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Reinventing Japan Inc.: Twenty-First Century Innovation Strategies in Japan

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Abstract *Japan has been a key player in the global competition based on scientific and technological innovation. Through a series of Science and Technology Basic Plans, the national government sought to restructure the country's approach to scientific and technological development, with initiatives ranging from a fundamental restructuring of public universities to major investments in regional clusters. Collaboration with business has likewise been a centerpiece of the Japan strategy, as has high level political leadership of the broad initiative. This paper examines the international and national context of Japanese innovation, outlines the core elements of the Japanese innovation strategy, and provides preliminary observations about the first decade of the country's extensive efforts to establish Japan as a global leader in the commercialization of science and technology.*

Keywords: cluster plans; innovation strategies; Japan; science and technology; university reform

Introduction

In the early years of the twenty-first century, all industrial nations are preoccupied with the development and implementation of national innovation strategies. The complex interplay of economic globalization, freer trade, the emergence of China as a formidable industrial competitor, and the disruptive commercial influences of scientific and technological innovation have undercut the verities of twentieth century industrial policy. With high wage industrial manufacturing being rapidly displaced as the cornerstone of national economic success, countries have moved quickly and aggressively toward the promotion of scientific and technological development as the means of competing in the new economy. Japan, having played a global leadership role in the evolution of manufacturing and industrial innovation, identified the shifting foundations of international competitiveness and has, for more than a decade, been investing heavily in a centrally-directed and collaborative approach to twenty-first century economic development. As in other countries, the

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hollowing out of industrial activity and the relocation of a great deal of manufacturing capacity to China and other low-wage economies has taxed Japan's capacity for economic transformation, producing at the same time creative and expansive efforts to establish a sustainable foundation for national innovation and the commercialization of science.

This paper first discusses the particular challenges faced by Japan as its economy shifted to a more technology-focused stage of development, in particular an apparent inability to commercialize much of its research investments. It then explains recent science and technology planning, and the special efforts made to reform the national university system to encourage innovation and collaboration with the private sector. The following sections look at recent approaches to regional cluster programs of the Ministry of Economy Trade and Industry (METI) and Ministry of Education, Culture, Sports, Science and Technology, as well as the Third Science and Technology Plan, 2006. A conclusion section provides initial observations on the extensive efforts made to establish Japan as a global leader in the commercialization of science and technology.

Japan's twenty-first century innovation strategy emerged from a legacy of active government engagement in economic and technological transformation. Japan's capacity to reinvent itself economically through national leadership and government–business collaboration began during the Meiji period (1868–1912) when Japan emerged from 250 years of self-imposed isolation to launch a comprehensive effort to reproduce the economic fundamentals of the Western economies, and continued into the twentieth century. Through the 1920s and 1930s, the mobilization of military and industrial resources established the country's pre-eminence in East Asia with, unfortunately, catastrophic regional and global consequences during the Second World War. Although Japan was reduced to ashes by the end of the war and seemingly destined for long term economic hardship, a campaign of personal and corporate sacrifice in the interests of the nation produced rapid economic growth. In the 1960s and 1970s, the Japanese government set out to move from rebuilding to creating a more prosperous and sustainable national economy. Setting ambitious targets for economic growth, the national leadership encouraged innovation in key sectors, including automobiles, transistors, and industrial processes. The formidable Japanese approach to economic affairs involved extensive collaboration between business and government, the establishment of favorable tax and regulatory conditions for key sectors, and major national investments in pivotal new technologies. Over 30 years, Japan transitioned from being a competitive, low-technology, low-wage economy to a world leading industrial superpower, noted for its innovations in miniaturization, computerization, automobile manufacturing, domestic and entertainment appliances, and the development of industrial robots.[1]

The Japanese Challenge in Science and Technology

After the boom years of the 1970s and particularly the 1980s when Japan's wealth and success had commentators enthusiastically extolling the virtues of Japanese corporations and government,[2] the economic bubble burst in the early 1990s. Analysts then claimed that Japan's vaunted approach to business–government collaboration was a smokescreen for an over-regulated, shoddily financed and ultimately uncompetitive approach.[3] Neither the over-the-top celebration of Japan's success or the overly harsh condemnation of national policy struck close to the

mark, but the extremes of the discussion illustrated Japan's emerging status as a touch-stone for international debate about the role of government in the management of national economic affairs and for the capacity of national policies and leadership to shape commercial and industrial innovation.

