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Searching for the factors dragging down the competitiveness of Japanese firms: problems and challenges from the perspective of R&D

Tetsuhiro Otsuka,
Economist

Mizuho Research Institute

Tetsuhiro Otsuka currently holds the position of economist at Mizuho Research Institute Ltd. (MHRI). His main field of research is Japan's real estate market and industrial structure. He is the co–author of *Nihon Keizai no Asuo Yomu* (Predicting the future course of the Japanese economy) (Toyo Keizai Inc., 2010).

E–mail: tetsuhiro.otsuka@mizuho–ri.co.jp

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Summary

1. Investment in research and development ("R&D") contributes to the growth of firms and economies through the rise of productivity and profitability.
2. Japan's R&D investment – both in terms of value and percentage of GDP – ranks among the top countries of the developed world. Furthermore, Japan also maintains high levels of scientific and technological capabilities. However, the large amount of R&D investment and high technological level are not necessarily leading to corporate earnings in recent years.
3. To provide a look at the relationship between R&D activity and corporate earnings and economic growth, an indicator which we shall refer to as "R&D efficiency" has been devised in this paper to gauge corporate earnings and value–added in relative terms by R&D expenditures. According to the trends in R&D efficiency on a macroeconomic level, Japan's R&D efficiency has been declining, falling below the US and Germany.
4. The four following points may be cited as the main factors contributing to the decline of R&D efficiency.
   (1) The concentration of R&D investment in industries and areas with low rates of return
   (2) The absence of efficient R&D systems
   (3) The decline in value of process innovation ("kaizen") – Japan's traditional stronghold – due to modularization of products and construction of structural models encompassing emerging countries by the countries of the US and Europe,
   (4) The inability to link technology with corporate earnings. It has become difficult for Japanese products to attract overseas demand due to their idiosyncratic characteristics to match Japan's domestic preferences. Furthermore, Japanese firms are not doing enough to generate profits from their technology, by for example, the acquisition of global standards.
5. Japanese firms must build R&D systems responding to the

changing environment. To do so, they must upgrade their efforts toward open innovation. In addition, it would be necessary to develop R&D sites overseas in order to capture demand from emerging countries.

6. Even though the government of Japan has implemented policies with emphasis upon the promotion of R&D investment, the decline of corporate competitiveness is not an intrinsic factor. Rather, it would be necessary to implement policies to promote the improvement of R&D efficiency such as policies to stimulate open innovation.

1. Introduction

Climbing out of its worst moments subsequent to the serious malaise stemming from the global financial crisis and recession, the Japanese economy is picking up, thanks to the series of economic stimulus measures taken around the world. However, in terms of absolute level, the Japanese economy is still in dire conditions. From a longer term perspective, Japan's condition may be described as languishing in a prolonged state of stagnation after the collapse of the bubble economy in the 1990s.

An oft–cited reason for such a prolonged economic malaise is the decline of Japanese firms' competitiveness. For example, the market share of the value–added of Japan's high–technology industry has been steadily shrinking since the latter half of the 1990s. Furthermore, Japanese firms are losing ground even in areas such as electrical appliances where they had once held major market shares.

It is extremely important for Japan to find out the reasons for its loss of competitiveness, and to discuss and implement effective measures to raise it. Presumably, the key to the improvement of competitiveness is research and development (R&D), and its underlying source is technological capability and innovation.

The purpose of this paper is to discuss the relationship between R&D investment and corporate competitiveness by focusing upon corporate R&D activity. More specifically, Section 2 deals with the question of whether R&D contributes to the reinforcement of corporate competitiveness through empirical analysis using corporate data bases. Section 3 looks at the past trends in Japan's R&D investment, to gain an understanding of the changes in performance. Upon doing so, Section 4 verifies the problems in Japan's R&D activities. Based upon the foregoing, Section 5 discusses the issues faced by Japanese firms and the government for the improvement of Japan's competitiveness.

2. The significance of R&D

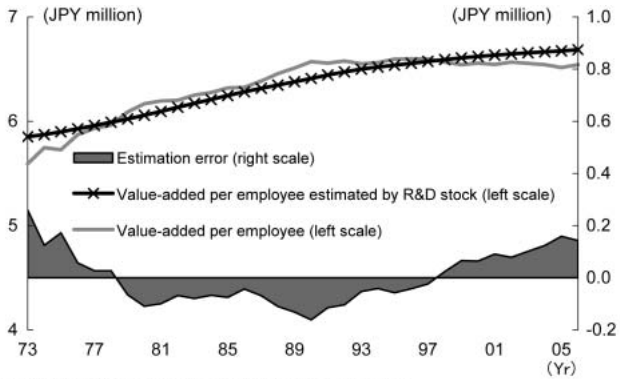
R&D investment is generally perceived as one of the prior investments indispensable for the sustainable growth of business firms. However, even if firms engage in R&D activities, it is uncertain whether the results will lead to the creation of practical technology and products. Moreover, even if the R&D culminates in product development, there is no guarantee that it will be purchased by consumers and generate appropriate returns for firms. Thus, this section will ascertain the significance of R&D activities through empirical analysis.

(1) Verification of R&D and competitiveness (① macroeconomics)

Firstly, let us look at the impact of R&D investment upon macroeconomic productivity and growth potential through quantitative analysis. Here, we shall ascertain the contribution by R&D investment toward productivity gains through estimates based upon R&D stock (note 1) resulting from the accumulation of value–added per employee over the years. The results of estimation are set forth in **Chart 1**, which reveals a significant positive

relationship between R&D stock and value–added per employee. This shows that, over the long term, R&D investment contributes to the increase of per capita value–added, in other words productivity gains. However, note that the actual amount of per capita value–added is not growing as much as the theoretical amount estimated by R&D stock. This indicates that R&D investment is not leading readily to the rise of productivity. The same relationship and change may also be verified by calculating the correlation coefficient between R&D stock and value–added per employee (**Chart 2**). In other words, in contrast to a positive correlation between the two up to 1995, such correlation may not be observed from 1996 onward.

Chart 1: Value–added per employee estimated by R&D stock



Notes: ln(value-added per employee) = 0.36*ln(R&D stock)+2.41
(14.99) (9.15)
Estimation period: 1973 to 2006, Adjusted R-squared=0.87,
Durbin-Watson stat=0.18

Sources: Made by Mizuho Research Institute, Ltd. (MHRI) based upon releases by the Ministry of Internal Affairs and Communications, *Survey of Research and Development*, and Ministry of Finance *Financial Statements Statistics of Corporations*.

Chart 2: Correlation coefficients of R&D stock and value–added per employee

Year	Correlation coefficient
1973 - 2006	0.90
1973 - 1995	0.97
1996 - 2006	-0.82

Sources: Made by Mizuho Research Institute, Ltd. (MHRI) based upon releases by the Ministry of Internal Affairs and Communications *Survey of Research and Development*, and Ministry of Finance *Financial Statements Statistics of Corporations.*

(2) Verification of R&D and competitiveness (② corporate earnings)

Next, we shall check the impact of R&D investment upon the earnings performance of individual firms. Here, we ascertained whether the change of R&D led to the rise of corporate profitability in the subsequent seven–year period using "OSIRIS" (a financial data base of firms listed on the Tokyo Stock Exchange).

