher Administrator (URA) support programme with groups of different universities being selected that will ultimately provide financial and administrative support (MEXT 2012).

### 3.3.3 Academic funding

The main funding instruments are institutional grants for the national and public universities. These account for around 40% of university income and are in the region of €11.5b (2012) (11,604b yen) (MEXT 2012a). Additional income for the universities is derived from medical fees from hospitals (30%), student tuition fees (12%), competitive research funding (14%), or donations and other sources of income (4.5%). In particular competitive research funds have increased from just over 10% between 2005 and 2008, to just over 14% in 2010 (MEXT 2012). MEXT apply a formula for funding universities, based upon the number of faculty, the facilities, medical facilities, income, as well as the number of students, tuition fees and expenditures. Most university expenses are used for personnel (36%), medical school and related costs (34%), research, and tuition costs. Institutional operating grants declined by 1% on an annual basis between 2004 and 2010, resulting in an overall budgetary reduction of €723m for the national universities (MEXT 2010).

For the national universities, overall competitively allocated funds from government and other external sources have increased from €2.8b (2005-8) to €3.8b in 2010 (MEXT 2012b). The main programme for the distribution of these programmes is the Grants-in-Aid programme operated by MEXT and the Japan Society for the Promotion of Science (JSPS). These are bottom-up grants evaluated through peer review and allocated on a competitive basis. Between 2011 and 2012 the budget declined -2.5% and again in by -7.8% for 2012 to 2013 (MEXT 2013b). Over the past decade the role of competitively awarded research grants has come to play an increasingly important role.

## *3.4* KNOWLEDGE TRANSFER

### 3.4.1 Intellectual Property (IP) Policies

The Government of Japan have a stated aim of creating "a nation built on intellectual property" (see Cabinet Office 2006). An Intellectual Property Strategy Headquarters was established in the Cabinet Office in 2002 for developing measures for the creation, protection and use of intellectual property. The Headquarters are directed and supervised by the Prime Minister, and a strategic plan for intellectual property is published on an annual basis.

The University Incorporation Law went into effect in 2004 and gave universities independent legal status. Due to this, Article 35 of Japan's Patent Law enabled employers to require assignment of employee inventions. MEXT urged national universities to assert ownership over commercially valuable inventions (Kneller 2011). Co-inventor ship can give the sponsor co-ownership rights. University inventors can designate company employees as co-inventors and thereby obtain exclusive control without commitments to further development (Kneller 2011).

For universities, significant reforms have been undertaken since the late 1990s to change the nature of interactions between universities and companies. The introduction of legal mechanisms and policy guidelines by government has formalised methods of interaction, especially between universities and industry, and the national universities gained ownership of intellectual property when they became corporate entities in 2004. To manage the ownership of such intellectual property technology licensing offices have been established at universities.

Incentive policies for IPs are in place at the universities and published in their rules and practice regarding the licensing of institutional intellectual property. These rules vary by institution, but structure how licence payments will be divided by the institution. Typically the academic researcher can expect around 30% of licensing revenue, 30% will be awarded to the university, and 30% will be awarded to the licensing office.

Monitoring of knowledge transfer activities is undertaken annually by MEXT. This data includes the number of collaborative or contract agreements, patenting and licensing activities. The data includes financial, number of cases, and disciplinary orientation, as well as rank ordered data for the top 30 institutions (MEXT 2012).

Most staff in Japan's TLOs are former academics with an engineering background. There is a propensity to hire people near to their retirement age (55-64 age bracket), and very few of them have undergone any professional training for working in the technology transfer profession (Woolgar et al. 2008).

### 3.4.2 Other policy measures aiming to promote public-private knowledge transfer

**Spinoffs**

Following declines in the number of spin-offs since 2006 when they peaked at 252 before dropping to 47 in 2010, the number has rebounded slightly rising from 2010 to 2011 to 69. This brings the total number of spin-offs to 2,143 since they first began to be promoted in the mid-1990s (MEXT 2012).

Public funding for the support and establishment of academic start-up incubation laboratories at universities has been occurring since the mid-1990s, with slightly over 200 such offices at universities throughout Japan (NISTEP 2010). Survey data has also suggested that until now there has been an emphasis placed on establishing firms to the neglect of later managerial development; faculty have tended to maintain stronger relations with universities than student developed ventures (NISTEP 2010).