The Japanese government took heed of the criticism and international commentary. Faced with a ballooning deficit, years of deflation, a looming demographic crisis, and moribund consumer demand, the government took significant steps towards reform. The banking and insurance sectors were deregulated, allowing in foreign investors, and regulations governing international trade were relaxed, opening the Japanese market to more foreign goods and challenging the domination of long-standing domestic firms. Foreigners were selected to manage some of the most venerable Japanese companies and firms like Wal-Mart, Ikea and Carrefour arrived in the country. Japan's economy slowly improved, due at least in part to the government's acceptance of the need for major structural and regulatory reforms.[4]

At the same time—and attracting far less attention than efforts at trade and investment liberalization—Japan also launched a major innovation agenda. As in other industrial nations, Japanese officials became convinced that scientific and technological developments would be the key to twenty-first century competitiveness. Like its major competitors, the government of Japan concluded that state investment in the fundamental building blocks of university training and research, scientific infrastructure and the commercialization of scientific discoveries could bring major dividends to the country.

In particular, Japan was concerned that the country produced too few patents and too few Nobel Prize winners.[5] Despite the impressive number of universities and scientists and major research activities within the large corporations, the country's scientific contributions seemed surprisingly small. Japanese researchers were quite limited in their collaborations with foreign scientists,[6] and in their impact on advancing scientific knowledge. [An assessment of the top 1% of scientific articles between 1997 and 2001, based on the number of citations, put Japan in fourth place (with 6.9%), far behind the United States (62.76% of the total), the United Kingdom (12.8%) and Germany (10.4%). In terms of the scientific impact of publications, the author put Japan, in 2002, nineteenth in the world.[7]] The research showed, however, that the relatively poor performance of Japanese scientists did not stop Japanese firms from capitalizing on major academic developments:

> The good news for Japan is that neither the alleged weaknesses of Japanese university science nor the alleged barriers to interaction between Japanese universities and Japanese firms have fully prevented Japanese multinationals from exploiting the opportunities for 'using science'. Japanese R&D managers expect that, for the foreseeable future, foreign institutions will continue to be an important source of breakthrough science, and their firms continue to make the necessary investments required to tap this knowledge.[8]

Science and Technology Plans

The latest stage of Japanese innovation commenced in the mid-1990s.[9] In 1995, Japan passed the Science and Technology Basic Law and declared its intention to become a 'science and technology based nation'.[10] Thus began a series of broad and dramatic reforms designed to modernize and revitalize the management and research

structure of universities and to encourage greater government–industry–university collaboration. Historically, industry had been almost exclusively responsible for research and development in Japan. Universities graduated generalists who later developed their specialized skills and knowledge while working for Japanese companies. Universities were managed by the Ministry of Education, with little commitment to commercialization. Informal connections permitted a limited flow of ideas across the academic–industry divide, but relations were far from close or symbiotic.

In 1995, the Japanese government enacted the 'Science and Technology Basic Law' which stated the government's recognition of the important role science and technology played in the economic and social development of a nation and the world.[11] The first five year Science and Technology Basic Plan was launched shortly thereafter in 1996[12] and the Japanese government began its concerted efforts to set the course for Japan to become a science and technology-based nation. Between 1998 and 2005 the Japanese government also set in motion a series of dramatic reforms of the legal framework governing university–industry cooperation, removing many of the barriers to university-based IP generation and commercialization. These government-legislated reforms along with the stagnant economic conditions of the 1990s that led industry to decrease in-house R&D and to look to universities for better-trained graduates and research expertise, forced academia, industry and government in Japan into re-defining national R&D practices, including now the formal engagement of universities in the commercialization process.

The First Science and Technology Basic Plan, which ran between 1996 and 2000, had no less a goal than the construction of a new Research and Development system for the country. This was accomplished, in the first instance, largely through an expansion of the existing research apparatus. Support was provided for an additional 10,000 PhD students and post-doctoral fellows and funding for competitive research grants was expanded greatly, at a total cost of 17 trillion yen. The government also signaled its intention to promote industry–academic–government collaboration, believing that a cooperative approach was essential to long-term success and seeking to make the university system more responsive to commercial and industrial needs.

The expansion continued with the Second Science and Technology Basic Plan, covering the period 2001–05. Competitive research grant funding was doubled, the total investment in the program increased to 21.1 trillion yen, and the government expanded its range of interests to expand the commitment to basic scientific research (i.e. projects without immediate commercial relevance) and to include activities targeted at matters of pressing national and social concern. Efforts to promote scientific and technological research were very broad. Public opinion polls and surveys of researchers, looking in particular at female and younger scientists, sought to identify barriers to advanced research and commercialization. How to attract foreign scientists to carry out their research in Japan was another challenge for the government. In 1998 then Minister of State for Science and Technology Sadakazu Tanigaki spoke about his concern that younger foreign scientists were not attracted to the opportunity to research in Japan perhaps finding the research community uninteresting or the costs too high. 'This is not a good situation' he said. 'I would like to hear the voices from abroad saying: "The research in Japan is exciting. Don't miss it!"'[13] So to this end, Japan began working to make the research environment more inviting to foreign scholars.

