HUMAN RESOURCE MANAGEMENT OF SCIENTISTS AND ENGINEERS IN JAPANESE COMPANIES

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INTRODUCTION

Japanese companies have long been internationally acknowledged for their strength in production engineering. Since the early 1980s, their high efficiency in market-oriented product development has also attracted considerable attention (Clark & Fujimoto 1991).

In the field of more "upstream" basic and applied research, however, it is regarded that Japan has failed to make sufficient contribution considering her economic strength. In the mid-1980 s, R&D expenditure of Japanese major manufacturers began to exceed investment in plant and equipment, which made some people argue that manufacturers have transformed themselves into "creators"; in other words, that creative research and development has become a major determinant of the fate of Japanese industries (Kodama 1995). Considering that active research and development, especially a creative one, would play an important role in breaking through the status quo of Japanese industries, we conducted a questionnaire survey targeting about 1,000 researchers in Japanese private enterprises. This paper is a summary of our study.

1. LITERATURE SURVEY ON HUMAN RESOURCE MANAGEMENT OF RESEARCHERS

Recently, increasing numbers of survey reports and papers have been published on the human resource management of Japanese R&D engineers. Among them, we surveyed those concerning (1) the mobility of R&D engineers, (2) technological obsolescence and the "age-limitation theory", (3) career development and technical career, and (4) the motivation and satisfaction of R&D engineers.

(1) Mobility of R&D Engineers

Japan Productivity Center (Shapira, 1995) conducted a questionnaire survey on R&D engineers in West Germany, the United Kingdom, the United States and Japan, and compared the findings among different countries. The survey results indicated that 5.8% of Japanese scientists and engineers have changed companies, compared with 42.0% in West Germany, 40.1% in the United Kingdom, and 38.2% in the United States, showing much higher ratios than Japan.

In Japan, it is said that while human resources are immobile among major companies, intracompany transfer of personnel is carried out frequently. This also holds true for R&D engineers. The National Institute of Employment and Vocational Research (1989) analyzed the career formation of scientists and engineers in detail and found out the patterns of intracompany/interdepartmental transfer on the basis of a questionnaire survey on eight thousand and several hundred engineering managers in assembly industries (e.g. automobile, electronics and precision machinery) and in process industries (e.g. steel and chemicals). According to the survey, the majority of scientists and engineers experienced transfers to other departments in their career, though a quarter or one third of them never worked in other departments. The mainstream of interdepartmental transfer is from "upstream" to "downstream", that is, from basic/applied research to product development and to production engineering/manufacturing. However, "countercurrents" from downstream to upstream are also seen quite often; especially those from production engineering/manufacturing to product development are as often as in upstream-to-downstream transfers. In addition, a large number of scientists and engineers are transferred from these three major

Table 1 Relation between Age and Effectiveness as a Front-Line R&D Worker

(%)

Age Limit	Britain	Germany	Japan	USA
Up to 30	1.0	1.0	2.2	0.9
Early 30s	2.7	0.8	17.2	1.4
Late 30s	5.8	4.4	29.2	2.2
Early 40s	5.3	5.2	30.8	2.2
Late 40s	3.9	7.0	4.7	1.9
Over 50	6.3	8.8	0.5	13.0
No relation to age	75.5	71.8	14.7	78.5
Total	100	100	100	100
(N)	(414)	(258)	(552)	(586)

Source: International Survey of R&D Workers (Shapira 1995)

departments to planning and technical management, to sales and technical services and to outside the company (e.g. a subsidiary). Such wide-range interdepartmental transfer may contributes to the development of knowledge and skill of scientists and engineers, the vitalization of workplace, and the integration of departments. However, interdepartmental transfer is not the only thing that is constantly carried out: projects are frequently organized crossing the boundary of departments, personnel are often sent to other departments on a short-term basis, and departments communicate with each other on a daily basis.

Kusunoki and Numagami (1996) observed the interdepartmental transfer of R&D engineers, based on the personnel records of a major chemical company. Similar to the indications of the survey results mentioned above, they found that: the mainstream was from upstream to downstream; there existed quite a few countercurrents (from downstream to upstream); and interdepartmental transfer of engineers centred on the product development department. In this case, 17.3% of the engineers had no experience of any interdepartmental transfer, and the remaining engineers experienced transfer 2.67 times on average. On the basis of the personnel records, they analyzed the relation between the capability of R&D engineers (their academic background, promotion speed, and job position) and the interdepartmental transfer, and found that competent engineers are transferred more often and that the transfer of them centred on basic research and development departments. The authors observed that wide-range work experience of competent engineers enhances development of their knowledge and skills and that the strengthened integration of departments accelerates R&D activities. The existence of the "standard pattern" of intracompany transfer that has been confirmed by two studies mentioned above is also supported by Imano (1986) and Sakakibara (1995).

(2) Technological Obsolescence and the "Age-Limitation Theory"

Under the above mentioned international survey conducted by Japan Productivity Center, engineers and scientists were asked: "Until what age can R&D engineers work at the front-line?" The findings are shown in Table 1.