Programmes have been reformed or merged to facilitate the flow between different stages of the technology development cycle, as shown by reference to A-Seed Programme mentioned in Section 2.3.3. NEDO continue to maintain funding towards venture companies in the energy field (NEDO 2012). Under the innovation system reform outline of the 4th Basic Plan, the promotion of bio-ventures is given particular attention, as well as the support systems for university ventures.

### Inter-sectoral mobility

Mobility is small scale and tends to be intra-sectoral. As of 2010, just over 4,000 people left industry or non-profit organisations to work in universities; with only 357 people moving in the opposite direction from the universities. Movement from public laboratories to industry is likewise small scale, with 227 people moving to industry/NPOs and 305 people from industry in the opposite direction. 4,141 people moved to university from public laboratories, and only 383 people moved in the opposite direction. Within each sector the numbers tend to be slightly higher. 7,528 university staff moved to other universities, 13,267 industry/NPO staff moved to other such organisations; 1,926 personnel moved between different public research laboratories (METI 2012: 24).

In comparative perspective, research by NISTEP suggests that university faculty have some of the lowest levels of mobility in comparison to faculty in other countries. In Japan, there are 0.78 moves per faculty, at a similar level to South Korea (0.83). Faculty in the Netherlands, Hong Kong and Australia tend to see the highest mobility (3.53, 2.69 and 2.58 respectively) (NISTEP 2009).

### Promoting research institutions - SME interactions

University interactions with SMEs tend to be quite low. In 2011, there were 16,000 projects with large-scale companies, and 4,500 with SMEs. The overall level of collaborative research is tending to increase rising from 3,900 in 2006 (Cabinet Office 2012). Contract research projects are stable over 2006 to 2011 at around 1,800.

### Involvement of private sector in the governance bodies of HEIs and PROs

Since the passage of the University Corporation Law in 2004, the involvement of the private sector in the governance bodies of HEIs and PROs is now quite widespread. No data could be obtained regarding the proportions and role such private sector actors play with regard to university governance.

### Regional Development policy

The 4th basic plan talks positively of the role of regional clusters, and will maintain support to regional initiatives, promote collaboration between regional actors, as well as utilise special zones for nurturing regional innovation. Centre of Community funds were introduced in the 2013 budget for MEXT as a new budgetary line of €17.6m.

There have also been a number of new schemes to support science in the Tohoku region, totaling around 104m. This includes the following:

- Tohoku Marine Science Centre (€11m)
- Tohoku Medical Megabank (€29m)
- Next generation energy project (€16m)

- Advanced materials project (€10m)

## 3.5 ASSESSMENT

To summarise this section, it is apparent that Japan has high numbers of human resources in science and technology predominantly in the business enterprise sector. Researchers in Japan are generally well-paid, but in the public sector there has been an aging of faculty and growth in part-time and temporary positions. In the public sector there have been efforts to improve the working environment to address key issues that may shape future researcher careers. Research institutions are supported through a range of mechanisms and increasingly encouraged to broaden their engagement with society. As with earlier sections, there is clearly a lack of internationalisation with barriers to international recruitment. The lack of internationalisation was seen to undermine university performance in ranking exercises, even though in many areas of scientific research, Japanese performance is excellent.

# 4 INTERNATIONAL R&D&I COOPERATION

## 4.1 MAIN FEATURES OF INTERNATIONAL COOPERATION POLICY

The objectives and principles underpinning international science and technology cooperation relate to the need to foster greater internationalisation of the Japanese research landscape, cooperate with key international partners, and the expansion of relations with Asian countries to address key challenges. Science and technology is also being linked closely with overseas development assistance (ODA), or through new initiatives to cooperate with developing countries.

With Asian partners the $4^{th}$ plan, talks of promoting the notion of the East Asian Science and Innovation Area which will work to address issues of mutual interest to Asian partners such as environmental, energy, food, water or disaster prevention initiatives. The government is to explore an international cooperative fund or support for large scale collaborative projects (Cabinet Office 2011: 27).

The Plan also talks of the importance of opening up and developing new areas of cooperation with scientifically and technologically advanced countries. This concerns both general scientific collaboration, and also extends to large scale projects or data infrastructures (Cabinet Office 2011: 28). As a third country, following passage of the EU-Japan Science and Technology Agreement in 2011, the number of jointly funded calls with the EU has been expanding, between the Commission and counterpart funding and policy organisations in Japan.

