International Comparison of Determinants of R&D Performance

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Problem and Background

In the past 5 years we have been engaged in questionnaire surveys of industrial R&D engineers in Japan and foreign countries to find out what kind of work environments and management of human resource are appropriate to enhance creative research performance. In 1994 we conducted the first questionnaire survey of nearly 1,000 Japanese basic and applied researchers in pharmaceutical, chemical, electronics and steel industries and then we collected survey data of about 1,300 applied research and product development engineers in 1998. We started international comparative surveys with India and United Kingdom in 1997 and Korea and Taiwan in 1998. We are now being engaged in the same surveys in France and Germany.

In this paper we analyze the comparative data of the questionnaire surveys of applied research and product development engineers in Japan, U.K., India, Korea and Taiwan to reveal the universal factors to bring about creative R&D outcomes as well as differences in the critical factors in industrial innovations among nations and region.

Among the preceding studies on comparative human resource management of R&D engineers, two research reports are particularly pertinent to our present study. Japan Productivity Center conducted questionnaire surveys of about 1,800 R&D engineers of Japan, U.K., West Germany and U.S.A. in 1989 and 1990 (Shapira 1995). In analyzing the comparative data, they found out national differences of the career development and human resource management of R&D engineers. Inter-firm mobility of Japanese R&D engineers is extremely low compared with western countries. Western R&D engineers' mobility is much higher and they have broader job experiences than Japanese counterpart. Japanese R&D engineers are much more obsessed with age limitation as front-line researchers than western counterparts, who believe age-limit primarily depends on individual capability. Japanese R&D engineers wish to continue their technical career more than western engineers who are management career oriented.

Our survey of nearly 1,000 basic and applied researchers in 1994(Ishida 1998) found out the followings: Japanese researchers' mobility is very low, but their intra-company mobility seems comparatively higher. The main flow of inter-departmental personnel transfer is from "upstream" to "downstream", that is, from basic/applied research to product development and production engineering/manufacturing. However, "countercurrents" from downstream to upstream are also seen quite often. Japanese researchers are excessively age-conscious, but main reason for age limitation to come is because researchers become busy with management tasks or "chores" rather than because of declining creativity or technological obsolescence. More economic rewards are needed for high performing researchers, but greater freedom in research is even more desired for high performers.

Comparative Surveys of R&D Engineers

Based on surveys of the preceding studies, we focus on human resource and organizational factors to influence creative performance of researchers such as mobility of researchers, career and age consciousness, incentive systems, autonomy and freedom at work and information and communication flows.

Table 1 Survey Data

	Dates	Number of responses	Rate of collection
U.K.	1997~1998	767	42.2%
Japan	1997~1998	1,219	76.2%
India	1997~1998	411	43.4%
Korea	1998	921	*
Taiwan	1998~1999	512	43.0%

* Korean data are collected through internet.

Table 3 Mobility of Researchers (%)

	Change of companies		Total
	Yes	No	
U.K.	44.0	56.0	100.0 (761)
Japan	7.0	93.0	100.0 (1,219)
India	36.3	63.7	100.0 (408)
Korea	a6.8	83.2	100.0 (900)
Taiwan	51.7	48.3	100.0 (505)
Total	25.8	74.2	100.0 (3,793)

Now we analyze our questionnaire survey results of Japan, UK, India, Korea and Taiwan. Although our survey samples of each nation and region are varied as to industries and research areas, the respondents are mostly researchers and engineers of applied research and product development in electronics and information industries. But in Japanese sample about 50% of the total are pharmaceutical researchers, and in Indian and Taiwanese samples about half of the total are researchers of government institutes (Table 1).

Average age of our respondents is 35 years old and average tenure is 7.6 years, the longest 11.3 years of Japan and the shortest 5.1 years of Taiwan. Table 2 shows the academic degrees of respondents of each country and region. The highest percentage of doctorate holders is with U.K., followed by India. Over half of Japanese R&D engineers are with master's degree.

Mobility of R&D engineers

As expected, Japanese R&D engineers' mobility is the lowest 6.9 % and the highest is 51.7% with Taiwan, followed by U.K. 44.0% (Table 3). The first choice of the workplace they want to work in the future is the "present company" for all nationals; the highest is Japan (76.1%) and the lowest is Korea (34.6%). For Korean other research institute (e.g. university) and "establish oneself independently" are more important than other countries (Table 4). As to the means they were hired, "introduction by university professor" is overwhelmingly important in Japan but "prospectus and advertisement" and "applied directly" are more important in other countries.