The government examined innovation policies in other countries, focusing on research and development funding and academic output (academic articles

published in key areas). The government set an ambitious public target of producing 30 Nobel Laureates within 50 years, responding to the oft-repeated charge that Japan's research enterprise was not sufficiently innovative. For many years, critics of the Japanese system had pointed to two shortcomings: the small number of Japanese Nobel Laureates and the comparatively weak performance of Japanese researchers in securing patents. The Science and Technology Basic Plan sought to produce more of both. Early in 2001, the government created the Council for Science and Technology Policy (CSTP) within the Cabinet Office. This Council, with the Prime Minister in the Chair, had 14 members, six drawn from cabinet members responsible for science and technology-based ministries and seven individuals representing key industrial sectors and the university system.[14] In announcing the CSTP, then Prime Minister Mori described its mandate as being 'to hear the opinions of learned experts and draft a comprehensive strategy to serve as the basis for the promotion of science and technology in our nation in the twenty-first century'.[15]

During this same time period, the government of former Prime Minister Junichiro Koizumi also expressed its desire to make Japan an 'intellectual property-based nation'. Protecting intellectual property is vital to the competitiveness of Japanese industry, the Prime Minister said, and would therefore now be a national goal.[16] In March 2003 the Basic Law on Intellectual Property went into effect, outlining the regulations surrounding intellectual property.[17] For the next three years, the first phase of the planned program, work on the basic structure surrounding intellectual property, was laid and cooperation among the government, industry and academia was developed. An Intellectual Property High Court was launched and plans were made to strengthen and improve Patent Office procedures.[18] The second phase (2006–09) builds on this base, attempting to make Japan a more internationally-minded, world class nation in all areas of intellectual property.[19]

Japan has long been given to bold and declarative statements of national intent. The national science and technology policy goals fit in the same league. The national effort has been driven by three core ideas:

- create human wisdom;
- maximize national potential;
- protect the nation's health and security.

The three ideas, in turn, generated six national goals:

- quantum jump in knowledge discovery and creation;
- sustainable development;
- nation's good health over lifetime;
- breakthroughs in advanced science and technology;
- innovator Japan (strength in economy and industry); and
- the world's safest nation.

Policy initiatives, government goals, and spending were intended to align with these initiatives. Table 1 indicates that priority areas for funding science and technology were directed largely to energy, life sciences and information and communication sectors.

The Japanese population appeared to support the government's agenda. A public opinion survey from May 2005 indicated that almost 80% of respondents

Table 1. Government science and technology funding allocations to priority areas (% of total funding)

	2001	2003	2005
Life sciences	20.3	21.2	22.7
Info and communication	8.7	9.3	10.4
Environment	4.6	5.6	7.5
Nanotechnology	4.2	4.6	4.9
Energy	32.6	33.0	31.9
Manufacturing technology	1.0	1.0	0.9
Infrastructure	12.8	12.8	12.2
Space and oceans	15.7	12.6	9.5

Source: Annual Report on the Promotion of Science and Technology, 2006, available at: www.nistep.go.jp/achiev/abs/eng/rep037e/rep037ae.html.

felt science and technology was important to national development and 74% believed that the government should add to its financial support for the sector. Queried about the main reasons for supporting the area, the respondents gave top marks to environmental protection, safety/security, and the promotion of health.[20]

Reforming Research Universities

A cornerstone of the Japanese science and technology effort has been a massive reorganization of the Japanese university system, completed between 1998 and 2005. The primary goal, implemented over the objections of many faculty and administrators, has been to encourage greater university–industry collaboration and thus broaden the impact of academic research. The ambition—to make the prestigious and highly accomplished national Japanese universities more responsive, more independent, and less like a branch of the national government—has been quite remarkable.[21] Even more impressive has been the fact that the government largely succeeded in its goal, moving with dramatic speed in a sector long known for sober second thoughts and slow change. Part of the impetus for both the speed and the depth of the changes has been a real sense of urgency. As one analyst observed:

> If Japanese universities fail to reform themselves the nation will face immense difficulty in competing in the international world. Japan's future hangs on the vitality and quality of higher education and research. Whether or not Japanese higher education can meet this challenge remains to be seen. The government cannot accomplish anything without the cooperation of colleges and universities, and these institutions will not be able to reform themselves without continued, cogent political commitments from the government and strong support from the public. The success of the university reform movement in the 1990s will be a key measure affecting the welfare of the nation and perhaps the world.[22]

