THE JAPANESE INNOVATION SYSTEM: HOW IT WORKS*

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The R&D expenditures of the top five Japanese R&D spenders — Hitachi, Toyota, Matsushita, NEC and Fujitsu — is as great (in terms of purchasing power parity) as the total R&D expenditure of the entire private sector in Britain. One of the key determinants of success has been the institution of lifetime employment. The assumption of 'no exit' has had important consequences which have influenced organisational practices conducive to innovation in new product development, the interfacing of R&D, production, and marketing, and just-in-time and quality control activities which depend on information flows and cross-functional coordination. MITI's relatively great influence derives largely from its central nodal position in a vast and complex information network that criss-crosses not only Japan but also the world. MITI's internal organizational structure consists of a matrix of vertical units, which deal with issues that cut across the various sectors.

Keywords: information network, innovation, Japan, MITI, R&D.

It is now widely accepted that innovation drives competition at both the corporate and national levels. And in order to survive in a market-interdependent world, it is essential to become and remain competitive. This paper is concerned with the innovation process in Japan and with the major factors that influence it. Questions such as the following are examined: To what extent is innovation and the competitiveness that follows from it the result of the activities of the private sector in Japan? What role is played by the Japanese government and its various ministries? How great is the contribution of Japanese universities to the innovation process?

The examination of these questions hinges on the notion of the Japanese Innovation System (JIS). JIS is a complex system comprising processes, institutions, and forms of organisation. These include the market process, intra and inter corporate organisation, government regulation and intervention, and university teaching and research.

As with any complex system, the analysis of JIS involves a simplification, an abstraction of some of the major factors which influence the system and its behaviour and performance. The present paper accordingly will examine some of the major features of JIS without delving into some of the complexities that would require more space than is available here.

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Before proceeding with the analysis, however, a word of caution is necessary. Like the proverbial elephant, JIS can be all things to all people. For example, those who see market forces as the motor of capitalism see in JIS: cut-throat competition between Japanese companies and a government which spends a relatively small proportion of national income while ensuring that its interventions are exclusively of a market-conforming kind. On the other hand, those who believe in the virtues of government intervention see in JIS: a strong state which is oriented to the development of the nation's economy and which is prepared to put considerable pressure on Japanese companies to move in the directions which the government feels are desirable. The result has been a vigorous debate between the proponent of these two views (or versions of them) on the effects of industrial policy in Japan which shows little sign of abating.

JAPANESE COMPANIES' ROLE IN THE INNOVATION PROCESS?

One measure of the role of private industry in Japan in the innovation process is its contribution to total expenditure on R&D. According to this measure private industry contributes about 76 per cent, to the total, while government contributes about 18 per cent, and universities about 5 per cent.

From the point of view of competitiveness, however, this considerably underestimates the role of Japanese companies since much innovation which has an important positive effect on competitiveness is of an incremental kind and takes place on the factory floor (sometimes referred to as 'blue collar R&D') and therefore is not recorded in R&D statistics. (The absolute size of R&D expenditures of the major Japanese companies is worth emphasising. To get this into perspective, the R&D expenditures of the top five Japanese R&D spenders — Hitachi, Toyota, Matsushita, NEC, and Fujitsu — is as great (in terms of purchasing power parity) as the total R&D expenditure of the entire private sector in Britain.

It may accordingly be concluded that the bulk of expenditure on innovation is undertaken by the private sector in and for this sector. This is particularly true with respect to the 'downstream' portion of R&D, that is the applied research and development portion where the Japanese government and its various organs have little influence. In the following section more will be said about the role of the Japanese government in the innovation process.

Since innovation in JIS is largely the responsibility of Japanese companies, it is necessary to say a little more regarding the factors that influence the innovation process in these companies. Before doing so, however, another caveat is necessary. This is that, as Michael Porter has emphasised in his book, *The Competitive Advantage Of Nations*, while Japan has produced some sectors that have been outstandingly successful in terms of international competitiveness, this is by no means applies to all or even most sectors of the Japanese economy. Thus, while consumer electronics, machine tools, motor cars, and memory semiconductors are included in the outstandingly successful sectors, microprocessors, complex telecommunications equipment, chemicals, and pharmaceuticals must be excluded. To stamp all Japanese companies and sectors with the 'success stamp' would be to miss an essential part of the Japanese story.

