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An investigation to the situation of master's/doctorate degree holders assigned to manufacturing sites and their intended roles in Japan

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ABSTRACT

Compared with other developed countries, M.A or PhD holders are a minority in Japan. Regarding their acquired ability, the people who hold M.A or PhD can be defined as '*R&D oriented human resources*'. Today the manufacturing industry in Japan finds it necessary to improve its innovation capacity in order to recover its competitiveness. However, Japanese manufacturers have placed master's/doctorate degree holders in their producing sites for a certain period. Why have Japanese manufacturing industries stationed them in the production department rather than R&D? What is the intended role for 'R&D oriented human resources' in manufacturing sites?

This study is an attempt to investigate these points by questionnaire and interview research in Japanese manufacturers. The survey has produced responses from over 500 manufacturing companies of Japan in 2004. According to our survey, 61 companies out of 509 companies (12%) have doctorate degree holders stationed at factories while 271 companies out of 511 companies (53%) have masters' degree holders assigned to factories.

A major role of "R&D-oriented human resources" is to communicate the technological seeds developed at R&D sections to production sites. 60 to 70% of companies with doctorate/master's degree holders stationed at factories intend to continue their current policy. The consciously intended role of 'R&D-oriented human resources' is "*to realize smooth transfer of technology from R&D sections to production sections,*" not "*to communicate the needs of production sections to R&D sections.*"

Keywords: management of technology, Why have Japanese manufacturing industries stationed them in the production department rather than R&D?, 'R&D-oriented human resources'

1. The problems

1.1. The necessity of improving the innovation capacity of the manufacturing industry in Japan and the policy to increase doctorate degree holders

Today the manufacturing industry in Japan finds it necessary to improve its *innovation capacity* in order to recover its competitiveness which was lost after the collapse of the 'bubble economy'. The necessity to improve the capacity in the area of product innovation rather than process innovation, in particular in the area of radical innovation, would drastically renovate traditional technology and at the same time expand the market.

As innovation is closely related to R&D, in the following is provided as an overview of some data related to Japan's R&D and its comparison with other OECD countries:^[1]

- Japan's ratio of private sector R&D investors is the largest of all OECD countries.
- The ratio of 4-year college and graduate school graduates in the labor population is among the highest at approximately 35%.
- On the other hand, the ratio of PhD holders in the labor market is among the lowest less than at 1%.

Given these circumstances, the Japanese government formulated a '*Science and Technology Basic Plan*', Phase I (1996 – 2000) aiming to improve the innovation capacity, which included a plan to foster 10,000 post-doctoral researchers. As a result, the number of doctoral degree holders has drastically increased in recent years.

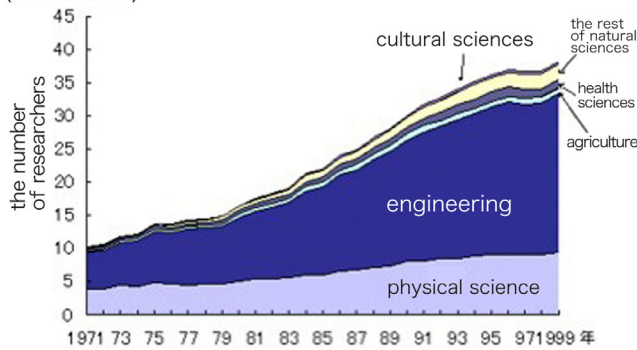
Looking at the breakdown of specializations of researchers who are with Japanese manufacturing companies, engineering major is the largest and science major is the next (Figure 1).

As of 1998, researchers with engineering major and these with science major constituted 87.2% of the total number of researchers.

These figures are natural given the nature of the manufacturing industry excluding the pharmaceutical

industry. In the rest of this paper, therefore, when we refer to engineers, researchers or master's or doctorate degree holders, we mean those in engineering and/or science fields.