## 4.2 NATIONAL PARTICIPATION IN INTERGOVERNMENTAL ORGANISATIONS AND SCHEMES

Japan participates in the following intergovernmental projects (MOFA 2013):

- International Thermonuclear Experimental Reactor (ITER)
- International Science and Technology Centre (ISTC),
- Global Biodiversity Information Facility (GBIF),
- Global Earth Observation System of Systems (GEOSS),
- Integrated Ocean Drilling Program (IODP),
- Human Frontier Science Program (HFSP),
- Argo Project

Japan is also a member of the following space cooperation activities:

- International Space Station (ISS),
- Member of the Committee on the Peaceful Uses of Outer Space(COPUOS),
- International Telecommunications Satellite Organization (ITSO),
- International Mobile Satellite Organization (IMSO).

## 4.3 COOPERATION WITH THE EU

### 4.3.1 Participation in EU Framework Programmes

There are now two main projects responsible for promoting Japanese participation in European projects. Following the cessation of the J-Bilat project in 2012 the results for the new project, following the call made in the summer of 2012, have yet to be announced.[25]

A Science and Technology Agreement was put in place between the European Union and Japan in 2011 (European Commission 2011).

Current programmes to support participation in EU Framework programmes are the following:

- ERA-NET, CONCERT-Japan[26] operated by TUBITAK in Turkey. They launched their first jointly funded call in 2012 in the areas of efficient energy storage and distribution and resilience against disasters.
- A second project is EURAXESS Links Japan[27] which aims to support research researcher mobility and cooperation between Europe and Japan.

Japan's participation in FP7 has been low. Specific details of the range of projects can be found in the two tables below. Altogether, there are 167 main listed projects in which actors from Japan are involved, totalling around 730m (see table below). Comparatively this is low against other major advanced countries and at a level similar to Tunisia and Morocco (European Commission 2012). Demand for participation varies by area, but is relatively modest overall. In total the acceptance rate for participation is around 30%. Most collaborative projects tend to be in the ICT sector – 25 mainlisted proposals), followed by the environment (10) and health (8). There are 43 Marie Curie awards. In European Research Council programmes, for those with Japanese nationality there are eleven grantees with Starting Grants, and one with an Advanced Grant (Gaudina 2013).[28]

Under the INCO call announced in 2010, there is a joint laboratory in Japan between CNRS and the University of Tokyo. The INCO-Lab programme is based at the Laboratory for Integrated Micro-Mechatronic Systems (LIMMS) at the Institute of Industrial Science at the University of Tokyo. The EUJO-LIMMS laboratory (which stands for Europe-Japan Opening of LIMMS) supports cooperation between the École Polytechnique Fédérale de Lausanne (EPFL), the Department of Microsystems Engineering (IMTEK) at the University of Freiburg (IMTEK) and VTT Technical Research Centre of Finland (see CNRS 2011).

In the COST programme Japan is participating in 15 projects. This is below that of the USA (54), and Canada (30), but at a similar level to China (15), and above that for India (8), and the Republic of Korea (6) (Dietl 2012).

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[25] http://www.j-bilat.eu/index.php?content=j-bilat-en
[26] http://www.concertjapan.eu/node/95
[27] http://ec.europa.eu/euraxess/links/japan/index_en.htm
[28] http://www.euinjapan.jp/wp-content/uploads/2.-Mr.-Massimo-Gaudina-The-European-Research-Council-funding-for-top-researchers.pdf

Japan has four nuclear-related agreements with Europe: Euratom Agreement for Fusion (1989), International Thermonuclear Experimental Reactor (ITER) (2006), EURATOM for peaceful use (2007), and the Broader Approach Agreement (2007).

