

NISTEP REPORT No.15

Ratio Analysis of R&D Expenditure vs
Capital Investment in Japanese Manufacturing Companies

FROM PRODUCING TO THINKING ORGANIZATIONS

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From Producing to Thinking Organizations

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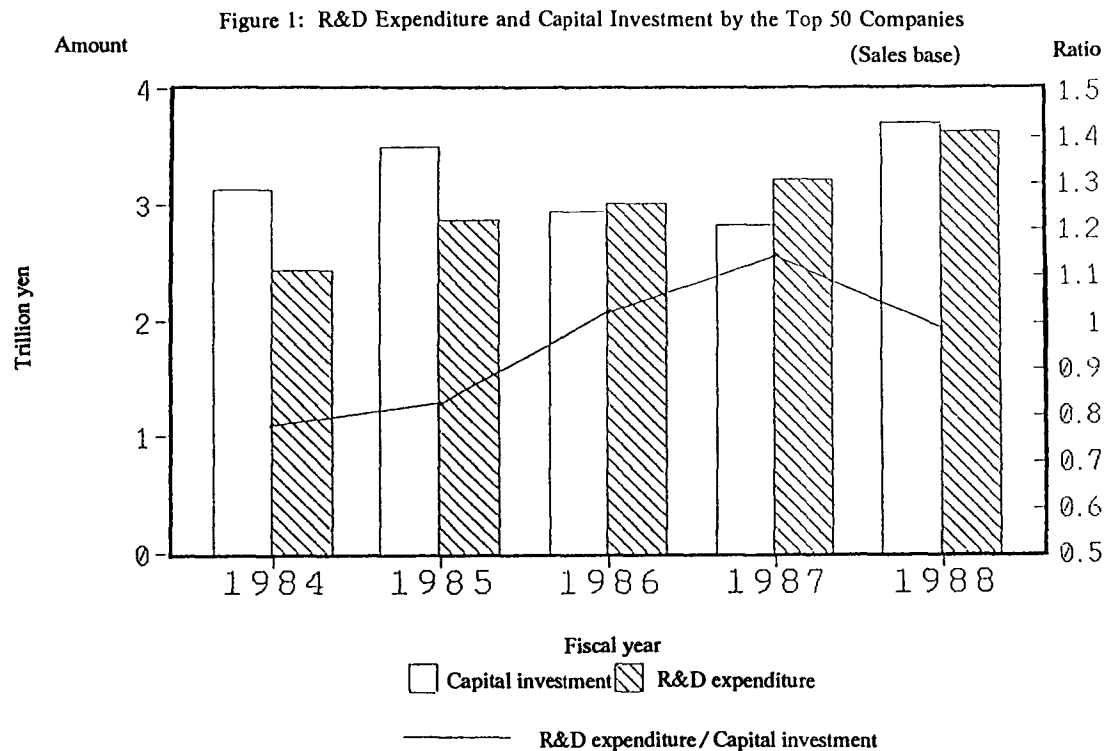
1. Introduction

Generally, private companies undertake research and development (R&D) to increase their knowledge base, and focus on capital investment to increase productivity.

The desire to invest in R&D has increased greatly in recent years, as evidenced by an average annual growth of 10.6% in R&D spending between fiscal 1984 and 1988 by the top fifty (in terms of sales) private manufacturing companies.

None the less, although capital investment by the private sector was sluggish in fiscal 1986 and 1987 owing to an uncertain business climate brought on by yen's revaluation, fiscal 1988 saw a surge of capital investment that matched the expansion of domestic demand which flowed on from the Japan-U.S. structural negotiations. This surge became the driving force behind the present Heisei economic boom. Indicators show that even in the present climate, the Heisei boom is still running at a high level.

We have seen in recent years the phenomenon in which an increasing number of private companies are spending more on R&D than on capital investment. The graph comparing the R&D expenditure / capital investment ratio over the past five years for the top fifty companies shows an increase from 77.6% in 1984 to 97.9% in 1988. In 1985 the corresponding ratio for the top ten companies increased to 103.3%, signifying greater spending on R&D than on equipment and facilities (Figure 1).