Figure 1: Changes in the number of researchers by specialization in Japanese manufacturing industry (10 thousand)



Source: "Indices of Science and Technology in Japan" (2000)

1.2. Characteristics of researchers' assignments in the Japanese manufacturing industry and their influence on innovation

According to an official survey^[2], from the late 1990s, the ratio of master's degree holders among new graduates with science and engineering background entering the manufacturing industry has been increasing. This fact indicates the industry's emphasis on R&D.

In the following, we would like to briefly describe some characteristics of researchers' assignments in the Japanese manufacturing industry and their influence.

With the traditional practice of life-time employment in the Japanese manufacturing industry, white color workers were usually transferred to various sections including manufacturing, sales and accounting under the "job rotation" system. The reasons behind this system were that company officers could easily build and expand internal human network and that this system was appropriate for enabling them to share and accumulate the company's unique experiences and information.

It has been said that, in the Japanese manufacturing industry, even engineers and researchers having completed their undergraduate or master's programs in science or engineering were often assigned not to the R&D section but to manufacturing sites (factories) for more than a few years as part of the "job rotation."

For example, in a company which succeeded in developing the first Japanese language word processors, the project manager responsible for the development of this product in its R&D section was assigned for a few years to the sales sections etc. and participated in its

sales promotion, which led to successful spread of the product. *The document citing this example even concludes that such "job rotation" was the primary reason of the successful product promotion*^[3].

Today, the Japanese manufacturing industry directs attention to the need for close cooperation between R&D sections and manufacturing sites from the perspective of Management of Technology, in order to avoid the "Valley of Death."

This is because it has become clear that customers and internal production/manufacturing sections are the primary two sources of information for *technological innovation opportunities* and because mutual exchanges of knowledge and information between manufacturing sites (factories) and R&D sections (research laboratories/institutes) are considered indispensable.

Figure 2: Sources of Information for R&D in Japanese companies (questioner research)

	Proposal for new project	Continuation of existing project
Suppliers with an ownership relationship	26.60%	32.30%
Suppliers without an ownership relationship	29.90%	36.20%
Customers	75.50%	76.80%
Universities	1.70%	41.40%
Rival firms	47.60%	51.20%
Other R&D departments within the firm	50.70%	54.20%
Production or manufacturing departments within the firm	57.50%	74.50%

Source: 後藤晃・永田晃也(1997)「イノベーションの占有可能性と技術機会」

As demonstrated by the example above, even for principal engineers, experiences gained at both manufacturing and R&D sections possibly promoted and lubricated information exchange between the two sections, technology transfer from the R&D sections to the manufacturing sites and the understanding of market needs at the R&D sections. We gather that, until the 1990s, job rotation was one of significant factors driving successful product innovation, especially incremental innovation, which the Japanese manufacturing industry was skilled at.

During the "bubble economy" period from the late 1980s to the early 1990, however, wages for the financial and service industries increased in comparison to the manufacturing industry. This situation led to the conspicuous trend among science/engineer graduates toward "evasion of work at manufacturing."^[4]

Especially, it is pointed out that a major reason of this trend attributed to the fact that graduates in science of prestigious universities, particularly those with master's degrees or above, avoided to be assigned at

manufacturing sites for several years after joining the company. Also during the bubble economy period, many major companies established affiliated basic research centers/institutes which weren't common. It is quite possible that companies assigned these new graduates with master's degrees or above to these institutes with the purpose of securing these advanced degree holders.

The above analyses are, however, derived from various episodes etc. cited in many references and not necessarily be based on sufficient data.

For example, although the "job rotation" positively contributed to innovation, it is not necessarily clear whether this effect had been an "intended" or an "unintended" fortunate result.

It is necessary to conduct a study of why the Japanese manufacturing industry has assigned these master's and doctorate degree holders—who are defined below as "R&D-oriented human resources"—to manufacturing sites (factories).

1.3. What are R&D-oriented human resources? – The people who play the role of initiating innovation

At the end of the previous section of this paper, we referred to master's and doctorate degree holders as "*R&D-oriented human resources*".

"R&D-oriented human resources" among the broader engineering-oriented human resources, refer especially to those assuming the role of initiating innovations.