With other international organisations or European organisations, Japan maintains a Fellowship Program with CERN, the European Organisation for Nuclear Research, which is targeted to young researchers with Japanese nationality. The European Bioinformatics Institute (EMBL-EBI) cooperates with the DNA Databank of Japan

**Table 1: Japanese participations in FP7**

| | | All submitted | | Mainlisted | | | Success Rate: applicants in mainlisted proposal / applicants in all submitted proposals |
|---|---|---|---|---|---|---|---|
| Proposal SP Description2 | Proposal Program | Number of Proposals | Number of Applicants | Number of Proposals | Number of Applicants | Proposal Total Cost | |
| SP1-Cooperation | ENERGY | 8 | 9 | 1 | 1 | 5,259,219 | 11.11% |
| SP1-Cooperation | ENV | 28 | 33 | 10 | 12 | 69,948,627 | 36.36% |
| SP1-Cooperation | HEALTH | 25 | 25 | 8 | 8 | 84,848,223 | 32.00% |
| SP1-Cooperation | ICT | 124 | 140 | 25 | 28 | 196,675,985 | 20.00% |
| SP1-Cooperation | KBBE | 13 | 15 | 3 | 3 | 16,278,264 | 20.00% |
| SP1-Cooperation | NMP | 22 | 32 | 6 | 6 | 49,647,743 | 18.75% |
| SP1-Cooperation | SEC | 7 | 7 | 4 | 4 | 53,994,013 | 57.14% |
| SP1-Cooperation | SP1-JTI | 1 | 1 | | | | |
| SP1-Cooperation | SPA | 29 | 34 | 6 | 7 | 18,441,957 | 20.59% |
| SP1-Cooperation | SSH | 16 | 16 | 1 | 1 | 10,085,231 | 6.25% |
| SP1-Cooperation | TPT | 19 | 27 | 4 | 10 | 9,840,102 | 37.04% |
| SP2-Ideas | ERC | 14 | 16 | | | | |
| SP3-People | PEOPLE | 132 | 158 | 43 | 54 | | 34.18% |
| SP4-Capacities | INCO | 15 | 31 | 6 | 16 | 10,368,719 | 51.61% |
| SP4-Capacities | INFRA | 13 | 13 | 7 | 7 | 126,430,448 | 53.85% |
| SP4-Capacities | SiS | 4 | 5 | 2 | 3 | 3,530,503 | 60.00% |
| SP4-Capacities | SME | 1 | 1 | | | | |
| SP5-Euratom | Fission | 7 | 8 | 6 | 7 | 81,395,290 | 87.50% |
| | **Sum:** | **478** | **571** | **132** | **167** | **736,744,324** | **29.25%** |

In Table 2 below, further information is provided on type of FP7 programme for cooperation with Japan. The table suggests that the main focus of activity is through the IRSES programme, on coordinating actions, and generic collaborative projects. There are a also a number of Marie Skłodowska-Curie outgoing fellowship proposals.

### Table 2: Japan Contract type of the FP7 projects with country's participation

| Proposal Sub Funding Description | Number of Proposals submitted | Number of Proposals main listed |
|---|---|---|
| Collaborative project for specific cooperation actions dedicated to international cooperation partner countries (SICA) | 11 | 6 |
| Collaborative project (generic) | 27 | 11 |
| Collaborative Project targeted to a special group (such as SMEs) | 4 | 2 |
| Combined Collaborative Project and Coordination and Support Action | 2 | 2 |
| Coordinating action | 29 | 11 |
| Initial Training Networks (ITN) | 12 | 1 |
| Integrating Activities / e-Infrastructures | 7 | 3 |
| International Outgoing Fellowships (IOF) | 42 | 4 |
| International Research Staff Exchange Scheme (IRSES) | 70 | 38 |
| Large-scale integrating project | 58 | 14 |
| Network of Excellence | 5 | 1 |
| Small or medium-scale focused research project | 96 | 18 |
| Small or medium-scale focused research project INFSO (STREP) | 57 | 10 |
| Supporting action | 34 | 11 |
| Other | 24 | |
| **Sum:** | 478 | 132 |

### 4.3.2 Bi- and multilateral agreements with EU countries

Japan's Ministry of Foreign Affairs (MOFA) lists all the science and technology agreements with overseas counterparts. Amongst European countries, the following countries hold such an agreement with Japan: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, the United Kingdom. With Associated Countries: Norway, Switzerland, Israel, Croatia, Montenegro, and Bosnia and Herzegovina (MOFA 2013).

Mostly these agreements tend to be general agreements covering all scientific relations. Where priorities exist, and where policy makers feel a need to support cooperative research in particular areas, then calls are issued in specific areas.