Age consciousness

Japan is well known as age-conscious country. To the question "do you think there is age-limit for researchers to perform effectively?" the majority of Taiwanese as well as Japanese respond in the affirmative. However, 76.9% of U.K., 66.3% of Koreans and 63.8% of Indians respond negatively to that question (Table 5). R&D engineers who admit age-limit think that it comes between late 30s and late 40s. In U.K. and India the majority of those who admit age-limit answer that "it depends on the individual". Concerning the "main factors that make researchers ineffective", "too busy dealing with administrative duties" and "too busy undertaking the chores" are more important reasons in all countries and region

Table 2 Educational Qualifications (%)

	Doctorate	Master's degree	College degree	Other	Total
U.K.	38.8	20.1	37.2	3.9	100.0 (761)
Japan	17.7	54.9	23.3	4.1	100.0 (1,209)
India	23.8	36.7	37.2	2.2	100.0 (403)
Korea	8.9	49.8	38.7	2.7	100.0 (902)
Taiwan	18.3	47.6	17.1	16.9	100.0 (502)
Total	20.6	43.8	30.4	5.2	100.0 (3,777)

Table 4 First Choise of Workplace in The Future (%)

	Present company	Different company	Research facility other than company	Establish self independently	Others	Total
U.K.	69.5	14.2	4.3	7.1	5.0	100.0 (747)
Japan	76.1	5.5	9.4	6.2	2.8	100.0 (1,208)
India	51.2	14.5	15.0	15.5	3.7	100.0 (406)
Korea	34.6	5.0	29.8	25.3	5.3	100.0 (908)
Taiwan	54.4	18.7	13.4	10.3	3.2	100.0 (493)
Total	59.2	9.8	14.4	12.5	4.0	100.0 (3,762)

Table 5 Age-limit for Researcher (%)

	Any age-limit for researcher?		Total	How comes the age-limit?		Total
	Yes	No		Specific age	Depends on individual	
U.K.	23.1	76.9	100.0 (765)	35.1	64.9	100.0 (174)
Japan	53.9	46.1	100.0 (1,219)	77.9	22.1	100.0 (656)
India	36.2	63.8	100.0 (398)	42.6	57.4	100.0 (148)
Korea	33.7	66.3	100.0 (911)	94.3	5.7	100.0 (370)
Taiwan	52.2	47.8	100.0 (504)	72.1	27.9	100.0 (269)
Total	40.8	59.2	100.0 (3,797)	72.9	27.1	100.0 (1,617)

Table 6 Main Factors That Make Researchers Ineffective (M.A.) (%)

	Physical factors	Psy-chological factors	Lack of fresh ideas	Less motivated to challenge new themes	Unable to keep pace with tech-nological innovation	Too busy dealing with administra-tive duties	Too busy undertak-ing tasks other than research	Others	Total
U.K.	4.6	14.9	45.1	40.6	36.0	65.1	59.4	12.0	100.0 (175)
Japan	27.1	15.2	34.5	24.1	22.4	69.4	52.6	1.7	100.0 (656)
India	32.1	48.8	28.0	43.5	38.1	49.4	51.8	8.3	100.0 (168)
Korea	15.1	19.4	39.4	33.5	24.3	59.6	67.0	4.9	100.0 (391)
Taiwan	39.3	22.7	32.2	25.1	36.6	48.1	42.0	3.1	100.0 (295)
Total	24.6	20.8	35.7	30.1	28.3	60.9	54.7	4.4	100.0 (1,685)

than such reasons as "lack of creativity", "less motivated to challenge new themes" and technological obsolescence (Table 6).

Incentives for high performance

What kind of rewards for researchers' achievements are currently accorded by company and should be emphasized in the future? Researchers' responses are summarized in Table 7. Respondents are requested to choose first, second and third items in order of importance among 14 items and figures in Table 7 show average points of each item, assuming that rank 1=3 points, rank 2=2 points and rank 3=1 point. Only 8 items with relatively high scores are shown in the Table, omitting other items with low scores.

Companies generally emphasize pay raise, bonus and promotion to manager except Korea where bonus, outside research oppor-

tunities and intracompany commendation are more emphasized by company.

