BIOTECHNOLOGY IN JAPAN: INDUSTRIAL POLICY AND FACTOR MARKET DISTORTIONS*

Gary R. Saxonhouse

There is a widespread feeling that the Japanese government is unfairly acquiring for its economy the few really good tickets to prosperity in the twenty-first century. Foreign reactions to Japanese targeting have ranged from concern that such practices are unfair and inconsistent with the international economic system and that Japan should be forced to eliminate them, to intense admiration and a hope the other countries can somehow emulate Japan. Understanding Japanese practices, particularly as they relate to high technology industries, requires an analysis not only of the relationships between government and business in Japan, but also of the relationships between government and education and between education and business. From the perspective of an analysis of the inter-relationships between these institutions, it is possible to understand the character of the market distortions and market failures with which Japanese policy has sought to cope. It should also then be possible to assess whether other countries face a similar set of problems requiring similar interventions. These analyses will proceed with particular focus on the development of the biotechnology industry in Japan and the United States.

Keywords: biotechnology, Japan, industrial policy, high technology, United States

GOVERNMENT AND BUSINESS: JAPANESE GOVERNMENT POLICY INSTRUMENTS IN AMERICAN PERSPECTIVE

A consensus has been reached at the highest government levels in Japan that biotechnology is of substantial importance to the future of the Japanese economy. From an American perspective the most picturesque manifestation of this consensus came at the 1983 Economic Summit in Williamsburg, where in the glare of global publicity, Prime Minister Nakasone commended biotechnology to President Reagan and proceeded to attempt to enlighten him on the

* Parts of this paper have been published in Gary R. Saxonhouse, 'What is all this about 'industrial targeting' in Japan?', *World Economy*, 6, 3, 1983, pp. 253-73 and in Gary R. Saxonhouse, 'Biotechnology in Japan and the United States' in Hugh Patrick (ed.) *Japanese High Technology Industries and Industrial Policy* (Seattle, Wash., University of Washington Press, forthcoming).

character and significance of recombinant DNA. This interest in biotechnology arises not because Japan faces unique problems for which biotechnology promises solutions, though such problems and solutions do exist. Rather biotechnology is viewed as reaching a stage of development where during the next five, ten, and twenty years, its many commercial applications, together with complementary developments, will yield an extremely high rate of return on resources committed. When biotechnology is commonly defined to include the industrial use of recombinant DNA, cell fusion, and novel bioprocessing techniques, under even the most optimistic appraisals of the future market size of biotechnology related projects, the future development of this industry cannot, by itself, have a significant impact on the aggregate growth and productivity of large industrialised economies. Nonetheless, as an element in a broader strategy of emphasising knowledge-intensive high technology industries and emulating American interest, biotechnology is well regarded by Japanese government officials. Characteristically, many Japanese government agencies believe that public policy working both through and outside market processes can affect the timing and form of biotechnology's impact in the economy.

Timing of Japanese Interest in Biotechnology

From as early as April 1971, when the Science and Technology Council (Kagaku gijutsu kaigi), a group of government, business, and academic leaders, serving in an advisory capacity to Japan's Science and Technology Agency (Kagaku gijutsu cho), identified the life sciences as an area worthy of special government and private sector assistance, there has been a steady stream of government reports and statements by leaders of business groups about the future of biotechnology in Japan.[1]

While the areas that have come to be known as biotechnology elicited Japanese government interest prior to such historic events as the first gene cloning in 1973, the first expression of a gene cloned from a different species of bacteria in 1974, and the creation of the first hybridoma in 1975, systematic consideration of biotechnology's place in the future of the Japanese economy by policy makers in either the private sector or the public sector is no more recent than late 1980. This acceleration in interest was fueled first by the extraordinarily favorable reception received by biotechnology-related companies in American equity markets. In October 1980 the initial public offering by Genentech, the first American firm founded to exploit recombinant DNA technology, set a Wall Street record for fastest price per share increase by going from $35 a share to $89 a share in twenty minutes.

At the same time that it became apparent there were widely held extremely optimistic expectations regarding biotechnology's future potential, it also became apparent that access to these technologies might not be so easy. In 1980, in the landmark case, *Diamond v. Chakrabarty,* the Supreme Court held that the inventor of a new micro-organism, whose invention otherwise met the legal requirements for obtaining a patent, could not be denied a patent solely because the invention was alive. This decision made possible the granting of what appeared at the time to be an extremely inclusive patent to Stanford University and the University of California at Berkeley for the work of Herbert Boyer and Stanley Cohen. Where earlier antitrust concerns and the 1956 Consent Decree with American Telephone and Telegraph had allowed the benefits of the research and development at Bell Laboratories to flow to Japanese firms at nominal or zero costs,[2] there was now concern in Japan that at just the time biology looked most promising American technology policies were about to change.

The Cohen-Boyer patent was issued six weeks after the Genentech offering and two weeks after that (in early December 1980) a hurriedly called meeting of the Committee on Life Sciences of the Japan Federation of Economic Organisations (Keidanren) was held. The stated purpose of this meeting was to help frame a Japanese response to these new developments. Attending were the president of Mitsubishi Chemicals, the chairman of Kyowa Hakko (a chemical company with significant involvement in pharmaceuticals), the president of Toray (a leading synthetic fiber producer), and representatives of thirty other Japanese companies with an interest in biotechnology. The Cohen-Boyer patent was seen as a matter of enormous concern because they had been advised that the patent would affect almost any product application of genetic engineering. Ironically, it was claimed at this meeting that the United States was designating biotechnology, in the wake of the Genentech success, as a strategic national industry and was weaving about it a new and unprecedented network of protective patents.[3]

While the very existence of such a committee in Keidanren reflected long-standing Japanese policy concern with biotechnology, the December 1980 meeting marked the first attempt to give high profile attention to this new industry. In the wake of this meeting, what had been a steady stream now turned into a veritable flood of authoritative statements by both public and private sector bodies as to what actions ought to be taken by Japan to insure Japanese participation in this promising new industry. This remarkable upsurge in interest was noted by a distinguished Japanese molecular biologist whose professional career had been in the United States but who happened to be in Japan in 1981:

> When I went back to Japan five years ago, I explained to Japanese scholars, government officials and businessmen, the importance of genetic engineering. However, most of them were not interested in genetic engineering at all. Now everyone is talking about it. This is a typical Japanese phenomenon, isn't it?[4]

Because of the rather heterogeneous character and the potentially far-reaching impact of what is called biotechnology, the breadth of both public and private interest is not surprising. What did, however, mark 1981 as the Year of Biotechnology in Japan was establishment by the Ministry of International Trade and Industry (MITI) in September 1981 of the Baiotekunoroji sangyō chōki bishon sakuei iinkai (Biotechnology Industry Long-Term Vision Discussion Group), its plans to establish the following year the Baiotekunoroji shinkō shitsu (Office of Biotechnology Promotion); and its inclusion of three major biotechnology projects within its Jisedai sangyō kiban gijutsu kenkyū kaihatsu seido (Program for Next Generation Basic Industrial Technology).

While the Ministry of Education, the Science and Technology Agency, the Ministry of Agriculture, Forestry and Fisheries, and the Environmental Protection Agency had previously had an interest in this area, apart from some energy-related interest in the development and use of biomass, 1981 marked the beginning of a major interest by MITI in this area. MITI's bureaucratic entry into high-visibility strategic planning for biotechnology signaled the beginning of spirited jockeying among a wide array of government entities for influence. It should be noted that the emergence of high profile Japanese concern with biotechnology was certainly no earlier than, and probably lagged slightly behind, the manifestation of high-profile government interest in biotechnology in West Germany, France, and the United Kingdom.[5]

Government Policy Instruments

With the establishment of the Office of Biotechnology Promotion in May 1982, MITI officials hoped special legislation might be passed in the Diet that would single out the biotechnology industry for special attention resembling qualitatively, if not quantitatively, such earlier special attention given by the Diet to computers and to structurally depressed industries. To this end, a 'biotechnology caucus' (Baio-saiensu gi-in kondan kai) of Liberal Democratic Party Diet members was organised with the specific intention of promoting a new set of government programs in this area which would be entirely immune from the sharp budget cutting associated with the Suzuki Administrative Reform Program.[6]

Despite continuing MITI interest in such legislation, in the time since the Diet biotechnology caucus and the Office of Biotechnology Promotion have been organised, no special legislation has been forthcoming. In the face of a continuing large budget deficit and a general disinclination to give special subsidies to non-agricultural activities, the political will has not existed in the Diet to make any special commitment of resources either directly or indirectly for the promotion of biotechnology in Japan.

The absence of special legislation for biotechnology does not necessarily mean that this industry is not receiving large amounts of special aid and comfort from the Japanese government. The political will may not exist for the Diet to give large high-profile, special help to any particular industry, but the bureaucracy may already have enough authority for the rapid promotion of biotechnology through existing policy instruments: tariffs, quotas and non-tariff barriers; grants and subsidy programs; tax expenditures; loans from government financial institutions; special aid through government procurement; regulation of market structure, financial markets and intellectual properties; and the government's role in education. In order to get a full assessment of what targeting biotechnology for special development might mean in Japan, the use of each of these instruments will be examined in comparison with the development of biotechnology in the United States.

Upon examination of each of these instruments, it will be seen that, on the whole, for reasons seemingly more of domestic politics than international pressure, it has been difficult for the Japanese government to take major overt steps to aid any industry other than agriculture. This is particularly so for high technology industries and is particularly true compared with the United States. The subtler and less financially onerous steps which the Japanese government has taken to guide high technology industries, such as biotechnology, and which have made such a vivid impression on foreign observers, can be seen as limited compensation for the absence in Japan of a number of market processes and institutions, found in the United States, particularly beneficial to the development of high technology industries. This does not necessarily mean that Japan is handicapped in high technology competition with the United States. Paradoxically, Japanese high technology in general, and Japanese biotechnology in particular, draw signficant direct benefits from America's own high technology policy.

