科学技術政策研究所
調査研究資料
調査資料ー１７

日本における科学技術政策
SCIENCE AND TECHNOLOGY POLICY IN JAPAN

ピーター・ファン・デァ・スタール
オランダ　デルフト工科大学

Peter Van der Staal
University of Technology Delft
Faculty of Philosophy and Social Technical Sciences
Netherlands

１９９２年２月
February, １９９２

科学技術庁
科学技術政策研究所
第２調査研究グループ
Second Policy-Oriented Research Group
National Institute of Science and Technology Policy
Science and Technology Agency

◇　　本資料はPeter van der Staal氏が１９９０年５月より１９９１年８月までの１年３ヶ月の間、当研究所特別研究員として研究した成果の概要を取りまとめたものである。

SCIENCE AND TECHNOLOGY POLICY IN JAPAN

Report STA fellowship, August 1991

Peter van der Staal

CONTENTS

PREFACE i

Opportunity and reason for the study i

Object and methods ii

1

EXPLANATIONS ON SCIENCE AND TECHNOLOGY POLICY 1

Introduction 1

Explanations of Japan's success 1

2

HISTORY OF SCIENCE AND TECHNOLOGY POLICY 13

Introduction 13

WWII-1960 14

The 70th decade 16

The 80th decade 19

The 90th decade 20

3

SCIENCE AND TECHNOLOGY IN JAPAN 27

State of the art 27

Science and technology fields 32

Basic science 44

Research and development 49

4

ORGANIZATION OF SCIENCE AND TECHNOLOGY 55

Universities and colleges 55

National inter-university institutes 57

Public research institutes 58

National laboratories 59

Public research corporations 61

Private laboratories and research institutes 63

5

SCIENCE AND TECHNOLOGY POLICY IN JAPAN 65

Government intervention 65

Economic policy 67

Industrial policy 68

Education policy 70

Foreign policy 71

Foreign technology policy 73

Trade Policy 75

Science and technology policy 75
Integration of policies 84

6

ORGANIZATION OF SCIENCE TECHNOLOGY POLICY 87
Government agencies 87
Politics, bureaucracy and industry 87
Administrative reform 95
Corporations 96
Small business 97

7

INSTRUMENTS FOR SCIENCE AND TECHNOLOGY POLICY 101
Introduction 101
R&D infrastructure 101
Financing 103
Regulation and persuasion 107
Exchange of information 111

8

SCIENCE AND TECHNOLOGY POLICY RESEARCH 121
Introduction 121
Public policy research organizations 121
Private policy research organizations 123

9

IMPACT OF SCIENCE AND TECHNOLOGY POLICY 125
Causal relation policy and impacts 125
Measurement and indicators 126
Patents 128
Scientific papers 128
Technology imports and exports 129
Trade in high tech products 129
Economic impacts 130
Industrial impacts 130
Social impacts 130

10

EXPECTATIONS AND PERSPECTIVES 133
New realities and implications 133
Perspectives 135

EPILOGUE 139

LIST OF ABBREVIATIONS 145

VISITS AND INTERVIEWS 147

BIBLIOGRAPHY 151

PREFACE

Opportunity and reason for the study

My first encounter with Japan was on a research trip in the spring of 1989. The research was conducted on behalf of the Delft University of Technology in the Netherlands. The aim was to form an impression of policy making on science and technology in Japan and on underlying research activities, such as technology forecasting, assessment and policy analysis. My interest for science and technology originated in my work for the University in Delft, my interest in policy making in research in the Dutch Scientific Council for Government Policy and in three years research in the Department of Public Administration of Leyden University in the Netherlands.
The visits in Japan were well prepared by the Science Counsellor of the Netherlands in Tokyo. During two hectic weeks I travelled, together with two fellow researchers from the Dutch Center for Technology and Policy Studies, through Tokyo and visited a large number of private and public research institutes and advisory bodies. The resulting impressions w ere overwhelming indeed. Subsequent analysis back home, however, showed that the collected information was far from complete and not void of contradictions, paradoxes and other puzzles. My curiosity was further raised and I looked for an opportunity to enlarge my knowledge of the reality of policy making on science and technology in Japan.

The official Japanese policy of internationalization of research offered this chance. The Science and Technology Agency (STA), in the framework of its foreign fellowship program, could provide for the necessary living allowances and research funds. I applied at the National Institute for Science and Technology Policy (NISTEP) for permission to work there for a year as a research fellow. After receiving the invitation, the fellowship grant was awarded by STA and the Delft University permitted me to work in NISTEP from May 1990 to May 1991. This period was later extended with three months.
I used the research period to visit more persons, bureaucratic organizations and institutes, involved in research for underpinning science and technology policy. Besides I had the opportunity to refresh my knowledge about the state of the art in a number of key technologies, by attending conferences and by visiting national research institutes and public research corporations.
The main purpose of the research, however, was to get a better understanding of the way policy was formed and carried out in the for Japan very important sector of science and technology. one of the reasons for my specific interest in the Japanese situation was that this country obviously has been very successful in development of its science and technology, resulting in an amazing economic growth. It seemed of value to study these developments and try to find out whether, to what extent and in which fields important political and bureaucratic influences on this success could be identified.

Object and methods

The research focused on past and present developments in science and technology in Japan and on public policies, aimed at the promotion, control and guidance of these developments. Objects of study were official explicit policies, cognitive foundations underlying these policies, and relations between decision makers and policy researchers. The role of policy research institutes and the actual and normative utilization of knowledge in rational decision making had to be taken into account. Special attention was given to concrete measures and activities, intended to steer the progress of science and technology, and on the actual impacts of these measures on the scientific and technological paths. Science and technology policy is not an isolated phenomenon, but is embedded in a wider policy domain. Therefore economic and industrial policy making also had to be taken into account.

The accessibility of information in Japan for foreigners is steadily improving as a result of the official internationalization policy. The concrete measures of this internationalization are, socially, a more open attitude and transparency of Japanese officials in their contact with foreign researchers, and, linguistically, in the translation of many official documents. Ministries and other agencies, e.g. the Foreign Press Center, play an important role in this regard.

Valuable sources of information where available in NISTEP. This organization is one of the more open and internationally oriented research institutes for policy research in Japan. It employs a disproportionate large number of foreign researchers, some of which work in the framework of the fellowship program of the Science and Technology Agency. The institute frequently organizes seminars, in which sometimes foreign researchers are invited to present and discuss their results. The institute holds a yearly international symposium, in which foreign policy analysts are exchanging their ideas and findings with domestic researchers and policy makers. The staff of the institute appeared to be very helpful and cooperative. And the embedding of the Institute in the Japanese bureaucracy, especially in the STA, offered a smooth entrance to bureaucratic circles.

Nevertheless the problems in acquiring information are numerous. Important written material is still only available in Japanese. An attempt to master the Japanese language sufficiently to be able to read information at a policy research level is far too ambitious for a fellowship of just 15 months. Japanese children spend 1000 hours spread over 9 years to master about 2000 Kanji ideographs, necessary for reading newspapers. To be able to decode more technical and bureaucratic material, not only requires knowledge of more abstract and complex characters, but also mastering of a specific bureaucratic jargon and style, which even for Japanese people appears difficult to decode. Due to the absence of a promulgation law, many important documents belong to the so-called grey literature, which is not open to the general public, journalists or researchers.
The accessibility of the most important library, the Diet library, is hampered by a policy to remain exclusive for parliament members. Its computer catalogues exist only for Japanese literature or in Japan published books and the system is technically below the state of the art. Procedures for externally borrowing books are complicated and time consuming. The amount of foreign written material is limited and the selection criteria are difficult to gauge.
As for access to verbal information, the self confidence of Japanese people to use the English language is not always sufficient for fruitful interviews.
For these reasons I had to confine myself to the available English literature, and to meetings with a selection of English speaking informants in industry, research institutes and universities.

The employed methods in this research consisted in discussions with these interviewees and primary and secondary study of recent literature and documents.
The report contains an annotated bibliography and a list of inter-viewed persons. As some interviewees preferred not to be identified with their answers, no systematic explicit references to persons are made.

1

EXPLANATIONS ON SCIENCE AND TECHNOLOGY POLICY

Introduction

Technology policy plays a dominant role in the economic and industrial policy of the Japanese government and bureaucracy. The central goal of this policy is the stimulation of technological innovation. This is considered necessary for the promotion of the competitive position of companies, the export volume of industry and the economic growth of a nation.
Nowadays practically all advanced industrial countries seem to stimulate similar technologies, without much concern for comparative advantages or specific industrial, social and organizational structures. These generic technologies are micro-electronics, information technology, biotechnology and new materials. These advanced technologies are obviously perceived as of such importance for international competition and economic growth, that no country wants to stay behind in these fields.
Another remarkable fact is that, in a growing awareness of the economic importance of science and technology, countries tend for national reasons to compete and protect knowledge they possess. On the other hand, because knowledge is more and more internationalising, countries tend to communicate and cooperate in science and technology efforts for the sake of international dissemination, transfer and progress as well as for a national benefits from foreign technology.

After the second world war Japan has been very successful in its technological progress and economic development. The available explanations of this success form a wild mosaic. The kaleidoscope shows a wide range of inconsistent accounts of factors, which could be causes for this achievement. This disagreement can partly be explained by different cultural perspectives, ideological stances, hidden pragmatic intentions, or obsolete knowledge of past situations. Without the pretention of being complete or systematic, this chapter describes and reviews a number of circulating explanations.

Explanations of Japan's s success.

The field of science and technology policy research is supported by a number of abstract theories on the progress in science and technology, as well as a proliferation of casuistic descriptions and statistical facts. The available theories are generally too broad to explain most of the concrete phenomena. Meticulous, often quantitative statistical, descriptions, fall short in attempts to generalize. Much empirical research is characterized by inadequate theoretical underpinning of empirical analysis and also by insufficient measurement of technological progress.

A grand theory on technical change is presented by Schumpeter in his book on Capitalism, Socialism

and Democracy. 1
With regard to technical progress, Schumpeter focuses mainly on the role of big companies, which in everlasting competition create new proprietary technologies. Based on this knowledge, they produce new
products in a capitalist system in order to disclose, expand, attain or maintain markets, which afterwards make a selection of products. The role of the government in this process is restricted to the creation of basic scientific public knowledge, which helps companies to find new sources for their private technical problems. Schumpeter ignores largely the role of universities and government support for R&D and the fact that the activities of the big companies are complemented by other public and private institutions.

A relevant question is whether Japanese decision makers themselves are driven by any theory at all. In the literature nor in interviews, this question is answered positively. On the contrary, many sources mention that Japan after the World War deliberately ignored at that time popular economic theories, especially the theory of comparative advantages. 2 This theory claims that a country acts most rational when it export goods, in which it has a profusion of production factors and when it import goods for which its production factors are scarce. 3 If Japan would have acted according to this theory after the war, it would have followed a trajectory of industrial development, based on low costs of labor and current advantages in labor intensive industries. As a consequence Japan could not have realized a rapid technological catch up and strong economic growth, because it would have used its resources on industries lower in the live cycle curve.

In political terms, one can perceive the development of science and technology as quasi autonomous, or as planned or guided.
In the autonomy model, scientific and technological development is either perceived as a consequence of free flows of information or as the outcome of free actions and communications between actors in the scientific and technological communities.
In the planned or guided model, the regulators can be identified either in the scientific and technological communities in companies and universities or outside these circles. In the last case, these regulators can be classified as managers of companies or as administrators in the public sector. The managers act according to their corporate strategies, driven by interests either of stockholders, of labor or of themselves. Actors in government are politicians or bureaucrats. They are driven by public, sectoral, regional or national, industrial or military goals. The type of regulation can be a centrally planned economy or a more market oriented or market conforming economy. In Japan's policy, the economy is neither treated as a fully free marketplace nor a centrally planned system. The imperfections of the market are restored by market conform policies. Such policies are not only oriented to the needs of industry and markets in a narrow sense, but also to social and political requirements.

A popular explanation for Japan's economic expansion and rapid technological development distinguishes two factors:
The first refers to the advantage of a late developer. Initially Japan did not have to develop its technologies by itself. It could import, borrow, utilize or implement already developed technologies and concentrate all its efforts on the commercialization for its economic growth.
The second factor is the role of government, which in cooperation with the private sector, formulates a

long term planning for the nurturing of new, for rationalizing existing, and for eliminating obsolete industries. This implies that the government supported investment in new equipment, embodying advanced technologies, supported arising industries by various policy measures and helped industry in importing foreign technology by guaranteeing them the scarce foreign currency. On empirical grounds, it can be demonstrated that these factors do not form complete explanations. Many late developing nations and many centrally planned, or guided, countries in the world do not seem to be able to take off and catch up economically and technologically. It takes a minimum mass and effort to get airborne. Moreover by the late sixties the Japanese government lost its most regulatory tools in the process of trade and exchange liberalization. Government policies could only be effective because there was enough entrepreneurial spirit and labor effort in the private sector. The most important explanation must therefore lie in the will and ability of the production sector to react to opportunities, and to adapt to new technologies.

Okimoto explains Japan's s success by three factors:
The first factor is a political one. The Liberal Democratic Party's prolonged political monopoly established a durable political bureaucratic alliance and a close cooperation between the legislative and executive powers of government. This prevented science and technology measures from becoming politicked and inefficient.
The second factor refers to industrial relations and industrial policy. The relative weakness and cooperativeness of organized labor made it easier to develop and carry out an effective industrial policy .
The third factor is financial, especially the low level of defense spending. This gives the scientific and technological work force the possibility to focus on breakthroughs in knowledge, which can be commercialized. 4

Jiro Kondo, president of the Science Council mentions as causes for Japan's success, the policy of the Ministry of Education of popularization of higher education, which resulted in a high literacy rate and a quick catch up in knowledge with the West. In this respect he also refers to the buying of patents on intellectual properties and the addition of investment and infrastructure. He gives as second factor the political stability; political conflicts mainly regard positions and seldom issues. And as third factor he mentions the relatively strong role of bureaucracy in the public sector.

Most ordinary Japanese people see as main factor for their progress in science and technology, a close cooperation between business, academic institutions and the government, without being able to distinguish a dominant actor or line of influence. 5

Perceived main factors behind Japan's economic growth in the first decades of economic reconstruction and technological catch up after the second world war were active technological innovation, supported by adequate structures, such as close cooperation of private enterprises with the public sector. This created a process of high growth and accumulation in the past. But these policies are continuously revised according to the current state of Japan's development and the changed international environment.

Another explanation is the fast economic growth itself, which caused optimistic expectations, confidence and trust in and among cooperating companies. This led in a benign circle to more economic activity and growth. Paradoxically, the oil crisis worked as a blessing in disguise, in that it motivated Japan's industry to innovate in less energy consuming products and services. The companies implemented measures to reduce energy consumption, to conserve energy and to rationalize the production processes.

Other indicated factors behind the capacity for fast development of Japan's economy are the personnel management, organizational structures, managerial behavior patterns and inter-company relationship. These factors form the so called Japanese way of management or business practice. These features are seen as forming a characteristic system, aimed to the promotion of R&D for the maximization of long term profits . This behavioral pattern implies large and diverse information flows within companies, which lead to a high product differentiation and a short product life cycle.

Long established business relationship between companies, between manufacturers and parts suppliers, decrease the cost of transactions and facilitate the flow of information. These structures tend to promote technological capabilities, production efficiency and long term profits.
The system of life time employment, thorough in-house training and education, seniority wage system, enterprise based unions, transfers within companies, and internal seniority promotion systems are factors, which motivate personnel to see their work from a collective and longer time perspective and lead to a greater ability to accommodate to changes and adapting to new technologies. It leads to more and better communication between R&D, manufacturing and marketing departments. The enthusiasm for education and the diligence of the Japanese people result in a high quality of labor, which contributes to the rapid technological innovation.

Other reasons for Japan's economic success are the development and fostering of human resources. An example is that the Ministry of Education in anticipation of the need for the import of foreign technology and the education of their future scientists and engineers started to introduce English language in the schools. This enabled the later students and young professionals to read and understand English technical literature and follow lectures in the foreign universities.

The Japanese success can be explained from a larger number of each other mutually supporting factors and from a number of disciplinary perspectives; psychological, social (structural or cultural) , economical , technical or scientific , political, physical/militaristic, historical.

Japans post-war policy could be explained from a rational economical response to the disaster after the World War. There was an enormous shortage of daily living necessities such as food, houses and medical aid. High unemployment, inflation and agitation of radicals gave reason for concern for the social domestic order. This necessitated priority for economic development and the peoples support and working
attitudes. The Japanese people understood this and left to the Japanese government the responsibility for economic growth.

A socio-psychological Maslovian account points out that after the war Japan had tremendous problems in providing in its basic needs, and that in later phases, successively it needed to acquire wealth, and to satisfy intellectual and social demands. This succession can be seen reflected in Japan's technological development cycle. First the food and health related technologies such as anti-biotics, fertilizer, agriculture, breeding, natural resources were developed, later home appliances, television, washing machines, vacuum cleaners, refrigerators, cars, and again later information and intellectual matters, such as printing, publishing, telecommunications, broadcasting. At the moment policy is also directed at the quality of life.

Cultural sociological explanations are the attitude of cooperation, low crime rates, homogeneous society, collectivism, group loyalty, patriotism, and work ethics.
Structural sociological accounts indicate the system of lifetime employment, seniority wage system, weak enterprise based unions which, in combination, result in a high labor commitment, few strikes, greater innovative capability and faster production; the appointment of retired bureaucrats in senior management positions in the private enterprises; the industrial grouping, and the cooperation between large companies and a multitude of subcontractors; the minimal influence of stockholders; and the strong financial system, controlled by the government and caused by forced savings as result of weak social welfare program. 6 Another structural factor is the role of the state in the economic development, driven by late industrial development and need for catch up and economic nationalism.
Shares in companies are not concentrated but dispersed. The shareholders are relatively benevolent banks and other companies. The shares are reciprocally held by other share emitting companies. Interference of shareholders with management affairs is therefore unlikely.

International factors are the dependence on foreign defence, resulting in low military expenditures; a good access to large export markets and cheap transfer of technologies.

Chalmers suggests a series of economic political explanations: 7 After the war, the Japanese government limited the Japanese markets for the import of foreign goods, capital and labor. The import of foreign technology was promoted by the bureaucracy, under conditions unfavorable for foreign suppliers. MITI, assisted by the Ministry of Finance and other bureaucratic organizations, formulated and implemented policies for the promotion, expansion and reduction of earmarked industries. This policy was less based on current comparative advantages in production factors, than on expectations of the future national economic importance of such industries. The main criterium for the judgement of the importance of industries was the role of technological change.
Under violation of Japan's own anti-trust law, many cartel-like structures for the division and distribution of markets and risks were tolerated of even stimulated. Interest rates were deliberately held below market levels and credit was allocated only to appointed indus-
tries at low rates. Export of goods were promoted by a combination of fiscal, financial and protectionist easures.

These policies were based on the dynamic (Schumpeterian) idea that technological progress, or innovation in products and processes are in the long run more important factors in the market outcomes, and thus economic growth, than current prices. Under these conditions, policy measures can have a. greater effect on economic progress than the working of free market signals on industry.
The Japanese policy can thus be understood under the following considerations: Manufacturing sectors, with innovative technologies and structures, with a strong concentration of capital, high quality labor, strong government support and imperfect competition, have a higher chance on increasing returns and profits than other economic sectors. Increased production scale in these industries yield to the advantage of cost economies. This can lead to higher profits or market shares,

provided that the production can be absorbed by existing, new or foreign markets. Under these circumstances promotional and protectionist government measures can result in increasing world market shares for domestic producers. A second motive for such policies is that these industries tend to produce favorable spin offs for other sectors of the economy in terms of knowledge, skills, and contracts.

The remaining policy problem is which types of industries are potential contributors to economy and technology and to increased returns or secondary- benefits. Another question is, which policies will be favorable to this ends. Finally the success of such a policy depends on whether companies will act conform this policies and what will be the effect on and reaction of society as a whole. This requires vision on the future of economy, technology and society. These visions are continuously formed in networks of industrialists and bureaucrats, supported by analysts and think tanks.

The reasoning behind the Japanese policy were that from a longer term perspective, optimal allocation of resources cannot be left to the short term working of market forces, but that they need a future oriented and effective industrial policy. This idea and the strong urge to develop the country to the level of other advanced nations led Japanese government not to accept the imperatives of current comparative advantages, but to promote industries and technologies, which were considered to have the greatest potential for a fast technological development and economic growth.

The main assumption behind this policy principle is that the innovations and increased productive output could be absorbed by market. In the case of completely new products and of growing global net demands, this assumption is satisfied. In the cases of heavy international competition, and stagnating international demand or low income elasticities for the products in question, the policy will inevitably lead to increased international competition and trade frictions.

Another idea behind Japanese policy is that a forced increase in production scale tends to result in a faster decline of prices or descend along the learning curve. This rapid cost reduction can be used to compensate for the export of goods with a relatively low income elasticity or a potential to substitute other products with
similar functions. This is one of the reasons that Japanese companies, assisted by government support or guarantees, can afford to offer their products below cost prices, anticipating on future profits, when the costs are reduced and the market share, as result of low initial prices, has increased. One of the advantages for Japanese companies to invest in risky products is that the availability of patient capital for this supported capital is greater and that the current market signals are bad indicators of future profitability.

Japan is a nation poor of natural resources. The most rational way for such a country to develop itself is to use its human and financial resources to produce products with high added value and long term perspectives of high growing demand in world markets. On the other hand, high current returns can be used to finance higher investment in capital goods and R&D. This will also give options for the future, especially in high tech-industries. This is the other side of the coin. The availability of low interest, high risk capital as result of support by the Japanese government and Bank of Japan acts as an important incentive and multiplier in this respect.

Science is internationally transferred and not impeded by competition motives, technology is more embodied. Technical knowledge is produced within the firm and can not easily cross national borders. This is one of the motives for Japan to produce more of its own technology and not to rely to much on the import of technology, as it did in the past, and also to target industries with the highest technological potential.

On the other hand, it is difficult to predict the future market opportunities for products. Future oriented science and technology policies are therefore prone to errors and failures. For private companies the risk might be too great. But in general, strategic generic technologies, such as microelectronics, new materials, bio-technologies and perhaps superconductivity can be expected to have an overall beneficial and profitable effect for relevant industrial sectors as a whole. Government support for the sectors will always pay off in the long term. Moreover it can set into motion a process of self-fulfilling prophesies.
Policies, designed to provide in development costs and to create initial markets, can compensate for the relative short term productivity and efficiency disadvantages of these technologies over more established technologies.

Put in another way: Japan, did not base its policies on theories, but on collective common sense and on historically determined drives to catch up in technology with the most advanced nations, which it was confronted with and wanted to stay independent from. The costs for this policy were high for the population in terms of initial living standard and leisure time, but they were justified by the final economic benefits. On the other hand these costs can also seem too high as Japan is experiencing now. A present problem is whether the results of Japan's economic success are equally distributed among the Japanese people and contribute to the general welfare and well being. This question boils down to whether the Japanese affluence is reality for the Japanese individuals or not.

Recently Japanese policies are aimed at high tech industries, such as semiconductors, computers and telecommunications. The Japanese appreciate these industries as basic technologies, on which the future success of various sectors depend. They are assumed to stimulate production in other areas of the economy and will give profits, as well now as in the future. New materials and biotechnology are expected to require lower cost inputs and less energy in the longer term.
This will be a great advantage for a nation with scarce material and energy resources. It will result in a lower national import account and lower dependence on foreign sources of raw material and energy.

Technological direction and outcomes depend on a large number of individual decisions of scientists and engineers, natural and socio-economic conditions, corporate strategy, management decisions, government policy and pure chance. Innovations depend on current demands, indicated by market prices, future feasible needs and new contributions to the stock of scientific and technological knowledge.
It depends on the inherent uncertainty of chance and the behavior of multiple actors. This means that any policy contains an element of betting behavior. Therefore it might be rational not to place everything on one card but to spread the risks and to built in safeguards and redundancies.

Government policy is essentially indirect participation of society, via her political representatives, in economic matters, which transcend the competence, interests, vision and efforts of individual economic actors and production orqanizations. Freeman uses the term national system of innovation to denote a collection of institutions, which generate resources and allocate them to specific problems and approaches to technology and their modes of utilization. The national system of innovation is defined by him as "the network of institutions in the public and private actors, whose activities and interactions initiate, import, modify and diffuse new technologies". 8

The characteristics of such a system are:

a: horizontal integration of R&D, design, production and process engineering and marketing,

b: integration of process design with multi-skill training,

c: computer networking and collaborative research,

d: state support for generic technologies and university-industry collaboration,

e: new types of proprietary regime for software and biotechnology. 9

It seems that Freeman is using Japan as exemplary system for other developed countries. The question rises, to what extent innovation is restricted within national boundaries, and to what extent innovation policy can be characterized as systematic, in other words how strong the interaction and cooperation between the institutions is and how closed the boundaries, which protect the system from undesirable exogenous influences.

This systematic character tends to decrease to the extent in which Japan, and the world, is internationalizing, the influence of the bureaucracy on industries and firms is declining and more government departments are entering the policy arena and become engaged in bureaucratic competition.

According to Horsley, one of the intellectual driving forces behind Japan's recovery was the Yoshida Doctrine of capitalist economics. 10 Others think that the spiritual drive came from the Maruyama Doctrine of small nations, which advocated democracy and freedom and stated that Japan should be an economic rather than a military power. 11

Chalmers Johnson labelled Japan as a Capitalist Development State. 12

According to Saburo Okita, a better name for the first post war

decades would be catch-up capitalism. This earlier Japanese system serves nowadays as a model for many (Asian) developing countries.

In this variant the role of the government was to make indicative plans, and give administrative guidance in order to pilot the economy in its path of high growth. MITI and the Economic Planning Agency played a large role in this respect. The functions of such economic plans in a free market system are to provide private industry and society with an overview of the outlook, on the longer term, of the economy. In this framework companies can formulate their own long term plans. A second function is to set examples by demonstrating long tern commitments of the government expressed in concrete plans. Or to make statements on long range policy directions, consisting of policy programs to be carried out by the government. This could include the allocation and distribution of investments. A side function of such plans is to mediate between diverse interests. The Economic Council, e.g. , consists of members, representing virtually all interest groups in society. The results are the prevention or reconciliation of conflicts, compromises between these interests and a broad consensus of the direction, the nation should follow. 13 This implied a role for economic plans in the market economy, close cooperation between government and private enterprises and consensus building. This system is a model for developing countries at the moment.

Nowadays such large government role and intervention in the economic system is no longer necessary for two reasons: The Japanese industry is financially Strong enough to invest in its own R&D and production equipment. Furthermore is it already covering virtually all internationally important and promising fields of production and technology. Because the means are no longer scarce and allocation not so selective any more, there is less need for priority setting. 14

The trend in the official figures show that the government budget lags behind the growth of the national income and that, compared with industry, government spending on R&D is already very low and tends to decrease even further. R&D expenditure is 3% of the GNP and 80% of it was spend in the private sector. Although the ratio of non-defense R&D/GNP is higher in Japan than in the U.S., the Japanese government expenditure is lowest not only related to the total Japanese R&D expenditure, but also to that of the U.S.

The financial means and the need for government intervention are therefore continuously declining. Furthermore there is a shift in government policy away from industrial policy to science and technology policy for other needs such as (global) environment, safety, quality of life, human factors, etc. In the Japanese conception, science and technology are the most important means in striving for these goals.

Japan is minimizing the role of the government and relying more on market mechanisms in a move away from interventionist industrial policies. It considers this essential for maintaining harmonious relationships with other nations. Reducing the economic growth to

around 3% would also be good for the global environment, the alleviation of labor shortages, the increase of leisure time of the population and the reduction of economic frictions. 15

In the opinion of Kazushi Hasegawa, now the economy has been rebuild and the catch-up in S&T is reached, the following issues are important objects for government concern and -policy: The first is to assist the relatively independent private sector by establishing supporting conditions for maintaining a strong economic and technological position and, as new emerging issues, to find solutions for the rising problems of an aging society and the reduction of frictions in international relationships.

For the last two problems the role of S&T cannot be as large as for the first. For the problem of an aging society, a strong financial basis for the government or social overhead is needed. For the first role, one should realize that the industry already finances more than 80% of its R&D by own means and that this percentage only will rise in the future. The role in science and technology policy of STA could be larger than it is how, as well direct as in coordination. Regarding the role of the policy research institutes, they might provide the bureaucracy and government with valuable information. It is still too early to judge whether their influence or impact on policy is or will be large. 16

In the vision of Junosnke Kishida, the importance of national goals for the government will decrease in the light of an integrating world economy and of a relatively autonomous and internationalizing private sector. As far as national goals are concerned, an optimization of the total system of Japan, in the context of further internationalization, is one of the main tasks for the government in the future.

The big companies have as private goals the expansion of their activities in an economic world without frontiers. They will face deadlocks in this endeavor as result of limits of resources, of human capacities, of social acceptance and of environmental constraints. One of the most important supporting roles for all national governments will be the reduction of international frictions, the harmonization of different interests, and the education of all concerned parties including the corporations and themselves, regarding these limits and resulting responsibilities. This might raise the level of "enlightened self interest,, and invoke a necessary "paradigm shift" in all social and cultural spheres, in order to maintain a sustained evolution of the global society. S&T can play a role in the reduction of friction, but a better communication and consultation on the political level will be necessary. Summit meetings and Structural Impediment Initiatives are concrete examples of such a trend.

The elements of this new paradigm should be: an extensive feedback between all societal spheres and elements for a better (non-linear) progress, wide recognition of limits on sustainable growth, increased interest in and centralization of living beings, more emphasis on synthesis and integration than on specialization and analysis, more orientation to societal demand than to producers capabilities or intentions, and finally changes in existing priorities.

According to Kishida, this calls for a new idealism and learning from nature's examples.

Technology assessment can play an important role in this respect, not as a means of impeding productive activities, but as a means of

building a sound science and technology policy. Problems in reaching this ideal are the not yet enlightened vested interests. After the war the military and oligopoloid economic systems were abolished in Japan, but a strong bureaucratic system was maintained and played a important role in the economic reconstruction of Japan. Although it is getting gradually weaker, its strength is still large and this poses a big problem for the future of Japan.

The influence of the bureaucracy is not so much dependent on its financial means, but on its administrative guidance and regulations, on its think tank type of organization and wealth on valuable information. Unfortunately this information is not all free accessible, even not for the Japanese public and media. Apart from the white and blue publications there exist an enormous amount of grey papers, which is used to maintain vested interests, including those of the bureaucracy itself. In Japan, private organizations and individuals are not entitled by a promulgation law to get access to this information, even not the Japanese press. 17

Japan's s economy now is plagued with two imbalances. The first is the imbalance in the government budget, as result of declining tax revenues, caused by slower growth and thriving expenditures in social welfare and public infrastructures. Over the last two decades the Japanese government has build up a large debt in bonds and a large debt service. The last years however, Japan has succeeded in bringing back this debt. The general expenditures are kept very low the last decade, partly due to the decrease of the government debts since 1980 as result of a drastic cut back in issuing of and dependence on bonds. The second, external, imbalance springs from the trade surplus, which is reflected in the jump in the account surplus in this decade. This resulted in trade friction, currency appreciation and retaliation against protection. Policies, such as measures for opening the markets, for stimulating domestic demand and so on did not much to reduce this imbalance.

Unfortunately both imbalances are positively coupled in the sense that reducing the domestic balance increases the external balance. 18

The role for the government is changing due to a number of factors. Economic growth is no longer the sole dominant value. After succeeding in the catch up, a greater diversification of values and of policy goals came to the fore. The economic growth stabilizes on a lower level, so that there is less to distribute and thus choices should be based also on other than economic criteria. In comparison with the bureaucracy, politicians will win in importance, because other issues come to the foreground: internationalization, enhancement of market access, increase of domestic demand. There is more need for policy coordination, cutting through the vertical structures of the Ministries and agencies . The role of the government in the economy is complementary to the private sector, by indirectly creating a favorable climate for this sector, by removing unnecessary barriers and by indicating general directions. For the rest it should be left to the corporations and the market mechanisms to be creative and make the rational decisions which lead to optimal wealth and well-being.

2

HISTORY OF SCIENCE AND TECHNOLOGY POLICY

Introduction

Although Japan already studied European scientific and technological knowledge and skills when it came in contact with the Portuguese and Dutch, it is widely held that the modernization of Japan started after the end of the Tokugawa Shogunate and the beginning of the Meiji period in 1868. The Meiji government succeeded in avoiding Western colonization and setting up a policy of industrialization, thereby importing the latest technology by inviting foreign experts to Japan and sending Japanese scholars abroad. 19
Japans postwar economic success should partly be accounted for by the prewar period, in which it adopted modern western techniques, and helped to fill the post war gap and the final catch up in science, technology and industry.

National science and technology policy in Japan goes back to the time of the establishment of the Agency for Technological Advancement during World War II. But not earlier than after the founding of the Science and Technology Agency (STA) in 1956, these policies became effective. Nowadays science and technology policy is object of government concern in various ministries, under the formal coordination of the STA. 20
Japan, as an industrial and technological latecomer, developed an early awareness that science and technology play a dominant role in the military and economic strength of nations. Motivated by a strong feeling of ethnic uniformity, by naturally defined insular frontiers and a fervent national and patriotic sense, it eagerly adopted foreign science and technology.
After the defeat at the end of World War II, when their military role was constitutionally finished, they perceived the economy as their main instrument for maintaining their independence and keeping undesired foreign interference at bay.

The official stance regarding science and technology policy in Japan is that joint efforts of the government and private sector in the past has certainly helped to generate a beneficial spiral of accumulation of knowledge and wealth. But that not even in the period of rebuilding the country after the war and the catch up in knowledge with the West this has ever been a top down managed system. And that, certainly at the moment, neither the role of the government nor the style of management in private organizations can be conceived as unique Japanese systems .21 And that were remains of the post war central and oligopoloid elements linger, they should be redressed.

Japan is rightly proud on its sustained economic growth and achievement in advanced technology, its flexible and adequate response to the oil crises Yen revaluation, low stock prices and interest rates. Its problems now are of socio-political nature, as well internationally as domestically.

Internationally it is expected to play a becoming role in the global community, in accordance with its economic power. Domestically it needs to increase the concrete welfare, well-being and well-feeling of the Japanese people.
Thus the main problems, confronting Japanese policy maters are now the increasing role of Japan in the world economy and society and the reflection on and formulation and promotion of higher goals of a flourishing economy and the distribution of its benefits over all sectors of the Japanese and global society.

At the moment it is the first time that Japan wants to open itself for the world and wants to keep the world open for Japan.

WWII-1960

The post war period until 1960 was characterized by the introduction of foreign technology for rebuilding the nation and its production capacity.
The technological component was initially primarily directed at the production of food and the efficient use of natural resources. The work force mainly concentrated on the labor intensive primary industries and the increase of agricultural productivity.

The General Head Quarters of the Supreme commander for the Allied Forces (GHQ) carried out measures to prohibit military research but allowed and stimulated activities, systems and organizations for non-military related research.
The allied defense procurement during the Korean War stimulated the Japanese industries in metal working, machine tools, chemicals and textiles.

In 1953, the Economic Council advised the Prime Minister to strive for economic self-sufficiency by establishing normal foreign trade, especially exports, the development of domestic resources and the accumulation of capital. As necessary conditions were considered economic stability, free enterprises, cooperation between labor and management and development of science and technology. 22 Following these recommendations, the government formed a 5 year plan in 1955, comprising concrete measures for promoting science and technology. 23
The next year, the importance of technological innovation for economic growth was also stressed in a white paper of the Economic Planning Agency (EPA). 24

After the war, a number of government organizations for promoting science and technology were established:
The Japan Science Council (JSC), established in 1948, had as objective the representation of scientists for the promotion and dissemination of scientific knowledge.
The Science and Technology Advisory Committee (STAC), established in the same year, had the task to reflect on consults to the government, to coordinate between the Science Council and the administration and to implement international science and technology government projects. 25 In 1956 the Committee was followed up by the Science and Technology Agency.

The Committee for Natural Resources, was established in 1948, as a think tank in order to make effective use of Japan's natural resourc-
es. Later in 1956 it was attached to the STA. (Nowadays the Science and Technology Policy Bureau and Office of Resources are taking care of the research and secretariat of the Committee.)
The Industrial Technology Agency was established as an organ of the Ministry of International Trade and Industry (MITI) , when this Ministry came into being after the reorganization of the Ministry of Commerce. The Agency was meant to be the administrative organization for improving industrial technology.

The introduction of foreign technologies was imperative to catch up with the level of the West. Initially the U.S.A. assisted Japan in introducing foreign technologies within the limits of the availability foreign currency, derived from exchange or foreign capital. In 1949, the Foreign Exchange and Trade Act and in 1950-1951 the Foreign Investment Acts came into working for regulating imports of technology by short term and long term contracts respectively.

For the improvement of the international balance of payments and the development of important industries and public utilities, the Law concerning Foreign Capital was added to the Trade Exchange Law in 1950. This facilitated the introduction of foreign technologies, patents and know how and the conditional authorization of their payments. The restrictions were that these technologies should contribute to the sound development of Japanese industry, should not be detrimental to small companies, should not violate management rights, not lead to unfair contract conditions, not affect the ability to pay remunerations and not impede the growth of domestic technology.

Laws were made for establishing and regulating national and private universities with attached research institutes and aids to private research organizations.
In 1951, a special committee for the promotion of science and technology was formed within the Liberal Democratic Party (LDP).
In 1956, the Science and Technology Agency (STA) was established as a general administrative organ for science and technology.
The motives for establishing STA were:
- The need for coordinating S&T for reconstructing Japan's economy and industry.
- STAC had no influential power.
- Scientists and engineers also wanted to have influence on the developments (techno-bureaucracy).
- After the war there were fields and areas prohibited for Japan, such as nuclear radioisotopes, which were not jet claimed by MITI and could be taken over by STA
The Liberal Democratic Party stressed the need for an independent administrative organ, because of the alleged anti-government attitude of the Science council. The latter Council required certain conditions for the establishment of STA, e.g. that no basic policy in the jurisdiction of the Science Council should be made and that the Science and Technology Agency should have no jurisdiction over the atomic energy administration. 26
STA has no saying about the universities and if universities professors are working for STA projects they will be curtailed by the same amount by Ministry of Education. This implies a negative incentive for the universities to work for STA.