Freedom in research as reward for high achievements (two items "freedom in setting theme" and "delegation of authority") generally is not so emphasized by company, but in every country and region researchers think it should be more emphasized in the future, particularly in Japan. Although promotion to manager and intracompany commendation as reward are generally emphasized by company, they are much less emphasized by researchers. On the contrary, appointment to special-status research specialist is more desired by researchers than company (except Taiwan). The gaps between company's emphasis and researcher's desire are larger in Korea and Japan than other countries and region.

Importance and fulfillment of incentive factors

We asked researchers what are important factors to improve research performance and how much these factors are realized at workplace. We take up 26 factors and ask respondents to evaluate the relative importance and degree of fulfillment of those factors. We rated relative importance of each factor: High; Medium; Low and degree of fulfillment: High; Medium; Low. We define the item with High or Medium importance and High fulfillment to be A, the item with relatively High importance and Medium fulfillment to be B, the item with relatively High importance and Low fulfillment to be C, the item with relatively Low importance and relatively Low fulfillment to be D, and the item with Low importance and High fulfillment to be E. Table 8 shows the summary of the importance and degree of fulfillment of each item.

Among 26 items in Table 8, items such as research theme establishment, clear research goals, human relations at work, leadership capability are generally valued high by respondents (A or B). Such items as support staff, promotion opportunities, pay linked with achievements, communications with other institutes, fringe benefits are generally

Table 7 Reward Emphasized by Company and Researcher

		Pay Raise	Bonus and individual rewards	Promotion to managerial posts	Appointment to special status research specialist positions	Greater freedom in setting research themes and how to proceed	Great delegation of authority over research activities	Outside research opportunities	Intracompany commendation
U.K.	Company's	1.180	1.334	0.849	0.415	0.454	0.314	0.063	0.316
	Researcher's	1.257	1.081	0.304	0.729	0.832	0.424	0.198	0.130
Japan	Company's	1.042	1.313	0.938	0.355	0.321	0.178	0.267	0.956
	Researcher's	1.099	1.240	0.171	0.617	0.871	0.666	0.359	0.080
India	Company's	0.927	0.567	0.964	0.151	0.659	0.382	0.163	0.146
	Researcher's	0.954	0.788	0.543	0.399	0.735	0.530	0.616	0.139
Korea	Company's	0.377	1.456	0.498	0.179	0.242	0.250	0.481	1.421
	Researcher's	1.029	1.077	0.061	0.369	0.504	0.607	1.163	0.045
Taiwan	Company's	0.752	0.939	0.859	0.699	0.369	0.289	0.098	0.619
	Researcher's	1.313	1.229	0.354	0.467	0.490	0.596	0.361	0.141
Total	Company's	0.858	1.222	0.807	0.349	0.371	0.259	0.244	0.808
	Researcher's	1.127	1.119	0.236	0.536	0.709	0.579	0.548	0.096

valued low (C or D, except Taiwan). Taiwanese generally value highest (with 15A scores, 4B and only 1C) and Korean evaluation is lowest (with 12C and 7D) among nations and region. Indian researchers' evaluation is divided between favorable and unfavorable items (14A and B scores and 12C and D). U.K. researchers favorably value next to Taiwan (8A and 1C). Japanese researchers unfavorably value next to Korea (only 1A and 5C scores).

Autonomy at work

Freedom and autonomy at work are regarded important to improve the performance

Table 8 Level of Fulfillment

	Clearly established goals	Pertinent establishment of theme	Sound evaluation of achievements	Fair personnel evaluation	Promotion opportunity	Research-support staff	Research budget	Communication with other department	Research facilities
U.K.	A	A	B	B	D	D	B	B	A
Japan	B	A	B	C	C	C	B	C	B
India	A	A	B	B	C	C	B	B	B
Korea	A	A	C	C	C	C	C	D	B
Taiwan	A	A	A	B	B	B	A	B	A

	Location of research site	Communication with other institutes	Opportunities for presentation outside co.	Opportunities for skill development	Leadership capability of supervisor	Human relations at workplace	Freedom in research	Delegation of authority in work	Freedom of time management
U.K.	E	D	D	A	B	A	D	E	A
Japan	E	D	D	C	B	E	B	D	E
India	D	C	D	B	B	A	B	B	B
Korea	E	D	D	C	B	A	C	D	C
Taiwan	E	D	E	A	A	A	E	A	A

	Remuneration linked to achievements	Fringe benefits	Open organizational culture	Personnel rotation	Enthusiasm of top management for R&D	Recruitment of talented individuals	Diversity of researchers backgrounds	Employment security
U.K.	D	D	D	D	C	A	E	A
Japan	D	D	B	D	B	D	D	E
India	D	D	D	D	C	C	D	A
Korea	C	C	C	D	A	D	D	C
Taiwan	C	A	A	D	A	D	A	A

Cut-off points are set among High, Medium, Low in order that the number of respondents belonging to each group should be about the same.