1. Tariffs and quotas

In general, Japan no longer makes much use of such traditional instruments of direct protection as tariffs and quotas for aiding its non-agricultural sectors. In 1982, the import share weighted average

level of tariffs on industrial and mining products in Japan was lower than the average tariff level for the United States and for all members of the EEC. By 1984 Japan had implemented virtually all the tariff cuts related to non-sunset industries agreed to in the Multilateral Trade Negotiations (MTN), and its average level on all industrial and mining products had fallen to no more than 2.9 per cent. This level, which includes some unilateral reductions beyond the rates agreed to at Geneva, is not only lower than the levels of all other major market-oriented industrial economies, it will also be lower than the average tariff level of any of these economies after 1987 when all Tokyo Round Agreements will have been phased in.[7]

What is true for industrial and mining products generally is true specifically for high technology products. During the 1970s there had been some special tariff protection on computers and integrated circuits. On becoming a signatory to the MTN in 1979, however, Japan gave up such special protection and the tariff rates on these items are now comparable with American rates and considerably lower than EEC rates. It should be noted that there is no tariff at all on imported machine tools.

The situation for import quotas is much the same as for tariffs. Japan maintains fewer import quotas on industrial products than does the United States or France.[8] Rather than protecting high technology products, manufactures presently under formal Japanese quota include nothing more exciting than coal briquettes and four types of leather products.[9] Although manufacturing receives little protection, Japanese agriculture does remain heavily protected from foreign competition by a network of tariffs and quotas.

Considering the present character of biotechnology — an industry producing mostly knowledge and relatively little product — it is hardly surprising that tariffs and quotas cannot be found which protect this industry. Moreover, in view of Japanese government policy towards other high technology sectors, it is most unlikely that Japanese firms which have commenced research and development efforts in this area can believe protection will come from this source when tangible products do become available.

2. Product standards in pharmaceuticals

For most conventionally defined high-technology sectors, the use by Japan of product standards as a non-tariff barrier has not emerged as a major issue. Pharmaceuticals, which is now and which will continue to be in the future a major application area of the new biotechnologies, is an important exception. Pharmaceuticals is regularly cited as an instance of non-tariff barriers being used to frustrate the liberal international economic arrangements which Japan, in other fora, has agreed to support.

American and European pharmaceutical companies have bitterly criticised Ministry of Welfare product approval policies, product standards, and testing procedures as being designed to protect Japanese companies. Most Japanese pharmaceutical companies are widely recognised as not being internationally competitive. American companies, supported by the Office of the Special Trade Representative, have argued since at least the mid 1970s that the Ministry of Welfare procedures are extremely time consuming and work to make it difficult and costly for foreign drug manufacturers to introduce new products into the Japanese market.

American complaints on approval, standards, and testing procedures in pharmaceuticals have reached the highest levels of the Japanese government. On 28 May 1982 in the course of a public response to foreign criticism of the lack of reciprocity in Japan's international economic relations, the Prime Minister's office felt compelled to address this issue. The government defended its practice of not accepting foreign test data for the approval of new pharmaceuticals by arguing that physiological differences between Japanese and foreigners required testing anew in Japan. Copious reference was made to different incidence between Japanese and other ethnic groups in tests of a number of pharmaceuticals. No defence, however, was made of such other practices as requiring entirely new product approval when import agents are changed.

Further diplomatic pressure by the United States did finally result in the Japanese Diet passing new legislation in the Spring of 1983, amending 16 Japanese standard and certification laws. In addition to the amendments of the Pharmaceutical Affairs Law, amendments to the Agricultural Chemicals Law and to the Toxic Chemicals Law have particular pertinence for the future of biotechnology. The amendments are designed to give foreign producers direct access to the certification system, including direct ownership of approvals. Foreign manufacturers may apply for, and be granted, factory inspection and US product type approval. It is anticipated that the Ministry of Welfare will allow these factory inspections to be carried out by US testing firms. These amendments will bring Japanese practices into line with practices in other countries.

In addition to the amendments passed in the Diet, the Ministry of Welfare has agreed in principle to accept foreign clinical test data not done on Japanese nationals where there is evidence that ethnic and dietary differences could have no bearing on the test outcome. Another very significant change in procedure will allow product approvals to be transferred from one importer to another.

These changes in product approval procedures still leave Japan with a system that can delay approvals for years and is extremely expensive. With the changes outlined above, however, it is difficult to argue that

Japanese pharmaceutical companies are being particularly protected by Japanese regulatory procedures. For example, for all the concern about the length of the approval process in the Pharmaceutical Division of the Ministry of Welfare, the delays are, on average, no longer than those resulting from Food and Drug Administration procedures in the United States. Moreover, there is no concrete evidence that Japanese and foreign companies are being subjected to different standards. In the last fifteen years, in response to consumer pressure, the testing and approval processes of pharmaceutical regulatory authorities the world over have become more demanding, resulting in much more expensive and time-consuming processes in most countries.

Thus, it is hard to envision Japanese product standards as a protective device to be used as commercially-viable biotechnology-derived products enter the market-place in large amounts. Japan's National Institute of Health, a unit of the Ministry of Welfare, has had a committee, with an annual budget of over $US100,000, studying the framing of approval standards for products derived from recombinant DNA technology. While the formation of such committees is routine when approval standards are being developed, the committee's agenda is supposed to reflect a special sensitivity to the international ramifications of the standards recommended. In the light of regulatory changes since 1983 and those projected, Japanese firms are unlikely to be making commitments to the biotechnology industry in the expectation of protection by the manipulation of product approval standards.

3. Direct subsidies and grants

In striking contrast to the policies of some European countries, where large sectors of the economy are publicly owned, and where large subsidies may be given in order to maintain employment in otherwise unprofitable enterprises, there is very little in the way of direct subsidies and grants given to manufacturing industries in Japan.[10] In a study of Japanese government subsidy policy covering 1977 and 1978, for thirteen major manufacturing sectors, only one received direct subsidies greater than 0.1 per cent of gross domestic product originating in that sector. The sector targeted for special attention was food processing, which received subsidies equal to 0.6 per cent of gross domestic product originating in that sector.

Where there are large subsidies provided by the Japanese government, they go to agriculture, mining, and transportation. Aid given to the agriculture, forestry, and fisheries industries dwarfs that to all other sectors of the Japanese economy. In absolute amount, the actual subsidies given to agriculture are almost half again the total

amount of subsidies given to the rest of the Japanese economy. The rate of subsidy given to agriculture is fully 12.3 per cent of gross domestic product originating in that sector.[11]

What is true about direct subsidies, in general, is also true specifically about research and development grants. In the late 1970s, the Japanese government funded only 1.9 per cent of research and development undertaken by private sector industry. This contrasts with West Germany funding 15.8 per cent of private sector R & D, France funding 25.3 per cent, the United Kingdom funding 30.9 per cent, and with the United States so actively involved in private sector industry R & D as to fund fully 35.3 per cent of all research and development undertaken by private sector industry in the American economy.[12]

These aggregate research and development figures are reflected in Japanese government policies towards most leading edge technology sectors. The communications and electrical machinery industries receive research and development contracts, grants and subsidies equal to no more than 1 per cent of their total research and development expenditures. Sectors such as pharmaceuticals, machinery (excluding electrical), and precision equipment receive such funds from the Japanese government equivalent only to 0.3 per cent, 1.4 per cent and 0.5 per cent respectively of their total research and development expenditure.

The above figures do not mean that some sectors of the Japanese economy are not targeted for substantial research and development support. As might have been expected from the previous discussions of tariff quotas and subisidies, 18 per cent of agriculture's research and development expenditures is funded by the Japanese government. In this instance, agriculture is not alone in receiving such substantial aid: 19 per cent of mining's research and development expenditures, and 28 per cent of the railway, aircraft and shipbuilding industries' R & D are funded by the Japanese government.[13] By contrast, in France, the government funds 72 per cent of all aircraft research and development, 26 per cent of all electronics research and development, and 12 per cent of all chemicals industries' research and development. In the United States, individual sectoral support can be such that almost half the research and development undertaken by the electrical machinery industry is funded by the government.[14]

Because of the multidisciplinary character of biotechnology, it is difficult to speak with precision about the exact amount of government funding. Various Japanese government estimates regularly add, subtract, and reassign programs to biotechnology depending on the perspective desired. A recent estimate of current and future Japanese government funding is presented in Table 1.