In 1959, the Council for science and Technology was established and attached to the Prime Minister's

Office. Its task was to consult the Prime Minister regarding fundamental and general policy on science and technology, and to set and promote long term and general science and technology research goals.
In its first report the Council stressed the necessity to develop technology on international level in order to create a balance in technology transfer with other developed nations. 27 The improvement in scientific and technological levels, with as ultimate aim the bridging of the gap with the advanced nations, was the most important goal for science and technology policy.

For the support of science and technology by adequate information, the Japan Information Center of Science and Technology (JICST) was set up in 1957. The, from 1917 dating, Institute of Physical and Chemical Research (RIKEN) was reorganized, relocated, reconstructed and re-equipped in 1958.

The 70th decade

Science and technology policy was formed against the background of the final reconstruction of the Japanese economy, of sustained economic record growth, and of the need for changes in the industrial structure. This period was characterized by the production of low cost-high quality products, in order to advance in international competitiveness.
Due to technological improvements, the agricultural productivity was raised and caused a labor surplus, which was transferred to the secondary industries. Together with the entrance of young people, the labor market was in balance and this led to high economic growth and high individual incomes. The balance of trade became negative whenever there was an increase of domestic consumption.

During the 70th decade Japan's economy boomed. By the end of the decade the GNP was almost fourfold that of the beginning and surpassed the Income Doubling Plan of 1960 of the government by almost 100 %. Japan's industry developed and restructured itself rapidly by technological innovations. Shipbuilding industry, steel factories, power plants, petrochemical plants and other industrial complexes flourished and became large scale. This contributed to the growth because of the benefit of the scale economy.

During this decade, however, latent problems of the policy of high speed growth became manifest: Systematic and unbounded cheap import of technology, import restrictions and export promotion gave rise to trade frictions, while heavy industrialization increased the need for scarce resources and caused grave problems for the environment and the health of the population. Examples were pollution problems caused by organic mercury and cadmium poisoning, asthma-causing emissions and water and air pollution. The Basic Law for Environmental Pollution Control was established to cope with or prevent these problems.
In response to the trade frictions, Japan made a beginning of a policy for internationalization and liberalization.
The Plan of Basic Principles of Trade and Foreign Exchange aimed to liberalize trade to 80% by the end of 1963.28 Japan joined the IMF and the OECD in 1964. In June 1968 it liberalized its technology imports below $ 50,000, except for the fields of aircraft, weapons, powder, nuclear energy, space and computers. The liberalization of restrictions on trade in technology and products was not yet completed in these years, however.

To cope with the threat of domination of American capital, Japan promoted the combination of companies in order to resist international competition and to develop its own technology to become more independent from foreign technologies.

Science and technology policies in this decade concentrated on the following issues: 29 the promotion of linking and integrated treating of science and technology and their diverse fields e.g. by promotion of the interchange of information, methods and techniques.
The extension of international cooperation, especially directed at the training of engineers from and dispatching of engineers to developing countries.
After 1960 the official import of foreign technology increased drastically to 300 items per year. The import of technologies was more than twice that of the export in terms of paid prices, and probably higher in value.
In order to make itself less dependent of foreign technology and capital transactions and to enhance the competitiveness of its own industry, Japan in this period began to develop and improve its own leading and core technologies, e.g. via national projects, such as in nuclear energy and space technology. 30
In 1960, the Council for Science and Technology submitted, at his request, its recommendations for comprehensive and fundamental measures for the development of science and technology to the Prime Minister. The recommendations were derived from the opinions of 83 experts, divided under five panels in the fields of targets, personnel research, information and systems. The Council identified science and technology as a means for achieving industrial supremacy, being the source for national wealth. It recognized a lack of creativity, initiative and outstanding scientists and insufficient interest and understanding of science and technology by politicians and public. The Council set ten years targets, to be accomplished by scientists, engineers and industry, aimed to solve the mentioned problems and to bridge the gap with other nations. The necessary measures were directed at the qualitative and quantitative improvement of research personnel, facilities and structures, the raise of research investments and the domestic and international exchange of scientific and technological information. The Council feared that intensive domestic and political competition among the countries in the world would limit and restrict the freedom of the flow of valuable information.

Further cognitive and consultative underpinning of science and technology policies were provided by other specialized Councils and Committees, e.g. the Council for Marine Science Technology, the Council for Space Development, the Council for Electronics Technology and the Advisory Committee for Aircraft Technology.
The Science and Technology Promotion Budget in 1969 was originally aimed to promoting special research beyond the traditional boundaries of the separate Ministries and e.g. to the research interrelating special fields.
Much research is directly profit oriented research of enterprises, while individual basic research is free, but national research for
national projects in the public interest is conducted in national projects in national research institutes or international joint research programs.

National research laboratories and institutes were removed in the '70s from overcrowded Tokyo and obsolete facilities to Tsukuba Science City. Large Scale Research Projects were initiated in the fields of

atomic energy and space technology.
The Atomic Energy Committee (AEC) charted a long term program from the development and utilization of nuclear energy in 1996, followed in 1966 by a basic policy for developing power reactors.
In 1969, the National Space Development Agency of Japan (NASDA) was established in order to concentrate efforts for conducting space research and development. In the same year the Space Activities Committee (SAC) formulated a ten year space development program with as main goals the development of artificial satellites and launching rockets. The development of Q rockets for application satellites was postponed in 1970. N and M rockets for satellites are still underway. Ocean development was started, although already in 1968 the Shinkai, a deep sea exploratory vessel, was launched.

In order to respond to international demands to liberalize imports and capital, Japan started the development of national technologies and especially large scale technologies. The Industrial Structure Council, an advisory body of MITI, pointed out that Japan should raise its level of R&D budget to that of the other industrialized countries. In 1966, the Agency of Industrial Science and Technology (AIST) introduced a Large Scale Industrial Research and Development System and allocated a budget for 6 large projects: MHD power generation, super computer, ethylene manufacturing, underground goal gasification, exhaust gas desulphurization and high voltage DC transmission.
In order to develop national technologies for the private industrial sector an independent special public corporation, Research and Development Corporation of Japan (JRDC) was established.

The government promoted research in the form of industrial activities in the private sector by contracts and subsidies. The Japan Development Bank (JDB) was used for financing the industrialization of all new Japanese technologies. Special taxation measures helped to strengthen the general business structure of research organizations and enterprises which conducted research, e.g. by depreciation of costs of machines and equipment for the industrialization of new technologies. Special exemption for income derived from overseas transactions was another promotion measure. 31

New structures were introduced, e.g. a system for large scale industrial development, subsidies for key technology R&D, financing of domestic technology and tax exemption for additional R&D expenses.

The Japan Information Center of Science and Technology (JICST), established in 1957, grew with the introduction of computers into an important organization for the distribution of scientific and technological information. The Japan Science and Technology Promotion Foundation was established in 1960 as a central organization for joint government and non-government organization.

In this 70th decade, the industrial structure of consumer goods of Japan was mainly determined by home appliances and automobiles. In the fields of railway, telecommunications and construction fields, large scale development was carried out under the policy of government procurement.

The 80th decade

S&T policy in this decade was formed against the background of worsening pollution problems, upcoming consumer demands and more intense and frequent trade frictions.
This period was characterized as the self-development of advanced technology. On this basis, Japan's

exports of technology surpassed its imports. Japan was able to improve its production and social welfare systems, and to carry out anti-pollution and energy saving measures. The demand for products decreased because of saturation levels were reached and switched to increased quality of existing products.
The problems of high speed growth had to be overcome and a more harmonious relationship between science, technology, economy and men and society was sought. This was also reflected in a relative shift to behavioral, life and environmental science. Biological and human science technologies found a niche next to physical technologies.

The increase of productivity in manufacturing industries reached a top. With the saturation point in the secondary industries, a shift began to tertiary industries, e.g. in design, research and development. The growth in the number of science and engineering students slowed down, but the total number of researchers and engineers continued to increase.

Finally, Japan reached a R&D level per capita, comparable to that of the U.S.A..

Japan established organizations for R&D in nuclear energy, space (NASDA) , and other technological frontiers. Japan Marine Science and Technology Center (JAMSTEC) and the Council for Ocean Development were established in 1971, for the development and research of the ocean.

The efforts in R&D inputs yielded relatively great economic success, because they where not related to military goals, but to industrial purposes. Development was not carried out for goals, dictated by the top management of big military or space projects.

The Environmental Agency (EA) was established in 1970 for administrative guidance and development of environmental preservation technologies.

In 1971, the Council for Science and Technology (CST) stressed the importance of the integration of science and technology, the assessment of environmental safety and socio-economic effects of technology and industrial production. It wanted greater attention for humanization of science and technology in the future, by the further development of life sciences, software, .biosciences and health sciences. 32

In 1977, as result of the oil crisis, Japan began to develop technologies, related with the exploration, saving, reduction or efficient use of limited resources, and to welfare problems, not solvable by technological and material means. 33

The financial and technological means of industry in this period were considered to have improved to such an extent that the tax exemptions and the gross national investment in scientific and technological research could decrease yearly. This gave later rise of international criticism of Japan's free ride on technology. 34
For developing Japan's own advanced industrial technologies, the old laboratories were reorganized and provided with new tasks in the Electrotechnical Laboratory (ETL), and the Mechanical Engineering Laboratory (MEL) . For agriculture, forestry, high energy physics, genetic and

bio-engineering, specialized organizations were established.

The Law for the construction of Tsukuba Science City was enacted in 1970 and construction of the first research institutes started in the same year.
In 1974, the development of technology for substitute energy started with the Sunshine Project (new energy technology R&D system) by MITI and for the development of energy-saving technology with the Moonlight project (energy conservation technology development) also by MITI. MITI also stimulated measures for the promotion of R&D on pollution control. 35

In 1967 The Basic Law on Environmental Pollution Control was enacted and the government intensified pollution prevention control. And after the smog appearance in the Kanto area by 1968/9 the Environment Agency was founded.

In 1977 the Council for science and Technology reacted to serious problems in the field of the provision of food, energy, and environment and safety, and recommended the development of technologies for the substitution and more efficient use of resources. 36
In this period, Japan signed agreements and arrangements with twenty nations for international cooperation in the field of science and technology.
The National Institute of Resources also played an important role in the developing of pollution prevention technology.

In 1981 the government supported energy related R&D activities and increased cooperation between industry, academia and industry by a system for promotion of coordinated and creative science and technology.

The 90th decade

The science and technology policies in the first half of the 90th decade were formed against the background of increasing energy problems, protectionism as result of downward trend in global economy and the north south problem. The gap with the West was definitively closed especially in the field of production technology, pollution control and energy savings. Japan's international competitiveness was very strong and its trade surpluses kept growing. This favorable situation brought also problems. The international criticism on Japan's trade practices swelled and Japan could no longer rely on foreign examples for its own economic, and technological development. It had to develop its basic research in order to create the roots for its further scientific and technological developments. Japan was expected to independently develop its innovative technologies and to contribute with the results to the international community.

In 1984, the Council for Science and Technology stressed that Japan should increase its efforts and organizations in the basic research and development to promote mutual understanding, exchange and cooperation with the international research community. 37

Science and technology policy in this period was no longer defensively directed at the solving of problems, but actively at the finding of sources for new technologies.

In line with international developments, science and technology efforts were directed to shifts or breaks of frontiers in knowledge and skills, e.g. in the international high tech fields of materials, electronics and in life sciences (biotechnology). Other directions were the improvement of man-machine interfaces and the further substitution of men by machines.
In the field of education, efforts were made to increase individuality, creativity, capabilities and leadership in young people. These efforts were not as successful as expected, however.

In the sphere of its administrative guidance, the Council for Science and Technology increased the frequency of its policy recommendations, and formed a policy committee substructure, in order to cope with the increasing speed of technological development.
In 1980, the Council for science and Technology recommended to promote research in new materials, electronics, and biotechnology in order to create sources for new science and technology.

By 1983, the science and technology environment had been changing drastically due to industrial restructuring, stagnation of the world economy, sharpening of trade frictions and the maturing and aging of Japan's society. In the same the Prime Minister asked the Council for Science and Technology for expert advice on fundamental comprehensive measures for promoting science and technology on the long term.

Guidelines for a national science and technology policy were recommended by the Council for science and Technology as response of government inquiries. The advice on the 11th Inquiry was titled "Comprehensive fundamental policy for promotion of science and technology to focus current changing situations from the long term view", and dated 11 November 1984. The recommendations on the 12th Inquiry was named "General guideline for science and Technology Policy", dated 3 December 1985.
These policies had to be based on the following fundamental goals:
- The creative development of advanced science and technology.
- The harmonization and interfacing of science and technology with man and society.
- The nurturing of capabilities to deal with increasing internationalization.

The Council for Science and Technology suggested as future science and technology policy the following principles: Initiatives for developing international cooperation in research, contribution to the promotion of science and technology according to the available human resources, economic strength and scientific and other potentials, the principle that all nations should view basic research as public international properties and that all nations should contribute and benefit from international cooperation and exchange in a well balanced way.

March 1986, the Cabinet decided to adopt these recommendations, with amendments for concrete measures for administrative purposes, as the General Guideline for Science and Technology Policy.

The concrete measures for the implementation of the suggested policies were:
The establishment of the International Frontier Research System, of RIKEN, in 1986, of the Japan Key Technology Center in 1985, of the Bio-oriented Technology Research Advancement Institution in 1986 and of the Adverse Drug Reaction Sufferings Relief & Drug Research Promotion Fund in 1987.
The Research Exchange Promotion Act of 1986 contains measures to engage foreigners in important research positions and to promote international collective research programs. It allows foreign

organizations to use patents, owned by the State, free of charge or at low cost and flexible handling of property rights in general.
The Japan-U.S.A. Science and Technology Cooperation Agreement of 1988 is signed in order to guarantee realistic efforts and participation and exchange in research based on the economic and technological strength and conditions of the involved countries.
Other concrete measures were a fellowship program, financed by the STA to attract foreign researchers on a temporary base as of fiscal 1988. Also in 1988, Japan initiated the international Human Frontier Science Program. This program is administrated both by the STA and MITI. The Research Corporation of Japan (JRDC) is also responsible for the exchange of international research.
Japan was expected to present the world clear intentions of its fundamental stance regarding international cooperation in R&D.
A concrete answer was the Human Frontier Science Program for the promotion of joint international basic research in the field of bio-functions. The project was proposed by Japan at the Venice Summit in 1987. And in October 1989, the International Organization for this Program was established in Strassbourg in France. The outcomes of these studies are intended to become a global public domain knowledge. MITI and STA administer this program.

In 1985, the government established indirect fiscal subsidies, such as tax systems for the promotion of basic technology development and for the technical basis of medium and small sized firms. A special credit insurance system for medium and small sized firms was already in operation from 1980. Special organizations for the financing of basic technology were established. Direct subsidies were primarily aimed at the promotion of basic research.

More direct administrative measures were taken for the promotion of S&T. In reaction to international criticism, Japan started to intensify its efforts in the fields of basic science and advanced technology,
by increasing its budget for science research expenditures. It failed however to reach the comparable levels of researchers and basic research investments per person in the U.S.A. and Europe. 38
In this period, the Basic Biology Research Institute and the Life Science Department in RIKEN, several Agriculture Research Centers and Bioengineering sections were founded in the biological (life) science sector.
In government and academic settings, research organizations for research of new materials were established.
To foster the basic technology level in the private sector, the Japan Key Technology Center (JKTC) was established in 1985. The Japan Development Bank and other financing organizations provide the funds for this type of research.

Under the Promotion System for Creative Science and Technology, a research system for coordinating researchers in industry, government and academic organizations was established, which guaranteed life time employment and organizational conditions for projects of creative research activities. Important product of this approach was the New Frontier Project in RIKEN, and the reorganization of the National Research Institute for Metals. Japan followed a policy in 1980 to promote material science and technology as one of the most important development areas.

In 1981, the Next Generation Industry Basic Technology Research and Development System was

established by MITI in order to develop new technologies in the fields of new materials, biotechnology and new functional devices. In the same year, a new budget system for eminent basic research in cooperation between industry, government and academia was created. National research institutes also increased their efforts in basic research.
The Joint Research System for Universities and Private Industries brought together researchers from academia and industry.

Administrative deregulation appeared necessary to open the way for more cooperation in S&T. To deregulate cooperation among different fields and industries, the Research Exchange Promotion Act was established in 1986. 39

In 1971, the STA had set as target the field of life sciences, among others covering biotechnology, health and medicine and agricultural and industrial production. In Report No 5 of 1971, it had defined this more general term as technology for clarifying the mechanisms of life phenomena of bio-organisms and applying them to solve various problems concerning human life. The research targets were formulated in 1981, full-fledged R&D activities started and research in fields such as senility control, bio-reactors, artificial organs, intelligent machines, recombinant DNA, cancer research started to bear fruit by the end of the 90th decade.

For harmonizing man and technology, MITI's Fifth Generation Computer Program started in the field of artificial intelligence. And the Minister of Construction started a program on intelligent building. In these fields, a number of basic technologies have to be developed. The first step is to discover the intelligent, perceptive and sensitive,
psychological and mental, cultural and ethical functions of man, including those of acculturation of science and technology itself. 40

In 1980, MITI's Industrial Structure Council produced a report on the Vision of International Trade and Industrial Policy for the 1980s. The report focused the spotlight on the role Japan had to play in the international community, on the needed changes in the industrial structures and the development of new creative technologies. Resulting concrete measures were the establishment of an R&D system for regional development and for building a future industrial infrastructure, subsidy programs for the building of industrial R&D and technology promotion, and the promotion of new power generation technology. 41

In the last half of the 90th decade, the Japanese economy continued to flourish. The surplus of the trade balance stabilized over $94 bln. Because the U.S.A. share of GNP dropped and its account deficit increased, the economic friction between Japan and the U.S.A. became more tense. The U.S.A. required from Japan to stimulate domestic demand and to open its markets. In response, the government decided to take urgent economic measures to readjust the economic structure of Japan drastically to a domestic demand. In this period the growth rate of domestic demand rose more than the growth of the Japanese GNP, which implies a deficit in the external balance of payments. Japan developed as a creditor to the world's nations. In the end of this decade Japan is internationalizing, not only by sending but also by receiving products, labor and capital from overseas.

One of the driving forces of this internationalization is the change in the world economy by the

forming of regional economic zones, e.g. the Market integration of the EC, the U.S.A.-Canada Free Trade Zone and the Asia-Pacific Free Trade Zone.
In both hypothetical cases, that these zones are regionalistic and protectionist as well as that they are open for exchange, for Japan it is most important to avoid isolation and to contribute to the economic development of the world, by opening its markets, by correcting trade imbalances, by tolerating deficits and by aiding developing nations. 42

The domestic problems which Japan is facing at the moment are:
- A disproportionate concentration of people and material in the metropolitan area and depopulation of agricultural and mountainous areas.
- A rapid aging of the population, the decline in marriages and a birth rate to low to reproduce its own population.
- The lack of leisure time of the male working population.
- An insufficient social security system.
- The remaining problem of scarceness of resources.
- And the domestic as well as border crossing and global problems of environment.
- Moreover, Japan seems to have a qualitative and quantitative lack of researchers in basic sciences. The younger generation prefers to work in the more profitable banking and business sector.

There is a growing awareness that science and technology play a major and ever increasing role in the economies of nations and regional
zones. In order to strengthen international competitiveness national efforts in science and technology are therefore regarded as of the highest importance. On the other hand it is also understood that science and technology is an increasingly international phenomena and that international cooperation is advantageous not only for national interests but also for the international public interests. This means that for free exchange of information, each country is required to contribute to R&D science and technology according to its economic capabilities. Just as other nations, Japan seeks an optimal balance between competition and cooperation.

The Environment Agency raised funds for international measures for the improvement of the environment.

Japan also started participation in the international Space Station Program, in cooperation between the U.S.A., the European Space Agency (ESA) member countries and Canada.

In 1988, a multi-disciplinary research project on high temperature, superconductivity was promoted with the cooperation of a network of research organizations. The time elapsing between the start of a project, the discovery of a new basic technology and its industrialization is too large to evaluate the success of these new activities by now.

In 1989, Japan's total R&D expenditures were 2.87% of its GNP, which is higher ratio than that of the other advanced nations. The government investments, however, were considerably lower. This reflects partly the low spending on defence related R&D and on basic research. The output of research in patents, as measures for the application of R&D, and their quotations show a good quantitative and qualitative performance of R&D for applications. The output in terms of research papers show that

Japan is leading in a number of fields. Measured in terms of quotations, Japan is still far behind that of The Anglo Saxon countries. 43 It is not clear whether this can be ascribed to the lack of originality and or to linguistic and cultural impediments.

Regardless, whether or not qualitative analysis will reveal a real lack of creative research in basic science is true or not, great effort is made at the moment to create basic technological know how as well by government measures as by the establishment of basic research institutes in private companies. Because results of private institutes do not necessarily belong to the public domain, the Japanese government is expected to increase its funding and basic research efforts and to make it available for foreign countries, in order to prevent rising international criticism or, more positively stated, to contribute to global development of science and technology.
The inherent problem, in this respect, evidently is how to manage the efficient use of these basic research investments.
In order to promote the exchange of research in terms of personnel, a better balance in the number of incoming and outgoing researchers is needed, and Japan is seeking to invite more foreign researchers.

In 1988, Japan agreed on a renewed agreement on R&D in science and technology with the U.S.A.. The reasons were that the U.S.A. now recognized Japan as an equal competitor in economic, scientific and
technological aspect, ascertained an imbalance in the efforts in basic research efforts between the nations and requested the strengthening of Japanese science and technology capability and better protection of intellectual property. The nations agreed to share contributions and benefits according to their strength and resources, comparable access to public research programs and facilities, broad exchange of information on S&T and sharing of cost, risks and benefits of the collaboration.

In 1988, the Cabinet decided on a five year Economic Plan, in which the need was stressed, for further internationalization of many fields, including science and technology, not only for the sake of other countries but for the sake of the Japanese society and economy. 44

3

SCIENCE AND TECHNOLOGY IN JAPAN

State of the art

Since the Meiji area, Japan has been introducing, modifying and elaborating Western technology with the aim to catch up with the West.

In the post war period it made strong attempts to lead in virtually all fields of industry and technology and industrial products. At the moment it is a world leader in a number of advanced technologies, such as semiconductors and superconductivity.

The state of the art in S&T is often measured and quantitatively expressed in efforts, or inputs, and results. or outputs:

The figures for the major S&T input indicators for Japan, for the indicated year with their increase in the preceding five years within parentheses, are stated below:

R&D expenditures: ¥9.8 trln (1988, +46%)
number of researchers: 462,000 persons (5-1989, +25%)

including the humanities and social sciences these figures were:

R&D expenditures: ¥10.6 trln (1988)
number of researchers: 535,000 persons (5-1989)
basic research
expenditures : ¥1.3 trln = 13.3% (1988)

The figures for the major S&T output indicators for Japan are:

number of published articles: ¥30,000 (1986, +19%)
value of technology export: ¥280 bln, (1989, +190%)
value of high-tech products
export: ¥11.6 trln (1986, +93%)
number of applied patents: 339,399 (1988, +33%)
number of granted patents: 55300 (1988, +1%)
Source: 45

Japan's input of foreign technology in number of cases is given in the
table hereunder:

The introduction of foreign technology: 2834 cases
among which of advanced technology: 1557 cases
and electronic computer technology: 1067 cases
among which software with: 985 cases
hardware followed with 77 cases
and services only amounted to 5 cases
semiconductor technology: 240 cases
foreign atomic energy technology: 70 cases
foreign aerospace technology: 71 cases
foreign medical and drug technology: 85 cases
foreign biotechnology 24 cases

The technological fields in which Japan considers itself to be fully self sufficient are micro-electronics, ground transportation, nuclear power plants, sophisticated machine tools, civil engineering, construction tools, building technology, shipbuilding, uranium enrichment, rocket launch vehicles. Given the dynamic development of technology, however it is aware of the necessity to maintain open channels for international transfer of knowledge.

A Japanese source for self assessment of its relative status in S&T is included in a summary in

English of the white paper on industrial technology of MITI from 1988. 46
The paper contains a comparison between the U.S.A. and Japan regarding its present technological level and its capability to develop high tech products for 40 technologies. The evaluation is a result of a survey of private companies on Japan's technological strength and potential.
The results show that in comparison with the U.S.A., the responding companies consider Japan's technological level as:
- lagging: only in data bases, aircraft engines, magnetic resonance imaging and satellite launching rockets,
- leading: in the fields of semiconductor lasers, photovoltaic power generation, high strength steel, home VTR, charge coupled devices, semiconductor memory devices, spectrum analyzers and fine ceramics.
- equal: for the rest of the fields
However, they consider their potential capability for development higher in: micro processors, copy machines, assembly robots, new glass, amorphous alloys, polymer separation membranes, computer aided design and manufacturing, laser printers, accelerators and D-PBX systems and satellite launching rockets.

Another survey in the same report shows that Japan is considering its place in 47 basic technologies at the present as:
- only leading: in ferromagnetic materials and advanced robotics,
but expects also to take the lead by the year 2000 in the fields of:
- fine ceramics, carbon materials, superconducting devices, wide circuit elements, organoid biomaterial, disaster prediction and environmental control technologies.

The STA has also made evaluations of the status of Japan's S&T level. The White paper on S&T of 1987 compares the relative strength in R&D capability.
Among 20 fields. the responding private industry considers itself: superior to the U.S.A.:
- in mechatronics, ultra large scale integrated circuits, high precision production processing and opto-electronics and equal in computer hardware.
- in all electronics technologies and, in production and processing,
- almost equal: in the field of materials and
- slightly lagging: in the life sciences.
In comparison with Europe it only considers itself inferior: in the life sciences. 47

The White paper on S&T of 1988 compares the relative strength in basic research with Europe and U.S.A..

In comparison with the U.S.A. ,Japan considers itself:
- inferior: in almost the whole spectrum, worst in the life sciences and geological sciences, and somewhat less worse in the material and information S&T.
- competitive: only in new materials and semantic processing of audio visual and linguistic information.
In comparison with Europe the picture is slightly better, it thinks it has a lead: in the whole field of

information and electronics and in the field of new materials. 48

The value of such self evaluation should obviously be taken with great care.

A recent international comparison of critical technology levels shows the difference in perceptions between Japan and American expert judgments:
Consensus exists about the lag of Japan in the fields of software production capability, parallel computer architecture, integrated optics, data fusion, air breath propulsion.
Consensus about equal positions exist in the field of microelectronics circuits and their fabrication, high temperature, strength and lightness composite materials and superconductivity.
The US experts tend to see Japan leading in compound semiconductors, such as GaAs, fiber optics and biotechnology materials and processing. 49

A survey of STA in 1990 on the self assessment of technical capabilities of Japanese corporations shows a slightly different picture. Most of the companies think that Japan:
- takes a lead in household products, and
- is lagging in welfare equipment for the elderly and handicapped, and - is almost on the same level in the fields of medical treatment equipment.
There was less consensus on the fields of information and communication equipment, engineering and construction technology, transportation and shipping control systems and environmental pollution prevention systems. 30

An American study of the Department of Defense in 1990, indicated as technological capabilities in which Japan had a lead over NATO allies, the fields of semiconductor materials and microelectronic circuits, machine intelligence and robots, photonics, superconductivity and biotechnology materials and processes.
The only field where Japan was suspected to be lagging was in weapon systems environment, and air-breathing propulsion. 51

A survey of the U.S Department of Commerce on the relative strength of the U.S.A. in 12 emerging new technologies yield the following picture. The report considers Japan:
- to lead already 1989 in advanced materials, advanced semiconductor devices, data imaging technology, high density data storage and optoelectronics,
- to be at pace in superconductors and
- to lag in artificial intelligence, biotechnology, flexible computer-integrated manufacturing, high-performance computing, medical devices and diagnostics and sensor technology.

But it expects that Japan will be able to catch up in the field of artificial intelligence and flexible computer-integrated manufacturing, and to take the lead in the other mentioned fields. 52

These comparisons should be interpreted with caution, because the soundness of the methodology can be questioned on the basis of the possible nationalistic bias, the pragmatic function of these reports, the lack of objective measures, and the selection of the fields and respondents. Nevertheless it gives an overall indication that Japan has caught up with the West in proportion to its resources and development period in a number of important technological fields. That it seems to lead especially in the fields of new materials and microelectronics, and that there is a relative lag in basic science. It also indicates that Japan tends to estimate its own R&D capabilities lower than the U.S.A.. And that its relative development capability for the future promised to yield a lead in still other fields.

Japan is almost on equal level and in the future probably surpassing the U.S.A. in the field of new advanced materials, which form the basis for a diversity of applications such as metals alloys, polymers, plastics, composites and ceramics. Its capability for technical and commercial application is probably already greater.
Japan is especially strong in the field of advanced ceramics. After the discovery of the possibility of superconductivity at higher temperatures, Japan has explored this field eagerly and, and invested heavily in R&D efforts. At the moment especially in applications such as magnetic levitation and propulsion, magnetic energy storage (SMES), large scale integrated electronic circuits and supercomputers, medical equipment, and Squids (superconducting quantum interference devices).

In biotechnology, Japan seems to be quickly catching up with the U.S.A.. In this field it is supported by government agencies, especially established research associations and the adoption of biotechnological research by ERATO e the HFSP (human frontier science program). Japan puts a lot of effort in application of recombinant DNA techniques.

MITI sponsors a project for software co-development with industry, SIGMA (Software Industrialized Generated and Maintenance Aids). This program intends to yield a national network of software tools, for partial automation of software writing.
Another initiative was to establish a university-industry cooperation in the development of Real Time Operating System (TRON), specifically for Japanese hard and software and natural language.
The project for the development of the Fifth Generation Computer is now in the end of its ten year period. The results do not quite meet the high expectations at the beginning of the program, and are expected not to lead to the promised breakthrough of a totally new computer program. The main concrete product so far, is a program to make deductive inferences, which are not strictly based on numerical calculations. 53

Telecommunication can be divided in transmission systems and information processing. Japan is carrying out R&D in two advanced technologies, optoelectronics among which fiber-optics and direct broadcasting
of TV satellites. The final objective is to build a national communications network ISDN for transmitting digital signals.
A fiber optic network is rapidly laid in the country and a (experimental) broadcast satellite is in operation.
Telecommunications is a combination of various technologies, processing and transmitting opto-electronic information. Japan is already far in the field of computers, in the field of TV it already has a commercial high-definition television in its High-vision system, even though the system is still to expensive for a large market.
A broadband digital communications system will open the possibilities for other component technologies. HDTV in Japan is developed in two versions. The analogue version is already on the market and is transmitted via the cable; the digital version has to wait for broad band optical fiber

transmission or dedicated satellite connections. The introduction of digital HDTV will open new possibilities for connection with computer technology and peripheral systems, such as recorders, camera's etc.
The analogue High Vision System is endogenously developed in Japan and can be viewed as a major breakthrough in TV technology. On the other hand, as a system already on the market it will be technologically inferior to systems, being developed in as well as outside Japan, which are digitalized and (hence) compatible to computer technology and thus has a greater potential for application. A big struggle is going on about standards and no camp seems willing to give in.

Japan is not at world top level of in aerospace technology. For production the domestic market is too small and, given the constitutionally limited role, will remain small in the foreseeable future. In 1988, plans to produce commercial airplanes for short take off and landing, developed by the National Aerospace Laboratory, were cancelled because Japan Air Lines was not interested in buying them. The foreign competition is too big for selling them at the international markets. Japanese manufacturing companies are providing components and subassemblies for foreign airlines and provide capital for foreign production facilities. The plans to develop independently a next generation fighter aircraft (FSX) have encountered strong US opposition and seem to impose too much technical problems for Japan at the moment. The costs of this project already surpassed twice those initial calculations by mid 1991.
The space program must cope with the same problems. There is no military space program. The government investment in space applications is over ¥1 bln. But the space efforts are fragmented over several organizations.
The Institute of Space and Astronautical Sciences (ISAS) of the Ministry of Education is an interuniversity research center, involved in space science research and the National Space Development Agency (NASDA) is a public corporation of STA involved in applied research. The independently developed N-II rocket will be able to bring 2200 kg in orbit, but was delayed one year for fabrication reasons. Communication satellites are independently developed in the 2000 kg class. The space science program uses small satellites in a low orbit, launched by an ISAS base.
Japan is involved in the U.S.A. space station program with the contribution of an Experimental module at the total cost of ¥2 bln. In the last decade, an experiment with materials processing in space will be carried out by a Japanese astronaut in the US space shuttle.

Nuclear power forms the largest R&D program in Japan and its state of the art is of high class.

The factory automation is a example of a fruitful integration of technologies, such as machine tools, robotics, inspection devices and computers and the software tools such as computer aided design.

Science and technology fields

For this section I have drawn heavily on the Historical Review of Japanese Science & Technology Policy, without consequent citation. For more details I refer to this valuable book. 54

The major fields in terms of advancement and economic significance are: Big sciences, Infrastructure technology, Industrial technology, Agricultural technology.

1. Big Sciences:

(Nuclear Power, Space Development, Medical and Life Sciences, Ocean development)

Nuclear Power.

Japan has 37 nuclear plants with total capacity of 30 mln kilowatts of power with a share of around 30% of the nation's power generation. Given the scarcity of resources for conventional power generation, nuclear power is considered to be of major importance for Japan's economy. The cost of the uranium fuel is low compared to the capital invested in the plant. Moreover Japan is trying to increase its self sufficiency by plans and research for increasing the efficiency of the use of natural uranium resources, by development of a nuclear fuel cycle, including enrichment of uranium and reprocessing of used fuel, advanced power reactors, a fast breeder reactor and in the far future even nuclear fusion.

The Atomic Energy committee (AEC, 1956) and the Nuclear Safety Committee (NSC, 1978) are bodies for providing recommendations, respectively concerning fundamental policies for the development of nuclear power and for planning, discussion and decision making on the promotion of nuclear safety. Their establishment laws stated that the Prime Minister should respect the decisions of these Committees highly. The administration is under the jurisdiction of STA and MITI. 55

The industry is involved via the Japan Atomic Industrial Forum Inc. Since April 1988, Japan has been involved in design activities in the international Thermal-Nuclear Experiment Reactor together with the U.S., E.C. and the S.U.

In its annual report on atomic energy of 1989, the Atomic Energy Committee mentioned as reasons for policies to promote Atomic Energy:

-the expected rising demand of energy especially in the developing countries with inevitable price rises of petroleum, and

-the rising global environment problems connected with the increasing burning of fossil fuel.

This calls for the need to conserve energy and to develop alternative sources. The energy need in Japan is still large and is expected to grow sharply in the future. To assure a stable supply Japan is seeking diversification of its energy sources in a "best mix energy" policy.

Nuclear power generation as a stable and economic energy source is perceived as one of the viable alternatives for petroleum, on the condition that safety of operation and radioactive waste disposal is guaranteed.

The Committee stresses the need to use uranium more efficiently and to develop its own nuclear fuel cycle technology, to search for technology for safe handling and disposal of radio active waste and to increase the safety of nuclear power plants. And to secure public support, to work on a better public understanding of the benefits and risks of nuclear power plants.

Japan also intends to contribute to the international body of knowledge on Atomic Energy, by cooperation in research projects for safety, fast breeder reactors, nuclide partitioning and transmutation and nuclear fusion. It will also assist developing countries in their efforts to develop and use nuclear power generation, contribute to international nuclear associations and collaborate on a framework for nuclear non-proliferation.

Japan is promoting R&D in the development of light water reactor technology, reactor dismantling, the establishment of a nuclear fuel cycle via uranium enrichment, reprocessing of spent fuel from light water reactors, handling and disposal of low- and high level radioactive waste, the development of uses of plutonium in light water reactors, advanced thermal reactors, fast breeder reactors, the reprocessing of spent fuel and MOX fuel processing.
Other research is carried out on radiation uses for medical, agricultural, forestry and fishery, industrial, environmental and research purposes.
In basic research it is involved in reactor and nuclear physics, physiological radiation research, fuel and material irradiation experiments, radioactivity in the environment and ecosystem, materials, artificial intelligence, laser technology and radiation hazards. In innovative development it is involved in nuclear fusion at the JAERI, containment methods, reactor engineering technology and the nuclear powered ship Mutsu. 56

Space Development

Space Development of Japan is promoted, regarding practical utilization, by the National Space Development Administration (NASDA), regarding research, by the National Aerospace Laboratory (NAL) of STA and the Institute of Space and Astronautical Science (ISAS) of the Ministry of Education. At the moment Japan's H-2 rocket is under development, using only original technology. There are also promising achievements in the fields of satellites, the creation of new materials, using the microgravity and high vacuum of space.
In the last decennium Japan has, succeeded in launching several scientific satellites, broadcasting satellites, communication satellites, meteorological satellites, engineering test and experiment satellites and payload rockets.
Industry plays an important role with the Special Committee for the Peaceful Utilization of Space in the Federation of Economic Organizations.

The administration of the space development programs is divided over the STA, the Meteorological Agency and the Ministry of Post and Telecommunications.

For the coming period, an impressive number of space projects are scheduled, including satellites for marine observation, communications, meteorology, broadcasting, earth resources, engineering tests, test flights, materials processing, ground test vehicle, payload capacity examination, space flyer unit, experimental space station module and an earth observation platform engineering satellite. 57
Development and production of artificial satellites is conducted by the government institutes, universities and private enterprises.
Japan also participates in international space development projects, e.g. the exchange of observation data of the earth and outer space.
Japan is involved in international manned space programs with the S.U., U.S.A. and Europe. The first Japanese in space was a television journalist aboard of the Soviet Mir space station in December 1990, and an astronaut of NASDA will conduct materials processing tests aboard a U.S.A. space shuttle in 1991. NASDA has a budget of ¥136 bln, mainly to be spend on the development of the H-2 launching rocket.

Japanese aerospace industry lags well behind that of the West. Because the U.S.A. occupying forces banned Japan from this field and the Japanese government had other priorities in the early post-war years. But by now Japan has an ambitious space program. It wants to achieve commercial applications this decade and manned space activities next decade.
The commercialization will be under severe constraints. One of them will be the American pressure on Japan to open its satellite market. (The U.S.A. earlier forced Japan to co-develop and co-produce its next-generation jet fighter, the FSX.) Other restraints will be the unexpected higher development costs than foreign competitors. (The maiden launch of the H-2 is postponed by one year to 1993, due to development problems and an explosion.) And a last restriction is formed by the legal ban on military payloads with the most extensive and profitable market potential.
Aerospace will not follow the path, which other commercial industries such as automobiles, home electronics, camera's have pursued. Aerospace industry is largely sustained by the military sector with its air and space programs, its procurement and R&D investments.