A: Level of importance is high or medium and level of satisfaction is high.

B: Level of importance is high or medium and level of satisfaction is medium.

C: Level of importance is high or medium and level of satisfaction is low.

D: Level of importance is low and level of satisfaction is medium or low.

E: Level of importance is low and level of satisfaction is high.

of researchers (Pelz & Andrews 1966). In our survey we take up 3 indicators of autonomy at work as follows: freedom over expenditure and staff management, independent decision over working hours and whether individual interests are considered on research theme decision. Respondents assess their workplace situation in 5 points scale; "always" 5 points and "not at all" 1 point. Table 9 shows the comparative results. As for freedom over expenditure and staff management it is highest in Taiwan and lowest in Korea. Japan, India and U.K. are intermediate. Japan enjoys highest freedom over working hours and the freedom is low in Korea and India. Freedom in deciding research theme is high in Taiwan, U.K. and India, but it is rather low in Korea and Japan. Taiwan and U.K. enjoy more freedom than other countries and researcher's freedom seems to be most limited in Korea.

Information flows

Performance of R&D engineers is thought to be influenced by information flows—internal as well as external (Allen 1977). Japanese companies were regarded to have more frequent interdepartmental information flows than other countries and it was said that Japanese closer interdepartmental information flows certainly contributed to better organizational integration and R&D performances, particularly in product development (Clark and Fujimoto 1991). In our survey we take up intradepartmental, interdepartmental (with production and sales departments), and external communications (e.g. with researchers in other companies, university, government labs). Table 10 shows comparative data on information flows by managers and researchers respectively. To compare managers with researchers, managers are more actively participating in internal as well as external information exchanges in every country and region. Taiwan has most frequent internal information flows. As to external information flows Taiwan is also a little more active than other countries.

Our research data do not support "active internal communication hypothesis" of Japanese companies. Table 8 shows that Japanese

Table 9 Degree of Autonomy

		Researchers freedom over expenditure and staff management	Independent decisions over working hours	Individual interests are considered on theme
U.K.	Mean	2.394	3.559	2.776
	s.d.	0.976	1.202	1.024
	N	756	759	753
Japan	Mean	2.889	3.991	2.493
	s.d.	0.966	0.840	0.924
	N	1216	1217	1218
India	Mean	2.511	2.628	2.774
	s.d.	1.265	1.358	1.220
	N	395	395	394
Korea	Mean	1.976	2.544	2.052
	s.d.	0.947	1.267	0.941
	N	917	913	917
Taiwan	Mean	3.610	3.532	2.794
	s.d.	0.962	1.012	0.996
	N	490	491	491
Total	Mean	2.622	3.352	2.511
	s.d.	1.122	1.260	1.033
	N	3774	3775	3773