TABLE 1

Major Biotechnology-Related Projects in 1983 and 1984 Budget (million ¥)

Ministry/Agency	Topic/Project	1983	1984
Ministry of International Trade and Industry	1. Planning and promotion of biotechnology	13	52
	2. Biotechnology projects in the Next Generation Basic Technologies Program	1191	1201
	• recombinant DNA technology	364	n.a.
	• bioreactor	452	n.a.
	• mass cell culture	376	n.a.
	(Ten-year plan with a total budget of ¥ 20 billion started in 1981)		
	3. Biomass-related R & D (alcohol production from celulose resources such as garbage) (Seven-year plan with a total budget of ¥ 35 billion, started in 1980)	1071	1284
	4. Biotechnology R&D except (2) and (3), (biotechnology portion of special R&D expenses at the Agency of Industrial Science and Technology)	311	935
	5. Expansion of the storage program for patented micro-organisms and the construction of a new laboratory at the Fermentation Research Institute	20	22
	6. R&D co-operation with developing countries on the production technology for palm oil	15	105
	Sub-total	2621	3599
Science and Technology Agency	7. Life Sciences R&D at the Institute of Physical and Chemical Research	1134	1281
	• development of bioreactors		
	• research on enzyme production technology		
	• development of new medicines		
	• screening and breeding of new micro-organisms with		

Ministry/Agency	Topic/Project	1983	1984
	recombinant DNA methods • construction of P4 facility at Tsukuba		
	8. Biotechnology-related budget of New Technology Promotion and Commissioned Research on New Technologies	1070	1480
	9. Biotechnology-related other New Technology Promotion Fund	390	740
	Sub-total	2594	3441
Ministry of Agriculture, Forestry and Fisheries	10. Co-ordination of government, industry, and academic biotechnology R&D	0	14
	11. Basic R&D expenses for bio-technology at Ministry of Agriculture, Forestries and Fisheries affiliated national research laboratories	416	612
	12 Commissioned research at private companies	41	395
	13. Comprehensive system for genetic information on crops and breeding	174	182
	Sub-total	631	1203
Ministry of Education	14. Research on recombinant DNA techniques	73	8
Ministry of Welfare	15. Securing biological resources	1044	n.a.
	16. 10-year 'War on Cancer' program	—	150
	17. Study Group for the Application of NDA-related technologies to Health Care and Medical Practice	31	n.a.
	18. Establishing approval standards for the pharmaceutical applications of DNA technologies	27	n.a.
	Sub-total	1175	158
Environment Protection Agency	19. Environmental impact of the development of new micro-organisms	8	
	Total (excluding 15, 17 and 18)	5864	7696

Source: *Nikkei baioteku,* 30 January 1984.

The Japanese government's expenditure on biotechnology research and development is a rather simple reflection of Japanese R & D policy as a whole. (1) The amounts involved are relatively small. (2) A large proportion is energy related. (3) Agriculture receives a large amount relative to its size in the economy and relative to the importance of biotechnology R & D specific to agriculture's interests. (4) Much of MITI's interest in biotechnology is motivated by a desire to help the structurally depressed chemical, pulp and paper, and textile industries. (5) Much of the research builds on traditional Japanese strengths in bioprocesses, such as fermentation. (6) The timing of programs seems to be a reaction to foreign developments.

a. Japanese government programs in biotechnology

In common with the experience of flexible manufacturing systems, semiconductors, and computers,[15] and despite the importance which even Prime Minister Nakasone has attached to this industry, Japanese government funding of biotechnology is exceedingly modest even by comparison with the programs of other countries. While funding will increase as much as 31.4 per cent in fiscal 1984 over 1983, total government funding will still be no more than $US35 million.[16]

By contrast, the Office of Technology Assessment estimates that the West German government funds from $US49 million to $US70 million in research projects related to biotechnology, the British spend upwards of $US60 million, and the US federal government funds $US522.3 million of biotechnology R & D (see Table 2).[17] In other words, the United States funds more than double the high estimates of biotechnology R & D expenditures for the West German, British, French and Japanese governments combined.

It is often suggested that comparisons between the enormous scale and scope of US government funded R & D and the much smaller governmental efforts elsewhere are misleading. It is generally argued that while the US government funds predominantly basic research, foreign governments fund research which has an applied character to it and which is designed primarily to enhance directly the competitiveness of one or another national industry.[18]

Such generalisations are difficult to substantiate except with much more detailed analysis. In biotechnology, where circumstances may be quite special, such a distinction seems unhelpful. Hundreds of millions of dollars in venture capital resources have been attracted to small private firms whose primary assets are scientists with university positions and who characteristically have recently completed so-called basic research projects with long-term funding from the National Institute of Health, or who may even retain such funding as they engage in more commercially-oriented activities.

A more helpful distinction may be the degree of dissemination of the knowledge derived from the research and development funded by the government. In this regard there is probably a major difference between Japanese and American government activities. Relatively more government funding goes to universities in the United States than in Japan. There is a much greater incidence of active publishing among American scientists and engineers relative to their Japanese counterparts, so it is fair to say there is wide dissemination of a relatively high proportion of the results of biotechnology research funded by the US government. Indeed, US government funding may

TABLE 2

US Federally Funded Research in Biotechnology ($US million)

Agency/Topic	Year	Amount
National Institute of Health		
Molecular biology, generic manipulation, hybridoma, monoclonal antibodies	FY 1982	378.0
immobilized enzymes	FY 1982	2.0
National Science Foundation		
Recombinant DNA research	FY 1982	12.8
Bioprocess engineering	FY 1982	1.7
Other biotechnology related research	FY 1982	38.6
Department of Agriculture		
Agricultural Reserve Service		
Plant biotechnology	FY 1983	7.2
Animal biotechnology	FY 1983	6.4
Other	FY 1982	20.4
Department of Defence		
DARPA	FY 1983	2.2
Army/Navy/Air Force		
Recombinant DNA research	FY 1983	3.3
Other biotechnology	FY 1983	2.0
Department of Energy		
Photosynthesis, stress mechanisms of plant and micro-organisms, genetic mechanisms and methanogenesis	FY 1983	9.9
Conservation and Renewal Energy Program	FY 1983	23.7
Biocatalysis research	FY 1983	0.5
Others	FY 1983	2.0
Total		522.3

Source: Office of Technology Assessment, *Commercial Biotechnology: An International Analysis,* Washington DC, 1984.

be of considerable benefit to the Japanese biotechnology industry, but it is unlikely that Japanese programs are of much benefit to the American biotechnology industry.

b. Alternative energy sources and Japanese government programs in biotechnology

The Japanese government's first commitment of new resources to biotechnology research and development came as part of a broader response to widespread concerns about the availability and price of future sources of energy. The release of energy as a by-product of enhanced biological reactions in organic matter is known loosely as biomass. Biomass has attracted the Japanese government as one of a number of alternative energy strategies. Government funding of biomass is, however, a very small part of energy-related R & D, which has focused primarily on nuclear reactors, and it seems noteworthy only because Japanese government funding of R & D for other areas of biotechnology is so relatively modest.

From as early as 1971, when OPEC's Teheran Conference first substantially raised the price of oil, MITI has been a major bureaucratic force shaping Japanese energy policy. It is within this context that MITI has shown continuing and substantial interest in research and development of biomass as an alternative energy source. Most recently, this R & D has been sponsored as part of MITI's Shin nenryoyu kenkyū kaihatsu (New Fuels Research and Development). As shown in Table 1, the ¥ 1.3 billion devoted to this single area of biotechnology is more than is being spent on any other MITI biotechnology promotion activity (including the high profile Next Generation Technologies biotechnology projects). Little connection has been made between these biotechnology efforts and other MITI projects and little liaison exists among them.

MITI biomass activities are housed in the Petroleum Refining Section of the Agency for Natural Resources and Energy. In common with the Next Generation projects, much of the biomass research and development work which MITI is promoting is being conducted by private sector laboratories. Of the eighteen firms whose laboratories are participating in the biomass portion of MITI's New Fuels Research and Development program, only one, Kyowa Hakko, is also participating in any other of MITI's biotechnology projects. In common with Japanese government practice in co-operative projects, these eighteen firms are also organised into a research association. This association is not exclusively concerned with biomass R & D, as it includes all firms participating in any New Fuels Research and Development project. As is most typical of such research and development associations, except for a program office,there are no inter-firm or supra-firm facilities.

Like MITI, MOAFF's (the Ministry of Agriculture, Forestry and Fisheries) interest in the new biotechnologies first came as a by-product of an interest in alternative energy sources. in 1978, MOAFF, through its Institute of Agricultural Technology, inaugurated a ten-year Green Energy program. This project was supplemented in 1981 with yet another ten-year project, the Biomass Conversion program. Together the Green Energy program and the Biomass Conversion program account for more than half of MOAFF's budget for biotechnology R & D. Despite the similarity of the topics covered and the research strategies pursued, there is no formal or informal co-ordination of the MITI and MOAFF programs.

c. Non-energy related biotechnology programs of the Ministry of Agriculture, Forestry and Fisheries

Cell fusion is a basic process among the biotechnologies. Cell fusion, by artificially joining cells, attempts to combine the desirable characteristics of different types of cells into one cell. As a technique it has as much future promise as either recombinant DNA, bioreactor, or mass cell cultures. What interest MOAFF has had in the new biotechnologies beyond alternative energy sources has been concentrated in this area. In 1982, MOAFF prevailed on MITI to remove cell fusion technologies from MITI's projected Next Generation Technologies program in favour of MOAFF's new effort in cell fusion.

Elementary hybridisation has long been a technique to improve crop species. For all the work done with this technique, limits to its use arise rather quickly. MOAFF hopes fusion of cells from two different plant species can be used to overcome these barriers. While this rationale has legitimised MOAFF's new lead role within the government in sponsoring cell fusion techniques, hybridoma (cell lines which follow from such a cell fusion) can be used for many other purposes, including the diagnosis and treatment of a wide variety of non-agriculture related diseases.

d. The Ministry of International Trade and Industry's interest in biotechnology

It is generally found in surveys of Japanese businessmen that while the new biotechnologies will have broad use, the most immediately promising application areas are in pharmaceuticals. Despite such prospects and doubtless because MITI has never had a role in regulating the pharmaceutical industry, MITI's high profile research projects in biotechnology have not involved existing pharmaceutical companies.