We conducted our analysis by categorizing the survey group into four patterns as follows. The survey group is comprised of Japanese firms with data available from OSIRIS and have sales–to–R&D cost ratios of 1% or above.

(1) The change of return–on–assets (ROA) of firms which increased/decreased R&D expenditures during the period from 1999 to 2000, during the subsequent seven–year period in comparison with the year 2000
(2) The change of return–on–assets (ROA) of firms which increased/decreased R&D expenditures during the period from 1999 to 2001, during the subsequent seven–year period in comparison with the year 2001
(3) The change of return–on–assets (ROA) of firms which increased/decreased R&D expenditures during the period from 2000 to 2001, during the subsequent seven–year period in comparison with the year 2001

(4) The change of return–on–assets (ROA) of firms which increased/decreased R&D expenditures during the period from 2000 to 2002, during the subsequent six–year period in comparison with the year 2002 (note 2)

The results are as set forth in **Chart 3**. Generally, the rise of ROA was higher among firms which increased, rather than decreased, their R&D expenditures (note 3).

Chart 3: Changes in R&D expenditures and the subsequent changes in ROA

(% Pt)

①1999→2000	(no. of firms covered)	ROA growth (change from 2000)						
		2001	2002	2003	2004	2005	2006	2007
Firms which increased R&D expenditures	197	-1.15	-0.56	1.05	2.61	3.13	3.38	3.37
Firms which reduced R&D expenditures	113	-1.96	-0.52	0.62	1.66	2.24	2.88	3.02

(% Pt)

②1999→2001	(No. of firms covered)	ROA growth (change from 2001)						
		2002	2003	2004	2005	2006	2007	2008
Firms which increased R&D expenditures	103	1.49	1.68	1.08	0.50	0.67	-0.32	-5.09
Firms which reduced R&D expenditures	205	0.96	1.54	0.89	0.34	0.42	0.17	-4.34

(% Pt)

③2000→2001	(No. of firms covered)	ROA growth (change from 2001)						
		2002	2003	2004	2005	2006	2007	2008
Firms which increased R&D expenditures	274	0.72	17.65	19.02	19.25	19.69	19.81	15.53
Firms which reduced R&D expenditures	226	0.73	16.87	17.72	18.09	18.89	17.89	14.36

(% Pt)

④2000→2002	(No. of firms covered)	ROA growth (change from 2002)					
		2003	2004	2005	2006	2007	2008
Firms which increased R&D expenditures	268	8.92	9.59	9.88	10.25	9.87	5.69
Firms which reduced R&D expenditures	226	6.93	7.91	8.57	9.18	8.61	5.04

Notes: 1. The graph above includes firms with data available from OSIRIS (a corporate finance database) whose R&D expenditures/sales are at least 1%.
2. Intermediate values
3. Shading indicates firms with higher ROA in the comparison of firms which increased R&D expenditures and firms which reduced R&D expenditures.

Source: Made by MHRI based upon OSIRIS.

Summarizing the above, we were able to verify that R&D investment contributes to the improvement of macroeconomic productivity and growth potential, and that even on a microeconomic level, it provides a positive impact upon corporate earnings

performance. That said, the correlation may be undergoing shifts in Japan, suggesting that R&D investment is not leading to macroeconomic growth as readily as it had in the past. This issue will be revisited in Section 4.

3. The trends in Japan's R&D

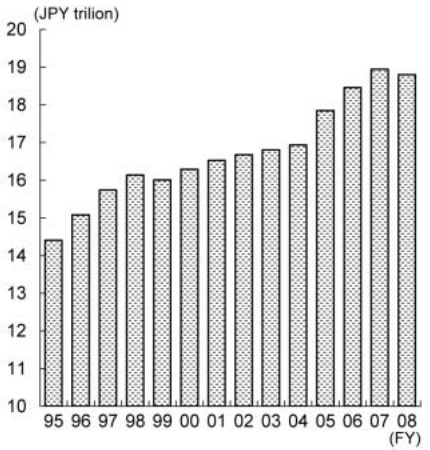
In the previous section, we looked at the contribution of R&D investment toward macroeconomic growth and corporate earnings. We will now look at the actual trends in Japan's R&D investment and the changes which have taken place in the environment surrounding R&D activities. In addition, we shall also look at the actual condition of Japan's technological capabilities and corporate earnings generated as a result of R&D.

(1) The characteristics of Japan's R&D investment

a. From a macroeconomic level

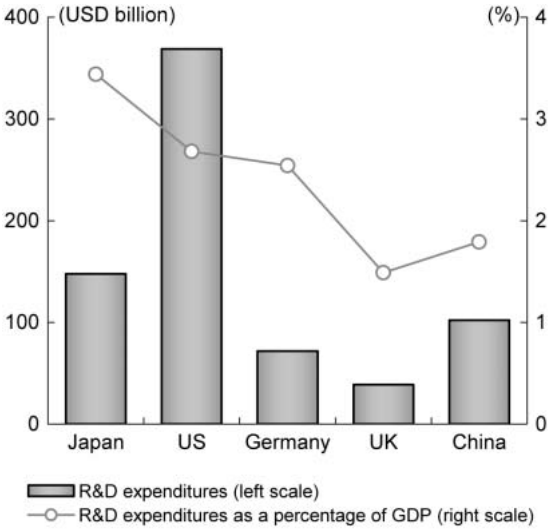
We shall first look at the trends in R&D expenditures in terms of Japan as a whole. According to the *Survey of Research and Development* of the Ministry of Internal Affairs and Communications, Japan's expenditures on R&D (in nominal terms) have been following an upward trend, reaching approximately JPY19 trillion (3.8% of nominal GDP) in FY2008 (**Chart 4**). This is high, even on a global level. A comparison of R&D expenditures with major countries of the world on the basis OECD data as of 2007 shows that Japan's R&D expenditures is lower than the US in terms of actual value but is the highest in the world as a percentage of GDP (**Chart 5**).

Chart 4: R&D expenditures (nominal)



Source: Ministry of Internal Affairs and Communications, *Survey of Research and Development.*

Chart 5: International comparison of R&D expenditures and R&D expenditures as a percentage of GDP

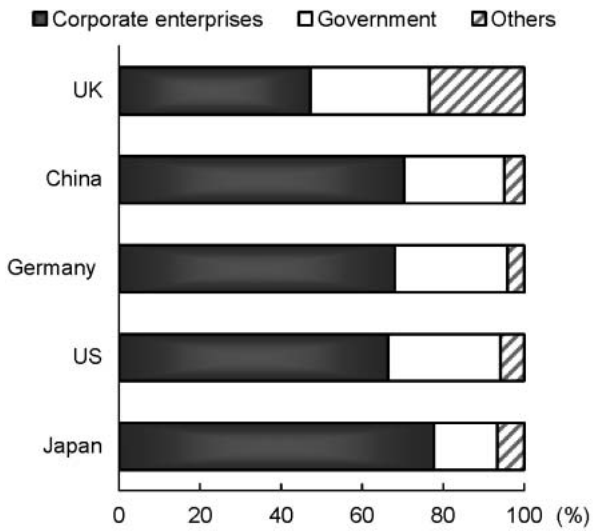


Notes: 1. Purchasing power parity basis.
2. As of 2007.