Domestic and international factors compelled the Japanese government to look very seriously at the higher education and academic research capabilities of the country. The declining population of high school leavers forced Japanese universities and colleges to consider radical reforms, both to meet society's needs but also

simply to be able to continue to operate.[23] Western criticisms of Japanese institutions as being too insular and not sufficiently creative struck a harsh note in Japan.[24] So, too, did the awareness that Japanese graduate education was not competitive with the best universities in the world.[25] The government was determined to reinvigorate the research capacity of national universities, but faced the challenge of responding to growing public pressures for accessibility, demands for greater accountability, and structural rigidities in the Japanese system.[26] Furthermore, the declining student population forced governments and institutions to rethink their assumptions about the size and scale of universities. The low national birth rate, which resulted in the supply of spaces exceeding demand by students in 2006, was joined by budgetary challenges at the national level.[27] The government responded by insisting upon administrative reforms. The *Nippon Keidanren* (Japan Business Federation) agreed and argued for structural reforms to the universities (in 2001, it even created a sub-committee on Industry–University Promotion to look at research and development within universities and ways to develop more exchanges of researchers between industry and academia),[28] as did METI.[29] In the early 2000s, a series of reports about declining academic standards at Japanese high schools produced a lively and self-critical debate about the steps needed to revitalize instruction and achievement.[30] In addition, industry which had traditionally trained its employees in-house could no longer afford the training costs and was now demanding that universities produce graduates that would be immediately workforce-ready.

The Japanese government was determined to change the unflattering portrait and to mobilize the universities for purposes of national competitiveness. The government charged METI with developing a new strategy for universities and academic research. An informal group operating within the Industry Research Institute produced the Hiranuma Plan (named after METI Minister Takeo Hiranuma) in 2001, which recommended 'specific measures to encourage new market and job creation through wholesale university reform'.[31]

Opposition surfaced almost immediately, led by academic faculty and staff unions and supported, in the first instance, by the Japan Association of National Universities. The task fell to the Ministry of Education, Culture, Sports, Science and Technology (MEXT), which was charged with developing and implementing wide-ranging reforms. The government was determined to 'introduce market principles into university governance—fundraising, academic labour management, performance evaluation, and university–industry cooperation in order to make Japanese universities globally competitive on the one hand and locally responsive to rapidly changing social and economic needs on the other'.[32] The National University Corporation Law passed in 2003 converted national universities into individual corporate entities as of April 2004.[33] Citing a goal of developing 'independent universities that conform to the highest international standards in a competitive environment',[34] the long-standing national universities became quasi-independent administrative agencies, with greater autonomy and more independence from government. The changes included major financial shifts as well. In 1979, the national universities secured 75% of their funding from the government. By 1996, less than 20 years later, that percentage had fallen to 59%. MEXT announced that it would reduce funding by a further 1% per year.[35]

Universities were encouraged to bring outsiders onto their boards, academic administrators gained additional powers, and universities became subject to potentially intrusive external evaluations. The government wanted an end to the infamous administrative rigidity of Japanese universities. The rigid academic hiring system

was transformed. Faculty were no longer classified as civil servants, the granting of tenure was tightened, and academics faced more rigorous annual performance reviews. Research funding was to come through a competitive process. The initiative sought, as a high priority, to encourage greater collaboration with the private sector and endeavored to liberalize research. The government exercised control through the oversight of medium and long-term institutional plans, which in turned determined the level of funding provided to the university.[36]

The essence of the Japanese reforms was the determination to make academic research in the country more internationally competitive and ensure greater university engagement in the national innovation strategy.[37] A new emphasis on the third role (after teaching and research) of universities emerged; the commercialization of university created technology through licensing, start-ups and closer links with industry generally. Beyond the renovations to the internal management of the institutions—which resulted in major shifts in university culture—the government advocated more specific objectives including encouraging the establishment of professional graduate schools, facilitating academic–industry partnerships, providing additional five year grants to the top 30 universities in five identified fields and allowing for profit universities.[38]

Government insistence that academic research contribute more directly to commercialization emerged as a key element in the national innovation strategy. The government largely succeeded in its goal of changing the university system and the universities responded to the new realities, forming relationships with the private sector, consortia of professors and companies, partnerships with other Japanese and foreign universities, extension programs targeting children for future recruitment and market-oriented MBA programs.[39]

Regional Cluster Programs

The Japanese government also placed a high priority on science and technology clustering, believing that combining industry, government and academic research in a single location would produce economies of scale and much greater collaboration.[40] In 2001, METI started an initiative to create industrial clusters, hoping to revitalize regional economies in the process. An initial list of 19 projects was pared down to 17, with the clusters involving 250 universities and close to 6,100 companies.[41] The clusters ranged from large to enormous. The Shikoku Techno Bridge Cluster combined 300 companies and five universities collaborating in the health, welfare and environmental fields.[42] The Tokai Project to Create Manufacturing Industry Cluster attracted 770 companies and 30 universities.[43] In addition, MEXT (the Ministry of Education, Culture, Sports, Science and Technology) started an Intelligent Clusters Project in 2002, creating 12 clusters designed to enhance connections between academic knowledge and industrial development.[44] In the clustering enterprise as in other areas, the government used direct investment, its influence over universities, and its commitment to science and technology advancement to cajole, encourage and compel widespread engagement, all with considerable success.