Generally, capital investment is made first and foremost with a view to increasing profit, which is the essence of corporate activities, based on production plans covering several years into the future, and therefore has the character of a stock as opposed to a flow resource. It is clear that capital investment is investment in fixed property, such as land, buildings and production machinery, all of which cannot be easily converted.

On the other hand, R&D expenditure is considered as a flow resource. Of course, it is a fact that a part of R&D expenditure is used in the medium to long term for experimental or trial equipment, but we must take note of the fact that about 40% of general R&D expenditure is set aside for personnel expenses.

Although it is not entirely wise to make a sweeping statement about the duration from R&D to commercialization, as an example, according to a report concerning research into corporate projects¹⁾, it takes about four years from the time R&D starts to the time results materialize. So a much longer duration is necessary before an actual profit can be accrued from R&D investments.

The key point here is to understand why Japan's major companies place importance on R&D investment when they know it will not necessarily bring about direct or immediate profit.

Focusing on the point that the number of private manufacturing companies whose R&D expenditure exceeds their capital investment is increasing, this research sought to explore the structural change in which companies in the manufacturing industry, exemplified as "producing organizations", have evolved into "thinking organizations".

Questionnaires were sent to ascertain the member of major private manufacturing companies spending more on R&D than on capital investment. The purpose was to study structural changes and the reasons for these changes in R&D and capital investment.

1) NISTEP REPORT No.14 "Dynamics of Research and Development", National Institute of Science and Technology Policy, Kikuchi, Mori, Baba, Morino

2. Questionnaire on Comparison Between R&D and Capital Investment

2-1 Survey Aim

To this end, questionnaires were sent out to ascertain how many of the major private manufacturing companies spend more on R&D than on capital investment, why such a change occurred, and what lies behind this change.

2-2 Survey Items

Keeping the above aim in mind, a questionnaire was sent which included the following survey items (see attached data).

- I Expenditure and other results
Sales, R&D expenditure, capital investment.
- II Future trends in which R&D expenditure exceeds capital investment
- III Against a hypothesis in which the introduction of FMS has curbed the increase of capital investment - the circumstances of FMS introduction and the results of the decrease in capital investment.
- IV R&D
Background and reasons for expansion; aspects that have been given more weight; Areas and stages of R&D in which importance will be placed in the future.
- V Move towards external production outside the corporate structure

2-3 Survey Method

A questionnaire was prepared based on the items listed above, and mailed, together with explanatory letters signed by Fumio Kodama, Senior Research Supervisor, to the companies selected for the survey.

(1) Selection of Companies for the Survey

The top fifty companies in term of sales were selected for the survey. The reason we did not chose the top companies in terms of R&D expenditure was that we would not be able to exclude the contradiction that it is natural for R&D expenditure to exceed capital investment. The companies surveyed were the top fifty companies according to the special Corporate Ranking 1980-1988 edition of the weekly magazine DIAMOND (questionnaires were sent to sixty companies). The survey focused on the manufacturing industry, so we excluded NTT, power companies, the construction industry, the oil industry and other companies/industries with extremely large capital investment, and also of course trading firms and the service industry. The top fifty companies chosen for the survey account for about half of the total amount of private sector spending on R&D in Japan (¥7.2193 trillion; fiscal 1988; Management and Coordination Agency survey), so we believed that we could gain an overall picture of the R&D operations of Japanese companies by focusing on these top fifty companies.

(2) Response to Questionnaire

Usable responses were received from forty-three companies (of the sixty that were sent questionnaires). Of the forty-three companies, twenty-six are in the fabrication industry, while most of the remaining seventeen are in the material industry; so in analyzing the companies on an industry base, we categorized them into 'fabrication' and 'material', although considering the past several years, it may be preferable to change 'material' to 'equipment'. Most data we obtained regarding company results were from fiscal 1984 (gaps in the data were covered by information from the Company Quarterly Bulletin published by the Oriental Economist).

3. Survey Results

3-1 Private Manufacturing Companies Whose R&D Expenditure Exceeded Capital Investment

(1) Number of Companies Whose R&D Expenditure Exceeded Capital Investment

The following table shows the number of companies in the survey that spent more on R&D than on capital investment.