Source: OECD, *Research and Development Statistics.*

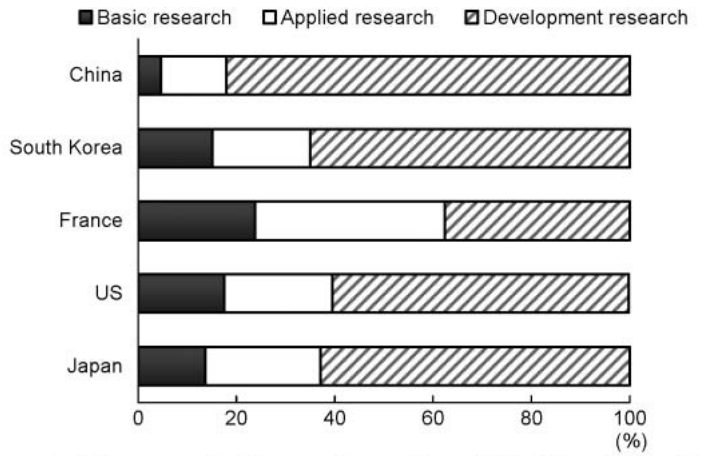
Next, we shall look at the breakdown of R&D expenditures by organization (business enterprises, governments, others) and type of activity (basic research, applied research, development research). First of all, the breakdown by organization reveals that more than 70% of Japan's R&D expenditures are funded by the corporate sector (**Chart 6**). In contrast, the government funds only 15%, which is extremely low even in global terms (note 4). Due in part to the large weight of the corporate sector, a large part of Japan's R&D by type of activity is comprised of applied research and development research, with the total of the two types of activities running up to 86% as of 2008 (**Chart 7**).

Chart 6: R&D expenditures (breakdown by organizations)



Notes: As of 2007. As of 2006 for Germany.
Source: OECD, *Research and Development Statistics*.

Chart 7: R&D expenditures (breakdown by nature of research)

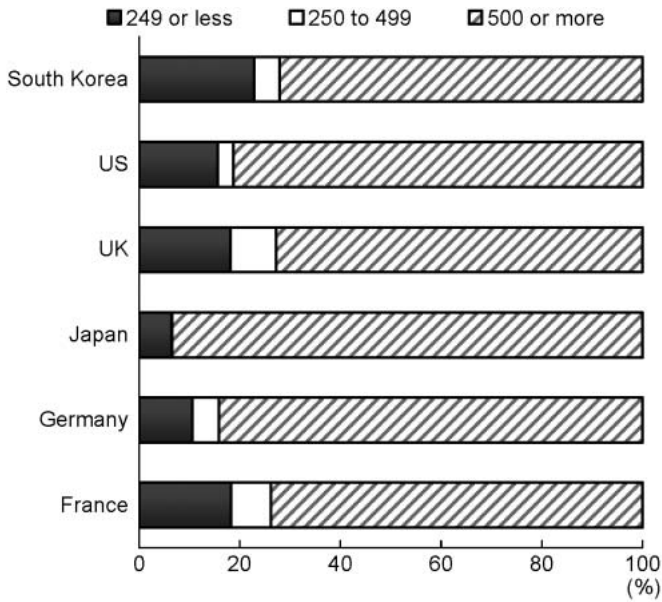


Notes: As of the years set forth in parentheses: Japan (2008), US and China (2007), France and South Korea (2006).
Source: OECD, *Research and Development Statistics*.

b. The corporate sector

Let us turn to the trends in R&D in the corporate sector. Firstly, a breakdown of R&D expenditures by the size of enterprise reveals that large enterprises account for a large part of the Japanese corporate sector's R&D activity. For example, in terms of the percentage of R&D expenditures by the number of researchers, corporate enterprises with at least 500 employees (of which many are large enterprises) account for 93% of R&D expenditures (**Chart 8**). This is significantly high even in a comparison with other major countries of the world. The percentage of countries such as South Korea, the US, the UK and Germany is approximately 80%.

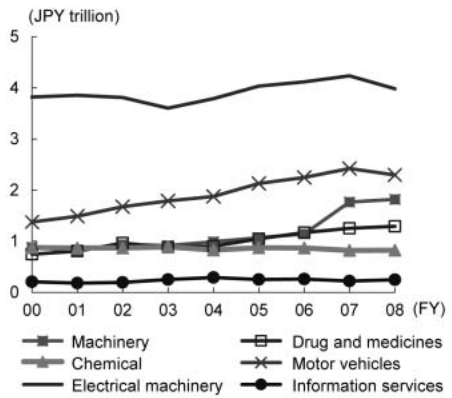
Chart 8: Percentage of R&D expenditures of firms (by no. of employees)



Notes: As of 2007.
Source: OECD, *Research and Development Statistics.*

Turning next to R&D expenditures by industrial sector, manufacturers of hardware such as the electrical machinery, motor vehicle and machinery industries earmark a large amount of R&D spending (**Chart 9**). In contrast, R&D expenditures of industries such as chemicals and information services fall sharply below those of the foregoing. Past trends also show a similar pattern of hardware industries spending large sums on R&D compared to flat spending among software industries.

Chart 9: Trends in R&D expenditures (by industrial sector)

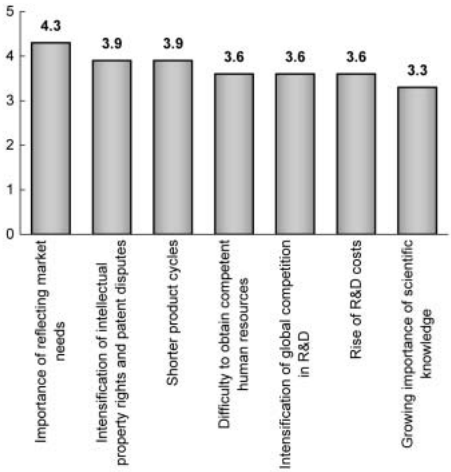


Notes: Machinery = general-purpose machinery + production machinery + business oriented machinery
Electrical machinery = electronic parts & devices & electrical circuits + electrical machinery + information and communication electronics equipment
Source: Ministry of Internal Affairs and Communications Statistics Bureau

(2) Shifts in the environment surrounding R&D

As shown above, Japan's R&D has been driven mainly by private enterprises – in particular large enterprises and hardware manufacturing industries. That said, note that significant shifts are taking place in the environment surrounding R&D amid the progress of globalization and intensification of competition both within and outside of Japan. A survey by the Research Institute of Economy, Trade and Industry (REITI) (note 5) in 2004 ("*Nihon no inobeshon shisutemu ni kakawaru sangakurenkei jittaichousa hokokusho*" (The Japanese innovation system: a fact–finding survey on university–industry linkages)) reveals issues such as the following with respect to R&D: "importance of reflecting market needs", "shorter product cycles", "intensification of global competition in R&D", and "rise of R&D costs" (**Chart 10**).