Medical and Life Sciences.

Biological science and technology aims at the understanding of phenomena and functions of live and living objects. Much progress is made in the field of molecular biology and biological technology, especially the understanding the translation and transfer of information from the DNA to messenger RNA and to protein by unraveling the genetic code and gene manipulation. The results promise to find applications in the field of medicine, agriculture and engineering. The results transcends the traditional boundaries between the conventional life sciences between the levels of living systems and between science and technology. Biotechnology offers great promises for industrial application. In 1979 the Japanese government decided on the Guidelines for Recombinant DNA Experiments and since then basic research, R&D application and commercial production is conducted on a wide scale in Japan.
In 1984, the Tsukuba Life Science Center was established in RIKEN for the promotion of research in basic life sciences and recombinant DNA technology. For experiments in universities and research organizations, the Ministry of Education issued its guidelines in 1979. The
ministries MHW, MITI and the MAFF also established research groups in recombinant DNA technology for their specific application fields. At the moment Japan caught up with the state of the art in the U.S.A. and is now a world leader in the production of B-form hepatitis vaccine out of yeast. Research on safety assurances on introduction in the environment has led to the physical and biological containment theory. Cancer research is promoted by the STA, Ministry of Education and MHW. This has led to the discovery of a new cancer gene and methods for diagnosis and therapy methods, using monoclonal antibodies. Japan is now leader in cancer gene research, with its successes in isolating gastric cancer, colon carcinoma and liver cancer genes.

Ocean development.

As a country completely surrounded by seas and oceans, after developing a Plan for Ocean Development in 1969, Japan unfolded several activities in the field of ocean research and development, In 1971, the Council for Ocean Development and the Japan Marine Science and Technology Center (JAMSTEC) were established to promote and carry out marine science and technology.
Since then, JAMSTEC has been experimenting in the fields of underwater living, in wave power

generation and deep diving techniques. It disposes of the oceanographic submersibles Shinkai 2000, Shinkai 6000 with their depot ships Natsushima and Yokosuka, a hydrolaboratory Kaiyo, and an unmanned marine research vessel Dolphin-3K.

After a stagnation, due to the oil crisis and subsequent restructuring of Japans' industry, Japan developed new efforts in ocean development In the exploration of the sea floor, the Shinkai 2000 obtained results in the discovery of hydrothermal emission and the existence of life in its surroundings. The Shinkai 6500 made first test dives below the 6000 meter level and provided submerging training.

In order to contribute to research on the role of the ocean in the absorption and circulation of heat and carbon dioxide (as an important sink for green house gases and compensator for global warming), Japan carries out a feasibility study for joining an international project of the World Circulation Experiment of the World Meteorological Organization and the International Council of Scientific Union and the Intergovernment Oceanographic Committee of UNESCO.

Other international joint projects, in which Japan participates are research on the Rift system and abyssal benthic mineral resources with the French, hydrothermal polymetalic ore with the Germans, and various marine projects with the U.S.A. and with China. 58

2. Infrastructure Technology:
(Construction Technology, Transportation, Communication technology)

Large scale civil engineering and construction technology

Japan is pushed under pressure from the international community to use its capital, labor and technology (resources) to improve its own infrastructure. In the field of construction technology and civil engineering it constructs dams, public roads, express ways, river improvement, buildings, bridges Japan is committed to new construction technologies in the so called new frontiers of space, ocean and underground. The policy for the direction of R&D in construction technology is laid down in a report

of the Council for the Development of Construction Technology of the Ministry of Construction of 1988. 59 The policy comprises R&D themes for safety and disaster prevention, city and housing planning and development, new use of space ocean and underground, effective utilization of resources, facilities, operation management and operation, construction productivity, the integration of other advanced technologies, conservation and creation of environment, transport development and rationalization and land information.

Transportation.

In the projected Shinkansen Line Plan of the Ministry of Transportation of 1988, a construction of a limited narrow-gauge line with a maximum speed of 200 km/h is provided. A research project for noise reduction of the high speed train is underway. The role of integrated transportation systems in Japan is and will continue to be extremely important, due to its mass potential, speed, safety, stability and low burden for the environment.

Further developments in soft-and hardware for the improvements and optimization of railways systems are under way. In the future much is expected from the magnetic levitation. Under development is the superconducting of Japan's railway and a normal conducting system.

For magnetic levitation transport systems, initially separate superconducting coils were used for levitation, propulsion and guidance, whereas now these three functions are integrated in a single superconducting coil. The MLU002 test vehicle is equipped with superconducting magnets, built in a small helium refrigerator. The vehicle body has an almost practical size and is undergoing test runs under realistic conditions, involving passing opposite trains and tunnels, in order to check reliability and safety. The record at the moment is set at almost 400 km/h. Future application of high temperature superconductors will further enhance the superiority of the system for high speed ground transport.

Communication technology.

Telecommunication.
Japan seems to be determined to develop itself into an information society. Whatever that may be, telecommunications will play a large role in this strive.
With the transition of the advanced economies to information societies, the role for science and technology in the field of communication of information is increasing, particularly in the field of telecommunications and broadcasting.
Telecommunication has been a public service in Japan since 1869. Since 1952/53, resp. Nippon Telegraph and Telephone Public Corporation (NTT) and Kokusai Denshin Denwa Co., Ltd. (KDD) (for international communications) were in charge of the construction and operation of the telecommunication network. In 1985, a new Telecommunication Business Law was enacted in order to cope with the increased and diversified supply and demand of communication services and to promote an open competition in the field. Since then many enterprises entered the business with a variety of services.

Transmission and exchange systems.
The commercial use of optical fiber started in 1981 with the introduction in telephone stations in twelve national areas. In 1985 optical fiber cable with a capacity of 5,760 telephone channels were laid throughout the country and is momentarily expanded to four times that capacity.

Data Communication.
After the diffusion of computers for information processing in companies, the demand for high speed and quality data transmission increased and computers were linked with networks to enable data communications. The amendment of the Public Telecommunication Law of 1981 opened the network for public exchange. The Telecommunication Business Law of 1985 completed liberalization and the number of companies exchanging information from datacommunication systems and multiple computers, via value added networks, increased drastically.
For international communications, KDD started to operate satellite communication lines via foreign satellites over the Pacific and Indian Oceans. The first Japanese satellite SAKURA was launched in 1977 by Nasa.
After failures in 1979 and 1980, the experimental communication satellite 2, built with Japanese technology, was launched by an N-2 rocket of NASDA in 1983, followed by its successor the CS-3 in 1988. In 1989 the first commercial Japanese communication satellites were launched in 1989 with various services.
In the field of mobile telecommunications a wide number of services were opened, domestic ship

telephone services, telepaging, radio paging, mobile car telephones, shoulder phones, aircraft and train telephones, aero-satellite telephones etc. 60

In 1988, NTT started her new service in Integrated Service Digital Network (INS net), combining communication services such as telephone, facsimile, data communication, video communication etc., linked in a single digital communication network. The service comprises a basic interface INS net 64 with two 64 kbit information channels with line switching, and a large capacity INS net 1500 with packet switching.

Japan will work with other industrial nations on the development and standardization of ISDN.

In the domain of telecommunications, a distinction is made between two types of carriers: Type I carriers, including NTT and KDD, offer the domestic services, such as home and (auto)mobile telephone. Type II carriers, offer services, such as data, image and voice transmission or a combination.
NTT booked an 1.3% increase in operating revenue to ¥2,859 bln and a profit of ¥203 bln in fiscal 1989.
Over 80% of the profits came from telephone communications. Data transmission grew as result of the growth of corporate networks. Business telephone and network service subscriptions boomed as result of the increase in facsimile use. Mobile communications services, such as radio pagers and automobile telephones also showed considerable growth. Leased circuits, as well ordinary for voice transmission as high speed digital for data-transmission, also flourished considerably. INS-Net started in 1988 as Japans ISDN service and was the next
year enhanced with a circuit switching networks for high speed communications, e.g. teleconferencing.
Three companies operate satellite service in Japan.
International telephone calls are increasing rapidly, hand in hand with the internationalization of Japan. Satellites handle call services, facsimile and datacommunications. International private leased circuits and data transmission (Venus) services are provided by KDD. International electronic mail is growing steadily. 61

Important developments in the field of telecommunication are the increase of international exchanges of telecommunications and new issues in information communication.

In fiscal 1988, the sales of the telecommunications industry increased with 4% to a total of ¥5.985 trln. This was 1% less than the total growth of the Japanese economic growth. Especially the domestic growth in the field of mobile telecom services and the leasing of high speed digital services contributed to this growth. The international telephone calls and international leased circuits were also great contributors.
On the production side the intensified competition was an important factor as result of the privatization of NTT and the opening of, and the entrance of new entrants to, the market.
The role of information in companies and households tend to grow, although not as much as the producers and providers had hoped for. The amount of information provided by the suppliers grew with 7.3% in 1988 to 41.4*10 16 words. The actually received information, however, was stabilizing at around only 1.99*10 16 words. This information consumption ratio has been decreasing every year. 62

The variety and amount of information equipment in, as well as the amount of information send to, the homes increased. Far the most time spent on information consumption in the homes is still on broadcast television. On the other hand, the number of communications equipment offered to the households is steadily growing. The use of leased circuits and computer installations has risen remarkably, especially facsimile.

In the Japanese offices the number of networks is growing fast and the trend in international exchange of information is growing.

Due to the great increase of exports, travelling, capital investments and provision of media information, reinforced or supported by the strengthening of Japan's infrastructure for information telecommunication, has led to a considerable increase of Japan's international information exchanges. 63

Broadcasting.

Broadcasting in Japan started in 1925 and developed swiftly after the establishment in 1947 of Nippon Hoso Kyokai (NHK), the Japanese Broadcasting Corporation. The Broadcasting Law of 1947 also permitted private enterprises to enter the sector.

Next to standard radio and CTV, Japans' broadcasting provide a number of other services, such as FM, multiplex satellite, multi-channel CATV.

Television sound resp. character multiplex broadcasting opened the possibility of stereo and bilingual resp. large capacity information transmission. For HDTV, test broadcasts are transmitted.

Cable television was introduced for reception in areas with poor reception as well in rural, mountainous as in urban areas. CATV is now diffusing over the whole of Japan.

As of 1985, a full scale application broadcasting satellite was launched. Japan has two satellite broadcasting channels. A third one is underway.

NHK booked an 0.1% increase in operating revenue to ¥354.8 bln and a deficit of ¥8 bln in fiscal 1989. 64

Postal services.

New mall services include mail order service, parcel post etc.

3. Industrial Technology:

(Shipbuilding, Steel industry, Petrochemicals, Automobiles, Home electronics, Computers)

Shipbuilding.

In the '60s, Japan's shipbuilding became a world leading industry, due to comparative advantages in cost, prices, technology, delivery and reliability. Japan's shipbuilding appeared very successful in vessel specialization, increase of vessel size, automation of navigation and operation, labor and energy saving and vessel performance. As for the production process, Japan built new, highly automated production facilities, standardized and modulized the building parts and introduced a efficient management technology.

The shipbuilding industry is characterized by a strong technical cooperation among large, medium sized and small shipbuilding companies and between related steel and machinery industries.

For its R&D the industry is strongly supported by universities, public research institutes and the bureaucracy, especially the Ministry of Transportation.
After 1975, in the wake of the oil crises, the global economic depression, the decreased consumption of oil and demand for tankers and the competition from Korea, the shipbuilding capacity declined and the industry is at the moment undergoing transformation. In this restructuring process the industry is undergoing a second reduction of its building facilities, a rationalization of production process and a merging of shipbuilders.
Its R&D is directed at the development of highly automated and reliable ships and at the increase of process productivity by introducing computer aided design and -manufacturing and robot technology.
Future technologies under development are superconductive electromagnetic propulsion vessels, 50 knot techno-superliners and large passenger ships.

Steel industry.

The Japanese Steel industry is also a world leader in terms of production quantity and quality.
The steel industry developed in the 60's with mass production facilities, in close relation to the shipbuilding, automotive and other much steel using industries.
Modern developments are the system of continuous casting in order to increase the steel yield, energy saving to cut costs and decrease the dependence of imported oil, and process computerization.

The quality of iron and steel products is high, due to refining by desulphurization, degasification, degassing and surface treatments. Recently the industry works further on innovation, diversification and quality enhancement of its end products, such as fine steel products and high grade steel in terms of precision, thinness, heat and cold and corrosion resistance and to new design and engineering of manufacturing technologies. 65

Petrochemicals.

The demand for ethylene is now well over 5 mln tons per year.
The petrochemical industry suffered most from the oil crises, because the cost of fuel and feedstock contributed for more than 90% to the ethylene production costs. However adequate government policies and the execution of rigorous plans for saving energy and raw material, and for diversification in feedstock (besides naphtha, also heavier propane, butane etc.), resulted in the highest energy efficiency in the world. At the moment the energy needed to make 1 kg of ethylene at an ethylene plant with a capacity of 300.000 t/y is less than 5000 kcal. Though not yet fully overall price competitive, the Japanese petrochemical plants are competitive in product quality and in meeting user needs.
Due to its lack of natural resources, however, Japan is continuously confronted with vulnerability and international competition.

Automobiles.

As is well known, the Japanese car industry has grown prosperously and now is on the top of the production in the world. With an output of more then 10 mln automobiles per year it accounts for

more than 30% of the worlds total production. This industry is one of the main pillars of Japans' economy as it accounts for more than 10% of Japan's total manufacturing output and 20% of its export value. MITI promoted the car industry and planned to make it an export industry in the '50s.
During the '70s, problems due to air pollution by exhaust gasses, traffic accidents and motor noise occurred. The Japanese government issued many strict regulations on exhaust emissions and promoted research on auto exhaust pollutants. At the moment Japan has the strictest standards for gasoline passenger cars. This led to the developing of emission reduction technology, e.g. combustion improvement, air-fuel ratio control and catalysts.
The energy saving policies following the oil crises prompted the Ministry of Transportation and MITI and to issue a standard energy efficiency guideline in 1979. This led to the development of technologies for the improvement of engines and drive systems, lighter bodies and decreased aerodynamic and rolling resistance.
A series of safety regulations 66 and an experimental safety regulations program 67 aimed at the improvement of automobile safety.
The resulting technological improvements paid off later, because since export countries also increased their regulations.
As result of the high demand for quality in the domestic market, the Japanese automotive industry strives for a reconciliation of high quality and productivity. For this purpose the Just-in-time (Kanban) production technology and quality inspection management technology were introduced.

The combination of competitive pricing, high performance, reliability, quality, safety, cleanliness and service were decisive factors in giving Japan its superiority in the automobile market.

The international environment of the automobile industry is changing rapidly as result of trade frictions, high yen rate, market maturity and internationalization of the global automotive industry. Japanese car industry is expected to respond according to its international leadership. 68

Electronics.

In electronic technology Japan has also a leading position, as well in the basic electronic elements of semiconductors and integrated circuits, as in industrial application such as computer technology, and home electronics.

Home electronics.
The successful history of the Japanese production and export of transistor radios and televisions is also well known.
The application of digital technologies to the processing of analog signals led to the appearance of digital TV's, culminating in a single chip, large scale integrated television in 1986. The brightness and dimensions of the cathode ray tube were gradually improved in the '80s. The interest and demand for higher resolution screens was raised by the launching and operation of nation wide super high frequency broadcasting satellites. In 1989, extended definition television was introduced as a step to real high definition television. The Japanese version of high definition television, Hi-Vision is introduced on the market in 1990 and broadcasting already started in 1989.
Although the price of the system is still rather prohibitive, high expectations of the market diffusion

and penetration exist which will lead to a fast decrease in prices and the substitution of the conventional system.
A bottleneck is the fact that, again, no world standard for high definition could be reached, which can be qualified as an anachronism in the age of global mass media.

In the field of video recording, recent trends are the miniaturization of video cameras, with incorporated magnetic recorders and monitoring facilities. The video disc developed in its optical laser vision and video high density disks came on the market in the beginning of the '80s and at the moment various video disk for application of high definition television are in development stage.

In the audio field the high fidelity systems are reaching ever higher quality, integration and multi-functionality.
The gradual improvement of the VTR and cassette tape recorder find a breakthrough in the digital audio tape recorder.
The compact disc player was introduced in 1984 and in the mean time is substituted by the LP record by the optical compact disc. Digital audio broadcasting via the BSII satellite started in 1987. The MPT took the initiative to establishing a standard for home buses for the development of an integrated control system for the individual control of audio and video devices and eventually for all devices in the home.
Computers.
Japan entered the field of computers in the '50s as well in industry, universities as national research laboratories
The government promoted the computer industry by proclamation and enforcement of the Law on extraordinary measures for the promotion of electronics industry in 1957, which aimed at the encouragement of experiments and research and the start of industrial production.
The development of the computer came about as well on individual basis, via joint efforts of Japanese companies as in technical tie-ups with foreign firms.
In 1966, the Agency of Industrial Science and Technology (AIST) of MITI started a large national program for R&D for the development of a super-high performance electronic computer. In the '70s, the government gradually liberalized the capital and imports of hardware and software. This decade saw a strong progress of development and production of indigenous computer systems and equipment.
69

In the past decennium rapid advancements are made in the hard and software, especially in increasing processing speed and storage capacity.
In the field of supercomputers, the speed of scientific and technological calculations finds remarkable progress. Networks for inter- and intra-datacommunication are being developed. The personal computer is widely penetrated in industry and society and changes the public image and attitude to computer systems considerably.
In 1981, a nine year plan for a high speed computing system for science and technology uses started under AIST's national R&D program for large-scale, high speed calculation, for computer simulation and image processing with targets of 10 gigaflops and for research on high speed logic, memory devices such as Josephson junctions, gallium arsenide memory devices, and parallel processing.
In 1985, a seven year plan was made for developing an inter-operable database system for the free transmission and reception of data between different information devices. In this framework, research

is conducted on the development of a network structuring technology, compatible with the OSI system (open system inter-connection) . This should allow for the use of different types of scattered databases as a single database, multi-media technology, that permits the handling of data, containing characters, figures, images and aiwain, and the high reliability technology, that enhances operation safety in case of emergency.
In 1982, a ten year program started for developing a fifth generation computer, aimed to the creation of innovative functions such as the analysis of natural languages, knowledge information processing. The goals are the realization of functions of problem solving and reasoning on the basis of stored knowledge, knowledge-base management for processing information with meaning and regulations, intelligent interface for the flexible and natural conversation with the computer and an automatic programming function.
In 1987, an international research project is started to develop a machine translation program.
Further development of computer technology will largely depend on cooperation between government, academia and industry. 70
In the field of electronics and computers Japan has especially been successful in its efforts to reach the world top level as well technically as commercially. The industry branch disposes of immense financial means from its sales of consumer electronics and reinvest much of it in R&D for advanced electronic and computer technology.

4. Agricultural technology.

During and immediately after the second world war Japan struggled with serious shortages in food supply. Its war and post war food policy was aimed to the raise of the food shortage and a fair food distribution in times of shortages. Policies were aimed to the expansion of arable land and the increase of crop yields. These policies were predominantly directed on rice, being the staple food of Japan. Policy measures were a price control and distribution system. Although this goal was reached, the productivity of the agricultural sector still lags far behind that of the other industries and other nations. This led to the relatively overall low level of self sufficiency of 70% and to trade frictions due to import restrictions of food products, especially the staple food, rice. At the moment the policy and research is directed at the solving of these problems.

Agriculture depends on the specific Japanese ecology and, within the constraints of climate, geography and environment, can never fully compete with countries where these natural factors are more favorable. The most important natural constraints are the availability and quality of arable land.
The productivity of food production is also low, because efficiency is limited by the existence of too tiny plots of land, and the low quality of labor. The population engaged in farming decreased at a fast pace. Many elderly people work on these plots and younger people are mainly working part time in farming or not at all, in order to increase their income by more profitable activities. After 1985, urbanization of the rural population, the agricultural product liberalization and expansion policies have led to a freeze in agricultural production and the decrease of self-sufficiency in food supply.
In fiscal 1988, agricultural productivity in terms of volume declined with 0.5%. Measures to raise productivity and effective use of land resources are necessary for the enhancement of self support capability.
The Ministry of Agriculture, Forestry and Fisheries considers high agricultural productivity as very

important. It suggests to promote higher domestic productivity by developing labor skills, improving rice fields, water resources and drainage, and promoting agricultural and biological research and technology transfer.

Modernization and rationalization of agriculture, forestry and fishery industries are required to internationalize the economy, improvement of income and a more varied production menu and diet.

In essence, agricultural technology aims at improving the sufficiency and efficiency of the production of food and other resources from the living nature using solar energy and soil and the preservation and enhancement of the ecosystem.

In 1961, the Basic Law of Agriculture was proclaimed and technical development apart from rice was also promoted in market gardening and stockbreeding. Research on paddy field productivity, transplanters,
harvesters, breeding, fertilizers, dry field farming and cultivation started.

Recent policies are directed at technical innovations to develop agricultural production and efficiency. Technologies, relevant and applicable to agriculture, forestry and fisheries are electronics, new materials, biotechnology energy, ocean development and space technology. Biotechnological innovations find place in tissue cultures (virus free nursery plants, mass seed multiplication), cell fusion (experimental research on artificial creation of hybrids of plant species) and recombinant DNA (anti-herbicide and -insect characteristics in plants) are or can possibly be applied to crops, recombinant DNA(experiments with introduction of target genes in animals), fertilized egg transplantations to livestock, especially cows.
Electronics and computer technology are applied in the agricultural production, transportation and manipulation, in remote sensing, and management.
The agricultural sector is very diverse and fragmented, there are many types of soil, crops and farms. Farms and their management are generally small. Under these conditions R&D is mainly carried out by central and local public bodies. Research is carried out by prefectural Agricultural Experiment Stations. The results are disseminated to the farms by an extensive consulting and service system.

Basic science

Partly in reaction to international complaints that Japan is free riding on the efforts and costs of other countries in the advancement of scientific knowledge, and on the awareness that it is itself approaching the borders of the most advanced S&T, Japan intends to increase its efforts and investments in fundamental and basic research.
Other reasons for more efforts in basic science are:
1 For the further development of S&T in Japan.
2 Contribution and participation in international projects.
3 Japanese financial contributions to body of scientific knowledge.
4 Shifting the frontier of science in the world.
5 Industry does not carry out enough basic science.
6 Science is pre-competitive so that internationally everybody can participate.

The drive for international recognition in basic science can be illustrated by the Nobel Price Syndrome. This term implies the sensitivity of the Japan for the fact that they have relatively few Nobel price winners. So far it counts only five scientists, two of which live in the US. Ironically enough, there appears to be a negative correlation between the number of Nobel prices, a country received, and its economic performance. The underlying cause of the drive is the allegation that Japanese people are not creative. There is no scientific ground for this statement. Japan is worldwide recognized for its creative technological achievements. But it has a relatively rigid school system and research environment, and did not yet invest proportionately enough in basic science. If the environment will be made more stimulating with respect to creativity, than this premise of individual lack of creativity can be tested.

For the government there is a special role in basic research and big technology, because such projects seem to be too costly, too risky or too protracted to be feasible or interesting for the private firms.

The appeal of the government on industry to invest more in basic research has a limited effect. Industry cannot be expected to conduct basic research without any private interest. In the extent that industry increases its effort in basic research, it is already doing this spontaneously with the ultimate aim of eventual support of its later R&D. The direction of this type of research corresponds with the. business interests of the company and is thus more or less goal oriented.

The motivations of Japanese industry for doing basic research are that in the drive for innovation they can no longer rely on the creativity in the West for new ideas. Moreover, now they have the financial and personnel resources to invest in basic research. They rather reinvest these resources in the perspective of future growth and continuity. Japanese companies increase their effort in basic research by centralizing their laboratories and by diversification in other sectors. International competition among private enterprises is supposed to become increasingly fierce in the coming age, especially in the hightech areas. This motivates Japan enterprises to establish new institutes with the sole task of basic research.
Examples of more basic research in the firms are the third generation or intelligent robot. This project needs much basic research in artificial intelligence and new materials, advanced electronics, and even biotechnology.
The electronics industry is setting up special basic research institutes, detached from the R&D laboratories. The turn to basic research is the natural consequence of the technical, personnel and financial growth and maturity of the big companies. This does not only provide them with the need to provide in their own new scientific knowledge but also the means to carry out the necessary basic research.

NISTEP has conducted a study on the situation of basic research in major enterprises. The research is based on the expert opinions of managers in basic research or R&D planning of companies with leading positions in basic research.
The mentioned reasons for corporate efforts in basic research are various :
-to enhance flexible responses to changing environments, by creating a stock of sources for potential new and diversified business activities and original products.
-to enhance the general technological level of the enterprises, with the aim to keep the company on the

technological edge, in order to be able to assess scientific and technical literature and to increase the communication with sophisticated users and the scientific community. -to recruit and train highly qualified staff.
-to improve the corporate image to academia, general public and the international community.
-to avoid the criticism of free ride on foreign efforts and investments in basic science.

The general characteristics of basic research, as conceived by the majority of industrial managers are:
-separation from development of specific products and processes,
-based on scientific and fundamental knowledge,
-carried out with a considerable amount of freedom, using the free imagination of individual researchers,
-aiming to open ended goals and expecting results only in the long term of 10 to 20 years.
-results should have a connection with potential future business of the enterprise,
-should be appreciated by the academic community and
-should have cost within the margins of profits of the enterprise.

The consulted managers exclude from their responsibility that kind of pure basic research, which only serves to satisfy scientific curiosity, of which no potential application even can be perceived, or which only serves the personal interest of a researcher. They consider this pure basic research to belong to the responsibility of the government and to be carried out in the universities and national research organizations. They are of opinion that the role and effort of the government in basic research needs to be strengthened. Private enterprises have spread their business activities over the world and have in the past made extensively use of the results of basic research in the West. They recognize that the actual level of basic research, as well in input as in output, is at a comparably low level. They feel ashamed that Japan, in its present economic position, is not willing or capable to contribute to the body of basic scientific knowledge. And that it is still not able to produce independently the fundamental knowledge, necessary for the sustaining of its own continuous development. They regard it as an imperative that the government of Japan should promote basic science more actively than in the past.

Their main criticism on the government is that the amount of the budget for basic science is too low and that the rigid application of the one year budget cycle doesn't allow for the planning of long range research. The procedures for carrying out contract and joint research with the governmental scientific institutions are too complicated and time consuming, to really interest the industry.
The national research institutes are divided in units, too small to form a critical mass in personnel and equipment. It is necessary to increase the quality of the equipment and to concentrate extremely costly advanced and super-large equipment and make it available for use of private companies. Young researchers do not dispose of enough means to use their creative potential. The universities are also loosing ground, because the private companies are increasing their efforts in basic science and thus indirectly compete with the universities. 71

The Japanese government is now expanding its efforts in basic science. In 1989, Japan was spending on basic research about 12% as a ratio to total R&D expenditure. This is more than the U.S., but less than France and Germany.

The major basic research programs sponsored by the government are listed hereunder with the responsible agencies, starting years and budgets as of 1989. 72
STA
Special coordination funds for promotion of S&T:
1981; ¥10.1 bln
Encouragement of basic research:
1985; ¥1.4 bln
Exploratory Research for Advanced Technology (ERATO):
1981; ¥4.6 bln
Frontier Research Program:
1986; ¥1.7 bln
Human Frontier Science Program:
1989; ¥1.5 bln

Ministry of Education
Scientific Research Expense Subsidy:
1965; ¥62.5 bln
Special Researcher Fellowship Program:
1985; ¥1.9 bln

MHW
Welfare Science Research Subsidy:
1979; ¥5.5 bln

MITI
Next Generation Fundamental Industrial Technology Research and Development Program:
1981; ¥6.8 bln
Human Frontier Science Program:
1989; ¥0.9 bln

MAFF
Advanced Biotechnology Research and Development Program:
1984; ¥0.8 bln

MPT
Frontier of Telecommunications Research:
1988; ¥0.2 bln

Various Ministries
Operating expenses of National Research Institutes:
¥34.5 bln

Three most important individual programs for promoting basic science are:
- ERATO system of STA for exploratory research on advanced technology, projects, implemented by

JRDC for the advanced research projects.
- Frontier Research Program of STA in the RIKEN to carry out long term fundamental research.
- Next Generation Industry Basic Technology Research and Development Program of MITI 1981

According to a survey among Japanese researchers, bottlenecks and policy issues for the promotion of basic research in the government sector are the lack of funds and the rigid research structure and systems. Main obstacles for developing top level research centers are weak financial support, lack of opportunities for young scientists, shortage of scientific quality. The notorious weakness in basic science so far has cultural roots in the education system, in which students are trained to absorb enormous amounts of information, but are not trained in developing critical and creative attitudes and skills.
Structural impediments for basic research are the system of life time employment, which seems to make the research environment too rigid and uncreative for basic science, which can be expected to shift frontiers.

A real step forward would need an sharp increase in budget and a strong scientific leadership. Due to budgetary restraints, the practice that new budgets require the termination of other projects or programs and the scarce scientific management qualities, this big step is not expected to be made soon.
Japan intends to play an important role in projects on the frontiers of science. These projects need enormous amounts of money and large facilities, highly qualified personnel and sound management. The first project was the Human Frontier science Program. This program is still in its initial state, the budget is increasing only gradually, dependent on evaluations. The results of the first evaluation were cautious, and the project attracts still more domestic than international interest.

The number of native science doctors produced in Japan is small in comparison with the U.S.A..
The total number of science doctorates per capita is 25% and of young doctorates (under 35 years) only 17% of the number in the U.S.A.. 73 The percentage of candidates to the final doctorate program from the initial doctorate and masters programs is declining.
The number of young engineering doctorates produced in Japan shows a better picture.
The total number of engineering doctorates per capita is 13 % higher, than in the U.S.A.. However, the average age of new engineering doctorates is 42 years, whereas the median in the U.S.A. is 31 years. Thus the number of doctorates of under 35 years is approximately only 56% of that in the U.S.A.. 74

Needless to say that these figures form an object of great concern for the Ministry of Education. Reasons for the low numbers are economic limitations, relatively inferior research facilities in universities compared to the private industry. There is no guarantee that the PhD degree can be obtained within three years. 75
The policy to increase the number of PhD's is to create places in the university for post-doctoral researchers without an appointment as (assistant) professor in the national universities.

Japanese industry systematically recruits college graduates and offer them further training within the corporation or further academic education paid by the company. They can even obtain a PhD for research carried out in the company, without following PhD courses in University. Actually the number of dissertation doctorates form a majority. This explains the late average age of 40 years of engineering doctorates. It is hard to judge whether this phenomenon is a drawback for basic technology. The course work doctorates have theoretically the potential of a longer scientific career afterwards. But their employment rate is low and it is not certain that they will enter a scientific career. There is a lack of positions in academia and the preference in industry for employees with a lower academic level.

The dissertation doctorates dispose over much better research facilities in industry and are very motivated in a productive environment in their effort to get a PhD. The systems are so different that no good evaluative comparison seems possible. They might also form a good complement of each other.

Research and development

R&D is carried out in different classes of organizations:
-local and central laboratories of big companies.
-non-profit research organizations.
-public research corporations.
-local and national government research institutes.
-national, prefectural and private universities.

Japan's total spending on R&D, as share of GNP, is more than other large countries, including the U.S.A.. The share of government funding of this research, however is rather low. The private sector spends more on R&D than the other industrialized countries and considerably and increasingly more than government.

The rapid growth of corporate R&D expenditure is explainable by the restructuring of production to knowledge-intensive high-tech industries, the increasing complexity of products, the shortening of the product life cycle and the relatively less capital intensiveness of flexible manufacturing systems.

Japan's industry is moving slowly from heavy industry to high tech areas, such as biotechnology and computer software, without giving up its position in manufacturing though. The bulk of industrial R&D remains oriented to manufacturing products with large export potential. The national R&D system is still mainly commercially oriented and is aimed at a fast translation of scientific breakthroughs in concrete commercial products. According to Mansfield the Japan firms spend more R&D on improving production processes than product innovation. 76 This seems to be true for the past. Recently however, the Japanese R&D shifted from methods for cost reduction to an interaction between product differentiation, and process innovation. Process improvements and product differentiation seem to go hand in hand.

Intense competition between the manufacturing firms for market share for similar products works out in continuous technical change in the manufacturing sector, has led to short product life cycles. This evokes the need for large investments in R&D.

An important quasi autonomous trend in large companies is extreme diversification. Under the continuous pressure of competitors and short life cycles of products and technologies and fields, the large companies spend their enormous financial means rather on R&D and reinvestment in new promising high tech fields than on labor and stockholders. New promising fields for these investments seem to be new materials, biotechnology, software and aerospace industry.

Japanese companies high tech companies are now more investing in R&D than in plants and equipment. Many companies have to change from low tech manufacturing to products with a higher market value. And flexible automation makes it possible to change from products by programming and adapting their flexible production systems without much costs and time involved. 77

Because Japan has caught up or is leading in many fields. many sources for new technologies can no longer be imported. Foreign firms grow more reluctant to export their technology They feel the need to create these sources themselves. And especially in high technology the importance of the scientific basis for commercial success has become more clear and inevitable.

The top ten of big spenders in R&D among industrial companies, plus NTT, are ranked according to their R&D expenditures by the following table: These investments can be compared with their income and sales and capital investments, all in billions of Yen and for fiscal 1989.

	R&D	Income	Sales	Invest ments	R&D % of Sales
Toyota Motor	400	573	7191	418	5.6
Matsushita Electric	346	256	4249	355	8.1
Hitachi	343	205	3525	263	9.7
Nippon Electric	280	98	2761	270	10.1
Fujitsu	273	119	2126	185	12.8
NTT	238	423	5769	1736	4.1
Toshiba	233	174	3061	197	7.6
Nissan	220	100	4006	169	5.5
Honda	180	66	2749	132	6.6
Mitsubishi Electric	166	127	2388	134	7.0
Sony	165	77	1536	324	10.7
Sources:	78	79	80	81	

These figures show the relatively heavy investment in R&D of these big companies. The R&D investments are in the same order as the income and capital investments and in most cases even surpass them. The high tech companies spend more in research than in plant and equipment investment.
The figures also support the impression that Japanese cooperative R&D is not so much a system directed by the Japanese government. Japanese industries have enough own means to achieve technical progress.

On the expected condition, that the Japanese economy and industry keeps growing, the national R&D expenditures will continue to rise, along with the reinvestment of profits in innovation. The increase of government income is higher than the increase of government spending on R&D or the Increase of the ratio to private spending on R&D.

Compared with other advanced nations, Japanese government doesn't play an important role in

financing and conducting R&D in Japan.
Due to public financial restraints, government investment in R&D is in the order of 0.5% of domestic GNP, which is roughly half that of all OECD countries and needs to be strengthened. The government S&T budget has increased at the same speed as the GNP growth of the last five years. But it has stayed behind the activities in the industry.

The main post of its science budget is allocated to the national universities. This percentage is higher than in the other countries. The net difference is even higher since salaries are in a separate account in the budget. The funding from industry and other private organizations is not substantial.

The distribution of the government funds over the institutes were as of 1987 as follows: 82
universities: 50%,
national research institutes: 20%,
public corporations: 23%,
private corporations: 7%

The financial government support of industrial R&D through contracts or grants and joint projects doesn't exceed 5%. This is lower than common in European countries.

Large scale research projects in nuclear energy, space, oceanographic ask for great amounts of money and manpower. Therefore it is carried out by public research corporations.
There is a tendency to shift away from government support for large scale industrial R&D projects to smaller scale advanced technologies in the pre-competitive phases, with no expected concrete results of proprietary technology or product developments.
Now Japan has become a pioneer in several fields, a number of problems rise, such as a lack of interaction between universities, corporations and government, underdeveloped scientific research and pre-commercial R&D. At the moment Japan has ambitious series of national research projects, which are basically pre-commercial.
Not all these national research and development projects have been as successful as desired.
National research projects have the following objectives
-discerning core technologies for cooperative R&D.
-communication between industry government, universities and financial institutes, and between engineers and scientists.
-allocating research expenditures and subsidies to private companies.
-committing companies to important pre-commercial technologies and to diffusion of these technologies.
-transfer of knowledge and methods to corporate laboratories.
-dispersing knowledge and methods among firms and
-increasing the speed of innovation.
Also non-participating companies can profit because the research is considered pre-commercial and patents are freely available and at low costs.

The government agencies initiate joint R&D projects after consulting industry. This guarantees that only those projects will be chosen, which are expected to result in advanced technologies, for which the

industry believes, that there will be a need in the future, but which are too risky to be undertaken by the individual firms.
The industry is apart from their recommendations also committed to these projects in order to maintain the typical Japanese harmonious and cooperative relationships with the government. They limit their financial risks by keeping their commitment low and their proprietary risks by mainly participating in pre-competitive research.

The prime reason for the government is the information and consensus building in industry of the future direction of the nations technology. Other reasons are the financial possibility to initiate more projects and to increase their credibility in the eyes of the Ministry of Finance.

Fields in which MITI has an important joint effort are:
Optoelectronics 1979-88
Supercomputers 1981-90
Fifth generation computers 1979-91
Future Electronic Devices 1981-90
Biochips 1986-90
Fine Ceramics 1981-90
Speech synthesis and recognition 1983-88
Sigma Software 1985-92
New artificial diamonds 1987-..
Biocomputers 1985-95
Okimoto describes the progress but also the problems and failures in these projects. 83

The possibilities of publicly supported joint R&D are limited.
cooperative R&D is based on a law of 1961, which allowed the formation of research associations. The reasons were to improve technical communication between rivalling industries for technology transfer, and to legitimate government support for business. Since then, many technological associations were established under Japanese ministries, notably MITI. The main tasks of these associations are information exchange and coordination. The actual research is carried out with the facilities and personnel from the participating companies. Research associations are mainly financed by public funds via private organizations in the form of a contract or an acquitable loan. 84 This loan should be repaid only if a project yields a result. Research organizations also give tax favors, e.g. via depreciation of equipment.

There are several limits of joint research:
For obvious reasons of competition and ownership of knowledge, industry is not very eager to participate in joint projects with public organizations and eventual competitors and tend to limit their input in knowledge and information.
Only bigger firms participate in cooperative R&D. Most of them are private contractual arrangements between two parties. The majority of the companies, are already affiliated otherwise. The amount of money involved is only a small portion of their R&D expenditure.
The total amount of public funding is relatively small. The main reasons for participating is the access

of information in private public consultation, the access to information of government and other companies, the review of these parties of own work and the access to information on fusing new technologies.
The output of cooperative research is more basic and generic than commerciable.
The influence of the government on the research agenda and research content and outcome is very limited. Its role is more intermediating than planning.