In fact, master's and doctorate degree holders are considered to be capable of initiating innovations, which is evident from the definition, or expected roles, of master's degree holders as stated in the "Standards for the Establishment of Graduate Schools (Ministry of Education ordinance)."^[5]

Thus, master's and doctorate degree holders have developed independent research capability and expertise in respective fields of specialization, which are indispensable qualities for initiating innovation.

1.4. What are the intended roles of "R&D-oriented human resources" at manufacturing sites?

As stated in the beginning, the improvement of innovation capability is an issue of pressing urgency. The scarcity value of "R&D-oriented human resources," especially doctorate degree holders, is high.

- How many companies assign "R&D-oriented human resources" to manufacturing sites?
- What are duties and responsibilities given to "R&D-oriented human resources" assigned to manufacturing sites?
- What are the intended roles for "R&D-oriented

human resources" assigned to manufacturing sites?

- How often is personnel rotation between manufacturing sites and R&D sections conducted? Will it be more actively conducted in the future?

There has not been a study that undertaken to estimate the ratio of their existence in Japanese factories and little attention has been given to the purpose of this behavior which seems to be in vain among Japanese manufacturers.

This study is an attempt to investigate these points by questionnaire and interview research in Japanese manufacturers.

2. Survey result and its characteristics

In relation to these agenda, the followings are hypotheses regarding reasons why doctorate and master's degree holders are assigned to manufacturing sites:

- (1)"R&D-oriented human resources," too, should understand and share the company's unique information and resources as part of their job rotation from the perspective of internal career path, as in the case with other executive candidates
- (2)Some production technologies can be dealt with only by "R&D-oriented human resources
- (3)The role of "R&D-oriented personnel" as a liaison between R&D sections and production sites is necessary.

In order to examine these hypothetical reasons, the following survey was conducted.

The study surveyed 4,998 manufacturing companies selected in Japan. The selection criterion was their industry being manufacturing. The questionnaire was sent to *the personnel section of each company*. The survey period was from early March to mid April, 2004. 530 responses were collected by the end of May (collection rate: 10.6%). Due to the limited pages of this paper, the details of the survey content and the breakdown of companies by segment are omitted.

2.1. Assignment of master's /doctorate degree holders to factories

61 companies out of 509 companies (12%) have doctorate degree holders stationed at factories while 271 companies out of 511 companies (53%) have masters' degree holders assigned to factories.

The company profiles—based on their capital and personnel sizes—show that 27 of these companies with

doctorate degree holders stationed at factories, or close to 50%, have capital to 100 million yen to less than 1 billion.

Similarly, 124 out of the 271 companies, or 45.8%, with master's degree holders stationed at their factories have capital from 100 million yen to less than 1 billion.

An examination based on the personnel size of their factories shows that 24 doctorate degree holders, or approximately 40%, are stationed at factories with 100 or more and less than 300 employees.

Similarly, 126 master's degree holders, or 46.5%, are stationed at factories with 100 or more and less than 300 employees.

It became clear that more medium-sized companies, rather than large-sized companies, have doctorate degree holders stationed at factories.

Next, we will give an overview of the number of doctorate and master's degree holders by industry.

Based on the Japan Standard Industrial Classification^[6] the industries with a number of doctorate degree holders stationed at factories are food (10), chemical (10), machinery (10) and electric machinery and apparatus (5). Over a half of the doctorate holders are belong to these four industries.

In case of master's degree holders, industries with 30 or more master's degree holders stationed at factories are food (37), chemistry (36), machinery (33) and electric machinery and apparatus (31). A half of master's degree holders are in these four industries. This result shows a similar tendency with the case of doctorate degree holders.

Thus, it has been demonstrated that companies with doctorate and master's degree holders stationed at factories are mainly, in terms of capital size, those with the capital of 100 million or above and less than 1 billion; and, in terms of personnel size at factories, those with 100 or more and less than 300 employees. By industry, many are in food, machinery and electric machinery and apparatus.