Chart 10: Questionnaire survey on R&D



Notes: 1. Respondents were asked to evaluate each of the items on a 1-to-5 scale, ranging from "I think so" to "I do not think so". In the chart above, averages are computed by giving each item a score.
2. Survey as of 2004.

Source: Research Institute of Economy, Trade and Industry , *Nihon no inobeshon shisutemu ni kakawaru sangakurenkei jittaichousa hokokusho* (The Japanese innovation system: a fact-finding survey on university-industry linkages)

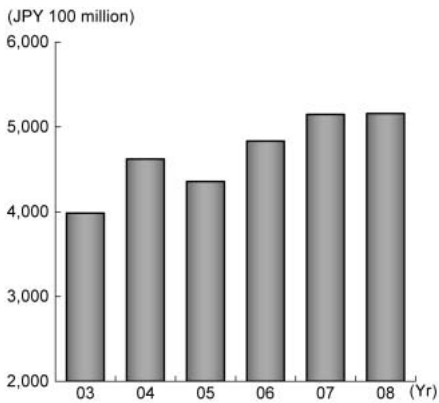
Of the foregoing, the most difficult issue for firms would be to respond to the diversifying needs in the light of the "importance of reflecting market needs". Given the increase of information and progress of demographic ageing, consumer needs toward products are diversifying. If firms are to tackle this challenge alone, it would become necessary to develop multiple lines of products, necessitating the increase of researchers, and thus resulting in a sharp rise of R&D costs. Furthermore, the "shorter product cycles" and "rise of R&D costs" are also difficult issues for firms.

To break through such a situation, it would be necessary to facilitate "open innovation" (note 6) and to promote linkages with other firms (or the public sector). In fact, "open–sourcing" of R&D is progressing steadily, as with the rise in percentage of costs allocated for joint research in R&D expenditures of Japanese corporations. However, Japanese firms are lagging considerably behind their

overseas counterparts in the area of open innovation, given their growth and development based on in–house R&D.

Another shift occurring along with open–sourcing is the globalization of R&D. Business firms are facilitating the globalization of R&D in a bid to cope with fierce international competition of R&D and to tap the global market. R&D expenditures of overseas subsidiaries of Japanese firms are climbing, reaching approximately JPY500 billion as of FY2008 which is around 4% of R&D expenditures of the corporate sector as a whole (**Chart 11**). Nevertheless, note that Japanese firms lag behind US and European firms also in the globalization of R&D just as in the case of open–sourcing.

Chart 11: R&D expenditures of overseas subsidiaries of Japanese firms



Notes: The readings on each year should not be subject to a simple comparison due to the volatility of response rates and respondents.
Source: Ministry of Economy, Trade and Industry, *Survey of Trends in Business Activities of Foreign Affiliates.*

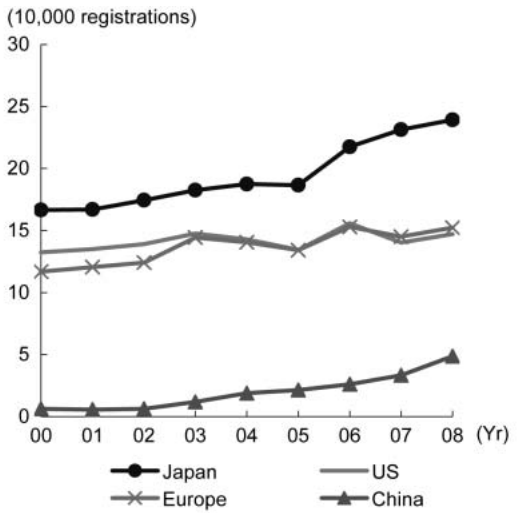
(3) Japan's R&D performance

In the sections above, we looked at the trends in Japan's R&D investment and the recent shifts in the environment surrounding R&D. Here, we shall examine the performance of Japan's R&D.

First of all, let us look at the trends in patents registrations and

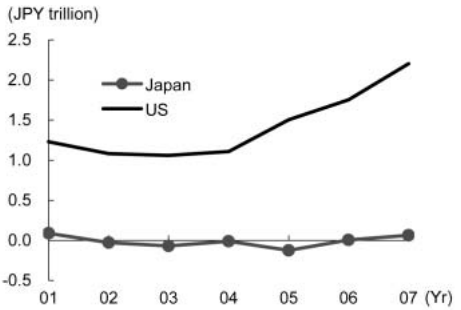
profit performance. Japan continues to rank first place in terms of the number of patent registrations both in Japan and overseas, with the number increasing sharply in recent years (**Chart 12**). However, Japan falls far below the US and Europe in terms of the profitability of patents (note 7). For example, Japan's technology trade ratio (note 8) reveals an idiosyncratic situation regarding patents in Japan. Even though Japan's technology trade ratio is continuing to record a surplus on a superficial level, the major part is accounted for by transactions with overseas subsidiaries of Japanese firms. The trade ratio excluding parent–subsidiary transactions is more or less balanced (**Chart 13**).

Chart 12: Patent registrations



Notes: Total of patent registrations in Japan and overseas.
Sources: World Intellectual Property Organization, *Industrial Statistics*, Japan Patent Office, *Japan Patent Office Annual Report*.

Chart 13: Japan–US comparison of the technology trade ratio (excluding parent–subsidy transactions)



Notes: 1. Definitions of parents and subsidies differ in Japan and the US. In Japan, companies are deemed as subsidiaries in the event of a capitalization ratio of more than 50% by the parent company. In the US, companies are deemed as subsidiaries in the event the parent possesses 10% or more of the subsidiary's stocks or voting rights.
2. Definitions of technology trade differ in Japan and the US. In Japan, technology trade includes (1) patents, utility models, copyrights, (2) design rights, (3) technical guidance, and (4) technical assistance. In the US, technology trade only includes royalties, licenses and computer data processing (from 2006 onward).
3. Based upon the average foreign exchange rate each year.

Source: Ministry of Internal Affairs and Communications, *Survey of Research and Development*, National Science Foundation.

Turning next to the comparison of the competitive edge of advanced technology between Japan and the US, experts are of the opinion that the technology in the US is higher in many areas in comparison with Japan. According to the "*Kagakugijutsu kenkyukaihatsu no kokusai hikaku (2009nen ban)*" (International comparison of scientific technology and R&D (2009)) by the Japan Science and Technology Agency, the level of Japan's R&D is lower than the US in most technological areas (**Chart 14**).

Chart 14: Japan–US comparison of technological fields of excellence

Category of technological field		Electronic information & communication	Environment	Advanced gauging technology	Life science	Nanotechnology
Japan	Level of research	27	23	26	31	42
	Level of technological development	29	28	15	5	40
	Industrial technology	25	26	8	3	32
US	Level of research	54	25.5	35	47	40
	Level of technological development	53	21.5	31	38	37
	Industrial technology	42	15.5	25	31	25

Notes: 1. Experts in each of the fields ranked the technological levels of each of the technologies in the technological categories as of 2009 on a four-point scale. Based upon these rankings, the categories with the highest evaluations in each technological field are tallied for each of Japan and the US.
2. The numbers of categories in each technological field are as follows: electronic information & communication (59), environment (43), advanced gauging technology (42), life science (50), nanotechnology (66).
3. In the event it is difficult to differentiate between the 1st and 2nd highest evaluations, the category is given a score of 0.5.
4. Shading indicates the party (Japan or US) which possesses the highest evaluation in competitiveness.