There are also other means for cooperation between companies than via the government, especially in the conglomerates of bigger companies and their contractors and affiliates.
The Japan Fair Trade Committee must formally review associations and forms and activities, in order to prevent anti-competitive practices. Its role is more informal and advising than regulating and compelling. So far the judiciary has not played a role whatsoever. 85

As a consequence of its constitution, Japan ' s defense technology is necessarily derived from and dependent on commercial technology. Especially in the case of semiconductors, much initially civil technology is used in defense technology. The high quality electronic components or subsystems are not only used domestically for defensive weapon systems but also in foreign and offensive weapon systems, even of potential military enemies of the West.
The producing companies are not pure defense contractors or manufacturers, but are producing primarily for commercial markets. The official defense R&D spending is extremely low. Fiscal 1988 budget was $650 mln, which boils down to less than 5% of the total S&T budget of the government. These figures should be interpreted with caution however. The defense R&D is partly hidden in the civilian R&D statistics. The Japanese defense technology is more a spin on of commercial technology. The R&D costs, ultimately used for defense, are in many cases calculated in the price of the commercial applications. Moreover, repayment of other R&D costs can be claimed in negotiations over defense procurement between government agencies and numerous companies, which have also commercial interests.

The Japanese industry and government have marked as key technologies f or the next century information-, aerospace and nuclear energy technology.

4

ORGANIZATION OF SCIENCE AND TECHNOLOGY

Universities and colleges

The university system in Japan is divided in national, public (prefectural and municipal) and private universities and colleges.
Not all of them are full-fledged universities, since some of them have only undergraduate courses, while others do not provide in PhD courses. In the following table the breakdown is shown: 86

Category University	Number	Graduate Universities	PhD courses Schools
national	96	91	54
public	37	22	16
private	342	175	126
total	475	288	196

The national universities are funded by the central government, the local universities by the prefectures, the private universities by private organizations and industry.

R&D expenditures in these organizations were ¥1.2 trln in 1988 and they employed around 130.000 researchers in 1989. This amounted to an increase of 125% in five years, which is small, because not inflation corrected. Since a few years, universities are engaged in joint research with industry and contract research.

The universities in Japan have a double role of transfer of knowledge by training and education at the highest, academic level and of conducting scientific research in the disciplines of natural and human sciences. The results of this research in terms of new theories, laws, principles, methods, new knowledge and techniques, new scientific fields are considered as values in itself and as potential sources for new uses and applications for new developments in practical life.
The University is seen as the responsible institute for systematic development of scientific knowledge in all fields of human, social and natural sciences, as a means for strengthening applied S&T in Japan.
The university system in Japan consists of 96 national universities, with attached 66 research institutes, 14 national inter-university research institutes and 342 private and 37 public universities with attached 240 research institutes in total.
The national universities are almost entirely funded from the central government and the staff are government officials. The private universities are funded mainly by tuition fees and gain additional income from research contracts.
The most famous private universities are Waseda and Keio. The best national universities are Tokyo University, Kyoto University, Osaka University and Tohoku University (Sendai).
Their, number of reports and their intersubjective evaluation from 1976-1986 is given in the next table:

		Number of reports		Evaluation
Tokyo University	9463	7822.76		
Kyoto University	6096	4541.06		
Osaka University	6062	4232.75		
Tohoku University	6344	3930.58		
Nagoya University		3737	2825.93	
Tokyo Institute of Technology. 87	3824	2169.83		

The production of the Japanese Universities can be compared internationally with foreign universities.

From an evaluation in Journals the score of the universities with more than 3000 points were: [88]

University	Country	Evaluation
MIT	US	10108
Berkeley	US	9965
CalTech	US	9796
Tokyo University	J	7823
UCLA	US	6893
Stanford	US	5433
Cambridge	UK	5070
Harvard	US	4861
Kyoto University	J	4541
Imperial College	UK	4273
Osaka University	J	4233
Oxford	UK	4009
Tohoku University	J	3931

The universities have suffered under budget cuts during the period of financial reconstruction of the Japanese financial system. The research money in real value per researcher and students and for facilities were reduced. And the available budget was for an important deal spend on building new facilities at the cost of old facilities.
The national universities are believed to yield the best scientists and engineers. They possess excellent facilities and professors of reputation and good connections for their students. The education system in Japan yields in an extremely high national literacy level.

The number of scientists and engineers, graduating from university and entering the labor force is high. The level of academic and postgraduate education and research however is, according to comparative OECD statistics and in the eyes of the Japanese themselves, not yet at the level of other advanced nations. Despite increasing demand, the entrance of engineers in manufacturing tends to slow down. This is due to the relatively small young cohort in the population and to their considerably better career chances in the business and finance sectors. This seems a paradox in a society where S&T is regarded so highly.
The number of PhD's in science and engineering is low and their unemployment level is high, because industry does seem to esteem product and process development higher than the more fundamental science. This might change when industry gradually will spend more efforts on basic research.

The attempts to improve the quality and creativity of academic research is constrained by limited budgets and by a conservative culture in education and university management. As partial solution of this problem, Japan is sending a great number of researchers and scientists overseas for post academic education and research.

The relationship and cooperation between the academic and industrial system is comparatively low and this is object of government concern and evokes measures to increase the exchange of R&D funds, knowledge and personnel between academia and industry. In the Universities there remains

resistance against too much commitment to industry. The policy of Ministry of Education in this regard is to permit professors from national universities to give consults to industry and to accept research grants. Since then, the formalized joint projects of university and industry is growing rapidly but is still on a relatively low level.
Rivalries and competency questions between the various ministries and government agencies are leading to duplications of allocations, and conflicts over managerial and financial responsibilities.

The national universities are mainly funded by the central government and account for the biggest share of academic R&D.
Despite the policy intention to increase funding of basic research, budget constraints and bureaucratic resistance do not yet seem to allow a drastic increase of effort in this field

The dual university system inhibits a large influence of the government because of the existence of a large number of private universities, enjoying a minimum of government funding and thus a maximum of freedom.

National inter-university institutes

These institutes are supervised by Ministry of Education

The National Laboratory for High Energy Physics (KEK) (Ministry of Education) is involved in the building of large accelerators for research on elementary particles in the natural sciences. It built a large experimental synchrotron complex with a proton synchrotron of 12 GeV, for research in particle and nuclear physics, a 500 MeV booster synchrotron beam for nuclear and solid-state physics and a .2.5 GeV synchrotron radiation source for research, ranging from materials to life science. A large colliding type accelerator, producing 32 billion electron volts was built in 1986, for research on new quarks and leptons.

Okazaki National Research Institute was established in 1981 under the Ministry of Education, in order to coordinate molecular, biological and physiological basic research.
The Okazaki Institute consists of and coordinates the following institutes:
The Institute for Molecular Science conducts research into structures and functions of molecules.
The National Institute for Basic Biology carries out comprehensive studies in the fields of life, substances and molecules.

The National Institute for Physiological Sciences conducts comprehensive studies on the human body in order to promote a healthy human life.

The Institute of Space and Astronautical Science (ISAS) conducts research of space science and engineering and their application.

Public research institutes

Japan is expected to develop innovative technologies, as well for its own use as for the needs of other countries. Under this requirement, the national research institutions are urged by the government to conduct basic and advanced research in order to break through the frontiers of science and technology. To this end, the Council for Science and Technology sent a report on National Testing and Research Institutions from Medium- and Long-term Viewpoints to the Prime Minister in 1987. In the General Guidelines for promoting Educational Reform, measures were suggested to increase creative research in the academic institutes.

The public research organizations are ceaselessly renewing their activities and ameliorating their organizations. Examples are the recent reorganizations of the National Institute for Environmental Studies and the National Research Institute for Earth Science and Disaster Prevention.

The Japan Key Technology Center is founded in order to help funding R&D, that is planned and originated by private industries. The Center is controlled by MITI and MPT. Tasks of the Center are the investment in and financing of joint and assigned research, international cooperation and dissemination of key technology information. Funds are invested in cooperative or joint R&D in key technologies, carried out by research companies, set up by two or more enterprises. Loans are granted free of interest for the reduction of the risk in technology development.

Tsukuba Science City is constructed to form a research and education center of standing, including a university and testing and research institutes. In order to make use of the potential synergy of a concentration of research institutes, a mutual exchange of scientific research results is highly promoted, e.g. since the establishment of the Research Exchange Center of STA and the Tsukuba Research and Development Support Center. For the international exchange of research, a large number of foreign scholars, researchers and students are presently working in the institutes. To give an idea of the relative importance of Tsukuba, 40% of the researchers and 50% of the total budget for all national institutes is concentrated in the Science City. Since more than 100 private enterprises moved to the region, exchange with the private sector is flourishing as intended. The Technopolis project, started in 1983 aims at a harmonious combination of living area, nature, agriculture and industries in advanced technologies.

National laboratories

In 1988, the R&D budget for the national government research institutes came to ¥470 bln. 89
Some of the more important organizations are shortly summarized hereunder: 90

The Electrotechnical Laboratory (ETL) (AIST, MITI) is the largest national research institute in Japan. Its budget in 1989 amounted to ¥9.7 bln and it had a staff of 690 persons. The lab has been leading in electric and electronic technologies. Its former achievements are the Kondo effect in 1964, the first data-flow super-computer SIGMA-1 in 1987 and the worlds' first Josephson computer in 1989. The main research projects are in the disciplines of basic electronics, standards and measurement, energy related technology, information and computer technology and inter-disciplinary research. In these frameworks it is active in the fields of superconductivity and its applications, of optoelectronics, amorphous materials, functional organic materials, advanced VLSI technologies, bionics, utilization of renewable energy resources, nuclear fusion applications and advanced lasers. In information and computer technology there are projects in cognitive science parallel processing, software engineering, artificial intelligence and intelligent robotics. 91

The Mechanical Engineering Lab in Tsukuba (MEL) was established to promote progress of the machine industry. The institute is active in diverse projects, e. g. energy saving and -resource development ; material engineering, e.g synthesis of new materials such as advanced composites and fine ceramics; product engineering in e.g. sophisticated machine tools, computer integrated design and manufacturing; intelligent robots, tele-operation and cybernetics; and research on new and fundamental mechanical engineering technology.

The National Institute for Radiological Science ((STA,NIRS) conducts research on the mechanisms of radiation injury, and prevention diagnosis and treatment and research on the medical application of radiation and radioactive isotopes.
Its research activities cover the fields of physics, chemistry, clinical- and bio-medicine and environmental science. The center has the disposal of a medical cyclotron, a Van de Graaff accelerator, a positron and in the near future a heavy ion medical accelerator.

The National Aerospace Laboratory (STA,NAL) conducts R&D in aeronautics and space technology. Its facilities are hyper-, super- and transonic windtunnels, a STOL flight simulator, experimental aircraft, a supercomputer for numerical simulation and a high altitude rocket engine test facility. Recent research is directed at STOL aircraft, aeronautical and space transportation and numerical simulation.
The Aerospace Technology Research Institute has research projects in the fields of trans-, supersonic and V-STOL aircraft and aircraft safety. It disposes of and administers several large wind tunnels.
Tsukuba Space Center (NASDA) conducts research and development in space technology and engineering tests of satellites and launch systems.

Government Industrial Research Institutes
The Institutes for Industrial Research of the Government are established for the regional development through S&T. They are located in Kyushu, Shikoku, Tohoku and Chugoku and a Development Laboratory in Hokkaido.
The Industrial Research Institute of Osaka is carrying out research mainly directed at the chemical industry. Its research activities cover the fields of new materials e.g. fine ceramics and composite materials, of energy technology and of processing and system technology.
The Industrial Research Institute of Nagoya is conducting research in various industrial fields. It is active in mechanical and metallurgical engineering, chemistry, radiation research and ceramic S&T. Recently, the emphasis of its research is on advanced ceramics, including high temperature engineering- and electronic ceramics, under which high critical temperature superconductors.

The Communications Research Laboratory of the Ministry of Post and Telecommunications is the sole national institute in the field of telecommunications technology. It is active in radio science and application technology, space science, communications science and atmospheric science. It carries out R&D in integrated communication systems. In space communication, it launches satellite systems. In the future is scheduled an ETS-VI satellite for inter-satellite communication, and the BCTS for advanced broadcasting and navigation. It also monitors and forecasts changes in the space, the atmosphere and on earth. A cooperative research program on the frontiers of telecommunication contains project on ultra high speed communications, biological communications and high performance intelligent networking.

The National Cancer Center of the Ministry of Health and Welfare has at its disposal laboratories for radioisotopes, recombinant DNA experiments and nuclear magnetic- and electron spin resonance- and mass spectrometers. The Center has as tasks, research on environmental mutagens-carcinogens and tumor promotors and its inhibitors and on oncogenes, growth factors and human cancer viruses at the molecular level.

The National Agricultural Experiment Stations in Hokkaido, Tohoku, Chugoku, Shikoku, Kyushu are set up for the improvement and development of agriculture in the respective districts.

The National Research Institute for Metals (Tsukuba) is attached to STA and conducts research on advanced and synthetic materials and on the assessment of the reliability of materials for ensuring safety and reliability of materials. It developed advanced superconductive materials, e.g. ceramics with high critical temperatures, super heat resisting alloys, e.g. titanium alloys for aerospace use and intermetallic compounds. The Institute conducts research on creep and fatigue properties and develops new material properties by controlling their fine structure. 92

The National Institute of Environmental Studies was established in 1974 in Tsukuba as the research organization of the Environment Agency. Its tasks are research on natural environment in relation to human activities. It conducts research projects on air and water
pollution, the effects of pollution on human health, plants and ecosystems and pollution measurement and prevention. Recently projects have started on the impact of the influence of man made emission of gases and the global environment, specifically on the changes in the stratospheric ozone and global temperature. 93 The institute underwent a reorganization in fiscal 1990

The role of many of these institutes is gradually taken over by the National inter-university institutes

Public research corporations

The public research corporations are under the supervision of a government agency, but are jointly funded by private organizations and industry, with a minor amount by the government. 94
In 1988, the R&D budget for the public research corporations and national government research institutes came to ¥430 bln. 95

The Japan Atomic Energy Research Institute (JAERl) (est. 1956, budget ¥105 bln in '89) conducts R&D on the use and safety of atomic energy. It develops research activities in reactor technology (design, construction and operation), nuclear fusion, radiation applications, nuclear powered ships. The Institute has a budget of nearly ¥105 bln. Facilities at its disposal are reactors for research, safety research, demonstrations, materials testing and a research vessel (Mutsu), diverse critical assemblies, accelerators, a fusion neutronics source and irradiation facilities.

The Power reactor and Nuclear Fuel Development Corporation (PNC) (est. 1967, budget ¥233 bln in

'89) conducts pioneering R&D in all fields of the nuclear fuel cycle. The corporation develops a fast breeder reactor (MONJU, 280 MW) , an advanced thermal reactor, uranium exploration and mining and uranium enrichment technologies, reprocessing and conversion of spent nuclear fuels, and waste solidification.
Already completed are a fast breeder reactor (JOYO) and an prototype heavy water reactor (FUGEN).

The reputed Institute of Physical and Chemical Research (RIKEN) was founded in 1917 and during the war even worked on nuclear physics with potential application for atomic weapons. In 1958 it was reorganized, reequipped and reallocated. It is now a non-profit research corporation (budget ¥17.35 bln in '89) and covers a broad research area, including physics, chemistry, engineering, science and biology. The main institute in Wako-shi, is equipped with a separate sector ring cyclotron, a heavy ion linac, centers for computation, beam analysis and chemical analysis, X-ray analysis, laboratory animals, plants, fungi and insects. The Center carries out a large variety of mono- and multi-disciplinary research, often in international cooperation with reputed foreign institutes and with visiting foreign researchers on a multilateral exchange basis.
In 1986, the center started the Frontier Research Program, aiming at the discovery of new knowledge, intended to form the basis of future technological innovation. The program contains the areas of the biology of homeostasis mechanisms, new functional materials, and intelligent functions of the brain.

In 1984, the well equipped Life Science Center of RIKEN was established in Tsukuba. The center conducts advanced and basic research on a variety of topics. To name a few: recombinant DNA technique safety, oncogenetics, herbal molecular genetics, gene regulation etc. Mission oriented research is conducted in the application of recombinant DNA techniques, molecular biological studies on human immune and nerve systems and DNA sequencing of human genomic chromosomes. The Center has formed a gene bank, containing cultured cell lines and DNA clones and DNA libraries.

The Research Development Corporation of Japan (JRDC) (est. 1961, budget ¥12.54 bln in '89) is active in the promotion of research cooperation and exchange of results. The Corporation intermediates between inventors or owners of technological knowledge and domestic or foreign companies, in order to transfer this knowledge and to promote its implementation in production processes and new products. It facilitates licensing between researchers mainly in the public sector and commercializing in the private sector as well domestic as international. It also loans money for equipment and costs.
It administers international research exchange programs for foreign research organizations and researchers.
Since 1981, the corporation administers and funds a research system for promoting the development of advanced technologies (ERATO). The ERATO projects are led by directors, with exclusive responsibility for personnel selection and management of their project and is manned by young researchers from all over the world, who work for the period of five years in innovative projects with open ends. Fields of research are broadly focused on basic understanding of life and matter and are intended to break through traditional disciplines and demarcations between science and technology.
In 1989 the corporation was reorganized in order to take up more responsibilities to promote basic research on advanced technologies and international research activities.

The National Space Development Agency (NASDA) (est. 1961, budget ¥136 bln, in '89) of Japan has the first responsibility for space development activities, especially application technology. It is equipped with facilities such as Tsukuba Space Center for testing and launching of vehicles and satellites, the testing of their components and systems and the tracking and operation control of satellites, Kakuda Propulsion Center for the test of propulsion systems components, an Earth observation Center for the reception and processing and distribution of data from earth observation satellites and Tanegashima Space Center for assembly, launching, operation, tracking and control of transportation systems, vehicles, rockets.
In this decade the H-2 rocket will be capable of bringing over two ton of payload into geostationary orbit. A new engineering test satellite ETS-VI will be launched in 1993. Other satellites are used for communications, broadcasting and earth observation. For experiments in space, several international joint programs are under development. For international microgravity experiments, NASDA will place equipment on the board the space shuttle/lab in 1991 and 1993.
NASDA will also develop onboard equipment to be installed on the Space Flyer Unit as a joint project with ISAS Institute of Space and Astronautical Science (ISAS) and MITI. In 1998 a Japanese Experiment Module (JEM), consisting of a pressurized module, an exposed facility and an
experiment logistics module will be launched by space shuttle as Japans' part of the International Space Station "Freedom".

Japan Marine Science and Technology Center (JAMSTEC) (est. 1971, budget ¥11.57 bln in '89) is the organization for the promotion and execution of R&D of marine S&T in Japan. It is active in the field of ocean floor survey, data acquisition, underwater living and working, in generation of ocean energy and deep diving techniques.
Its facilities are the oceanographic submersibles Shinkai 2000, Shinkai 6000 and their depot ships Natsushima and Yokosuaka, a hydro laboratory Kaiyo, and an unmanned marine research vessel Dolphin-3K.
The organization participates in and contributes to a large number of international research projects. These focus on the role of the ocean in the absorption and circulation of heat and carbon dioxide, research on the Rift system and abyssal benthic mineral resources, hydrothermal polymetalic ore, and various other marine projects. 96
97

Some important public corporations have been converted to joint stock companies, private utilities or corporations. Famous examples are NTT, NHK and KDD which though (mainly) government owned, now formally has to act as a private firm in competition with others. MPT carries out its influence in the field of telecommunications via those organizations and their R&D organizations.

NHK's Science and Technical Research Laboratories (est. 1930, budget ¥6.2 bln in '89) carry out studies in the field of the development of new broadcast media and applications, the improvement of existing broadcast services and techniques and more fundamental studies for future broadcasting engineering.
Besides the exploitation of the existing frequency bands, the laboratories develop new systems, such as formerly teletext, satellite TV and Direct Broadcasting Satellite Service. NHK also developed its high definition television system. This "Hi-Vision" system is recently on the market and high definition television programs are broadcasted. The laboratories are engaged in R&D for future

broadcast technology. This implies the audiovisual characteristics of human beings and the properties of components in emitting equipment. The research results of the laboratories are public domain.

Private laboratories and research institutes

The R&D expenditures of the private sector are larger than those of the public sector, as well in absolute terns of ¥7.6 trln as in terms of annual growth. Recently the private industry also puts more effort in basic research It recognizes that this could lead to sources of new technology, which could form new business opportunities.

The reasons for private research institutes to devote themselves to and to invest in basic research are the international criticism of free ride on basic research conducted in other countries, the call for more contribution to the world body of basic knowledge and, last but not least, the increased speed of innovation in science and technology. The last fact is probably the most decisive for big enterprises to change their strategy and to produce own basic research.

Research institutes, e.g. those of NEC Corporation and Hitachi Ltd., focus on high tech research in the fields of electronics, new materials, biotechnology and mechatronics. Research on the level of development were also established overseas, e.g in the field of office and communications equipment and user oriented R&D. In reverse, foreign firms also set up research institutes in Japan especially in the field of pharmacies and chemistry.

Nippon Telegraph and Telephone
NTT's R&D is directed at the development of new types of services, devices, networks and supporting advanced technologies.
This R&D takes place in its four Electrical Communications Laboratories, the R&D Centers of Atsugi, Ibaraki, Musashino and Yokosuka. Software is developed in separate software laboratories in Tokyo.

The NTT Electrical Communications Laboratories:
ISDN, or Integrated Services Digital Network, which NTT is commercially exploiting since 1980, is expected not only to expand globally but also to play a vital role in integrating the various types of information and communication services.
The R&D activities are classified in the categories of broad band communications, based on optoelectronics technologies, intelligent functions based on computer processed data technologies, and personal communications based on mobile communications technologies.
R&D topics are telecommunication networks, information and communication networks, human interfaces, communication switching, transmission systems, radio communication systems, software, large scale integration, optoelectronics, applied electronics, network systems development and software engineering. Concrete projects are speech recognition and synthesis, expert system building, etc. Recent achievements are a 16-megabit DRAM, ballistic conveyance transistors.

According to Foreign Press Center, the ten best Japanese research centers are:
-National Laboratory for High Energy physics of Education Ministry
-Institute of Physical and Chemical Research of Science and Technology Agency

-National Cancer Center of Health and Welfare Ministry
-Electrotechnical Labs of Ministry of International Trade and Industry
-Okazaki National Research Institute Ministry of Education
-Institute for Molecular science Ministry of Education
-Electrical Communications Laboratory of Nippon Telegraph and Telephone Corporation
-Earthquake Research Institute, University of Tokyo
-Kyoto University, Engineering Faculty
-Kyoto University (with Nobel Price winners in the Natural Sciences) 98

5

SCIENCE AND TECHNOLOGY POLICY IN JAPAN

General statistics

In order to put the following information in perspective, the next list presents some basic statistical data on Japan as of 1989, unless otherwise indicated:

Total land area	377,816 km2	
Ratio of agricultural area	14,4%	
Ratio of housing area	4.2%	
Population	123,39 mln	(4-1990)
Population density	326 persons/km2	
Birth rate	1,2%	
Mortality rate	0.64%	
Population increase	5.4%	
Mean span at birth; male, female	75.91, 81.77.	
Ratio of labor force/total population	50,9%	
Percentage in primary sector	7.6%	
Percentage in secondary sector	33.8%	
Percentage in tertiary sector	58.7%	
Ratio public servants/total employees	4.3%	(1988)
Unemployment rate	2.1%	(5-1990)
Gross national product	¥400 trln	(1990)
Gross national product	$2,887.7 bln	
Exports	$275.175 mln	
Imports	$210,847 mln	
Current balance	$57,157 mln	
National Income	¥318.34 trln	
National Budget	¥66.3 trln	(1990)
"	¥70.3 trln	(1991)

At the moment Japan produces, with only 2.5% of the global population, over 10% of the gross global product. Its level of science and technology can compete with that of other advanced nations.

The size of the Japanese government has been small in international comparison. The scale of the government was, as of 1979 and measured in ratio of total general government expenditures and GNP, as follows: Japan 31.8, against the U.S.A. at 33.5, West Germany 44.3 and Sweden 61.6. The ratio of tax plus social security burden was about 31.5, against the U.S.A. with 38.5, West Germany 52.5 and Sweden 64.1. Before 1970, this percentages were even below 20, the percentages of Japan are rising since 1970 to the present level.

Government intervention

General reasons for government intervention in economy and industry (production system) are the furthering of national goals and the correction of perceived imperfections of the market forces. Especially the economic and unfavorable social costs of secondary effects of unintended and unforeseen effects, imperfect or untimely information, the insufficient provision of social goods, furthering of narrow short
term private and commercial benefits, and the wasteful phenomenon of extreme competition.

The government has played a positive role in sustaining the growing national economy, by means of income tax reduction, minimizing the general budget account, establishing a framework for increasing and directing household savings to the private enterprises, redistributing incomes from the high growth sectors to the agricultural sector and the small and medium enterprises, supplying cheap capital for important industries and living facilities, and building social capital for the development of the economic society.

One the most basic level, the motive of the Japanese government in its economic and industrial policy is to develop itself to the position in which it can deal from an equal position with other developed nations i.e.:
-to defend itself against foreign military threats,
-to administrate and control its own citizens and
-to participate culturally in the international society. 99
These internal and external motives are basically not different from those of other nations. Japan differs only in the degree, in which it tries to reach these goals and in the nationalistic self centeredness. This degree can be historically explained by its (former) situation, as a country which came late in technological and industrial development, which needed to trade because of its scarceness of natural resources. Japan had lost a war and, as a consequence, suffered from a lack of basic needs, had for a long time a negative balance of payments, was dependent on foreign assistance and was subject to foreign interference in its domestic affairs.
These reasons now have partly no longer objective validity, but the socio-psychological attitude has a long after effect. For its foreign defense the country remains dependent on the protection of the United States. In the field of basic science it still does lack enough confidence to feel able to provide in its own fundamental knowledge, on which a lot of high technology depends.
Another reason is the increasing international economic dependencies. The state became increasingly aware of the international division of labor.
With the exception of precision instruments and consumer electronics, aerospace, jet aircraft and petrochemicals, Japan has great success in setting priorities for industry. It has a comparatively

optimal state intervention at minimum costs, in terms of income from taxes, state ownership of industries and regulatory control. 100
Basic reasons for industrial intervention of the Japanese government are still derived from its concern regarding national security: e.g. the safeguard of the procurement of raw materials, the maintaining of an optimal degree of national independence, the unhampered access to export markets and foreign technology and the optimal structuring of industry. 101
Because Japan cannot rely on its national security on military means it has to rely on its economic and technological strength. Its concern for the access to raw materials stems from the relative scarceness of natural resources and the increased necessity of these resources for industrial production. Japan seeks to secure the flow of these resources by establishing long term international purchasing agreements, by maintaining a high level of balance surplus and thus availability
of foreign currency and by stockpiling raw materials for times of emergency. Another way to decrease the vulnerability of raw materials is the further shift to industries, which require low amounts of energy and materials and which rely more on knowledge than materials.

Science and technology policy is embedded in industrial policy, trade policy, education policy and economic policy.
Economic policy in Japan consists of three fields of policies: fiscal, monetary and industrial policy.
Industrial policy is carried out either directly or indirect. Sectoral industrial policy is aimed to helping new industries to grow competitive and uncompetitive industries to disappear in the most anaesthetic way. Industrial policy is mainly aimed to economic goals, and consists of policies for restructuring industries and sectors, and science and technology policies. Industrial policy is the most important element in economic policy; whereas S&T policy is the most important in industrial policy, because technology is playing an increasing role in industrial production. Fiscal policies help to reduce the burden of selected industries in investments in production, research and development. Educational policies are aiming at the development of human resources for S&T progress and application. Trade policy helps to regulate the import and export of S&T knowledge, products, labor and capital.

Economic policy

The economic and development plans of Japan indicate the formulated goals to be achieved in the different post war periods.
In 1955, the goals were economic independence, full employment and stable economic conditions.
In 1957, additive goals were top speed economic growth and improvement of living standards.
In 1960, the improvement of living standards was the goal in the plan for doubling the national income.
In 1965, correction of unbalance between production sectors and between economy and society was an important sub-goal.
In 1968 e 1970, the fitting of life comfort to economic possibilities and the promotion of internationalization were added.
In 1973, the heightening of national welfare and promotion of international cooperation were at stake, which was further stressed in 1976
In 1979, the positive contribution to the international economy were added.
In 1983, the three goals of strong economy, safe and prosperous domestic life in stable and peaceful economic settings were the most important.

The second last economic plan is labeled "Outlook and Guidelines for the Economy and Society in the 1980s. The objectives were the forging of peaceful and stable international relations, forming a vital economy and society, and ensuring secure and affluent living. The plan stretched over the fiscal years 1983-1990.

The main issue for economic policy in Japan are to maintain a high growth of economy and development. Another issue is the harmonization of foreign trade and payments and the stimulation of domestic demand.

The economic security of Japan is served by large exports of end products, imports of natural resources and consequently large amounts of foreign currency. There are however limits to these means.
Trade unbalances and investment of foreign currency in overseas countries cause anti-Japanese sentiments and increase protectionist policy measures. The spending of surplus foreign currency in consumer goods, by opening domestic markets and by stimulating domestic demand are the obvious solutions to these threats.

Exports were the main motor of the economic expansion of Japan after the war. The American market was and is the biggest export market for products of Japan. Exports have decreased in volume for the last few years. The economy is changing from an export driven to a domestic demand stimulated economy. The reasons are the enormous rise of the value of the yen and the international criticism on the trade unbalances and frictions. This transformation is caused by factors such as the industrial rationalization since two oil shocks, the restructuring of businesses, the expansion of overseas production, the effective anchoring in overseas markets and the expansion of domestic production. This was reinforced by a global price structure, which was detrimental for Japans' exports and relatively expensive imports.
The last years this situation has been reversed. The ratio of prices of primary and manufactured products, the ratio of import and export prices and the ratio of flow prices and stock prices have all decreased.
The increased profits of industrial products, compensated for the stagnation of export growth. The relative reduction of import prices has increased the purchasing power. And the stock price increases have balanced the consumption expenditure of assets. This shows that a policy for a demand driven growth is not only a reaction to international trade friction but is also economically rational. 102
The climbing economic trend in 1990 is expected to sustain despite the triple decline in stock prices, bond prices and the exchange rate of the Yen.
Japan is since 1984 the world's largest creditor nation. The overseas assets were $293.22 bln in 1989.

The gross national product has grown by 6.9% in 1989, the consumer prices 2,9%, the real personal consumption expenditures 3 . 2%, the investment of private firms 16.5%, the total cash wages 4.8%, the exports 2.6%, the imports 5.8%, the ratio of current profit per sale 5.38%; only the public fixed capital formation showed a slight decrease of -0.3%.
These figures show that more economic growth is flowing to the private companies than to the public and consumers.
The government is trying to raise the amount of social capital for public investments, but public capital formation is lagging the capital formation in the private sector.

Industrial policy

Industrial policy is defined by Okimoto as the use of government authority and resources to administer policies to provide in the priorities, needs and circumstances of specific industries, with the aim of raising productivity of factor inputs (capital, labor, technology). 103

Industrial policy implies the support of those industries, which on the best information are considered to be the most important in the future. The policy itself works partly as a self-fulfilling prophesy and helps to make these ideas come through. Contrary to some foreign commentators this does not mean betting on the expected winners but supporting favorites in order to help making them winners. 104
Reasons for industrial policy are economic security. Formerly it consisted in industrial catch up, protection against economic and political foreign dictation and change of the undesirable current situation of comparative advantages and disadvantages.

Industrial policy is conducted on several levels:
On the micro level it implies the rationalization of specific enterprises in terms of innovation of production processes, investment in production means, social innovation of management, quality control and reduction of production costs.
On the level of the environment of the enterprises it implies the improvement of the infrastructure, i.e. transportation and location. On the level of industrial sectors, it means the establishment of a system in which companies can compete and cooperate in a societal beneficial way.
On the macro level it implies the forming and transformation of a sectoral structure of the whole national system of providing goods and services, i.e. the proportions of the different sectors of production. 105

In the '50s and '60s, industrial policy was mainly directed at a industrial and technological catch up with other advanced industrialized nations . The means for this catch up were deliberate change of the comparative (dis)advantages of Japan from agricultural and labor intensive light industries to technological and more capital intensive industries.
The allied powers stimulated a rapid industrial and technological development of Japan. The General Headquarters was initially a driving force in stimulating industry and technology. The aim was to develop its capacity, to exploit Japan's natural resources and to develop light industry, with the idea to establish an export market in the Asian continent. In fact however, Japan went further than the allies had intended. It ignored the viable economic theory, that prescribed a developing country to use its comparative advantages for its development. This theory implied that Japan should have made use of its cheap labor force and should develop labor intensive light industries. Instead, Japan also developed its heavy industry and later moved into high technology. Thus it was able to serve the markets of industrialized nations with high end, industrial and technological products.
This development asked for import of technology at the cheapest costs, in terms of required capital and foreign influence. Japan wanted to protect itself from foreign economic and political influence and to use its scarce financial means in the most efficient way.
The elements of its industrial policies were to establish industrial sectoral priorities, to mobilize resources in order to hasten developments, to protect young industries, to guide investment levels, to

promote rationalization on industries and industrial structures, to allocate foreign exchange credits, to regulate technical flows in and out Japan, to control direct foreign investments, to exert administra tive guidance and to form visions of Japan's future industrial structure. 106

The instruments for industrial policy were:
-the control of foreign exchange and the import of technologies, which yielded power to select industries to be developed;
-the preferential financing, tax breaks, protection of industries against foreign competitors, which opened the possibility to lower costs of selected industries;
-the authority to create cartels and bank based industrial conglomerates, which gave them the possibility to supervise competition. 107

Industrial policy now is shifting from traditional industries to more capital and knowledge intensive industries. 108
In general terms, there will be a relative shift to resource saving, knowledge intensive and service oriented businesses.

The role of MITI in determining industrial policy and steering the direction of technical change is slowly fading. Its support for national R&D projects in specific technologies is increasingly changing to support for more fundamental generic technologies and for filling niches in the R&D, which are not covered by the private industry.
The financial, personnel and technical capacities and industrial and technological experience of MITI are limited. It must rely strongly on information from and cooperation with the private sector. Its most important role is the provision of meeting opportunities for industry to deliberate on the important technological fields for the near future.

A general problem in industrial policy is the optimal amount of competition. In the Japanese perception, a certain amount of competition is necessary to guarantee efficiency and consumer interest. Too much or excessive competition however is perceived undesirable because of too much spilling of efforts. Too less competition is seen as not leading to high prices, unnecessary barriers for market entry for newcomers and as essentially illegal, because in violation of the Anti-Monopoly Law. Market opening and deregulation of distribution are important policy measures for decrease of high consumer prices

Education policy

Educational policy in science and technology regards the education of future students and scientists and the creation of an environment favorable for producing and implementing new science and technological knowledge.
The Ministry of Education is responsible for the promotion and distribution of science, education and culture.
The credo of this Ministry is that scientific research is not only of value for utilization and application in our daily life and further development of the world, but has a cultural value in itself as a common intellectual property of all human beings.
The University is seen as the responsible institution for systematic development of scientific

knowledge in all fields of human, social and natural sciences, and as a means for strengthening applied S&T in Japan.

Foreign policy

Japan produces more than 10% of the gross global product with only 2,5% of the world population and is thereby the second largest industrialized democratic economic power. 109
Japan has no natural allies among the world nations; it is isolated and traditionally tends to cultivate this isolation. Surprisingly its main enemy in the second world war, the U.S.A., turned out to be its economic ally during the early post war period. But Japan becomes more and more alienated from this partner, by what the latter perceives to be an economic war.
The resulting isolation makes Japan vulnerable. Paradoxically as result of its economic success, it has become even more dependent on natural resources and on export markets than before the war. This forces Japan to give up gradually its unique and isolated position. It also means that it tends not to rely on chance by let itself be imposed to unrestricted working of free market forces. Therefore it exercises active intervention, based on optimal consensus with maintenance of positive working of market mechanisms.
Economically the country faces a number of international problems, in the sphere of trade and payment imbalances, limited market access, protection of intellectual property rights, and foreign investments. This continuously leads, rightly or wrongly so, to international criticism.
Because the increased international importance of Japan for the world and vice versa, it is in interest of the country to strive for a harmonious international relationship and thus for solutions or dissolutions of these problems.

At the moment Japan is involved in a rapid process of internationalization. There are a number of factors which can explain the trend to internationalization:
The most well known motive for Japan has been the need for a rapid catch up and keeping up with other countries in the most efficient production technology and the most attractive products for the market. Especially multinational corporations want to tune their product development and design to foreign regulations, standards and markets. They need a better interaction with and entrance and contribution to local scientific activities, since science and technology becomes more and more entangled.

In the world economy, trade is becoming increasingly important. The flows of capital and technology are increasing even faster than that of goods. There is a world wide trend to international allocation of parts of the economic activity, in order to gain more competitive advantages and information in a region. Transport and communication means are facilitating the flow of information, goods and persons.
Many national government are increasing their protection of national industries by non-tariff barriers for imported goods. This forms a reason for migration of production and research activities.
Science and technology are increasingly international phenomena.
This is especially valid for information and telecommunication technologies. Competition is also increasingly crossing national borders, not only between multinational corporations but also between local firms.

There is more international collaboration between firms in the large economic blocs in big and large scale technologies, for reasons of high costs and economies of scale. Multinational corporations play a vital role in this respect and national governments are interested in attracting cosmopolitan and mobile companies.

The big Japanese companies are doing business in a borderless world, but fear the rising internationalism. The problem is how to continue global business without frictions and conflicts. Many Japanese big industrial companies are limited in their home markets and in order to keep growing, must become more global by going local. But all-Japanese companies can neither be successful overseas, just as all-American firms can not be so in Japan. They must take care that they do not endanger the interest of the host nations. Much of the complaints about Japans foreign investments boil down to the suspicion that they are merely screw driver factories. This means that they only assemble parts which are produced in the mother country and thus not contribute enough to the local economies. Japanese companies must have something to offer to overseas companies and nations, in terms of commitment, security, employment and added value.

