EUROPEAN COMMISSION

ERAWATCH COUNTRY REPORTS 2011: Japan

ERAWATCH Network

Lee Woolgar

Acknowledgements and further information:

This analytical country report is one of a series of annual ERAWATCH reports which cover the EU Member States, Countries Associated to the EU Seventh Research Framework Programme (FP7) and, since 2011, selected third countries (ERAWATCH International).

ERAWATCH is a joint initiative of the European Commission's Directorate General for Research and Innovation and Joint Research Centre - Institute for Prospective Technological Studies (JRC-IPTS). The reports are produced, under contract, by the ERAWATCH Network.

The analytical framework and the structure of the reports have been developed by the Institute for Prospective Technological Studies of the Joint Research Centre (JRC-IPTS) with contributions from Directorate General for Research and Innovation and the ERAWATCH Network.

The report is only published in electronic format and is available on the ERAWATCH website (http://erawatch.jrc.ec.europa.eu/). Comments on this report are welcome and should be addressed to jrc-ipts-erawatch-helpdesk@ec.europa.eu.

The author is grateful to Noriyuki Morichika for research assistance in drafting this paper.

Executive Summary

Japan is a large Asian country with a population of 127,787,000 (MIC 2012). This is roughly 8% for the total population of East Asia (United Nations 2011). Japan's level of economic development is high. It has an economy that is ranked as the third largest in the World with a nominal gross domestic product (GDP) of €4,579,204m in 2012; that for the EU27 is €12,875,482m for the same year. By contrast, that for the United States of America was €12,147,830m[1]. Japan is closest to Germany amongst European Union Member States (GDP of €2,652,209m for 2012). The economic crisis had a large effect upon Japan reducing economic growth by 5.5% in 2009, before rebounding to 4.5% in 2010 and settling down to lower rates over 2011 and those forecast for 2012[2]. GDP per capita is equivalent to that of the EU27, with Japan's GDP per capita at €25,000 (2009) while that for the EU27 is €23,600 (€27,200 for the Euro area). As of April 2012, the unemployment rate is 4.6% (MIC 2012).

On 11 March 2011, Japan experienced a magnitude 9.0 earthquake that triggered a chain of events with devastating consequences to the north east coastal areas of the main island, as well as Japan more generally. Over 15,000 lives were lost[3] and infrastructures and accommodation were destroyed, chiefly by the tsunami wave that also incapacitated the Fukushima Daiichi nuclear reactor. This had yet broader consequences for Japan. These events had a negative impact on the economy over subsequent quarters and in June 2011 the government estimated that the cost (not including those associated with the Fukushima reactor) at around €170b (¥16.9 trillion) (MEXT 2012a). The implications have been far reaching and are continuing to be felt across a number of areas. The most pressing issue to resolve, and most controversial, has been Japan's future energy policy. At the time of writing this is still under discussion with the publication of the government's energy plan to be made sometime in the summer of 2012. The place of nuclear power, which accounted for around 30% of energy production (World Nuclear Association 2012), is subject to debate with various scenarios for future energy mixes currently being explored. It is certainly credible that renewables will gain greater adoption than heretofore. For science, technology and innovation (STI) there was damage to research facilities and infrastructures, and in the immediate period the departure of many foreign researchers and students from Japan. The 4th Science and Technology Basic Plan, the main policy framework for STIthat was to be unveiled in the post-quake period, was postponed and then amended with new sections regarding how research can help address the challenges posed by the events, as well as the more general priorities regarding STI and how it should be promoted. The aftermath of the events also led to reflection on the best practices for the communication and management of scientific risk. Poor communications led to a decline of trust in science and technology over the post crisis period (MEXT 2012: 44).

High levels of business expenditure on R&D are the key characteristic of the Japanese innovation system. Policies are important in setting framework conditions, but ultimately it is companies that determine where and how they perform R&D. For the

[1] 2012 data is forecast. See Eurostat (2012: tec00001)

[2] 2011: -0.8%; 2012: forecast of 1.9% (Eurostat 2012: tec00115).

[3] According to the available data, 15,854 people lost their lives. A further 3,089 people are reported as missing. The earthquake and tsunami created over 300,000 evacuees (MEXT 2012).

most part, engagement with other actors is limited due to the autarkic nature of corporate R&D in Japan (Kneller 2007). Open innovation is a concept that is mentioned, but in reality has only modest application. There is overall stability in the concentration of activities by industrial sectors where Japan's R&D landscape continues to be dominated by large companies in the automobile, electronic and medical sectors. Many prominent electronics companies are now confronting major challenges due to their inability to compete in commoditised product markets against Asian competitors. New industrial sectors, such as those observed in the USA that are driven by small scale science based entrepreneurs in specialised markets (Mowery 2009) have not been observed in Japan (Foray and Lhuillery 2010); although researchers are now beginning to recognise the importance that Japanese machinery and component manufacturers play in global value chains (de Backer and Yamano 2012).

In the public sector, Japan has a large and diverse body of universities and graduate schools. These institutions are increasingly being encouraged to reach out to society and play a role in the Japanese innovation system. In international ranking exercises Japanese universities enjoy only modest performance. In other areas, such as citations to particular scientific disciplines such as nanotechnology, physics or chemistry, at an institutional level there are some that perform excellently but performance overall is static or declining at the top levels. There are also many national laboratories specialising in particular areas of research. Many of these also perform very strongly in bibliometric assessments.

Overall, across the range of relevant metrics Japan's innovation system has limited internationalisation. There are numerous initiatives and programmes to redress this. Where cooperation and collaboration occurs, cooperation with European partners particularly at the personal level is relatively strong with high levels of researcher exchange. Joint publications with European partners also show positive trends. Participation in Framework programmes is 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 in the future. At the bilateral level, Japan maintains 22 agreements with European Union member states, as well as six agreements with Associated countries. The 4th Science and Technology Basic Plan talks positively of extending cooperation with Asian partners in areas of mutual interest, as well as extending cooperation with advanced countries to address the major social and economic challenges. Policy outlines are also now advocating the adoption of a Japanese version of the Framework Programme potentially enabling more collaboration with foreign firms.

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, mobility and exchange, but the available data suggests that these have only been modestly successful.

	Recent policy changes	**Assessment of strengths and weaknesses**
Research policy	• 4th S&T Basic Plan • Reforms to the CSTP • Science of Science Policy initiative	• Stronger links with growth strategies than before • Increased emphasis on innovation and addressing societal challenges in new

	Recent policy changes	Assessment of strengths and weaknesses
	• Possible reforms or merger of core national research laboratories	governance structures for STI. • New funding for understanding science and research through the science of science policy initiative. • Lower performance on many research output measure, yet true excellence in many areas.
Innovation policy	• Funding initiatives for life / green innovation • Proposals for new openness in national projects • Renewable Energy Promotion Law	Closer links between STI and societal challenges. • Some fears expressed regarding the status of previously prioritised research fields. • Innovation at the heart of new growth strategies. • Decreasing performance in macro assessments of Japanese innovativeness. • Strengths in high technology components and other aspects of the supply chain; seemingly limited shift in industrial structures over time.
Education policy	- University Reform Action Plan - Initiatives to diversify educational curricula and career options for graduate students - Internationalisation initiatives in the universities - Growth in entrepreneurial education and internships - Possible shift or introduction of an autumn term.	• Plan to strengthen relations between Japan's universities and society, educational curricula, and internationalise the universities. • Continued concern over the relevance and content of educational curricula. • Concern of the modest internationalisation of the universities. • Concerns over the structure of job seeking and alignment between supply and demand.
Other policies	• Inward Investment Policy • Government reorganisation for managing space policy	• Stronger encouragement to attract inward investment than before but macro factors surrounding the Japanese economy may undermine attractiveness. • Redressing societal challenges may see greater employment of a range of different instruments beyond that of treasure.

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. Global challenges are recognised as increased competition for natural resources, energy and food; the economic rise of emerging nations, and the advance of economic globalisation; as well as changes in the functioning and operation of innovation systems. On this latter point, there is a need to develop and strengthen connections between research results and innovation for the creation of new products or industries.

The 4th Science and Technology Basic Plan provides the major pointers on national policies and measures towards various objectives. They are too numerous to list individually but the general measures and orientation 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	4th Science and Technology Basic Plan - Expanded funding for tenure track Positions - Graduate School Enhancement - Researcher promotion programmes - Career path development	- Slow but steady expansion in the number of openings and support structures for women researchers but comparatively low levels of female participation in research, and the labour force more generally - Gradual increases and increasingly positive actions towards foreign scientists but overall limited internationalisation of the labour market for researchers - Limited demand for doctoral graduates by business - Slight declines in doctoral school entry since 2002 - Very limited intersectoral mobility
2	Research infrastructures	4th Science and Technology Basic Plan - Promoting shared use facilities - Research information infrastructure - University facilities and equipment	• Recent research suggests use of these facilities, but various issues surrounding access and lack of sufficient personnel
3	Strengthening research institutions	4th Science and Technology Basic Plan - University Research Administrator - Proposed reform to national research laboratories - Strengthening of basic research - Evaluation Systems -	• Some globally strong centres of excellence in research evidenced through bibliometrics. • Overall declining share in number of publications and citations • Uncertainty over the merger of key research and funding institutes. • Lack of international participation and oversight in management and evaluation of most parts of the research system.
4	Knowledge transfer	4th Science and Technology Basic Plan - New support measures to commercialisation - Regulatory reform to promote innovation - Regional innovation systems - IP Strategies / Standardization	• Continued expansion in the number of agreements between universities and industry. • Low levels of inward R&D investment • Metrics suggest low levels of mobility exchanges and flows across the innovation system.
5	International R&D cooperation with EU member states	4th Science and Technology Basic Plan - New EU/JP jointly funded calls	• New found impetus for strengthening relations between Japan and the EU following S&T Agreement

		- INCO-Lab project implementation - International activities for advanced S&T	• Europe well placed as a location for outward mobility • Interest in adopting or learning from EU Framework programmes
6	International R&D cooperation with non-EU countries	4th Science and Technology Basic Plan - East Asian Science and Innovation Area - Continued efforts to link innovation with overseas development assistance - Expanding network of university offices in overseas countries	• Growing impetus for new, strengthened relations with Asian counterparts; though possibly at risk due to wider political context. • Very limited levels of internationalisation of the innovation, research and education systems.