Mostly, the programme driven collaboration and cooperation is towards basic research or advanced technologies in key areas of mutual interest.

Specifically with European countries, the following matched calls have been implemented over recent years:

- Croatia-Japan: Materials Science (JST/MSES)
- EU-Japan: Aeronautics (METI); Environment (JST/ DG RTD); Photovoltaics (METI/NEDO / DG RTD) Biotechnology; Superconductivity (JST / DG RTD); Industrial Technologies; Nanotechnology; Rare Earths; ICT (DG INFSO / MIC)
- Denmark-Japan: Life Science (JST/DASTI)
- Finland-Japan: Functional Materials (JST/TEKES and the Academy of Finland)
- France-Japan: Life Science/ICT including Computer Science/Marine Genome and Marine Biotechnology (JST / ANR or CNRS).
- Germany-Japan: Nanoelectronics (JST/DFG); Computational Neuroscience (JST/
- Spain-Japan: Multidisciplinary Materials Science (JST/MINECO)
- Sweden-Japan: Multidisciplinary Bio (JST/VINNOVA and SSF)
- Switzerland: Life Science (JST/ETHZ)
- UK-Japan: Systems Biology; Bionanotechnology, Structural Genomics and Proteomics (JST/BBSRC); Advanced Materials (JST/EPSRC); Advanced Health Research (JST/MRC).

One of the main mechanisms for many of these calls is the Strategic International Cooperation Programme (SICP) operated by the JST. This provides matched funding in the region of €130,000, to support partnerships lasting for three years. Within this scheme, under which most calls for proposals are annually announced, funding is provided to support researcher interchange, joint seminars, or other forms of collaboration.

The Core-to-Core programme implemented by the JSPS adopted three projects under the Strategic Research Networks dimension in 2013. Each of these projects includes participation with European actors.[29]

## 4.4 COOPERATION WITH NON EU COUNTRIES OR REGIONS

### 4.4.1 Main Countries

As noted in Section 4.1, collaboration on the grand challenges is set to occur with Asian countries in line with the priorities of the 4$^{th}$ Science and Technology Basic Plan.

Japan also maintains science and technology agreements with the following non-EU countries: Australia, Brazil, Bulgaria, Canada, China, Egypt, India, Indonesia, Israel, New Zealand, Russia, South Africa, South Korea, Ukraine, USA, and Vietnam. The

[29] See: http://www.jsps.go.jp/english/e-core_to_core/h25_kokusai_ichiran.html

agreements range from those that address specific topics, to more comprehensive all-encompassing agreements such as that with the USA (MOFA 2012).

Some mechanisms in relation to the ARA include the Asia Research Fund (ARF) providing cross-border research grants for multi-national collaborative research, promoting regional human resource development and circulation of knowledge, large scale research facilities, and the maintenances of the quality and integrity of scientific research. Other than the ARF, there is the Asian Technology Assessment Center (ATAC) that assesses technology from the standpoint of the general public, and the Asian Technology Incubation Center (ATIC) which supports development of new innovation and solves local needs.

The rationale for an ARA derives from concern over brain-drain issues. Also, Asia has experienced many problems that must be tackled through multilateral efforts, such as environmental and natural disasters, heightening the need for a stronger cooperative action in the region.

### 4.4.2 Main instruments

The main instruments for implementing international cooperation are operated by the two key funding organisations, the JSPS and the JST. In some areas, instruments are also developed by specific ministries or national laboratories. Some of the main instruments to support international cooperation include:

- Strategic International Cooperative Program operated by the JST is the main instrument that structures matched funding of research projects in specific areas. The areas with particular European countries have been outlined in Section 4.3.2.
- Core-to-Core programme operated by the JSPS. The purpose of the programme is building and expanding a cooperative international framework in leading-edge fields of science among universities and research institutions in Japan and with overseas counterparts.
- SATREPS (Science and Technology Research Partnership for Sustainable Development) is a Japanese government programme that promotes international joint research targeting global issues. This programme is with developing countries.
- East Asia Joint Research Programmes (e-ASIA JRP) – joint research programmes between Asian countries. It includes the ASEAN members, plus Australia, Japan, New Zealand, China, India, Korea, Russia, U.S.
- International training and experience programmes operated by the JSPS. The JSPS has a number of dispatch, incoming, joint seminars and other programmes to support international cooperation and fellowships for domestic and foreign researchers.
- Bilateral programmes – supporting joint research, seminars and exchanges (JSPS)
- International Joint Research Programmes operated by the JSPS. These include the JSPS-NSF International Collaborations in Chemistry; the JSPS-NSF Partnerships for International Research and Education; the G8 Research Councils Initiative.