The focus of MITI's biotechnology interest that is not on energy has been concentrated in a trio of seven-year projects on recombinant DNA, bioreactors, and mass cell cultures involving a combined research effort by Japanese government laboratories (including the Fermentation Research Institute, the Research Institute for Textiles and Polymers, and the National Chemical Laboratory for Industry) and private firms. These three projects are in turn part of MITI's Next Generation Industrial Technologies program (jisedai sangyō kiban gijutsu kenkyū kaihatsu seido). These projects are housed within MITI's Basic Industries Division, which has oversight responsibility for such industries as steel, non-ferrous metals, and chemicals. The locus of MITI's administrative responsibility for biotechnology reflects MITI's predominant interest in biotechnology as part of a general program of structural adjustment for the extremely depressed basic chemicals industry. While the application areas from MITI's three projects run the gamut from pharmaceuticals and food processing to textiles, eleven of the fourteen private sector participants in MITI's biotechnology co-operative research projects have been drawn from the chemical industry.

4. Tax expenditures

In common with foreign commercial policy, Japanese tax policy was once used as a major instrument to stimulate the growth of new industries. For example, in the 1950s, half the cost of a new automobile factory could be written off in the first year the factory was in operation. Today such industry-specific largess is much less common. If agriculture and food processing are excluded, Japanese effective sectoral tax rates on capital and labour are much more uniform than those of the United States and the United Kingdom, and this has been the case since 1973. In Great Britain in that year tax policy was clearly used to channel resources between industries and the effective tax rate on capital ranged from a low of 6.3 per cent on iron and steel products, through a confiscatory rate of 285.5 per cent on electrical machinery, to a still higher of 390.2 per cent on non-electrical machinery. In the United States, effective incidence of capital taxation ranged from a low of 19.7 per cent on petroleum and related products, through a rate of 131.2 percent on electrical machinery, to a high of 144.7 per cent on rubber products. By comparison, in Japan effective capital taxation ranged from a low of 34.7 per cent on non-ferrous metals to a high of 49 per cent on electrical machinery.[19] Since at least the early 1970's Japanese tax policy has, in practice, seemed more concerned with removing distortions between sectors rather than with giving special help to any particular sector. In the early 1980s, effective tax rates in Japan

remain far more uniform than the US Recovery Act of 1981 rates, as is shown in Table 3.

TABLE 3
Effective Tax Rates by Industry
in the Unites States (1982) and Japan (1981)

United States		Japan	
Sector	**Tax Rate**	**Sector**	**Tax Rate**
TRADED GOODS			
Agricultural production, agricultural services, horticultural services, forestry and fisheries	14.7	Agriculture, forestry and fisheries	17.4
Food and kindred products	27.0	Food, beverages and tobacco	49.3
Tobacco manufactures	24.3		
Textile products	22.3	Textile products	31.1
Apparel and other fabricated textile products	25.3	Wearing apparel	31.1
Leather and leather products	27.4	Leather products	37.1
Lumber and wood products	25.3	Wood products	37.1
Furniture and fixtures	28.6	Furniture and fixtures	32.1
Paper and allied products	18.3	Paper and paper products	32.7
Printing, publishing and allied industries	28.1	Printing and publishing	32.7
Chemicals and allied products	20.1	Chemicals	36.2
Petroleum and coal products	33.2	Petroleum and related products	36.2
Rubber and miscellaneous plastic products	17.8	Rubber products	36.2
		Non-metal miscellaneous products	33.4
Stone, clay and glass products	24.6	Glass and glass products	33.4
Primary metal products	26.0	Iron and steel Non-ferrous metals	29.7 27.4
Fabricated metal industries	23.3	Metal products	35.0
Machinery (except electrical)	24.6	Machinery (except electrical)	37.2
Electrical machinery, equipment and supplies	24.7	Electrical machinery	38.6
Transportation equipment except motor vehicles	30.4	Transportation equipment	36.1
Motor vehicles and motor vehicle equipment	21.3		

TABLE 3 Continued

United States		Japan	
Sector	**Tax Rate**	**Sector**	**Tax Rate**
Professional photographic equipment and watches	27.0		
Miscellaneous manufacturing industries	25.8	Miscellaneous manufacturing	35.0
NON-TRADED GOODS			
Metal Mining	34.3	Mining and quarrying	46.0
Coal Mining	19.1		
Crude petroleum and natural gas extraction	32.2		
Non-metallic mining and quarrying, except fuel	15.6		
Electric utilities	25.0	Electric, gas and water	25.9
Gas utilities	20.0		
Water supply, sanitary services and other utilities	39.4		
Construction	13.1	Construction	33.4
Wholesale and retail trade	18.7	Wholesale and retail trade	26.1
Railways and railway express service	21.4	Transportation, storage and communication	31.5
Street railway, bus lines and taxicab service	10.0		
Trucking service and storage	14.7		
Water transportation	6.3		
Air transportation	11.5		
except natural gas			
Services indicidental to transportation	17.1		
Telephone, telegraph and miscellaneous communication services	19.7		
Radio broadcasting and television	25.8		
Finance, insurance and real estate	37.3	Finance, insurance and real estate	36.1
Services	23.9	Community, social and personal services	25.3

Source: Alan J. Auerbach, 'Corporate taxation in the United States', *Brookings Papers in Economic Activity*, 2, 1983; Nihon ginkō tokei kyoku, Ōmō kigyō keiei bunseki; *Ōkusashō, Hōjōkin benran*. Because of differing methods of calculation the sectoral taxation rates in Table 3 are not comparable with the rates presented in Table 1.

Again, what is true at the aggregate level is true in the high technology sectors. Tax credits and special depreciation allowances designed to stimulate these activities are less generous in Japan than in other market-oriented industrialised countries, particularly the United States. For example, both the American and the Japanese tax code maintain a tax credit for encouraging increased private sector research and development expenditures. In Japan, a 20 per cent tax credit is given for R & D expenditures over and above a company's previous highest level of R & D expenditure since 1972. This credit is limited to 10 per cent of a company's corporate income tax liability, which limits its value to small R & D oriented firms in Japan. By comparison, in the United States, a 25 per cent tax credit is given on current R & D expenditures over and above the average of the previous three years. Quite apart from the absence of an American ceiling on the size of the credit, with continually growing expenditures, the US provisions effectively allow a 25 per cent credit on the difference between the current year's R & D expenditures and that of two years before, while the Japanese allow only a 20 per cent credit on the difference between the current year's and the previous year's expenditures. Not surprisingly, a National Science Foundation study finds the US research and development credit results in a tax expenditure of $US2 billion annually.[20] By contrast, the Ministry of Finance estimates that the Japanese R & D credit results in a tax expenditure of the equivalent of no more than $US140 million annually.[21]

The American tax code goes well beyond the R & D credit in providing encouragement to R & D oriented firms. The lowering of the long-term capital gains tax in 1978 is widely credited with substantially increasing the pool of venture capital for start-up firms.[22] The 1979 change in the interpretation of the Employee Retirement Income Security Act (ERISA) has also allowed substantial amounts of pension fund money to flow into venture capital investments. At about the same time, the Security and Exchange Commission changed Rule 144 to allow early investors in new companies to dispose of their restricted holdings much sooner than had been the case. This, in turn, has created a major new incentive for the provision of venture capital.

Still more important than changes in the tax code, the Supreme Court held in *Snow v. Commissioners* that limited partners could offset whatever other income they might have with partnership research or other experimental expenses. At that time, the Court extended the reach of Section 174 of the Internal Revenue Service code, which covers deductions for research and experimental expenditures, to include businesses not yet offering products for sale. Prior to this, such expenditures had to be capitalised. Almost as beneficial is the continuing treatment of the outputs of limited R & D

partnerships under Section 1235 of the IRS code. While investment in an R & D partnership can be written off against income, royalty income from any patent produced can be treated as a capital gain.

The elements of the American tax code just described have a profound impact on the form and quite possibly the volume of biotechnology R & D in the US. In marked contrast with Japanese tax provisions, there are numerous US tax incentives that particularly encourage R & D in small firms. Since 1979, American equity markets have raised $US1.5 billion for American biotechnology firms with net worths of less than $US5 million.[23] Almost one-third of this financing, about $US500 million, took the form of the limited R & D partnership.[24] This is an extraordinary response for a sector which has yet to generate significant commercially viable products.

5. Capital availability

Given the character of the Japanese financial system, Japanese industrial targeting of an industry such as biotechnology could be pursued by government manipulation of the availability and terms of access to industrial finance. Capital is much more concentrated in Japan than in the United States. Decades of Ministry of Finance regulation have insulated Japan's finance-poor corporations from direct contact with Japan's savings-rich households.[25] In Japan, external financing is characteristically by bank loans. Although the Federal Republic of Germany is similar, in the United States, France, and the United Kingdom direct equity financing is much more important.[26]

Japanese corporations, when they seek financing, quite regularly turn to the few, large banks dominating the domestic financial system. These banks are closely regulated by the Ministry of Finance. The large banks are not the only corporate source of loans in Japan. Some 13-14 per cent of corporate financing comes from government financial institutions.[27] The same financial regulation which has limited the direct financial relationship between household and corporations makes postal savings accounts, government-sponsored life insurance programs, and government pension plans favoured assets for Japanese households.

The financial resources accumulated in this way by the government are, in turn, lent by such government financial institutions as the Japan Development Bank and its sister institution, the Small Business Finance Corporation. These institutions have government-business-academic policy committees which shape the sectoral allocation of loans, and in this context the financial needs of promising new industries do play an important role.

Is this, however, the real locus of Japanese industrial policy for high technology? In practice, the largest portion of the resources of these

government financial institutions is not used for promising new industries, and the loans made to these new industries are granted on terms which are hardly different from what would be available from private banks. Indeed, the high profile biotechnology industry, identified in a major survey by the *Nihon keizai shimbun* (Japan's equivalent of the *Wall Street Journal*) of 28 December 1982 as the sector with the greatest future growth potential, as of March of 1984 had yet to receive any funding from either the Japan Development Bank or the Small Business Finance Corporation.