TABLE OF CONTENTS

1 INTRODUCTION

The main objective of the ERAWATCH International Analytical Country Reports 2011 is to characterise 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 (labour 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 main policy objectives and priorities as expressed in the 4th Science and Technology Basic Plan (2011-2015) are to address the following:

- The direct and indirect damages caused by the Great East Japan Earthquake, tsunami and Fukushima nuclear power station accident;
- An aging and decreasing population with declining social and economic vitality; and
- A long downward trend in industrial competitiveness.

In addition to these domestic challenges, policy makers also highlight the global challenges. These include global-scale problems, and increased competition for natural resources, energy and food; the economic rise of emerging nations, and the advance of economic globalization. The evolution of brain circulation and changes in the functioning of innovation systems are also key challenges (see MEXT 2012a).

The economic rise of Asia is accompanied by new importance placed on strengthening scientific cooperation with countries in the region. This is particularly so in areas of mutual interest to Asian partners such as the environment, energy, food, water or disaster prevention areas (Cabinet Office 2011). At the same time, the 4th Science and Technology Basic Plan recognises 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). Within 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 (discussed in Section 4). Currently there are around 100 FP7 related projects featuring Japanese engagement.

Japan has been actively supporting and science, technology and innovation (STI) since the mid-1990s but a review committee recently noted that "achievements in research and development have not been adequately utilized in society at large, and they have not led to the creation of new industries and employment" (Advisory Council on Science, Technology and Innovation Policy Promotion 2011). There is a need therefore to link the research system more closely with the innovation system than heretofore as well as address the framework conditions that shape technological product diffusion or development. .

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

Japan is a large Asian country with a population of 127,787,000 (MIC 2012). This is roughly 8% for the total population of East Asia (United Nations 2011). Japan's level of economic development is high. It has an economy that is ranked as the third largest in the World with a nominal gross domestic product (GDP) of €4,579,204m in 2012; that for the EU27 is €12,875,482m for the same year, compared to €12,147,830m for the United States of America[4]. Japan is closest to Germany amongst the Member States (GDP of €2,652,209m for 2012). In 2010, Japan was overtaken by China as the World's second largest economy as measured by GDP. The economic crisis had a large effect upon Japan reducing economic growth by 5.5% in 2009, before rebounding to 4.5% in 2010 and settling down to lower rates over 2011 and forecasted for 2012[5]. GDP per capita is equivalent to that of the EU27, with Japan's GDP per capita at €25,000 (2009) while that for the EU27 is €23,600 (€27,200 for the Euro area). As of April 2012, the unemployment rate is 4.6% (MIC 2012).

Research and development (R&D) expenditure as of 2010 was €170b (¥17.1 trillion) (MIC 2011), or 3.57% of GDP. Government expenditure is roughly €37b (¥36,693m and with the addition of supplementary budgets and local government expenditures can rise to €46b per annum. Undoubtedly, however, it is industry that is the main performer of R&D.

Japan's corporate R&D activities are shaped by its key technology markets, with most technological exports destined primarily to North America and Asia. North America is also where most corporate R&D laboratories are located (NISTEP 2011). At the scientific level, around 27% of Japan's papers are internationally co-authored, which tends to be lower than that of other countries[6]. The USA is typically the main partner with 74,973 co-authored scientific publications between 2000-9; 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). Europe tends to be a popular destination for outward mobility of Japanese researchers, particularly for longer term stays (discussed in Section 4.6).

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 CSTP is currently undergoing reform to become a new Council of Science, Technology and Innovation Strategy (Cabinet Office 2011and 2012). This is due both to the need for more strategic control over the innovation system and also in response to the crisis in March 2011. The new body is to have more comprehensive functions as a "watch tower", with increased coordination between ministries, more scientific advice, clearer communication, and more information aggregation and analysis. A new science, technology and innovation advisor and advisory system will also be put in place.

The science and technology basic plans provide stability to policy expectations over five year periods, and although there are frequent changes in political leadership and

---

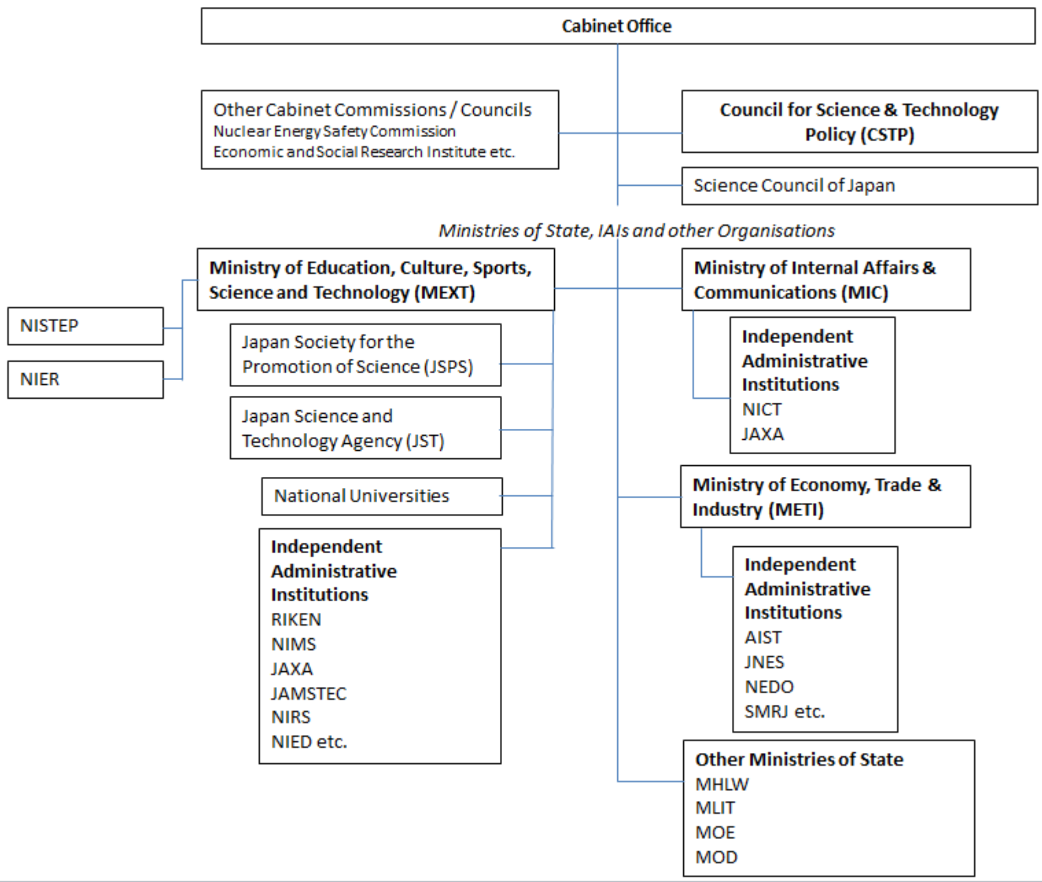
[4] 2012 data is forecasted. See (Eurostat 2012: tec00001)
[5] 2011: -0.8%; 2012: forecast of 1.9% (Eurostat 2012: tec00115).
[6] For instance, Germany (51%), the UK (52%) and France (53%) (NISTEP 2012: 119).

intense levels of party competition that can hinder legislative changes, there is a generally supportive consensus towards STI policy and its promotion.

At the operational level are the main ministries of state. For STI, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Ministry of Economy, Trade and Industry (METI) are the major actors, accounting for 67.8% and 14.4% of governmental expenditures respectively. 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. Other important ministries are the Ministry of Health, Labour and Welfare (MHLW) (4.4% of government R&D expenditures); the Ministry of Internal Affairs and Communications (MIC) (1.5%) which has numerous policies related to information and communications technologies (ICT); and the Ministry of Defense (2.9%) (Cabinet Office 2012).

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 €1.1b (¥116b) (2012)), 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 (2012).

Japan has 47 prefectural governments and eight regions[7]. There is a high concentration of activities around the greater Tokyo region, which has a population of 36.6m people (World Bank 2012: 199), and is the industrial and business centre. Tokyo is followed by the Kansai region (Osaka, Kyoto and Kobe) with a population of 11.3m people. STI performance tends to be aligned with population density: the greater Tokyo area, Kyoto/Osaka area and Nagoya area.

For paper production the following areas dominate: Tokyo (19.87% of total papers), Osaka (7.70%), Ibaraki (6.78%), Kanagawa (6.69%), and Kyoto (6.17%) (2007-2009). By disciplinary focus, Tokyo accounts for most life science papers, followed by Osaka, Kanagawa, Kyoto and Aichi. Okinawa sees the highest growth rate in papers in the life science field, with the Okinawa Institute of Science and Technology (OIST) becoming a new graduate university in 2011. Other scientific fields tend to follow the same patterns of concentration (see NISTEP 2012). Patenting activity follows a broadly similar pattern, but with a much stronger concentration in Tokyo (accounting for 51.6% of patent applications between 2007-9)[8]. Tokyo is followed by Osaka (15.85%), Aichi (8.99%), Kanagawa (5.36%) and Kyoto (2.89%) (NISTEP 2012: 180-181).

On the whole, regional governance in Japan is limited. There are no real local level organisations in Japan other than the regional bureaus of central government ministries with any significant role in innovation policy (OECD 2011). The CSTP estimate that local governments spend around €4.6b per annum on R&D, which are basically fees transferred via MEXT. The OECD has called for greater regional autonomy since 2005, arguing that the Japanese government should transfer more autonomy to local governments by increasing local tax revenue, reducing ear-marked grants and expanding block grants, and abolishing the regional offices of the national government (2011a: 92)[9].

A number of regional initiatives have begun to gain prominence over recent years. The Tsukuba Innovation Arena is the most prominent example where joint initiatives and relationships in the nanotechnology field are being nurtured between research institutions in the area and with industry[10]. The life science cluster around Kyoto is also held up as an example (Ibata-Arens 2009) where there are special zones to support industries and collaboration in the area.

In terms of the share of Gross Domestic Expenditure on R&D (GERD), the business enterprise sector accounts for 78.2%, and is dominated by large firms in the automobile, electronics, and medical sectors. The government sector accounts for 15.6%, which includes just over 100 independent administrative institutions (IAIs), with prominent research organisations such as the National Institute of Physical and Chemical Research (RIKEN) or the National Advanced Institute of Science and Technology (AIST). There is a diverse higher education sector (5.1% of GERD) that comprises 780 universities. The private non-profit sector and funding from abroad account for only small proportions of R&D (0.7% and 0.4% respectively).