Table 10 Information Flows

			Intra-department communication	Inter-department communication	External communication
U.K.	Non managerial	Mean	3.674	1.877	1.899
		s.d.	0.564	0.924	0.695
		N	329	349	361
	Managerial	Mean	3.805	2.157	2.272
		s.d.	0.578	0.915	0.833
		N	270	277	289
	Total	Mean	3.733	2.001	2.065
		s.d.	0.573	0.930	0.781
		N	599	626	650
Japan	Non managerial	Mean	3.795	1.837	1.743
		s.d.	0.718	0.759	0.660
		N	489	492	491
	Managerial	Mean	3.910	2.168	2.210
		s.d.	0.623	0.824	0.765
		N	710	717	718
	Total	Mean	3.863	2.033	2.020
		s.d.	0.665	0.814	0.759
		N	1199	1209	1209
India	Non managerial	Mean	3.655	1.933	2.000
		s.d.	0.644	0.801	0.842
		N	146	126	139
	Managerial	Mean	3.732	2.530	2.360
		s.d.	0.620	0.928	0.885
		N	215	183	211
	Total	Mean	3.701	2.286	2.217
		s.d.	0.630	0.925	0.885
		N	361	309	350
Korea	Non managerial	Mean	3.637	2.059	2.027
		s.d.	0.624	0.901	0.784
		N	245	244	243
	Managerial	Mean	3.699	2.312	2.165
		s.d.	0.624	0.872	0.880
		N	621	630	629
	Total	Mean	3.681	2.241	2.126
		s.d.	0.624	0.887	0.856
		N	866	874	872
Taiwan	Non managerial	Mean	3.978	2.238	2.252
		s.d.	0.604	0.936	0.879
		N	226	231	236
	Managerial	Mean	4.166	3.086	2.559
		s.d.	0.552	0.830	0.876
		N	159	157	165
	Total	Mean	4.055	2.581	2.378
		s.d.	0.590	0.986	0.890
		N	385	388	401
Total	Non managerial	Mean	3.755	1.957	1.934
		s.d.	0.653	0.869	0.765
		N	1435	1442	1470
	Managerial	Mean	3.830	2.320	2.249
		s.d.	0.625	0.898	0.840
		N	1975	1964	2012
	Total	Mean	3.799	2.166	2.116
		s.d.	0.638	0.904	0.824
		N	3410	3406	3482

researchers are most dissatisfied with communications with other departments, though they think it very important.

Commitment and motivation

In Table 11 we show comparative data on researcher's attitude variables: job involvement, organizational commitment, professional commitment and job satisfaction. Job involvement score is the average of 11 items in 5 point scale, commitment to organization with 3 items' average, professional commitment with 3 items' average and overall job satisfaction with 26 items' score in 5 point scale. As for job involvement score, India is highest and Japan and Korea are lowest, other countries in-between. Organizational commitment is also highest in India and lowest in Japan. Professional commitment is higher in India and Taiwan, but lower in Japan and U.K. As to job satisfaction, Taiwan and U.K. are a little high and India and Korea are low. Japanese researchers are lower than other countries in all attitude variables except job satisfaction. Job satisfaction of Japanese researchers was higher than other occupations (ICEF-JAF 1988). International comparative surveys of workers' attitudes indicated that the scores of Japanese workers' satisfaction and commitment were generally lower than those of other countries' workers (Lincoln and Kalleberg 1990). Therefore, we can say that our research findings are fairly consistent with preceding research results.

Influence of Three Factors on Research Performances

Among the factors that we have chosen and discussed so far, we take up 3 critical factors—researcher's attitude, information flows and autonomy at work. To explore the relationships between these 3 factors and the research performances, we have conducted regression analyses with research performance indicators as dependent variables and personal attribute factors as control variables. The results of the analyses by countries and region are shown in Table 12 to Table 16. The indicators of 3 critical factors are the same as we used them.

Concerning the indicators of the research performances, we decide to divide them into two separate variables—practical performance

Table 11 Attitude Variables

		Job involvement	Organizational commitment	Professional commitment	Job satisfaction
U.K.	Mean	3.744	3.491	2.866	3.267
	s.d.	0.472	0.722	0.604	0.514
	N	759	760	761	712
Japan	Mean	3.516	2.971	2.846	3.126
	s.d.	0.474	0.714	0.537	0.423
	N	1212	1218	1216	1204
India	Mean	4.128	3.958	3.346	3.098
	s.d.	0.456	0.742	0.779	0.729
	N	383	396	390	293
Korea	Mean	3.582	3.188	3.173	3.054
	s.d.	0.483	0.813	0.506	0.467
	N	896	910	907	804
Taiwan	Mean	3.684	3.207	3.311	3.395
	s.d.	0.497	0.707	0.605	0.583
	N	499	500	504	493
Total	Mean	3.663	3.262	3.042	3.173
	s.d.	0.509	0.801	0.617	0.520
	N	3749	3784	3778	3506

Table 12 Results of Regression Analysis for Research Performance (Japan)