The official policy of internationalization in S&T is fueled by a set of motives. There are idealistic, official and pragmatic motives. The motives are the following:
Japan realizes that, now it is economically and technologically strong enough to compete successfully with the advanced nations, it is not only capable to play an international role without damaging its national interests, but that it has to play such a role in order to maintain and further its well understood and enlightened national interest.
In its increased physical and informational traffic in the internationalizing, reordering and shrinking world, Japan cannot longer afford to practice introspection and isolationism or a unidirectional policy.
In order to be recognized as an equal partner in the world, it realizes that an economic and technological strong position is not enough. It must also show that Japan can play a reciprocal role in the contribution to the worlds scientific body of knowledge. And that it must contribute to the economic and socio-political well-being and development of the other nations, as well the advanced as the developing nations, and to the security of the world order.
Japan is reliant on overseas countries for its natural resources, food and energy. It must therefore internationalize and transcend the national boundaries with its economy.

Japan realizes that it must respond to the expectations of the other nations, that it must do something in return for the knowledge and assistance it has received from other countries in the process of rebuilding its economy. This corresponds to the typical Japanese giri, or feeling of indebtness.
More self interest driven motives could be that Japan is willing to try to reduce the international criticism on its free riding attitude in order to maintain access to foreign technology, information and markets and to avoid protectionist measures.
Another motive is that in approaching the frontiers of S&T, there is a diminishing return if Japan does not internationalize its own
scientific and technological personnel and promote international exchange and cooperation actively.

At the moment Japan is involved in a process of internationalization in virtually all domains of life.

This is expressed by the ever increasing flow of persons, products, money and information. In science and technology policy this process is translated in a forced increase of international cooperation in research projects and exchange of information and researchers in S&T. International cooperation is especially promoted in the field of the big sciences, such as space development and nuclear energy.
Economically, Japan is changing from a traditionally export dependent, to a domestic demand oriented system.
In the framework of the Official Development Assistance program, Japan is continuously expanding its already second largest development budget of ¥1.17 trln (1988) in the world and is gradually improving the focussing and quality of this aid.

The increased contribution to the world is no longer seen as contradictory to Japan's further growth. Opening domestic markets can also have a purging or sanitating effect on economic segments with a low efficiency, such as distribution channels. This can lead to an increased robustness of the national economy as a whole.
The prevention of global protectionism and regionalism in a unifying world economy is considered beneficial for Japan's further economic growth in an era where Japan is more and more internationalizing economically.

Foreign technology policy

In order to safeguard the availability of and access to foreign technology, Japan seeks to produce high technology and to enhance its own innovative capacity either for own use or for exchange of overseas technology.
one of the reasons for shifting beyond the frontiers of technology is the fear that the entrance to foreign technologies will be more difficult in the future due to the caught up of Japan in many technologies and to possible protectionist measures from other countries. The open access to export markets is necessary to provide in foreign currency for the import of raw materials and technology. Increasing protectionist trends in export countries call for cautiousness in this respect. This is the reason, why Japan is voluntarily restricting imports in certain product areas and is stimulating domestic demand in other areas. This must lead to the cure of unbalance in payments and to create domestic markets necessary for the offtake of its products.

Japan is now relatively self sufficient in technology and is exporting medium technology to developing countries and increasingly, although still moderately, also high tech to Western countries.
In space and nuclear energy Japan now is successful in its own development. It is involved in multilateral projects in the framework of the agencies of the United Nations and the OECD.

In its international relations Japan's main partner is still the United States. This relationship remains important because Japan depends on this country largely for its defense, its scientific knowledge and academic education, its export and its participation to large R&D projects. Japan's attitude regarding the U.S.A. is a mixture of indebtness, economic self-interest, military dependence, and irritation about the continuous criticism.

The U.S.A. is putting pressure on Japan to become a leading participant in the superconducting supercollider accelerator project at the cost of around ¥330 bln. A more applied project is the participation in the Space station, in which Japan intends to carry out experiments In critical military, economic and industrial areas, bilateral cooperation, participation and transfer of knowledge is rejected by the U.S.A., for reasons of national, military, economic and trade security. The problem of dual use technologies is whether knowledge acquired from military projects can be used for other commercial purposes, and vice versa if commercial technologies used in military applications are classified as military secrets. The substantial technical cooperation with other individual countries is smaller. There is some technological import from France and Germany in space and nuclear technology.

Japan is offering fellowships and employment for scientists and engineers in the university and government institutes. The political influence on private companies and private research institute in this respect is naturally limited. The Japanese government has granted a gift to the NSF for academic and institutional fellowships.

Japan opened the possibility to establish foreign owned and managed R&D facilities in the country. This has led to foreign investments of about ¥300 bln by mainly foreign multi-national corporations. Many of these companies already have sales and manufacturing activities in Japan. Their motives are to be found in the local marketing skills, commercial product design, qualitative products, efficient manufacturing processes, better market accessibility, better treatment by government agencies and distribution and retail firms. There appears to be little official barriers to restrictions on these foreign R&D investments, but the amount of candidates is still limited.

One of the main bottlenecks in this respect is the access to Japan's scientific and technological information. This is the result of the inability or difficulty to understand, speak, write and read Japanese language. Japan is increasingly putting effort in translating or abstracting Japanese journals and documents by professional or government agencies. The amount of information is too huge however to be translated completely and there is no good criterium for a selection. So the selection is more or less dependent on the availability of goodwill, abilities and funds of the translating agencies. The principle question however is why Japan should translate its literature in to English while the reverse is not the case. Other cultural barriers are communication difficulties, different life and work styles, resistance to changes in the Japanese traditional methods and the protection of the ethnic homogeneity.
Internationalization of Japan cannot be proceed unilaterally and loose from global political and economic contexts and considerations.

Trade Policy

The free trade system encounters a number of problems such as a growing number of non-tariff barriers, long negotiations and disputes, increasing regionalism and the need for rules for new fields e.g. service trades. It seems in Japan's interest to support the free trade system e to be active in settling these problems, preferably in the multilateral negotiations, such as the in GATT. 110

Because Japan is still dependent on the U.S.A., for its defense and, export markets, the bilateral relationship with the U.S.A. is of critical importance for Japan's peace and prosperity. In April 1989 the Office of the U.S. Trade Representative listed, in its report on Unfair Trade Barriers, a total of 34 items including import barriers to semiconductor and supercomputers, the distribution system and the large retail store regulations. The annual trade statistics for 1989 showed the sharpest decline of the trade surplus ever of $13.129 mln (16.9%) to $64,433 mln. 111

In the framework of the Structural Impediments Initiative (SII), the two countries try to discuss their mutual constraints in realizing an optimal economic relationship and try to find the best possible solutions. SII started in september 1989 and was intended to resolve the economic friction between Japan and the U.S.A. In April 1990 an interim report was made on the progress of the talks. Japan views these talks as a means of taking away the one sided blame of the economic frictions between the two countries and as a possibility to point at structural problems in the U.S.A. side. It can lead to a better mutual understanding of the constraints in both countries in finding a quick solution.
Japan has pointed at imbalance in savings rates and investments in the U.S.A. and the reasons for low competitiveness of American enterprises, the need for improvement of the individuals savings rates and the budget deficit
On the other hand the U.S.A. complained about the high trade surplus, high savings rate and low spending on infrastructure in Japan. In the framework of the SII, Japan promised in April 1990 to ease a law restricting large retail stores, to revise the Anti-Monopoly Law and to set a target for public works projects in the next ten years. In June it came to an Agreement with the U.S.A. of $430 mln expenditure on public works projects. January 1990, MITI announced the continuation of a voluntary restraint on cars. In April 1990, the President of the U.S.A. announced that Japan would be removed from the list of countries with unfair trade obstacles.

Science and technology policy

There is a general feeling in Japan that there is no division between science and technology. One of the reasons might be that Japan have earned its spurs more in technology so far than in science. Another reason is that in the more advanced technological fields, the demarcation is blurred indeed. High technology is more and more science driven, while the underlying scientific fields rely more and more on technology for experimental and instrumental research. Nevertheless, in the official documents the terms are used often separately and in policies are sometimes separately defined. Big companies establish
separate scientific institutes deliberately to protect scientific work from too much influence from more applied intentions. And the government takes on an explicit task in promoting and funding basic science.

The main motives for science and technology policy are the unshakable Japanese conviction that science and technology in principle are essential for the growth of the nation, the improvement of its living standard and the fulfilling of an equal role in the world community. This conviction is enforced by the perception that S&T in the past were the most important factors in the social and economic reconstruction of Japan.
According to the Economic White Paper for 1990, a breakdown of the growth factors for the Japanese economy reveals that over the past decade, total factor productivity, played a role roughly equal to that of capital and labor. 112 The 1990 White paper of the Science and Technology Agency identifies technological progress (wrongly so, but not without pragmatic value) with this factor productivity. 113

For the importance of other factors or for a critical stance regarding the negative impacts of S&T on society and environment seems to be little attention.
The White paper however is aware of the fact that S&T now should not only be developed and used for economic growth of the nation but should also serve the material and immaterial needs of the individual Japanese people.

The White papers on Science and Technology give a good indication of Japan's science and technology policy intentions over the last years:
The White Paper on Science and Technology 1987
The White Paper of 1987 indicated the need to internationalize Japan's S&T. In comparisons with other nations, it shows in which S&T indicators Japan should strengthen its efforts. In technology trade, it has to decrease the still negative gap between imports and exports of technology further. In basic science it also did not score well so far.
The paper points at a worldwide consensus on the ever increasing importance of S&T in the improvement of the world economy, and the endeavor of the most important blocs, the U.S.A., Europe and the NIC's to step up efforts in S&T. Japan is expected to increase its efforts in basic science, but wants to agree with the other nations upon a mutually compatible policy for protection of intellectual policies. It wants to contribute in scientific and technological cooperation, but is well aware of competition in the advanced S&T fields.

The exchange of foreign researchers still registered bottlenecks. In fiscal 1986, 43,686 foreign scientists and researchers entered the country, of which 70% of Asian countries, while 55,869 left the country, of which 505 to America.
JRDC, ERATO and RIKEN's Frontier Research program are aiming at higher participation of foreign researchers, international joint projects for promoting S&T and raising statutes for attracting foreign researchers in universities. The paper recognized the necessity to increase efforts in the application of international patents, in international conferences, in the amount of international prices for basic science, in the number of foreign students and in technical cooperation. 114

Since then Japan has by policy measures improved considerably in the field of patents and international conferences.
In order to gain international recognition .and attract foreign researchers, the government should promote basic research and raise the level of S&T, especially in state operated laboratories and universities. This should increase cooperation between industries, universities and government and joint research with other organizations.
Measures are being taken to improve the institutions for the internaionalization of S&T, by increasing the exchange of researchers and improving the research environment, the accommodation facilities and the information for participation of foreign researchers.
In order to contribute to the global body of knowledge, this should raise S&T to a global level, contribute to global problems and transfer technology to developing countries. 115

The White Paper on Science and Technology 1988
This White Paper stood in the sign of the promotion of a new creative research environment.
The reasons are the establishment of fundaments for Japan's further technological developments and

the wish to play a more important role in the international scientific community. By promoting basic research Japan would be able to meet its own long term technological needs, to use its potential based on applied R&D, to contribute to the global stock of fundamental knowledge, to prevent criticism on unequilibrated efforts and frictions and to live up to the expectations of the world community.
The policy instruments are the strengthening of the research infrastructure and the fostering of creative talents. This implies the improvement of the R&D environment including research management, the securement of research personnel, the improvement of facilities and equipment, the improvement of gathering and exchange of scientific and technological information, the emphasis on individual rather than group performance and the granting of more freedom in formulating research contents, choosing methods, time scheduling and self evaluation of scientists.
The government should provide in large-scale facilities for which the industry cannot be expected to take care. More cooperation between industry, academia, government and foreign research communities is needed.
The JICST should further build up its international scientific and technological information network.
In order to secure international property rights, a better system of protection and worldwide standardization should be created. International competition and cooperation should be promoted simultaneously.

Policies on strengthening basic research are being taken. The institutions for the strengthening of government driven basic research are the national research institutes and the universities. In the 13th report of the Council for Science and Technology, commitments were made to reform, reshuffle and improve the organization and administration of national research institutes. A fundamental principle of educational reform, adopted by the Cabinet in 1987, indicated future policies, such as the expansion of grants in aid for original and pioneering basic research, the training of young researchers, the implementation of joint research with private corporations and international organizations and the promotion of international research
exchanges. Though Japan's overall expenditure on R&D is now second after the U.S.A., international comparisons show that the government spending on basic research per GNP in Japan is still lagging U.S.A. and Europe. In specific fields Japan is considered to be lagging in life sciences and marine sciences in 1988. 116

The White Paper on Science and Technology 1989
This Paper of 1989 was devoted to the new Imperial era of Heisei. 117 The problems, Japan is facing in this era are global internationalization, the increase of its aged and the decrease of its young population, stronger domestic calls for more diversified values and international calls for more contribution and responsibility for the development of the world. A great problem is that more science and engineering students tend to avoid employment in manufacturing

The global development will inevitably affect Japan, as it makes itself more dependent upon foreign countries, while it gets economically more stronger.
The paper perceives science and technology still as the main instruments for accomplishing the waiting tasks. Science and technology policy has therefore a comparatively higher importance than in other advanced nations.
The level of science and technology has developed satisfactorily, especially since the last decade. The research expenditures have grown considerably more than the GNP. In 1988 it reaches the

international high level of 2.81%. This is primarily due to the determined investment in R&D by private companies. These companies are not longer willing to depend on foreign technology and government assistance. They need to develop their own knowledge sources for future development and dispose over the financial means to invest in the generation of this knowledge. Japanese industry finances their R&D mainly from own means. Based on these trends and on conducted surveys, it can be expected that the private sector will continue to give R&D highest priority. The role of the government in Japan has not followed the international situation and the domestic private trend however. The share of government expenditure is only 0.5% of GNP.

The number of researchers in the work force approximates 0.7 % and surpassed that of the United States.
The number of patent applications in Japan is now more than 300,000 and the number of Japan's share of patents granted in the U.S.A. is also very high.
In international comparisons with the U.S.A. and W. Germany, Japan shows its strength in the export value of high tech products and the number of researchers. It demonstrates its weakness in basic research expenditures, the number of internationally published articles and the value of technology exports. It can satisfactorily match in R&D expenditures. 118
The number of scientific papers amounts to 220,000, but only 10% is published in journals of international reputation, which might be contributed to cultural and linguistic barriers or to a lower productivity or creativity.

Research in Japan is concentrated in the field of electronics, a number of fields like communications, electronics, and electrical
instruments. The effect is that in electronics the product development rate, the product life cycle. the market introduction, and the competition are intensified.
R&D in industry is becoming long term oriented and the amount that is spend on basic research is increasing; the average proportion was 6.6% in 1988. In Japan's industry there is an increasing trend to develop basic research programs. These programs, however, tend to be directed at limited companies business areas and goals. In order to transcend the too narrow corporate goals and negative financial effects of economic fluctuations, it is necessary to set out a policy and create conditions to carry out and carry on wide, broad basic research

The government is no longer giving only direct support to industry for he promotion of development and utilization of advanced technology
for national reasons. Secondary motives are to make an international contribution for the increase of the international body of basic knowledge and to improve the domestic quality of life.

The bottlenecks in promoting basic research are the lack of funds in the public sector and the rigidities in the research structures and systems . Measures to strengthen basic research are the promotion of a free research system, more flexibility in researchers exchange and R&D management and more competition in research conditions and evaluation. 119
In order to contribute to the international body of knowledge, more foreign researchers should be invited. The domestic academic world should be more internationalized, advanced research facilities more open and more results of basic research should be produced.

A recent trend in internationalization is the transnational business and R&D activities of Japanese companies, as well in developing as developed countries. In reverse many foreign companies open research centers in Japan. The international exchange of researchers is steadily increasing. On the other hand nations increasingly strengthen their competitive and economic strength. The corollary is that internationally methods and modes should be developed to simultaneously increase competition as well as cooperation. The paper confesses that Japans internationalization policies have barely started. 120

The White Paper on Science and Technology 1990

For the first tine, a White Paper was focused on non-economic goals of S&T for Japan. It had the socially appealing title of S&T as the source of a more fulfilling life. It points to the growing need of the Japanese people to lead a more comfortable and satisfying live. The results of a survey show that 85% of the respondents was of opinion that S&T should contribute more to the improvement of the quality of life. 121

The paper starts with a proud overview of the R&D performance, expressed in main indicators of Japan over the past five years.

In the five years before the mentioned data, Japan increased its R&D expenditures with 46% up to ¥9.8 trln (¥10.6 trln including human and social sciences) in 1988. In April 1989, the number of researchers increased with 25% up to 462,00 researchers in engineering and natural sciences and 73,000 in the social sciences. These efforts resulted in a 190% increase of technology exports up to ¥280 bln in 1988, an

increase of 19% up to 30,000 journal papers in 1986 and a four years increase of 93% up to ¥11.6 trln on high technology products value. The value of high tech products is now the highest of all countries.

The desired concrete contributions to a more fulfilling daily ordinary life mentioned in the white paper are:

The provision of society with new visions on human life and his environment, by the promotion of curiosity driven pioneering basic science especially in fields as space, life and matter.

Life sciences can contribute to the maintenance and improvement of health, technology for a healthy daily life, disease prevention diagnostics and treatment, knowledge about balanced diet and sufficient relaxation, technology for physical exercise, methodology for diagnosis and technology for treatment and revalidation of the sick and handicapped.

The provision of theoretical, technological and factual knowledge on the environment for protection and improvement of the individual local, regional and global environments.

The development of transportation, information and communication technologies for the human physical and psychological mobility,

The social philosophy behind these ideas is, that S&T are expected to provide individual human beings with information and technology. This can enable them to learn more about themselves, their sociological and physical environment and to improve their conditions according to own needs by choosing from a "technological menu" in what is called a "techno-amenity" society.

The public sector is expected to play a leading role in the promotion and establishment of such a "techno amenity society", by promoting basic leading research, in which the private industry cannot or doesn't want to provide, to assess the safety and impacts of technologies and by providing reliable information to the public. 122

The impact of the White Papers cannot easily be measured. The absence of concrete policy measures and feasibility evaluations might give the impression of sheer paper tigers. The influence of the guidelines of the Council for Science and Technology seems more substantial.
The content of the Papers is for a major part an account of recent accomplishments in S&T and to a lesser extent an indication of a future program. On the other hand, the Papers reflect a general feeling of the problems which Japan currently is facing and suggestions how they could be solved by science and technology. This might well influence other documents and decision making in public and private institutions.

Information Policy

Japan is gradually working to develop itself in the direction of an information society and economy.
The aim of a recent Symposium on Communications Policy for the 1990s of MPT was to discuss necessary comprehensive and long term policies on communications and to deliver a report with considerations and recommendations to the Minister of MPT. 123
The resulting report identifies as basic global trends in the near future: worldwide integration, industrial networking and information distribution, urbanization and changing lifestyles and the growth of
information and communication into a vital and central element of all economic activities.
International communications policy should be focused on the following elements. The building of high capacity and high speed global communications networks, consisting on a mix of connecting media and unifying existing networks. Integration of the national communications markets and improving the information and communications structure in the Asia-Pacific area.
Domestic policies regard the creation of new information communication industries, new radio industries and local information services.
R&D is considered necessary, e.g. in the field of remote sensing by satellites for environmental and climatical monitoring and forecasting. And the use of very small aperture terminals for cheap and easy communications between satellites and corporate networks.
Improvement of international exchange of information needs improvement of the info-com structure in developing countries, scientific and technological cooperation with other countries, improvement of the international infrastructure, e. g. satellite links and undersea cables, the developing of international standards for telephone, radio and broad-band ISDN and open systems interconnection to regulate the
high speed information channels and data transmission.

Important recent issues of government concern, regarding S&T are the promotion of Japan's capacities for doing basic research, international cooperation and exchange, large scale research projects, building an infrastructure for the promotion of science and technology and related policy research. If the characteristics of new government sponsored R&D projects are analyzed, the government policy seem to be more synthetic than in the past: more basic R&D, longer range projects, linking smaller projects, joining participants, crossing traditional disciplinary demarcations and stimulating foreign participation.

Basic research.
The government is active in strengthening basic research, especially with the aim of laying the

foundations for future generations of technology. A Special Coordination Funds, allocated by STA is being used to promote and coordinate important leading and basic research activities in national research institutes and between researchers from various government agencies.
STA promotes creative S&T via the ERATO program and via the Frontier Research program of RIKEN. MITI has set up an R&D program for a next generation fundamental industrial technology. MAFF is conducting an R&D program in advanced biotechnology. MPT is involved in a research program on the frontier of telecommunications. The Ministry of Education is encouraging original scientific research in the academic community. STA and MITI jointly support the Human Frontier Science Program for international cooperative basic research on the functions of living organisms. 124

International cooperation and exchange.
Major programs for the promotion of international cooperation and exchange in S&T, include the STA fellowship program for bringing foreign researchers in national universities and research institutes, the Japan Society for the Promotion of Science post-doctoral fellowships for foreign researchers, the International Research Exchange
program of MITI's AIST, and STA and MITI jointly support the Human Frontier Science Program for the international cooperation in basic research on the functions of living organisms. 125

Large scale research projects.
Research projects in fields of nuclear energy, space development and oceanic development are conducted in public research corporations. The reasons are that they require large investments in money and manpower and take a long time to achieve results, which are not immediately commerciable and thus too costly or not immediately interesting for private companies.
Nuclear energy is intended to become one of the important energy sources for Japan as a country poor on resources. This tendency is boosted by the desire to decrease dependence on fossil fuels. The country is too vulnerable, as result of too much dependence on oil from the Middle East. Other reasons are the protection of domestic and global environment. There are research programs for the improvement of light water reactors, the establishment of a nuclear fuel cycle and new power reactors, a prototype fast breeder reactor and a nuclear fusion project (JT60). Apart from the technology itself, research is conducted in the field of safety maintenance.
In space development and utilization Japan is active in the field of artificial satellites for different functions and space transportation.
In the development of oceanic resources, Japan is conducting research in deep oceanic diving technology and survey of the deep sea bottom.

Infrastructure for the promotion of S&T.
The infrastructure for the promotion of S&T includes e.g. equipment and facilities. Equipment of national research institutes is renewed such as the next generation synchrotron radiation (SPRING 8) for basic research in the fields of materials, life sciences and photochemistry. Information distribution systems, are set up such as an international S&T information network with JICST, the U.S.A. and Germany, genetic resources banks etc.

Science and technology policy research:
S&T is expected to have an ever increasing influence on society and environment. In 1990, the

government submitted its 18th inquiry on "Comprehensive basic science and technology policies to be adopted in the new century" to the Council for Science and Technology. The government is now conducting a study with the aim of establishing a comprehensive basic science and technology policy for the future.

New trends in science and technology policies:
The Council for Science and Technology ventilated as his opinion that Japan should increase its efforts in basic research, for two reasons: Basic research should produce new knowledge, which can function as sources for future technologies and new products and processes for Japanese industry. The industry has caught up with the West and can no longer rely on the import and modification of foreign technology. The other more idealistic reason is that Japan recognizes and acknowledges its task as an economic and technological leader nation to contribute to the international public scientific body of knowledge and to promote international cooperation and exchanges in S&T.

Creating a scientific environment will attract and commit high quality researchers, as well from Japan as from abroad.

In large projects in the field of big technology, Japan is increasing its R&D efforts. Examples are a conceptual design for an International Thermonuclear Reactor (ITER) under the assistance of the IDEA, the Plan for the superconducting super collider (SSC), and the human genome analysis project for analysis of human genes.

Global environment.
Global environment is a fashionable issue in Japan for three reasons. Japan has a history of environmental problems and solutions, after the diseases, caused by cadmium and mercury pollution and the air pollution in the big cities, notably in Tokyo. The last years, however the awareness is growing that environmental problems are no longer domestic. Overseas pollution is already affecting Japan for e.g. air pollution, carried by prevailing winds from mainland China, effects on the quality of imported food. There are also problems expected from the warming of the global atmosphere as result of the emission of trace gases and problems as result of the destruction of the ozone layers by fluorocarbons. Japan is expected to play its role in the scientific discussion and policy making in the world, not only in its own but also in the global general interest. It is aware that further deterioration might have only losers and no winners. Industry is also increasingly interested in these questions, because it can develop or utilize its technology for the protection or restoration of the environment and export this technology.
In 1990, the government developed plans for studies on global environment preservation and the advancement of comprehensive related research. 126 It produced the report on the 17th Inquiry containing "Basic Plans for Research and Development on Earth Science and Technology". This plan listed as important research themes: the increase of scientific knowledge of the earth, development of methodology for forecasting meteorological fluctuations, which may cause disasters, earthquakes and volcanic eruptions, the exploration of S&T for the use of natural energy, the development of technologies for countering global warming, acid rain etc.

S&T for social goals.
Science and technology is not only expected to contribute to economic growth but also to a more

fulfilling daily ordinary life.
Curiosity driven, pioneering basic science especially in fields such as space, life and matter can contribute to this goal by providing new insights in human life and his environment.
S&T can make more concrete contributions to the improvement of the quality of life in the fields of health, environment and the extension of the range of human activities. Life sciences are expected to contribute to a healthy daily life, as well disease preventive as curative. It can bring forth knowledge about balanced diets, sufficient relaxation, technology for physical exercise and methodology for diagnosis and technology for treatment and revalidation.

For protection of the global environment, S&T can play a role in further developing renewable energy resources or nuclear energy, as alternatives for carbon dioxide emitting and otherwise polluting substances, and finding substitutes for fluorocarbons. For the regional
environment, catalytic technology can contribute to the alleviation of water and air pollution by reducing the emission of sulphur dioxide, nitrogen oxides and carbon monoxide. Technology might be developed for minimizing the production of waste materials. For increasing safety and comfort, diverse technologies are needed for the prevention of theft of information and goods and fire and gas.

For a greater range of physical mobility new transportation means and systems should be developed, e.g. on the basis of superconductors. For the extension of the immaterial functions, new information and communication systems, based on electronics and material technology.

The 1990, the White Paper on S&T uses the concept of a technological menu as a metaphor to express that Japan strives for a wide range of technical knowledge, founded on basic leading research, in electronics, materials and life sciences. This menu should be made available for the population in order to allow them to choose among alternatives those technologies, that enable them to lead a richer and more fulfilling live.

The increasing importance of S&T in Japan can be measured as for their output by an increase of technology exports of 190% from 1984-1989, by the values of high tech exports of 90% from 1982-1986 and by the number of published papers by 20% from 1981-1986.
Indices of the rising input are that the total R&D expenditures climbed from ¥6.5 trln in 1983 to ¥9.8 trln in fiscal 1988 and the number of researchers grew from 370,00 in 1984 to 462,000 in 1989.
Government financing of this R&D, however, is relatively low compared with major industrial countries.

Integration of policies

Integration of science and technology policies in Japan is problematic due to a reluctant attitude of industry and the bureaucratic inertia and competition. A full coordination on government policies is not plausible due to the political and bureaucratic structures and the relative independence of a strong industry.

Formally STA has an important role in the integration of science and technology policy, because its tasks are the coordination of the ministries involved in science and technology policy and the setting of science and technology policy for the government. It performs the secretariat and staff work of the

Council for Science and Technology, as the highest S&T deliberation body, and thus has the potential to be more powerful than the other agencies. But actually it faces many difficulties in fulfilling this task because of the resistance of the other ministries.

The coordination and integration of S&T policy is hampered by the relative containment of the ministries and other central government agencies. Another impediment is the intense competition, not only in the private sector, but also within and between Ministries. These organizations traditionally compete for limited research budgets and act quite autonomous in conducting research.
Within MITI, the so-called international trade faction, the industrial structure faction and the small and medium enterprises faction are
striving for supremacy and have often conflicting goals. Between MPT and MITI exists a heavy competition for the field of electronics, information and telecommunication. E.g., NTT under the aegis of MPT has set up a program for the development in the field of VLSI technology parallel to that of MITI.
Every year similar or overlapping proposals appear for programs and funds in different ministries and agencies. This doesn't make the task easy for the MF, in charge of providing the funds and STA, entrusted with the overall coordination of science and technology policy.

Integration of policies depend on collective consensus between the competent ministries and between ministries and between industry.
The last years there is a tendency for either forced or voluntary cooperation. Examples are the Key Technology Center and the joint administration of the Human Frontiers Science Program, originally initiated by MITI, but now administered together with STA.
A policy to break through the situation is e.g. to formulate joint research projects crossing the jurisdictions of several ministries. Multidisciplinary research is e.g. stimulated by the Erato program, sponsored by STA and the Key Technology Program sponsored by MITI.

Large scale industrialization projects by government and industry together are decreasing in importance, because Japan is shifting to more advanced technologies.

An example of a problematic attempt to integrate socio-economic, demographic and science and technology policy is the technopolis project of MITI. This project, supported by regional governments, aims at spreading industry and population more over the country and thus at contributing to relieve the congested metropolises and to regional development. The private industry seems less interested in this project. Their interests are more in technology and production than in the demographic spread and regional employment. This a reason why they set up a rivaling plan of the Kansai City, located in a very populated area.

6

ORGANIZATION OF SCIENCE AND TECHNOLOGY POLICY

Government agencies

The most important Government agencies are listed hereunder:

Prime Ministers Office (PMO)
Council for Science and Technology (CST)
Science and Technology Agency (STA)
Environment Agency (EA)
Science Council of Japan (SCJ)
Ministry of Justice (MJ)
Ministry of Foreign Affairs (MFA)
Ministry of Finance (MF)
Ministry of Education, Science, and Culture (ME)
Ministry of Health and Welfare (MHW)
Ministry of Labor (ML)
Ministry of International Trade and Industry (MITI)
Ministry of Transport (MT)
Ministry of Construction (MC)
Ministry of Agriculture, Forestry and Fisheries (MAFF)
Ministry of Post and Telecommunications (MPT)
Ministry of Home Affairs (MHA)

Politics, bureaucracy and industry

In Japan, there is a long tradition of government intervention in the economy and industry. The Japanese bureaucracy is especially equipped for this. The S&T bureaucracy consists of a relatively small competent bureaucratic staff of civil servants, with high intellectual managerial skills and a high corps spirit, divided over a number of relevant ministries.

Their task in the early post war period was to form and restructure industry in order to stimulate a fast economic growth.
They performed this task by:
-recognizing and selecting economically important industries, research organizations and technologies which deserve support in their development,
-to determine the best and most rapid ways for this development,
-to provide in the means for this development and
-to create, guard and maintain an optimal degree of competition.

The principle behind these tasks is an optimal mix of state intervention and market forces. The Japanese economic system is neither classifiable as market controlled or as centrally controlled, but as a form of collective informing and communicating. The state intervention is directed at effecting and realizing national economic goals. The market forces should secure efficiency. This system is sometimes labeled market conforming state intervention. Bureaucracy intervenes in the economy on the level of the companies, on the condition of optimal working of the market. The aim is both to preserve or promote an optimal amount of competition for securing efficiency, and to
prevent extreme competition for minimizing redundancy and inefficient conflicts.

The influence of the bureaucracy rests on a combination of factors: on its continuous and close relationships with business, on its furthering of national interests, on informal pressures and means for influencing business, among which the necessary approval by the government in the case of future requests. Their instruments are to issue orders, requests, warnings, suggestions and urges.

In Japan there is principally no ownership of the state in important production organizations. However there is a good cooperation between government and big business. Government is regulating a healthy degree of competition between industries. And the companies often listen and respond positively to signals and indications of the government.

Now that the financial and technological position of the Japanese companies is strong enough to compete with foreign companies and to provide in their own technological knowledge, the influence of the state and its bureaucracy on industry tends to decrease. Industry is in general strong enough to finance its own investments and is less dependent on government assistance in importing foreign technology.
The role of the private sector has remarkably increased. It spends e.g. around 80% of the countries expenditures on R&D. The role of the government has correspondingly decreased as result of budgetary restrictions and lacking political support for the increase of financial means for the university system and the national and international programs.

There is a difference between the image and reality of influence relations between bureaucracy and industry. A fundamental question is if the Ministries are really powerful or that they only function as bully or scapegoat for stockholders and workers and legitimators in the interests of industry.

The most important role, the Japanese bureaucracy actually plays, is the creation of networks for the exchange of information of different aggregation levels between different segments of society. This information exists of communication of national and regional societal needs and demands, transcending the direct short term interests of the private firms. It also exists of government policy intentions to the private sector and in return of non-proprietary general technological knowledge, companies strategies and foresight of technologies and markets to the public sector.
Industrial associations and government form committees or study groups to examine industrial problems and emerging technologies for identifying new opportunities. The association in reverse plays a role in the communication between government and industry.

The Japanese system is coordinated through a network with many layers, with links within and among firms, industries, governments, and universities . The government tries continuously to increase the intensity of this network.

The political system leaves much room for the bureaucracy to initiate and carry out the necessary measures. The present Minister of STA has
qualities and experience in other fields than S&T. Ministers are mainly political figures, which do not need to have much knowledge of the peculiarities of their portfolio. Vice ministers are often recruited from within the bureaucracy and can give more technical lead to their ministry.
The political system is organized in such a way as to allow the bureaucracy to develop initiatives and

to operate effectively. It leaves industrial and S&T policy making to the bureaucracy, but let them not take over their political authorities. Legislative and judicial functions are only functioning to support bureaucratic actions or to prevent or correct bureaucratic actions, which go beyond its bureaucratic discretion. The Diet has no significant role in S&T policy and mainly authorizes what the bureaucracy and policy is cooking.

The Ministries, most actively involved in science and technology policy, are listed hereunder:

In terms of available budget and influence, the most important ministries are:
Science and Technology Agency (STA)
Ministry of Education, Science, and Culture (ME)
Ministry of International Trade and Industry (MITI)
Prime Ministers Office (PMO) ,
advised by the Science Council of Japan (SCJ)
and the Council for Science and Technology (CST)

Other important ministries are:
Ministry of Post and Telecommunications (MPT)
Ministry of Agriculture, Forestry and Fisheries (MAFF)
Ministry of Health and Welfare (MHW)
Ministry of Transport (MT)
Ministry of Construction (MC)

More indirectly involved are:
Ministry of Foreign Affairs (MFA)
Ministry of Finance (MF)
Ministry of Labor (ML)
Economic Planning Agency (EPA)

Council for Science and Technology (CST)

The Council for Science and Technology is the supreme advisory body for the formulation of comprehensive policies for the promotion of science and technology and the coordination of the policies of the relevant administrative agencies.
The Science and Technology Council has a competence, transcending the task suggested by its title. Its recommendations carry the weight of a semi-government decision system. It more or less acts as a shadow cabinet. The Prime Minister is chairman, the ministers of Finance, Education, STA and Economic Planning Agency are permanent members and other ministers may be invited as temporary members. The President of the Science Council and important representatives of industry, academia and the bureaucracy are added as expert members. This composition illustrates the weight of the consults of the Council. For the more detailed and urgent matters the Council is equipped with the Committee
on Policy Matters. This is a standing organ for reflection, discussion and recommendations on science and technology policies. It has subcommittees on policy studies, on research evaluation and on research projects. The last mentioned committee organizes hearings from representatives, ministries,

agencies, industry and leading scientists.

The main activities of the Council are the formulation of basic policies by issuing general guidelines, the improvement of institutional structures and infrastructures for the promotion and support of S&T, and the promotion of R&D in specially selected key areas. It has determined as major areas: matter and material, information and electronics, space, ocean, geophysical (earth), life and soft sciences and technology. 127

In its yearly proposal on key actions for the promotion of S&T, its "Key Guidelines for Fiscal Year 1990" proposed three items:

1. the promotion of fundamental and frontier S&T,
2. the development of creative talents,
3. playing a more significant role in the international community.

In June 1990, the Committee on Policy Matters of the Council for Science and Technology suggested to promote basic and pioneering S&T, to intensify international cooperation and exchange, and to further conditions for scientific and technological progress and research exchange. Mid-1990, the Prime Minister asked the Council to deliberate on new comprehensive policies for Japan for the next ten years, given the rapid changes in global environment and S&T.

Although the council has a politically dominant role in science and technology policy, the various ministries also have the freedom to formulate their policies and to negotiate bilaterally with the MF. This makes a tight coordination almost impossible. On the other hand, because all important groups have contributed to the resulting public reports, it reflects many of their ideas and intentions and the future direction is likely to be set according to the grown consensus.

Science and Technology Agency (STA)

The STA was established in 1956 to support the administrative structure of science and technology in Japan. STA had to take over some of the competencies of e.g. the Science Council of Japan and MITI. The tasks of STA are the following:

-Formulation of science and technology policy in Japan, planning R&D programs and issuing guidelines to implement these policies.
-Coordination of the administration and estimation of the budgets of ministries, involved in the execution of S&T.
-Support of joint international research and international exchange of personnel and information
-Establishment and administration of research institutes for promoting or conducting creative research, expected to lead to sources for new future technologies.
-Improvement of infrastructure, facilities and activities for research and development.
-Promotion of large scale and inter-ministerial R&D.
-The monitoring of scientific and technological trends in Japan and abroad.

-Enforcement of safety measures and protection against hazards related to atomic energy.
-Serving as secretarial office of the advisory bodies of the Prime Ministers Office: the Council for Science and Technology, the Atomic Energy Commission, the Nuclear Safety Commission, the Space

Activities Commission and the Council for Ocean Development.

STA produces annually a White Paper on Science and Technology.

STA maintains its relations with and exert influence on industrial firms, via completely owned public corporations, involved in R&D in its four areas of responsibility.
These public corporations are NASDA in aerospace development, JAERI and PNC in nuclear energy, JAMSTEC in ocean development and RIKEN in physical and chemical research. JRDC as a public corporation of STA is originally set up in 1961 to coordinate joint R&D projects of the government and university and to license the resulting patents to industry. In 1981, it initiated the open ended and creative ERATO program for multidisciplinary research on fundamental technologies, with a budget of ¥4 bln, managed by JRDC

Ministry of International Trade and Industry (MITI)

As already explained, MITI has played a important role in the industrial reconstruction of Japan. In the times of the GHQ, it still thought in terms of economic competition as a kind of war. Not any longer so. The industrial faction in MITI has been loosing ground to the international faction, embodied in the International Trade Policy Bureau. The more important issues now are how to prevent trade frictions, protectionism and how to establish good international relationships with the main trade partners. The International Trade Policy Bureau formulates international trade policies, which have to be carried out by the International Trade Administration Bureau. The role of MITI has shifted from industrial policy to international trade policy. In this international trade policy, the emphasis has shifted from the promotion of exports to the promotion of imports and the free trade system with the aim of reducing trade imbalances. MITI's policy style has shifted from direct and formal measures to indirect and informal influence and communication.
Another important field of interest for MITI is the support of basic research.

