Chapter 3 An R&D Financing-Type Business Model Needed —Issues with the promotion of the commercial use of new mechanical technology and measures to be taken—

3.1 Focus of this survey

In the wake of the prolonged recession of the Japanese economy, there now exists mounting concern that Japanese industry will deteriorate in terms of its international competitiveness. In the case of the machine industry, for example, there are issues such as the hollowing of domestic industry due to China's rapidly catching up industry and the decreasing efficiency of research and development. However, it is unclear as to what extent the perception of the decreasing international competitiveness is justifiable and to what extent the proposed remedial measures will be effective. In this article, we shall examine the plausibility of the prevailing arguments relating to the decreasing efficiency of research and development.

3.2 Sorting out the problems with prevailing arguments

Let us start our discussion by creating a simple model for the flows of R&D investment and its return at a typical company:

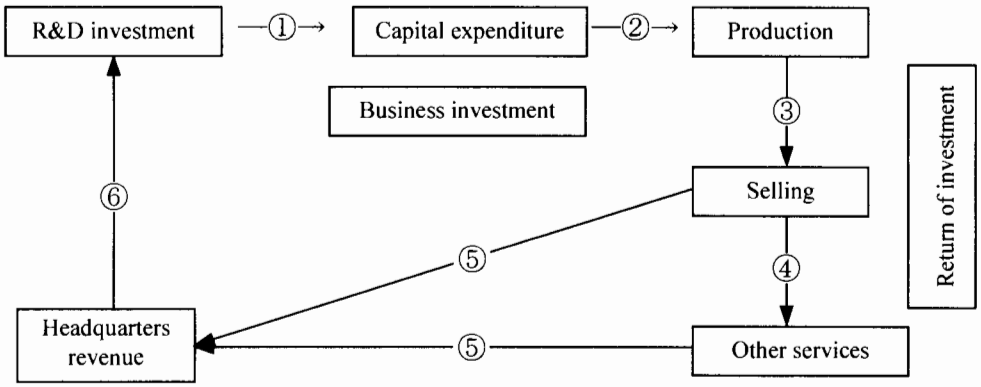
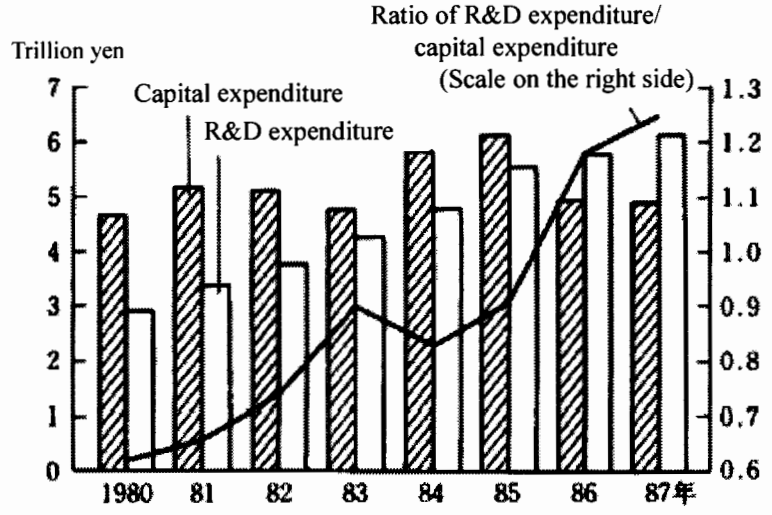


Chart 3-1 R&D investment and its return at a company

Arguments about the decreasing efficiency of R&D can be classified into two types. First, there are arguments triggered by the now famous schemata used by Fumio Kodama in his article *Paradigm of High Technology* published in 1991 (Chuo Koronsha). According to Kodama, the Japanese manufacturing industry experienced a reversal of the amount of R&D investment and the amount of capital expenditure in the late 1980s. At first, Kodama thought that this phenomenon suggested the transition of the manufacturing industry into a "creation" industry. However, Kodama admits that this explanation subsequently underwent modifications, and it is now generally recognized that the real problem was with the process of R&D investment through capital expenditure (part ① in Chart 3-1); the apparent decreasing efficiency R&D actually meant that the portion of R&D investment that did not lead to capital expenditure had been increasing (*Why Japanese companies' R&D has suffered deterioration in efficiency*, K. Sakakibara et al., Socio- economic Research Center 2003). At the same time, Sakakibara didn't fail to point out the fact that American companies such as Intel and IBM had experienced increases in both R&D investment and capital expenditure. After reviewing other reports relating to this issue, Sakakibara proposed a hypothesis that the major cause of the phenomenon was that Japanese companies had been increasingly placing emphasis on in-house R&D efforts, reflecting their excessive self-reliance while experiencing the mounting criticism against Japanese industry's free ride on research work conducted abroad in the latter half the 1980s.

However, this argument has two major problems. First, it lacks verification of what happened in the latter half of the 1980s and the implications of what followed. According to the Ministry of Economy, Trade, and Industry's "Trends of Japanese Industrial Technology R&D Activities—Major Indices and Survey Data," it appears that the manufacturing industry as a whole has been experiencing increased R&D spending and decreased capital expenditure.



Source: F. Kodama, 1991

Chart 3-2 Changes in R&D Spending and Capital Expenditure in Manufacturing Industry

Nevertheless, it is questionable as to whether or not the same phenomenon can be observed in all segments of the manufacturing industry and whether or not it will be temporary. Second, there may be a problem in the use of different methods to determine R&D investment and capital expenditure. It is conceivable that a company increases its R&D spending because it has to venture on a promising future business in a situation that requires it to reduce capital expenditure on its existing business or new technology. This could have easily been the case in the latter half of the 1980s following the Plaza Accord, because capital expenditure does not respond to new R&D results alone. It is therefore critical to determine in what manner the results of R&D effort have eventually been materialized.