Combining industrial innovation and regional development is a long-standing element in national economic planning, and Japan's contemporary strategies are no different. Indeed, many countries, mesmerized by the success of California's Silicon Valley, have attempted to reproduce the synergies of high-technology research and commercialization, hoping to enhance national economic performance and build a regional super-hub of scientific and technological innovation. In Asia, initiatives

like Malaysia's Multimedia Super Corridor Cyber Java,[45] Singapore's Science Hub,[46] and Cyberport in Hong Kong[47] are all examples of this strategy. Countries as diverse as Finland, France, Germany, Canada and India have attempted to create new economic concentrations, typically using research institutes and technology centers as key drivers of economic development.[48]

Facing the economic uncertainties and disappointments of the post-bubble era, and hearing a barrage of suggestions from outside the country for trade liberalization and deregulation, the Japanese government concluded that direct intervention was necessary to stimulate innovation and ensure that Japan remained internationally competitive. These initiatives emerged in the period before the 'innovation agenda' became a mantra for national governments around the world, and represented a continuation of the belief of Japanese politicians that state direction, in concert with industry and business, would lead the country out of the recession and back to international prominence. The most significant of these undertakings, many of which focused on the dual and often incompatible efforts to stimulate general economic growth and redress regional imbalances, was the implementation of a cluster strategy. Managed by the Ministry of Economy, Trade and Industry, the Cluster Plan was described by Katherine Ibata-Arens as 'the most ambitious and comprehensive METI plan since its 1960s bet on heavy industry'.[49] It sought to 'improve productivity, spur innovation, and foster new business creation', focused largely on the high tech sectors of the economy and, most significantly, paid surprisingly little attention to the politically important but commercially stagnant traditional and declining economic sectors.

Japan's Cluster Plan (following a long-established pattern of importing commercial ideas from foreign thinkers) drew heavily on the theories of Michael Porter of the Harvard Business School.[50] Porter had posited a 'diamond model' of innovation, which called for the development of a coordinated and region-specific approach to the clustering of innovative firms and state infrastructure so as to capitalize on opportunities for synergies, economies of scale and integration of government and private sector activity. Porter argued that regions and nations seeking competitive advantage had to draw together a series of interlinked and advanced economic factors. In modern economies, Porter argued, the specialized factors determined international winners and losers, for they required large investments and long-term commitments and could not be easily replicated by competitors. The availability of these key resources, therefore, determined a region's or nation's competitive advantage and hence their economic future.

Porter's model appealed to the government–industry collaborative ethos that has long dominated Japanese economic planning. In Porter's Diamond Model, government was intended to act:

> as a catalyst and challenger; it is to encourage—or even push—companies to raise their aspirations and move to higher levels of competitive performance … They must encourage companies to raise their performance, stimulate early demand for advanced products, focus on specialized factor creation and stimulate local rivalry by limiting direct cooperation and enforcing anti-trust regulations.[51]

Porter's model called for government leadership and vigilance, investment in the preconditions for commercial success (education and infrastructure being foremost among these) and assigned national and regional authorities an on-going

role in the stimulation of commercial clusters and thereby the national economy. Michael Porter spoke to the Industrial Cluster Conference in Tokyo in 2003, drawing an audience of over 500 Japanese civil servants and academics and promoting a concept that the Government of Japan had introduced as a major policy initiative two years earlier.[52]

Japan's Third Science and Technology Basic Plan, 2006

Japan's Third Science and Technology Basic Plan was launched in April 2006.[53] In December 2005, as a result of a statement by the Minister of Finance that science and technology would no longer be protected from budget cuts (in line with the government's desire to reduce the huge national debt), there was a flurry of support from the senior science and technology community in Japan strongly lobbying for sustained, if not increased funding in the next budget. This included the signing of petitions and meetings with Prime Minister Koizumi, the State Minister of Science and Technology, and the MEXT Minister of Science and Technology by Japanese Nobel laureates and other high-profile scientists. As a result of this very public pressure, science and technology funding was in fact the only part of the FY 2006–07 budget that was not cut, and the numerical target for the Third Science and Technology Basic Plan (2006–10) was subsequently set for a record 25 trillion yen (around $254 billion).[54] Beyond the politicking and difficult resource allocation questions, Japan committed itself to a 'foresight' plan, whereby greater emphasis was placed on anticipating future trends and less on responding to specific market conditions or political considerations. From the government's perspective, this marked a shift away from top-down, centralized decision-making toward a more science-based evaluation of future possibilities. (This approach involved detailed surveys of scientists and sought to generate a greater appreciation of the opportunities for rapid scientific and technological advances.) The 2005 survey, interestingly, revealed a marked drop in the identification of the environment as a key priority topic, with an even larger decline in the life sciences. Protection from natural disasters had jumped dramatically in the ratings, as had issues relating to nanotechnology and human resources. Human safety and security, importantly, had emerged as areas of both urgent societal need and rich potential for rapid scientific advance.[55]