MITI 's main tasks are now the increase of Japan's effort in basic research and the promotion of international cooperation and avoidance of frictions.

MITI has an Industrial Structure Council and its Industrial Technology (sub) Council. In 1980, this Council advised to develop Japan as a technology-intensive nation, in order to safeguard economic security in an unstable world order. It identified the fields of aircraft, space, nuclear power, ocean development, fine ceramics and new materials as those new advanced technologies on which the industry should focus in the medium and long term.

The Key Technology Center, created at the request of the private sector, but administered by MPT and MITI, has taken over the management of large funds, for financing capital investments and loans for R&D projects of private organizations. The annual budget of ¥26 bln is allocated to selected projects of a number of applicants, either as capital investments funds for research corporations of more than one participating corporation, or as loans with a low interest for individual companies, with the aim to carry out research on key basic technologies. The involved companies should spend at least 30% of the investments of the loans

themselves. The results should be practical applications.
Companies, who participate, as well as those who do not participate, also carry out R&D in their fields parallel to these joint projects. These joint projects require the MITI declaration that they do not violate anti trust laws.

The repayment of loans on joint national or large scale projects has not been very high, which could be explained either by not strict enforcement of the rules or by a small amount of commercially successful results.

MITI's research organization AIST carries out industrial R&D in its own laboratories under frequent consults with industry on the floor level.
AIST is carrying out 8 large scale projects, with an applied character and a total government funding of about ¥14 bln. AIST is also carrying out an R&D Project on Basic Technologies for Future Industries, with a budget of around ¥5 bln in the more fundamental technological fields of new materials, biotechnology and electron devices.
AIST, located in Tsukuba is responsible for 16 laboratories of which 5 in regional areas.
Via NEDO, it leads the R&D project for Basic Technologies for Future Industries and the Moonlight and Sunshine projects, on respectively energy conservation and alternative energy resource technologies.
The quasi-governmental New Energy and Industrial Technology Development Corporation (NEDO) took over R&D management tasks from MITI/AIST in the fields of Large Scale Projects and of the Basic Technologies Program. It is a public corporation with much more flexibility in its management structure and fund raising. It employs more technical and industrial expertise. NEDO works with an annual budget of around ¥2.5 bln.
An example of a research institute, paid by MITI but manned with scientists from and paid by industry, is the Institute for New Generation Computer Technology (ICOT) The institute is responsible for the development of the Fifth Generation Computer. The project is now in the final phase of its ten year period. The results do not yet meet the high expectations at the beginning of the program.

The Agency of Natural Resources and Energy has the general responsibility for policies for energy conservation and alternative energy resource technologies and the exploitation of natural resources of the ocean.

The Small and Medium Enterprise Agency is responsible for modernization and rationalization of small and medium enterprises and for consultations to their management.

The Patent Office is in charge of patent applications and patent registration.

Ministry of Education, Science, and Culture (ME)

The Ministry of Education promotes scientific research via universities and related institutes. It promotes science by preparing the basic conditions for scientific research and by encouragement of creative and social relevant advanced research. Concrete measures are: the establishment and improvement of national universities and attached or inter-university research institutes; the provision of subsidies for research and facilities to universities and non-profit research institutes; the provision of research grants; the promotion of national important scientific fields; scientific cooperation with industry; encouraging international exchange, etc. 128

The opinions of scientists are well reflected in Japan's science policy. The Ministry of Education has established several advisory groups, such as the Science Council for examination and recommendations on basic policies for the promotion of science. Its members are drawn from all sectors of society. The Council is mainly concerned with academic research and higher education. The Geodesy Council is another advisory body. The reports of theses councils have important implications for Japan's science policy.

The Japan Society for the Promotion of Science is an independent private foundation, which works under the auspices of Ministry of Education. It contributes to the advancement of science through various programs.

The Japan Society for the Promotion of Science fosters researchers via fellowship programs, promotes international scientific exchanges and cooperation between industry and university It carries the management of patents and science information services and financial support by programs funded by private contributions.

Ministry of Post and Telecommunications (MPT)

Relevant Agencies are the Communication Policy Bureau and the Telecommunications Bureau and the Broadcasting Bureau. The first two are responsible respectively for general regulation policies for telecommunications and the administration of regulation of wired telecommunications. The Broadcasting Bureau is responsible for planning and implementation policies on wireless and wired broadcasting and for supervision over the operators.

The Communication Policy Bureau is involved in the establishment of general principles for telecommunications policies and the Teletopia project for the development of information communities in model cities, equipped with advanced communications infrastructure, by media such as bidirectional CATV and videotex, a telecom research park, telecom plaza, teleport, including intelligent buildings and a multimedia tower. It is also committed to R&D in telecommunications technology and space communications.

The Telecommunications Bureau is responsible for the supervision over NTT and KDD, radio communications and the promotion of activities of the private sector in telecommunications business
The Broadcasting Bureau is involved in the development of new broadcasting media, new teletext services, satellite broadcasting, High Vision HDTV broadcasting, multi channel PCM broadcasting, new types of CATV broadcasting, promotion of CATV, e.g. Space Cable Network. 129

The Ministry gives scientific support to its Radio Regulatory Bureau's and its Communications Research Laboratory. This institute has facilities at Kashima space Research Center. The ministry also supervises the Telecommunications Satellite Corporation of Japan and the Japan Broadcasting

Corporation with its NHK Science and Technical Research Laboratories.
The Ministry runs the Japan Key Technology Center jointly with MITI.

The national public telecommunications were privatized to form the Nippon Telegraph and Telephone Corporation together with its R&D facilities. A part of the money that came free from selling NTT stock to private shareholders was used to start a new industrial R&D program jointly under MITI and MPT. These ministries are together administering the Key Technology Center. Another part is used to set up smaller R&D programs under MAFF and MHW.

Ministry of Agriculture, Forestry and Fisheries (MAFF)

This Ministry runs research institutes in fields of its competency as well on national as on regional level.
The most important institutes are the:
National Agricultural Research Center,
National Institute of Agrobiological Resources,
Genetics Research Center,
National Agricultural Research Center
National Institute of Agro-Environmental Sciences,
National Research Institute of Fisheries Engineering,
National Research Institute of Aquaculture
and in cooperation with MHW the
Bio-oriented Technology Research Advancement Institution,
National Health Center
and the Institute for Neuroscience.

Ministry of Health and Welfare (MHW)

This Ministry supports research at attached research institutes such
as the:
National Institute of Health,
National Institute for Neuroscience
and the National Cancer Center Research Institute.

The Science Council of Japan (SCJ)

The Science Council of Japan represents scientists and their orqanizations, as well domestic as international, through affiliation with international scientific organizations. Its function is the promotion and diffusion of science in society. It is attached to the Prime Ministers Office, but operates independently. The Council can make
requested or unsolicited recommendations to the government. It advises the government at request on matters such as grants for scientific research or important policies involving science. The Council advises on measures for the promotion of S&T, the utilization of scientific results, the training of scientific researchers, the reflection of science in public administration and the penetration of science in industry and the individual lives.

The influence of the science Council of Japan on policy making has decreased, since its independent operation yielded in suboptimal relations with the government, and since the establishment of the Council for Science and Technology.
The Councils' budget is limited and the Council has no means to carry out own research

Administrative reform

After the World War, the need for innovative science and technology was already considered necessary for international competitiveness and economic growth. There was a need to increase the level of administration of science and technology and effective allocation of the competencies over the concerned ministries. 130 This already called for a reform of the administrative system, but due to political reasons, this reform was not effected. Only after the problems of the '70s, such as diminishing financial means, energy constraints, the aging population and the need and demand for internationalization, serious attempts were undertaken to establish an organizational structure, suitable for a science and technology policy, needed to tackle these problems.
The second Provisional Committee for the Promotion of Administrative Reform was established in 1981 for the studying on and drafting of the necessary administrative reform. One of the first results was the founding of a Committee for Science and Technology Policy in 1983. The task of the committee was to assist in preparing decisions on research objectives, which were issued by the Council for Science and Technology The follower of the Committee, the provisional Council for the Promotion of Administrative Reform recommended the administration of science and technology in a report in 1985. 131
The assumptions in the report were that science and technology formed the basis for socioeconomic development of the nation, for contribution to industrial activity, for improving national living standards and welfare, and for furthering Japan's international relations. It emphasized the need for more original R&D, especially basic science. Finally it pointed out that a good distribution of tasks and efforts between and exchange of research and results between the private, public and academic sectors should be strived for.

The concrete results of these recommendations were the following:
In 1986, the General Guidelines on Science and Technology Policy were adopted by the Cabinet for the establishment of an all-encompassing and effective science and technology policy.
For the promotion of these guidelines, the STA was reorganized by establishing a Science and Technology Policy Bureau, a Science and Technology Promotion Bureau and a R&D Bureau. This resulted in the strengthening of the secretariat function of the Council for Science and Technology and the establishment of an extensive adjustment function for the administration of science and technology.

The NISTEP was established, for research on progress in science and technology with the ultimate aim to adjust the research system.
For the increase of the government share in basic science an adjustment, rationalization and activation of the national research institutes was recommended. This resulted in the establishment of the Research Institute for Polymers and Textiles in MITI, the National Research Institute of Agricultural Engineering and Forestry and the Forest Products research Institute in MAFF and the

Communications Research Laboratory in the MPT.
The Law for Facilitating Governmental Research Exchange was enacted in 1986 and joint research institutes at national universities were established, for the promotion of exchange of research results in private, public and academic sectors and the promotion of cooperative research. 132
The national public telecommunications and railways, together with their R&D facilities, were privatized to form the Nippon Telegraph and Telephone Corporation and the Japan Railways Transport Corporations, The Japan Key Technology Center was established under MITI.
The Bio-oriented Technology Research Advancement Institute was established under MAFF. The Japan Atomic Energy Research Institute in STA was enriched with the Nuclear Ship R&D Agency.

Corporations

R&D and manufacturing are concentrated in Keiretsu. These are large vertically integrated groups of firms, with a bank as financing center and a large number of small suppliers of components. Keiretsu are groups of collaborating and sub-contracting firms. There are strong and continuous vertical cooperations between user and suppliers, between affiliated firms, sub-contractors, distributors and others. This enables the involved groups to share information about technologies and products and to establish social relationships based on trust, loyalty and influence.
This system appeared to be very successful and will essentially remain so in the near future, although independent manufacturers and overseas production tend to erode this system in the longer run. The industrial sector will remain the dominating economic sector, although there will be a shift away from heavy industries to information technologies, e.g. electronic communications.

Industrial and research organizations, sponsored by MITI act as instruments for fast and effective communication, for reaching consensus and for coordination. The tasks of these research organizations is usually limited to a specific technological field and a definite period of time. They have a wider scope and a more indefinite lifetime. Virtually all industrial companies belong to one or more of the numerous industrial associations. They all participate regularly in meetings, conferences and MITI can exert influence by its administrative guidance.

Keidanren or the Federation of Economic Organizations is coordinating the largest Japanese industrial organizations. It has a large staff, including a division, which is able to consult advise and influence the R&D policies of the government.

Small business

The small and medium enterprises employ 70% of the working population and rely for 60% on subcontracts from the large companies.
Small and medium enterprises in Japan are defined by their number of employees :
retailers and services have less than 50 employees
wholesalers less than 100 employees
and remaining enterprises less than 300 employees:

In 1986, 99,3% off all firms in the non primary sector were small and medium enterprises and they

employed 80,6% off all employees.
In comparison with large companies, sectors with the lowest number of employees in small and medium enterprises are services (67%), utilities (69%), manufacturing (74%) and mining (76%).
Sectors with comparatively the most employees are real estate (98%) and construction (96%).
Sectors with the relatively lowest percentage of small firms are the utilities (97.3%) and services (98.3%).
In real estate and construction, practically all firms are small.
Ranked in absolute figures, most big firms can be found in services, wholesale and retail, and manufacturing.
Most small firms can be found in services, wholesale and retail, and manufacturing.
The manufacturing industries count 870.262 (99,55%) small and medium enterprises with 9,920,555 (74,4%) employees and 4.209 (0,5%) large enterprises, with 3,421,281 (25,6%) employees. 133

The economic significance of small and medium enterprises in manufacturing (with more than 4 and less than 300 employees) can be read from MITI's industrial census as of 1987: 134

There were 416,992 (99,55%) of these small and medium enterprises with 7,869,000 (74,4%) employees, against 3,689 (0,5%) large enterprises, with 2,936,000 (25,6%) employees.
The shipment value of manufacturing industries of small and medium enterprises was ¥133,293 bln (52,6%) and of large enterprises ¥120,104 bln (47,5%).
The annual added value productivity per employee in small and medium enterprises was ¥6,713,000 (48.8% of the large enterprises) and in large enterprises ¥13,785,000.

These figures give an image of the relative importance of the two sectors and at the same time of the relatively low productivity in the small and medium enterprises

The figures also give a good idea about the structure of the Japanese industry. This structure is characterized by many small firms and a relatively small number of gigantic firms. The small firms are in many cases working in subcontracting for big firms, especially in the manufacturing sector.
The reasons for big companies to engage in subcontracting relationships are mainly cost reduction, but also flexibility in delivery and the use of the specialization of small and medium enterprises. This last motive plus partnership in R&D tends to become more and more important.

For affiliated domestic subcontracting firms the selection criteria of quality and technological specialization are becoming important motives. 135

Under the influence of changing external circumstances, small and medium enterprises will have to undergo important structural changes. The high appreciation of the Yen and the fast development of newly industrializing countries have changed the international trade conditions for these firms, in the direction of decreasing opportunities for export and increased imports. The expansion of foreign production activities of the bigger companies and the growing import of materials and parts, bring about changes in their relationships with their smaller sub-contracting firms. The growing demands and higher quality preferences of the domestic markets on the other hand offer new opportunities.
The small and medium enterprises will have to react to these changes by developing new products, by

diversification and by conversion to other activities. Improvement of its management, increased efforts in R&D and the addition of more value to their products are necessary to meet the changing requirements of bigger companies. The growing trend of the number of small and medium enterprises expanding overseas will also continue.
In order to cope with the changing environment and to survive, small and medium subcontracting enterprises tend to rationalize and reduce their costs, they are increasingly trying to diversify, sophisticate and develop new end products and manufacture higher value added products and improve quality. They also change their relationship with parent companies from only technical guidance to more joint R&D development and diversifying parent companies.

In high tech areas the share of small and medium enterprises is high in X-ray equipment, electron tubes and electronic parts. There is a strong growth in electronic equipment, integrated circuits and semiconductor devices, new ceramics for pottery, porcelain and glassware, and biotechnology for food, fermentation and brewing (sake, miso, yeast, beer), pharmaceuticals, chemicals, animals, plants and arochemicals. 136

The tightening manpower shortage in Japan is particularly pressing on small and medium enterprises. They have a shortage of engineers, researchers, overall technical capabilities, R&D know how, research facilities, etc. 137

The Small and Medium Enterprise Agency of MITI is especially responsible for and concerned with the improvement of the productivity of small and medium enterprises. 138
The measures of the government to help small and medium enterprises in coping with the changing environments are the following:
Apart from fiscal measures, financial measures for credit increase, and tax benefits, the government takes a variety of measures to promote structural changes:
-support of R&D and product innovation,
-industrial support for regionally important companies,
-promotion of fusion of small and medium enterprises in different industries,
-promotion of traditional local industries,

-promoting direct international investments of small and medium enterprises,
-restructuring of business,
-improvement of management capabilities, such as training of management, computerization, technical training
- and promotion of independent development of small scale firms: 139

7

INSTRUMENTS FOR SCIENCE AND TECHNOLOGY POLICY

Introduction

A simple classification for policy instruments in S&T promotion, is the distinction between S&T push and demand pull. S&T push finds place via e.g. mechanisms such as research projects, institutes and personnel and demand pull via mechanisms such as commissioned research and public procurement of products.
This scheme is difficult to apply for our purpose. It is e.g. not always easy to decide, whether or not the budget of a research institute or the salaries of university professors, must be considered as S&T input or as the reward for their scientific output.
Therefore another scheme shall be tried.
In this taxonomy, .instruments for R&D policy are classified in the following categories:
1 R&D infrastructure:
Research organizations, research personnel, universities, education, 2 Financing:
Budgets, procurement, financing, investments, loans, subsidies, tax incentives, legislation,
3 Regulation and persuasion:
Import and export regulation, indicative planning, administrative guidance, white papers, information exchange, public opinion, policy research.

R&D infrastructure

Research organizations

The universities and national and public research organizations are already extensively described in the previous chapter.

Personnel

In the post-war period, the government in her policy for accelerated catching up with the West, continued to increase the number of research personnel in the natural and engineering sciences. The number of researchers in Japan has grown sharply during the last two decades.

In april 1989, the total number of researchers in the natural sciences
amounted to 462,000 ,
with the greatest rise in industry with 294,000 persons (63.7%) ,
followed by the universities with 132,000 persons (28.5%),
and the research institutes 36,000 (7.7%).
Including the social and human sciences these figures were respectively: 535,000 (100%),
294,000 (55%),
201,000 (37.5%) and
4,0000 (7.5%). 140

In 1988 Japan had a total of about 513,000 researchers among which 442,000 researchers in natural sciences, of which around
279,000 (63.2%) worked in companies,
128,000 (29%) worked in universities and
34,000 (7.8%) worked in research institutes.
This roughly is the same number as in the West.

The number of researchers per 1000 is 4.2, resp. 3.6.
In comparison, the U.S.A. had 806,000 researchers (1987) or 3,3/1000 capita. 141

More than 60% of the researchers are employed in private enterprises. 142 The average age is lower than in the comparable countries, almost 49% was younger than 35 years.
There appears to be a shortage of advanced research personnel. According to a survey, 62% of the corporations consider their research personnel insufficient in quality and quantity.
The way to improve the quality in private industry is mainly by internal training. For the national research institutes by scouting from other institutions. Other methods are to hire new graduates and foreigners. In Japan there is a shortage of technicians and other personnel for support of research.
As of 1987, the number of students enrolled in master courses in science and engineering totaled 29,250 and in doctorate courses 5874. In the past the Ministry of Education developed a special enrollment expansion plan, which worked out in a considerable increase of the number of students.

Universities offer training programs for research personnel from private enterprises in order to increase their knowledge and skills for accelerating industrial progress.
Research personnel, especially in nuclear energy and information processing, are trained in private training centers and schools.
Under the Fullbright program, a mutual exchange program of students and researchers between Japan and the U.S.A. is operative.
A fellowship program of the Ministry of Education exists for Japanese scholars and researchers to study abroad, and there are overseas training programs for government research personnel. The research Exchange Promotion Law, provides in the exchange of foreign and Japanese researchers and joint research projects.

Research programs

In the previous chapters attention is given to the various research programs and projects under the auspices of the governmental agencies. The major basic research programs as of 1989 with their respective agencies and budgets in millions of Yen are listed hereunder: 143

STA :
Special coordination funds for promoting basic S&T. 101
Exploratory Research for Advanced Technology (EIRATO). 46
Frontier Research Program (RIKEN). 17
Human Frontier Science Program (HFSP) 15
Ministry of Education:
Scientific Research Subsidy 526
Special Researcher Program 19

MHW:
Welfare Science Research Subsidy 55
MITI :
Next Generation Fundamental Industrial Technology R&D Program 68
Human Frontier Science Program (HFSP) 9

MAFF:
Advanced Biotechnology R&D Program 8
MPT:
Research on Frontiers of Telecommunications Systems 2
Various Ministries:
Working expenditures of national research institutes 345

The number of current applied and technological programs and projects is too large to list here. The JKTC, JRDC and JICST and other agencies
avail over lists of current public and joint research projects.

The financial participation . of industry in public R&D projects is moderate. Only big companies participate with low shares of their total R&D expenses. Their motives are more to be sought in retaining harmony with the bureaucracy than in the expected results. These projects mainly focus on pre-competitive stages in the life cycle.

Financing

Budgets

The Japanese budget system consists of a general account and a special account. The general account is mainly fed by taxes and bond issues and covers spending on policy measures. The special account is partly fed by the general account and the funds of the FILP. The FILP comes from postal saving and other reserve funds. This division makes it rather difficult or impossible to clearly distinguish the flows of money and budgets for specific purposes.

In fiscal year 1990, Japanese total government expenditure amounted to ¥66.236 trln.
Of this sum was available for general expenditures the amount of ¥35.373 trln.
The total budget for S&T amounted to
¥1919.6 bln, which was thus roughly 2.9 % of the total national account or 5.4% of the general account.
The biggest share of 46.9% of this S&T budget was allocated to the Ministry of Education, followed by STA with 25.8% and MITI with 13%. The rest was divided in small percentages over the other Ministries.

In the general account a post of ¥5.113 trln was earmarked for education and sciences. This amount was allocated as follows:
¥1.199 trln was transferred to the special account for the national schools for higher education.
¥1.183 trln went to national universities,
¥0.146 trln to research institutes and
¥0.463 trln to academic hospitals.
¥0.475 trln was spent on the promotion of S&T.
From, this last figure,
¥0.126 trln went to space development and
¥0.163 trln to research institutes of ministries. 144

The budget of the Science and Technology Agency was ¥494.8 bln or 25.8% of the total budget for S&T by Ministries and Agencies. 145
The largest posts of ¥469.1 bln in the STA budget was destined for the promotion of R&D activities in advanced and important fields of S&T, in which the most demanding posts are Nuclear Development and Space Development with ¥296.2 and ¥119.4 bln respectively.
The third largest post of ¥62.9 bln was allocated for contributions in S&T to the global community, mainly to be spent on international cooperation and communication.

Nuclear development and utilization: ¥ 296.2 bln
Space development : ¥ 119.4 bln
Ocean development: ¥ 9.9 bln
Earth S&T: ¥ 26.9 bln
Material S&T: ¥ 13.7 bln
Life sciences: ¥ 19.1 bln
Human Frontier Science Program: ¥ 1.9 bln 146

To draw conclusions on the various proportions of the Japanese R&D expenditures, figures not later than of 1988 and distracted from the 1990 White Paper of Ministry of Education, can be of use. 147
In 1988, the budget for R&D in Japan, including the social sciences and humanities, totaled up to ¥10.628 trln.
Broken down this leads to the following table:

Expenditures -->	R&D expenditure		Government share	
Sectors	trln ¥	%	%	trln ¥
Universities :	2.104	19.0	51.4	1.035
Public Research Organizations :	1.394	13.1	70.0	0.976
Private Research Organizations :	7.219	67.9	1.5	0.108
Total	10.628	100.0	19.9	2.119

The S&T budget for Japan in 1988 was ¥1,757 bln, of which ¥814.3 bln for grants in aids to special corporations, ¥621.8 bln to national universities, ¥265.5 bln to national research institutes and ¥23.5 bln to administration.

The total R&D amount spend on the humanities and the social sciences was ¥835 mln. In 1988, the budget for R&D in Japan, excluding the social sciences and humanities, totaled up to ¥9.775 trln.
Broken down to percentages this leads to the following table:

Sectors	Fields -->	Science	Basic Research	Applied	Development	Overall

Universities:	52.8%	38.5%	8.7%	12.7%
Public Research Organizations:	14.9%	25.4%	59.7%	13.5%
Private Research Organizations:	6.6%	21.7%	71.7%	73.8%
Overall	3.6%	24.3%	62.1%	100.0%

Expressed in absolute figures of trillions of Yen, the following table shows the distribution of R&D over the various sectors and fields:

Fields --> Sectors	Science	Basic Research	Applied Development	Total
Universities:	0.655	0.477	0.108	1.24
Public Research Organizations:	0.197	0.335	0.788	1.32
Private Research Organizations:	0.477	1.567	5.176	7.22
Totals	1.329	2.3796.072		9.78

Figures in: trillions of Yen

These tables reveal that in 1988, the private industry was spending 73.8% of all R&D in Japan, especially in development, but that it still spends relatively little in basic science. The government spending in R&D is only 26.4%, but her spending in basic research is relatively high. Her contribution to the social sciences and humanities, especially that carried out in the universities, is also high.
These figures, however, do not reveal the whole picture of the contribution of the government to S&T. Much is hidden in salaries for university personnel, in other means of promoting S&T and in the contribution of the local governments, which are hidden in the special accounts.

The total government budget for fiscal year 1991 was ¥70.3 trln.
For the same year, the general account totals ¥37.3 trln.
The public R&D expenses fell below 20% of all R&D funding, due to heavy R&D expenditures of the private sector on the one hand and to political incapability to increase taxes with the resulting budgetary constraints, on the other.

In 1966, the total R&D investments were targeted at 2.5% of the national income in order to reach the level of the advanced countries. This target as well as the international level is now surpassed. However, direct government funding of industrial R&D, as ratio of total R&D spending is declining. Indirectly the government encourages and supports investment in R&D in the private sector with subsidies and tax incentives. The increase in government spending on R&D does not hold pace with the growth of the GNP. A reason is that a substantial part of the increase of the government revenue is spend on diminishing the government debt and paying its interest. Another reason is the pressure on the government to spend more money on the infrastructure and on meeting social needs.

The relatively low importance of government financing of R&D can be judged by comparing some inputs in industrial R&D. The number of researchers in the MITI research institutes is about 3000, which is a fraction of the 260.000 in industry. All government funding in R&D is only 20% of Japans annual R&D investment and only 2% of the industries R&D investment comes from government funding.

Procurement

The main fields of government procurement in the West are defence and aerospace. The Japanese defense procurement e.g. is only 1% of the Gross National Product. Government procurement in Japan is considerably lower than in other Western countries. Exact data were not available to me.

Financing

There are mainly three ways of financing S&T promotion:
1. Availability of inexpensive capital derived from savings accounts.
2. The allocation of credit to marked industrial sectors.
3. Government financing of R&D in the private sector.

The access to capital is far easier in Japan than in other capitalist nations. The savings in Japan are very high due to incentives in the tax structure, the inadequate social security system and high costs of housing. Another reason is the lack of consumer credit facilities and inadequate leisure opportunities.

Investment in Japan is high by international standards. But public investment in infrastructure and social overhead capital is relatively low.

Apart from industry, the following organizations are active in
financing of R&D in Japan:

Japan Development Bank:
¥75 bln of loans for development of new technology.
Japan Research Development Corporation:
¥5 bln for commercialization of new technology.
Japan Key Technology Center:
¥26 bln of partial capital investments and loans for industrial R&D projects.
Japan Key Technology Center and Ministry of Health and Welfare:
¥3 bln of partial capital investments and loans for joint projects in biotechnology.
New Energy Development Organization:
¥2.5 bln of partial capital investments and loans for industrial R&D. 148

Loans

The Fiscal Investment and Loans Program (FILP) or Zaisei Tooyuushi Keikaku, dating from 1953, is

the most important source of public funding. The funds are derived from postal savings and insurance funds, pensions and government guaranteed bonds. The FILP describes the ways, in which these funds are invested or lent to special accounts of the government, public financial institutions , public agencies, local government and the private sector.
The FILP was the main financial tool for Japan's economic development after the war. It has declined however and is below 10% of the capital, available to industry. The FILP amounts to about 40% of the total general account of the government budget.

Industry is now capable of financing its own investments via retained earnings, bank loans and stock and bond issues. To give an impression: In fiscal 1990, the private plant and equipment investment was ¥82.8 trln, and the total of the FILP only ¥34.6 trln. Of this sum, only ¥4.3 trln went to small and medium enterprises, and ¥0.8 trln to industry and economy. 149

Subsidies

The Enterprise Rationalization Promotion Law of 1952 offered the possibility to give subsidies for experimental installation and operation of new systems, to give exemption of local taxes, to allow rapid amortization, to invest in R&D development and to spend public money on infrastructure by approved industries.
The responsible organizations for the administration of subsidies are the Research Development Corporation and the Research Cooperative.

In the 1970's subsidies were established for scientific research from the Ministry of Education, for important technological developments from MITI and for experimental and research expenditures from MAFF.

Some examples of subsidies for R&D in the private sector are: 150
in small and medium enterprises ¥3 bln from MITI,
subsidy for revitalizing industrial technology ¥1 bln from MITI,
improvement of the industrial R&D system ¥5.2 bln from NEDO,
R&D in health ¥20 bln from MHW,
and agricultural R&D ¥2 bln from MAFF.

The Japan Development Bank formed a funding system, consisting of long term loans for industrialization and commercialization of new risky technologies. The Bank also offers low-interest Yen loans to companies which are 50% or more owned by foreigners to help to cover plant and equipment costs.

Tax incentives

A tax exemption system for additional experimental and research expenditures was introduced by 1967. This system covered increases of R&D expenses of private companies, by giving tax exemptions from corporate or income tax.
Some government incentives for S&T promotion in the tax domain are in existence: Research associations can receive preferential tax deductions, in the form of special depreciation allowances, in

terms of costs and depreciation period, reduction of fixed asset tax, the treatment of research donations as losses and deductions of parts of R&D expenditures or of its increases. 151

Regulation and persuasion

The aim of import and export regulation is the promotion of exports by stimulating foreign consumption of Japanese products by quality or price manipulation and by the restriction of imports of foreign consumer products by tariff and non-tariff barriers.

In the post-war years Japan's trade policy was characterized by stimulation of cheap import of foreign technology and natural resources,
increasing the export of Japanese products and minimizing the import of foreign products.

Several restrictive principles for the introduction of foreign technology were applied. They should not damage small and medium sized enterprises, disturb the industrial structure, infringe on management rights, force acceptance of unfair contract conditions, transcend financial capabilities or prevent the development of domestic technologies.
In the gradual process of liberalization after the joining of the IMF and the OECD, Japan relaxed the strict approval conditions of these restrictions in all individual cases and for a large number of technologies. The policy measures for this liberalization were the amending of the Law on Foreign Capital in 1964, the delegating of the execution to the Bank of Japan in 1978 and the amendment and integration of the Laws on Foreign Capital and the Trade Exchange Law.
At the moment the policy is free in principle.

For technology transfers, the Tax Exemption System for Income Obtained from Technology Transfer was established in 1959. It was renamed in Special Tax Exemption System for International Technology Trade in 1964. This system is applied to technology exports.
A Special Tax Exemption System for Income Obtained from Technology Transfer is applicable to the transfer of industrial property rights, copyrights and engineering services.

Since 1970, technology transfer exceeds technology introduction when new contracts amounts are considered. At the moment the total amounts of technology introduction and transfer are approaching each other.
Japan is still more paying on royalties than receiving.
For new contracts the situation is reverse. If only the among these new contracts with advanced countries is considered, than Japan is still more importing than exporting.
Technology introduction is predominantly imported from the U.S.A. and Europe 70% and transfer is predominantly to the Asian countries
40%. 152

Indicative planning

According to Chalmers Johnson, Japan has a plan oriented market economy, as contrasted with the free market economy of the United States of America, and a plan ideological system of Communist

Systems. 153 The plans are not directive but indicative.

The characterics of this indicative planning are:
-To help formulating goals and to give guidelines to industry.
-The recognition of industries with long term importance for the economy.
-The promotion of these industries by treating them with preference, such as the granting of large subsidies.
-Protection of young immature industries.
-Intense communication and cooperation of government and business.
-Guided or controlled system of competition.
-Development of a long term vision for Japan's industrial future.

The government does not formulate R&D and industrial goals or structures unilaterally, but with the information, advice and cooperation of the industry involved. This is the process called indicative planning. In this process the initial goals are dependent in the course of time on new information and outcomes repeatedly reset.
The Japanese government continuously collects and distributes information about possibilities and risks for the nation, in order to promote consensus about the desirable future of society and industry and the role of the government in this respect.
This is an instrument to formulate a national and economic policy and to steer the nation conform such policy in the desirable direction. As one of the instruments for forming such national economic and industrial policies the government uses the means of long range visions. Economic Plans and the Reports of the Council for Science and Technology have an important function in this respect.
In the process of preparing these plans, many scholars and experts from industry, academia and government participate actively in the respective councils, committees and working groups. This gradually leads to a high degree of convergence of opinions. This consensus stimulates actions in different areas to bring forward the developed vision.
Long term vision for Japan's industrial future, are e.g. expressed in the White Papers on Science and Technology of STA. This series of white papers started in 1958. The second white paper appeared in 1962, followed by the third in 1964. Thereafter white papers were issued on a yearly cycle base.

Administrative guidance

Administrative guidance refers to administrative actions of bureaucratic bodies, which are intended to influence private or public parties without the binding force of legislation. Administrative guidance can be regulatory, reconciliatory or promotional.

Regulatory guidance attempts to persuade parties to abstain voluntary from intended actions, either in their own interest, e.g. because they will violate laws, or are not in the sake of the general public.
Regulatory guidance is conducted for instance in matters of environment or of the industrial structure, e.g. for avoidance of exorbitant competition.

Conciliatory guidance seeks to harmonize conflicting interests between private parties.

Promotional guidance is meant to bring out actions, beneficial for the public cause or for private interests. Promotional guidance has been an important instrument of the Japanese bureaucracy for realizing desired states in economy, industry, education, science and technology.
Administrative guidance is not supported by legislation. It allows the bureaucracy to conduct specific industrial policy, without passing laws in the Diet. It rests mainly on persuasion and implicitly on a number of unofficial sanctions, e.g disturbed relations with the administrative organs or public opinion.
Administrative guidance implies that government is forming visions of a desirable state of the country, its economy, industrial structure
and state of technology. These visions are formed in committees, councils and other deliberating and consensus forming organizations. It is fed by public opinion and the public opinion is influenced by these visions. The resulting visions indicate the future direction, which subsequently is strived for by all involved organizations in charge of science, research, development and production.

Organizations for administrative guidance are:
-for specific scientific and technological fields: the Atomic Energy Committee and the Space Activities Committee;
-for affairs under the jurisdiction of Ministries: the Council for Science of the Ministry of Education, the Council for Agriculture, Forestry and Fisheries Technology of MAFF, the Council for Industrial Technology of MITI and the Council for Transportation of the Ministry of Transport;
-for overall direction of the country's S&T: the Council for Science and Technology, which provides the general guidelines.

After the war, the most import Ministry for industrial and science and technology policy was MITI. Immediately after its re-constitution in 1949, it began to explore the frontiers of technological knowledge and their industrial potentials. It set out national priorities for technological catch up, by selecting industries to be set up and nurtured and by selecting others to decline. An important instrument was the control over foreign trade. MITI controlled the imports and exports, and all foreign transactions needed its approval.
Another instrument was administrative guidance. MITI exerted this guidance by issuing directions, requests, advice, counseling, warnings, reprimands, reproofs or suggestions and other more subtle ways of influencing. Trade control and administrative guidance, jointly enabled MITI to restructure industry by setting up subsequently coal and steel, shipbuilding, petro- and other chemical industries and finally the electronic industry.

Other instruments for S&T policy are groups appointed by a ministry or agency study groups, deliberation advisory boards and councils. The final results are often guidelines or recommendations from a ministerial council, which also exert the effect of administrative guidance.

The system of administrative guidance has met criticism from foreign trade partners, on the allegation of too much government intervention in the economic domain. In fact the effectiveness of the system has been exaggerated. There are many examples of failure of intervention, because the necessary consensus between government and industry or between the ministries was lacking. Well known examples are the failure of MITI to describe the tolerated number of automobile manufacturers and the failure to combine the efforts of major electronics companies.

In the last twenty years, the role of MITI and administrative guidance declined for a number of reasons. To name a few: the restoration of free trade, the financial and technological strength of the private companies, the distribution of government initiatives over more ministries, and the division of tasks within MITI between the international and the industrial factions.

The General Guideline of Science and Technology Policy of 1986 is the most important actual document containing the official science and technology policy in Japan.

White papers

The Japanese White Papers are official reports and statistics of the Japanese government. They are annually prepared by the government and its agencies, submitted to the Cabinet for approval and subsequently presented to the Diet. They serve as instruments for rendering official accounts of states of affairs in the fields of government concern and contain indications for future directions and commitments. The white papers of STA, MITI and MPT contain the most relevant information for the state of Japan's S&T.
The previous chapter contains an anthology of some of the actual White papers of these Agencies.

Exchange of information

Information supply and distribution

Japan promotes science and technology by the provision and distribution of information on science and technology.
The Japanese government decided to take various measures to improve data bases, for information acquisition, to enhance international informational relations and to improve knowledge and know how on generation, processing and distribution of information.

The National Diet Library is established to serve the legislature, and is the center for domestic library activities via the legal book delivery system.
Japan Information Center for science and Technology (JICST) was formed in 1957 under the STA. It functions as a central organization for the production, import and distribution of scientific and technical knowledge and organizations. It plays an important role in information support as strategic tool for technology utilization. It collects, classifies and disseminates information. In 1976, it started its on-line information system and operates now two systems (JOIS-I and JOISII). Since 1985, these facilities are extended to foreign industrial sources.
The National Center for Science Information Systems links computer centers, information centers, university libraries, foreign journal centers and national inter-university research institutes via a data communication network.
On suggestion of the Council for Science and Technology to form a national information system for science and technology, the information producing and consuming organizations started to develop their information systems and to share and cooperate these functions. The ultimate aim is to combine these systems under government control and to build a nation wide information distribution system.
In 1979, the Patent Office started an on line service in the Japanese Patent Information Center to produce Japanese and American patent information .

In 1986, the Academic Information Center was established, to provide patentable researchers with academic information.
In order to respond to the international demand for Japanese technical literature, in 1984, the Council for Science and Technology issued a
report, enclosing measures to solve problems in distributing scientific and technical information.
More recently, JETRO is established for the import and distribution of industrial information.

Relevant, valid and reliable data on S&T are required for the development of science and technology policies. In 1984, the STA initiated the development of a Japanese S&T Indicator System (JSIS) for the gathering of quantitative data. The JSIS consists of a set of S&T indicators and is organized in a cascade structure. It is developed by NISTEP and is published in the japanese language in 1991.
The separate indicators were initially ordered under the following major categories: societal infrastructure, S&T infrastructure, R&D infrastructure, R&D results, R&D contribution to S&T and public acceptance of S&T. 154
The final ordering is:

1 Training of S&T personnel
2 R&D infrastructure input
3. R&D activities
4. Regional R&D activities
5. R&D output
6. Internationalization of R&D
7. S&T and society
8. Public acceptance of S&T

Research exchange

Research exchange between private sector, academia, government agencies and foreign countries is stimulated by the various means. The exchange can take the form of the communication of knowledge, joint, entrusted or commissioned research, the use of mutual research facilities, and the mutual use of research information.
In the '70s, the government promoted cooperation between different fields of science and technology and between the government, academia and the private sector, predominantly for developing science and technology for solving problems in the provision of energy and food.
In the '80s, this cooperation was sought with emphasis on creative basic and advanced ,science and technology. In this period, a great many joint research projects were started under the control of various Ministries. For the facilitation and enforcement of research exchange policies, a number of auxiliary policies were adopted, to explain the government policy 155 and to appoint foreigners as research managers. In 1987, the Cabinet decided on basic policies for research exchange between the government, academia, private sector and foreign countries and established a Research Exchange Promotion Liaison Council for advise on policies to promote future research exchange.