Table 1 Number of Companies Whose R&D Expenditure Exceeded Capital Investment

Fiscal Year	Number of Companies	%	Number of Companies That Responded
1980	6	28.6%	21
1981	5	22.7%	22
1982	6	24.0%	25
1983	7	25.0%	28
1984	10	21.3%	47
1985	15	30.0%	50
1986	19	38.0%	50
1987	22	44.0%	50
1988	18	36.0%	50

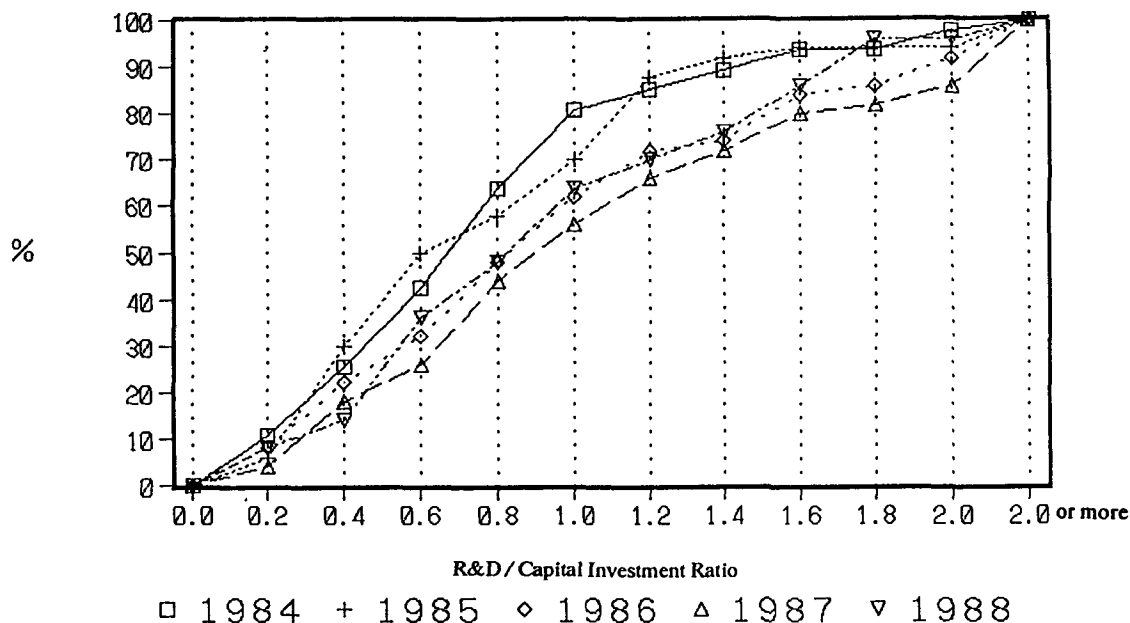
From this we can clearly see an increase in the number of companies whose R&D expenditure exceeded capital investment; the figure of ten companies in fiscal 1984 almost doubled to eighteen in the four years to fiscal 1988.

Figure 2 shows the company cumulative distribution curve based on the ratio of R&D expenditure / capital investment of the fifty companies (x axis) for fiscal 1984-88.

The more the curve moves to the right and down, the greater the number of companies whose R&D expenditure exceeded capital investment. The figure shows that

this trend became more prominent from year to year, and that in 1987 almost half of the companies spent more on R&D than on capital investment.

Figure 2 Company Cumulative Distribution Based on R&D / Capital Investment Ratio



(2) Difference Between Categories of Companies Whose R&D Expenditure Exceeded Capital Investment

To analyze trends based on type of business, we divided the fifty companies into 'fabrication industry' and 'material industry'.

Figures 3-7 divides the R&D expenditure and capital investment distribution of the fifty companies (1984-88) into 'fabrication industry' and 'material industry' categories.

The straight line in the figures represents $Y=X$; companies positioned below this line spent more on R&D than on capital investment. As can be seen in the figures, in fiscal 1984 companies in the fabrication industry were generally distributed along this straight line, but tended to shifted downwards with each subsequent year. In contrast, almost all companies in the material industry were distributed above the straight line in 1984, and this did not change to any noticeable extent in subsequent years. This clearly

shows that there is a difference in the way companies in the two industrial categories approach R&D.