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In most sectors, however — including microprocessors, complex telecommunications equipment, chemicals and pharmaceuticals — Japanese companies tend to be committed and patient innovators. This commitment and patience is attributable to a number of interrelated factors. One of these factors is the generally intense competition that Japanese companies face in both the domestic and international markets. Competition through innovation is a common response on the part of the Japanese companies to this competitive pressure.

The Japanese market, however, does not only provide a source of pressure which motivates innovation. It also provides users of products and processes who are extremely sophisticated and demanding regarding what they are willing to accept and who generally have alternative sources of supply if a supplier is unwilling or unable to comply with their demands. This demanding environment also generates feedback for companies and gives them the opportunity to learn how to improve their products and processes, in addition to creating the pressure for innovative change.

But why, in those cases where Japanese companies have been internationally successful, have they managed at times to out-innovate their Western rivals? Surely these Western rivals also exist in the same intensely competitive domestic and international markets and therefore should be similarly motivated to innovate like their Japanese counterparts?

One factor which has at times assisted Japanese companies is their possession of what may be referred to as 'committed shareholders'. Committed shareholders may be defined as those who will remain loyal to the company in which they hold shares by retaining their shares in that company even in the face of expected share price differentials which would leave them better off in the short run if they were to sell their shares and switch to another company.

Why do these shareholders choose to 'stay and fight rather than switch'? The reason is that, unlike pension fund managers who are attempting to maximise the short run value of their portfolios and who therefore have an arm's length relationship with the companies in which they hold shares, committed shareholders usually have close business relationships with these companies.

Committed shareholders, for instance, are often banks or other financial institutions which deal with the company, or major customers or suppliers who buy from or sell to it. They therefore have a longer term stake in the health of the company. Their commitment has removed many (though by no means all) of the pressures that Western companies face when short term profitability does not meet with the expectations of arm's length shareholders, pressures that frequently impede the process of innovation.

Japanese companies have also been helped in their attempts to innovate by organisational practices that have evolved over time in their companies. One of the key determinants behind these practices has been the institution of lifetime employment for most white and blue collar workers in larger firms. More accurately, the assumption of 'no exit' has had a number of extremely important consequences which have influenced organisational practices which, in turn, have been conducive to innovation. The difference between the assumption of continuing employment in the same organisation or life-time employment on the one hand and the assumption of no exit on the other hand must be stressed. While some Western firms have traditionally offered life-time employment, this does NOT mean that their employees operate on the assumption of no exit. The functioning of labour markets in Western countries typically means that employees, particularly those with sought-after skills, do have the option of exit through employment by another organisation.

The no-exit assumption has facilitated innovation in Japanese companies in a number of ways. Firstly, this assumption has given Japanese companies a strong incentive to train their employees since, by ensuring that these employees do not leave, it has allowed them to reap the returns from investment in training. Secondly, the no-exit assumption has encouraged the companies to provide more general and flexible skills since these allow employees, who have been provided with long term employment, to be more easily redeployable in different parts of the company. Redeployment may be necessary when a company faces a downturn in some of its business areas. Thirdly, the possession of more general and flexible skills on the part of the workforce has facilitated the widespread practice of job rotation within the company. One major benefit of this practice has been more efficient flows of information within the company which has allowed more effective coordination across corporate functional and other boundaries. This has encouraged innovation in activities such as new product development, the interfacing of R&D, production, and marketing, and just-in-time and quality control activities which depend on information flows and cross-functional coordination.

The no-exit assumption has also benefited the innovativeness and competitiveness of many Japanese companies in another more indirect way. By requiring companies not only to provide continuing jobs for its employees but also to provide opportunities for promotion and other incentives the no-exit assumption has made it more difficult for Japanese companies to engage in merger and acquisition activities. In turn, this has encouraged Japanese companies to 'stick to their knitting' and concentrate on those activities where they have already acquired distinctive competences, a tendency that has been further encouraged by the engineering background of many Japanese corporate leaders who are often keener than their Western counterparts with financial backgrounds to keep to areas which they know and understand. This has often meant that Japanese companies have been able to focus their limited attention on where they have established distinctive competences and have deepened these competences while some of their Western rivals, lured by the hope of financial gain through merger, acquisition, or competence-unrelated diversification, have had their attention diverted to other concerns. The result has been that over time some Western companies have not been able to keep up with the innovation of their more focused Japanese competitors.

These are some of the factors which have generated an innovative dynamic in some Japanese sectors which has resulted in strong international competitiveness and rapid growth in sales and market share both in Japan and abroad. But what role is to be attributed to the Japanese government in accounting for the innovative performance of Japanese companies? It is to this question that we now turn.