Technology transfer

The transfer of technology from abroad has been greatly facilitated by the General Head Quarters, which provided the technology for the rebuilding of Japan's heavy industry and transportation system.

The introduction of English lessons on secondary schools by the Ministry of Education was another important facilitator. It enabled the future young engineers and technicians to read foreign literature.

Industry acquires technology via monitoring, foreign consultants, licensing agreements and joint ventures.

Japan reports that especially in Europe more or less open and organized restrictions of transfer of technology are being encountered. Reverse technology transfer is facilitated via a number of channels. One is the increased translation in English of technical literature. Another is the increased possibility to employ university professors or researchers in government institutes and in programs such as HFSP of MITI and STA, Frontier Science Program of STA, Key Technology Center and the International Superconductivity Research Center of STA. The number of foreign researchers, who want to make use of this possibility is still limited however.

Public opinions and participation

In Japan, science and technology enjoys a high esteem as the main factor in the well-being of the nation and individuals. The official organs, invariably mention science and technology as the main driving force behind its economic revival and reconstruction. Knowledge of and support of the population for S&T is high. This can be explained by the general belief that S&T is the main motor for the post-war economic development, for maintaining the present welfare and for further improvement of the quality of life. This belief is frequently fostered by the government and the media.

The promotion of science and technology is brought forward almost as an imperative. To this end, people need to understand and appreciate the importance of science and technology and their cooperation has to be obtained. The independent opinion of the general public is seldom sought. In order to promote understanding and cooperation, the government undertakes a number of activities. The STA produced movies, TV programs and issued diverse publications such as the white papers on science and technology and educational magazines on science and technology.

Every year the STA organizes a Science and Technology Week, to deepen the public interest in science and technology in general, and an Atomic Energy Day for nuclear energy in particular.

Technology promoting policies can count on wide political support. As an issue in itself, almost never meets political or extra-parliamentary opposition.

An anti-nuclear movement is active, but primarily against nuclear armaments. Public environmental concern is mainly alive in fields where direct effects are perceived. Most environmental concerns regard chiefly domestic problems, such as in the past the emissions of mercury and cadmium and the smog causing exhaust emissions in the big cities.

The recent interest in global environmental questions, seems to have been generated mainly top down. Already some border transcending pollutant effects can be experienced, coming from mainland China and Korea. But main motive seems to be the role, Japan can play in the world's efforts in global environmental protection and the role the Japanese industry can play in exporting technology for saving energy,

preventing pollution at the sources and cleaning the polluted environment.

Forecasting

Forming visions on future economic important scientific and technological developments is one of cognitive S&T policy instruments. The process of forming these visions, has in a minority of cases the character of a formal forecast procedure. More often it is a continuing dialogue between the bureaucracy, industrial management, R&D personnel, academic scientists and engineers. This discussion finds place at all levels, national, companies, regional, universities, bureaucratic think tanks. It forms expectations and intentions regarding future states of scientific knowledge, technological fields and industrial structures. The results of these visions perse are not so important as the diffusion of the visions during the process. It helps industry to set out their corporate strategies in accordance with widely held views of what would be promising fields for the competitiveness of firms and for the Japanese economic system as a whole.
The major government agencies involved in the production of these visions STA, MITI and EPA.

The most important explicit forecasting exercise in Japan is a combination of a formal forecasting method and the informal process of forming expert opinions. The experience of Japan with forecasting S&T are dominated by a series of Delphi surveys. The first of these surveys was carried out in 1971 and was followed up by three other surveys with a time interval of around 5 years. The fifth survey is now in preparation. The full results of the fourth survey and a compilation of the first are available in English. The fifth survey will be finalized in 1991 and will be published in Japanese and English by 1992.
These surveys contain questions on a wide range of technological and scientific developments and related phenomena, to be expected within 30 years after the year, in which the surveys were held.

The first survey of 1971, included, apart from expectations in science and technology, extra questions about related phenomena, such as attitudes of the general public and policies of governmental and political bodies. A compilation of the outcomes of the survey is available in English. The outcomes are evaluated ex post, with a mixed result.

For the 4th Delphi survey, a Steering Committee was set up by STA. The Committee formulated around 1071 questions about future developments in scientific and technical topics, classified under 17 fields. These fields were: substances, materials and processing; information, electronics and software; life science; outer space; marine science; earth science; agriculture, forestry and fisheries; mineral and water resources; energy; production and labor; health and medical care; consumer lifestyles, education and culture; transportation; communications; urbanization and construction; environment; safety.

Subsequently, 3142 specialist were selected from companies and from academia. A minority came from the civil service and from staffs of industrial and professional associations. These experts were asked about their opinion on 6 aspects of these questions, in which they were competent.

These aspects were:
-the degree of importance for Japan;
-the year of realization, between 1985 to 2015;
-the constraints or obstacles for realization;
-methods for promoting R&D;
-institutional sectors for promoting R&D;

-the role of the government.

After the second round, 2,007 or 64% of the experts had responded. After this final round, the convergence in the answers was considerably larger than the change in the expected tines of realization of the technologies.

The outcomes of the survey were in conclusion:

Fields with high importance were regarded to be, in order of ranking: life science; health and medical care; earth science; outer space; agriculture, forestry and fisheries; information, electronics and software. The most important considered topics were in the sub field of cancer research.

Relatively early realizations were expected in the fields of:
information, electronics and software; consumer lifestyles, education and culture; communications; environment and safety.
Late realizations were expected generally in the fields of
life sciences; outer space; energy; urbanization and construction.
Health and medical care had a wide dispersion in realization.

As the most important impediments for early developments were mentioned technical constraints, followed on a large distance by economic constraints. Social constraints were by most respondents not considered to play a prominent role.

Technical constraints were considered to severely affect the:
life science; substances, materials and processing ; information electronics and software; and to a lesser degree:
health and medical care; earth science; agriculture, forestry and fisheries.
Economic constraints were mainly expected in the fields of:
outer space; energy; mineral and water resources; communications;
urbanization and construction.
Social constrained were primarily anticipated to play a role in:
safety; environment; production and labor; urbanization and construction; energy; health and medical care.

As methods for promoting R&D, domestic development was in most cases considered necessary, especially in the infrastructural fields of:
urbanization and construction; communications; substances, materials and processing; information electronics and software;
In a relatively high number of cases, joint international development was expected to play an important role in:
life science; health and medical care and outer space.
Private promotion of R&D was considered sufficient for fields of:
transportation; consumer lifestyles, education and culture; production and labor; communications; urbanization and construction;
The public sector was expected to take responsibility in R&D in:

earth science; outer space and environment.
In around three quarters of the cases, a joint effort was judged necessary especially in the fields of: health and medical care; life science; substances, materials and processing; information, electronics and software; energy and marine science.

The role of the government was regarded as very important in funding R&D in the fields of:
outer space; substances, materials and processing; mineral and water resources; agriculture, forestry and fisheries; health and medical care.
Organization of R&D by government is perceived as important in:
environment; consumer lifestyles, education and culture; urbanization and construction; safety; production and labor.
The provision of personnel is recognized as important in the fields:
information, electronics and software and life science.
The areas of the highest interests were considered those where intelligent functions could be taken over by technology and those where international R&D is important.

For details of the expectations the full report should be consulted. 156

In the fifth survey, which will be reported in 1992, the experts will not only be asked to score their own expertise, but also their feeling of certainty of their answers. This opens the possibility to weigh their predictions, by applying the now fashionable theory of fuzzy sets. A social scenario group helps to formulate questions on social needs and to analyze the social impacts of the S&T in question.
The main sectors in the fifth survey are geo-sciences, life sciences, materials, information and electronics, resources and energy, agriculture, fisheries and forestries, production technology, social infrastructure, medicine and health, and quality of life.

The series of Delphi surveys are interesting for methodological reasons, since they form a sequence of predictions which can be used for evaluation, comparison and improvement of the Delphi instrument as a forecasting technique.

The prediction period of this first survey is now almost past. This means that it could be subjected to an empirical ex post analysis. This gives the opportunity not only to verify or falsify the predictions and the value of this particular survey, but also to test some of the assumptions underlying the technique. One of these assumptions is that the quality of the answers is proportionate to the level of expertise of the respondents. In this survey the respondents were asked to score themselves on a scale of expertise and the answers were weighted in the statistical compilations.

The series of Delphi surveys as such can also be used in a longitudinal evaluation. This can also result in improvement of the instrument. For those questions, which are identical or similar to a certain extent, the series of answers of the expert panel can be used to produce a more accurate prediction based on the learning process and the progress of information.

Another utilization of the series can be made by analyzing the effectiveness or influence of government policies on science and technology.

Ex-post evaluations in Japan on the Delphi surveys show that the overall reliability of the results of former surveys was not high.
In the evaluation of the first Delphi survey of 1991 the ex post results were the following:
In the fields of health, medical care, life sciences, and mineral and water resources, the real innovation was considerably earlier than foreseen. In the fields of energy and transportation, the realization was much later than foreseen.
In the fields of communication, agriculture, forestry and fisheries, information, electronics and software, the foreseen subjects were realized within 5 years boundaries. This seemingly good absolute score should be relativated, because the average prediction time was short and the relative reliability therefore not very great. 157 Only predictions in fields which develop quite smoothly, due to incremental improvements in gradually extending technical parameters, seem in the short run to be more reliable in absolute terms. But relative to the short predicting periods the reliability show not to be promising either. Breakthroughs seem to be unpredictable, even by expert methods. The inability to meet the original objectives of the fifth generation computer program forms an illustration of this fact.

One of the methodological conditions of the application of fuzzy theory on the fifth Delphi method is, that the self esteem of the experts is independent of their feelings of certainty. Psychologically it does not seem plausible that this condition is met. If a high correlation appears between these scores, the surplus value of the fuzzy set approach, will be low.
The value of fuzzy set theory for the Delphi method could be tested a on the results of the fifth survey. One tests could be a comparison of obtained predictions and of the dispersion between the individual predictions, using respectively the basic statistical techniques, the technique with weighing of expertise degrees and the one with the fuzzy technique. Comparing the quality of the predictions and the measure of dispersion will indicate what the surplus value of the refinements is. This could also be done across the several rounds of iteration.

In general, as is suggested by the result of evaluative case studies, the Delphi technique does not seem to be superior to other forecasting techniques, especially not on the criteria of the quality of the answers and the general appreciation of panel members. 158
The Delphi method, as a instrument to produce reliable forecasts has been outlived in the Western countries. The inadequacy of expert judgments for producing information about future developments in their fields has met persuasive criticism. The information hidden in tacit knowledge is generally recognized in the philosophy of science, but this information doesn't necessarily extend the time boundaries of past and present experience and knowledge.

The value of Delphi in Japan seems to exist less in the production of reliable forecasts, than in the functioning of networks. In these networks, communication on potential promising fields among influential professionals and institutions can lead to actions which, in some cases, have a self-fulfilling effect. This effect starts already in the stage of formulating the questions. And after the first round, all participants can anticipate on the final outcome and base their actions on it.

Recently, EPA produced a report of a systematic study of the potential effects of future technology on industry and the economy. The study consisted of four rounds of forecasting. The report forecasts the

timing for practical use of 101 future-oriented technologies over the next 20 years and beyond. It analyzes their expected effects on society and economy.
Technologies, expected to be diffused soon, are e.g. high definition television, videophones and electric cars. In the areas of electronics, new materials, life sciences and energy it will take more time to advance technologically. E.g. fuel cells by 2015, biocomputers by 2020, cancer medicines by 2030 and nuclear fusion reactors by 2050.
The forecast study of EPA aroused some turbulence in the other agencies. The reasons are that technology forecasting does not belong to the fields under the EPA's jurisdiction and because it crosses the fifth Delphi survey, which is carried out by the IFTECH under STA.

In general, a need for formal technology forecasting in Japan seems not be very high. There are only a few institutes which have a marginal task in technology forecasting.
In the past, the future of Japan's S&T was already reality in the advanced countries. The most important forecasting activities existed in careful monitoring what happened in the international scientific and technological scene. At present, Japan covers almost all technological fields and does not necessarily have to "pick" the potential "winners". Who will win is for a great deal left to the power structure and to the market.
Martin and Irvine contend that the process of policy formulation consists of discussions on priorities and budgets, authoritative councils for reaching consensus on policies and a process of setting general guidelines, which have to be made operational by mediating bodies and to be implemented by research organizations. 159
The question is if there is much alternative and much to coordinate The impression is that the process of deliberation, communication and consensus forming with many influential and authoritative participants is more important than the results themselves.
Furthermore Japan has been involved in developing virtually all technological fields. The country seems to have the luxury and resources to try out most of the promising fields, thus spreading its risks and appears to be able to take the losses.

Technology assessment

Although some interviewed persons with enlightened ideas have stressed the need for a technology assessment revival in Japan, this instrument is rather underdeveloped in Japan. There are several reasons. The main reason is that in Japan, technology is judged as of extreme importance for the development, maintenance and further growth of its economy. Much effort is put in the increase of public acceptance of scientific and technological development and its social embedding. TA is
perceived in Japan as an activity with an anti-technology character. There are only a small number of institutes and persons explicitly working under the denominator of TA. The total budget for explicit TA is around ¥10 mln, which is extremely low, as well in absolute terms as in relation to the total S&T budget.
The overall number of researchers in social and human sciences is low, compared to those working in the natural sciences and engineering, and compared with other developed countries. The number of social scientists in techno-economic fields among them is still smaller. Therefore, the pool of potential TA researchers is very limited. Much social science is still organized along the traditional boundaries of disciplines.

In the field of environment, a few organizations are conducting TA, though under another name. Examples are the Environmental Agency, the Research Center for Advanced Technology and the National Institute of Environmental Studies.
Other research activities such as risk analysis, system analysis and policy impact on industry, strive for a better human interface from the viewpoint of safety, product reliability and environmental protection. Examples are in the fields of automobile production, big infrastructural projects, dams and nuclear reactors. In these fields TA might revive, but expectedly under another name.
The public as participant in technology assessment is virtually an unknown phenomena in Japan. The public in the best case is informed about science and technology policy. In the worst case it is drawn out or manipulated.

8

SCIENCE AND TECHNOLOGY POLICY RESEARCH

Introduction

The reasons for conducting science and technology policy research are multifold and diverse:
-understanding the relationships between policy and science (policy for science and science for policy).
-understanding how governments can use S&T for the furthering of public goals.
-understanding how S&T develops,
-understanding how policy system works.
-understanding which S&T can further societal public goals, i.e. which S&T should be selected among alternatives.
-understanding which science and technology policies should be followed -striving for these societal goals, by selecting the most effective and adequate policy instruments
-providing public decision makers with this information about alternatives or with policy recommendations.

The position of science and technology policy of Japan is more bureaucratic than scientific or political. Consequently, Japan's policy research is more oriented to supporting government policy by providing descriptive and quantitative information, than by analysis and critical evaluation of government policies.

Public policy research organizations

National Institute of Science and Technology Policy (NISTEP, STA)

NISTEP, founded in 1988 under the STA, is a central organization for theoretical and policy oriented research on science and technology policy in Japan. The institute conducts research in close relation with STA, the Council for Science and Technology and other relevant government organizations. The objective is to provide cognitive support for the creation of appropriate and effective policies for science and technology, in the frame work of a fast and drastically changing and internationalizing

environment in which S&T plays an increasing role. Important research fields are the dynamics of innovation and diffusion processes of S&T, fundamental data on inputs an outputs of S&T, development and use of indicators systems and statistical data, trends in R&D and their interaction with S&T resources and society, international S&T aspects etc.
It maintains a good working relationship with the statistical bureau. Nistep has organized two international conferences on science and technology policy research. The function of such networks is to stimulate the progress in science and technology policy research. The dual structure of theoretical and policy oriented research aims at an optimal balance between scientific and policy relevant research. The budget for NISTEP was ¥443 mln in 1988

Institute for Future Technology (IFTECH, STA)

The Institute for Future Technology was founded in 1971 under the authority of STA, as a neutral non-profit organization to promote and carry out research on issues related on science and technology. It carries out own and commissioned research for government bodies on various levels and for private enterprises.
It identifies trends in S&T and related future changes in society and economy. The research aims to recommendations on optimal R&D systems, methods for product development and social beneficial applications. Its main fields of research are science policy, new energy systems, space development, technology forecasting and assessment, human science frontiers, telecommunications and information processing, social systems and urban development, disaster management and social safety, and structural changes in industry and government.
Its policy research implies the systematization of statistical data on S&T, international comparisons of R&D structures, policies to promote creative R&D and international research activities, program planning on of strategic importance of R&D projects, intellectual property and R&D, and high level R&D personnel and its organization. The institute carries out various types of forecasting activities, the most important being the five yearly Delphi survey for the STA. It conducts an analysis of the technology innovation model. It develops methods for TA and carries out a systematic survey on R&D subjects based on social needs, the identification of conditions for a harmonious relation between S&T and society. For identification of major options for governments households and companies, it analyses industrial and industry related structures and econometric model analysis, simulation and forecasting.

Research Institute of International Trade and Industry. (MITI/RI)

The Research Institute of International Trade and Industry of the MITI is established in 1987 to conduct basic and theoretical research into the political economy of industrial and trade policies and to invite expert opinions on policy proposals and methods of policy management. The need for such information roots in the rapid change of the economic environment of Japan, especially the rapid increases in the international mobility of commodities, capital, technology which has led to fundamental changes in the industrial structure and organization, global economic interdependency, interconnectedness of global economic policies and increased trade frictions.
Due to these changing environment, industrial policies have to be reconsidered, adapted and put in an international perspective.
The results of the research and expert opinions are aimed to base MITI's policy recommendations and

formation in the light of a supra Japanese policy point of view. 160
Examples of research relevant for science and technology policy are studies on the industrial adjustment policies for the textile industry and the effectiveness of the law for the promotion of the machine industry. 161

National Institute for Research Advancement (NIRA, EPA)

National Institute for Research Advancement is a joint public-private research institute, connected to the Economic Planning Agency.

The institute is established in 1974, to promote the study of future policies, regarded to deal with rapid changes in a global industrializing society, science and technology, and styles of local communities and individuals. It conducts research itself or commissions or subsidized studies in the private research institutes. The main research themes are the identification of future problems and changes and necessary social, economic and political responses. The themes are: Japan and the world in the next fifty years, problems facing Japan in the '90s trends in international relations, methods for revitalizing a sustainable economic world system, economic policy in the new industrial society, the role of government and reforms of Japans' socio political system, new developments in S&T, changes in Japanese lifestyles, continuing urbanization and large cities and the revitalization of regional communities. It has some interest in TA
Nira also carries out studies on the relationship between enterprises and government, e.g. the impact of science and technology policies on the activities of multinationals.
NIRA disposes of ample funds of ¥30 bln, provided by national and local governments and the private sector. The NIRA budget is mainly derived from own income and doesn't press on the government account. The government share is ¥5.78 mln.

As research institutes on policy research with more distant and lateral interests in science and technology policy, worth to be mentioned are:

Technology Research and Information Division, AIST, MITI.
This institute e.g carries out studies on trends in indicators on R&D activities in Japan. 162
Institute for policy sciences.
The institute conducts research on international relationships, policies on social, economical, industrial, scientific, technological and environmental developments, human and natural resources and policies, and basic research.
Japan Society for Science Policy and Research Management.
Institute for Domestic and International Policy Studies.
Japan Techno Economic Society (JATES).
The Japan Research Institute.

Private policy research organizations

Mitsubishi Research Institute

Mitsubishi Research Institute was established in 1970 by Mitsubishi.. as an independent institute for

research and consultation of clients in the public as well as the private sector in businesses, industries and governments. It is specialized in the soft research and consultancy, but disposes of a computer center and databases.
It carries out research in technological advanced developments, technological forecasting and technological assessment, market research and forecasts, domestic and international economic studies, industrial analysis and corporate management and development.
Examples: Macro-economic analysis, and forecasting, technical and economic analysis of industries, corporate behavior and management distribution and transportation, advanced technology study and forecasting, urban and regional analysis and development, energy resources
and environments, developments of systems engineering technology, for solving social, economic and technical problems, development of software systems and other computer-based technology.
The Institute produced around 1000 research reports of which about 50% on research policy. government can participate in fields as the 5th
generation computer, nuclear power, NASDA.

Nikko Research Center

Nikko Research Center is a research institute, established in 1970 to make a better use of the resources of Nikko Securities Co., Ltd's Research Department. The Center is gathering information, conducts surveys and analysis and forecasts trends in domestic and overseas economies, the development of industrial sectors and the direction of financial and securities markets. The research is of great importance as result of the rapid pace of financial liberalization and internationalization, which substantially changes the structure of industry and of financial markets. The results are of specific importance for investors. The Center has representative offices in New York and London. It publishes a large number of periodicals in Japanese and English language.

9

IMPACT OF SCIENCE AND TECHNOLOGY POLICY

Causal relation policy and impacts

The impact of policy measures on S&T and economic growth is often assumed to be very large in Japan. This assumption has never been decisively tested and proved. Paradoxically it goes contrary to classical capitalist doctrine and ideology.
A strong and direct connection between industrial policy and success in technology and economy can hardly be demonstrated. Scientifically, the connection can only be hypothesized and might be even spurious.

In 1978, Kodama has tried to develop a model for the measurement of policy impact. 163 Kodama's study attempted to provide a quantitative formal model for evaluating the effect of policy on scientific, technological, industrial and market developments. The model compared with a situation of no policy. His tentative model has led to questionable results, however. The model was based on a simplified and unrealistic, policy-on/policy-off comparison. It did not allow for calculating long term effects with distributed lags, and latent and unintended impacts. In reality science, technology and policy have history, memory, momentum and inertia, which calls for more dynamic models with feedback, interaction, lags and leads. Moreover the way of calculating the difference between policy-on and policy-off impacts is controversial. Since in reality only one of the situations can exist, an empirical database for at least one of the impacts is not available. Their calculations must necessarily be based on questionable assumptions. The policy-on/off model was a laudable first attempt for the start of the building of a full fledged realistic model. Unfortunately it has never been picked up by others nor been elaborated by Kodama himself.

But also qualitively, a large effect of policy measures on S&T and economic growth in Japan is not proven.

There is also counter evidence for a large impact of S&T policy.

First the input of S&T policy is very small.
The size of the given incentives for allocation of scarce foreign currencies, tax breaks and subsidies and low interest rate loans have always been relatively small. Direct government funding of industrial R&D as ratio of total R&D spending is declining. Indirectly the government encourages and support investment in R&D in the private sector with subsidies and tax incentives. All government funding in R&D is only 20% of Japans annual R&D investment and only 2% of the industries R&D funding comes from the government. The private sector receives this 2% usually in subsidies and research contracts. Revenues from preferential tax incentives and a lower interest on loans come to around 2.5% of industrial R&D and subsidies are also in the order of 2.5%. Companies are already spontaneously motivated and able to invest in R&D, to import potentially profitable foreign technology and to develop it further in own house.

First it is necessary to distinguish between the means a government has for exerting influence on industry. Second it is necessary to realize that not all influence is equally large.
The Japanese bureaucracy doesn't dispose of large amounts of money, as incentives for industry. The available means are influence via the government bank on the investment plans of companies for increasing scale of production. These means are not so effective for companies, which are not so capital intensive as well as for those, which dispose of enough own capital or market position to take a risk on the free capital market.

Other means are the supply of cooperation in R&D. These means are not of much interest for companies, which are scientifically and technological strong enough e well equipped to finance and carry out their own research and are not very willing to share the results with others. The small importance of governmental support can be estimated by comparing the number of researchers in the MITI research institutes of about 3000, with 260.000 in industry.

The third type of means is exerted via influence on the industrial structure.
The question is whether the accounts of many foreign analysts on the influence of the Japanese bureaucracy, and especially MITI, on industry is as large as perceived and sketched or at the moment is as great as during the period of reconstruction of Japans' economy and industry and technological

catch up with the West. In principle there are two extreme answers possible. The first is that the government is in full control of the most important levels of the industrial system and that industry is obeying al missives and guidelines from the government. The other extreme is that industry is profiting form the impression of public control, but meanwhile in a subtle way is using and manipulating the public bodies for their own interests.

In fact one should distinguish between the companies, which tend to be obedient, those who are resisting openly and those who do not resist openly but in a more subtle way conform demonstratively when it is in their interest and try to go their own way subtly and stealthily if it is not in their interest. 164
The impression is justifiable that the Japanese government, especially MITI, domestically embellished themselves with borrowed plumes, without realizing the international boomerang effect.

Instead of trying to answer these difficult and controversial questions here, it is more fruitful to look at the relation between S&T efforts of Japan, and compare these with their output.

Measurement and indicators

For the quantitative description of the impact of S&T efforts in a country, the most internationally important indicators are:
Economic indicators: national income per capita, growth rate of net GDP, expenditure of gross domestic product.
Industrial output indicators: GDP by industrial sector, net growth rate of industrial activities net growth rate of exports, export of manufactured goods, gross production in industrial sector.

Industry input indicators: employment by industrial sector, import of manufactured goods.
Educational activity indicators: public expenditure of education by GNP, enrollment ratio by education level, public expenditure of education by education level, third level students by course of study, R&D input indicators: ratio of R&D expenditure to GDP, number of students and engineers, sources of R&D expenditure, R&D personnel by industrial sector:
R&D output indicator: patent applications.

An indicator often used to measure efforts of a country in science and technology are the expenses for R&D related to the gross domestic product. The problem is that these data are aggregated data of the input. They reveal not so much about the details of the innovative and industrial power of a country nor about its output in terms of concrete research results or its economic significance. These results are strongly dependent on the composition of the industrial structure, the role of the defence related R&D, the organization of R&D and the transfer and diffusion of knowledge and technology. Research and development indicators are thus weak measures for the success of R&D policy.

The following indicators are as of 1988: 165

R&D expenditures	¥9775.2 bln
Government funds	18.4%
R&D/GNP	2.62%
R&D/national income	3.35%

Number of researchers 441,876
Researchers per population 0.36%
R&D expenditure per researcher ¥22.12 mln
GNP 373 trln
population 122,780,000
International in- and outputs:
input import $172.1 bln
input S&T import ¥650.2 bln
input direct investment foreign capital $0.3 bln
output exports $267.4 bln
output S&T export ¥215.3 bln
output direct foreign investment $35.7
output S&T papers 22,000
output patent applications 48,000
Domestic in- and outputs:
input R&D funds ¥9.7752 trln
input R&D personnel 462,000
input S&T budget ¥1.7065 bln
output S&T papers 220,000
output patent applications 340,000

Japan's technological development shows a large growth in R&D expenditures and patent applications.
In international comparisons with the U.S.A. and W. Germany, Japan shows its strength in the export values of high tech products, the number of researchers, and weakness in the basic research expenditures and the number of internationally published articles and the value of technology exports. It can satisfactorily cope in the R&D expenditures. 166

Patents

Japan have ratified major conventions for the protection of intellectual property. The international patent protection system, however, is still far from complete, because patent systems and enforcement differ among the countries and because most systems are not adapted to the new fields of biotechnology and information. International harmonizing is therefore necessary among the United States, Europe and Japan. Japan is revising its system for protection of intellectual property, under the influence of foreign criticism but also because it now possesses a large amount of proprietary information and grants most patents in the world and is self faced with pirating proprietary information by foreign competitors.

The number of patents is increasing exponentially during the last decade. In 1987, Japan led other nations with 341 patents applications against the U.S.A. with only 117. A problem for foreign patent applications is that they should be written in Japanese.
The Japanese number of patent applications has remarkably increased. to 341,000 applications in 1987.167 This high figure should be taken carefully, because in the Japanese patent system, technologically similar or closely related inventions are granted separately. From 1978 to 1988, the

number of Japanese granted patents in the U.S.A. has also remarkably increased from 10.5-20.7%, especially in the fields of petrochemicals and electronics, information and communication. This shows the that the increased R&D inputs are bearing fruit.

Scientific papers

The Japanese scientists are already major contributors to scientific papers. In 1989, Japan's contribution to the world literature was 7.7% of all contributions of the seven most scientifically important countries (USA, UK, Germany, France, USSR, Japan and Canada).

In the field of engineering and chemistry this percentage was the highest, respectively 12.7% and 10.7%.

In mathematics and earth space sciences, the contribution was lowest with respectively 3.4% and 3.7%.

The data are based on a 3200 journals on the Science Citation Index Corporate Tapes. 168

The total number of publications of these countries were in 1986:

country	articles	percentage	population (*10 6) (1989)	articles per million people
USA	137782	35.6%	248.76	554
Canada	16642	4.3%	26.25	634
UK	31736	8.2%	57.20	555
Germany	22448	5.8%	61.99	362
France	18964	4.9%	56.16	338
USSR	29414	7.6%	285.86	103
Japan	29801	7.7%	123.12	242

For the field of engineering the figures are better for Japan:

country	articles	percentage	population (*10 6) (1989)	articles per million people
USA	9773	37.3%	248.76	39
Canada	1284	4.9%	26.25	50
UK	1965	7.5%	57.20	34
Germany	1834	7.0%	61.99	30
France	943	3.6%	56.16	17
USSR	1467	5.6%	285.86	5
Japan	3328	12.7%	123.12	27

According to an international survey of Ministry of Education, Japan ranked in 1985 among these countries second in electronics, in pharmaceutical-, agricultural- and bio-chemistry, in all engineering fields except chemical and agricultural engineering, in all medical sciences, except physiology. In all other fields it ranked third. 169

The figures suggest that Japan is already giving an important contribution to the scientific literature.

Per head of the population, however, it is still lagging main European and American countries. The same will hold if the amount of GNP is taken into consideration.

Technology imports and exports

The number of technology exports has increased in the recent years, but still lags the total of technology imports.
Japan is now exporting medium technology to developing countries and increasingly also high tech to Western countries.

In the technology trade of products of Japanese industries Japan has a large surplus in automobiles: exports ¥54.19 trln versus imports ¥6.56 trln, and a smaller surplus in textiles and iron and steel. 170

The technology trade balance shows a improving trend over the last ten years :

	1970	1980	1989
Trade balance	128.2	220.8	456.5
Import/export ratio	7.518	3.745	2.638

Figures in trillions of Yen. 171

In 1988, the input of S&T import ¥650.2 bln, whereas the output of S&T export was ¥215.3 bln.
According to the Nikkei Industrial Daily of jan 4 1990 The export of Japan amounted to $272,885 mln and the import $193,995 mln.

Trade in high tech products

In 1987, the ratio of exports over imports of high tech products of Japan showed the following picture:

aircrafts and parts	0.11
pharmacy	0.29
transformers	4.40
measurement instruments	5.95
office machinery and computers	6.49
communication, machinery and electric parts	8.37

The export share of high tech products of Japan in 1987 was 20.6%, compared with 33% for the EC, 24.5% for the U.S.A. and 10.5% for the Asean NIE's. 172 These figures show the competitive strength of Japan in the important high technology fields. The big Japanese electronics companies have become world leaders in integrated memory circuits, while the major ones also are become competitive in the field of supercomputers.

Economic impacts

According to Okimoto the impact of industrial policy on the economic performance is mixed at best. The medium tern gains of promoting targeted industrial sectors could on the longer term well be compensated by long term economic efficiencies. These efficiencies can be found in the sectors of agriculture, lumber, coal, retail distribution food processing and tobacco. These inefficiencies have led to a suboptimal allocation of resources and chronic trade conflicts. These sectors are out of the jurisdiction of the part of the bureaucracy that has the most and successful experiences with industrial policy, MITI.

Industrial impacts

In 1974, the Industrial Structures Council of MITI published its Long Range Vision, and indicated the electronics sector as a key industry in the future industrial structure of Japan. 173 One of the reasons was the increased awareness after the oil crisis, that Japan was still vulnerable, dependent as it was on the import of energy and raw materials. Electronics technology is efficient in the use of energy resources, labor and space. This would help Japan to decrease its vulnerability of imports and to increase its competitiveness, which became under stress as result of the increased oil prices and the later revaluation of the Yen. Based on this report, plans were formulated to accelerate innovation in components, computers and their diffusion in products and services. This medium and long term program stimulated the Japanese industry to develop itself to the present strong position in the world electronic industry, where it is even able to challenge the seemingly almighty American competition. 174

Social impacts

An unintended impact of Japanese economic and industrial policy is the demographic reaction of the population to the fast speed of life, lack of leisure time, the high cost of living, the minimal housing space, the growing economic independence of women, resulted in the fast decreasing number of marriages and child births. It has already led to a birth number, which is declining since 15 years (apart from a secondary baby boom already since 40 years), and is expected to decrease still further. This is caused by a decreasing number of marriages and a decreasing fertility rate, which at 1.57 in 1989 was already far too low to reproduce the population. The expectations are that around the change of the century the Japanese population will start to decrease despite the expected further increase in average life span. This will lead to a further aging population with an expected peak year for the elderly population ratio around 2020. 175

These expectations evidently indicate future problems for the work force, national welfare, and support for the older generation.

10

EXPECTATIONS AND PERSPECTIVES

New realities and implications

July 1990, Council for Industrial Structure of MITI produced a report on international trade and industrial policy in the 1990s. 176

The analysis ascertained rapid political and economic global reforms, changing international order and increasing uncertainty about the future. It pointed at reduced military tensions between the global powers, growing populations and improved living standards of developing countries, limited resources and environment deterioration. It considered that Japan could and should use its present economic and technological strength to contribute to solutions for these global problems.
It expresses the belief in a free market economy, democratic systems and international fairness as culturally universal and essential for global peace and wealth.0
It stresses the need to respond to rising international criticism, not only for the sake of reduced criticism but also for the nation's enlightened long term interest, to strive for a better harmony with the rest of the world by an international contribution and by making its systems, procedures and customs more transparent and understandable for the world.
It recognized that Japan's economic growth has not solved or reduced a number of problems for its own citizens, such as a lack of time for individual self realization, suboptimal work conditions and living space, and limited consumers freedom. The public policy and corporate activities are more oriented on production than on peoples needs and demands . Economic development does not any longer automatically contribute to the improvement of the daily lives of the ordinary Japanese people. In order to prevent feelings of frustration and decline of motivation, Japan should respond to the need of its own citizens by raising their standards of living and well-being in accordance with its national high economic performance.
At the same time Japan must maintain and secure the foundations for its long-term economic growth as an imperative to contribute to the world and to the needs of its own people. Problems are the increase of domestic demand, the flexible response to changing values and needs of people, filling gaps between industries, developing new industries, rationalizing or converting low productive industries and fostering small and medium enterprises. S&T was considered to play a dominant role in this regard. Other problems are lasting dependency on foreign resources, the deteriorating living and natural environment, the increasing shortage of manpower and mismatches in the labor force in an aging population.

Based on this analysis of its domestic and global position the report formulated three interrelated overall objectives for Japan's international trade and industrial policy in the last decade of this century:
1. The contribution to the international society and the promotion of domestic reforms.
2. The improvement of the quality of life for the Japanese people.

3. The securance of the fundament for long-term economic growth. These goals are perceived as supporting, complementing and amplifying each other.

The tasks for realizing the objectives which will be stated briefly here:
ad. 1.
a contributing to the building of a new international economic order.
b matching and explaining domestic institutions.
c reducing external imbalances.
d promotion of internationally acceptable economic activities,
e support of developing countries
f response to east west issues

g tackling global environment and energy issues.
h funding measures for realizing global initiatives
ad. 2.
a stabilizing prices and informing and expanding choice of consumers
in terms of products and prices
b improving working conditions and options of men and women.
c securing lives and significance of elderly
d improving the living and transportation conditions
e improving the social infrastructure
f spreading the urban population and improving the regions
ad. 3.
a building flexible and vital industrial structure
b promoting technology and information society
c securing and diversifying necessary material and energy resources.
d improving labor market and working conditions.
e promoting an open and sound financial infrastructure
f developing public facilities.
g handling natural disasters

The proposed policies measures form a long wishing list which is partly responding to and reflecting the external criticism and which will not meet many objections from the general public. They do not form stepwise plans to carry cut a policy agenda. It seems that MITI has threaded a path, on which it has little experience, jurisdiction or competence. For concrete actions it needs the cooperation of other ministries, industry and other vested interests groups. If they do not cooperate or resist, the report merely is an exercise good for domestic and international public relations of MITI. 177
Nevertheless overseeing the report, the main impression is that the Industrial Structure Council has a clear and pragmatic view of the external problems and domestic problems which Japan will be facing in the coming decade.

In historic perspective, the Japanese society seems to have arrived at a crossing point, of which the most salient characteristics are:
1. The population is stabilizing and will decline next decade.
2. The average age is increasing fast.
3. The economic growth is slowing down but remains on a high level.
4. The country has caught up and is at top world level in most S&T
fields.
5. Japan is expected and intends to play a more open and important role in the world community.

6. Japan must spend more effort in increasing the affluence and quality of life of its population.
7. Labor ethics especially for the younger generation are changing.
8. Social values are diversifying.

The implications of this new situation are that:
The ratio of productive age people to dependent people will slowly decrease, the labor structure will change, the ratio of older people in the productive age bracket will slowly grow.

The growth of production will level off, though will remain on a slightly higher level than other developed countries.
Japan will develop more technology and scientific knowledge endogenously.
Japan will be more open to the world community, will try to avoid frictions and play a responsible role in the development of the world economy.
The Japan recognize the inevitability of structural transformations to increase domestic demand, and develop new products for providing in this demand. Japan will stimulate its domestic demand and direct its production capacity more to the improvement of the individual and immaterial needs of its citizens.
The results of Japan's economic success must be more equally be distributed among the Japanese individual people and must really contribute to its general welfare and well being.

Perspectives

By the end of 1989 Japan registered its 49th straight month of economic growth due to continuing domestic personal consumption and high investments in plants. In fiscal 1989, Japan's GNP grew at an inflation adjusted rate of 5%. Japan's GNP exceeded ¥400 trln in fiscal 1989, which placed it as second after the U.S.A.. 178
The Japanese business cycle is in a growth phase for a long time and is expected to stay there. The international economic situation is favorable, the domestic demand is expanding and the external frictions tend to be relaxed as result of growing imports. The labor markets are tightening and the employment level is high. The prices, wages and currency rates are relatively stable. The expectation thus is that this favorable economic situation will continue in the foreseeable future.