Second, there have been arguments put forth that center on the estimation made by Murakami of Sumitomo Electric Industries (K. Murakami: *Innovation Management Arising From A Sense of Crisis*, Works, Recruit, 1999/12 and 2000/1). Murakami calculated the efficiency of companies' R&D activities in terms of the ratio of operating profit to R&D spending by dividing five years' accumulated R&D spending by the preceding five years' accumulated operating profit/loss. In this manner, he analyzed nine manufacturing companies, including Sumitomo Electric Industries, NEC, and Canon, which placed the emphasis on R&D for the period from 1988 to 1998. Murakami's analysis found that almost all of the surveyed companies experienced a significant decline in the efficiency of R&D efforts in the latter half of the 1990s.

Chart 3-3 Comparison of R&D Efficiency

R&D Efficiency

(=[5 years' accumulated operating profit]/[Preceding 5 years' accumulated R&D spending])

(Unit: year, %)

Company name	1988-92	1989-93	1990-94	1991-95	1992-96	1993-97	1994-98
Sumitomo Electric Industries	173	158	138	116	110	108	112
NEC Corporation	44	34	25	21	21	26	33
Toshiba Corporation	71	58	38	35	39	37	39
Sony Corporation	43	24	12	3	14	23	32
Matsushita Electric Industrial Co. Ltd	51	42	32	24	21	22	26
Toyota Motor Corporation	154	120	88	59	63	79	93
Sharp Corporation	63	65	62	59	58	52	45
Canon, Inc.	110	93	80	82	93	106	121
Bridgestone Corporation	304	274	251	228	216	210	226

* Nine companies focusing on R&D; calculated using data from their financial reports

Source: M. Murakami, 1999

Murakami made a comparison of these companies in terms of the efficiency of R&D efforts by focusing on ⑥ and ⑤ of Chart 3-1. The publication of his article was a very timely and beneficial event. Regarding the results of his analysis, however, the validity of his hypothesis that R&D efforts would bear fruit in five years' time remains to be tested. Furthermore, some people question whether or not it is reasonable to use operating profit as the output indicator of R&D activities because there are many other factors that can affect operating profit. This differs widely, for example, from Uenohara's and other researchers' argument that as the output indicator of R&D activities, either sales or sales profit/loss (sales less manufacturing cost) should be used, depending on whether the emphasis is placed on the contribution to the economy or the contribution to the company (M. Uenohara et al: *Research and Development Management*, Corona Publishing, 1995). We have also found through the interviews that we conducted for this survey that companies want to fix the ratio of R&D spending to sales. From this, it can be said that Uenohara's hypothesis that R&D efforts would bear fruit in five years' time amounts to comparing the current and past sales profit/loss. This would lead to a simplistic conclusion that the efficiency of R&D activities is high in a company with increasing profit and low in a company with decreasing profit.

Another major problem lies in the fact that the period covered by Uenohara's analysis overlaps with the transition of the Japanese economy from the so-called bubble to its collapse. The outbreak and collapse of the bubble economy and the deflation in the wake of its collapse were basically macroeconomic phenomena. Corporate earnings are definitely influenced by such macroeconomic phenomena. It is highly probable that the magnitude of the influence of macroeconomic phenomena far exceeds the effect of microscopic economic factors such as R&D spending. The latter half of the 1990s saw some improvement of the index, but it is unlikely that the improvement was due to improved R&D efficiency. It is absolutely necessary to take the influence of macroeconomic factors into consideration. This will be discussed herein. It may also be necessary to examine whether or not the satisfactory performance reported by Canon and Bridgestone reflects the improved efficiency of their R&D activities.

What Kodama and Murakami questioned should be reconsidered from a different perspective, that is, why companies increased their R&D spending more than the growth of revenues and what results were produced.

3.3 Assumptions and analysis

Drawing upon the above-mentioned study results, we conducted a survey and analysis. We also tested the hypothesis on which the above-mentioned work was based.

(1) Analysis of financial data with respect to machine industry R&D investment

The subclassification of industry employed in the above-mentioned work is inadequate; it discussed the manufacturing industry as a whole and did not specifically focus on the machine industry. Even the Ministry of Economy, Trade, and Industry's "Trends of Japanese Industrial Technology R&D Activities—Major Indices and Survey Data" subclassifies the machine industry only broadly into electric equipment, automobiles, and general machines. To get a more detailed picture of the correlation between R&D spending and company performance, therefore, we, with collaboration from the Research Institute for Capital Formation, the Development Bank of Japan, analyzed company data from the 1990s by subclassifying the listed machine industry companies into 21 segments. (This is similar to what Kodama did with his chart for the 1980s.) We analyzed the data for both the 1980s and the 1990s in order to examine the performance in the 1990s in the wake of the 1980s and determine the difference in trends between the 1980s and the 1990s.

Our analysis specifically covers the correlation between 1) R&D investment and sales/profit, 2) R&D investment and capital expenditure, 3) capital expenditure and sales/profit, and 4) these factors during the 1980s and the 1990s.

(2) Interviews related to the status of research and development

We conducted interviews with ten companies to test the validity of the prevailing theories and our hypothesis described below. The ten companies interviewed included one automobile manufacturer, one automobile parts manufacturer, four computer and electric equipment manufacturers, one civil electric equipment manufacturer, one electronics parts manufacturer, one machining tool manufacturer, and one construction machine manufacturer.