- Collaboration with Asian and African Countries. The JSPS operates bilateral programmes, the Asian CORE program, AA Science Platform Programme, A3 Science Platform Programme, Core University Programme, Asian Science Seminar, Asian Heads of Research Councils: ASIAHORCs programme, HOPE Meetings, Dispatch of Science and Technology Researchers.
- International Scientific Meetings (JSPS)
- JSPS Alumni activities, Japan-Affiliated Research Community network; Strategic Programme for Building and Asian Science and Technology Community.

Other organisations also provide international fellowships or bilateral exchanges. For instance, many national laboratories have their own fellowships for supporting incoming researchers, such as RIKEN or the National Institute for Communications Technology (NICT). There are no known systemic maps of the range of programmes and initiatives.

## 4.5 OPENING UP OF NATIONAL R&D PROGRAMMES

For the most part Japan's national funding programmes are nationally oriented and only those programmes which explicitly include an international dimension are used to support international openness. There are no known programmes where nationally funded projects are open and given support to foreign participants based in overseas countries. As shown in Section 4.3.1, there is one prominent example of a European laboratory supported at a Japanese institution. This is however, jointly funded by the CNRS and the University of Tokyo.

As noted in Section 2.5.2, the Industrial Structure Committee within METI published a report in April 2012 where it was recommended that Japan should follow a model similar to that of the Framework Programme involving collaboration between companies across different countries. This is only currently a recommendation.

## 4.6 RESEARCHER MOBILITY

### 4.6.1 Mobility schemes for researchers from abroad

Transnational outward mobility has become an important issue over the past few years. There has been a great deal of concern over the willingness of young researchers and students to gain international experience.

Data trends for researchers suggest that for short term and long term overseas visits there has been a decline from 2003 to 2008. This data, which comes against the backdrop of a decreasing population, suggests that the number of long term overseas stays declined from a peak of 7,600 in 2000 to 4,000 in 2008. From then the trend flattened out and stabilised at the 4,000 level. For short term stays there have been upward trends over the past decade (MEXT 2012).

if we are looking at inward mobility, the number of Europeans visiting Japan is also high, where around 6,000 researchers came on a short-term basis. Visitors from Asia are the most numerous, at around 10,000 for 2010. Short term visits show 3,000 from Europe and 8,000 from Asia (MEXT 2012).

The main mobility programmes for researchers from third countries are provided by the Japan Society for the Promotion of Science (JSPS). The JSPS provides long term (up to two years) fellowships for postdoctoral researchers, short term fellowships (between 1 to 12 months), and the opportunity to attend summer schools in Japan. Furthermore, at advanced levels, the JSPS provides opportunities for Nobel Prize winners to work in Japan through the Invitation Fellowships programs for Research in Japan.

There have been a number of policy initiatives in the area. MEXT introduced a target for attracting 300,000 overseas students to Japan's universities by 2020, and have put in place grants to support the hiring of foreign researchers to help with the development of English curricula. The New Growth Strategy, introduced in 2010 under the previous government talked of making it easier for 'foreigners to work in Japan as researchers and in positions requiring specialist expertise' (Cabinet Office 2010: 25). There have subsequently been changes to immigration policy and the introduction of a points based system for people with the requisite skills and experience.

There have been some large scale initiatives to provide opportunities for inward mobility. Chiefly, the World Premier International Research Centre Initiative provides large scale funding to interdisciplinary research centres in pioneering areas of research. To foster an international environment, 30% of researchers at these centres are to be from overseas. Other schemes aim to support the attraction of overseas students through expansion of English courses at Japanese institutions. The G30 Programme, also funded by the JSPS, has provided funding for 13 institutions to develop English programmes.

In addition to the JSPS, a number of inward mobility schemes are provided by research institutes or other funding organisations. The National Institute for Physical and Chemical Research (RIKEN) as well as the National Institute of Advanced Industrial Science and Technology provide fellowships for foreign researchers.