The table shows that 70 to 80% of engineers and scientists in the west answered: "no relation to age". On the contrary, Japanese scientists and engineers considered age to be an important factor; 60% answered that the competence as an R&D engineer would reach the limit in the age span of late thirties to early forties. In the survey conducted by Japan Productivity Center (1985), most of the direc-

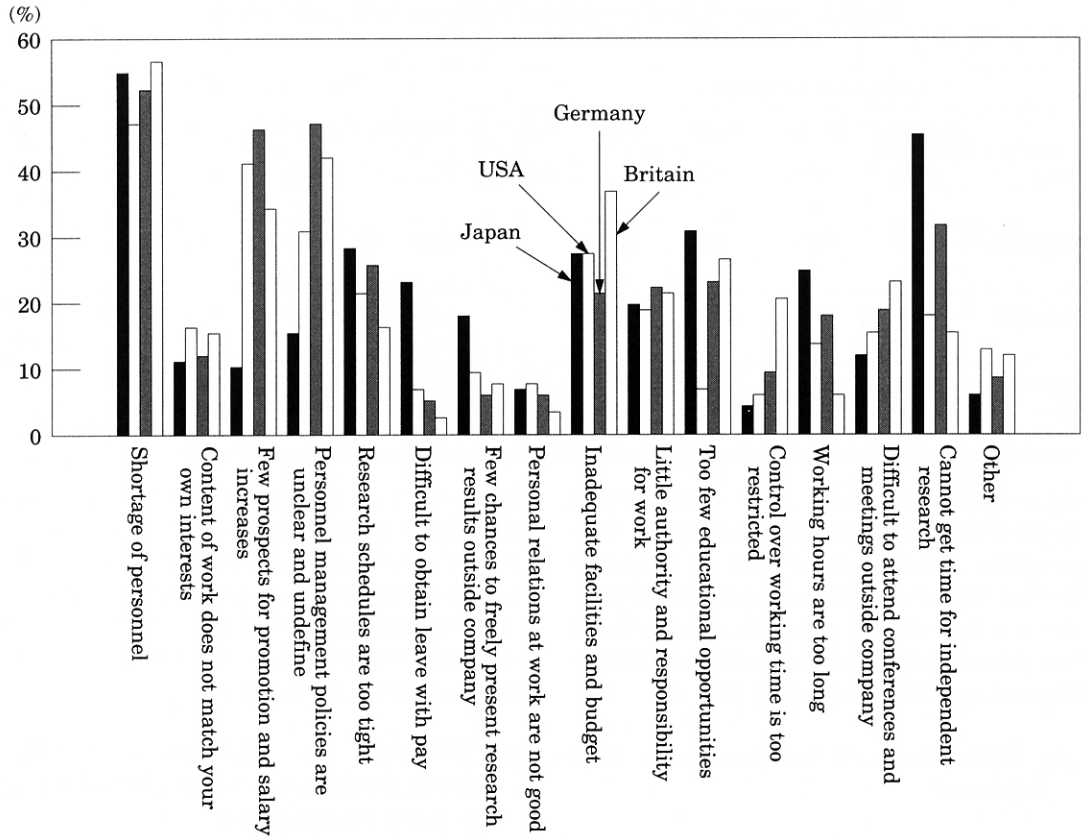

Figure 1 Disatisfaction Factors of R&D Workers (M.C.)

tors in charge of R&D and the engineers themselves answered: "The capability to undertake technological and creative work will begin to decline at the age of 40".

(3) Career Development and the Dual Ladder

According to the conventional "standard promotion course", scientists and engineers will be appointed to managerial positions around the age of forty when their technical ability in R&D begins to decline. Some of them may stay in the laboratory to undertake research management, and others may be transferred to the operating department or a factory to administer the workplace or to manage staff functions of the research department. Today, managerial posts do not increase as much as they used to, owing to the aging workforce and slower economic growth, and there is a growing awareness that research and development is the major determinant of the competitiveness of companies. As a result, it has become increasingly important to effectively utilize the knowledge and skill of competent researchers without wasting it on "chores". Thus, greater attention has been paid to the dual ladder promotion system for R&D engineers.

According to the survey of Japan Productivity Center (1985), a little more than 50% of research departments implement the dual ladder system. However, some problems have been pointed out, say, that most of the specialists are aged persons and that the professional status of specialists are underrated under the system. According to a survey conducted by Shakaikeizai Kokuminkaigi (1991), two thirds of major research institutes employ the dual

Table 2 Academic Background and Doctorate Holders-by Industry

(%)

	Academic Background					How to get doctorate				
	Bachelor	Master	Doctor	Others	N.A.	As Student	On the job	non	N.A.	Total
Drug	20.1	62.1	12.6	4.8	0.4	11.0	23.0	62.5	3.5	100.0 (483)
Electronics	18.9	62.5	16.5	2.1	–	13.0	10.3	71.1	5.6	100.0 (339)
Materials	16.1	66.4	16.3	0.7	–	12.6	14.0	67.8	4.6	100.0 (143)
TOTAL (N)	19.1 (184)	62.9 (607)	14.6 (141)	3.2 (31)	0.2 (2)	11.9 (115)	17.2 (166)	66.3 (640)	4.6 (44)	100.0 (965)

Source: Survey on Japanese Researchers (1994) All following tables from the same source

ladder system, and one third implement a scheme of appointing corporate directors from specialists. Although these findings show that the dual ladder system is widely introduced, there is a long way to go before establishing a "dual career system" wherein managerial positions and specialists are equal in status.

(4) Motivation and Satisfaction of R&D Engineers

According to a survey by ICEF-JAF (1988), R&D engineers are generally more motivated and satisfied with their work than those engaging in other types of job (e.g. manual work, clerical work, sales, engineering and computers). In particular, the findings show that they are highly motivated as they find their work interesting and rewarding. By age, R&D engineers tend to find their work more rewarding and obtain greater satisfaction in general as they grow older. The aforementioned international comparison made by Japan Productivity Center reveals what complaints R&D engineers had in their job (see Figure l). The results show that the shortage of personnel is the largest single source of dissatisfaction among R&D engineers, which is not peculiar to Japan but common to other countries as well. Japanese scientists and engineers have less complaints than those in other countries concerning the content of work, promotion prospects, performance appraisal, and trips to academic meetings. They are, however, more dissatisfied with: the difficulties involved In finding time for autonomous research and in taking paid holidays; scare opportunities for training and development; and long working hours. In other words, their dissatisfaction stems from the lack of time to spare and scarce opportunities to develop knowledge and skills.