[7] These regions, which have no official administrative status, include: Hokkaido, Tohoku, Kanto, Chubu, Kansai, Chugoku, Shikoku and Kyushu.

[8] This concentration may be due to the many of the corporate headquarters being based in Tokyo who will file patent applications on behalf of the company (see NISTEP 2012: 181).

[9] New political movements are emerging in the Kansai region that may campaign in national elections for more regional autonomy.

[10] http://tia-nano.jp/en/index.html

The overall pattern of performance is quite different to that of the EU27. For instance, for the EU as of 2009, 54.1% is performed by industry, 34.9% by government, 14.3% by higher education, 1.6% by the private non-profit sector, and 8.4% from abroad (Eurostat 2012). Both the government and higher education sectors thus play a larger role in the EU than they do in Japan. For the latter governmental intramural expenditure on R&D (GOVERD) accounts for €9,494.024m as of 2008 while for the same year it is €30,537.372m for the EU27 rising to €32,601.919m for 2010) (Eurostat 2012). Higher Education expenditure on R&D (HERD) expenditure is €13,264.342m as of 2008, this compares against €59,509.205m for the EU27 (2010) (Eurostat 2012).

2.3 RESOURCE MOBILISATION

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

Progress towards R&D Investment Targets

R&D expenditure in Japan has been increasing over time. In 2000, €141.7b (¥16.2 trillion) was spent, totalling around 3.19% of GDP. This increased to €170bn by 2010. However, since 2008 GERD intensity has declined from 3.84% of GDP to 3.57% of GDP (2010). The New Growth Strategy decided by the Cabinet Office in June 2010, first outlined the objective of a 4% GERD target of GDP by 2020. This would increase the proportion by the business enterprise sector to 3% (it is currently 2.7%) and the governmental sector to 1% of GDP.

Over the course of the 2000s, industry generally increased their expenditures on R&D, but with the onset of the economic crisis BERD declined by -1.2% and -11.1% for 2008 and 2009. It has since begun to return to positive territory, increasing by 0.4% for fiscal year 2010 (MIC 2011). Issues surrounding the 3% of GDP expenditure target are likely to centre around the hollowing out of the domestic industrial base[11], the potential for future economic growth, and the ability of Japan to either nurture new R&D active industries or to attract R&D active firms from overseas. These topics are discussed in greater detail in section 2.3.3.

At the governmental level, over the course of the 4th Plan the government will aim to spend €250b (¥25 trillion). 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); yet under the 2nd and 3rd plans it only attained around 86% of its specified targets[12]. Whether the government will be able to fully meet the targets set for the 4th Plan may depend not only on the economic growth rate, but also on whether it will be possible to raise additional financing or redirect expenditure from other areas[13],[14].

[11] This is a particular concern due to the appreciation of the Yen against other major currencies (see World Bank 2012: 14).

[12] 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)

[13] Negotiations are currently underway on raising the consumption tax from the current 5% to 10% by 2015. Current discussions centre on using this towards social welfare, which is placing increasing burdens on public expenditure (increasing from 16.6% to 29.2% of public

Provisions for R&D Activities

Four science and technology basic plans have been implemented between the years 1996-2000, 2001-2005, 2006-10, and 2011-2015[15]. While the 1st plan was more concerned with strengthening basic research, the 2nd and 3rd plans prioritised 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[16].

For the 4th Plan these priorities were changed towards addressing societal challenges. This change reflects 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). These changes in priorities have not led to dramatic changes in the budgetary situation, which has been extremely stable, despite the economic crisis since 2008. The immediate response for fiscal year 2009 was to increase expenditure on science and technology through a large supplementary budget (see CSTP 2012). Indeed, there has been a tendency to use supplementary budgets to further top up funding for science and technology (see CSTP 2012)).

Most expenditure on R&D is not aligned with policy priorities. From the total governmental expenditure on R&D of €36.8b (¥3,669.5m) for 2012, the Action Plan component is €2.4b (¥235.9b), and the prioritised project package accounts for €352m (¥35.1b), €5.3b is towards basic policies (such as grant-in-aid; strategic research projects), €11b is for university institutional funds, €8.1b is for independent administrative institution support, as well as other funds. 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 €11.4b (2012) (¥11,423b) (MEXT 2012a). Competitively awarded research grants have increased considerably over the past two decades, rising from €800m (¥82.4b 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 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 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 2011). 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

expenditure between 1990 and 2012) (for an overview of current governmental expenditures, see MOF 2011).

[14] Government revenues have tended to decline over recent years with increased reliance on bond financing. This has risen from 48% to 49% of governmental expenditures between 2010 and 2012. Outstanding bonds account for 148% of GDP as of 2012 (195% if long term local and central government are combined) (Ministry of Finance 2011).

[15] 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).

[16] See Stenberg and Nagano (2009) for funding allocations under this prioritisation.

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. In 2008, direct public funding of BERD amounted to 0.02% GDP while indirect measures such as tax incentives amounted to 0.06% (OECD 2011). Overall, Japan is towards the lower end of the scale in how government supports business investments in R&D (OECD 2012). According to the Ministry of Finance annual outline of taxation policy changes, there have been no new measures introduced regarding R&D taxation recently (see MoF 2011; 2010). In 2012, the government announced that in order to expand foreign direct investment (FDI) it is to initiate exemptions for foreign companies undertaking R&D in Japan (see also Section 2.3.3 below).

Recent policy changes affecting the funding of research

There were a number of changes affecting how research funding is allocated over the past year.

In July 2011, the CSTP published the Resources Allocation Guidelines for the Science and Technology Budget (CSTP 2011). These set out the priorities as stated in the Action Plan for budget prioritisation, which were: 1. Recovery and rebirth of Japan, safety and disaster prevention; 2. Green innovation; 3; Life innovation; 4), basic research and human resource development (CSTP 2011). In a top down fashion the CSTP would then prioritise particular projects in these areas. Furthermore, where ministries outlined areas that would support the objectives of the fourth basic plan through prioritised project package, the CSTP would evaluate these proposals and select the most important (CSTP 2011). In terms of importance, the Action Plan is the major priority; the prioritised project package has secondary importance.

In August 2011 the revised version of the 4th Science and Technology Basic Plan was published (CSTP 2011). There were no changes in the overall funding targets over the course of the plan, but the priorities and key issues were changed.

The main priorities are the reconstruction and revival from the disaster, which includes the rebuilding and revival of industries in the affected areas, renewal of the social infrastructure and a safe living environment in the affected areas. The plan adds STI specific content to the new priorities. For green innovation the emphasis is on the realisation of stable and low carbon energy usage, improvement of energy use and low carbon technology. For life innovation, the priorities are the development of disease prevention and early diagnosis methods, and quality of life for the elderly or disabled. Emphasis is also placed on system wide reforms for the promotion of STI. These include the systems for promotion of STI such as strategy councils and knowledge networks. New systems for developing STI which extends to commercialisation, use of regulatory reform, regional innovation systems, and intellectual property strategies (MEXT 2012b).

Mechanisms to build 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. In the most recent 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, heightening distrust and uncertainty towards science and necessitating the need for new cooperation and openness in how scientific issues are expressed. 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 of 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

The societal challenges facing Japan can be identified as responding to an aging society; effectively managing and responding to the a declining population, energy and the environment, including natural disasters; rare earth materials; combating deflation and stimulating economic growth; and also addressing growing concerns over the fiscal deficit. Since the earthquake, tsunami and nuclear crisis affected Japan, recovery, revitalisation and security against disasters has been added to the list of societal challenges to redress.

More generally, for 2011, Governmental Budgetary Appropriations on R&D (GBAORD) are €32,815m. Of this, 97.3% 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 36.4% of GBAORD. Other important areas include energy 13.3%, industrial production and technology (6.7%), exploration and exploitation of space 6.6%, transport, telecommunications and other infrastructures 2.8%, health 4.4%, and agriculture 3.1% (EUROSTAT 2012).

Within the Action Plan component (€2.4b), there are 38 projects which are oriented to revival and regeneration €480m; 77 projects in the green innovation field (€1.3b); 29 projects in the life innovation field (€391m), and 3 projects in basic research and human resource development €165m (this excludes grant-in-aid expenditures).

Within the prioritised project package (€352m - the bottom-up requests from ministries), there are projects on strengthening industrial competitiveness; quality of life initiatives, and basic research and human resource related schemes.

2.3.2 Providing qualified human resources

There are roughly 660,000 researchers in Japan (or using headcount data, 890,000) (NISTEP 2011). For the total distribution of researchers as of 2010, 74.9% of researchers were in the business enterprise sector, mostly in key sectors such as the automobile sector, and the ICT sector. There are only a small number 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).

For the other main stakeholders, 18.9% are in universities and colleges, 5% in public organisations and 1.2% in non-profit institutions (NISTEP 2011: 65). This distribution pattern is quite different from the EU27 (2009), where 45.0% are employed in the business enterprise sector, 41.1% in universities and colleges, 12.6% in public organisations and 1.3% in non-profit institutes (NISTEP 2011: 65).

Women are poorly represented within the Japanese research landscape, accounting for only 13.6% of researchers in 2010. There is an upward trend in the ratio overall, increasing from 7.9% 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.

Researchers with foreign nationality are also a small component of the labour force, and are mostly employed in public institutions, with only 1.2% of corporate researchers having foreign nationality (NISTEP 2012: 48). Some companies, such as Hitachi or Rakuten, have stated that they wish to increase the number of foreign employees but this is for more general employment rather than researchers specifically. The New Growth Strategy and the 4th Basic Plan talk of making it easier for foreign researchers and specialists to work in Japan. In summer 2012, the Immigration Bureau introduced a new points based system to determine eligibility to migrate to Japan for academic researchers, technical specialists and business managers[17].

Many foreign researchers left Japan following the March crisis, but surveys appear to suggest that many of them subsequently returned (see NISTEP 2012: 74; Kuroki 2011).