3) Hypothesis

To conduct our survey, we employed the following working hypotheses:

1) The decline in the efficiency of R&D experienced by companies in the 1980s (the phenomenon of R&D investment exceeding capital expenditure; part ① in Chart 3-1) indicates that there existed a situation that forced companies to curb capital expenditure while increasing R&D spending.
2) The fact that company profits were less than satisfactory in comparison with R&D spending was due primarily to macroeconomic factors. The relative difference between high-profit and low-profit companies (segments) reflected the difference in their organizational setup (business model) to recoup the money invested.
3) Conventional business models could not avoid collapsing due to competition policy changes and technological innovation. However, low-profit companies (segments) failed to cope with the situation because they were slow to implement new relevant business models.
4) The problem was not in R&D investment but in the existing business model for recouping R&D spending. With inadequate revenues making internal R&D financing difficult, it was urgent for companies to build business models that would allow internal R&D financing. This required establishing technology and business models based on solid principles.
5) Kodama's hypothesis remains valid.
6) The government should provide support for basic research efforts and help build business models capable of meeting the needs of the times by closely examining problems that prevent companies from coping with the current situation.

3.4 Findings

In the following pages, we summarize the results of our analysis of R&D-investment-related financial data and company interviews by focusing on automobiles, computer/electric equipment, civil electric equipment, electronics parts, office equipment, and optical equipment, which are particularly R&D-intensive segments (those that record high R&D spending both in the amount and the ratio against sales) in the manufacturing industry. In automobile manufacturing companies, the percentage accounted for by "R&D" in the sales administrative expense budget is by no means large, but a massive amount of expense is allocated to design, development, factory testing, etc. This is why we classified automobile manufacturing into the R&D-intensive segment. The revenue and other basic data used in our analysis are the average of the companies belonging to individual segments of the industry.

(1) Financial data analysis

Our time-series analysis of R&D investment by segment found that the machine industry does not necessarily comprise R&D-driven segments alone. In the latter half of the 1980s, only limited segments made R&D spending in excess of capital expenditure. However, there were few segments that experienced a decline in R&D spending as the percentage of sales.

1) Changes in revenues and operating profit/loss (Charts 3-5 and 3-6)

The sales trends in the six segments of the machine industry obviously changed from the 1980s to the 1990s. This is a macroscopic factor. It must, however, be noted that even under the influence of the collapse of the bubble economy, the office equipment segment achieved almost as consistent growth in the 1990s as it did in the 1980s.

In terms of operating profit/loss, all of the segments recorded a sharp drop in performance after the collapse of the bubble economy. However, the automobile, office equipment, and electronics parts segments exceeded the 1980s levels in the 1990s. Put simply, the focus of the problem is decreased earnings on decreased revenues in computers/electric equipment and civil electric equipment, which, if combined, form the largest segments of the Japanese machine industry.

Though not explicitly clear at this stage of our survey, it appears likely that the problem is solely related to the computer/electric equipment manufacturing segment in view of the fact that the civil electric equipment segment achieved a significant recovery in 2003.

2) Changes in the ratios of R&D spending to sales and of R&D spending to commercialization investment (Charts 3-7 and 3-8)

In general, Japanese companies are said to have managed their R&D budgets in terms of percentage of sales. Since, however, sales fluctuate widely from year to year, the term percentage means a fixed ratio with respect to trends instead of annual sales. Chart 3-7 well supports the established theory for the automobile, civil electric equipment, and optical equipment segments in the 1980s. However, the office equipment and electronic parts segments increased R&D spending as percentage of sales through the 1980s and 1990s and even recorded increased earnings, as discussed above. No phenomenon of lowered R&D efficiency can be identified. True, the computer/electric equipment segments increased R&D spending significantly, but it is difficult to find any singularity of the latter half of the 1980s in the other segments. On the other hand, the 1990s saw beefed-up R&D investment in all of the segments besides computer/electric equipment. For example, the civil electric equipment segment added to R&D spending in terms of percentage of sales during the period.

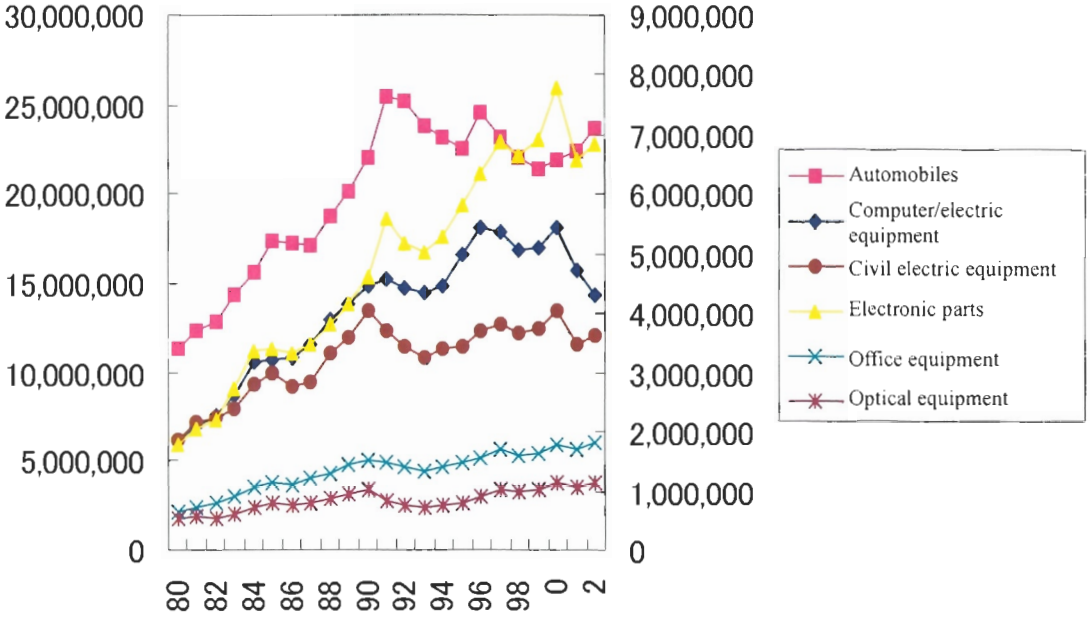


Chart 3-5 Changes in sales (unit: ¥1 million)