2. SURVEY ON HUMAN RESOURCE DEVELOPMENT AND MANAGEMENT OF R&D ENGINEERS

(1) Method and Subject of the Survey

From July to August 1994, 1, 110 questionnaires were sent out to ten research institutes belonging to the four industries: pharmaceutical, electronics, chemicals, and steel. The questionnaires were collected in the first half of September. Among 989 questionnaires which were collected, 965 were considered valid, with the validity rate as high as 86.9%. Each questionnaire was sent to the department managers concerned and collected in an envelope. It seems that the collection rate was very high owing to the cooperative stance of research management departments of the companies.

Among 965 researchers who answered our questionnaire, those in their thirties accounted for 52.7%, those over forty 30.7%, and those in their twenties 16.5%.

Table 2 shows their academic background and the percentage of doctorate holders.

Nearly 20% of those held a bachelor's degree, a little over 60% held a master's degree, and 15% had completed a doctoral course, reflecting their advanced academic career. Nearly 30% were doctorate holders, but those who obtained a doctorate after getting a job (17.2%) exceeded those who acquired one as a full-time student (11.9%). Although the pharmaceutical industry had the smallest number of researchers who finished a doctoral course, a significant number got a doctorate after getting a job; as a result, those with a doctoral degree accounted for a little more than 30%, scoring the highest percentage among the four industries.

Table 3 shows the managerial posts held by R&D engineers who answered our questionnaire. The "managerial level" includes not only managers in the "line" but also manager-class staff and specialists. The table shows the "qualification level" rather than the "post level". As we cannot tell whether a post is in the "line" or not from the questionnaire, we collectively called posts of section-chief level and higher "managerial posts" and posts of sub-section chief level and lower "non-managerial posts". According to this classification, managerial posts represented 32.4%, and non-managerial posts 66.7%.

Table 3 Qualification Levels of Respondents

(%)

Board Member Level	0.3
Department Manager Level	4.9
Sub-department Manager Level	2.7
Section Manager Level	24.5
Sub-section Manager Level	34.2
Non-managerial Level	32.5
Others	0.6
N.A.	0.3
Total (N)	100.0 (965)

Table 4 shows the departments to which R&D engineers currently belong by industry. Basic research departments accounted for 33.8% of all, and applied research departments amounted to 37.9%, totalling a little more than 70%. This shows that "basic oriented" samples were more or less collected as intended. Product development departments represented 14.3%, R&D belonging to operating divisions 3.7%, and R&D planning and management departments 5.3%. The share of basic research in the pharmaceutical industry was greater than in other industries, whereas that of applied research was large in the electronics industry.

As for the gender ratio, 93.3% of R&D engineers surveyed are male, and only 6.7% are female.

Table 4 Currently belonging Department-by Industry

(%)

	Basic Research	Applied Research	Product Development	R&D of Operating Division	Planning & Management of R&D	Others	N.A.	Total
Drug	38.7	28.4	15.9	4.8	6.6	5.0	0.6	100.0 (483)
Electronics	30.7	50.1	8.6	2.4	4.4	2.6	1.2	100.0 (339)
Materials	24.5	41.3	22.4	3.5	2.8	4.1	1.4	100.0 (143)
Total (N)	33.8 (326)	37.9 (366)	14.3 (138)	3.7 (36)	5.3 (51)	4.0 (39)	0.9 (9)	100.0 (965)

Table 5 Means to Get the Current Employment–by Age Grade

(%)

	University Professor	University Alumni	University Placement Office	Parents, Relatives, Friends	Company Visit	Company Prospectives	Company Sollicitation	Employment Agency	Others	N.A.	Total
Up to 30	41.3	11.9	8.1	3.1	26.2	2.5	2.5	0.0	4.4	0.0	100.0
Early 30s	44.9	12.2	8.0	2.3	21.7	3.8	3.8	0.4	2.7	0.4	100.0
Late 30s	46.9	11.8	9.8	5.7	9.4	6.5	3.7	1.2	2.9	2.0	100.0
Early 40s	49.7	6.5	10.3	8.4	10.3	6.5	3.2	1.3	1.9	1.9	100.0
Late 40s	51.1	4.3	16.3	4.3	8.7	3.3	4.3	0.0	6.5	1.1	100.0
Over 50	52.0	4.0	8.0	8.0	2.0	8.0	4.0	0.0	12.0	2.0	100.0
Total	46.5	9.9	9.6	4.8	15.2	4.9	3.5	0.6	3.7	1.1	100.0

(2) Survey Findings

(*a*) *Recruitment*

Among all of the respondents, only 6% answered they had changed companies before. Though there are arguments for greater mobility of research personnel and the need to enhance such mobility. In Japan an overwhelming number of researchers stay in the same company. Looking at their academic backgrounds, we find that 12.8% of those who had completed a doctoral course changed their job, compared with 3.8% of M. A. and 8.2% of B. A. holders. No marked difference was found based on age or type of industry. Those who changed their jobs stated the following reasons in the order of significance.

(1) In order to conduct further studies on one's research theme
(2) Due to head-hunting
(3) Due to favorable financial terms and conditions (e.g. salary)
(4) Due to stressful personal relations at the previous workplace
(5) Due to dissatisfactory working conditions at the previous workplace
(6) The new company seemed more promising than the previous one

Table 5 shows how respondents secured employment at the present company by age group. As a whole, an overwhelmingly large number of researchers joined the company through the introduction of university professors. By age group, most of the older researchers entered the company through the introduction of university professors, whereas younger researchers increasingly joined by visiting companies directly on their own account. Nonetheless, in the age group of 25 to 29, slightly over 25% of researchers entered the company through "company visit", while 40% did so through introduction of university professors.

(*b*) *Intracompany Personnel Transfer*

In our survey, the data on intracompany personnel transfer is the record of work in which R&D engineers were involved in chronological order.