Figure 3 Correlation Between R&D Expenditure and Capital Investment (1984)

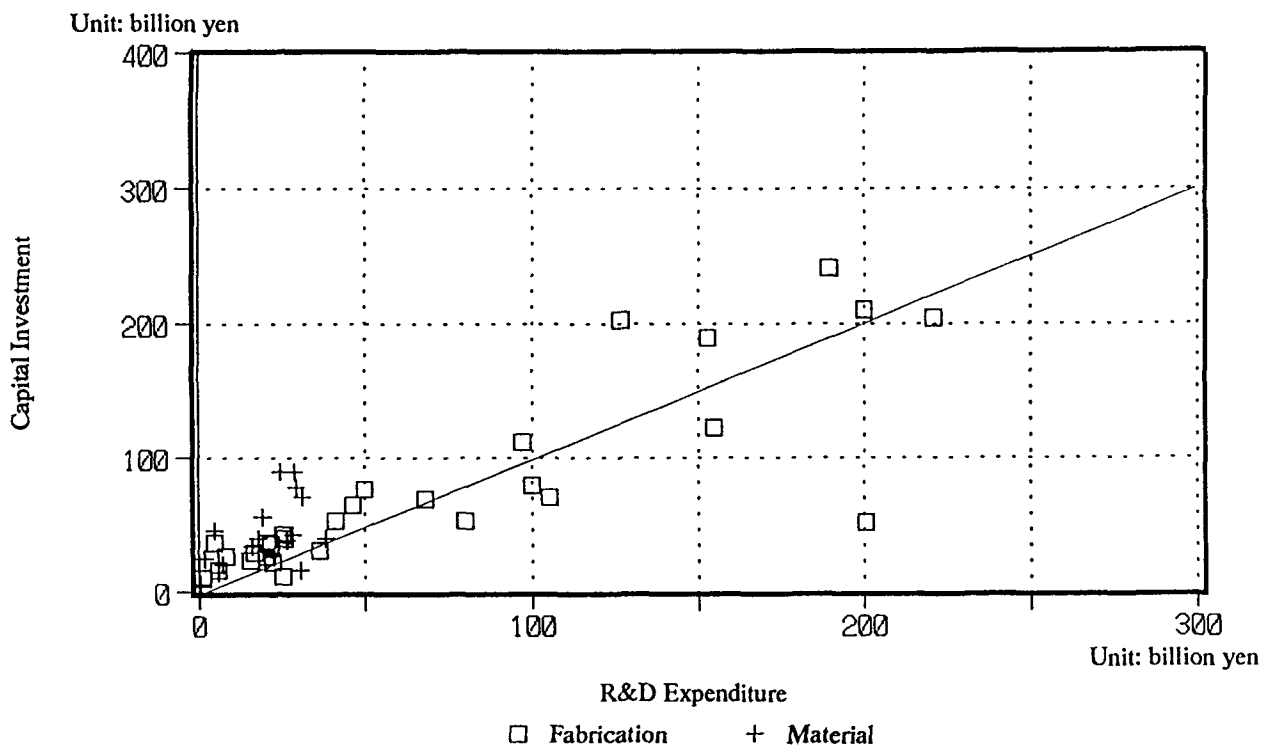


Figure 4 Correlation Between R&D Expenditure and Capital Investment (1985)