If, in Japan, firms pursuing biotechnology projects have not been able to receive financing from government financial institutions, in the United States, biotechnology firms have found far more accommodating circumstances. SBICs (Small Business Investment Corporations), licensed by the Small Business Administration (SBA), had already made available more than $US7 million for 22 small biotechnology firms in 1981 and 1982 at rates 300 or 400 basis points below prime. Loans on such favourable terms have been possible because US law allows the SBA to lend an SBIC up to three times its equity on extremely favourable terms. As an incentive for investing in SBICs, stockholders can treat losses from disposal of SBIC stock or SBIC convertible debentures as offsets to ordinary income, while any gain is taxed as a capital gain. Also, SBIC stockholders can get generous long-term dividend exclusions.[28]

6. *Regulation of market structure*

Japanese pharmaceutical companies, most of which have a substantial interest in biotechnology, have been subject to a form of price regulation that might have had the potential for creating large implicit subsidies. Close to 90 per cent of the drugs sold in Japan are available under prescription from the Japanese national health plan, and the Ministry of Welfare sets standard prices for each of these. This system is applied to new products from abroad as well as to Japanese pharmaceuticals. The possibility that this price regulation might be used as an instrument either directly against foreign competition or indirectly by arranging large implicit subsidies certainly exists in theory. In practice, the opposite appears to have happened, as the Ministry has regularly cut its posted prices. The price controls have no explicit basis in law and in the last analysis are ineffectual. Pharmaceutical companies undercut government regulation by varying the effective discount given buyers, and by varying the quantity of sample drugs being offered. Recognising that this system of regulation is contentious but ineffectual, and hoping nonetheless that burgeoning health care costs can be lowered in other ways, the Ministry of Welfare now plans to cut sharply the price of most drugs

that it regulates. Pharmaceutical price regulation is unlikely to serve in the future as a source of new subsidies for a government-targeted biotechnology industry.

DIFFERENT INSTITUTIONS — SIMILAR FUNCTIONS? — SIMILAR OUTCOMES?

It is possible to argue that a policy instrument by policy instrument survey of the pecuniary incentives given Japanese industry by the Japanese government misses the true manner by which competitive advantage in an industry is created. The whole may be bigger than the sum of its parts. Possibly, it is not necessary for the Japanese government to make large formal interventions in private sector activities for the government to achieve its ends. In the industrial targeting context, there are four strands to this argument. First, it is possible that it is not the total amount and terms of Japanese government financial institution loans or R & D grants that are important but rather that such loans or grants are given at all. In this way, it is argued, the Japanese government communicates to the closely regulated private financial system that an industry, such as biotechnology, is of considerable future importance to the Japanese economy, that the government stands behind this industry, and that the private financial system should actively participate in the development of this industry.

A second strand suggests it is not proper to measure the impact of Japanese government research and development projects by the size of government expenditure. Even in a case as prominent as the Very Large Scale Intergration (VLSI) project, by the standards of the Subsidies Code negotiated at the Tokyo Round the amount of direct government aid is trivial and is not a possible subject of a countervailing duty. What is important, it is argued, is that a small dose of government aid and a large dose of government involvement helps diverse Japanese companies co-ordinate their research. By preventing duplication of effort and by sharing information, the true impact of government involvement is the sum of all the relevant R & D expenditures of private companies participating in a project **and** the government R & D expenditures, not just the government expenditures alone. This is the contention of the American Semiconductor Industry Association.[29]

The third strand, which has already been partially dealt with earlier, emphasises that the link between total R & D spending on any program and future commercial success is in any event weak. In every high technology area, American government R & D expenditure is much higher than in Japan, but American expenditure is concentrated on basic research, the results of which are available to all, including

Japanese competitors, at nominal cost, or it is defence-related. By contrast, Japanese funding is small, but concentrated in applied research and in product development. In short, it is carefully targeted.

The fourth strand, which will not be pursued in detail here, views Japanese targeting as a misleading tactic in the oligopolistic rivalry between American and Japanese high technology industries. The Japanese semiconductor industry stresses what is, in fact, an inaccurate account of the closeness of its relationship with Japanese government in order to divert venture capital and other resources from American rivals.[30]

Japanese Government Financial Institutions and Signaling

A spate of loans from the Japan Development Bank to a promising new sector may be a signal to private finance to get involved, but in doing this it may be simply compensating — and not very well for that matter — for the absence in Japan of American-style equity markets.

American equity markets have a history of great success in concentrating large resources on very promising, but risky, ventures on the technological frontier. Indeed, given the American legislative, judicial, and regulatory decisions of the last ten years, over and above historic precedents, an enormous array of incentives now exists for the American economy to direct resources to research and development intensive activities. These incentives may well be justified on the grounds of the substantial externalities associated with these activities, but it is also important to point out that most such incentives are not offered in the Japanese economy.

As the case of biotechnology seems to confirm, such American incentives are having a considerable impact. Between 1977 and 1983, 111 American firms were formed with the explicit intention of exploiting biotechnology. In addition, 108 established firms entered the field. As pointed out earlier, in the five years since 1979, American equity markets raised $US1.5 billion for American biotechnology firms having net worths of less than $US5 million, and almost $US500 million went into R & D partnerships. Established US firms had invested almost $US400 million by July 1983 in new biotechnology companies. Not surprisingly, the market value of the equity of the largest new biotechnology firms has reached almost $US3.5 billion.[31]

Quite apart from the entry of new firms into the American biotechnology industry on a flood of venture capital, and quite apart from investments in these new firms by established companies, many established companies within the American economy have also made significant commitments of resources within their own firms to this new field. For example, four large American chemical and pharmaceutical companies (Schering-Plough, Eli Lilly, Monsanto and

DuPont) have annual R & D budgets for biotechnology which together came to over $US300 million in 1982.[32]

By contrast with the American situation, in Japan the government has regularly announced that the development of biotechnology is a priority, yet, despite enormous discussion, resources have been relatively slow to move into this area. In 1983 Japanese private concerns invested the equivalent of $US203 million in biotechnology research and development, up from $US140 million in 1981.This reflects a respectable 20 per cent average annual increase in research and development expenditures, but it in no way compares with the explosive increase in the US commitment. While the four largest established American companies active in biotechnology spent $US302 million, which is 40 per cent more than the entire Japanese biotechnology R & D expenditure public and private, the four largest Japanese companies active in biotechnology spent no more than $US24 million. This comparison is particularly compelling because, while the Japanese industry is being developed exclusively by established firms, the distinctive feature of the American industry is the important role played by newly-established biotechnology firms. For example, the four largest newly-established American biotechnology firms in 1982 spent more than three times what the four most active, established Japanese companies spent on biotechnology R & D.

Whether the characteristic American response indicates a bold, far-sighted commitment of resources through the marketplace to insure an important role in the dynamic industries of the twenty-first century, or a faddish over-reaction; and whether the Japanese response indicates a prudent assessment of the level of resources actually required at this time to participate in the future growth of a new technology or instead an inevitably inadequate response because of cumbersome financial bureaucracies, remains an issue to be discussed. It is clear, however, that whatever Japanese industrial policy may accomplish, it does not provide the Japanese economy with a unique capacity to search out promising new technologies and concentrate large new resources on their development. Indeed, in the biotechnology case, the American economy seems better able to grasp these opportunities.

The relatively limited Japanese response to the opportunities presented by the new biotechnologies does require some explanation, particularly given the high-profile emphasis of this new industry by the Japanese. The different Japanese response is a result of different policies by the Japanese government and a different financial, industrial and scientific structure in Japan. Government policy in Japan has left potential Japanese entrants into biotechnology without either an uncapped R & D tax credit or limited R & D partnership

arrangements. Their presence in the US has allowed new entrants into biotechnology to obtain financing and retain their autonomy while allowing some other entity to take immediate benefits from the tax write-offs associated with biotechnology's relatively long gestation period.

The Japanese response to the tax incentive opportunities presented by biotechnology has also been more limited than it otherwise might have been because of the character of Japan's industrial structure. The single most attractive opportunity for commercially viable products in the near future within biotechnology is in pharmaceuticals; chemicals are a distant second. Large American and European pharmaceutical companies have made enormous new commitments to biotechnology as a defensive strategy to protect existing market shares. Japan's smaller and much less successful pharmaceutical firms have not had the need to make investment anywhere on such a scale. Even though biotechnology will in the future yield important applications in chemicals, textiles, agriculture, paper and pulp, and food processing, most Japanese companies already in these areas are interested in biotechnology as a means of diversification, most often into pharmaceuticals. In the Japanese context, this motive, by itself, has not been enough to call forth large private resources.

Venture Capital Institutions in Japan

Quite apart from tax advantages and considerations of existing industrial structure, Japan's still heavily regulated financial system, where venture capital remains unimportant and where the supply of capital is not freely competitive, must bear a considerable share of the blame or praise for the biotechnology outcome. Where the supply of capital is not freely competitive and where resource allocations are made bureaucratically, government-business decision making has had little capacity to move quickly.[33] Small wonder that not a single entrepreneur and/or research scientist has been willing to give up his permanent status at an existing firm and assume the risks of starting a new biotechnology firm. In consequence, entirely unlike the US case, no new firms have come into existence to exploit this special new opportunity.

It is possible to argue that it is the information provided by American equity markets which provides much of the glue for what Japanese government-business consensus building there is in the allocation of new resources. Indeed, industrial policy in Japan may hinge on the existence of relatively unregulated and competitive capital markets in the US. In an era when Japan was well away from the global technological frontier, observation of what other, more advanced economies had already accomplished provided a guide for

such consensus building. That is past now. With Japan at the technological frontier, what other countries will do — not what they have already done — is most interesting. In Japan, equity markets play too marginal a role in capital allocation to serve as an ultimate arbiter of future prospects. In the United States, where they do play a central role, values determined by capital markets serve as an extremely rich source of information on the future prospects of industries. As each wave of American venture capital and over-the-counter market interest has focussed on one or another new technology, they have sparked a boom in Japanese government-business interest in the same sector.