The following facts were found after analysing the career of researchers thirty-five years old and over.

1) Around 20% of the researchers in basic and applied research departments had never been transferred to any other department (18.8% in basic research, 23.2% in applied research, and 8.3% in product development).
2) The number of the "mobile-type" increased, as researchers became older and served for longer years.
3) As for the percentage of "mobile-type" researchers, 25% were in the basic research department, and 40% in the prod-

uct development department, showing that more researchers were transferred as going further downstream.

4) There was also some difference based on academic background. Those who had completed a doctoral course were more likely to stay in basic research, and those with a bachelor's degree were more likely to be transferred.

5) There was also difference by type of industry. The pharmaceutical industry had more "consistent-type" and fewer "mobile-type" basic researchers. The electronics industry had a relatively large number of "consistent-type" applied researchers and more "mobile-type" in research and development. In the material industry, the "mobile-type" is more common than other industries.

Table 6 Effective Method of Skill Development

(%)

Supervisor's Guidance, OJT	25.6
Highly Responsible Work Experience	19.7
Extensive Job Rotation	3.9
Transfer to Operating Division	0.6
Interdepartmental Project	3.5
Participation in New Projects	7.1
Transfer to Affiliated Company	0.3
Outside Joint Research	3.6
Study in Japanese University	3.6
Study in Foreign University	4.0
Self Development	8.9
Professional Seminar	3.9
Outside Study Group	4.3
Intra-Company Study Group	2.4
Academic Meeting	8.6
Total	100.0

Note: Respondents were asked to state the best three in order. The table shows the percentage assuming that Rank 1 = 3 points; Rank 2 = 2 points; Rank 3 = 1 point

(c) *Development of Knowledge and Skills*

Table 6 shows the methods, which were effective in the development of knowledge and skills. It indicates that informal on-the-job training and learning within the company was by far the most important means, such as guidance from superiors / supervisors and OJT (25.6%), experience in highly responsible work (19.7%), and self development (8.9%).

Academic meeting was considered to be the most effective as an opportunity outside the company for developing knowledge and skills (8.6%). Other effective means included: study meetings with experts outside the company; studying abroad; professional seminars; joint research outside the company; and studying in domestic universities.

(d) *"Age Limitation Theory"*

Among the researchers who were asked if

Table 7 At What Age R&D Engineers Reach the Age Limit as Front-Line Researchers? –by Industry

(%)

	Early 30s	Late 30s	Early 40s	Late 40s	Over 50	Depend on Individual	N.A.	Total
Drug	0.6	8.2	29.8	30.1	4.7	26.0	0.6	100.0 (319)
Electronics	1.8	22.0	31.1	10.4	3.0	30.5	1.2	100.0 (164)
Materials	2.8	4.2	25.4	19.7	2.8	40.8	4.2	100.0 (71)
Total (N)	1.3 (7)	11.7 (164)	29.6 (127)	22.9 (22)	4.0 (22)	29.2 (162)	1.3 (7)	100.0 (554)

Table 8 Reasons for Age Limit as Front-Line Engineers (M.C.)–by Industry

(%)

	Decline in Physical Strength	Decline in Concen-tration	Decline in Creativity	Decline in Challenge Spirit	Difficult to Catch up With Inno-vation	Busy With Adminis-trative Job	Busy With Chores	Others
Drug	36.4	16.9	33.5	28.5	18.2	68.3	52.7	1.6
Electronics	15.2	18.3	29.3	23.8	14.0	73.8	58.5	2.4
Materials	25.4	25.4	25.4	19.7	14.1	66.2	53.5	5.6
Total	28.7	18.4	31.2	26.0	16.4	69.7	54.5	2.3

Table 9 Do You Wish to Take High-Ranking Specialist Post? –Manager and Non-Manager

(%)

	Yes, Absolutely	Yes, if Possible	Prefer Not To	Definitely Not	Cannot Decide	N.A.	Total
Manager	9.9	27.9	27.9	13.1	19.9	1.3	100.0 (312)
Non-Manager	16.1	39.6	15.2	5.9	22.4	0.8	100.0 (644)
N.A.	11.1	44.5	11.1	0.0	33.3	0.0	100.0 (9)
Total (N)	14.1	35.9	19.3	8.2	21.7	0.9	100.0 (965)

there is an "age limit" to act as front-line researchers, 57.4% of them answered "Yes" and 42.5% answered "No". Among the researchers who has completed a doctoral course, 48.9% responded "No", exceeding M. A. holders who said "No" (41.4%) and B. A. holders (43.8%). Table 7 shows the answers by type of industry to the question "At what age do researchers reach the age limit?" Generally, most of the respondents (29.6%) answered that age limit would be in the early forties followed by 22.9% who said late forties, and 11.7% who said late thirties. 29.2% responded that such age limit would depend on the individual. Researchers in the electronics industry considered that their ability would peak earlier than those in other industries: 54.7% said that age limit would come by one's early forties, compared to 38.6% of researchers in the pharmaceutical industry and 31.9% in the material industry.

Table 8 shows what researchers considered to be the causes of such limitation by age. In general, the most common answer was: "Because people become busy dealing with administrative duties" (69.7%), followed by those who said, "Because people become busy undertaking tasks other than research" (54.5%). More emphasis was placed on these two factors than on psychological and technological obsolescence, such as the decline of creativity and ideas, physical strength, challenge spirit and concentration as well as "difficulty in catching up with technical innovation". More researchers in the pharmaceutical industry (66.0%) recognized "age limitation" than those in the other industries, emphasizing that the decline of physical strength, creativity and challenge spirit are the main causes.