Sources: Made by MHRI based upon Japan Science and Technology Agency.

(4) R&D efficiency

Even though Japan continues to hold a relatively high level of technological capacity as observed in the foregoing sections, its profit performance is not necessarily high. This is also true on a micro level. Despite the large number of firms placing emphasis upon R&D and the ongoing high level of R&D expenditures, more firms are suffering under low profit performance. This suggests the possibility that Japan's technology – which is supposedly high – is not leading steadily to the business performance of firms. Thus, in the following section, we shall analyze this issue by using an indicator which we shall refer to as "R&D efficiency".

a. Measuring R&D efficiency

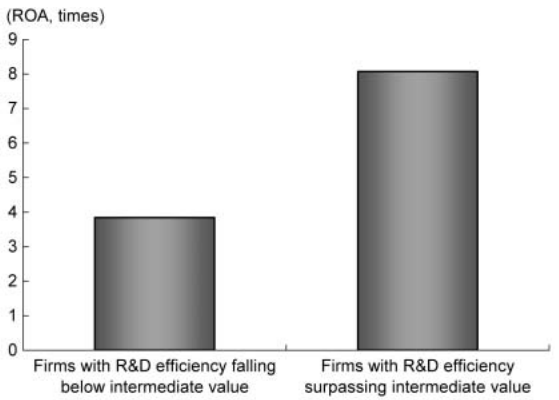
R&D efficiency is a quantitative measure of "a firm's business performance relative to its R&D investment". However, its actual measurement requires the establishment of certain hypotheses due to the time necessary for R&D investment to achieve results and the difficulty to extract the impact of R&D alone. Various methods to estimate R&D efficiency have been devised in previous studies.

In this paper, we assumed that three years worth of R&D activity would affect corporate earnings during a period of four years subsequent to a one–year lag after the initial three years of R&D activity (note 9). This, represented in a formula to compute R&D efficiency, would be as follows:

R&D efficiency = (cumulative operating profit during the past 4 years) / (cumulative R&D expenditures during the period starting from 8 years ago to 6 years ago

We measured the R&D efficiency of 504 Japanese firms using this formula on the basis of a corporate finance database (ORBIS). **Chart 15** sets forth the relation between R&D efficiency and return on assets (ROA). This chart ascertains the close relationship between ROA which indicates the earnings efficiency and R&D efficiency.

Chart 15: R&D efficiency and ROA



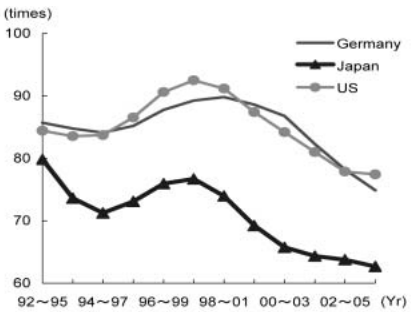
Notes: 1. The graph above includes firms with data available from ORBIS whose R&D expenditures/sales are at least 1%.
2. Intermediate values
3. R&D efficiency = 2004-2007 cumulative operating profit/ 2000-2002 cumulative R&D expenditures
4. ROA readings pertain to 2007.
5. No. of sample firms = 252 firms each

Source: Made by MHRI based upon ORBIS.

b. Japan's R&D efficiency

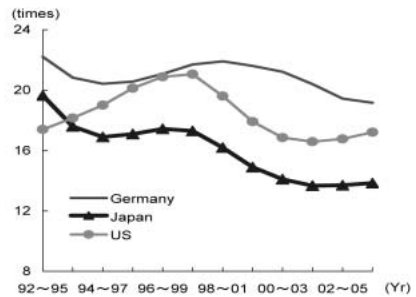
Let us now measure Japan's R&D efficiency on a macroeconomic level and compare it with other countries of the world (note 10). Japan's R&D efficiency thus calculated is following a downward trend in recent years both on an all–industries basis and on a manufacturing sector basis. Compared with the first half of the 1990s, Japan's R&D efficiency is approximately 20% lower on an all–industries basis and approximately 30% lower on a manufacturing sector–basis (note 11) (**Charts 16, 17**). Moreover, the level of Japan's R&D efficiency is lower than the US and Germany.

Chart 16: R&D efficiency (all industries)



Notes: R&D efficiency = (value-added during the past 4 years)/
(cumulative R&D expenditures during the period from 8 years ago to 6 years ago)
Source: Made by MHRI based upon OECD statistical data.

Chart 17: R&D efficiency (manufacturing sector)



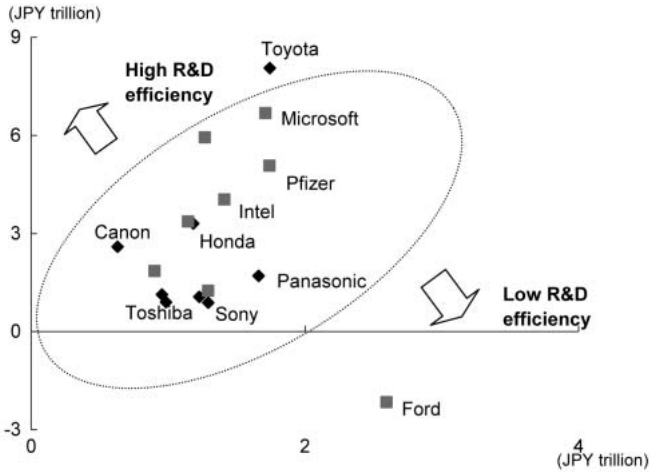
Notes: R&D efficiency = (value-added during the past 4 years)/
(cumulative R&D expenditures during the period from 8 years ago to 6 years ago)
Source: Made by MHRI based upon OECD statistical data.

We also compared the R&D efficiency of major Japanese firms with their US counterparts (note 12). In **Chart 18**, we have plotted the operating profits (cumulative value from 2004 to 2007) and R&D expenditures (cumulative value from 2000 to 2002) of major firms of Japan and the US. The cumulative value of R&D expenditures is set forth on the horizontal axis and cumulative operating profits set forth on the vertical axis. Thus, plots on the higher left hand side indicate a higher R&D efficiency while plots on the lower left hand side indicate a lower efficiency (note 13). As shown in this graph, the Japanese firms with relatively high R&D efficiency are Toyota, Honda, and Canon. In contrast, Japanese firms having relatively low R&D efficiency are Panasonic, Toshiba and Sony.

Taking the foregoing into consideration, let us look at R&D efficiency and the characteristics of major products. Generally speaking, firms with high R&D efficiency possess common characteristics that they produce integral–type products (note 14) and that they possess highly advanced approximation & optimization technology. On the other hand, most firms with relatively low R&D efficiency are producers of a wide range of modular–type products (note 15).