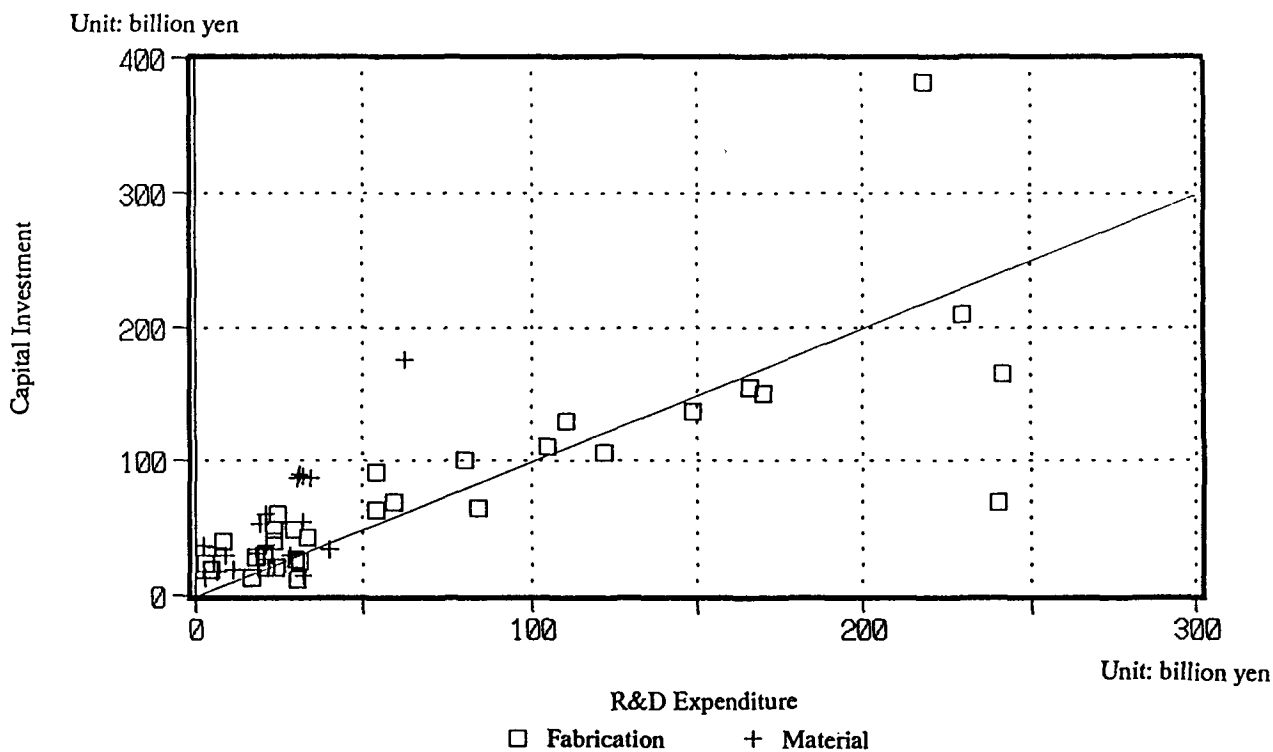


Figure 5 Correlation Between R&D Expenditure and Capital Investment (1986)