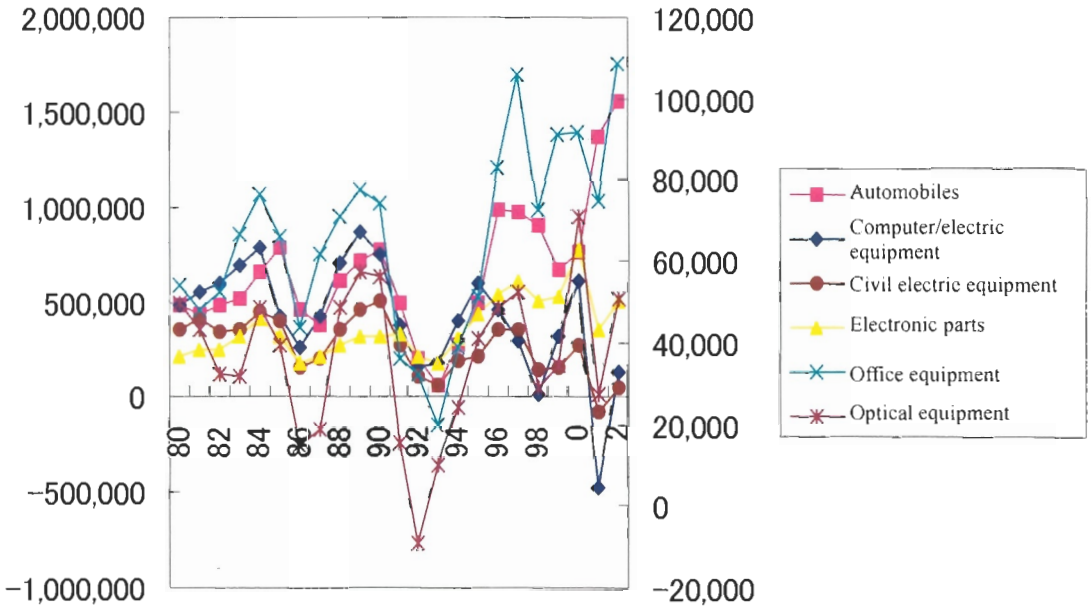


Chart 3-6 Changes in sales profit/loss (unit: ¥1million)

Next, let us examine Chart 3-8 in order to examine the reversal of R&D spending and capital expenditure that took place in the latter half of the1980s, as reported by Kodama. For this purpose, we used the ratio of R&D spending to commercialization investment (total of R&D spending and capital expenditure). If R&D spending exceeded capital expenditure, the ratio becomes more than 0.5. Our analysis found that Kodama's theory holds true for the computer/electric equipment and office equipment segments in the latter half of the 1980s. Further, in the 1990s, the ratio started to exceed 0.5 in the optical equipment, automobile, and electronics parts segments as well. In the civil electric equipment segment, too, more emphasis was placed on R&D.

Under these circumstances, only the computer/electric equipment segment has been lagging in terms of earnings. This suggests that only this segment of the machine industry has issues related to R&D efficiency.

It must be noted here that Japanese companies adjust their R&D and capital expenditure budgets, that is, their commercialization investment budgets, based on the previous year's business performance. The practice of making R&D investment, which is to provide for the future, dependent on the previous year's business performance may seem strange. But this is a clever device to ensure consistent R&D spending.

3) Changes in the ratios of commercialization investment to sales and of capital expenditure/depreciation (Charts 3-9 and 3-10)

Chart 3-9 shows the changes in the ratio of commercialization investment (total of R&D spending and capital expenditure) to sales. It is probable that in the process of translating the fruits of R&D into commercial production through capital expenditure, if R&D spending can be increased while the efficiency is maintained, capital expenditure may also be increased depending on the fruits of the R&D efforts. Another possibility is that R&D spending and capital expenditure have an alternative relationship with each other. This idea was a hypothesis used by Kodama in his "creation industry" hypothesis. We examined how companies manage their commercialization investment budgets in terms of percentage of sales. Interestingly, it was found that the ratio of R&D spending to commercialization investment remained almost constant in all of the segments except computer/electric equipment in the 1980s and the 1990s. Does this mean that companies, whether consciously or not, manage their commercialization investments in terms of percentage of sales for allocation between R&D spending and capital expenditure?

Before discussing this problem, it is necessary to determine if R&D spending has exceeded capital expenditure and if capital expenditure has been kept constant in terms of percentage of sales because capital expenditure has to be curbed for some reason or other, although R&D spending cannot be cut for competition reasons. Chart 3-10 illustrates this situation. In ordinary companies, R&D spending is covered by internal funds while capital expenditure is financed by internal money in addition to externally raised funds. In an adverse fundraising environment, however, companies have to keep R&D spending within their retained earnings. This means that depreciation serves as the guideline. We must therefore examine to what extent capital expenditure is above (or below) the amount of depreciation.

Our survey found that in the 1980s and 1990s, every segment of the machine industry showed a tendency toward decreased dependence on external funds in an effort to contain capital expenditure within the scope of depreciation. We originally presumed that this phenomenon was caused by the plummeting of the value of assets such as land and securities in the wake of the collapse of the bubble economy, making it difficult for companies to raise funds. Since, however, the phenomenon existed in the 1980s as well, only the collapse of the bubble economy does not seem to be the contributing factor.