JAPANESE GOVERNMENT INFLUENCE ON THE INNOVATION PROCESS?

One measure of the influence of government on the national innovation process is its share of total expenditure on R&D. According to this measure the Japanese government plays a significantly smaller role than its Western counterparts. The latest figures show that in 1988 the Japanese government was responsible for 18 per cent of total R&D. This compared with about 50 per cent in France, 45 per cent in the United States, and 35 per cent in West Germany. In 1989 the figure for the United Kingdom was 37 per cent. If defense-related R&D is excluded, the figures become 18 per cent for Japan, 34 per cent for France, 26 per cent for the US, and 30 per cent for Germany.

What is the significance of the figure for Japan? The first point to make, underscoring that made in the last section on the role of Japanese companies, is that private Japanese companies undertake 76 per cent of R&D in Japan, a significantly higher proportion than in the other industrialised Western countries. Since a greater proportion of R&D is undertaken in companies in Japan which are 'closer' to the point of production and marketing, it follows that a larger proportion of R&D is commercially targeted. (It is worth noting, however, that the Japanese government and the ministries responsible for science and technology expenditure are committed to increasing government's share of total R&D and raising it to a proportional level more commensurate with that of the other Western industrialised countries. With Japan's fiscal commitments in its recession-bound economy, however, this will take some time to achieve.)

Secondly, it is necessary to get the relatively low figure of 18 per cent into perspective. It would be wrong to conclude from this figure that the Japanese government has had a negligible influence on the innovation process. This is so for a number of reasons. To begin with, as will be reiterated in the following section on the role of universities, the Japanese government has had a major impact on the process of innovation through its education and training activities which have supplied Japanese companies with a high-quality, literate, numerate, and cooperative work force. This work force, with its high level of general skills, has then been further enhanced by the corporate organisational practices referred to in the last section which have facilitated the development of competitive distinctive competences.

Furthermore, although the Japanese government has had a negligible impact on the 'downstream' part of R&D — namely, applied research and development which constitutes some 90 per cent of total R&D — its influence on the 'upstream' part has been significantly greater. This upstream part relates to basic research and, extremely important in Japan, what may be referred to as 'oriented basic' research. In these areas the Japanese government has directly and indirectly had a greater impact, largely as a result of the degree of uncertainty in this kind of research and the reduced incentive that companies accordingly have to engage in such research.

What impact have Japanese ministries had on innovation and competitiveness? While in answer to this question much Western policy and academic analysis has focussed on the role of the Ministry of International Trade and Industry (MITI), it is necessary not to ignore the distinctive role of some of the other ministries. One example is the Ministry of Posts and Telecommunications which is currently, independently of MITI, playing an extremely important role in shaping the whole of the Japanese telecommunications sector in the post-liberalisation era. Another example is the role of the Science and Technology Agency and the Ministries of Health and Welfare and Agriculture, Forestry and Fisheries which, together with MITI and the Ministry of Education, Science and Culture, have exerted influence in the area of biotechnology.

Having said this, some concentration on MITI's role is justifiable in view of the influence which this ministry has had, and continues to have although in changing ways, on the largest parts of the Japanese manufacturing and distribution sectors. Historically, MITI's influential role has derived from Japan's position as a late-coming industrialising country with a strong state committed to the development process. Until the late 1960s MITI's power vis-a-vis the companies which fell within its sphere stemmed largely from its control of foreign exchange allocations and its ability to influence the extension of credit to the sectors and companies which it prioritised. Through the exercising of this power MITI was able to influence the allocation of resources within Japan, although analysts continue to debate the extent to which this influence benefited the Japanese economy.

Most analysts now recognise, however, that since the 1960s MITI's influence has changed considerably. This has followed for several reasons. Firstly, from the late 1960s MITI lost most of its direct influence over foreign exchange and credit. Secondly, Japanese companies grew in size and strength and their increasing globalisation gave them access to international capital markets thus reducing their dependence on the government for finance. Thirdly, as they grew Japanese companies also began allocating larger absolute and often proportional amounts to R&D and as a result came to depend less and less on government research institutes which formerly played a significant role in transferring advanced technologies to these companies.