A full listing of the range of funding schemes for mobility between Europe and Japan can be found from Euraxess Links Japan (Woolgar 2012).

### 4.6.2 Mobility schemes for national researches

Amongst Japanese researchers, Asian countries are the favoured destination for both shorter stays, and European countries the most popular for longer term stays.[30] According to 2010 data from MEXT, there were 39,746 short term (<1 month) visits to European countries by Japanese researchers; there were 52,723 visits to Asian countries. For longer term stays there were 1,748 stays in Europe, with 1,225 stays in North America (MEXT 2012).

Some of the reasons cited by researchers for not going overseas are the uncertainty of finding a new position once returning to Japan. Secondly, those Japanese researchers do not have the necessary connections overseas (NISTEP 2009).

[30] See: http://kyoyonavi.mext.go.jp/info/about02

Recent budgetary outlines from MEXT have increased funding for students to gain overseas experience. In the 2013 budget the allocation totals 332m (MEXT 2013a). It outlines the expansion of funding opportunities for students and researchers to undertake outward and inward mobility under the notion of developing globally oriented human resources. The new budgetary allocation provides for the expansion in funding towards overseas student visits (from 50 students to 300), and an expansion of places for incoming students from overseas. Other schemes include the expansion of long-term and short-term exchange schemes (long term (>1 year)) from 100 to 200 researchers; and a slight expansion in the Postdoctoral Fellowship Abroad programme operated by the JSPS (from 486 to 501) (MEXT 2012: 5).

# 5 CONCLUSIONS

This report has reviewed Japan's efforts towards science, technology and innovation over the 2012-2013 period, broadly up to the end of May 2013. This means that the full implications and outcomes from the Comprehensive strategy, and the Revitalisation strategy are only covered at a cursory level; the substantive policy measures and proposals will be unveiled in due course.

Until these two strategies were decided upon, activity towards STI had been rather quiet. Firstly, the Science and Technology Basic Plan had been introduced in 2011 which combined with other factors led to some decline in activity. Chiefly the government had relatively weak political capital and was concerned with enacting legislation regarding increases in the consumption tax, as well as beginning preparations for the national election campaign in December. With the election results and the change of government, the LDP came back into power. From that point onwards activity began to pick up as a new government and new agenda introduced a number of new initiatives.

The influx of new members to the CSTP, the increased expenditure allocated through the supplementary budget, the on-going discussions regarding the development of a comprehensive long-term strategy suggest new impetus for science and technology. The revitalisation strategy published in June also has a lot of relevance to the broader aspects of STI. While this is to be seen as new activity, much of what is being introduced or stated is not new and has been stated in various other economic growth initiatives or other policy documents. In many ways, the new policy agendas show the implementation gaps on earlier initiatives and statements.

As this report has shown, Japan faces numerous challenges and issues going forward. Undoubtedly, science, technology and innovation are accorded a fundamental role in helping to resolve some of these issues. The revitalisation initiative to be published in June 2013 is likely to strongly emphasise the role that STI can play, along with other macro-economic policy adjustments.

Japan still enjoys a reputation as a technological powerhouse or innovation leader. However on many metrics its performance is fairly low against the very top performers. This declining performance is regularly being cited and referred to in government policy documents. The policy agenda is also increasingly trying to reverse these trends. The scale of investment since 1995 has been significant but that these debates and concerns are arising suggests that the system has had numerous problems. These include the means and policies for how expenditures are used, the lack of mobility and flows between different sectors, the structure of industrial R&D and corporate strategy, the general lack of internationalisation, the evaluation system and culture, the nature and structure of how research projects are implemented, as well as the governance or degree of control over the system.

This report has shown that, although expenditure on R&D has tended to increase as a proportion of GDP, in real terms there has been only very modest increases in expenditures since the start of the millennium. The economic crisis of 2008 further dented the increases that had been made over that decade. Substantial and varied efforts will be necessary to increase expenditures by industry or attract and nurture new entrants. Government itself is likely to face challenges in how it finances STI and other activities should borrowing become more expensive. Given this, it is unlikely that the 4% target will be met. This also depends ultimately on the degree of reform ushered in by the "third arrow" growth initiative. It should be remembered that over the past decade there have already been around ten growth strategies or initiatives unveiled, with only modest success in terms of implementation.