Articulation of Education Policies within the Knowledge Triangle

Firstly, it is to be noted that there is no concept of the “knowledge triangle” employed in Japan. Nonetheless, there are currently initiatives to enhance the educational curricula at tertiary levels, and develop vocational training for engineers It should be mentioned that Japanese students perform well in international scientific and mathematical assessments that are undertaken[18]. At the time of writing, MEXT is proposing a new University Reform Action Plan to strengthen engagement with the local community, increase globalisation, and enhance research strengths through governance reforms and more accreditation (MEXT 2012) (these points are discussed further in Section 3.3.1). Programmes towards entrepreneurship training and curricula are promoted chiefly by METI which has a number of programmes in this area.

Universities also have their own schemes and policies in place in these areas. According to a survey by METI around 250 universities are implementing courses which seek to nurture entrepreneurship. The number has gradually increased since 2001, where universities and graduate schools have programmes dedicated to the topic. Such programmes include internships, business plan contests, and visiting lectures by businesspeople (METI 2009).

Debate is occurring on the balance between supply and demand. Limitations have been observed over a number of years in the recruitment of graduates and the employment rate is a closely observed statistic. According to data on those students who wanted to obtain employment after graduation, over 90% of students obtained employment. This increased by 2.6% on 2011 following efforts to match students with employers, particularly in the SME sector (Nikkei Shinbun 2012) where graduates have often been reluctant to work (Keidanren 2010). However, for many young people there has been a growth in non-regular employment and labour market

[17] http://www.immi-moj.go.jp/newimmiact_3/en/index.html

[18] On a country by country basis, in mathematics Japan is at a similar level to the Netherlands or Switzerland; for science performance, which is higher ranked than mathematics, performance is closest to Finland or Estonia (OECD 2010: 135 & 152).

dualism (OECD 2011). Some sectors in particular have shortages, even though they form part of future growth initiatives, such as nursing (see Koll 2011). Furthermore, as many Japanese companies seek growth opportunities in Asia or other parts of the world, they are facing difficulties in recruiting globally minded graduates (METI 2012a). 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). The University Action Plan aims to connect the tuition received in university more closely with the needs of society (MEXT 2012: 7). Other programmes are also in place to enhance international aspects of the Japanese higher education system, such as the Global 30 Programme.

The New Growth Strategy aims 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.

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, declined in the post economic crisis period. It has since started to recover. The overall sectoral composition has not changed greatly, 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). Specifically for BERD as a proportion of GDP, the target as expressed in the New Growth Strategy is for 3% by 2020. 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 Ministry of Internal Affairs and Communications (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).

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 (MIC

2010a: a201). 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 has also changed little over the course of the 2000s (MIC 2011: 6). What has been noted is that since the economic crisis 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).

In longer term perspective, recent assessments of the US industrial landscape and innovation system suggest that policy changes have enabled substantial changes in the nature of the US industrial structure with new industries in biomedical and information technologies emerging, accompanied by the emergence of small science based industries (Mowery 2009). Europe is somewhere behind this trend where traditional industries have tended to increase their specialisation, and modest changes to the overall contours of the industrial structure have occurred (Foray and Lhuillery 2010). Although there have been no substantial studies of a similar nature of Japanese industry, it can be seen as closer to the European landscape than the American, particularly with regard to increased specialisation and an absence of new industrial sectors (Advisory Council on Science, Technology and Innovation Promotion 2011). This is despite widespread emulation of the US innovation policy model since the mid 1990s (see Section 3.4.1).

Policy Mixes towards Increased Private R&D Investment

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

As noted in Section 2.3.1, the government has outlined a target to increase business enterprise sector expenditure to 3% of GDP by 2020, utilising tax incentives to further stimulate industrial R&D (Cabinet Office 2010).

This report has already shown the relative concentration in large firms and the dominance of particular industrial sectors. Amongst such firms it may be difficult to further increase expenditure, especially given the trends witnessed in parts of the electronics industry. The alternatives therefore would be to aim to increase investments from other types of firms and industrial sectors (see Nikkei Shinbun 2011); ensure that those high R&D spending firms already in Japan maintain their presence and do not migrate to lower cost centres; and nurture the growth of new R&D activities, new companies and industries. Absent these factors, then the options would be to lower the corporate tax rate or enhance other tax incentives (METI 2010). On this latter point, surveys suggest that there is scope to increase awareness of this due to its limited visibility and adoption (see NISTEP 2011).

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

There are various policies and programmes to support the promotion of new indigenous R&D firms and they have been a priority since the late 1990s. At a policy level, the Science and Technology Basic Plans have been positive about the role of venture companies and sought to stimulate their growth both through specific funding, procurement initiatives, and growth of the venture capital industry. The New Growth Strategy also talks of the need for nurturing venture companies in the innovative pharmaceutical, medical and nursing industries and has set targets for job creation that number over 1.4m new jobs in the green field and 2.84m new jobs in the life field The intended routes to these ambitious targets is through regulatory reform, R&D, and overseas and domestic market expansion initiatives.

On the funding side, the JST, NEDO, NICT and other ministries and agencies maintain their own support funds, as well as implement the Small Business and Innovation Research (SBIR) scheme. Other funds have also emerged that aim to bridge the gap between research, exploitation and diffusion such as the A-Step scheme operated by the JST[19].

Aside from the low levels of perceived opportunities for entrepreneurial activities and high levels of fear of failure; there is felt to be strong media support given to entrepreneurship and entrepreneurs are gaining a higher social standing (Kelley et al. 2012: 8). Japan continues to face obstacles in nurturing a large venture capital (VC) industry however, and has one of the lowest shares of VC in the OECD area (OECD 2011:93). 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). University ventures, however, continue their year-on-year decline from 2005. Between 2009 and 2010 the number of new ventures dropped from 74 to 47. 2,074 ventures from universities have now been established (MEXT 2012: 16). Some papers have noted that some schemes, such as the SBIR programme have not been effective replacement funding vehicles for smaller companies (Harborne and Hendry 2012).

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

There are no known policies in this area.

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

Currently the proportion of R&D from abroad is very low. As of 2009, this accounts for only 0.4% of GERD in Japan (Eurostat 2012d). In Europe by contrast it is 8.4% of GERD in 2009, and as high as 16% in some countries, such as the UK or Austria (Eurostat 2012d).

In 2010, METI undertook a review as means for developing an Asian technology hub in Japan. Japan has over recent years seen the departure of Novartis, which closed their laboratory in Tsukuba and relocated to Shanghai; Nokia, which relocated from Tokyo to Singapore; and Proctor and Gamble which moved from Kobe to Singapore (METI 2010). The report observed some of the strengths and weaknesses of framework conditions for foreign R&D in Japan, outlining the comparative strengths of Japan regarding the research environment, the environment for recruiting high level human resources, and the intellectual property (IP) regime. Weaknesses were seen to lie in the costs associated with Japan and corporate tax rates (METI 2010). The Invest Japan office in the Cabinet is now aiming to increase FDI to Japan and has set a target of €350b (¥35 trillion) by 2020. Five year exemptions of corporate taxation are being proposed to help stimulate demand (Cabinet Office 2012)[20].

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

The proportion of extramural R&D has tended to increase. Statistics from the MIC suggest that the proportion of self-financed intramural R&D has decreased from

[19] See: http://www.jst.go.jp/a-step/

[20] See: http://www.invest-japan.go.jp/en_index.html

93.9% to 85.1% in 2010 (Prime Minister's Office 1980; MIC 2010). The overall levels of funding are however, lower than those in Europe or the United States, where €2.3b is spent extramurally in the United States, and €2.2b in the EU, only around €90m is spent in Japan extramurally as of 2003 (METI 2008:4). Eurostat data gives the intramural level of expenditure as 0.01% of GDP as of 2008 (it is 0.03% for the EU27 for 2009; the highest level in the EU27 is for Germany (0.07% (2009)).

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. In order to further promote open innovation, METI has proposed to lessen the restrictions on technology exploitation derived from publicly funded research, and opening more government held patents to public use, especially to SMEs. The proportion of HERD financed by industry is comparatively quite low, but has been increasing. There is still scope for this to increase further, but as discussed in Section 2.4 below, extra-mural R&D is dependent on the willingness of firms to engage in such practices. Surveys suggest that internal R&D is still the preferred route for technology development by most firms (see METI 2011). Furthermore, should foreign industries seek to collaborate with universities, there are only a handful which may have the competencies and administrative capabilities to deal with non-Japanese firms.

Overall, however, the systems in place for the public support of industrial R&D from public bodies are transparent and well known. The major agencies such as NEDO, the JST or the National Institute of Information and Communications Technologies (NICT) publish calls through public announcements that are then evaluated and assessed through peer review. These calls all tend to be announced in Japanese so it would be difficult for international firms to participate in these programmes.

Route 6: Increasing R&D in the public sector

Increasing R&D in the public sector is supported through three routes, measures to support research infrastructures and institutional operating expenses, competitively allocated funds, and research agreements with different partners.

As shown in Section 3.2 below, there have been investments for the creation of research infrastructures in Japan. Universities will also now face fewer financial restrictions due to the repeal of the 1% annual reduction in operating expenses, and the continued commitment and support given to investing in STI. Competitive funding has also increased quite substantially over recent years and is now a characteristic feature of the Japanese research landscape. The policy frameworks have been put in place for this, but universities have been relatively slow to capitalise effectively.

Overview of the Policy Mix for R&D

The need to stimulate new sources of R&D expenditures from new industrial sectors and from overseas appears to be well acknowledged. The orientation and routes appear to in accordance with the expenditure targets. The major challenges surround the Japanese political economy more generally. A decreasing population and lower economic growth will impel firms to expand overseas. Under the product cycle model, this would also lead them to expand their R&D overseas, diminishing or replacing activities in the home market. These trends are to some degree occurring already but

R&D has for the most part been kept at home so far.

A further issue is the political capacity to achieve reform. As noted elsewhere in this report, the government has introduced numerous growth strategies over the past decade. As it acknowledges itself, performance in reaching the objectives set out has been relatively modest. It is questionable to what degree policy makers can move towards the new sets of targets. Movement overall appears to be very slow and lagging. A key factor that may explain this is perhaps the scale and size of Japanese industry. This is so large and dominant that it tends to overshadow other aspects of the innovation system: it is largely autarkic, and seems to have only modest links with other actors. As a result, the opportunities for external collaboration with the public sector are lessened. Likewise, the attractiveness of these large firms at a recruitment level may lessen the attractiveness of working in other smaller or more specialised companies or ventures (see Section 2.3.2). New firm growth and ventures have been very modest over the past decade and it is unlikely that new industries or ventures will emerge to trigger new sources of growth. Entrepreneurial training and internships are now encouraged, but they will take time to yield results, and the attitude to risk-taking may further undermine any movements in this area.