If industrial policy in Japan appears as no more than a substitute for what could be equally well or better accomplished by the instituion of efficient capital markets in Japan, why does industrial policy persist? In fact, the deregulation of some financial markets has become an explicit objective of a fading Japanese industrial policy. Indeed, eyeing the almost $US6 billion in venture capital now current in the United States, of which some 25 per cent is biotechnology-related, and the 13,000 security issues now traded over-the-counter, MITI is once again showing interest in developing a venture capital market in Japan. Parallelling the creation of the Office of Biotechnology Promotion, MITI has also set up last year a new Office of Venture Enterprise Promotion. Whether the development of such venture institutions as an over-the-counter market for company equities will be successful remains to be seen.

This is not the first time that MITI has shown an interest in venture capital institutions. In the early 1970s MITI made a similar effort. While widely publicised, this effort yielded very little in the way of tangible accomplishments. In Japan, only 111 companies have their securities traded over-the-counter and total venture capital investments amount to no more than $US84 million. In its current phase of interest, MITI is attempting to change the regulations on Japan's over-the-counter market to ease greatly the requirements for listing a security. Since regulation of securities markets is vested in the Securities Bureau of the Ministry of Finance, and not in MITI at all, the importance of the changes in regulations which might occur is not clear. The Ministry of Finance is the architect of the present financial system and retains considerable influence through its continued existence. Numerous cosmetic steps in deference to MITI are likely, but the extent to which the Ministry of Finance will allow significant steps toward direct financing of new investment and research remains to be seen.

Quite apart from the Ministry of Finance, there is a more deep-seated view in Japan that unregulated capital markets are unreliable. Japanese inspired criticism of American performance relies heavily on

this mistrust.[34] Such critiques complain that American corporate managers are excessively short-sighted in their decision making because of the heavy reliance of American corporations on equity markets. Decisions are allegedly made with undue concern for how any given action will affect the next quarterly earnings statement. Reliance on equity financing has led to compensation packages for top-level American managers that tie bonus payments to the market performance of company equities.[35] This, however, need not lead to an excessively short-run outlook for corporate managers. Tying compensation to equity market evaluation, rather than directly to earnings, should help the longer-term view to prevail. Efficiently working equity markets should distinguish between ephemeral manipulation and long-term structural improvements. Only if it is accepted that there is pervasive and persistent destabilising speculation is it possible to argue that pre-occupation with quarterly earning reports by top management will enhance equity values at the expense of the long-term performance of the firm.[36]

In fact, the Japanese mistrust of equity financing, which has very nearly taken on the status of an issue in bilateral economic diplomacy between Japan and the United States, is rooted in the experience of many Japanese business leaders during the pre-Pacific War period. It has little to do with current conditions in the United States. In pre-war Japan, new investment was commonly equity financed. Equities in major industries, such as textiles, were characteristically pledged by owners as collateral for the bank loans which permitted their purchase. The interests of equity holders, which dominated the pre-war boards of directors of Japanese enterprises, often demanded that unrealistically high dividends be paid out so that equity holders' bank loans might be serviced.

Japanese Government-Business Co-operative Research and Development Program

In the light of actual industrial performance in Japan, it is hard to imagine Japanese government-sponsored research and development projects, such as those organised for biotechnology, as the pivot around which all industry research and development expenditure revolves. Consider the performance of such projects in some other sectors. For example, between 1977 and 1983 the Japanese machine tool industry was the beneficiary of a $US44 million MITI-sponsored co-operative research project on laser-using complex manufacturing systems. This project, large by Japanese standards, was one of ten during the late 1970s that MITI had given special priority, designating it a Large Scale National Research and Development Project. It is unlikely, however, that such a project, despite involving the co-operative effort of twenty Japanese firms, could really be the

centrepiece for the intimate co-ordination of collusive activities by members of the Japanese machine tool industry.

In fact, during the six-year period that this National Research and Development Program has been underway, the Japanese machine tool industry experienced extremely rapid growth which created as much upheaval domestically as it did among its foreign competitors. The leading machining centre producer in 1981, with almost twice as much production as its nearest rival, was not even among the top ten producers in Japan in 1975. Indeed, the top ten Japanese machine tool manufacturers produced 80 per cent of all machining centres in 1975, but these firms produced only 46 per cent in 1981. During this period, new Japanese machine tool companies, some of which had been small, family-owned firms in the early 1970s and others which had not participated in the MITI-sponsored project, have assumed positions of technological leadership. And some of the firms dominant in 1975 have been forced to undergo painful readjustment in capacity and labour force.

If the high profile co-operative research and development projects sponsored by the Japanese government are not research pivots around which an industry cartel functions, what is their role? Co-operative research and development projects are important in Japan only because in Japan, relative to other industrialised countries and particularly the US, there is much less informal communication and co-operation among scientists and engineers working in different firms. As Japanese government survey after survey shows, Japanese firms rarely look to other firms and individuals in their own industry as a source of new technological information.[37] In the United States, the diffusion of useful research results across firms is possible because of the high degree of professional orientation among firm scientists and engineers. This pattern has developed in the United States because of the strong, common theoretical background of university-trained R & D staff, which not only facilitates communication, but also creates labour market-related incentives for communicating effectively with R & D workers at other firms.

Between Japan and the United States, the roots of these different patterns of communication lie in the very different means of financing education and training. In the United States, from the beginning of the post-war period there has been a number of extremely significant programs to subsidise skill accumulation directly or to facilitate use of financial intermediaries for financing such accumulation. These programs began with the GI Bill of Rights and include Veterans Educational Benefits and Guaranteed Student Loans. Most require training be done in educational institutions which are in some fashion officially accredited. In consequence, these programs have helped to increase greatly the demand and therefore, in time, the supply of

vocational, undergraduate and — in this context what is most important — graduate education in the United States.

In Japan, in the post-war period, skill accumulation has been institutionalised in a rather different way. There have been no major government programs directly subsidising individual education. Instead, there has been a relatively modest increase in the number of heavily-subsidised public institutions, which provide education at a very low tuition. For the most part, however, the very large increase in the number of Japanese receiving higher education has been at private universities which finance themselves largely out of tuition charges.[38] These major differences between Japan and the US in the financing of higher education have led to major differences in the character of educational institutions in the two countries, to major differences in the character of the education, and, ultimately, to major differences between the Japanese and American labour forces.

In the United States, government programs have almost exclusively subsidised training which takes place outside the firm. This has resulted in the development in the United States of a large number of graduate research institutions and professional schools. American firm managers and scientific personnel receive a relatively large amount of their training outside the firm. Relatively speaking, this training is general and theoretical in character. Such training is consistent with the academic character of the institutions imparting the training. By contrast, in Japan, most advanced managerial and scientific training is carried out under firm auspices.

While a PhD is almost a prerequisite for active participation in a US corporate R & D laboratory, such an advanced degree is much less commonly found in otherwise comparable Japanese facilities. For example, while a number of subsidised public universities (including Tokyo, Kyoto, Osaka and Kyushu) have significant programs in biotechnology, the role of these programs as a source of advanced research personnel for Japan's industry is limited. More than 1,200 PhDs work in US biogenetic engineering according to a 1982 survey by the Office of Technology Assessment and the National Academy of Sciences. In contrast, a Keidanren survey found only 161 PhD scientists and engineers engaged in firm-based research and development work in biotechnology in Japan in 1982, including Japanese with PhDs from American universities. It is not surprising to find that in a dynamic, high technology industry, like biotechnology, 80 per cent of the research personnel in a MITI sample of 104 firms had been trained in biotechnology methods exclusively in their own firms. At the same time, in surveys conducted in 1981 and 1982, over 40 per cent of Japanese biotechnology firms indicated that some engineering and scientific personnel would be sent abroad for either primary or supplementary training.

Japanese industry has apparently discovered there are cheaper ways of obtaining the relevant R & D skills than sending large numbers of employees through doctoral programs. Often the right mix of skills and information can be obtained by using foreign consultants on a temporary basis. The resulting training that Japanese personnel receives is less general and less theoretical than what might be received in extra-firm institutions in the US, but it is more closely co-ordinated with the Japanese firm's actual needs. There is little or no emphasis on turning out well-rounded members of a profession, occupation or craft.[39] It is commonplace to note how few lawyers per capita there are in Japan relative to the United States and Western Europe. While this is often incorrectly attributed to a homogeneous Japanese society that has informal mechanisms for conflict resolution, it is rather the simple consequence of the Japanese educational system not offering many opportunities for advanced professional training. The United States has thirty times the number of lawyers of Japan, but each year it also graduates thirty-six times the number of PhDs in biology and ten times the number of PhDs in chemistry.[40]

The differing locus and emphasis of training in Japan have led to much lower mobility among firms than in the United States or even Western Europe. There is much less of a professional and occupational orientation in Japan than in the United States. The American economy's pervasive extra-firm training programs and the American economy's market allocation of skilled and experienced labour also mean that, in contrast with Japan, large amounts of potentially proprietary scientific information readily become public goods. Both the prospective American employer and the prospective American employee may operate under strong incentives to disclose some proprietary information as a means of signaling quality. Such disclosure can occur directly or in the context of professional association activities. Strong professional identity makes possible the use of professional association activity as an avenue to job mobility.