		Patent application		Publication of a paper in a journal	
		B	t	B	t
(Constant)		−5.92	−1.54	−1.50	−1.41
Age		−0.04	−0.42	−0.03	−1.27
Tenure		0.06	0.64	0.05	2.16*
Gender (1: Male)		4.93	3.51***	−0.03	−0.07
Managerial or non managerial (1: managerial)		−0.02	−0.03	0.18	0.75
Doctorate (1: Applicable)		−1.82	−1.67	3.14	10.39***
Master's degree (1: Applicable)		−2.87	−3.42***	0.39	1.69
Job involvement		2.48	3.32***	0.57	2.74**
Organizational commitment		−1.42	−2.84**	−0.26	−1.84
Communication	Inter-department	1.62	3.79***	−0.36	−3.04**
	External	−0.11	−0.23	0.99	7.51***
Autonomy	Expenditures and staff	0.81	2.24*	0.14	1.44
	Working hours	−0.34	−0.85	0.01	0.10
	Research theme	0.70	1.87	−0.07	−0.69
R^2		0.06		0.23	
Adjusted R^2		0.05		0.22	
F		5.42***		25.13***	
N		1135		1134	

(* $p<0.05$, ** $p<0.01$, *** $p<0.001$)

Table 13 Results of Regression Analysis for Research Performance (UK)

		Patent application		Publication of a paper in a journal	
		B	t	B	t
(Constant)		−1.33	−0.60	−5.98	−2.20*
Age		−0.01	−0.25	−0.08	−1.39
Tenure		0.01	0.28	0.08	1.57
Gender (1: Male)		1.54	2.57*	1.06	1.45
Managerial or non managerial (1: managerial)		1.50	3.18**	1.29	2.23*
Doctorate (1: Applicable)		0.54	1.03	3.32	5.20***
Master's degree (1: Applicable)		0.89	1.50	0.42	0.58
Job involvement		0.49	0.94	1.89	2.95**
Organizational commitment		0.22	0.63	−0.60	−1.41
Communication	Inter-department	−0.22	−0.83	−0.22	−0.69
	External	0.06	0.18	1.19	3.19**
Autonomy	Expenditures and staff	−0.04	−0.18	0.10	0.34
	Working hours	−0.07	−0.36	0.10	0.41
	Research theme	−0.16	−0.71	0.10	0.35
R^2		0.05		0.15	
Adjusted R^2		0.03		0.13	
F		2.13*		7.31***	
N		566		565	

(* $p<0.05$, ** $p<0.01$, *** $p<0.001$)

Table 14 Results of Regression Analysis for Research Performance (India)

		Patent application		Publication of a paper in a journal	
		B	t	B	t
(Constant)		−0.63	−0.54	−18.36	−2.03*
Age		0.01	0.42	0.19	1.12
Tenure		0.04	1.97	0.31	2.06*
Gender (1: Male)		−0.12	−0.34	−1.21	−0.47
Managerial or non managerial (1: managerial)		0.22	0.88	1.33	0.68
Doctorate (1: Applicable)		0.41	1.28	9.48	3.80***
Master's degree (1: Applicable)		−0.28	−1.03	−1.23	−0.60
Job involvement		0.22	0.75	2.86	1.29
Organizational commitment		−0.07	−0.41	1.76	1.28
Communication	Inter-department	−0.01	−0.07	−1.80	−1.70
	External	0.17	1.23	0.44	0.41
Autonomy	Expenditures and staff	−0.03	−0.34	−0.21	−0.28
	Working hours	−0.15	−1.57	−0.96	−1.33
	Research theme	0.06	0.61	−0.29	−0.38
R^2		0.17		0.31	
Adjusted R^2		0.12		0.27	
F		3.50***		7.42***	
N		231		231	

(* $p<0.05$, *** $p<0.001$)

Table 15 Results of Regression Analysis for Research Performance (Korea)

		Patent application		Publication of a paper in a journal	
		B	t	B	t
(Constant)		−7.18	−0.93	−1.33	−1.88
Age		−0.24	−1.14	0.01	0.54
Tenure		0.95	3.26**	−0.05	−2.05*
Gender (1: Male)		2.20	0.69	−0.28	−0.94
Managerial or non managerial (1: managerial)		4.17	2.05*	0.46	2.54*
Doctorate (1: Applicable)		2.24	0.82	3.33	13.78***
Master's degree (1: Applicable)		3.09	1.99*	0.32	2.32*
Job involvement		4.10	2.47*	0.34	2.24*
Organizational commitment		−0.26	−0.28	0.01	0.16
Communication	Inter-department	−0.75	−0.83	−0.08	−1.04
	External	−1.14	−1.23	0.30	3.63***
Autonomy	Expenditures and staff	1.77	2.03*	−0.04	−0.48
	Working hours	−0.15	−0.25	−0.01	−0.27
	Research theme	0.06	0.70	−0.05	−0.60
R^2		0.10		0.44	
Adjusted R^2		0.08		0.42	
F		4.41***		27.49***	
N		525		475	