According to Fujimoto (2006), Japanese firms excel in their capacity to create "a flow of customer–oriented design information" through teamwork by close mutual coordination of various divisions within the company. He also says that this is compatible with integral–type products in which intra– and inter–organizational coordination leads readily to competitiveness. As a result, firms whose main product lines are comprised of integral–type products such as cars and digital cameras are able to maintain competitiveness by making use of their strengths as Japanese firms. R&D effectiveness of these firms turns out to be higher. On the other hand, firms with product lines with a large percentage of modular–type products such as general–purpose IT appliances and household electric appliances tend to lose market share due to fierce competition with emerging countries, thus resulting in a lower level of R&D efficiency.

Chart 18: Operating profits and R&D expenditures of leading firms of Japan and the US



Notes: Horizontal axis: R&D expenditures (2000-2002 cumulative value).
Vertical axis: Operating profits (2004-2007 cumulative value)
Source: Made by MHRI based upon Ministry of Economy, Trade and Industry and OSIRIS.

4. The factors behind Japan's dwindling R&D efficiency

Thus far, we have looked at the performance of Japan's R&D. The findings reveal that Japan is maintaining a high level of technological capability but that profits thus generated is following a downward trend. Japan's corporate sector, in particular, is finding it difficult to gain returns commensurate to its R&D expenditures. Why has it become difficult for Japan's R&D to generate corporate profits? This section will examine the problems of Japan's R&D to find the causes for the stagnation of R&D efficiency.

The four following issues are the most typical of the problems

cited with respect to Japan's R&D.

(1) R&D investment concentrated in low profit areas
(2) Inefficient R&D system
(3) Decline in value of Japanese technology
(4) Weakening bond between technology and profits

(1) to (3) are problems with respect to the technology itself and the stages of technological development while (4) may be interpreted as a problem in the utilization of the technology in businesses and products. We shall elaborate on these issues below.

(1) R&D investment concentrated in low profit areas

The foremost factor causing the decline of Japan's R&D efficiency is the concentration of R&D investment in low profit areas.

Chart 19 sets forth the percentage of R&D expenditures and operating margins of Japan's industrial sector. The percentage of R&D expenditures is higher in the electrical machinery and motor vehicle industries which have lower–than–average operating margins. In contrast, R&D expenditures are low at 1.8% in software & information processing sectors which have high operating margins. This shows that R&D investment is polarized in low profit areas in Japan.

Chart 19: R&D expenditures and operating margins (by industrial sector)

Industrial sector	R&D expenditures		Operating margin
	Amount (JPY 100 million)	Percentage	
Electrical machinery	41,106	30.2%	2.6%
Motor vehicles	23,240	17.1%	3.3%
Machinery	15,776	11.6%	6.5%
Software & information processing	2,449	1.8%	7.7%
Telecommunications	2,695	2.0%	6.8%
All industries (ex finance and insurance)	135,956	100%	4.4%

Notes: 1. Averages during the period from 2007 to 2009.
2. The percentages of R&D expenditures refer to percentages in the entire industrial sector concerned
3. Limited to companies engaging in R&D activities
4. The definitions of the machinery and electrical machinery sectors are the same as those in Chart 9.

Source: Made by MHRI based upon Ministry of Internal Affairs and Communications, *Survey of Research and Development*.

The lag in "selection and focus" in R&D may be one of the reasons for Japan's condition. According to the OECD, the ratio of Japan's R&D expenditures by industry has remained virtually unchanged during the period from 1987 to 2006 (**Chart 20**). That said, this is not a problem limited only to R&D and may point to the fact that there has been little progress in the readjustment of Japan's industrial structure.

Chart 20: Japan's R&D expenditures (percentage by industrial sector)

Industrial sector	1987	1998	2006
Radio, TV and communications equipment and apparatus	23%	24%	23%
Motor vehicles, trailers and semi-trailers	13%	13%	17%
Chemicals and chemical products	17%	15%	15%
Computer and related activities		3%	2%

Notes: 1. The cell is left blank when there is no available data.
2. Based upon OECD data which differ from data in the *Survey of Research and Development* of the Ministry of Internal Affairs and Communications.

Source: Made by MHRI based upon OECD, *Research and Development Statistics*.

The large proportion of R&D investment toward low profit sectors also applies to R&D investment in terms of corporate size. As mentioned before, Japan's R&D investment is skewed toward large corporate enterprises. However, a look at the profit margins of corporations engaging in R&D reveals that profit margins are the highest among small and medium sized enterprises (SMEs) with capital of JPY10 million to less than JPY100 million whose R&D expenditures are only 3.2% of all corporate enterprises (note 16) (**Chart 21**). Since small and medium venture firms are generally said to be the ones most likely to come up with break–through innovations, ways to increase the amount of R&D investment of small and medium venture firms are necessary.

Chart 21: R&D expenditures and operating margins (by size of firm)

Capital	R&D expenditures		Operating margin
	Amount (JPY 100 million)	Percentage	
JPY 10 mil ~ less than JPY100 mil	4,359	3.2%	5.1%
JPY 100 mil ~ less than JPY 1 bil	7,430	5.5%	3.6%
JPY 1 bil ~ less than JPY 10 bil	24,870	18.3%	3.8%
JPY 10 bil or more	99,081	73.0%	4.6%

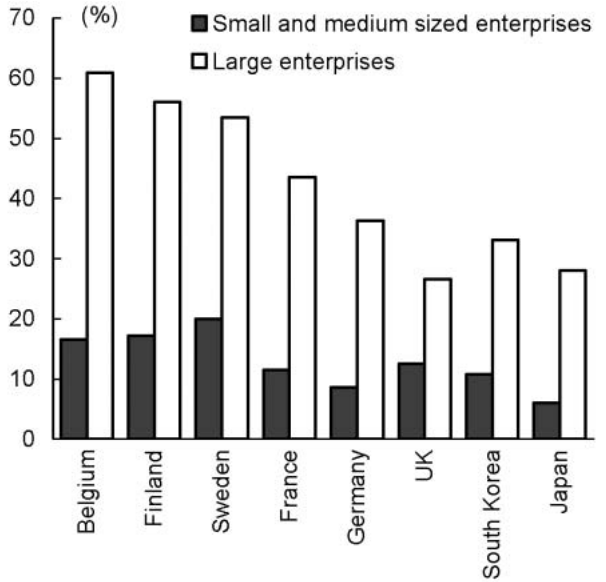
Notes: 1. Averages during the period from 2007 to 2009.
2. The percentages of R&D expenditures refer to percentages in all the firms covered.
3. Limited to companies engaging in R&D activities.
Source: Made by MHRI based upon Ministry of Internal Affairs and Communications, *Survey of Research and Development.*

(2) Inefficient R&D system

Japan's inefficient R&D system should be cited as the second factor. Given the large number of Japanese corporate enterprises which grew on the basis of in–house R&D, they are lagging in joint research with other firms, universities and public research institutes. According to the OECD, the percentage of Japanese corporate enterprises which have cooperative relations with external entities in

R&D activities fall below the level of major countries of the world such as Germany, France and South Korea and are only half of countries such as Belgium and Finland which take a proactive stance toward research cooperation (**Chart 22**). Moreover, Japan is also lagging in terms of industry–academia collaboration. Japan falls far below the US and Europe in this area, according to an evaluation of industry–academia collaboration by the International Institute for Management Development (IMD) (note 17).