2.2. The duties and responsibilities of doctorate and master's degree holders at factories

Responses to the multiple-answers questions regarding the duties and responsibilities of the total of 61 companies with doctorate degree holders stationed at factories show the following results(Figure 3):

- 57.4% of them are responsible for “*production management*” while 44.3% are for “*technology training and consulting*” .
- 19.7% are for “*administration and management of intellectual property rights including patents*” .
- 13.1% are for “*education and training*” .

Figure 3: the duties and responsibilities of doctorate degree holders stationed at factories (responses: multiple- answers)

	total	production management	technology training and consulting	education and training	administration and management of intellectual property rights including patents	other	no answer
stationed doctorate degree holders	61	35	27	8	12	28	-
%	100	57.4	44.3	13.1	19.7	45.9	-

Source: Hidetomo Oyaizu and Toshiya Kobayashi (2004) " A research into the ratio and the intended role of master's/doctorate degree holders in Japanese manufacturing sites "

Responses to the same question regarding the duties and responsibilities of the total of 271 master's degree holders stationed at factories show the following results (Figure 4):

- 64.9% are responsible for “*production management*” while 39.1% are for “*technology training and consulting*” .
- 11.4% are for “*administration and management of intellectual property rights including patents*” .
- 11.1% are for “*education and training*” .

Figure 4: the duties and responsibilities of master's degree holders stationed at factories (responses: multiple- answers)

	total	production management	technology training and consulting	education and training	administration and management of intellectual property rights including patents	other	no answer
stationed master's degree holders	271	176	106	30	31	113	4
%	100	64.9	39.1	11.1	11.4	41.7	1.5

Source: Hidetomo Oyaizu and Toshiya Kobayashi (2004) “A research into the ratio and the intended role of master's/doctorate degree holders in Japanese manufacturing sites”

2.3. The intended roles of “R&D-oriented human resources” at factories

Regarding the roles of doctorate degree holders stationed at factories, 73.8% responded that their roles are “to transfer research results developed at R&D sections to production sections smoothly.” (Figure 5) On the other hand, 42.6% responded that their roles are “to communicate the needs of production sections to R&D sections” .

Figure 5: the roles of doctorate degree holders stationed at factories (responses: multiple-answers)

	total	to realize smooth transfer of technology from R&D sections to production sections	to communicate the needs of production sections to R&D sections	other	no answer
stationed	61	45	26	12	1
%	100	73.8	42.6	19.7	1.6

Source: Hidetomo Oyaizu and Toshiya Kobayashi (2004) "A research into the ratio and the intended role of master's/doctorate degree holders in Japanese manufacturing sites"

In the case of master's degree holders, 63.1% responded that their roles are "to transfer research results developed at R&D sections to production sections smoothly". (Figure 6)

On the other hand, 41.3% responded their roles are "to communicate the needs of production sections to R&D sections".

Similar tendencies can be seen from both doctorate and master's degree holders.

Figure 6: the roles of doctorate degree holders stationed at factories (responses: multiple-answers)

	total	to realize smooth transfer of technology from R&D sections to production sections	to communicate the needs of production sections to R&D sections	other	no answer
stationed	271	171	112	73	10
%	100	63.1	41.3	26.9	3.7

Source: Hidetomo Oyaizu and Toshiya Kobayashi (2004) "A research into the ratio and the intended role of master's/doctorate degree holders in Japanese manufacturing sites"

As a result, it can be said that a major role of "R&D-oriented human resources" is to communicate the technological seeds developed at R&D sections to production sites.

2.4. Assignment policy for doctorate and master's degree holders

Regarding the assignment policy for doctorate degree holders, 62.3% of the companies with doctorate degree holders stationed at factories responded that they would "continue the current assignment policy".

On the contrary, 32.8% of the companies without doctorate degree holders stationed at factories responded that they have "not decided whether to continue the current policy".

60.5% of the companies with master's degree holders stationed at factories responded that they would "continue the current assignment policy".

75% of the companies without master's degree holders stationed at factories responded that they have "not decided whether to continue the current policy" indicating a sharp contrast with the case of doctorate degree holders.

These results indicate, basically, 60 to 70% of companies with doctorate/master's degree holders stationed at factories intend to continue their current policy.