Professionally oriented, potentially mobile managers and technical personnel might be implicitly disclosing proprietary information to enhance their employment prospects, but they also might be disclosing such information to receive in exchange, albeit informally, information of commensurable value. Such trading could make everyone better off.[41] Such information swapping can be quite complementary to explicit market transactions in information. Actually, in many instances, such informal trading is a necessary prerequisite to more formal market transactions.

To the extent that informal exchanges are useful and are facilitated by having professionally-oriented technical and managerial personnel, it is quite possible that Japan, by virtue of its employment system, does have a competitive handicap. On average, senior research

personnel in the American biotechnology industry meet with scientists from other firms in information-sharing contexts, such as professional association meetings, fourteen times a year. In Japan, even including government-sponsored projects, the average in biotechnology is no more than six. More narrowly, the Japanese government's inter-firm co-operative research projects can be viewed as an effort to insure Japanese R & D efforts do not become still more narrowly firm specific than they are because of the permanent employment system. Rather than an effort to pool R & D resources to create special competitive strength in a way not possible in the United States, such projects are best viewed as a substitute for the unusual degree of informal inter-firm communication which takes place among the more professionally oriented R & D personnel in the United States. The importance of the government role here can be seen in a 1982 survey where it was found that, on average, 40 per cent of the inter-firm professional scientific and engineering interaction in biotechnology in Japan took place under government auspices.

Co-operation among firms in Japan does not come easily, as is illustrated by the difficulties the government has had in securing participation in its projects. In biotechnology,while most of the major firms in the chemical industry are participating in MITI's three co-operative research programs, most have also been careful to avoid joining the biotechnology group researching its own specialty area. For example, Kyowa Hakko and a number of other companies with advanced research expertise in DNA are not participating in the co-operative Recombinant DNA group. Tanabe, a medium-size pharmaceutical company noted for product development and a leader in bioreactor work, has decided not to participate in any of the co-operative MITI projects. Many firms that have joined are quite ambivalent about their participation. Progress in biotechnology has outstripped government planning. The Next Generation project is often derisively referred to as the 'This Generation' project, as firms outside MITI's supervision have regularly beaten government-aided firms in reaching recombinant DNA, cell fusion and bioreactor goals. Many MITI project participants complain they would be better off co-operating with firms outside the project or with foreign firms.

The inter-firm co-operation that does take place in Japan is quite secondary to the research and development each firm conducts independently. Government-sponsored projects characteristically absorb only a small amount of the resources devoted to research and development in the area in which the project is undertaken. Quite apart from the relatively small amount of government expenditure on these projects, another indication of the relatively small scope of these efforts is the limited fiscal participation in the co-operative research associations which are characteristically created to co-ordinate firm

co-operation and to hold patents resulting from joint activities. The assets which member firms use in connection with research and development performed under association auspices can be totally written off for tax purposes in the first year, yet the Ministry of Finance estimates only $US17 million in tax revenues was lost in 1982 from the use of this provision.[42]

American R & D — A Public Good: Japanese R & D — A Private Good?

In case after case, high technology sectors of the Japanese economy seem to be globally competitive despite research and development expenditures modest by comparison with efforts in Western Europe and particularly in the United States. This may result from much overseas research and development benefiting Japan about as much as the economies in which it is conducted, and from so much overseas research and development being defence related.

At the level first of privately-sponsored firm-conducted research and development, it is true that the same mechanisms which encourage the diffusion of potentially proprietary information among American firms also make probable the leakage of at least some of this same information to Japanese firms. The leakage of such data is facilitated by the sophisticated information gathering programs of Japanese firms and of the Japanese government. Since, in general, the same sorts of information do not diffuse among Japanese firms, except with the aid of formal programs, it is doubtful whether the development of Japanese-style information gathering programs in Japan by foreign government entities and foreign firms would yield rates of return comparable to those the Japanese have experienced.

Of at least equal importance to what has been learned through informal channels at American professional association meetings, from American technological consultants, from American professional journals, and from Japanese firm-sponsored graduate students studying in American graduate research facilities, is what has been learned from technology held directly by the American government. Unless it is defence-related and classified, the results of the very large amount of contract research sponsored by the American government are available globally on demand. Patents resulting from contract research have been held by the American government and characteristically have been licensed at a fixed rate to all comers. Japanese firms have been avid consumers of reports issued by the National Technical Information Service and other information agencies of the American government, and they have licensed many American government-held patents.

In marked contrast, in Japan the results of the relatively small amount of corporate research funded by the Japanese government have generally been held privately. For example, most of the thousand patents generated by MITI's VLSI project came to be held by the VLSI Research Association, whose membership are the companies participating in the VLSI joint project; no more than fifty patents are held jointly or individually by the Japanese government.

In the last several years there have been important changes in the policies of both the Japanese and American governments regarding the results of the research they fund. In the US, rather than belonging to the public, patents developed under American government grants or contracts now belong to the grantors or contracting companies that use Federal funds to develop new technologies. Moreover, unless a specific government waiver is obtained, the right to sell or use any government patent in the United States may be limited only to firms manufacturing substantially in the United States.

Just when US technology policy is becoming markedly more protectionist, Japanese technology policies are beginning to display some important elements of US policies of the 1970s. At Ministry of Finance insistence, MITI's practice of giving research subsidies (hōjōkin) and then allowing the recipient of the subsidy to hold the patent, is ending. In MITI's Next Generation Technology program, in contrast with the VLSI project, all firm participation is on a contract (itaku) basis. All biotechnology patents resulting from projects under this program will be held by the Japanese government. MITI has stated that these patents will be licensed on a non-discriminatory basis to both foreign and domestic firms. Given that research progress has often been faster by Japanese firms outside this project than by firms in it, there have been complaints that itaku financing is dulling the incentive to rapid progress.

JAPANESE ECONOMIC PERFORMANCE

If there is little Japanese government use of the conventional instruments of industrial policy and if much of the government high profile but largely informal involvement in private resource allocation and research and development is a substitute for, not a complement to, market institutions which work successfully overseas, why is Japanese industrial and trade structure so distinctive by international standards? And why has Japanese economic growth been so rapid by international standards?

In fact, it is possible to answer both these questions on the basis of economic considerations that have little to do with a distinctively successful Japanese industrial policy. What is distinctive about the Japanese trade structure is its low share of manufactured good

imports as a proportion of GNP and total imports. Japan does have a distinctive trade structure by comparison with other advanced industrial economies, but only because the Japanese economy's other attributes are also distinctive. No other advanced industrialised economy of its large size combines such high quality labour with such poor natural resources at such a great distance from its trading partners. These distinctive characteristics and not, for example, an industrial policy which other countries might or might not wish to emulate give Japan a robust comparative advantage in so many manufactured products. It is the natural resource wealth of the United States and the natural resource poverty of Japan which explain the relative Japanese success in so many manufacturing lines. It is the large size of the Japanese economy relative to its East Asian neighbour, Korea, which explains why, as a percentage of GNP, Japanese imports are so much lower than Korean imports.

If, when the Japanese experience is properly normalised for capital stock, labour force, geographic position and material resource endowment there is little variance left to be explained by industrial policy, there is still the matter of explaining why, for example, over so much of the post-war period Japan's capital stock grew so rapidly, which in turn changed Japan's trade and industrial structure rapidly, if normally. The same financial regulation which both necessitated and limited the supply of financial intermediaries and which, in turn, did require of the government an industrial policy (if only to emulate the allocation decisions of other economies) did have a major influence on the rate of capital stock growth. During much of the period when Japan was experiencing particularly rapid growth in its capital stock resources, an average of eight to nine per cent of GNP was annually transferred from the household sector to the corporate sector.

Augmenting the historical thriftiness of the Japanese household, the Ministry of Finance has worked assiduously to create and maintain this flow. For much of the post-war period Japanese government regulations so sharply limited the kinds of assets and liabilities, both real and financial, that Japanese households might acquire that household savings, and household savings available for corporate sector use, rose well above what Japanese time preference might otherwise have dictated. It is in this area, rather than in sectoral policy, that Japanese government policy could make a difference. For much of the period since 1945, the Japanese financial system provided few inflation hedges and effectively limited Japanese household financial assets and liabilities to fixed rate savings accounts and closely related instruments offered by the Postal Savings system and commercial banks, and to residential mortgages offered on extremely poor terms. These policies left Japanese households target saving for

residential housing, which required large down payments, and for higher education, both of whose prices were inflating rapidly, with instruments yielding highly negative real rates of return. Given Japanese motives for savings, this worked to raise the savings rate.

FINALE

Examination of the familar instruments of industrial policy indicates Japan gives less formal aid and comfort to its high technology sectors, and to biotechnology in particular, than do the governments of most other advanced industrialised economies. Targeting is largely reserved for agriculture. What other high-profile government intervention does take place is best understood as a response to the distinctive institutions in Japan for accumulating and allocating capital and labour skills. What effective elements of industrial policy exist in Japan are an effort to overcome the distortions which might result from the long-term absence of well-developed capital markets. Japanese industrial policy has been a substitute, and not an unfair complement, for the market allocation of capital.

In the same way that industrial policy in Japan operates to insure that the concentration of capital does not lead to a misallocation of resources, the widely discussed co-operative R & D projects sponsored by the Japanese government must be understood as a substitute for what is achieved in other industrialised economies, particularly in the United States, as a by-product of well-functioning markets for experienced scientific and engineering manpower. These projects and related government policies are an effort to insure that the barriers to informal inter-firm transfer of information created by Japanese employment practices do not slow the pace of technology diffusion within Japan.

In the light of this analysis, it is not surprising to find that there is nothing abnormal about Japanese trade and industrial patterns. If Japanese experience is properly normalised for Japan's capital stock, labour force, geographic position and material resource endowment, there is little left to be explained by an industrial policy which is more than a substitute for market processes, or for that matter by trade barriers. If Japan's high profile, but mostly informal, industrial policy is necessitated by the character of the Japanese financial system, ongoing financial deregulation in Japan may further undermine its utility, even as its continued existence is a source of annoyance among Japan's more market-oriented trading partners. In such circumstances, total abandonment of this traditional Japanese practice could be a distinct possibility.