The encouragement of inward R&D investment, which has been a priority for other advanced economies for over three decades has only really begun to be taken seriously by policy makers in Japan. It is still uncertain to what degree the policies that have been introduced will be effective but Japan is comparatively late to the game and despite the many research strengths and excellent research facilities in place, there are still many factors which may undermine Japan's attractiveness, including language abilities (see Section 2.4 below), high tax rates, transportation links (see METI 2010), and lack of international exposure. Only a handful of universities would also be competent to deal with international university-industry links and the administrative obligations required. R&D in the public sector continues to be well funded, but as the budgetary situation deteriorates (see fn. 13) then the need for alternative sources of revenue will be more apparent. This will be difficult given the points noted above.

In summation, the routes to achieving higher R&D expenditures appear well recognized and targeted at the policy level. There is, however, some stasis in the innovation system which makes it slow to adjust and change. With more than 10 growth initiatives and strategies over the past decade, it is uncertain to what degree the objectives and strategies from the current raft of documents will be successful. There is perhaps only a slim chance that the expenditure targets will be met by 2020.

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.

Innovation oriented procurement policies

Although procurement is directed towards areas of technology and technological products, it is mostly seen as a commodity. In many areas competition proceeds on the basis of price rather than potential added value. One area that has seen activity over recent years is that for green procurement. The government has enacted a series of laws towards energy efficient goods as part of procurement policy over the past decade.

Other policies affecting R&D investment

Efforts have been made over the past decade to make it easier to establish a company in Japan. The capital requirements were lowered for Kakunin Kabushiki Kaisha (or companies requiring 1 Yen capital). Other costs are also associated with the establishment of these companies such as registration or tax stamps, but they were seen as an effort to make it easier to establish a company. The number of companies being established is relatively stable overtime, but the number of companies ceasing business (exiting the market) tends to exceed establishment rates. This is across most industrial sectors (METI 2011: 180-1). The Ease of Doing Business Survey, undertaken by the World Bank, put Japan at 18th in the world for doing business in 2011 an improvement of one position from the year before (World Bank 2011). In particular, Japan is very poorly ranked on the ease of establishing a company (98th; 23 days), taxation issues (112th), but is 1st on the ease of closing a business, getting credit (15th), trading across borders and enforcing contracts (International Bank for Reconstruction and Development and The World Bank 2011).

More generally, the Japanese economy has rather low levels of competitiveness according to the IMD Competitiveness rankings (Japan is at 27th position for 2012; dropping from 16th in 2006) (IMD 2012), and performs particularly badly at foreign language skills (where it has some of the lowest TOEFL scores globally (135th out of 165 countries) and in Asia (27th out of 30 countries)), governmental efficiency, and the overall economic environment (summarised by Cabinet Office 2011a).

2.4 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. Similar findings have also been observed by OECD analysts (see 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) also poses risks to the structure of knowledge demand. More companies are reported to be considering and investigating the opportunities for undertaking R&D as well as other activities in overseas markets (METI 2012: 12). This will have major implications on the domestic industrial base as well as the performance of research, development and innovation.

The 4th 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, the scale of public funding of industrial R&D is small. Where it does occur then it is through schemes that are implemented in accordance with the priorities set out by the Cabinet Office.

2.5 KNOWLEDGE PRODUCTION

2.5.1 Quality and excellence of knowledge production

Japan is seen to be a relatively good producer of knowledge and technologies with reasonably high production of papers and patents. Performance is tending to decline year on year, and there are mismatches between the levels of inputs and outputs.

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).

In patenting, Japan is also very strong and second in volume to that of the USA in USPTO and EPO applications with around 350,000 applications. The number of applications has been declining over recent years Japan has a large presence in nanotechnology and ICT applications. However, Japan's patent applications have been on a downward trend in recent years. In 2009 in particular, the number of applications fell by 10% compared with 2008 (NISTEP 2012:133).

To broaden this discussion by looking at macro level assessment of inputs and outputs, the European Innovation Scoreboard has traditionally classified Japan as an 'Innovation Leader' (2009). According to the most recent assessment, which does not use such terminology, the EU27's performance is gradually catching up on that of Japan's, but Japan still has a lead in seven indicators[21]. These indicators include R&D expenditure in the business enterprise sector, patent cooperation treaty (PCT) applications, medium to high tech exports, public-private publications, and PCT patents on societal challenges. EU performance is stronger in new doctorate degrees, international co-publications, most cited publications and knowledge intensive service exports (2011: 20).

A second macro level assessment that offers a clear insight into the input/output balance is that of the Global Innovation Index exercise performed by INSEAD and the World Intellectual Property Organisation (WIPO). Under this assessment Japan's performance is not particularly strong. According to the country ranks, Japan is in 20th position, behind many European or Associated countries[22]. Japan was seen to perform reasonably well on indicators in the innovation input sub-index (18th rank) such as researchers, GERD, institutions, some infrastructure aspects (particularly ICT), knowledge workers, and some of the innovation linkages. On the Innovation Output Sub-Index, however, Japan is at 26th position and although performing strongly on patenting aspects, performs poorly on imports and exports of goods and services, FDI inflows, tertiary outbound mobility, renewables in energy use, education expenditures, creative service exports, and growth rate of GDP per person employed (INSEAD 2011). For the 2012 assessment Japan's position deteriorates further to 25th in the world ranking (INSEAD 2012) [23].

---

[21] The lead has declined from 27 points in 2007 to 18 points in 2001. For the USA the lead has also declined but less steeply (from 38 points in 2007 to 31 points in 2011). South Korea has accelerated their lead on the EU27 from 5 points to 17 points over the same time period. Japan's lead declined from 12 indicators in the 2009 report to seven in the 2011 report (see European Commission 2011: 19).

[22] Japan is behind Switzerland (1st), Sweden (2nd), Finland (5th), Denmark (6th), the Netherlands (9th), the United Kingdom (10th), Iceland (11th), Germany (12th), Ireland (13th), Israel (14th), Luxembourg (17th), Norway (18th), Austria (19th).

[23] Some of this decline may be due to the addition of new measures and country inclusion (see INSEAD 2012: 68).

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

New policies aimed at improving the quality and excellence of knowledge production are a regular feature of the Japanese innovation system. Over recent year, attention has been given to training university research administrators; the science of science policy initiative may also yield insights that will feed into policy discussion. International benchmarking is a characteristic feature of policy assessment. Despite this, most institutional and programme evaluations are evaluated only by domestic peers, with only a small number of international assessments.

In January 2012 the government announced that it intends to merge some of Japan's key national research laboratories (Cabinet Office 2012). This includes RIKEN, the National Institute for Materials Science (NIMS), the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), the National Research Institute for Earth Science and Disaster Prevention (NIED) and the Japan Science and Technology Agency (JST). This merger would promote economies of scale and cross-disciplinarity but was a largely unexpected development. Since the announcement there has been no substantial follow up on the status of the plan.

The University Reform Action Plan published in summer 2012 also seeks to enhance the quality and excellence of knowledge production (MEXT 2012). It sets out proposals to enhance university evaluation systems that may include a portrait of each university in terms of its publication profile as well as other strengths, and seek to improve university governance.

International benchmarking is undertaken by NISTEP with their Science and Technology Indicators (2012). 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.

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 research managers use 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. 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. The World Premier International Research Center (WPI 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.

National competitive funding (such as Grants-in-Aid) is evaluated through the peer review process. Mostly, the evaluators are from Japanese institutes, with proceedings mostly performed in Japanese. There are generally no call openings for international evaluators and experts to participate in such schemes. The acceptance ratio is around 28% for new proposals (2012).

At the policy level, there has been ongoing concern over the relative efficiency of expenditure on R&D and the exploitation of outcomes. This has warranted policy attention over a number of years. The latest development is the METI published report that represents a new development in how projects should be structured and oriented. This includes greater use of problem oriented research that enables stronger cooperation between different ministries. The encouragement of foreign companies in these projects is also recommended. METI explicitly refer to this as a Japanese version of the Framework Programme (METI 2012: 32-3).

2.6 KNOWLEDGE CIRCULATION

2.6.1 Knowledge circulation between the universities, PROs and business sectors

Japan has substantially revised the structures through which public-private collaboration should be performed since the late-1990s, under changed conceptions of the role of universities within the economy (Hatakenaka 2010). A series of legal mechanisms, policy guidelines and organisational reforms have been introduced to formalise the process of university-industry cooperation. Such policy measures have been supported by subsidies by METI and MEXT to develop the range of linkages between firms and universities. There are currently 42 Technology Licensing Offices (TLOs) in Japan (JPO 2012). 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 2012: 7). The University Reform Action Plan seeks to further strengthen relations between universities and society, but chiefly related to educational aspects (MEXT 2012).

Although relations are modest, indicators suggest increased flows between the different actors[24]. In terms of industrial financing of higher education expenditure on R&D, this has gradually increased from 2.5% in 1995 to 3.0% in 2008 (OECD 2010). This is still low in comparison to the EU27, which has witnessed an increase from 6.0% to 6.8% up to 2007. Japan's level is similar to that of Denmark (2.2%) (OECD 2010). By modality, the number of collaborative research projects with private companies has been increasing. In 2005 there were 11,054 joint projects and by 2010 the number had risen to 15,544. 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 185 in 2010. 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 6,056 in 2010[25]. Again there are small increases in the number of projects with SMEs (from

[24] See section 3.3.2 for discussion of the management and expertise limitations in Japanese universities.

[25] Ibid and ERAWATCH Research Inventory Report for Japan

1,647 in 2005 to 1,913 in 2010) and with foreign enterprises (41 in 2005 to 88 in 2010).

University patenting activities are broadly stable but have declined from a high in 2007. The number of applications (both overseas and domestically) were 8,527 in 2005 rising to 9,869 in 2007 then declining to 8,675 in 2010. Foreign patent applications tend to be increasing, rising from 15.6% in 2005 to 25.8% in 2010. 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 2007-9 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 €1b (1093b yen), €16m (1.6b yen) for supporting technological seeds and €32m (3.2b yen) for supporting application development (NEDO 2012).