(*e*) *Dual Ladder System*

To grasp whether researchers wish to follow a "specialist career", we asked, "Do you wish to take a high-ranking specialist post such as 'Fellow'?" Table 9 shows how the managerial

Table 10 Relative Importance of Incentives for R&D Engineers

	Point	Rank
Leadership of Supervisor	1.27	1
Freedom in Research	1.00	1
Freedom in Time	0.75	2
Interaction With Other Departments	0.89	2
Research Exchanges With Outside Researchers	1.04	1
Recruitment of Talented Researchers	0.77	2
Employment of Researchers from Abroad	0.19	3
Nice Research Facilities	1.14	1
Research Expenditure on a Priority Basis	0.96	2
Top Management's Enthusiasm for Research	1.29	1
Capability of Leaders of the Research Department	0.15	1
Remmuneration Directly Linked to Research Achievement	0.70	2
Human Relations at the Workplace	1.02	1
Open Organizational Culture	1.13	1
Clear Research Goals	1.41	1
Fair Performance Evaluation	1.27	1
Extensive Rotation	0.09	3
Solid Research Support Staff	0.80	2
Atmosphere to Empasize Professional Skills	0.75	2
Indulgence in Hobbies and Leisure	0.12	3
Support by Family	0.75	2

Note:
(1) The table shows the percentage assuming that: "Extremely important"=2 points; "Important"=1 point; "Not Very Important"=−1 point; "Irrelevant"=−2 points
(2) Rank 1=rated 1 and more points; Rank 2=rated 0.5 and more but less than 1 point; Rank 3=rated less than 0.5 points

class (section chief level and higher posts, including senior staff and specialists) and the non-managerial class answered this question. Among the respondents, 14.1% answered "Yes, absolutely", and 35.9% said, "Yes if possible". In other words, half of the respondents wished to take a high-ranking specialist post, substantially exceeding those who did not wish (27.5%). Among the managerial class, 41.0% did not want a high-ranking specialist post, surpassing those who did (37.8%). Nevertheless, we can conclude that a substantial number of researchers do wish to take high-ranking specialist posts (including the managerial class researchers). Asked why they wanted a high-ranking specialist post, 67.0% answered "Because I want to concentrate on research", and 64.3% said, "Because my personality and ability are fit for research", which both excelled other reasons by far. Asked why they did not want the post, 43.8% answered "Because more extensive work could be done as a manager", 38.1% said "Because I want to gain experience in departments other than research", and 29.1% said "Because a managerial post would suit me better".

Table 11 Job Satisfaction

	Point	Rank
Research theme	0.55	1
Workload	0.23	2
Evaluation of research performance	0.04	2
Personnel appraisal	−0.04	3
Prospects for promotion	−0.01	3
Research support system	−0.28	3
Research budget	0.07	2
Interaction with other departments	−0.04	3
Research facilities	0.17	2
Location of the research institute	0.27	2
Environment of the research institute	0.07	2
Exchanges with other research institutes	−0.32	3
Presentation of research results outside the company	0.11	2
Opportunity for skill development	−0.03	3
Human relations with superiors	0.50	1
Human relations with colleagues	0.69	1
Freedom in research	0.43	2
Delegation of authority in work	0.24	2
Working hour	0.32	2
Salary and bonus	−0.05	3
Fringe benefits	−0.22	3
Overall satisfaction	0.29	2

Note:
(1) The table shows the percentage assuming that: "Totally satisfied" = 2 points; "Relatively satisfied" = 1 point; "Relatively dissatisfied" = −1 point; "Totally dissatisfied" = −2 points
(2) Rank 1 = rated 0.5 points and more; Rank 2 = rated more than 0 points but less than 0.5; Rank 3 = less than 0

(*f*) *Motivation and Commitment*

The following indicate how researchers think of their job. The figures show the percentage of affirmative answers.

I am interested in my job 83.3%

I want to improve my job 93.8

I have worries about unfinished work even after I get home 66.9

Working would be dull if I'm not given the opportunity to present my views 70.3

I do job-related study even in my spare time 56.2

I want to continue my present job in future 76.6

I always think how to proceed with job 77.8

I am prepared to work harder for the company than others 36.0

My idea is compatible with the company policy 31.4

I'm glad to have chosen this company 49.2

Table 12 Importance, Satisfaction, and Importance × Satisfaction

	Importance (I)(1)	Satisfaction (S)(2)	(I)×(S)(3)
Research Theme	1	1	A
Evaluation of Research performance(4)	1	2	B
Personnel Evaluation	1	3	C
Research-Support System	2	3	C
Research Budget	2	2	B
Cooperation with Other Departments	2	3	C
Research Facilities	1	2	B
Exchange with Outside Institutes	1	3	C
Human Relations with Supervisors(5)	1	1	A
Human Relations with Colleagues	1	1	A
Freedom in Research	1	2	B
Working Hour	2	2	B
Salary and Bonus	2	3	C
Overall	1(6)	2	B

Note:
(1) In Table 11, the ranking assuming that: 1=degree of importance rated as more than 80%; 2=50~79%; 3=less than 50%
(2) In Table 12, the ranking of the difference between ratios of satisfaction and dissatisfaction assuming that: 1=30% or more; 2=0~29%; 3=negative figures
(3) The ranking of (I)×(S) was decided in consideration of the degree of importance and degree of satisfaction
(4) In Table 10 "fair performance evaluation"
(5) In Table 10 "leadership of supervisors"
(6) Rank 1 refers to 13 items that are common to Table 10 and Table 11 with a high average of the degree of importance

While researchers are strongly committed to their work, as the above figures show, they do not necessarily have a strong sense of identification with the company. To study this from another angle, we asked the researchers to prioritize the following six items related to their commitment to work and their sense of identification with the company. We found that they rated in the following order, regardless of their age, academic background, and position. The results clearly show that researchers are strongly committed to their work, but their sense of identification with the company was not so strong