Chart 22: Percentage of firms which have cooperative relations with external entities in R&D activities



Source: OECD, *Science, Technology and Industry Scoreboard 2007*.

(3) Decline in value of Japanese technology

The third factor is the decline in value of technology developed by Japan. Japan has traditionally excelled in process innovation (note 18), known also as "*kaizen*" technology. However, as a result of the

modularization (note 19) of products and construction of manufacturing models encompassing emerging countries by American and European firms, the value of process innovation (*kaizen*) itself has fallen.

(4) Weakening bond between technology and profits

So far, we have looked at the problematic aspects in the technological development process as well as the technology itself. However, the most serious problem is not technological development but Management of Technology (MOT) which is unable to connect the technological prowess to corporate earnings.

The declining competitiveness of Japanese products is starting to become a serious problem. Given the progress of modularization and intensification of world–wide R&D competition, high technology and quality is not necessarily leading directly to the competitiveness of products. Admittedly, Japanese high–function devices, which have developed to stellar standards but in such an idiosyncratic way, are referred to with a touch of mockery as "Galapagos–ized" (note 20). Even though these products may possess competitiveness in the Japanese market, they do not fit the needs of general consumers in overseas markets. Such tendencies are most prevalent in digital products such as mobile telephones. Thus, Japanese firms only have an extremely limited presence in the overseas markets of these products (**Chart 23**).

Chart 23: Market shares of major products held by Japanese firms in the global and overseas markets

Product	Global market share of Japanese firms	Overseas market share of Japanese firms
Mobile TVs	11.4%	0.2%
Notebook PCs	21.7%	2.2%
Digital cameras	60.4%	36.4%
Liquid crystal display TVs	43.4%	1.6% (Note 1)
DVD recorders	66.3%	3.7% (Note 2)
Memory	16.1%	13.9%

Notes: 1. The readings on the market share of Japanese firms for liquid crystal display (LCD) TVs in the overseas market refer to all TVs.
2. The readings on the market share of Japanese firms for DVD recorders refer to all video appliances.
3. Readings on mobile telephones, notebook PCs, LCD TVs and DVD recorders are market shares as of 2007 and the rest are as of 2006.

Source: Ministry of Internal Affairs and Communications, *ICT International Competitiveness Index*.

A key to understanding Japan's situation is the fundamental stance among Japanese firms which place emphasis upon hardware. Japanese firms have traditionally excelled in product development with priority upon hardware, due in part to their growth as technology–intensive vertically–integrated (note 21) corporate enterprises. However, the global trend of digital appliances is shifting toward an emphasis upon functions as a network device allowing network access to new contents – for example so–called "smart–phones" – rather than the functions as a hardware device.

Moreover, Japan is also falling behind in its efforts to upgrade the value of its own technology. It is becoming difficult to maintain the continuous creation of technological value without mechanisms such as *de jure* standards (note 22) and *de facto* standards (note 23). In the US and Europe, R&D, market strategy and global standardization strategy are all perceived of as being integrated as a whole, leading to a focus upon preemptive acquisition of global standards. Japan, on the other hand, has not taken an active stance toward the acquisition

of global standards due to its sizeable domestic market and hence its tepid interest toward global markets. A telling point is the number of cases in which Japan acted as manager (note 24) for the International Organization for Standardization (ISO) which falls far below the US and Europe.

5. Challenges for the improvement of competitiveness from the perspective of R&D

The previous section, which examined the reasons behind Japan's stagnant R&D efficiency, found that many of the problems are related to the fundamental elements of Japan's industry and management such as Japan's unchanging industrial structure, lack of progress among firms in breaking out of "in–housing" its R&D, insufficient MOT, and R&D systems skewed toward large corporate enterprises. To survive in global competition, it is necessary to overcome these issues, build corporate enterprises' foundation for business development and profits, and to construct an R&D system leading to Japan's vitalization. Here, we shall discuss the issues which need to be addressed in both the corporate and government sectors for Japan to revive as a competitive technology–driven country.

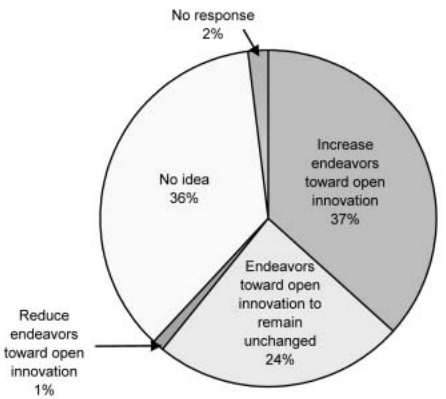
(1) The corporate sector

The greatest challenge facing Japanese firms is to raise their sagging R&D efficiency. To do so, the promotion of open innovation and the reinforcement of R&D activities in emerging countries are indispensable. We shall elaborate on these issues in the following sections.

a. The promotion of open innovation

The promotion of open innovation is essential for Japan to win in global competition of R&D and to improve the competitiveness of its products. However, given Japan's economic growth based on an "in–house" approach, very few firms are seriously contemplating open innovation (**Chart 24**). In view of the progress of globalization, advancement of information technology, and the faster pace of change in economic and technological environments, it is absolutely necessary to form a system of innovation to match the changing times without adhering to past practices.

Chart 24: Open innovation in Japan (outlook)



Notes: 1. Based upon a questionnaire survey of firms.
2. Data as of 2008.
Source: Japan Economic Foundation, *EPA/FTA no shinten to wagakuni kigyo no kaigaijigyotenkai ni kansuru chosakenkyu (Research on the progress of EPA/FTA and overseas business of Japanese firms).*

The concept of open innovation is not entirely understood in Japan. Open innovation is not the mere shift of production and development sites to emerging countries or the use of technology of other firms. According to a definition used by an expert panel of the Cabinet Office of Japan, open innovation is "a method to maximize innovation efficiency through the optimum combination of innovation existing both within and outside of one's own company by

accelerating the development of new necessary technology while minimizing the uncertainties in the development of new technology, reaping maximum results in the shortest time span possible by minimizing the time necessary for product development while taking in cutting–edge technological advancement in a flexible manner, and at the same time, take outside the company internal inventions not being used within the company" ("*Opun inobeshon o saiteigi suru*" (Redefining open innovation), Expert Panel on Basic Policy (7th Session), Council for Science and Technology Policy, Cabinet Office).

To spread such a paradigm and to effectively actualize open innovation among Japanese firms, it would be necessary to strengthen the Management of Technology (MOT) and management of intellectual property, and to acquire and/or nurture high quality human resources well–versed in MOT. For this end, Japanese firms should re–acknowledge the importance of MOT human resources, and should do all it can to attract high quality MOT human resources from overseas.

b. The expansion of R&D activities in emerging countries

The expansion of R&D activities in emerging countries is another important challenge along with the promotion of open innovation. Further forays into emerging markets are essential for Japanese firms which are faced with a stagnant domestic market. However, as mentioned earlier, Japanese firms have been unable to expand their market share since many of their products do not accurately reflect the consumer needs of emerging markets. In order to accurately capture the future expansion of emerging market demand, it is necessary to develop products matching local market needs in terms of both functionality and price level. The first step of the process is R&D rooted in the local market. Furthermore, the expansion of R&D activities in emerging countries would be beneficial also from the perspective of securing highly capable human resources and reducing R&D expenditures.