Japan's cluster policies have undergone reform and in 2011 MEXT inaugurated a new Regional Innovation Strategy Support Program. This aims to support and build upon the achievements from earlier cluster initiatives (see MEXT 2011). For 2012, expenditures on regional innovation by MEXT are €114m (11.4b yen). As a response to the earthquake and related crisis in March 2011 special funds have also been allocated to support scientific activities in the affected region. For instance, MEXT's 2012 budget includes funding for a new marine science centre in Tohoku €15m (1.5b yen), new energy projects in the region, a plan for a medical megabank, advanced materials technology projects and university-industry projects in the region, and other initiatives (see MEXT 2012).

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.
- Japan has shifted its policy orientation towards addressing the major social, economic and environmental challenges. Previous funding of science and technology has not yielded major economic benefit and has been poorly translated and integrated. Japan performs well on input related measures, but is less successful at outputs to innovation.
- 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-sectoral 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.
- There is an imbalance between inputs and outputs and an increasingly recognised failure to fully capture benefit from the investments being made in STI.
- Paper production, citations and patenting are tending to decline numerically and as a global share.
- Efforts have continuously been made to strengthen the relationship between science and society. The series of catastrophic events in spring 2011 have fundamentally altered that balance. New systems are now being put in place to improve how science is communicated and managed.
- 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 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 and sectors. 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

The 4th Science and Technology Basic Plan acknowledges that under previous plans importance had chiefly been placed on graduate school provision, with modest attention given to researcher career paths. 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).

Firstly, overall Japan has relatively high levels of researcher stocks on a full time 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 10.0 FTE researchers per thousand total employment. This has increased from 4.9 in 1995 (OECD 2010: 31). 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 students in Japan in 2009. Entry to doctoral schools has recently been in a horizontal trend, having initially declined from 2003. In 2010, around 16,000 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).

The impact of the economic crisis from 2008 on researcher careers is difficult to ascertain. The unemployment rate for Japan increased from 3.9% in 2007 to 5.1% in 2009 and 2010 (OECD 2012). As of Q1, 2012 the unemployment rate is 4.5% (in comparison to 10.1% for the EU27) (OECD 2012a). Looking at national data on unemployment levels by the occupation of the previous job, there is no distinct category for researchers.

3.1.2 Providing attractive employment and working conditions

There has been an expansion in the number of temporary short-term positions for those employed in research in Japan, with an aging of faculty. Time that researchers are spending on research has diminished due to other obligations such as teaching and administration duties. Policy is now trying to redress these issues through expanding tenure track programmes and enabling researchers to move to different sectors. Institutional support is also being developed.

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 (MEXT 2010). 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, with MEXT increasing the number of tenure track openings in the 2012 budgetary statement (MEXT 2012). 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 who instead have increased their time for teaching, or other administrative activities. A paper by Kagami and Kuwahara found that time for research had declined from just under half to 36.1% of time between 2002 and 2008. The decline was largely seen to be due to increases in the time given to education and public service (2011). Policies have been introduced to redress this situation and are discussed further in Section 3.3.2.

Gross 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).

The low levels of female participation in the research labour force as mentioned in 2.3.2 is due to issues surrounding inadequate maternity leave, insufficient family and child support, and contract duration (CSTP 2009). It should be emphasised that these are issues that are not limited to those employed in research. Nonetheless, the 4th Science and Technology Basic Plan has introduced numerous objectives towards female researchers including increasing the proportion of females with doctoral degrees in science, engineering, agriculture and other fields; improving facilities such as those for childcare and other types of support that will enable women to maintain their careers. The government will also draft a specific plan regarding the promotion of research careers for women. According to Japanese regulations, maternity leave is supported six weeks until birth, and eight weeks following child birth. Following which it is also possible to have leave of absence if the child is less than one and a half years old (MHLW 2011a).

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). As noted in 2.3.2, 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 or projects. 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 years of schooling, 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).

Joint or double degrees have been encouraged at undergraduate and postgraduate levels as part of the package to attract 300,000 foreign students to Japan. According to data from 2008, which is the most recent that could be located, 84 Japanese universities had close to 250 double degree programmes for that year. Most of these were at the Master level. One barrier that has been recognised for some time is the structure of the academic year in Japan (MEXT 2012). Due to the academic year beginning in April it has been difficult to align courses with international institutions. Since 2011, the University of Tokyo, considered by most exercises to be the lead institution in Japan has initiated a debate on shifting the academic year to Autumn, in line with universities around the world. Other universities in Japan are also now moving in this direction.

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 one 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 standardise 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).

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)[26]. Some research suggests that there are various issues surrounding access and lack of sufficient personnel (Ito 2012).

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 780 universities in Japan, with three main categories:

- National University Corporations (86 Institutions)

- Public Universities (95 Institutions)

- Private Universities (599 Institutions) (MIC 2012)

The National universities obtain their funding directly from the Ministry of Education; whilst the Public universities tend to have stronger connections and receipt of funding from local governments. The private universities obtain some national funding, but for the most part obtain their funds from private sources. The percentage of higher education expenditure on R&D as a percentage of GDP is 0.4% as of 2008. This is equal to 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). As of 2009, around 30% of students enrolled in undergraduate courses are studying natural science and engineering, agricultural sciences, or medical sciences; close to half are studying social science and humanities courses. 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 remainder work in non-manufacturing 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 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

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

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 rather than the content and performance during the degree itself (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 percent of Master degrees students and 24.6 percent of doctoral students (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%[27], 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 2011), Japan has no institutions in the top 20 ranking, five institutions are in the top 100 rankings, and four institutions are in the top 101-200 institutions, with 14 institutions in the 201-500 rankings. By contrast, there are 32 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

[27] 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).

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.

There are no official comparisons of institutional bibliometric performance, although macro-level indicators are used in NISTEP assessments (see NISTEP 2012). 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 2012). By field, some Japanese universities have very strong performance. Tohoku University is ranked 3rd in the World for materials science citations; the University of Tokyo is 3rd for physics citations; Kyoto University is 4th for chemistry citations; the University of Tokyo is 3rd for biology and biochemistry citations, and Osaka University is 4th for immunology citations (Thomson Reuters 2012).

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 are 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).

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) (MEXT 2012a). Additional income for the universities is derived from medical fees from hospitals (30%), students' 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 to 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% (MEXT 2012b). 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-inventorship 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

As shown in Section 2.3.3, there has been a drop in university ventures in recent years. Policies in the area comprise both funding and other types of support. 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 tends to be intra-sectoral and limited by the needs of companies, the types of training in universities, as well as the pension systems. 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 terms of collaborative research projects for the national universities, 23.9% are with SMEs as of 2008. This has declined overall since 2002, when 34.4% of collaborative research projects were with SMEs. Overall for all three types of university, the level of collaboration with SMEs is 23.5% for 2008. With entrusted, contract projects the proportion of collaboration between the national universities and SMEs is 3.8%. For all three universities it is 8.8%.

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.

3.5 ASSESSMENT

To summarise this section, it is apparent that Japan has high numbers of human resources in science and technology dominated by the business enterprise sector. Researchers in Japan are generally well-paid, but 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 science, 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 4th 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

The logic for cooperation in international government organisations and schemes is expressed as the need to access excellent research knowledge and equipment, as well as strengthen the domestic research base. Japan participates in the following intergovernmental projects (MOFA 2012):

- International Thermonuclear Experimental Reactor (ITER)
- International Science and Technology Center (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 three main initiatives aiming at promoting Japanese participation in European projects. The J-Bilat project is operated by the EU-Japan Centre for Industrial Cooperation and provides Japanese services and support as well as the organisation of events in Japan to promote FP7 participation. It has included a range of Japanese liaising organisations.[28] A second project is CONCERT-Japan[29] operated by TUBITAK in Turkey which is an ERA-NET to promote coordinated science and technology cooperation between Europe and Japan. They are to launch the first jointly funded call in 2012 in the areas of efficient energy storage and distribution and resilience against disasters. A third relevant project is Euraxess Links Japan[30] which aims to support research researcher mobility and cooperation between Europe and Japan.

Japan's participation in FP7 is, given the size of its innovation system, low. Altogether, there are 100 main listed projects in which actors from Japan are involved. Most (47) of these are collaborative projects (199 proposals) (dominated by the ICT sector – 22 main listed proposals), followed by health. There are 35 Marie Curie awards (102 proposals submitted) and 14 coordination and support actions (53 proposals submitted). There were 379 applications from 456 applicants, with 100 accepted projects that include 123 applicants, an acceptance ratio of 26.7%. The total budget of main listed proposals is 445m.

It is likely that Japan's presence in framework programmes is to increase now that there is a Science and Technology Agreement in place (European Commission 2011). Under the INCO call announced in 2010 a new joint laboratory in Japan has now been established. 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) will see 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). Some examples of participation include the Japan Advanced Institute for Science and Technology (JAIST) and the National Institute of Communications and Technology (NICT) in IC1004 on wireless cooperative communications supporting green (less-energy consuming) society. Musashi Institute of Technology is a member of C24 (Analysis and design of

[28] http://www.j-bilat.eu/index.php?content=j-bilat-en
[29] http://www.concertjapan.eu/node/95
[30] http://ec.europa.eu/euraxess/links/japan/index_en.htm

Innovative Systems for Low-EXergy in the Built Environment (COSTeXergy)) project, the Research Institute for Sustainable Humanosphere (RISH) are a member of IE0601 on wood science for conservation of cultural heritage (WoodCulther); the Forestry and Forest Products Research Institute and Nagoya University are members of the Belowground carbon turnover in European forests (FP803); Tokyo Institute of Technology are involved in the Physics of Competition and Conflicts (M081) project (COST 2011).

4.3.2 Bi- and multilateral agreements with EU countries

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 where there is exchange of information on databases and updated data. Japan is also a signatory in the ITER programme.

The EU and Japan signed a Science and Technology Agreement in 2009. This was ratified on 29 March 2011.

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, Bosnia and Herzegovina (MOFA 2011).

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 2012. Each of these projects includes participation with European actors (JSPS 2012a). Under the Integrated Action Initiatives, in 2011 four projects were adopted. Similarly they all involved European participation (JSPS 2012b).

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 4th 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. Agreements range from those that address specific topics such as atomic physics, electronics, agriculture, 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.