(1) Subject of my research
(2) Research as a job
(3) Seniors and colleagues at the workplace
(4) Direct supervisor
(5) The research institute
(6) The company

(g) Incentives for R&D Engineers

Table 10 shows the relative importance of various factors in stimulating researchers and promoting research achievements. Researchers regarded most of the factors listed in the table as important in stimulating research. Those of "Rank 1 importance" included clear research goals; top management's interest in research; fair evaluation of performance, leadership capability of superiors/supervisors; capability of leaders of the research department; open atmosphere of the organization; research

Table 13 Rewards for High Performing Researchers

	Emphasized by Company	Emphasized by Researcher
Pay Raise	12.7	11.5
Bonus and Personal Rewards	11.5	11.7
Sabbatical Leave	0.2	2.8
Long Vacation	0.03	2.1
Promotion to Managerial Posts	17.9	5.1
Appointment to High-Ranking Research Specialist	5.6	7.7
Greater Freedom in Research Themes and How to Proceed	5.9	13.8
Greater Authority over Research Activities	4.0	13.4
Larger Research Budget	3.6	10.3
More Research Staff	4.9	8.8
Outside Research Opportunities	7.4	8.1
Intracompany Commendation	14.9	2.2
Acquisition of Patent	2.5	0.5
Others	0.2	0.3
Total	100.0	100.0

Note:
Researchers were asked to state the best three in order. The table shows the percentage assuming that: Rank 1=3 points; Rank 2= 2 points; Rank 3=1 point

exchange outside the company; human relations at the workplace; and freedom of research. Only three of the factors were regarded as less important (Rank 3): wide-range rotation of engineers; hobbies and leisure activities; and employment of foreign researchers.

Next, Table 11 shows the results of ranking the degree of satisfaction with the present research environment, in the same way as Table 10. Findings show that researchers are most satisfied with human relations with colleagues, research themes, and human relations with superiors/supervisors. In contrast, they are less satisfied with regard to; opportunities to exchange with other research institutes; fringe benefits; research-support system; opportunities to develop knowledge and skills; salary and bonus; and performance evaluation.

Not all the items in the "relative importance" list were same as those in the "relative satisfaction" list, but thirteen items were common or comparable. We matched "leadership capability of supervisors" with "human relations with supervisors" and "evaluation of research performance" with "performance appraisal". Then, we calculated "overall importance" by averaging the importance of each item, and arranged them in order (Table 12). Rank A means the items were highly important as well as satisfactory. Rank C means importance was rather high (Rank 1 or 2) but satisfaction was low (Rank 3). The three items ranked A were research themes, human relations with supervisors, and human relations with colleagues.

This indicates that researchers are content with their present research themes and human relations at the workplace. On the other hand, items ranked C, which were high in importance but low in satisfaction, included: performance appraisal; research-support system; cooperation with other departments; opportunity to exchange with other research institutes; salary and bonus. It is necessary to work on these issues to improve the situation.

Table 14 Management of R&D Engineers

	Point
Competent Researchers Tend to be Competent Managers	−0.54
Competent Researchers Should Become Research Managers	−0.03
Pay Differentials Should be Extended Based on Research Achievements	0.79
Promotion Speed Should be More Unequal Taking the Past Achievements into Account	0.68
Career Routes Should be Diversified according to Academic Background	−0.62
Working Hour and Work Rule Should be More Flexible	0.99
Personnel Exchange Between Research and Other Departments Should be More Active	0.92
More Researchers from Other Companies Should be Recruited	0.71
There Should be More Foreign Researchers	0.74
Employment Contracts Should Take Various Forms	0.44
Age-Limitation Theory Should be Ignored	0.97

Note:
Arguments for and against are rated from 1 to 5, assuming that: "Fully agree" = 2 points; "more or less agree" = 1 point; "more of less disagree" = −1 point; "Disagree" = −2 points

Other items (i.e. evaluation of research performance, research budget, research facilities, freedom in research, and working hours) were ranked B, with which researchers were relatively content, even though not fully. "Overall importance-satisfaction" was also ranked B which is fairly good.

(*h*) *Research Incentives*

We asked "What form of remuneration and reward for researchers making substantial research achievements, do you think, are emphasized by your company at present" and "What form of remuneration and reward should be emphasized from researchers' point of view?" We made researchers select the three most important items, and the results are shown in Table 13. In order of significance, companies emphasize: (1) promotion to managerial post, (2) intracompany commendation, (3) pay rise, (4) bonus and personal reward, and (5) outside research opportunities (e.g. studying at universities abroad). In contrast, the researchers regarded the following items as important: (1) greater freedom In research themes and how to proceed, (2) greater delegation of authority over research activities, (3) bonus and personal rewards, (4) promotion, and (5) larger research budget. The conspicuous difference was that the companies place emphasis on commendation and promotion, whereas the researchers wanted more freedom in research.

Table 14 shows the answers to the questions, "How should research personnel be managed?" Most of the researchers opposed the two items, "The career paths should be divided based on academic backgrounds" and "Competent researchers are also competent managers". Opinions were divided as to "Competent researchers should manage research".

"Diversified employment forms such as term contracts" gained approval but ranked low. All the other items were strongly supported, including: flexible working hours and work management; eradication of "age limitation" superstition; more personnel exchange with other departments; salary system based on merit rating, introductions of foreign researchers; recruitment of talented individuals; and merit-based promotion scheme.