In terms of total expenditure on science and technology, however, MITI's role is dwarfed by that of the Ministry of Education, Science and Culture and the Science and Technology Agency which spend 46 per cent and 26 per cent respectively of total government expenditure on science and technology compared to MITI's mere 12 per cent. In view of these figures, is it justifiable to argue, as usually is argued, that MITI has a greater influence on the innovation process in Japan than these other ministries?

In the view of the present writer, MITI's relatively great influence derives largely from its central nodal position in a vast and complex information network that criss-crosses not only Japan but also the world. This information network provides MITI's decision-makers with outstanding high-quality information over a broad range in the areas of science, technology, industry, and trade. On the basis of the information which is possesses MITI is able to make maximum impact, not only with the direct resources which it commands, but also with the influence that it wields through indirect contacts and connections.

The close links that MITI has forged over the years with the Japanese companies

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in the sectors of manufacturing and distribution that are under its influence reinforce both the information flows which the ministry receives and the influence which it exerts. This information network, it is worth noting, was developed originally as a useful resource to help MITI in its efforts to enable Japanese industry to catch up with the more advanced Western countries.

While the costs of collecting, storing, analysing, and recalling information were and are substantial, MITI as an organisation became committed to these costs in view of the policy-making benefits which it derived from the information collected. While other ministries also have their own information networks, and while there are important cross-connections between the networks of the different ministries, these are not as extensive as MITI's. The Ministry of Finance, for example, relates closely to the private sector financial institutions, the Ministry of Health and Welfare to the pharmaceuticals companies, the Ministry of Construction to the construction companies, the Ministry of Agriculture, Forestry and Fisheries to the agriculture and food processing sectors, etc.

How is MITI's information network constructed? MITI's internal organisational structure consists of a matrix of vertical units, which correspond to the main industrial sectors in the economy, and horizontal units which deal with issues that cut across the various sectors. Examples are the vertical Machinery and Information Industries Bureau which deals with areas such as computer hardware and software and electronics and the horizontal Industrial Policy Bureau which has responsibility for questions of overall industrial policy. Regular rotation of senior MITI staff between the various units, while sacrificing some of the benefits of specialisation, helps to improve knowledge and information flows within the ministry. MITI also has a number of formally-constituted Advisory Councils the membership of which includes company representatives and academics and which constitute important channels of information flow.

Equally important are the informal networks that exist between MITI officials and the corporate and academic sectors which provide similar information. Furthermore, industry associations, often set up originally with MITI's assistance and staffed by MITI personnel, such as the Electronics Industry Association of Japan, serve as subnodes which collect and process information at industry level and form an important link between that industry and the corresponding units in MITI. Abroad the well-staffed JETRO (Japan External Trade Research Organisation) provides information about markets and technologies in other countries. It is common for MITI officials to be seconded to JETRO offices abroad in order to accumulate international experience. (Ironically, JETRO, originally established to aid Japan's export drive, now, in view of Japan's large trade surplus, assists the attempts of foreign organisations to export to Japan.)

But this account of MITI's role in a vast information network raises further questions. Why do Japanese companies continue to cooperate so closely with MITI? Do they need the information that MITI has at its disposal or would they be better off going their own way?

These questions are difficult and within the large companies which have close relationships with MITI there are contradictory answers that are given. Neverthe-

less, there are a number of considerations that have a bearing on these questions which would probably be fairly widely accepted. To begin with, it is accepted by the companies themselves that government (in this case MITI) must do for private industry what needs to be done and what industry cannot do for itself.

One important example is the resolution of international trade conflicts. As the study of cartels shows, it is extremely difficult for autonomous players to coordinate their actions so as to act in their collective self interest. This is so for the simple reason that an incentive often exists for individual players to break ranks in the hope of increasing individual gain but to the detriment of the collective interest. Relating this to Japan's international trade conflict, an individual semiconductor or motor car company has an incentive to increase its exports when its counterparts in the industry are voluntarily restricting theirs in order to reduce trade conflict.

Another example is environmental protection where MITI is playing an expanding role. Here too the incentives facing private firms may not be compatible with the socially desired outcome thus justifying involvement by MITI. It is widely acknowledged in Japan that MITI's intervention is necessary in these kinds of situations in the interests of all the companies concerned as well as in the national Japanese interest. Here the information that MITI has at its disposal is an invaluable aid in both policy-making and implementation.