- 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 program that promotes international joint research targeting global issues. This programme is with developing countries.
- 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 Programs 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 Program, A3 Science Platform Program, Core University Program, 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 recently become an important issue for researchers in Japan. There has been a trend for young researchers to not leave Japan for long term periods for research. When looking at inward mobility, The number of Europeans visiting Japan is also high, with around 27% of Japan's papers are internationally co-authored, which is lower than that of other countries such as Germany (51%), the UK (52%) and France (53%) (NISTEP 2011: 119).

For transnational inward mobility, there has been an upward trend in the number of researchers coming from Asia on a short-term basis from 3,994 in FY1999 to 13,367 in FY2009 (MEXT 2010c). At a policy level, there is increasing recognition that Japan should aim to introduce measures to attract more researchers and students from overseas to help foster the internationalisation of Japan's educational system, as well as attract capable students to Japan. At the student level, MEXT introduced a target for attracting 300,000 overseas students to Japan's universities by 2020. More recently the New Growth Strategy, which is the centrepiece strategy for the government in the period up to 2020, mentions the importance of making it easier for 'foreigners to work in Japan as researchers and in positions requiring specialist expertise' (Cabinet Office 2010: 25).

The main mobility schemes 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 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[31]. 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). In the 2010 supplementary budget a new scheme was introduced to extend opportunities for Japanese researchers to go overseas. This programme only ran for one year however, and has not been extended (JSPS 2009).

The budgetary outline from MEXT, 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).

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

5 CONCLUSIONS

Japan continues to enjoy a reputation as a "technological powerhouse" and "innovation leader" yet its performance across many measures does not justify these labels. Although there are undoubtedly pockets of true excellence and strength, on most macro level benchmarks Japan is a high level performer when all the different factors that shape innovation are considered, but is not at the forefront. There is a clear imbalance between inputs and outputs due to the structure of the innovation system and the range of different factors covered in this report.

Over the past year, much has changed for the innovation system. This was to be expected as a new Science and Technology Basic Plan was anticipated. However, the earthquake, tsunami and nuclear crisis added a further element of change. Even after one year the full implications of this series of events are still not apparent, particularly in the energy field where much discussion, debate and public protest has been underway. Given the likelihood that renewable energy sources are to gain greater importance than before, this could have broader influences on other areas of innovation and policy areas in the future, such as the structure of regional governance or revitalisation, energy supply, competition policy, building standards and energy efficiency, or many other areas. The events of March 2011 may thus trigger sweeping changes to the innovation system and the economic structure. For instance, historically the energy crisis of the 1970s is largely seen to have positively influenced the performance and structure of Japanese firms. The current energy crisis could possibly act in similar ways.

What is clear is that the questions over how STI has contributed to Japanese economic growth which had been arising over the past five or so years have now prompted a dramatic change and reorientation of the system. This is towards societal challenges and broader systemic reforms that are being talked about at governance levels, funding levels, and systemic levels. There are still many barriers and gaps within the Japanese STI system and the 4th basic plan will aim to strengthen the linkages between different actors within the system. In many ways the policy environment is one of the easier factors to change. What is more difficult is the institutional rigidity of corporate activities in terms of how R&D is performed and how recruitment is undertaken. Even though about €75b of public expenditure has been spent on R&D since the mid 1990s, the realisable benefits are not readily apparent. There is thus an input / output inbalance that will be difficult to sustain should Japan's financial situation worsen further. What is more is that many of the policy reforms that were introduced to nurture innovation and develop new industrial structures were derived from the US innovation model. At similar time points in the policy cycle Japan shows a significant lag on the US suggesting either that the model is somehow inappropriate for the Japanese economy or that further reforms are necessary.

As Japan is now aiming to increase investment in STI to 4% of GDP, it will need to nurture new industries, attract more R&D and retain current highly R&D intensive industries. This will require the maintenance of Japan's high level stocks in human resources, and will also require other reforms concerning attitudes towards failure and risk taking, competition and incentive structures, as well as openness to foreign companies and personnel. Policy makers are embracing these notions and new curricula and programmes are being introduced in universities to encourage entrepreneurialism, accompanied by new policies to attract FDI, and expand cooperation and linkages between different stakeholders. Again the issue will come down to overcoming institutional rigidities towards a more open and flexible system.

Internationalisation and international linkages have been one of the key factors that have arisen in this report. On most measures Japan has weak international linkages: personal mobility; joint papers; participation in international projects; inward FDI all tend to be at the low end of the scale. Some suggest that this can undermine aspects of the Japanese economy and technological development strategies which can become introverted. This is a controversial issue and one that has both supportive and contradictory elements. Nonetheless, the widespread absence of an international dimension or international evaluation diminishes opportunities to learn of international insights and perspectives to truly assess comparable performance of much of the public research that is being funded. As shown, a lot of research in Japan is excellent, both in publication performance and in technology development. More widespread international evaluation of competitive funding and programmes may contribute to further development of other fields as well as present new opportunities and linkages.

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 further increase scientific and innovative performance. Funding is important to maintain these levels, but other measures and reforms will also be important. 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.

6 References

Advisory Council on Science, Technology and Innovation Policy Promotion 2011), Advisory Council on Science, Technology and Innovation Policy Promotion Report, 19 December

Cabinet Office (2011), *Kagaku Gijutsu Kihon Keikaku (Science and Technology Basic Plan*, 19 August, available from: http://www8.cao.go.jp/cstp/kihonkeikaku/4honbun.pdf

Cabinet Office (2011a), Kanren Shiryō / Data Shū, http://www.kantei.go.jp/jp/singi/global/dai2/siryou4.pdf

Cabinet Office (2012) (TLO data) http://www8.cao.go.jp/cstp/tyousakai/innovation/3kai/sanko1-1.pdf

Cabinet Office, (2012), Heisei 24 Nen do Kagaku Gijyutsu Kankei Yosan An no Gaiyō ni tsuite, February, available from: http://www8.cao.go.jp/cstp/budget/h24yosan120223v1.pdf

Cabinet Office, (2012), Invest Japan http://www.invest-japan.go.jp/program/en_index.html

Cabinet Office (2012), Dokuritsu gyosei hōjin no seido oyobi soshiki no minaoshi no kihon hōshin, 20 January, available from: http://www.cao.go.jp/gyouseisasshin/contents/03/pdf/120120_khoshin.pdf

Chesborough, H., (2003), *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business School Press

CNRS, (2012), *EUJO-LIMMS: Launch of the European Commission's First Japan Based International Laboratory*, 30 January http://www2.cnrs.fr/en/1971.htm

CSTP (2011), Heisei 24 nen do Kagaku Gijutsu Kankei Yosan no Jyūtenka ni tsuite, 26 September

De Backer K. and Yamano, N., (2012), *International Comparative Evidence on Global Value Chains,* OECD Science, Technology and Industry Working Paper 2012/3, DSTI/DOC (2012) 3

Dietl, M., (2012), COST General Presentation, February 2012, http://www.cost.eu/download/aboutcost2012_2013

European Central Bank, (2012), Euro Foreign Exchange Reference Rates, http://www.ecb.int/stats/exchange/eurofxref/html/index.en.html

European Commission, (2011), Innovation Union Competitiveness Report, 2011 Edition, http://ec.europa.eu/research/innovation-union/pdf/competitiveness-report/2011/iuc2011-full-report.pdf#view=fit&pagemode=none

European Commission, (2011), Innovation Union Scoreboard 2011, http://ec.europa.eu/enterprise/policies/innovation/files/ius-2011_en.pdf

European Commission, (2011), Fourth FP7 Monitoring Report 2010, http://ec.europa.eu/research/evaluations/pdf/archive/fp7_monitoring_reports/fourth_fp7_monitoring_report.pdf

Eurostat (2012), Science, Technology and Innovation Database, http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/database

Eurostat, (2012), Total GBAORD by NABS 2007 Socio-Economic Objectives (gba_nbafin07), Last update: 23-04-2012

Eurostat, (2012c), Key indicators - GERD by source of funds (%) [rd_e_fundgerd] Last update: 06-03-2012

Eurostat (2012d), Key indicators - GERD by source of funds (%), 6 March

Eurostat, (2012e), Tertiary students (ISCED 5-6) by field of education and sex, 19 June

Fasol, G., (2012), *How to turn Galapagos into a Competitive Advantage in both Directions,* talk at the European Institute of Japanese Studies, Embassy of Tokyo, 13 June

Foray, D., and Lhuillery, S., (2010), Structural Changes in Industrial R&D in Europe and the US: Towards a New Model? *Science and Public Policy,* Vol. 37, No. 6

Franzoni, C., et al., (2012), *Foreign Born Scientists: Mobility Patterns for Sixteen Countries*, NBER Working Paper 18067, May 2012

Fuyuno, I., (2012), Numbers of Young Scientists Declining in Japan, *Nature*, 20 March

Harborne, P., and Hendry, C., (2012), Commercialising New Energy Technologies: Failure of the Japanese Machine? *Technology Analysis & Strategic Management,* Vol. 24, No. 5, May 2012, 497-510

Hatenaka, S., (2010), What's the Point of Universities? The Economic Role of Universities in Japan, *Japan Forum*, 22(1-2), pp. 89-119

Ibata-Arens, K., (2009), Kyoto Cluster Culture: National and Regional Entrepreneurship Strategy and Policy in Japan and the United States*, Asian Business & Management*, 8, 395-428

IMF, (2012), *World Economic Outlook: Growth Resuming, Dangers Remain*, April 2012 http://www.imf.org/external/pubs/ft/weo/2012/01/pdf/text.pdf

Inomata, S., (2012), *Expansion of the Tenure Track Scheme,* talk given at the German Research Foundation (DFG) Expert Meeting, Competing for Young Talent: Tenure Track as Best Career Track? (Japan and Germany in Comparison), Tokyo, 26 April 2012

INSEAD, (2011), *The Global Innovation Index 2011*, http://www.globalinnovationindex.org

International Bank for Reconstruction and Development and The World Bank (2011), *Doing Business 2011: Making a Difference for Entrepreneurs*, available from: http://www.doingbusiness.org/~/media/FPDKM/Doing%20Business/Documents/Annual-Reports/English/DB11-FullReport.pdf

Ito, Y. (2012), *Proposal on Shared University Research Facilities and Equipment - Status of the Usage of Research Facilities and Equipment by University Researchers outside their Affiliated Laboratories*, NISTEP Discussion Paper No. 85, August