Given the scale of commitment towards STI, the competencies and skills of researchers, and the quality of research infrastructures and equipment, Japan has the potential to build a substantial international presence in science and research. Funding is important, but other measures and reforms are also important, perhaps more so than funding alone. It is the ability to reform or restructure current practices, or other regulatory, legal and other system related structures that may determine Japan’s performance over future years. These will also be more difficult to implement given the nature of the political system and political economy.

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# 7 LIST OF ABBREVIATIONS

| | |
|---|---|
| AIST | National Institute of Advanced Industrial Science and Technology (独立行政法人産業技術総合研究所) |
| ARF | Asia Research Fund |
| ATAC | Asian Technology Assessment Center |
| ANR | French National Research Agency |
| ATIC | Asian Technology Incubation Center |
| BBSRC | Biotechnology and Biological Sciences Research Council |
| BERD | Business Expenditure on Research and Development |
| COST | European Cooperation in Science and Technology |
| CSTP | Council for Science and Technology Policy (総合科学技術会議) |
| EPFL | École Polytechnique Fédérale de Lausanne |
| EPSRC | Engineering and Physical Sciences Research Council |
| EU | European Union |
| FDI | Foreign Direct Investment |
| FP | European Framework Programme for Research and Technology Development |
| FTE | Full Time Equivalent |
| GBAORD | Government Budget Appropriations or Outlays on R&D |
| GDP | Gross Domestic Product |
| GERD | Gross Domestic Expenditure on Research and Development |
| GOVERD | Government Intramural Expenditure on R&D |
| HC | Headcount |
| HEI | Higher education institutions |
| HERD | Higher Education Expenditure on Research and Development |
| HES | Higher education sector |
| IAI | Independent Administrative Institution (独立行政法人) |
| ICT | Information and Communications Technology |
| IIS | Institute of Industrial Science (University of Tokyo) ( 生産技術研究所) |
| IMTEK | Department of Microsystems Engineering (IMTEK) at the University of Freiburg |
| IP | Intellectual Property |
| ITER | International Thermonuclear Experimental Reactor |
| JETRO | Japan External Trade Organisation (日本貿易振興機構) |
| J-PARC | Japan Proton Accelerator Research Complex (大強度陽子加速器施設) |
| J-RECIN | Japan Research Career Information Network (研究者人材データベース) |
| JSPS | Japan Society for the Promotion of Science (独立行政法人日本学術振興会) |
| JST | Japan Science and Technology Agency (独立行政法人科学技術振興機構) |
| LIMMS | Laboratory for Integrated Micro-Mechatronic Systems |
| M&A | Merger and Acquisitions |

| | |
|---|---|
| METI | Ministry of Economy, Trade and Industry (経済産業省) |
| MEXT | Ministry of Education, Culture, Sports, Science and Technology (文部科学省) |
| MIC | Ministry of Internal Affairs and Communications (総務省) |
| MICINN | Ministry of Economy and Competitiveness (Spain) |
| MHLW | Ministry of Health, Labour and Welfare (厚生労働) |
| MOFA | Ministry of Foreign Affairs (外務省) |
| MSTI | Main Science and Technology Indicators |
| NEDO | New Energy and Industrial Technology Development Organisation (独立行政法人新エネルギー・産業技術総合開発機構) |
| NIAD-UE | National Institution for Academic Degree and University Evaluation (独立行政法人大学評価・学位授与機構) |
| NIMS | National Institute for Materials Sciences (独立行政法人物質・材料研究機構) |
| NIS | National Innovation System |
| NISTEP | National Institute of Science and Technology Policy (科学技術政策研究所) |
| NSI | National Science Indicators (XXX) |
| ODA | Overseas Development Assistance |
| OECD | Organisation for Economic Cooperation and Development |
| PCT | Patent Cooperation Treaty |
| PRO | Public Research Organisations |
| R&D | Research and development |
| RIKEN | National Institute of Physical and Chemical Research (理化学研究所) |
| SME | Small and Medium Sized Enterprise |
| S&T | Science and technology |
| STI | Science, Technology and Innovation |
| TLO | Technology Licensing Organisation (技術移転機関) |
| URA | University Research Administrator |
| USD | United States Dollars |
| VC | Venture Capital |
| WIPO | World Intellectual Property Organisation |
| WPI | World Premier International Research Center |