The Third Science and Technology Basic Plan, 2006–10, proved even more ambitious than its predecessors, with the goal of ensuring that Japan becomes and remains a global leader in science and technology research and application.[56] As the government's plan outlined,

> It is never easy for Japan, a resource-poor country, to occupy an honourable position in human society. In fact, the country's future prosperity depends on the development of unique, outstanding S&T. With this understanding, Japan set the goal of 'becoming an advanced science-and technology-oriented nation' as a national strategy … Of course, people expect much more than economic contributions from Japan's S&T in the third basic plan. They also expect: contribution to society, which is changing remarkably due to rapidly aging population and declining birth rate; resolution of safety issues relating to public concerns about large-scale natural disasters and accidents, as well as complicated global security issues including terrorist attacks; and resolution of deteriorating global-scale problems concerning population and the environment, etc. Thus, the society expects S&T to play more extensive and profound

> roles. Moreover, the world never stops in making progress in S&T. China, South Korea, and other Asian countries, as well as the US and European countries are rapidly coming to enhance S&T as a basis of national strength.[57]

With a total investment in the program of ¥25 trillion, the initiative called for government spending of the impressive sum of C$30 billion annually for five years. The Third Plan sought to capitalize on earlier investments in basic science and infrastructure by expanding the impact of the research. The government aimed, in particular, to capitalize on research and development to enhance the quality of life in Japan and to focus on the development of human resources and national competitiveness through public education, commercialization and industry commitment. The ambitions underlying the government's program expanded as well, targeting six major policy goals: a dramatic growth in overall research and development; significant accomplishments in advanced science and technology; a serious commitment to sustainable development; the enhancement of Japan's status as an innovative nation; discoveries designed to improve health and wellness in an aging society; and improved security for individuals and the country.[58]

Japan's Third Basic Plan is impressive and unique more in the scale of the commitments than the elements within. Within its overall strategy, the government identified four priority fields: life sciences (including biotechnology); information technology; environmental research; and nanotechnology/material science. It established several secondary priorities, including energy, *monozukuri* (manufacturing) technology, scientific and technological infrastructure, and frontier science, meaning outer space and oceans. Some 62 areas of research were listed as further areas of emphasis. In other words, the 'priorities' were very broad and bear a striking resemblance to the research goals of every major industrial nation. Japan's Basic Plan also continued the emphasis on promoting research among young scientists and female researchers, attracting more foreign researchers, spurring senior scholars and developers to further action and encouraging and strengthening industry–academic–government collaboration. The government placed very strong emphasis on patents and patent management, the funding of research through competitive grants, and maintaining a national system of evaluation. Japan placed more importance on the formation of research clusters than did most other nations and in its commitment to the continued reformation of public universities and academic research. In part, this was because the country believed that it had to catch up with more entrepreneurial nations, particularly the United States, where commercialization and industry engagement with academic research has been already well-established.

The Administration of the Japanese Science and Technology Plan

The Japanese science and technology effort has, of course, a variety of administrative and financial manifestations. The acceleration of national efforts in this regard led in 2003 to the establishment of the Japan Science and Technology Corporation (JSTC) based on the work and operational presence of two earlier organizations.[59] JSTC is now a major force in national and international innovation, managing a wide variety of institutes and sub-ordinate organizations (ranging from the Center for Research and Development Strategies, JST Basic Research Programs, International Cooperative Research Project, Research Program for Development of Innovative Technology), a major technology transfer initiative, a nation-wide

information sharing and promotion initiative on science and technology, and a broad program for promoting public awareness of science and technology. The funding for the JSTC would make the agency the envy of any comparative organization in the industrial world.[60] JSTC's commitments and programs reveal a wide-ranging strategy for science and technology that covers the range from education and public promotion to international engagement and commercialization. The organization plays particularly important roles in supporting early stage research and development and working with scientists, technologists, universities, businesses and international agencies to promote innovation for the betterment of Japanese society and business development.