JSPS (2011), J*apan Society for the Promotion of Science Brochure*, October

JSPS (2012a), *Strategic Research Networks: List of Adopted Projects in FY2012*, http://www.jsps.go.jp/english/e-core_to_core/h24_kokusai_ichiran.html

JSPS, (2012b), *Integrated Action Initiatives: List of Adopted Projects in FY2011*, http://www.jsps.go.jp/english/e-core_to_core/h23_kyoten_ichiran.html

JVR, (2012a), *Regular Report: Japanese Venture Funds Launched in 2011,* 4 June http://www.jvr.jp/news-press-releases/jvr-news/20120604

JVR, (2012b), *Regular Report: 2011 Japan IPO Survey*, 9 May http://www.jvr.jp/news-press-releases/jvr-news/20120509

Kanda, Y., and Kuwahara, T., (2011), *Shrinking Research Time for University Faculty Members Comparison of 2002 and 2008 in the "Survey on Full-Time Equivalents at Universities*", December, Discussion Paper No. 80, National Institute of Science and Technology Policy

Keidanren, (2010), Chūsho Kigyō wo Sasaeru Jinzai no Kakuho, Teichaku Ikusei ni Kansuru Hōkokusho, 20 July http://www.keidanren.or.jp/japanese/policy/2010/064/part1.pdf

Kelley, D., et al., (2012), Global Entrepreneurship Monitor 2011 Global Report, 19 January http://www.gemconsortium.org/docs/2201/gem-2011-global-report

Kneller, R., (2007), Bridging Islands: Venture Companies and the Future of Japanese and American Industry, Oxford: Oxford University Press

Kneller, R., (2011), Invention Management in Japanese Universities and its Implications for Innovation: Insights from the University of Tokyo, in Wong, P. K., (Ed.), (2011), Academic Entrepreneurship in Asia: The Role and Impact of Universities in National Innovation Systems,

Koll, J., (2011), Poised for Prosperity, in *Reimagining Japan: The Quest for a Future that Works*, McKinsey and Company, San Francisco

Kuroki, T., (2011), WPI Centers on March 11, 2011 and Aftermath, available from: http://www.jsps.go.jp/english/e-toplevel/data/e_WPI_PDreport_on_M9quake.pdf

METI, (2011), *White Paper on Small and Medium Sized Enterprises in Japan: Rebuilding from the Earthquake and Surmounting Growth Constraints*, Japan Small Business Research Institute, available from: http://www.chusho.meti.go.jp/pamflet/hakusyo/h23/h23_1/2011hakusho_eng.pdf
METI, (2012), Sangyō Kōzō Bangikai – Sangyō Gijyutsu Bunkakai kenkyu kaihatsu http://www.meti.go.jp/press/2012/04/20120411001/20120411001-3.pdf
METI, (2012a), Heisei 24 Nen han Tsushō Hakusho Gaiyō, June, http://www.meti.go.jp/report/tsuhaku2012/2012honbun_p/2012_gaiyou.pdf
MEXT, (2011), *Regional Innovation Strategy Support Program*, available from: http://www.mext.go.jp/english/science_technology/1313333.htm
MEXT, (2012) White Paper on Science and Technology, available from: http://www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2012/06/15/1322246_007.pdf
MEXT (2012a), White Paper on Science and Technology, available from: http://www.mext.go.jp/b_menu/hakusho/html/hpaa201201/detail/1322246.htm
MEXT, (2012b) Kokuritsu Daigaku Hōjin nado no Heisei 22 Jigyō Nendo Kessan nado ni Tsuite, available from: http://www.mext.go.jp/a_menu/koutou/houjin/detail/__icsFiles/afieldfile/2012/03/29/1319048_01.pdf
MEXT, (2012b), The 4th Science and Technology Basic Plan (Tentative Translation), available from: http://www.mext.go.jp/component/english/__icsFiles/afieldfile/2012/02/22/1316511_01.pdf
MEXT, (2012), Kokusai Kenkyū Kōryū no Gaiyō (Outline of International Research Flows), 18 April, Ministry of Education, Culture, Sports, Science and Technology, available from: http://www.mext.go.jp/a_menu/kagaku/kokusai/tyousa/__icsFiles/afieldfile/2012/05/18/1260318_01_1.pdf
MEXT, (2012), University Reform Action Plan, available from: http://www.mext.go.jp/b_menu/houdou/24/06/1321798.htm
MEXT, (2012a), Heisei 24 Nendo Monbukagashō Kankei Yosan An ni Tsuite, available from: http://www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2012/02/07/1314488_17.pdf
MEXT, (2012b) http://www.mext.go.jp/component/a_menu/science/detail/__icsFiles/afieldfile/2012/06/04/1321737_01.pdf
MEXT (2012) Budgetary Statement for Fiscal Year 2012 http://www.mext.go.jp/component/b_menu/other/__icsFiles/afieldfile/2011/10/05/1311679_009.pdf
MEXT, (2012), Kaigai no Daigaku to no Double Degree nado no suishin no taiou ni tsuite (An), 14 January, available from: http://www.mext.go.jp/b_menu/shingi/chukyo/chukyo4/027/siryo/__icsFiles/afieldfile/2011/01/26/1301488_03_1.pdf
MIC (2012), Basic School Survey, 6 February, available from: www.e-stat.go.jp/SG1/estat/List.do?bid=000001037169&cycode=0
MIC (2012), Population final estimate 1 Dec. 2011 http://www.stat.go.jp/english/data/jinsui/tsuki/index.htm
MIC, (2011), Heisei 23 Nen Kagaku Gijutsu Kenkyū Chōsa Kekka no Gaiyō, available from: http://www.stat.go.jp/data/kagaku/2011/pdf/23youyak.pdf
MHLW, (2012), *Outline of Results for the Basic Statistical Survey on Wage Structures*, Ministry of Health, Labour, and Welfare, available at: http://www.mhlw.go.jp/toukei/itiran/roudou/chingin/kouzou/z2011/index.html
MOF, (2011), *Japan's Fiscal Condition (Provisional Translation),* December 2011, Ministry of Finance, available from: http://www.mof.go.jp/english/budget/budget/fy2012/e20111224b.pdf

MOFA (2012), Waga Kuni no Sanka suru Shuyo na Takokukan Kagaku Gikutsu Kyoryoku no Torikumi, available from: available from:http://www.mofa.go.jp/mofaj/gaiko/technology/takoku/pdfs/koken.pdf
MOFA, (2011), Nikokukan Kagaku Gijutsu Kyōryoku no Wakugumi, available from: http://www.mofa.go.jp/mofaj/gaiko/technology/nikoku/framework.html
Motohashi, K., (2008), Licensing or Not Licensing? An empirical analysis of the strategic use of Patents by Japanese firms, *Research Policy,* Vol. 37(9), pp. 1548-1555
Mowery, D., (2009), Plus Ca Change: Industrial R&D in the "Third Industrial Revolution" , *Industrial and Corporate Change*, Vol. 18, Issue 1, pp. 1-50
NEDO, (2011), *Profile of NEDO*, October http://www.nedo.go.jp/content/100079541.pdf
NEDO, (2012), *Profile of NEDO April 2011-March 2012*, http://www.nedo.go.jp/content/100079541.pdf
Nikkei Shinbun, (2012), College Grad Employment Up from Last Year, 15 May Evening Edition
Nikkei Shinbun, (2012), *Globalizing Campus Comes with High Costs*, 7 May
NISTEP, (2011), Survey on Research Activities of Private Corporations (2010, October,
NISTEP, (2012*), Analysis on Research activities and Financial Situation of Doctoral Graduates from University in Japan at Fiscal Year 2010*, March
NISTEP, (2012), Japanese Science and Technology Indicators 2012, National Institute of Science and Technology Policy
OECD, (2010), *PISA 2009 Results: What Students Know and Can Do - Student Performance in Reading, Mathematics and Science, (Volume 1),* http://www.oecd.org/dataoecd/10/61/48852548.pdf
OECD, (2011), OECD Science, Technology and Industry Scoreboard 2011
OECD, (2011a), *OECD Economic Surveys: Japan 2011*, April 2011, Paris: OECD
OECD, (2012), *Gross Domestic Product: GDP Per Head US $, Current Prices*, Current PPPs, OECD.StatExtracts
OECD (2012), *Harmonised Unemployment Rates – Percentage of Civilian Labour Force*, Seasonally Adjusted, http://www.oecd-ilibrary.org/economics/harmonised-unemployment-rates-2012_unemp-hur-table-2012-1-en
OECD, (2012a), *Key Short Term Economic Indicators: Harmonised Unemployment Rate,* http://stats.oecd.org/index.aspx?queryid=21760
Pilling, D., (2012), Sayonara Decline! Japan is Globetrotting Again, *Financial Times*, 6 June
Shaede, U., (2011), *Show me the Money: Japan's Most Profitable Companies in the 2000s*, School of International Relations and Pacific Studies, University of California, San Diego, Working Paper, February 2011
Stenberg, L., and Nagano, H., (2009), *Priority Setting in Japanese Research and Innovation Policy*, Vinnova http://www.vinnova.se/sv/Aktuellt--publicerat/Publikationer/Produkter/Priority-setting-in-Japanese-Research-and-Innovation-Policy/
Thomson Reuters, *Ranking of Japanese Research Institutes by Papers Citations*, available from: , http://ip-science.thomsonreuters.jp/press/release/2012/esi2012/
United Nations, (2011), *World Population Prospects: The 2010 Revision*, http://esa.un.org/unpd/wpp/.
University of Tokyo 2011, *Propius21*, September http://www.ducr.u-tokyo.ac.jp/jp/materials/pdf/20110913Proprius21jp.pdf
University of Tokyo, (2012), *Forest 2015*, 2012 Revised Version http://www.u-tokyo.ac.jp/scenario/pdf/2012action_scenario_c_all.pdf
Woolgar, L., (2012), *The European Funding for Researchers and Students in Japan*, Delegation of the European Union to Japan, Tokyo
World Bank (2012), *World Development Indicators 2012*, April http://www.imf.org/external/pubs/ft/weo/2012/01/pdf/text.pdf
World Nuclear Association (2012), *Japanese Nuclear Energy*, 21 June 2012 http://www.world-nuclear.org/info/inf79*.html*

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
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)
JREC-IN	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
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 (世界トップレベル研究拠点プログラム)