2.5. Situation of job rotation between factories and R&D sections

The current situation of job rotation between factories and R&D sections shows that 73.8%(=11.5%+62.3%) of the companies with doctorate degree holders stationed at factories conduct job rotation between factories and R&D sections. (Figure 7)

On the other hand, almost a half of the companies without doctorate degree holders stationed at factories conduct no job rotation.

Figure 7: The current situation of job rotation between factories and R&D sections

	total	very often	often	not conduct	no answer
total	530	30	245	190	65
%	100	5.7	46.2	35.8	12.3
not stationed	448	23	200	171	54
	100	5.1	44.6	38.2	12.1
stationed	61	7	38	14	2
	100	11.5	62.3	23	3.3
no answer	21	-	7	5	9
	100	-	33.3	23.8	42.9

Source: Hidetomo Oyaizu and Toshiya Kobayashi (2004) "A research into the ratio and the intended role of master's/doctorate degree holders in Japanese manufacturing sites"

74.9%(=10.3%+64.6%) of the companies with master's degree holders stationed at factories conduct job rotation between factories and R&D sections. (Figure 8) On the other hand, 50.8% of the companies without master's degree holders stationed at factories responded that they conduct no job rotation between factories and R&D sections.

These results indicate that a significant majority of companies with doctorate/master's degree holders stationed at factories actively conduct personnel exchange between factories and R&D sections.

In sharp contrast, a half of the companies without doctorate/master's degree holders stationed at factories conduct no active personnel exchange between factories and R&D sections.

Figure 8: The current situation of job rotation between factories and R&D sections

	total	very often	often	not conduct	no answer
total	530	30	245	190	65
%	100	5.7	46.2	35.8	12.3
not stationed	240	2	65	122	51
	100	0.8	27.1	50.8	21.3
stationed	271	28	175	63	5
	100	10.3	64.6	23.2	1.8
no answer	19	-	5	5	9
	100	-	26.3	26.3	47.4

Source: Hidetomo Oyaizu and Toshiya Kobayashi (2004) "A research into the ratio and the intended role of master's/doctorate degree holders in Japanese manufacturing sites"

2.6. The objective of conducting job rotation between factories and R&D sections

Regarding reasons for conducting job rotation between factories and R&D sections, 37.8% of the companies with doctorate degree holders stationed at factories responded that the objective is "to realize smooth transfer of technology from R&D sections to production sections".

On the contrary, only 17.8% responded that the objective is "to communicate the needs of production sections to R&D sections". 28.9% responded the objective is "for career development".

Figure 9: The objective of conducting job rotation between factories and R&D sections (responses: multiple- answers)

	total	to realize smooth transfer of technology from R&D sections to production sections	to communicate the needs of production sections to R&D sections	for career development	no information	other	no answer
total	275	80	51	76	6	17	68
%	100	29.1	18.5	27.6	2.2	6.2	24.7
not stationed	223	61	43	60	6	10	58
%	100	27.4	19.3	26.9	2.7	4.5	26
stationed	45	17	8	13	-	7	8
%	100	37.8	17.8	28.9	-	15.6	17.8
no answer	7	2	-	3	-	-	2
%	100	28.6	-	42.9	-	-	28.6

Source: Hidetomo Oyaizu and Toshiya Kobayashi (2004) "A research into the ratio and the intended role of master's/doctorate degree holders in Japanese manufacturing sites"

Similar results were gained from the companies with master's degree holders stationed at factories.

25.4% of the companies without master's degree holders stationed at factories responded the objective is "to realize smooth transfer of technology from R&D sections to production sections".

While, 23.9% responded the objective is "to communicate the needs of production sections to R&D sections". These two percentages are rather close to each other.