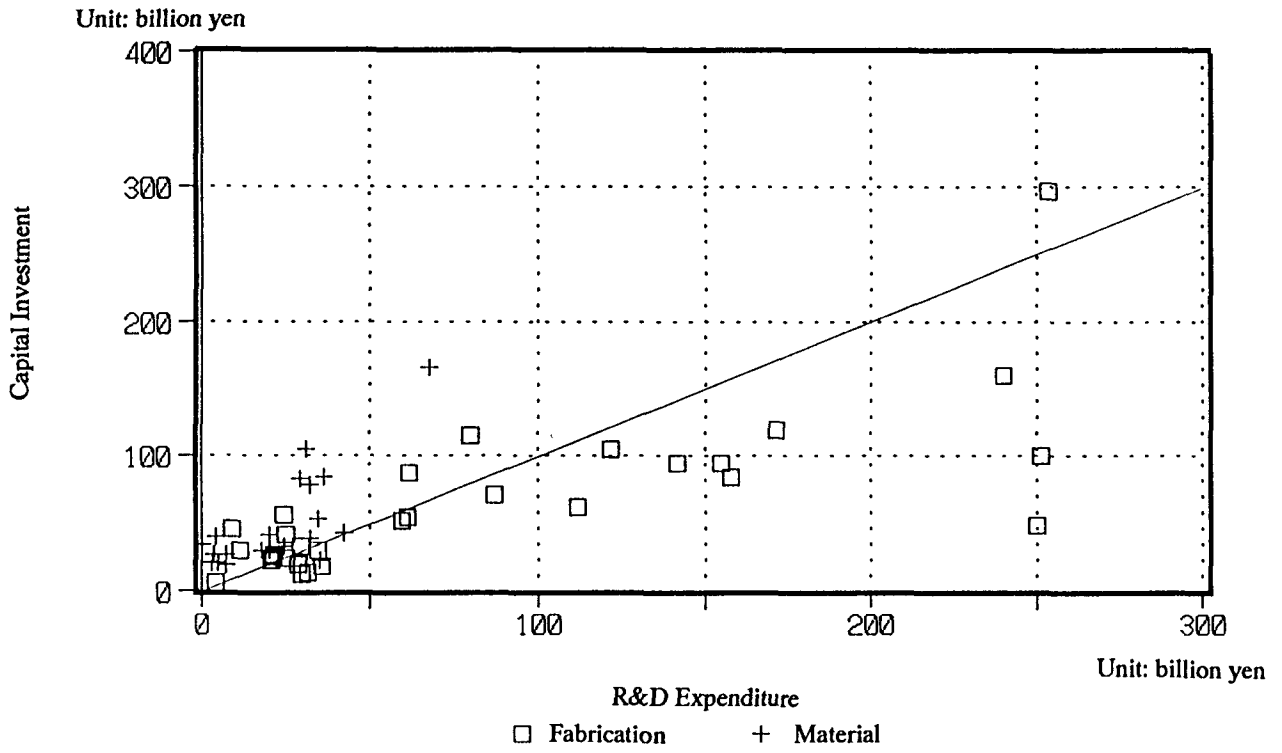


Figure 6 Correlation Between R&D Expenditure and Capital Investment (1987)