Secondly, and more closely related to innovation, MITI is able to play an extremely constructive role in facilitating cooperative research between competing companies that in the absence of MITI's interventions would be less likely to cooperate. Here the information at MITI's disposal has been invaluable in facilitating the choice of research projects in strategic technology areas that will increase the competitive strength of Japanese companies, in selecting appropriate companies to participate in the cooperative research, and in securing the right kind of participation from these companies. Examples include the Fifth Generation Computer Project, its successor the Real World Computer Project that is still in its formative stage, and the Protein Engineering Research Institute which MITI established through the Japan Key Technology Center which it controls together with the Ministry of Posts and Telecommunications. The role that MITI has played in cooperative research has been analysed in detail by the present writer in *The Market and Beyond*.¹

Thirdly, the rich information available to MITI's decision-makers has enabled the ministry to complement the 'bounded vision' of private companies which tend to have good information in the areas in which they are involved but which are often unable to perceive the importance of emerging new technologies and markets in hitherto unrelated areas. On the basis of its broad detailed information MITI has been able to identify new technology areas with important commercial potential which have not received the attention they deserve in Japan and takes steps to encourage companies to more actively develop these technologies and related markets. Recent examples include biotechnology and new materials where MITI has played an extremely important (though not very costly) role in facilitating entry by a large number of Japanese companies.

This discussion on MITI and information provides an answer to the question regarding how MITI is able to exert significant influence on the innovation process

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while accounting for only a relatively small proportion of the Japanese government's expenditure on science and technology. Drawing on work by Chihiro Watanabe, one of MITI's leading younger theorists, it may be concluded that for the reasons analysed in this section MITI has been able to "induce" innovation in Japanese companies on the basis of relatively modest financial sums. The information network which MITI orchestrates has been a crucial resource facilitating its inducement role.

But how important are Japanese universities in the Japanese Innovation System? It is to this question that we now turn.

IMPORTANCE OF JAPANESE UNIVERSITIES

A common judgement by analysts of Japan is that Japanese universities tend not to measure up to their Western counterparts in terms of research and that most advanced research is found, not in universities, but in the research laboratories of the leading companies. As it stands, this judgment, though with some evidence to support it, obscures the role that Japanese universities play in the innovation system. The aim of this section is to briefly elaborate on this role.

The first point to make is that one of the most important functions played by the universities in the innovation system is to provide graduates with good general levels of education to private companies. These graduates are then given companyspecific training as outlined in the first section of this paper. University professors, with close informal links with numbers of companies, frequently play an important role in helping to allocate their students to places in companies. This allocation mechanism with its tight networks of personal contact and information stands in strong contrast to the more impersonal labour market mechanism which is often used in Western countries.

Secondly, while there is some evidence suggesting that in many areas Japanese universities tend not to be as strong as their Western counterparts in frontier research, judgment of the role of Japanese universities based on this evidence overstates the importance of such research for innovation and competitiveness. The reason is simply that what counts immediately for most companies is not frontier research but intra-frontier research. And Japanese universities are often an important source of this kind of research for Japanese companies. My own research on Japanese biotechnology, for example, suggests that Japanese universities are a more important source of knowledge for some of the major Japanese biotechnology companies than are other companies and non-Japanese universities. Supporting this, a recent study based on publication citation has concluded that the scientific research of Japanese companies "draws most heavily on Japanese, not foreign sources, universities being the most important Japanese source."²

CONCLUSION

In this brief account of the Japanese Innovation System it has been possible to do no more than provide an analysis of some of the main characteristics of this system. While it has been stressed that the 'engine' of the system lies in the Japanese companies and the competitive processes of which they form a part, the important role of both government and universities in encouraging innovation and competitiveness has also been emphasised. Returning finally to the proverbial elephant, while the 'true nature' of the beast may still be subject to debate, a satisfactory analysis of innovation and competitiveness in Japan will have to take account of the Japanese Innovation System as a whole and many, if not all, of the points raised in this paper.

NOTES AND REFERENCES

- 1 For further elaboration on the concept of bounded vision and for a study of Japanese biotechnology, see M. Fransman, *The Market and Beyond Cooperation and Competition in Information Technology in the Japanese System*, Cambridge University Press, Cambridge, 1990; M. Fransman and S. Tanaka, 'The strengths and weaknesses of the Japanese innovation system in biotechnology' in M. Fransman *et al.*, *The Biotechnology Revolution*?, Blackwell, Oxford, 1994.
- 2 D. Hicks et al., 'Japanese corporations, scientific research and globalisation', DRC Discussion Paper, No. 91, Science Policy Research Unit, University of Sussex, Brighton, 1992.