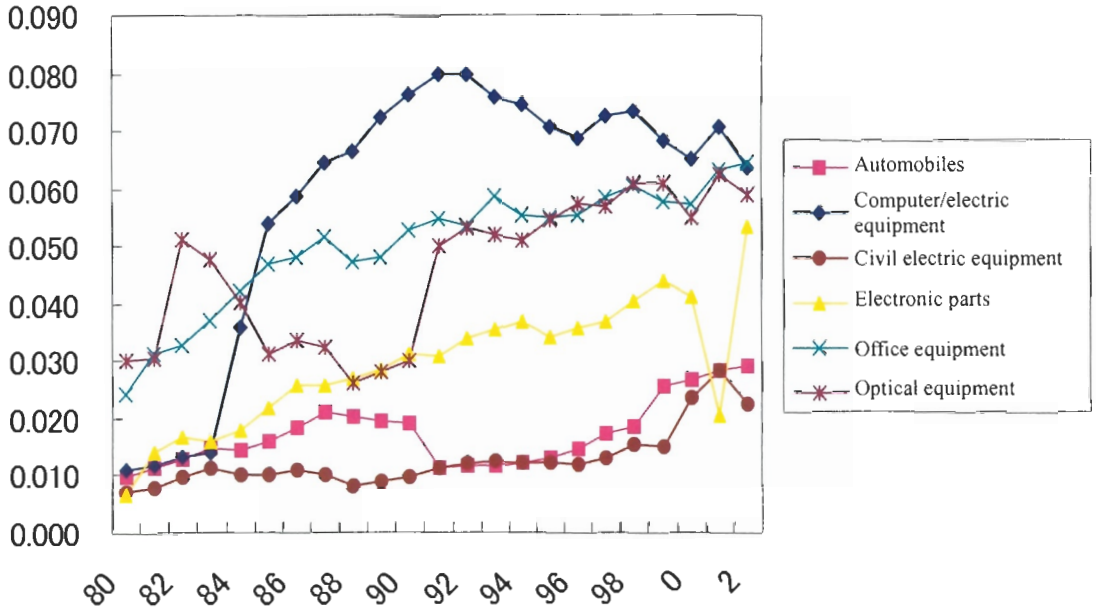


Chart 3-7 R&D spending/sales

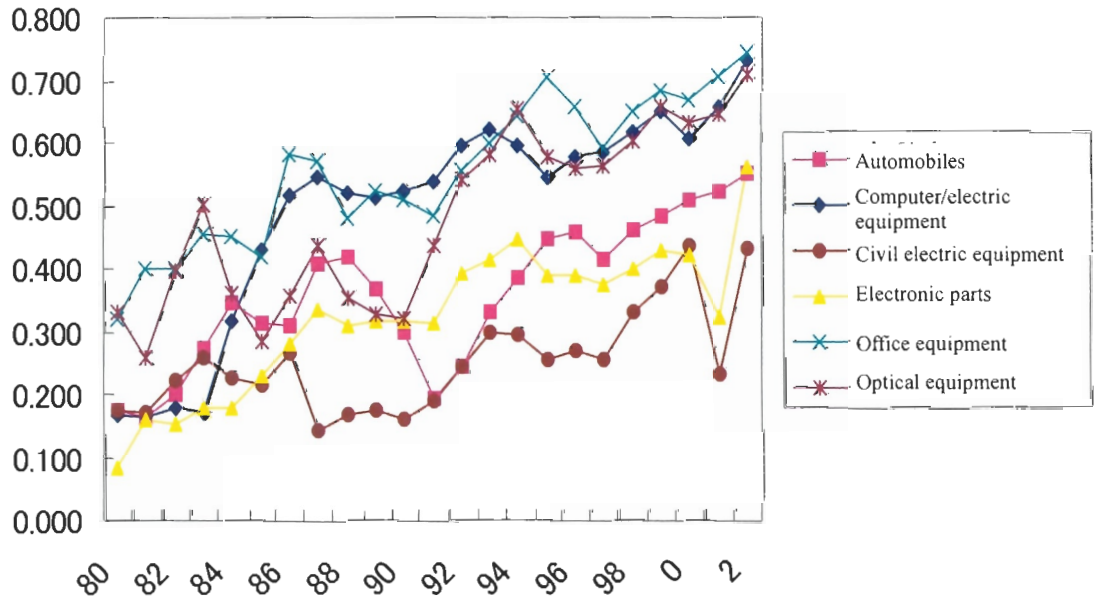


Chart 3-8 R&D spending/commercialization investment

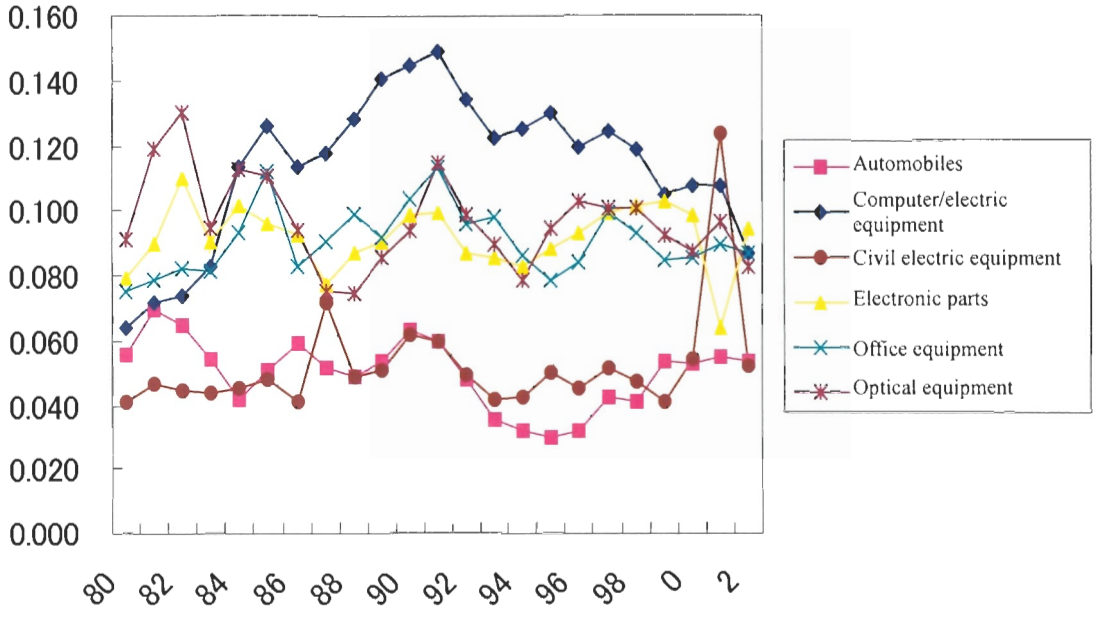


Chart 3-9 Commercialization investment/sales

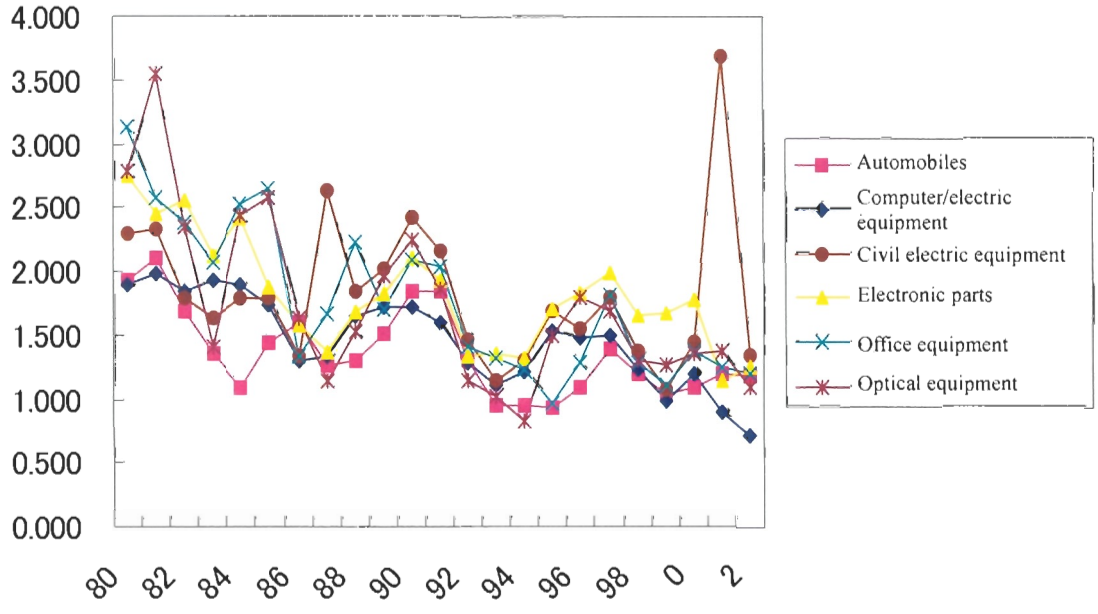


Chart 3-10 Capital expenditure/depreciation

It is noteworthy that capital expenditure was below depreciation only in the computer/electric equipment segment. Companies in this segment have been curbing the volume of their commercialization investments by keeping R&D spending in terms of amount as well as in terms of percentage of sales while at the same time keeping capital expenditure within the scope of depreciation. It is feared that they may have become trapped in a vicious circle.

4) Summary

Our financial data analysis confirmed that the trend pointed out by Kodama, that is, that R&D spending exceeds capital expenditure, still continues throughout the machine industry. It was also found that the phenomenon does not necessarily involve the lowering of the efficiency of R&D except in the computer/electric equipment segment, in which the two factors seem to be obviously linked.

In the 1990s, civil electric equipment manufacturers sharply increased their R&D spending despite waning profitability. It seems that, upon entering the twenty-first century, their efforts have at last begun bearing fruits in terms of profitability.

Companies have been more and more inclined to cover not only R&D spending but also capital expenditure with internal funds. This may account for the phenomenon that the amount of commercialization investment, which is the sum of R&D spending and capital expenditure, is becoming fixed in terms of percentage of sales. At the same time, the portion of R&D spending in commercialization investment has been increasing. These phenomena, if combined, suggest a possibility of an alternative relationship between R&D spending and capital expenditure. Judging from the recent profitability trends of the major segments in the machine industry, it can be said that Kodama's "creation industry" hypothesis is still valid or, rather, that it is occurring throughout the machine industry except in the computer/electric equipment segment.

(2) Analysis of data obtained through interviews

What follows is a summary of the findings obtained from our interviews:

1) Facts about R&D

- The R&D budget is managed based in terms of percentage of sales (almost all companies interviewed).
- The number of R&D projects has increased in the past ten years (despite decreased budgets).
- The number of new business/new product proposals has remained almost the same over the past ten years.
- R&D budget allocations to different business areas vary, reflecting changes in the breakdown of business structure.
- The importance of R&D has been increasing because of the recognition of the need for pushing with R&D differentiation from the ground up (almost all companies interviewed).
- Mounting expectations for R&D reflect the increasing number of cases in which R&D helps enhance differentiation and competitiveness.
- As often as not, original technologies resulting from basic research help maintain a leading position in the market for an extended period. Such experience carries weight.

2) Strengths

- Strong areas have common serendipity factors such as high-caliber staff members and long-term R&D projects.

3) R&D strategy, etc.

- Enhancing profitability requires a kind of market dominance. It is difficult for any company to build a monopolistic business model without a R&D foundation of its own.
- The most important thing is to maintain long-term basic research activities in high-tech areas by meeting demanding the personnel and financial requirements burden instead of pursuing short-term R&D projects.
- To this end, many companies are tightening their relations with universities and other related businesses to profit from joint research efforts.
- It is essential for any company to beef up its own research potential on the basis of R&D experience and results in order to take leadership in pushing with joint research projects with universities and/or related businesses efficiently.
- The major difference in engineering development between the 1970/1980s and the present is the drastic changes in the business/ competition environment, specifically: i) the deregulation of electric power procurement, ii) the deregulation of telecommunications and the spreading use of PCs and the emergence of the Internet, and iii) the rise of new competitive relations through globalization. These factors were pointed out by the computer/electric equipment and civil electric equipment segments, among others.