Planning for current and future science and technology policy is coordinated through the Council for Science and Technology Policy (see Figure 1).[61] Reporting to the Minister of State for Science and Technology Policy, the substantial secretariat has a series of Directors with responsibility for key elements in Japan's scientific future, including several dedicated to the oversight of the enterprise (Science and Technology Policy, Resource Allocation, Evaluation, Research and Analysis) and a series of sectoral specialists (Life-Science, Information and Communications Technology, Environment/Energy, Nanotechnology and Materials/Manufacturing, Infrastructure/Frontiers, Social Issues and Atomic Energy).[62] MEXT (the massive Ministry of Education, Culture, Sports, Science and Technology) plays a high profile administrative role and is the most public organization associated with the implementation of the country's innovation agenda.[63] Since MEXT controls almost two-thirds of Japanese funding for research and development, it clearly has a powerful position within the Japanese scientific and technological field; over half of MEXT's funding, however, flows to the National University Corporations,[64] which limits the direct involvement of MEXT in actual research activities.

As the cornerstone of a national innovation strategy, Japan's Science and Technology Basic Plans and its administrative arrangements deviate little from the priorities and investments of other leading industrial nations. There is a strong international consensus on the need to expand basic research, train more researchers, build ties between the academy and industry, shift university research away from scholarly concerns and towards commercialization, and seek transformative scientific discoveries and technological innovations. Japan benefits more than most countries from the national emphasis of its research community; relatively few key Japan researchers leave to work in other countries and there are strong links to regional development activities and local companies. The strategy itself, including the priority research areas, are much the same as those in Canada, Australia, the United States, Germany, France, the United Kingdom and other research intensive nations. There is a strong consensus that bio-technology, nanotechnology, information technology, and environmental research are keys to regional, national and international success. And all industrial nations appear convinced that long-term competitiveness rests on the commercial mobilization of science and technology research.[65] Table 2 shows that most industrialized countries have been increasing their investments in research and development. Japan, however, stands out in the percentage of its GDP committed to the field. While in 2002, for example, the EU average investment stood at 1.8% and the OECD average was 2.3%, Japan invested 3.1% of its extremely large GDP in research and development. The country's business community also invests considerably more than most other nations in research and development, providing a solid foundation for the commercialization of science and technology.