(* $p<0.05$, ** $p<0.01$, *** $p<0.001$)

Table 16 Results of Regression Analysis for Research Performance (Taiwan)

		Patent application		Publication of a paper in a journal	
		B	t	B	t
(Constant)		1.19	0.11	−0.47	−0.17
Age		−0.17	−0.66	−0.06	−0.93
Tenure		0.05	0.17	0.11	1.52
Gender (1: Male)		2.26	0.75	−0.15	−0.20
Managerial or non managerial (1: managerial)		3.79	1.83	1.07	2.01*
Doctorate (1: Applicable)		6.46	2.30*	3.82	5.31***
Master's degree (1: Applicable)		4.57	1.82	0.65	1.00
Job involvement		0.48	0.21	1.07	1.88
Organizational commitment		0.54	0.35	−0.25	−0.64
Communication	Inter-department	0.86	0.77	−0.56	−1.94
	External	−1.35	−1.13	0.88	2.87**
Autonomy	Expenditures and staff	0.16	0.16	−0.30	−1.17
	Working hours	−0.25	−0.25	−0.38	−1.51
	Research theme	−0.33	−0.32	0.33	1.25
R^2		0.06		0.27	
Adjusted R^2		0.00		0.23	
F		1.01		5.60***	
N		227		226	

(* $p<0.05$, ** $p<0.01$, *** $p<0.001$)

and academic performance, for the two separate research performances were certainly determined by different factors in the preceding studies. As the indicator of the practical performance, we take up the number of patent application in the past 5 years and as the indicator of academic performance the number of published papers in the past 5 years.

In the case of Japan, job involvement and autonomy in expenditure and staff management have positive influence and organizational commitment has negative influence on the number of patent application. In the case of U.K., India and Taiwan, no variables of the 3 critical factors have significant influence on patent application. In Taiwan's case, fitness of the regression analysis models itself is very slim.

To enhance the practical research performance such as patent application, that is supposed to be related with commercialization of new products, interdepartmental information flows might be very important, since information about the market needs as well as manufacturing department is essential for R&D. But any information flows don't have positive influence on patent application in any countries and region except Japan. In the preceding studies job involvement has positive influence on research performances, but it has no significant influence on patent application except Japan and Korea. Organizational commitment has negative influence on patent application in Japan.

Now we turn to the academic performance—published papers. Job involvement and external information flows have positive influence on the number of papers in Japan, U.K. and Korea. Only external information flows have positive impact on the academic performance in Taiwan. In India no factors have significant influence on the academic performance. Influence of job involvement on research performances, discerned in Japan, UK and Korea, is consistent with the result of preceding studies.

To enhance academic performance such as paper publication, professional information is

so essential that external information flows are regarded important to produce papers in all countries and region except India.

Conclusion

International comparisons of R&D engineers and other workers have been conducted many times, but most of them were comparisons of Japan and the western countries. Our surveys include comparison of Japan with Asian countries and region as well as comparison with the West. Our comparative study between Japan and Asian countries has revealed new findings and leads to a new evaluation of Japanese management practices. Strong age consciousness of Japanese is shared by Taiwanese and to some extent by Korean. As to very low mobility of Japanese R&D engineers, their strong desire for greater freedom at work and their low commitment to organization and job, our research findings are consistent with those of the preceding surveys. However, lower frequency of Japanese internal information flows and the same level of job satisfaction as other countries are not consistent with previous research results. Internal communication in a Japanese company was regarded more frequent and Japanese job satisfaction was generally regarded lower than other countries.

To improve creative performances of R&D engineers, it may be safe to make the following points. Reasonably higher mobility of researchers may be desirable for Japanese companies to reinforce talented researchers and enhance diversity. Japanese research management should achieve better balance between greater freedom at work and reasonable control in line with corporate research strategies. Frequent interdepartmental communications in Japanese companies might be just myth now. Effective network of internal and external information flows should be designed and activated.

It should be noted that contributing factors to research performances vary, depending on what sort of research performance is desired. Relative importance of academic research performance and practical research performance depend on industry, company's research strategy, area of research, etc. Therefore, it is important for technology officers to have clear research goals with regard to what kind of research performance be preferred and how to implement effective measures to attain them.

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