Industry

The Japanese currency has undergone a steep appreciation since the Plaza Agreement. This confronted the Japanese industry with severe problems, which it overcomes by following two strategies.
The first, offensive, strategy is the globalization of business by an increase of overseas production especially to the U.S.A. and Europe, by sharper international horizontal division of labor and by the stimulation of domestic demand.
A more defensive strategy is the saving of energy and resources, e.g. by industrial restructuring via shifting to high technology, service and information intensive systems. This latter also served to stimulate domestic demand and compensated for the reduction of exports.
The overall effect of the high Yen rate were partly reduced by the lower cost of raw materials, on which Japan relies heavily.

Overseas production increased especially to the U.S.A. and Europe, which will ease the trade friction and will give Japan more grip on a more united European market. There is a sharper horizontal international division of labor, especially in the relationship with the developing countries.
Stimulation of domestic demand forces companies to more international competitive strategy and cheap imports will enlarge the domestic market. 179

The industrial structure between 1989 and 1993 is expected to change with a overall shift away from primary and most secondary industries and towards the tertiary industry and processing and assembly industries. In the second sector, electrical and industrial machinery and parts of the chemical industry is expected to grow above average. As result of internationalization and informatization, financial and insurance industries are the biggest growers in the tertiary sector, followed by wholesale, retail and communications. 180

The basic materials industry will be forced to restructure, under the influence of the pressures of the internationally competitive Japanese processing and assembly industry the tendency in resource exporting countries to add higher value themselves.

High growth is expected for the following internationally relevant technologies: Industrial machinery, notably NC machinery, industrial robots and office equipment. Electrical machinery, especially heavy electrical machinery, high value added exports, such as color televisions, electronic machinery for industrial use, such as facsimile machinery and computers. Finance and insurance have the highest growth expectancy due to internationalization of finance and deregulation of interest rates. The communications industry, with the effects of lower prices as result of higher competition and internationalization of business. 181

The efforts of the government to stimulate the move to more information oriented economic activities and service industry can be explained by the perceived need to diversify the national product mix, to produce new information technology, to keep up with the West in high tech, to provide employment for the highly educated labor force and to provide information and communication media for industry as well as for the general public.

The self insufficiency in raw materials will force the country to add and export value by manufacturing and trade in order to guarantee its import of food and raw materials. Because Japan intends to increase its production and export in the same processing and assembly industries and high added value goods as the other industrialized nations, trade friction can be expected to continue in the future.
Medium growth together with will also mean the saturation of domestic markets which will result in further trade friction.

Internationalization will be further be promoted as result of rise of direct and indirect investment, loans in Yen credits and overseas international cooperation. Capital exports will increase as result of the direct and indirect investments, the Yen credits and the economic development cooperation. Capital imports will also increase because of
the foreign appreciation of Japan's strength and direct investment due to internationalization.

The Japanese industry is investing heavily and increasingly in R&D. This is the main factor in the fast growth of the internationally high level of Japan's R&D investment, which by now has reached almost 3%. 182
According to a survey by STA, enforcement of R&D is seen as the most important task for the corporate management. The motives are first, the self support in technological development and second, independent discovery of technological sources for future growth. The industry's share of R&D funding is more than 80% and this is financed mainly from own means. Industrial R&D focuses

especially on marketable products, although it increasingly tends to conduct research directed at finding fundamental knowledge for later technological development. The ratio of basic research is increasing, but remains directed at the area of interest of the companies. The research in advanced technology is considered to be necessary for the industries' transition to products of goods with high added value as a must in the maintenance and fostering international competitiveness, especially under the condition of a strong Yen. The research tends to be concentrated on the fields of communications, electronics and electrical instruments.
The STA forecasts and expects that the industrial efforts in R&D will
continue in the future.

The financial capability of investment banks and of private firms to invest and carry out their own R&D and their collective coverage of virtually the whole spectrum of technologies has radical implications for the role of the government in R&D.
Now that the role of the government in the support of industrial R&D is no longer urgent, the government is able to enhance its role in areas, not so well covered by industry. In general terms these are the fulfilling of international responsibilities, research in basic sciences, the improvement of the quality of life, (global) environment etc. The government is expected to promote basic research at academic institutions, to further increase S&T, to reinforce the role of public research institutes, to provide industry with sufficient and excellent natural scientists and engineers, to conduct science and technology policies in the regions, to promote S&T for diversified individual, societal, and spiritual needs and for the protection and improvement of the global environment.

The general consensus is that the Japanese growth should be achieved through shifting from an export led to a domestic demand led development. Japan recognizes the inevitability of structural transformations to increase domestic demand, and develop new products for providing in this demand. Medium growth will also mean the saturation of domestic markets which will result in further trade friction.

The very inefficient service sector will change by automation of lower qualified jobs and the creation of higher qualified jobs. On the other hand the service sector functions as a social safety net for the labor force, as a means to upkeep full employment. Moreover the productivity of this service sector can be estimated and judged higher by another product definition, e.g. faster and more attention for the public.

Scientists and engineers will increasingly find more jobs in the service sector than in the manufacturing industry. Already 90% of the scientists and 38% of the engineers are working in the service sector, compared with 10% and 30% respectively in the manufacturing.

EPILOGUE

The preceding account evokes the cautious conclusion that the role of science and technology policy in

Japan is far from being as potent or decisive in the development of S&T, industry and economy as is often suggested by foreign writers.

The role of the Japanese government after the war was to develop the economy by the development of a technologically late industry.
The post-war goals were to stimulate industrial production capacity, to promote exports and to secure full employment of the available labor force. In order to restart the catch-up process after WWII, the policies of the Japanese government aimed at industrial rationalization an fostering of new industries. In this process, Japan as a latecomer took full advantage of the law of the accelerating arrearage.
The government stimulated industry industrial structure policy and by state owned companies on the supply side and by infra-structural contracts and procurement on the other side.
These policies and corresponding institutions are to a lesser extent the result of rational planning or conspiracy, as some foreign scholars suggest, but only a partly deliberate, partly instinctive and incremental response to the problem of developing the post war Japanese economy and restructuring its industry and technological catch-up. This policy seems retrospectively very successful and even nowadays functions, not only as a model for developing countries but also as exemplary for apparently obsolete or ineffective economic industrial and technological policies of other advanced nations.

The role of the Japanese government is at present limited because the ratio of the means, available to government versus industry, have declined remarkably. The amount of government tools for science and technology policy is decreasing through the process of deregulation and liberalization.
Another reason for the reduced roles of the government are that Japan's industry has managed to catch up in technology with the West. Japanese government is no important actor anymore in financing and conducting research in Japan. The largest amount of R&D is done privately in the individual companies. The interference of government in the field of big sciences in Japan is lower than that done in e.g. the field of military and space R&D in the U.S.A.. For the bulk of product and process innovation the private firms make their own decisions, use their own money for investment in R&D and production facilities and depend on ex ante evaluation of the outcomes by the market.
The government is only playing an important role in communicating information with the private sector and guide them with voluntary export restraints. But because the dependency of the industry on the government is weakening, the communications and personal ties between the two are also weakening.

There is little reason to contend that the Japanese system is basically different from other industrialized western nations, it only is a
variant, which appears to be successful in its process of development and catch-up. Its success factors are not necessarily functioning as well in a process of passing and taking the technological or economic lead.
The Japanese system seems only to be more effective, because it has found ways to prevent much of the waste of resources, inefficiencies and social conflicts and ex ante influence of society within the context of competition, diversity and market selection than the in economic sense less social and political developed capitalist systems. This is the reason why the Japanese system is increasingly studied by Westerners as a possible example and why the Japanese example is already followed by newly developed countries in the Asian region. Just as companies look at more successful firms and learn from their experience, also other countries can. This holds especially in an internationalizing

global system.

Many new books on Japan carry in their title or conclusions a variant of the lessons to learn from Japan. This report does not draw conclusions which lessons can be learned from Japan, for two reasons: Japan is a fast moving phenomenon so that lessons learned from the past might not reflect the present or future state of affairs and are even invalid and obsolete for Japan. The Japanese historical premises, dynamics and culture differ in important respects from those of other developed countries. Parachuting these Japanese element s in the Western social fabric may be impossible, inadequate or counterproductive.
The only lesson that could be drawn in my opinion is that in the West public and industrial managers should communicate more as a cardinal element of corporate strategies and public policies. Both parties should gather, study and exchange information, necessary for the forming of ideas of promising technologies, industries and global competition. They should not pretend that they are independent, superior or whatever from national interests.

Driving forces for a new role for Japan's economic systems are diverse. The main drive is that it must sustain its economic vitality. Economic growth implies progress in technology, investment in capital goods, high quality of labor and labor ethics.
In a multi-polarized world Japan can no longer predominantly depend on the U.S.A. for its defensive, scientific and political needs. It is increasingly aware of mutual dependence with many nations as well in Europe, America as it Asian neighbors. It is also aware of the instability of the changing world order and structure.
On the basis of its technological competence and economic power its has the potential and intention to play a more important international role. Japan is dependent for its imports and exports on good relationships with other nations and free trade and must give an example in reducing trade frictions and protectionism.
It is increasingly affected by global environmental problems.
As its economy is highly dependent on S&T and international trade, it is aware that decreasing economic and technological vitality in the world is also dangerous for its own vigor.
In order to avoid undesirable domestic frictions, it must award the legitime demands of is own population in terms of quality of life and work, disposable income, housing and transport conditions, leisure time, individuality and diversity, etc.

It is not obvious that the reasons for government policy spontaneously will change much, certainly not because the Japanese see their system understandably as successful.
Present idealistic ideas for contribution of Japan to global peace, wealth and welfare, in particular for developing countries, should therefore be taken with some reserve. Sincere intentions, concrete actions, global public relations and image building of Japan and direct interests of the Japanese economy should all be carefully distinguished from each other.
But Japan is at present under severe criticism from other industrial nations, especially from its most important economic relation the United states, on the charge of profiting of the research and development efforts of other nations, the excessive exports and closed domestic markets.

It fears damage of its relations by trade imbalances, an undervalued yen and the avoidance of liberalization of trade, technology, capital and labor. In response to these threats and avoidance of

international isolation, it now attempts a controlled increase of its number of foreign laborers, the acceptance of foreign investments the development of exportable technology and the lowering of protectionist import barriers.
As usual, foreign criticism and pressure seems to be good for Japan. The country is essentially conservative and hardly changeable from inside. It seems to need foreign coercion to reform something internally. Outside pressures are even sometimes gratefully used by decision makers as a reason to induce changes. Eventually Japan always reacts in creative ways to take advantage of imposed impediments, if the need is there.
Three historical events helped Japan to break out of its self chosen isolation and rigidity. The first one was the earliest contact with Europeans, Portuguese and Dutch traders, which introduced foreign articles, fire weapons and medical and technological knowledge. The second event was the arrival of Commodore Perry with its black ships, who ordered Japan to open its country. The third event was the disaster after the second world war and the allied occupation.
The present external revolutionizing force comes in the form of a changing world order and increasing criticism of Japanese trade partners.
Other advanced countries are not free of the type of trade and investment barriers it condemns in others. Some barriers are caused by legislation, others arise from the differences between the regulatory systems in the respective countries. Many barriers and practices do seem in large measure to be the product of a certain current of protectionism and isolationism, triggered by the economic and trade deficit problems of the United States in recent years. 183
As long as the main production factors, labor, technology and capital cannot not move freely in the world, a global economic system will be a fiction and nations will maintain to protect their interests.

The global society has to look for a new paradigm for the old problem of reconciling individualism and collectivism in social and economic live. Japan cannot function as full model but possesses some aspects, which might be used as building stones for this new paradigm.

But it has to change itself also as much as the other developed nations, if it wants to surface from its traditionally self chosen isolation and play an equal role in the developing global community.
There is a wide recognition in Japan that the old paradigms of economy as a variant of war seem to be reformed to a new paradigm where a peaceful co-development of the world economy is more important.
There is a general believe that thinking of national economic developments as a kind of war with offensive weapons of competition in production and trade and defense mechanisms of protectionist measures are not in the interests of every individual country and of the world community as a whole.
The required new institutions are not yet available, although summits and SII, IMF, GATT etc. are steps in the right direction.
It should be hoped for that the integrating world will find more effective means for growing to a open, democratic and free global society with a sustainable economy and that Japan could be allowed to fulfill its desired equal role in it, without having to give up too much from its valuable identity.

LIST OF ABBREVIATIONS

FY = fiscal year
¥ = Yen
mln = million
bln = billion
trln = trillion

AEC = Atomic Energy Committee
AIST = Agency of Industrial Science and Technology
CST = Council for Science and Technology
EA = Environment Agency
EPA = Economic planning Agency
ETL = Electrotechnical Laboratory
GHQ = General Head Quarters Supreme Commander Allied Forces
ISAS = Institute of Space and Astronautical Sciences
ISDN = Integrated Services Digital Network
JAERI = Japan Atomic Energy Research Institute
JAMSTEC = Japan Marine Science and Technology Center
JDB = Japan Development Bank
JETRO = Japan External Trade Organization
JICST = Japan Information Center of Science and Technology
JKTC = Japan Key Technology Center
JRDC = Research and Development Corporation of Japan
KDD = Kokusai Denshin Denwa Co. Ltd.
LDP = Liberal Democratic Party
MEL = Mechanical Engineering Laboratory
MAFF = Ministry of Agriculture, Forestry and Fisheries
MC = Ministry of Construction
ME = Ministry of Education, Science, and Culture (Monbusho)
MF = Ministry of Finance
MFA = Ministry of Foreign Affairs
MHA = Ministry of Home Affairs
MHW = Ministry of Health and Welfare
MITI = Ministry of International Trade and Industry
MJ = Ministry of Justice
ML = Ministry of Labor
MPT = Ministry of Post and Telecommunications
MT = Ministry of Transport
NAL = National Aerospace Laboratory
NASDA = National Space Development Administration
NEDO = New Energy & Industrial Technology Development Corporation
NHK = Nippon Hoso Kyokai
NISTEP = National Institute of Science and Technology Policy
NSC = Nuclear Safety Committee
NTT = Nippon Telegraph and Telephone Corporation

PMO	= Prime Ministers Office
R&D	= research and development
RIKEN	= Institute of Physical and Chemical Research
S&T	= science and technology
SCJ	= Science Council of Japan
STA	= Science and Technology Agency

VISITS AND INTERVIEWS

The following list contains visited and interviewed persons and their affiliations.

10 5 1989
Yasuaki Mori, First secretary
Japanese Embassy,
The Hague, The Netherlands

31 5 1989
Masahiro Kawasaki, Director General
Hajime Nagahama, Fumio Kodama, Research Directors
National Institute of Science and Technology policy (STA, NISTEP),
Tokyo

31 5 1989
Mr. Hirano
Mitsubishi Research Institute,
Tokyo

1 6 1989
Yoshihiro Kogane
Nikko Research Center,
Tokyo

2 6 1989
Katsuhiko Hayashi, Research Planning Department
National Institute for Research Advancement (EPA, NIRA)
Tokyo

2 6 1989
Satoshi Okmnura, Director Technology research and Information Division
Kenji Yoshioka, Technology Research and Technology Assessment Section
Agency of Industrial Science and Technology (MITI/AIST)
Tokyo

5 6 1989
Mr. Kobayashi
Research Institute for Technology and Economy

6 6 1989
Mitsugu Ishizuka, Director General
Yasumichi Hirose, Deputy Director General
Kensuke Higo, planning Division
Satoru Ohtake, Policy Division
Science and Technology Policy Bureau (STA/STPB)
Tokyo

6 6 1989
Jiro Kondo D.Eng. President
Science Council of Japan (SCJ)
Tokyo

7 6 1989
Mr. Soyama
Research Institute of International Trade and Industry. (MITI/RI),
Tokyo

8 6 1989
Satoru Kondo
Institute for Future Technology (IFTECH) (STA)
Tokyo

8 6 1989
Prof. Hirasawa
Japan Society for Science Policy and Research Management.
Tokyo

9 6 1989
Mrs. Tadano, Marumo, Nakano
Japan Techno Economic Society (JATES)
Tokyo

9 6 1989
Prof. Hiroyuki Itami
Hitotsubashi University
Tokyo

27 6 1990
Prof. Masanori Moritani,
University of Tokyo,

Research Center for Advanced Science and Technology.
Tokyo

9 7 1990
J.W. Stumpel
Scientific Attache,
Dutch Embassy
Tokyo

11 7 1990
Hisahide Sato; Director
Foreign Press Center Japan:
Tokyo

19 7 1990
Japan Marine Science and Technology Center
Natsushima, Yokosuka, Kanagawa

22 8 1990
Dr. Noboru Makino; Chairman
Dr. Kiyoshi Nagata
Mitsubishi Research Institute,
Tokyo

29 8 1990
Katsutoshi Yasufuku D.SC.
Kazuo Miyakawa, Director Frontier Research Programs
The Institute of Physical and Chemical Research (RIKEN)
Tokyo

26 9 1990
Akira Kayama
Kazuo Miyakawa, Director
Frontier Research Programs
Tsukuba Space Center of
National Space Development Agency of Japan:
Tsukuba

1 10 1990
Dr. Yasuharu Suematsu, President
Tokyo Institute of Technology
Tokyo

15 10 1990

Hiroei Fujioka, president
Dr. Yosaku Hasegawa
Institute for Future Technology:
Tokyo

? 11 1990
Prof. Mitsuhiro Kojina
Yoshihiro Kawana
Department of Management Information
Teikyo University of Technology
Chiba

25 12 1990
Naoki Motoshima
Key Technology Center
Tokyo

30. 1. 1991
Prof.Dr. Hajime Eto
Tsukuba University
Institute for Socio-technology
Tsukuba

26 3 1991
Hiroshi Nagano, Director Research Division
Tsuyoshi Maruyama, Head Budget Division
Science and Technology Policy Bureau (STA/STPB)
Tokyo.

23 3 & 12 4 1991
Dr. Saburo Okita,
Former Foreign Minister
Chairman of the Institute for
Domestic and International Policy Studies,
Tokyo

14 4 1991
Dr. Kazushi Hasegawa
Institute for Policy Sciences
Tokyo

19 6 1991
Junosuke Kishida
Senior advisor

The Japan Research Institute Ltd.
Tokyo

BIBLIOGRAPHY

1. Schumpeter, J. A.; Capitalism, socialism and democracy, 1965.

2. Shinohara, M.; Industrial growth, trade and dynamic patterns in the Japanese Economy, Tokyo, 1982.

3. Dosi, G. et.al.; Trade technologies and development, in: Johnson, Chalmers et.al. eds.; Politics and productivity, How Japan's development strategy works, Ballinger, Cambridge, 1989, p. 10.

4. Okimoto, D.I.; Between MITI and the Market, Japanese industrial policy for high technology, Stanford University Press, Stanford, 1989, p.232-235.

5. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.i.

6. Johnson, C. et.al. eds.; Politics and productivity, How Japan's development strategy works, Ballinger, Cambridge, 1989, p.11.

7. Johnson, C. et.al. eds.; Politics and productivity, How Japan's development strategy works, Ballinger, Cambridge, 1989, p.3.

8. Freeman C. ; Technology Policy and Economic Performance, Lessons from Japan, London, New York, 1987, p.1.

9. Freeman C.; Technology Policy and Economic Performance, Lessons from Japan, London, New York, 1987, p.75.

10. Horsley W. & R. Buckley; Nippon: New Superpower, London, 1990.

11. Takahashi Minoru, in: Journal of Japanese Trade and Industry: No.2, 1991, p.54.

12. Johnson C.; MITI and the Japanese miracle, the growth of industrial policy, 1925-1975, Charles E. Tuttle Co, Tokyo, 1987.

13. Okita Saburo; The 21st century: Japan's role, Japan Times, Tokyo 1990, p.15.

14. Okita Saburo; The 21st century: Japan's role, Japan Times, Tokyo 1990, p.15.

15. Interview with Dr. Saburo Okita, Chairman of the Institute for Domestic and International policy Studies, 13 6 1991, Tokyo

16. Interview with Dr. Kazushi Hasegawa, Institute for Policy Sciences, 14 4 1991, Tokyo.

17. Interview with Junosuke Kishida, Senior advisor, The Japan Research Institute Ltd., 19 6 1991, Tokyo.

18. Okita Saburo; The 21st century: Japan's role, Japan Times, Tokyo 1990, p.26.

19. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.4.

20. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.xxix.

21. Business Intetcommunications Inc.; White Paper on the Japanese Economy 1990, Tokyo, 1990, p.1.

22. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.57.

23. Five Year Plan for Economic Self-sufficiency, December 1955, Item 5, Part 2.

24. White Paper on Economics, Economic Planning Agency, 1956.

25. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.62.

26. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.76.

27. Council for Science and Technology; Comprehensive and Fundamental Measures for the Development of Science and Technology over the Next Decade, 1960.

28. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.87.

29. Science and Technology Agency; White Paper on Science and Technology, 1962.

30. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.92.

31. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.110.

32. Fundamentals of Comprehensive Science and Technology Policy for the 1970s.

33. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.121.

34. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.122.

35. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.177.

36. Council for Science and Technology; Foundation of Japan's Overall Science and Technology Policy based on Long-term Prospect.

37. Council for Science and Technology; Comprehensive and Fundamental Policy for the promotion of S&T to Focus Current Changing Situations from a Long-term Viewpoint, 1984.

38. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.138.

39. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.141.

40. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology

Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation December 1989, p.147.

41. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.177.

42. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.149.

43. The Commission on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.155.

44. Economic Management Within a Global Context, 1988.

45. Japan Institute of International Affairs, White papers of Japan, 1989-90, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991.

46. Ministry of International Trade and Industry; Trends and future tasks in industrial technology, developing innovative technologies to support the 21st century and contributing to the international community, summary of the white paper on industrial technology, MITI, Tokyo, 1988.

47. Science and Technology Agency ; White paper on Science and Technology 1987, toward the internationalization of Japan's Science and Technology, summary in English, Tokyo, 1987, p. 11, 12.

48. Science and Technology Agency; White paper on Science and Technology S&T 1988, towards the establishment of a new creative research environment, summary in English, Tokyo, 1988, p.22.

49. National Institute of Science and Technology Policy, Science and Technology Agency; Science and Technology structure of Japan, Tokyo, 1990, p.40.

50. Science and Technology Agency; Survey on private enterprises' R&D, 1990, in: STA; White paper on Science and Technology 1990, summary in English, Tokyo, 1990, p.27.

51. Department of Defense; Critical Technologies Plan, Washington, 1990, p.11.

52. U.S Department of Commerce, Technology Administration; Emerging Technologies, a survey of technical and economic opportunities, Washington, 1990, p.xi-xii.

53. Information from a project researcher at the conference InfoJapan'90, Information Technology Harmonizing with Society, Information Processing Society of Japan, 2-5 10 1990, Tokyo

54. The Committee on the History of Science and Technology Policy, supervised by National

Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989.

55. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.279.

56. Atomic Energy Committee; Annual report on Atomic energy -1989, Tokyo, 1989.

57. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.304.

58. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.320.

59. Council for the Development of Construction Technology; Long term View of the Research, and Development of Construction Technology, 1988.

60. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy ; The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.354.

61. Ministry of Post and Telecommunications; White Papers on Communications, 1989 and 1990.

62. Ministry of Post and Telecommunications; Information Distribution Census, Tokyo, 1988.

63. Ministry of Post and Telecommunications; White Papers on Communications, 1989 and 1990.

64. Ministry of Post and Telecommunications; White Papers on Communications, 1989 and 1990.

65. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.377.

66. Ministry of Transportation; Safety Regulations for Road Vehicles, 1951 and later

reinforcements.

67. U.S. Department of Transportation; Experimental Safety Regulations Program, 1970, in which Japan later participated.

68. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.401.

69. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.409-410

70. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.411.

71. Hirano, Yukihiro, Chiaki Nishigata; Basic Research in Major Companies of Japan, Nistep Report No.8, National Institute of S&T Policy, Tokyo, 1990.

72. Japan Institute of International Affairs, White papers of Japan, 1988-89, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1990, p.170.

73. Chiaki Nishigata & Yukihiro Hirano; Quantitative comparison of science and engineering doctorates in Japan and the United States, Report No. 7, National Institute of Science and Technology Policy (NISTEP) , Tokyo, 1989, p.82.

74. Nishigata Chiaki & Yukihiro Hirano; Quantitative comparison of science and engineering doctorates in Japan and the United States, Report No. 7, National Institute of Science and Technology Policy (NISTEP) , Tokyo, 1989, p.85.

75. Nishigata Chiaki & Yukihiro Hirano; Quantitative comparison of science and engineering doctorates in Japan and the United States, Report No. 7, National Institute of Science and Technology Policy (NISTEP) , Tokyo, 1989, p.102.

76. Mansfield Edwin; Industrial R&D in Japan and the United States, a comparative study, American Economic Review, May 1988, p.326.

77. Kodama Fumio et.al. ;Paradigm shift in a manufacturing company: from a producing to a thinking organization, Paper presented at the 2nd NISTEP international conference on Science and Technology Policy Research; What should be done? What could be done? January 24-26, 1991, Oiso, Japan, National Institute of S&T policy, Tokyo, 1991.

78. Kaisha-Shiki-Hou, (Annual report of companies activities), in: Tokyo Kaizai Sha, 4th

Quarter.

79. The 300 most profitable companies in Japan, in: Tokyo Business Today, June 1990 p.58-60. ($1=¥144.55)

80. Nihon Keizai Shimbun, June 14 1990.

81. Kaisha-Shiki-Hou, (Annual report of companies activities), in: Tokyo Kaizai Sha, 4th Quarter.

82. White Paper on Science and Technology 1989, (Summary), Expectation for S&T: the source of a more fulfilling life, Science and Technology Agency, Japanese Government, December 1990, p.15.

83. Okimoto, D.I. ; Between MITI and the Market, Japanese industrial policy for high technology, Stanford University Press, Stanford, 1989, p.232-235.

84. Heaton G.R. ; The truth about Japan's cooperative R&D, in: Issues in science and technology, 1988, 5/1, p.33.

85. Heaton G.R. ; The truth about Japan's cooperative R&D, in: Issues in science and technology, 1988, 5/1, p.32-40.

86. Ministry of Education, Science, and Culture; The University Research System in Japan, Tokyo, 1988, p.8.

87. Akito Arima; For the promotion of basic sciences in universities, Institute for Policy Sciences, Report 42, Tokyo, 1991, p. 67.

88. Akito Arima; For the promotion of basic sciences in universities, Institute for Policy Sciences, Report 42, Tokyo, 1991, p. 68.

89. Japan Institute of International Affairs, White papers of Japan, 1989-90, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991, p.169.

90. Research Development Corporation of Japan; National Laboratories and Research Public Corporations in Japan, Tokyo, 1990.

91. Public Relations Committee, Tsukuba Science City; Tsukuba Press, Tsukuba, 1990, p.32.

92. Public Relations Committee, Tsukuba Science City; Tsukuba Press, Tsukuba, 1990.

93. Public Relations Committee, Tsukuba Science City; Tsukuba Press Tsukuba, 1990.

94. Research Development Corporation of Japan; National Laboratories and Research Public

Corporations in Japan, Tokyo, 1990.

95. Japan Institute of International Affairs, White papers of Japan, 1989-90, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991, p.169.

96. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.320.

97. Research Development Corporation of Japan; National Laboratories and Research public Corporations in Japan, Tokyo, 1990.

98. Foreign press center unknown publication.

99. Johnson C.; MITI and the Japanese miracle, the growth of industrial policy, 1925-1975, Charles E. Tuttle Co, Tokyo, 1987, p.25.

100. Okimoto, D.I.; Between MITI and the Market, Japanese industrial policy for high technology, Stanford University Press, Stanford, 1989, p.2.

101. Okimoto, D.I.; Between MITI and the Market, Japanese industrial policy for high technology, Stanford University Press, Stanford, 1989, p.2.

102. Japan Center for Economic Research; Five-year Economic Forecast, Tokyo, 1990.

103. Okimoto, D.I.; Between MITI and the Market, Japanese industrial policy for high technology, Stanford University Press, Stanford, 1989, p.

104. Martin B. and J. Irvine; Research foresight: Priority-setting in Science, London, 1989.

105. Johnson C.; MITI and the Japanese miracle, the growth of industrial policy, 1925-1975, Charles E. Tuttle Co, Tokyo, 1987, p.27.

106. Okimoto, D.I.; Between MITI and the Market, Japanese industrial policy for high technology, Stanford University Press, Stanford, 1989, p. 23.

107. Johnson C.; MITI and the Japanese miracle, the growth of industrial policy, 1925-1975, Charles E. Tuttle Co, Tokyo, 1987, p. 199.

108. Gresser, J; Partners In prosperity, New York, p.202.

109. Japan Institute of International Affairs, White papers of Japan, 1989-90, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991.

110. Japan Institute of International Affairs, White papers of Japan, 1989-90, Annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991, p.94.

111. Ministry of Finance; Annual trade statistics for 1989, Tokyo 1990.

112. Business Intercommunications Inc. ; White Paper on Japanese Economy 1990, English abridged version, 1990, p.48.

113. Science and Technology Agency, Science and Technology White Paper in: Japan Institute of International Affairs, White papers of Japan, 1989-90, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991, p.167.

114. Science and Technology Agency; White paper on Science and Technology 1987, toward the internationalization of Japan's; Science and Technology, summary in English, Tokyo, 1987, p.25.

115. Science and Technology Agency; White paper on Science and Technology 1987, toward the internationalization of Japan's Science and Technology, summary in English, Tokyo, 1987.

116. White Paper on Science and Technology 1988, (Summary), Towards the establishment of a new creative research environment Science and Technology Agency, Japanese Government, December 1988.

117. White Paper on Science and Technology 1989, (Summary), New Developments in Japanese Science and Technology in the New Era of Heisei, Science and Technology Agency, Japanese Government, December 1989.

118. White Paper on Science and Technology 1989, (Summary), New Developments in Japanese Science and Technology in the New Era of Heisei, Science and Technology Agency, Japanese Government, December 1989, p.8.

119. White Paper on Science and Technology 1989, (Summary), New Developments in Japanese Science and Technology in the New Era of Heisei, Science and Technology Agency, Japanese Government, December 1989, p.18.

120. White Paper on Science and Technology 1989, (Summary), New Developments in Japanese Science and Technology in the New Era of Heisei, Science and Technology Agency, Japanese Government, December 1989.

121. White Paper on Science and Technology 1990, (Summary), Expectation for S&T: the source of a more fulfilling life, Science and Technology Agency, Japanese Government, December 1990, p.23.

122. White Paper on Science and Technology 1989, (Summary) , Expectation for S&T: the source of a more fulfilling life, Science and Technology Agency, Japanese Government, December 1990.

123. Ministry of Post and Telecommunications; A Communications Policy for the '90s, Report of the Communications Policy Symposium, Tokyo, 1990.

124. White Paper on Science and Technology 1990, (Summary), Expectation for S&T: the source of a more fulfilling life, Science and Technology Agency, Japanese Government, December 1990, p.5. and Japan Institute of International Affairs, White papers of Japan, 1989-90, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991, p.170.

125. Japan Institute of International Affairs, White papers of Japan, 1989-90, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991, p.170.

126. Global Environment Preservation Study and Comprehensive Research Advancement Plan, Tokyo, 1990.

127. Council for Science and Technology; Profile on the Council for Science and Technology, 1990.

128. Ministry of Education, Science and Culture The University Research System in Japan, Tokyo, 1988.

129. Ministry of Post and Telecommunications; Pamphlet.

130. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy ; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.270.

131. The Provisional Council for the Promotion of Administrative Reform; A report on the Execution and Promotion of Administrative Reform, July 1985.

132. The Committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.273.

133. Management and Coordination Agency: Census of Japan Establishments, in: Small and Medium Enterprises Agency, MITI; Small Business in Japan, 1989 White paper on Small and Medium Enterprises in Japan, Tokyo, 1989, p.184-185.

134. Ministry of International Trade and Industry; Industrial Census, in: Small and Medium Enterprises Agency, MITI; Small Business in Japan, 1989 White paper on Small and Medium Enterprises in Japan, Tokyo, 1989, p.186-188.

135. Management and Coordination Agency: Census of Japan Establishments, in : Small and Medium Enterprises Agency, MITI; Small Business in Japan, 1989 White paper on Small and Medium Enterprises in Japan, Tokyo, 1989, p.87.

136. Small and Medium Enterprises Agency, MITI; Small Business in Japan, 1989 White paper on Small and Medium Enterprises in Japan, Tokyo, 1989, p.77.

137. Small and Medium Enterprises Agency, MITI; Small Business in Japan, 1989 White paper. on Small and Medium Enterprises in Japan, Tokyo, 1989, p.74.

138. Small and Medium Enterprises Agency, MITI; Small Business in Japan, 1989 White paper on Small and Medium Enterprises in Japan, Tokyo, 1989.

139. Small and Medium Enterprises Agency, MITI; Small Business in Japan, 1989 White paper on Small and Medium Enterprises in Japan, Tokyo, 1989, p.182-183.

140. White Paper on Science and Technology 1989, (Summary), New Developments in Japanese Science and Technology in the New Era of Heisei, Science and Technology Agency, Japanese Government, December 1989, p.58.

141. Science and Technology Agency; in: STA Today, September 1990, Vol.2 No.9, p.12.

142. White Paper on Science and Technology 1988, (Summary), Towards the establishment of a new creative research environment Science and Technology Agency, Japanese Government, December 1988, p.17.

143. STA; in: STA Today, September 1990, Vol.2 No.9.

144. Ministry of Finance, Budget Bureau; The Budget in Brief, Japan 1990.

145. Science and Technology Agency; STA 1990, Its roles and activities, p.7.

146. Science and Technology Agency; STA 1990, Its roles and activities, p.7.

147. Ministry of Education; White Paper on Education 1990, Tokyo, 1990.

148. Ministry of International Trade and Industry; MITI budget Fiscal Year 1988, English summary, Tokyo 1988.

149. Ministry of Finance; The Budget in Brief, Japan 1990 Budget Bureau, Ministry of Finance, 1990.

150. Ministry of International Trade and Industry; MITI budget fiscal year 1988, English summary, Tokyo 1988.

151. Ministry of International Trade and Industry; MITI budget fiscal year 1988, English summary, Tokyo 1988.

152. The committee on the History of Science and Technology Policy, supervised by National Institute of Science and Technology Policy; Historical Review of Japanese Science & Technology Policy, The Society of Non-traditional Technology, Tokyo, Tentative translation, December 1989, p.264, 265.

153. Johnson C.; MITI and the Japanese miracle, the growth of industrial policy, 1925-1975, Charles E. Tuttle Co, Tokyo, 1987.

154. Niwa Fujio; The Japanese S&T Indicator System and an international S&T Comparative Study, NISTEP, Tokyo, 1989.

155. Council for Science and Technology ; General Guidelines on Science and Technology, report No.11.

156. Institute for Future Technology; Future technology in Japan, Forecast to the year 2015, The fourth technology forecast survey of the STA, Tokyo, 1988.

157. Science & Technology in Japan; Survey on the direction of Japan's technological development, Technology forecast report, Science & Technology in Japan, vol.6 (1987) No 24, Tokyo, 1987, p.38.

158. Dijk J.A.G.M. van; Delphi questionnaires versus individual and group interviews, a comparison case: in Technology Forecasting and Social Change, 37, 293-304 (1990).

159. Martin B. and J. Irvine; Research foresight: Priority-setting in Science, London, 1989.

160. Research Institute of International Trade and Industry (MITI/-RI); Annual Report 1989.

161. Research Institute of International Trade and Industry (MITI/-RI); An introduction, 1989.

162. Technology Research and Information Division, MITI/AIST; Trends of Principal Indicators on R&D activities in Japan, Tokyo, 1989.

163. Kodama Fumio; A framework of retrospective analysis of industrial policy, Institute for Policy Science Research Report No.782., Saitama University, Graduate School of Policy Science, 1978.

164. Johnson, C.; MITI, MPT and the telecom wars: how Japan makes policy for high technology, in: Johnson, Chalmers et.al. eds.; Politics and productivity,. How Japan's development strategy works, Ballinger, Cambridge, 1989.

165. National Institute of Science and Technology Policy, STA; Science and Technology structure of Japan, Tokyo, 1990, p.9.

166. White Paper on Science and Technology 1989, (Summary), New Developments in Japanese Science and Technology in the New Era of Heisei, Science and Technology Agency, Japanese

Government, December 1989, p.8.

167. White Paper on Science and Technology 1989, (Summary), New Developments in Japanese Science and Technology in the New Era of Heisei, Science and Technology Agency, Japanese Government, December 1989, p.48.

168. Computer Horizons Inc; Science & Engineering Indicators Literature Database, 1988.

169. Ministry of Education; International comparative survey on a number of scientific research articles, Tokyo, 1987.

170. STA; White paper on S&T 1990, Expectation for S&T: the source of a more fulfilling life, Tokyo, 1990.

171. STA; White paper on S&T 1990, Expectation for S&T: the source of a more fulfilling life, Tokyo, 1990.

172. JETRO; Trade of the World and Japan 1990, Tokyo, 1990.

173. Gregory G.; Japanese electronics technology : Enterprise and innovation, Tokyo, 1986, p.27.

174. Gregory G.; Japanese electronics technology : Enterprise and innovation, Tokyo, 1986, p.84.

175. 1988: "Population Estimates," Prime Ministers' Office, "Future Population Estimates of Japan," Institute of Population Problems, Ministry of Health and Welfare, (December 1986).

176. Council for Industrial Structure, MITI; International Trade and Industrial Policy in the 1990s, Toward creating human values in the global age, Tokyo, 1990.

177. Council for Industrial Structure, MITI; International trade and industrial policy in the 1990s, Toward creating human values in the global age, Tokyo, 1990.

178. Japan Institute of International Affairs; White papers of Japan, 1989-90, annual abstracts of official reports and statistics of the Japanese government, Tokyo, 1991.

179. Japan Center for Economic Research; Five-year Economic Forecast, Tokyo, 1990, p.26.

180. Japan Center for Economic Research; Five-year Economic Forecast Tokyo, 1990, p.35.

181. Japan Center for Economic Research; Five-year Economic Forecast, Tokyo, 1990.

182. Japan Center for Economic Research; Five-year Economic Forecast, Tokyo, 1990, p.12.

183. European Community; Annual Report on American Trade Practices, Brussels, 1991.