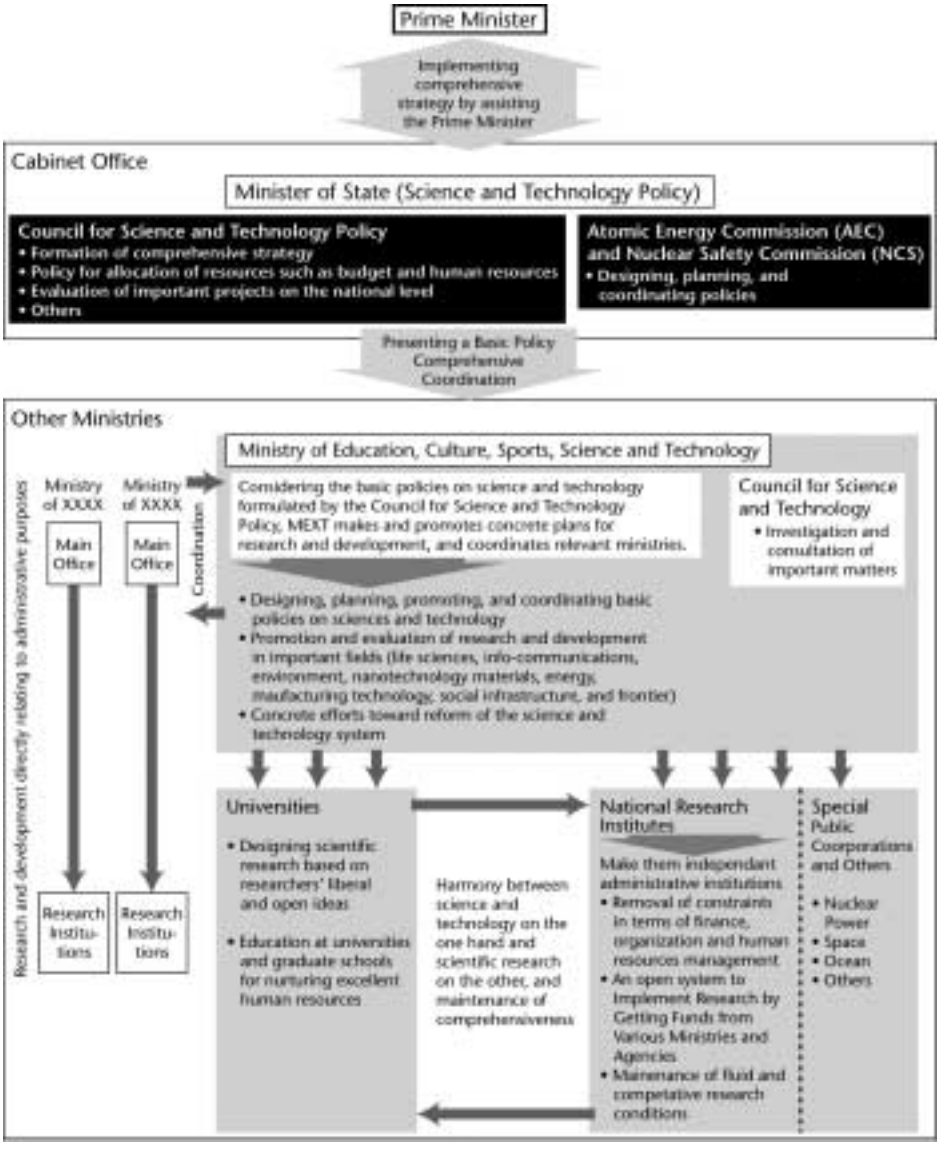

Figure 1. Japan's science and technology administrative structure.

This Japanese investment is clearly paying off. Figure 2 shows the percentage share of total triadic patent families held by various countries. (Triadic patent families are described by the OECD as a set of patents that are registered at the European Patent Office, the Japan Patent Office and the United States Patent and Trademark Office. Using triadic patent family data focuses on patents of higher value, as patentees only register in all three countries if they deem it worthwhile, and allows for greater international comparability.[66]) Japan is responsible for over 25% of worldwide patents (see Figure 2). When the percentage of triadic patent families is normalized using GDP and population, Japan ranks second worldwide after Finland (by GDP) and third after Finland and Switzerland (by population).

Table 2. National investment in research and development, 1995–2002

R&D as a % of GDP	1995	2000	2001	2002
EU-25	1.72	1.80	1.83	1.83
Japan	2.69	2.99	3.07	3.12
United States	2.51	2.72	2.74	2.67
OECD	2.09	2.24	2.28	2.26
Business R&D as a % of GDP				
EU-25	1.06	1.15	1.17	1.17
Japan	1.89	2.12	2.26	2.32
United States	1.80	2.04	2.00	1.87
OECD	1.40	1.56	1.58	1.54

Source: 'OECD countries spend more on research and development, face new challenge', 23 December 2004, available at: http://www.oecd.org/document/2/0,2340,en_2649_201185_34100162_1_1_1_1,00.html.

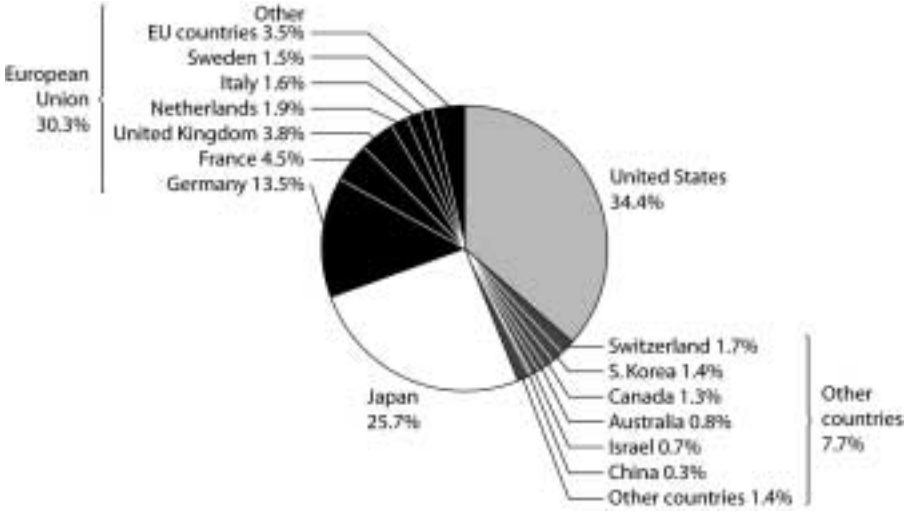

Figure 2. Country share of total triadic patent families, 2003.

Conclusion

The global competition for leadership in scientific and technological innovation remains open and highly competitive. This fast-moving field has produced corporate winners and losers, regional success stories and economic catastrophes, national achievements and challenges. Japan's cluster initiatives, like earlier commitments to Technopolis projects,[67] have produced uneven results, although they require several decades of operation before they are fully tested. The country's advantages, to date, appear to be the capacity to reform post-secondary education and research, the coordination of government, academic and corporate research activities, and a consumer society that is comparatively very open to the acceptance of innovative products and services.[68] The uncertainties of twenty-first century economic competition loom very large in Japan, as nations as diverse as Nigeria and Ireland, India and Canada seek to create economic opportunities based on scientific and technological innovation. The government of Japan, its universities and major corporations have invested heavily in the belief that Japan can, and

must, be a world leader in the innovation economy; only the passage of time will determine if the policies and strategies of the late twentieth and early twenty-first century have laid the proper foundation.

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