4) Summary

No company is worrying about the decreasing of R&D efficiency except for a few in the machine tool and construction machine segments. Rather, the problem here for companies (typically those in the computer/electric equipment segment) is the difficulty in securing an adequate R&D budget despite the increasing number of R&D subjects. Many companies admit that this is due to the fact that profitability has been slow to pick up, blaming the management, rather than R&D, for failure to cope with the changes in the environment.

Specifically, the changes are, as described above, i) the deregulation and the resulting changes in competition policy in the electric power and communications industries, ii) the spreading use of PCs and the emergence of the Internet, and iii) a new competitive environment in the global market. The problem is that while these factors have combined to make it difficult for companies to achieve growth within the existing business framework, they have yet to find a way out of the situation. Companies, particularly those that are aware of the situation, tend to ask the government to provide financial support for their R&D efforts.

3.5 Beefing up research and development

(1) Validity of our hypothesis

The results of our survey discussed above proved that our working hypotheses are essentially correct. Let us review and consider in more detail the survey results in reference to our working hypotheses.

Hypothesis 1) The decline in the efficiency of R&D experienced by companies in the 1980s was due more to the fact that companies had to curb capital expenditure while increasing R&D spending than to a sudden decline in the efficiency of R&D.

This phenomenon, observed exclusively in the computer/electric equipment segment, appeared to have been caused by a combination of three factors. The first factor was that in an effort to counteract the mounting criticism of Japanese companies for profiting freely from the fruits of outside R&D, companies in the computer/electric equipment segment rushed to build R&D centers by capitalizing on the overwhelming competitiveness of Japanese industry, resulting in a drastic increase in R&D spending. However, in the first half of the 1990s, many of these companies were forced to reduce or close their central R&D facilities because of declining company profitability (S. Fujimura: *Knowledge Creation in Re-*

search and Development, Hitotsubashi Review, August 2002).

The second factor was the rapid yen appreciation in the wake of the Plaza Accord, which forced Japanese companies to curb capital expenditure within the country. The third factor was the shift of policy emphasis to a domestic-demand-driven economic structure involving the deregulation of electric power procurement and telecommunications. This coincided with the economic conflict with the United States and the Plaza Accord, which originated from the same root. As a result, computer and electric equipment manufacturers, which had dominated the heavy electric equipment market, were forced to curb capital investments in existing business areas that could be detrimental to stable profitability while adding to R&D spending to help switch to new business areas and beef up competitiveness. However, this was followed by the deregulation of telecommunications, which in turn resulted in the communications equipment market being expanded. For this reason, the above-mentioned problem came to the surface slightly later in companies whose main products were communications equipment.

In the 1990s, the paradigm shift of computer technology from the mainframe to the PC and of communications technology to the Internet added to the confusion in the computer/electric equipment segment.

Hypothesis 2) The fact that company profits were less than satisfactory in comparison with R&D spending was due primarily to macroeconomic factors. The relative difference between high-profit and low-profit companies (segments) reflected the difference in their organizational setup (business model) for recouping invested money.

This may be recognized as a difference between the computer/electric equipment segment and the office equipment segment. To overcome the inadequacy of the classical manufacturing industry business model, office equipment manufacturers have built an organizational setup to recoup investments through both manufacturing and sales of products by incorporating the so-called consumables business and after-sale services. The same can be said for automobile manufacturers. They have in place large-scale setups for recouping investments covering brand-name parts (consumables) business and post-sale services as well as car manufacturing and sales. What characterizes these business models (which we may call the Toyota Model or the Canon Model) is that they provide investment recouping means covering the scope of business areas capable of profiting from the fruits of R&D efforts. With this type of business model, a company can recoup all of the R&D spending within its entire organization through the manufacturing, selling, and post-services of products and consumables selling.

Hypothesis 3) Conventional business models could not avoid collapsing due to competition policy changes and technological innovation, but low-profit companies failed to cope with the new situation because they were slow to implement relevant new business models.

This situation was also limited to computer/electric equipment manufacturers. The heavy electric equipment industry comprising a few market-dominating electric power companies once had in place an integrated organizational setup to recoup invested money, which was equivalent to the Toyota Model or the Canon Model. All investments made under the umbrella of each corporate group were recouped as electricity sales service fees, and earnings thus made were allocated to individual companies of the group. The same can be said for the NTT-centered communications family. It had a well-established business model with which NTT recouped all investments made within the family for reallocation to family businesses.

However, the electric power business model collapsed due to investment cuts in the electric power infrastructure and the deregulation of power generation, and the NTT business model disintegrated due to the deregulation of the telecommunications business and the spreading use of the Internet. Under these circumstances, they were forced to beef up their R&D efforts, but it appears that they still remain incapable of recovering their investments properly. This sufficiently explains the current situation of computer/electric equipment manufacturers.

Hypothesis 4) The problem was not in R&D investment but in the existing business model for recouping R&D spending. With inadequate revenues making internal R&D financing difficult, it was urgent for companies to build a business model that would allow internal R&D financing. This required establishing technology and business models based on solid principles.

R&D should basically be covered by internal financing. However, it seems that internal funds to meet R&D requirements have been getting especially short in the computer/electric equipment segment. Therefore, the need is urgent to provide adequate funds to R&D.

It can be put forth that it is not only the problem of R&D efficiency discussed in this paper, but all of the issues associated with today's R&D competitiveness that bear on the status of R&D financing in each and every company. These include the problems of indirect support for R&D through industrial-academic alliances, financing for venture businesses and R&D efforts in the phases of "Valley of Death" and "Darwin's sea." The crux of the problem is that companies cannot afford to provide adequate in-house financing while they are faced with the need for boosting R&D efforts and increasing R&D spending.