(*i*) *Creativity and Research Achievements*

We asked the researchers of different academic backgrounds, "Do you think you are

Table 15 Research Achievements after Entering the Company (M.C.)-by Educational Background

(%)

	Doctoral	Master	Bachelor	Others	Total
Overseas Patent Application	56.7	44.0	45.1	22.6	45.3
Domestic Patent Application	75.2	70.7	67.4	38.7	69.5
Presentation at Overseas Academic Meeting	57.4	45.3	38.0	16.1	44.7
Presentation at Domestic Academic Mssting	74.5	72.7	72.8	45.2	72.1
Publication of Paper in Overseas Journal	56.7	43.0	41.3	38.7	44.5
Publication of Paper in Domestic Journal	56.7	44.8	47.8	38.7	46.8
Commercialization of Research Achievements	29.1	32.8	44.0	22.6	34.1
Commendation in the Company	36.9	31.1	39.1	19.4	33.2
Commendation Outside of the Company	7.8	6.6	7.6	6.5	6.9
Meet Serious Demands of Operating Divisions	22.0	14.2	23.4	19.4	17.2
Invited Guest Speaker	21.3	9.2	16.8	16.1	12.6
Chairman of International Conference	10.6	3.6	6.0	0.0	5.0
Host of International Conference	2.1	1.6	2.2	0.0	1.8

creative ?" and "Do your superiors, supervisors, or colleagues say that you are creative?" Namely, we compared findings based on self-evaluation with the evaluation by others on creativity of researchers, and obtained the following results. (Two points were given to the answers "Frequently", one point to "Sometimes", and zero to "Not at all".

	Self evaluation	Evaluation by others
Researchers who completed a doctoral course	0.60	0.45
Researchers with M. A.	0.31	0.43
Researchers with B. A.	0.18	0.32

Researchers with higher academic career rated themselves higher and also enjoyed high ratings from others. The difference based on academic background was smaller in the evaluation by others.

Table 15 shows the achievements, which the researchers of different academic background made after securing employment at the present company. The difference in academic background was obvious only in terms of: domestic patent applications; presentation at overseas academic meeting; and papers printed in foreign journals. No difference was found in; presentation at domestic academic meeting; papers printed in domestic journals, commendation outside the company; meeting Important demands from operating divisions; lecture invitations; and even in chairmanship and sponsorship of international conferences. A "reverse academic gap" was recognized in intracompany commendation for research achievements and commercialization of products, which seems to reflect the fact that researchers are not differentiated on the basis of academic background in work assignment and treatment at Japanese research institutes.

As for the average age by academic background, those who had completed a doctoral course were 38.9 years old, M.A. holders were 35.5, and B.A. holders were 38.3 years old. M. A. earners were the youngest group.

3. DISCUSSIONS OF THE SURVEY FINDINGS

(1) Mobility of Human Resources and Homogeneity/Heterogeneity

Japanese researchers rarely change jobs once they are employed; they form a stable group. Now, fewer researchers are employed through "Introduction of university professors" than before, but this remains to be the single most important recruiting route. It seems that companies are obliged to regard this as an important stable source of recruits with quality assurance.

The economic boom and progress of globalization in the 1980s have led to recruiting of talented mid-career and foreign researchers. This trend, however, failed to influence the researchers group strong enough to change their nature as the stable core of human resources. The common view is that not only new graduates but also mid-career researchers and foreigners should be recruited as a supply source of human resources in the future. That is why it is becoming more acceptable to diversify employment forms. In other words, it is considered that this would be beneficial to introduce "heterogeneity" into the research groups in Japanese companies, which tend to become homogeneous. However, successful R&D activities in modern enterprises require a long-term group cooperation among many scientists and engineers. Existence of a stable core of research group would be indispensable to research and development. Nevertheless, creative research originates from creative individuals; therefore, it is important to stimulate creativity through vitality and synergy brought by the introduction of heterogeneity, but still more important is to employ creative researchers from outside. The fact that researchers are job-oriented rather than organization-oriented would make easier for them to be integrated into the core group.

(2) Intracompany Personnel Transfer

Compared with researchers in other countries, fewer Japanese researchers quit their job to take up a post in another company, but more researchers are transferred within the company. The actual patterns of intracompany transfer of researchers have been revealed to a certain extent, and it is generally considered that such transfer contributes to; the development of knowledge and skills; organizational integration; and improvement of R&D performance. However, intracompany transfer is not always carried out systematically nor intentionally for developmental purposes. In addition, the transfer may often be carried out in accordance with stereotyped "age limit theory", rather than on the basis of assessment of individual capabilities.

Our survey shows that 20 to 30% of scientists and engineers in the research department are of the "consistent-type", while the majority have experienced transfer. If they are transferred out of business necessity or the stereotyped "age limit theory", rather than based on human assessment, such transfer may do more harm than good, hindering professional specialization and nipping creative research in the bud. Even if researchers pursue the specialist career, there is a good chance that they will be influenced by diversity and heterogeneity through the changes in job and duty within their departments and internal/external information exchanges, making them more vitalized and creative. Even though personnel transfer has many advantages, we should not sacrifice professional profundity: the foundation of creativity. If the focus of research and development in Japan is shifting from development to research, from efficient development to creative research, it would be advisable to undertake more systematic and selective interdepartmental transfer and attach greater importance to specialization. Some reports say that competent researchers are more often transferred (Kusunoki & Numagami 1995), but it would be problematic if the majority of interdepartmental transfer is from upstream to downstream and if the "average career pattern" is that researchers reaching the stereotyped "age limit" are transferred to other departments. Basic research divisions should have a relatively large number of "consistent-type" researchers and the product development and research-planning departments should consist of engineers and researchers experiencing Interdepartmental transfer two or three times; this should be the standard "career patter".

(3) "Age-Limitation Theory" and Career Development

Western countries also discuss the issue of technical obsolescence, but unlike Japan, they seldom argue over "age limitation" (for example, the 40-year-old retirement system for researchers). In Japan, the "age limitation" concept is deep-rooted at the workplace as a norm. At the same time, social pressure is exerted upon researchers which makes them feel they should resign from the front-line at a certain age. Our survey, however, shows that over 40% of the researchers argued that there is no "age limitation". Among those who argued that there is an "age limitation", nearly 30% did not specify such age, saying that "It depends on the individual". Hence, we can assume that more than half of the researchers were opposed to specifying the age limit. When asked for the grounds of age limits, the vast majority answered "People become busy with administrative duties" and "People become busy with work other than research (so-called chores)", and a relatively small number said age limitation would be caused by declining creativity and technological obsolescence.