Nevertheless, this does not necessarily mean the full–fledged

overseas shift of R&D. The primary objective of overseas R&D should be the tapping of emerging market demand and the supplementation of human resources. Core technology should be developed through domestic R&D as in the past. Upon doing so, firms should strive for optimum R&D both domestic and overseas and maximize its effect in order to raise their R&D efficiency while avoiding the "hollowing out" of R&D.

(2) The government's challenges

Let us turn next to the challenges faced by the government of Japan. Japan's R&D support measures are formed mainly around tax relief for R&D. However, the decline of Japan's competitiveness is not the result of a shortage of R&D investment itself but stems from the low efficiency of R&D and the weak connection between technology and profits. Thus, measures to help raise R&D efficiency and support measures to improve firms' ability to connect technology with profits are necessary, rather than measures to promote a further increase in R&D investment.

In particular, the government should play a major role in building a system which would promote the ability of Japanese firms to cope with open innovation. The reinforcement of equity finance and entrepreneurship education/training are among some of the measures advocated by the Council for Science and Technology Policy of the Cabinet Office to promote open innovation. In addition to such policy measures, wide–ranging support measures including human resource training and infrastructure development are necessary.

6. Conclusion

There is no quick fix to the problems surrounding R&D since they pertain to the fundamental problems of present–day Japan.

Furthermore, the oft–cited decline of academic levels among Japanese students may be a cause of Japan's waning R&D. There is little room for optimism on whether Japan can maintain and improve its R&D capabilities in the future, given the concerns regarding the quality of researchers, the decline in number of students majoring in math & science and the reduction of budgets for education and research.

However, if effective measures are taken – including the proposals set forth in this paper – and firms continue to strive for R&D, there is hope yet in the future toward the rise of Japan's R&D. On a last note, these government and private sector reforms in R&D should lead to a roadmap to address the various problems faced by the Japanese economy.

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Notes:

1 "R&D stock" is calculated on the basis of the following premises: (1) the time lag from implementation to results of R&D is deemed as period 1, (2) the rate of depreciation is deemed as 10%, and (3) t period R&D stock = t–period 1 R&D expenditures + 0.9 × t–period 1 R&D stock. Since R&D stock is calculated on the basis of a fixed and nominal rate of depreciation during the survey period, it is necessary to take note of the possibility that depreciation periods may be shortened due to the shortening of product life cycles and the erosion of real R&D due to the rise of prices regarding R&D.

2 In the four patterns, the period of survey is six years, due to limitations in available

data.

3 Although analyses of cases other than (1) to (4) were conducted by staggering the time periods, the results were more or less unchanged, save for a few exceptions.

4 However, take note that both the US and China have large military–related R&D expenditures.

5 The Research Institute of Economy, Trade and Industry is an incorporated administrative agency under the Ministry of Economy, Trade and Industry (METI) which engages in policy research regarding public policy.

6 The creation of innovative products and business models through the use of both its own technology as well as the technology and ideas of other firms.

7 The METI's guideline on patent property strategy (*Tokkyozaisan senryaku shihyo*) sets forth the following criteria: "profitability of patents = GDP (current term)/ 5–period accumulated total of international patents. According to this criteria, Japan's patent profitability ranks fifth place among the five major countries (Germany, US, France, UK, Japan).

8 Technology trade refers to international global transactions related to the provision and acceptance of technology etc. (patent rights, trademark rights, design rights, knowhow, technical guidance etc.) obtained through R&D.

9 A paper compiled by METI in April 2005 on the ripple effect of the tax system promoting R&D (*Kenkyukaihatsu no sokushin zeisei no hakyukoka*) provides an average of corporate enterprises: average period of R&D = 2.9 years (1990 – 1999 data), average time–to–market = 1.2 years (data from 2000 onward), average period recording earnings = 4.1 years (1990 – 1991 data). The analysis in this paper is based upon the foregoing.

10 In the macroeconomic analysis of R&D efficiency, total value–added is used instead of operating profits as the indicator for accomplishments. We measured the accomplishments, assuming that the time lag is similar to the analysis of corporate businesses, that the accomplishments from a 3–year period of R&D would emerge in the next 4–year period after a 1–year lag, using nationwide indicators.

11 Given the inclusion of wholesalers and retailers which do not engage in virtually any R&D investment and hence a smaller amount of R&D expenditures which is the denominator of the formula, the calculation of R&D efficiency on an all–industries basis turns out higher than R&D efficiency among manufacturers.

12 As indicated by Suzuki (1993), it is necessary to take note that R&D expenditures in the financial statements of Japan's listed corporations tend to be understated.

13 The firms plotted for Japan are the following eight firms: Toyota, Honda, Canon, Panasonic, Sony, Toshiba, Hitachi, and NEC. The firms plotted for the US are the following firms: Intel, Ford, Microsoft, Pfizer, Cisco System, Merck & Co., Motorola, Johnson & Johnson.

14 Products which are made of parts and production processes especially designed for each product and which do not demonstrate their functions and capabilities without mutual adjustment and optimization.

15 “Modular–type products” refer to products whose functions and parts are matched on a one–on–one basis and whose interfaces are standardized.

16 The general understanding today is that the profitability of SMEs is lower than that of large enterprises. However, since Chart 21 covers enterprises which engage in R&D activity, the SMEs included in this chart are presumed to be SMEs with relatively high competitiveness which can engage in such activities. It is necessary to note the possibility that this may be the reason why the profitability of SMEs with capitals of JPY10million or over and less than JPY100 million is higher than corporate enterprises with capitals of JPY100 or over.

17 The International Institute for Management Development (IMD) is a major business school in Switzerland.

18 “Process innovation” refers to the improvement of the manufacturing process.

19 “Modularization” refers to the design and manufacture of complex products using small parts (components) which are individually designed and manufactured.

20 “Galapagos–ized” refers to the phenomenon where technology and services evolve in an idiosyncratic fashion in the Japanese market and stray far away from global standards.

21 “Vertical integration” refers to a method of product development in which the design and various manufacturing processes are undertaken by one company.

22 “*De jure* standard” refers to a public standard set forth by international organizations etc.

23 “*De facto* standard” refers to standards which are not public standards but are deemed as *de facto* standards due to widespread usage in the market.

24 Management operations refer to operations coordinating the various standardization organizations of countries around the world. By acting as manager, a country has the advantage of choosing proposals for the agenda and exercising leadership in determining the site of conferences, thereby leading the international standardization process.

Mizuho Research Institute

Nittochi Uchisaiwaicho Building
2-1, Uchisaiwaicho 1-chome, Chiyoda-ku, Tokyo 100-0011
TEL: (03) 3591-1241
FAX: (03) 3591-1399
http://www.mizuho-ri.co.jp/english/