NOTES AND REFERENCES

Titles of works in Japanese have been translated to English. This should not be taken to signify that the publications themselves are necessarily available in English.

1. Science of Technology Council, *The Basics of a Comprehensive Science and Technology Policy for the 1970s,* Tokyo, 1971.
2. United States Department of Commerce, *A Report on the US Semiconductor Industry,* US Government Printing Office, Washington DC, 1977.
3. S. Tatara, *Genetic Industry Revolution,* Bunyei shunju, Tokyo, 1981, pp. 142-7.
4. S. Susumu, 'Genetic engineering fever — government, business and the scholar', *Ushio,* April 1982, p. 126.
5. S. Jasonoff, *Public and Private Sector Activities in Biotechnology: The Federal Republic of Germany,* report prepared for Office of Technology Assessment, January 1983; M. Vaquin, *Biotechnology in Great Britain* and *Biotechnology in France,* reports prepared for Office of Technology Assessment, December 1982.
6. On the specific Diet legislation on behalf of the computer industry see Science and Technology Agency, *White Paper on Science and Technology,* Tokyo, 1972. On legislation to help structurally depressed industries in Japan see Gary Saxonhouse, 'Industrial restucturing in Japan', *Journal of Japanese Studies,* Winter 1979.
7. In 1987, US average tariff levels will still be 4.37 per cent. Among the nine members of European Economic Community average rates will vary from 5.2 per cent to 6.9 per cent. Alan Deardorff and Robert Stern, 'The economic effects of complete elimination of post-Tokyo Round tariffs on the major industrial and developing countries' in C. Bergsten and W. Cline (eds), *Trade Policy in the 1980s,* Institute for International Economics, Washington DC, 1983.
8. Economic Planning Agency, *Economic White Paper,* Tokyo, 1981.
9. United States Trade Representative, *Japanese Barriers to United States Trade and Recent Japanese Government Trade Initiatives,* Washington DC, November 1982, pp. 10-4. Apart from formal quotas, only Japan's sunset silk industry benefits from foreign voluntary restraint on competitive imports. This limited use of voluntary restraint agreements contrasts dramatically with the practices of Japan's trading partners.
10. On European policies see Wolfgang Hager, 'Industrial policy, trade policy and European social democracy' in John Prinder (ed.), *National Industrial Strategies and the World Economy,* Croom Helm, London, 1982.
11. Hiroya Ueno and Akira Goto, 'Subsidy schemes for industry in Japan', mimeo.
12. Science and Technology Agency, *Science and Technology White Paper 1981,* Tokyo, 1981.
13. What makes these figures for the non-automobile transportation sector so high is the continuing large R & D funding for Japan's structurally-depressed shipbuilding industry. These figures also include continuing unsuccessful efforts by the Japanese government to develop a broadly-based domestic aircraft industry. All ratios on Japanese government funding as a proportion of sectoral research and development expenditures have been estimated with data from Prime Minister's Office, Statistics Bureau, *Report on the Survey of Research and Development 1981,* Tokyo, 1982.
14. Science and Technology Agency, 1981, *op.cit.,* pp. 43, 82.
15. Described in Gary Saxonhouse, 'The micro- and macroeconomics of foreign rates to Japan' in William Cline (ed.), *Trade Policy in the 1980s,* MIT Press, Cambridge, Mass., 1983.
16. The Office of Technology Assessment estimates Japanese government funding to be about double that shown in Table 1. The source is the author's manuscript, 'Biotechnology in Japan'. OTA has taken the estimates in Table 2.1 of

'Biotechnology in Japan' (which are similar to those in Table 1) and effectively doubled them by wrongly assigning the **total** for all Japanese government funding of biotechnology in place of the otherwise small amount of research and development funded by the Ministry of Education, Ministry of Welfare and the Environmental Protection Agency, and then adding this figure to itself!

17. Office of Technology Assessment, *Commercial Biotechnology: An International Analysis,* Washington DC, 1984, p. 317.
18. *ibid.,* pp. 323-4.
19. Gary Saxonhouse, 'Tampering with comparative advantage in Japan' in United States International Trade Commission, *Testimony before United States International Trade Commision Hearings on Foreign Industrial Targeting and its Effect on US Industries, Phase 1: Japan,* October 1983.
20. Eileen Collins, 'An early assessment of these R & D tax incentives provided by the Economic Recovery Tax Act of 1981', *National Science Foundation Policy Research and Analysis Report,* 83.7, April 1983. The tax expenditure for the US R & D tax credit is estimated to be $US1.3 billion by Robert Eisner, Steven Albert and Martin Sullivan, 'The new incremental tax credit for R & D: incentive or disincentive?', *National Tax Journal,* 37, 2, 1984, pp. 171-84.
21. Ministry of Finance, Tax Bureau, *An Outline of Current Taxation Policy,* Tokyo, 1983, p. 188.
22. The size of the long-term impact of this change is a subject of debate, but no one doubts its immediate impact. See Gerald Auten and Charles Clotfelter, 'Permanent versus transitory tax effects and the realization of capital gains', *Quarterly Journal of Economics,* 97, 4, 1982, pp. 613-23; Joseph Minarik, 'The effects of taxation on the selling of corporate stock and the realization of capital gains: comment', *Quarterly Journal of Economics,* 99, 1, 1984, pp. 93-110; Martin Feldstein, Joel Slemrod and Shlomo Yitzhaki, 'The effects of taxation on the selling of corporate stock and the realization of capital gains: reply', *Quarterly Journal of Economics,* 99, 1, 1984, pp. 111-20.
23. 'Industrial policy: part 2 — Is a new deal the answer?', *Manhattan Report on Economic Policy,* 3, 2, 1983, p. 17.
24. Office of Technology Assessment, *op.cit.,* p. 282.
25. This is an increasingly controversial point for some Japanese economists. See Akiyoshi Horiuchi, *Financial Policy of Japan,* Toyo keisai shimposha, Tokyo, 1980; Kazumasa Iwata and Koichi Hamada, *Financial Policy and Bank Behaviour,* Toyo Keisai shimposha, Tokyo, 1980; Yasusuke Musakami, 'Towards a socio-institutional explanation of Japan's economic performance' in Kozo Yamamura (ed.), *Policy and Trade Issues of the Japanese Economy,* University of Washington Press, Seattle, 1982.
26. For example, in 1980 in the United States bank loans and other non-equity instruments accounted for only 13.8 per cent of new corporate finance. By contrast, in Japan such non-equity finance accounted for 41.2 per cent of new corporate finance.
27. Yukio Noguchi, 'The government-business relationships in Japan: the changing role of fiscal resources' in Yamamura (ed.), *op.cit.*
28. While SBICs are the principal vehicle by which small and medium sized firms in the United States can receive direct government financing, substantial indirect financing for such firms is provided by the Subchapter S Act and the Subchapter S Revision Act of 1982. Corporations satisfying the requirements of these Acts, which include that the number of shareholders not be greater than 35, give their owners the advantage of limited liability for debts, while allowing the corporation's income to be taxed at the shareholder's tax rate. Shareholders investing in R & D intensive corporations which have large initial losses can use these losses as offset against other income.
29. Semiconductor Industry Association, *The Effect of Government Targeting on World Semiconductor Competition,* Cupertino, California, 1983.

30. Avinash Dixit, 'International trade policy for oligopolistic industries', *Conference Papers: Supplement to the Economic Journal,* 94, September 1983, pp. 1-17. The October 1982 issue of *Scientific American* contains a lengthy advertising insert by the Electronic Industries Association of Japan extolling the special advantages of good government-business relations and inter-firm co-operation.
31. Office of Technology Assessment, *op.cit.,* p. 282.
32. *Ibid,* p. 78.
33. The press release when the Office of Technology Assessment issued its report, *Commercial Biotechnology: An International Analysis,* alleges that the Japanese government is arranging low interest rate loans for its biotechnology firms. This allegation is not documented and does not appear in the OTA report itself nor in the contract report on Japan submitted by the author.
34. R. Pascale and J. Athos, *The Art of Japanese Management,* Simon and Shuster, New York, 1981.
35. The 10K filings with the Securities and Exchange Commission by publicly traded companies in the United States must contain detailed statements on the compensation agreements with top corporate officers.
36. Marjorie Flavin, 'Excess volatility in the financial market: a re-assessment of the empirical evidence', *Journal of Political Economy,* December 1983.
37. Science and Technology Agency, *Survey on Japanese Firm Research,* Tokyo, 1979.
38. Akiyoshi Horiuchi, 'The economic return to tertiary education and education subsidies', *Journal of the Japan labour Association,* 15, 4, April 1973, pp. 28-39.
39. Ronald Dore, *British Factory — Japanese Factory,* University of California Press, Berkeley, 1973.
40. Ministry of Education, *Report on the Survey of Schools,* Tokyo, 1979; National Center for Educational Statistics, *Digest of Education Statistics 1982,* Washington DC, 1982.
41. Everett Rogers, 'Technological information exchange in high technology industries in the Silicon Valley' in D. Sahal (ed.), *The Transfer and Utilization of Technological Knowledge,* D.C. heath, Lexington, Mass., 1981; Richard Nelson, 'The role of knowledge in R & D efficiency', *Quarterly Journal of Economics,* 97, 3, 1982, pp. 453-71.
42. Ministry of Finance, Tax Bureau, *An Outline of Current Taxation Policy,* Tokyo, 1983, p. 192.