Therefore, to enhance the development and maintenance of research capability and to fully utilize it, we should first eliminate excessive concerns about age that is omnipresent in the Japanese workplace and change such organizational climate. Then, competent researchers should devote themselves to research and competent managers should advance their careers toward development, research-planning and business management. Those who are good at both research and management should play the role of a research manager, such as management of a research institute. According to the survey findings, there were more researchers than expected who said that they would like to take a specialist career. Though this may reflect the fact that there are fewer opportunities to become a manager in the low-growth economy, a substantial number of them probably really do want to concentrate on research and pursue the research specialist career because they are fit for it. So far, however, it is difficult to argue that the status of specialists is fairly valued under the dual ladder system in Japanese companies.

(4) Factors Vitalizing Researchers

Researchers are more highly motivated, but are less attached to the organization. They seem to be committed to work itself. According to our study on research work and environmental factors, the job itself (research theme) and human relations at the workplace ranked high in terms of both importance and satisfaction. The factors which ranked high in importance but low in satisfaction included: performance evaluation: research-support system; cooperation with other departments; exchange with other research institutes; and salary and bonus. As a reward for outstanding achievements, researchers wanted the freedom of research more than anything else, namely the freedom in theme setting, how to proceed, working hours and work system, exchange with outside the company, and research expenditure. Now, let us take a closer look at these issues.

a) Greater Freedom in Research

Traditionally, the management of research laboratories of Japanese companies tended to treat the laboratories no different from other departments, ignoring their unique requirements. As for working hours, no open complaints were raised in spite of their length, partly due to the introduction of the flexible-working-hour scheme. Unlike university laboratories, even basic research laboratories are strongly expected to achieve the results that ultimately lead to the development of new products. Such pressure has been growing under the economic stagnation in recent years. But to promote creative research, freedom of research is strongly demanded. While it is important for top management to clarify the research policies and targets to raise research efficiency, the freedom of research is called for to promote creativity; the major challenge is how to balance the two.

b) Performance Appraisal and Evaluation of Research Achievements

Usually, nobody is satisfied enough with performance evaluation. Our survey findings show that the evaluation of research achievements was relatively satisfactory, but performance appraisal was less satisfactory. We suppose this was the case due to difficulties involved in evaluating individual contributions to research achievements made as a team and due to the lack of openness and fairness of performance appraisal.

c) Exchange of Research and Support Systems

The respondents of our survey were mostly basic and applied researchers belonging to upstream departments. The findings reveal that they want to have more opportunities for research interaction inside and outside the company. Devotion to research does not contradict with active research exchanges, which stimulates the creative capability of researchers. Researchers would rather leave the chores involved in research to assistants and devote themselves to research. Needless to say, it is extremely important to build an environment where competent researchers can concentrate on research, and it is necessary to drastically improve the support system. Regarding this, let's turn to the issue of "career, differentiation based on academic background", which was opposed by many respondents in our survey. Though egalitarian work norms are desirable in view of equal opportunity, it would be problematic if they even force first-class researchers to undertake the chores equally. It seems that the difference in the role-taking should be more clearly defined on the basis of academic career and past achievements in Japanese research institutes.

d) Financial Incentives

There were not very strong complaints about financial incentives, such as salaries, bonuses and rewards. Researchers are probably satisfied with the financial aspects as long as they are motivated and satisfied with the work itself. It would be difficult to give extraordinary compensation even to researchers making outstanding achievements as it would arouse much complaints, considering that no achievement can be made without the cooperation of many people until the product is commercialized. The standard way of rewarding highly competent researchers would be to assign them better projects and duties than others, and promote them to a managerial post a little earlier in the long run. Nevertheless, we cannot ignore expectations for salaries and bonuses that are more directly linked with achievements. Research achievements should be linked with rewards within a shorter time span than usual. To that end, it will be necessary to introduce a system, which can accurately evaluate the research achievements of individuals, which tend to be hidden beneath achievements made as a team. It will also be important to internally commend useful patents and such activities that are highly appreciated outside the company (e.g. activities in professional meetings and academic journals) in more visible forms, not only nominal commendation but also rewards in substance.

CONCLUSION

One survey can be summarized as follows. Japanese researchers usually keep their job once they are employed, and the argument that greater mobility would promote creative research is not supported by solid evidence. Recruitment of talented individuals and employment of foreigners would help vitalize the stagnant research groups through the injection of heterogeneity, but the most important thing will be to introduce creative and original researchers. Intracompany personnel transfer is actively carried out in Japan, compensating the low mobility of human resources among companies, and contributing to the stimulation of researchers, career development, and the integration of departments. However, quite a few people-mainly researchers in basic research departments-pursue the same course of work single-mindedly. Excessive concerns over age are deeply embedded in the Japanese business climate and the workplace as a norm, reinforcing the researchers belief in the "age limitation theory". Unprejudiced human resource management without being influenced by the "ageism" concept would pave the way for more effective human resource utilization and career development. More researchers definitely intend to pursue a specialist career. If a system is established in which professional achievements are justly evaluated, competent researchers can devote themselves to creative research, aiming at the specialist career path. Researchers are calling for greater freedom of research and a result-oriented reward system to achieve better results. On the other hand, the present economic environment is such that the management is feeling strong needs to tighten control to raise research efficiency. To promote creative research and development, it would be necessary to keep a balance between freedom of research and control at a sophisticated level.

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