This situation reminds us of the past experiences of IBM (Watson Research Center), ATT (Bell Laboratories), and Xerox (Palo Alto Research Center). In these corporations, too, in-house financing for R&D stalled in the wake of the breakdown of their monopolistic investment recouping model, forcing them to review their business model in its entirety. The picture described above is quite a contrast to today's Intel and Microsoft: they are increasing R&D spending rapidly by capitalizing on their monopolistic earnings. Once again, we can understand that the crux of the problem is not in the efficiency and management of R&D, but in each company's setup to recoup invested money as well as the affordability of financing R&D.

Maintaining in-house financing for R&D requires building a business model that permits recouping R&D spending. This will be discussed later.

Hypothesis 5) Kodama's hypothesis remains valid.

We think that no particular explanation is required for this point.

Hypothesis 6) The government should provide support for basic research efforts and help build business models that are capable of meeting the needs of the times by closely examining problems that prevent companies from coping with the current situation.

The government has been increasing its subsidies to private-sector R&D efforts, which are expected to produce fruits for commercialization shortly. This may seem like an unavoidable measure, given the government's financial reform initiative under the long-stagnant economy. However, it can be understood as an inappropriate measure from the viewpoint of the true cause of the problem. What is actually needed is financing support for long-term corporate R&D initiatives. It is individual companies' responsibility to finance their short-term R&D projects and they can afford to do it. What companies cannot afford is long-term basic R&D. In view of this, the industrial-academic alliance seems to be a correct, though indirect, measure. In Japan, the government's R&D budget is allocated to universities and national research institutes.

In the United States, the government's R&D budget is allocated directly to private companies and is then given to universities as needed (Ministry of Economy, Trade and Industry's *Trends of Japanese Industrial Technology R&D Activities—Major Indices and Survey Data*). It is said that such budgets are enormous, especially in the field of military technology. Japan may follow suit.

It is safe to say that a company's affordability with respect to financing R&D depends on the effectiveness of its business model in terms of investment recouping. As discussed above, this requires a kind of monopoly. This is why preference is given to a focused business strategy to dominate a niche market over an all-inclusive business strategy to become a market leader; this is also why people talk about the shakiness of businesses ranking third or lower in terms of market share. Today, sustainable R&D financing matters reflect the growing importance of R&D. It is probable that this situation requires building a setup to ensure the recouping of R&D spending through some sort of market domination, which in turn may require implementing some competition policy without detriment to R&D potential. It was probably a good decision on the part of the government to implement electric power industry and telecommunication industry policies by giving due consideration to each industry's ability to afford R&D financing.

(2) R&D-financing-type business model—establishing the principle of technology-focused business models

1) The standpoint of being a manufacturing company

This section discusses R&D-focused business models from the standpoint of manufacturing companies.

Manufacturing companies have technology of their own that is the foundation of their business. At the same time, their raison d'être is that they should minimize the social costs associated with the supply of goods. That is to say, a manufacturing company is an organization that develops (or acquires) technology capable of helping attaining a minimal social cost and invests in equipment embodying the technology. This involves taking technological development and investment risks.

Technology continues to evolve autonomously until it reaches maturity. In the case of semiconductors, for example, there is the so-called Moore's Law, which says that the chip density of semiconductors increases four times every three years. Manufacturing companies accumulate technology of their own while taking risks involved in technological development and investment. It must be noted here that the principle of technological evolution is also the principle of technology geared to minimize social costs. A manufacturing company is an organization that i) recognizes the principle of technology, ii) makes investments in technological development and equipment based on the principle of technology, and recoups its investment for reinvestment. It is critical for any manufacturing company to have a basic technological principle.

Next, it is important for the company to be equipped with an organizational setup that helps make investments in technology based on the basic technological principle, recoup the invested money for reinvestment, and thereby accumulate technological expertise. What is most important is to have an organizational setup for financing high-risk, uncertain R&D and recoup invested money for sustained financing (that is, a business model).

2) Building a Japanese model

At one time, electric equipment and communications equipment manufacturers including Hitachi, Toshiba, Fujitsu, and NEC enjoyed prosperity with their heavy electric equipment segment and the transmission equipment, which supplied their products to electric power companies and NTT, respectively. The stable earnings enjoyed by these segments of the machine industry made it possible to sink money into high-risk R&D projects, which eventually evolved into new businesses making enough revenues to cover the investments made. In this business model, stable profit centers were also supported by corporate financing backed by the main financing banks. It was possible for electric and communications equipment manufacturers to beef up their competitive edge by raising huge risk money.

Obviously, the business model, or the in-house financing system for R&D was logical and compatible with the needs of the time. This is why it was called "deep pocketed" and regarded as a threat by US corporations in the 1980s. However, this system came to an end in the wake of the deregulation of electric power, the opening of material procurement to foreign companies, the deregulation of telecommunications, and the spreading use of PCs and the Internet, which were expedited by pressure from the United States. The difficulty that every electric equipment manufacturing company is now experiencing can be tracked back to the collapse of the business model. However, this is not to say that the deregulation of electric power and telecommunications was a mistake. Rather, a new R&D financing system should have been devised to succeed the collapsed in-house financing system. If in-house financing is to be sustained, it is necessary to build a new feasible business model as soon as possible.

Because of the success of the Wintel (Microsoft/Intel) model (horizontal specialization model) in the American IT industry, the vertical integration model has been growing less and less popular in Japan. But Toyota and Canon are, in fact, vertically integrated corporations. In view of this, the vertical integration model can still be effective as a total technology investment recouping model.

After the economic stagnation of the 1990s, the Japanese machine industry seems to have at long last found its market leader, in addition to automobile manufacturing, to replace the semiconductor business, that is, digital household appliances. With plenty of potential business opportunities, now is the time for companies with misgivings about their R&D financing to expedite their efforts to build R&D-financing-type business models of their own.

The government should support these companies with competition policy to help promote basic R&D efforts and build new business models.