Figure 10: The objective of conducting job rotation between factories and R&D sections (responses: multiple- answers)

	total	to realize smooth transfer of technology from R&D sections to production sections	to communicate the needs of production sections to R&D sections	for career development	no information	other	no answer
total	275	80	51	76	6	17	68
%	100	29.1	18.5	27.6	2.2	6.2	24.7
not stationed	67	17	16	11	2	4	17
	100	25.4	23.9	16.4	3	6	25.4
stationed	203	62	35	64	4	12	49
	100	30.5	17.2	31.5	2	5.9	24.1
no answer	5	1	-	1	-	1	2
	100	20	-	20	-	20	40

Source: Hidetomo Oyaizu and Toshiya Kobayashi (2004) "A research into the ratio and the intended role of master's/doctorate degree holders in Japanese manufacturing sites"

2.7. Conclusion of the survey results

The hypotheses in the beginning of this chapter are examined based on these survey results:

- (1) "R&D-oriented human resources," too, should understand and share the company's unique information and resources as part of their job rotation from the perspective of internal career path, as in the case with other executive candidates.

It has been demonstrated that career development of R&D section staff, in the case of doctorate degree holders, is recognized by 28.9% of the companies and that of master's degree holders is recognized by 31.5% of the companies—or roughly 30% in either case.

At those companies without advanced degree holders stationed at factories, the career path is recognized, in case of doctorate degree holders, by 26.9% and, in case of master's degree holders, 16.4%. This result indicates that those companies with doctorate/master's degree holders stationed at factories consciously conducting career development of R&D section staff.

- (2) Some production technologies can be dealt with only

by “R&D-oriented human resources”.

About 60% of doctorate and master’s degree holders stationed at factories are responsible for “*production management*” while roughly 40% are for “*technology training and consulting*.” This result implies the existence of some technologies that can be only dealt with by doctorate/master’s degree holders.

(3)The role of “R&D-oriented human resources” as a liaison between R&D sections and production sites is necessary.

It has been shown that the consciously intended role of R&D-oriented human resources is “*to realize smooth transfer of technology from R&D sections to production sections,*” not “*to communicate the needs of production sections to R&D sections*”.

3. Conclusion

Considering the given these facts from the point of management of technology, as follows, Stationing of ‘R&D oriented human resources’ in production departments is planned with an innovation policy rather than a mere “job rotation”.

These policies can also be seen as having important meaning for *the implementaiton of technology information into manufacturing sites*.

The consciously intended role of R&D-oriented human resources in manufacturing sites is “*to realize smooth transfer of technology from R&D sections to production sections,*” not “*to communicate the needs of production sections to R&D sections*”. If innovation can be defined in two types; ‘technology push type’ and ‘demand pull type’. The role of ‘R&D oriented human resources’ is mainly intended to contribute to ‘technology push type’ innovation.

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[3] 三橋規宏(1992)「先端技術と日本経済」岩波書店

[4] According to 「経済白書」(1994)published by Economic Planning Agency, the reasons for ‘the reluctance to work in the manufacturing of graduates from science and technology colleges’ are thought as follows,

- Compared to other industries, wages level in manufacturing industry have been declining since the late 1980’s.
- For many graduates from science and technology colleges, the work conditions in the manufacturing industry are unappealing do to the graduates perceived image of manufacturing sites.

[5] According to Article 3 of the Ordinance, graduate education toward master’s degrees are aimed at “providing deep and subtle knowledge from broad perspectives and developing research capability in respective specializations and sophisticated capability needed for careers requiring advanced expertise.” Article 4 of the Ordinance defines graduate education toward doctorate degrees as aiming at “developing sophisticated research capability as well as, as its base, rich knowledge and intelligence needed for conducting research as independent researchers and for assuming other highly specialized careers.

[6] “Major Groups” is a statistical standard included in the Japan Standard Industrial Classification and used to indicate statistical research results by industry and to provide categories of all the economic activities relating goods and services produced and/or supplied by companies as parts of social division of labor. It was established by the government of Japan in October 1949 with the purpose of maintaining the accuracy and objectivity of statistics and of improving the mutual comparability and usability of statistics. Specifically, it provides four stages of classification—divisions, major groups, groups and details (industries)—of various economic activities including agriculture, construction, manufacturing, wholesale, retail, finance, medical, social welfare, education and public sector.