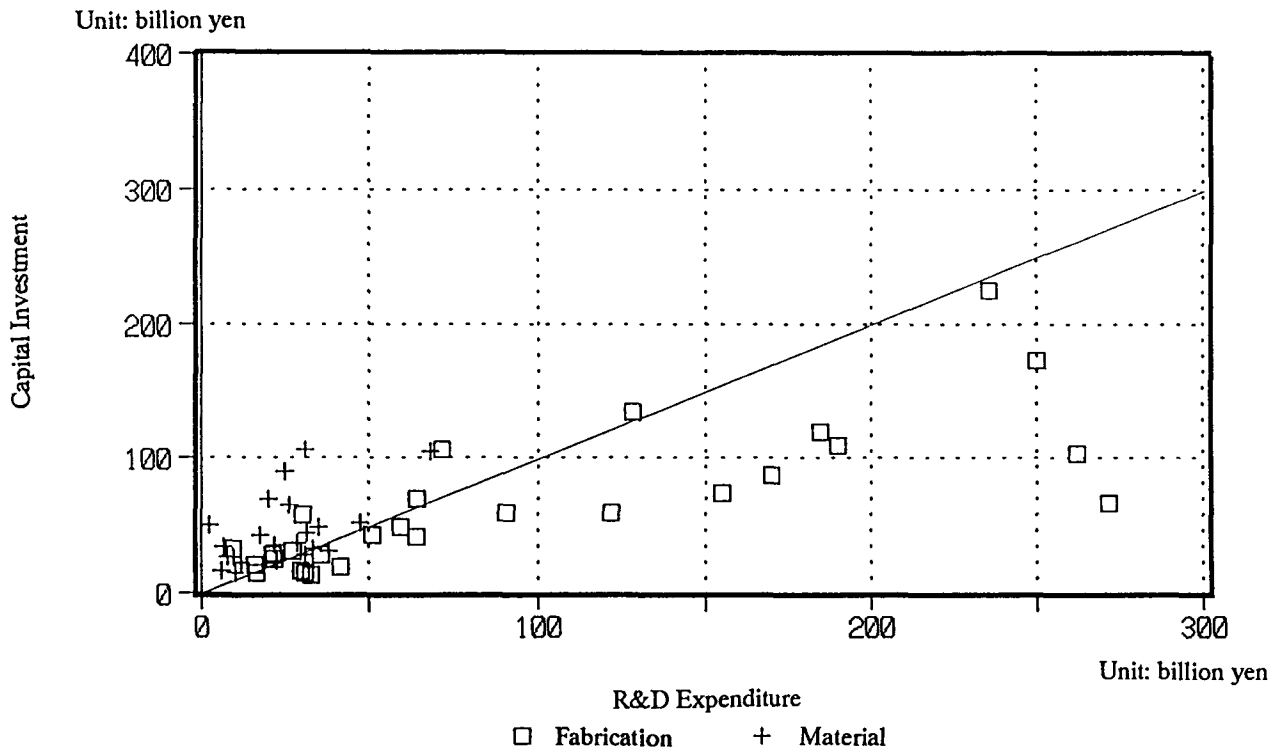
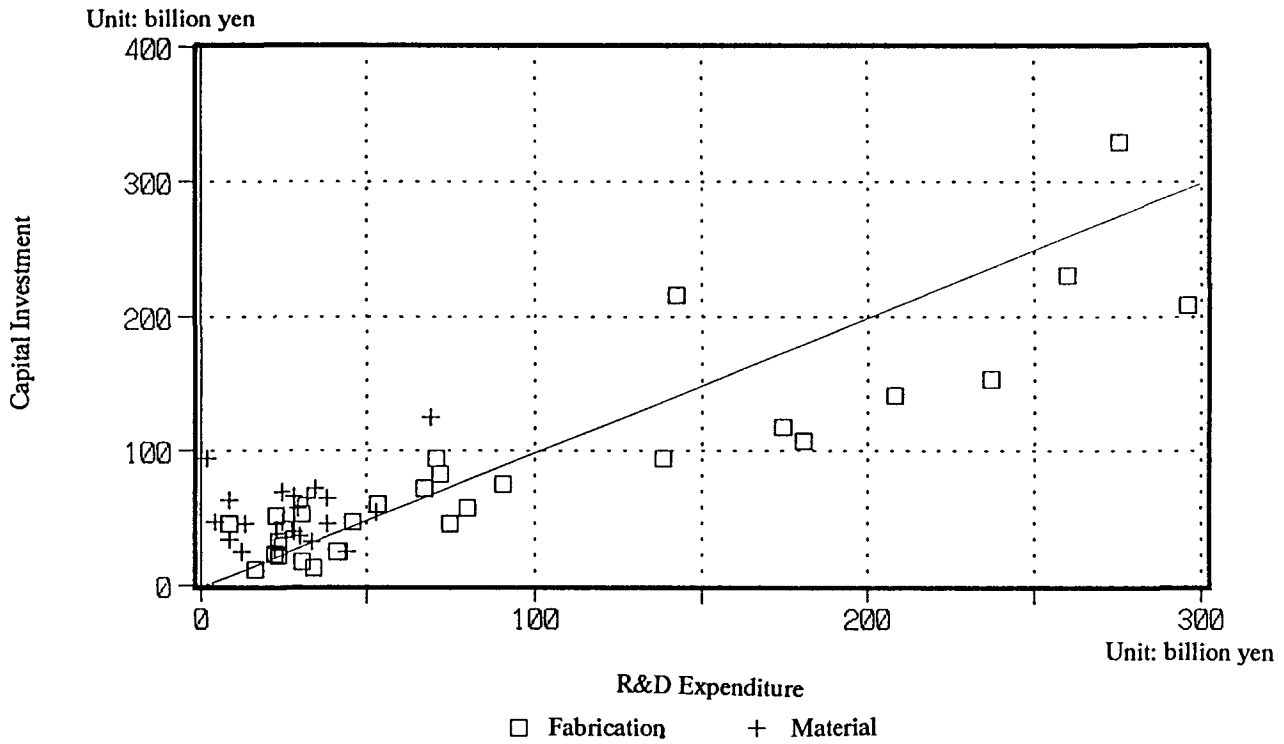


Figure 7 Correlation Between R&D Expenditure and Capital Investment (1988)



Figures 8 and 9 show the company cumulative distribution curve for each industry type based on the ratio of R&D expenditure / capital investment for fiscal 1984-88.

As can be seen in the figures, 70% of companies in the fabrication industry spent more on R&D than on capital investment in 1987, and this showed a prominent trend downwards after this. In contrast, the tendency for R&D expenditure to exceed capital investment was not particularly evident in the material industry; while there was only a very minor downward trend in this category, less than 20% of companies spent more on R&D than on capital investment.

Thus analysis based on this statistical data has made it clear that the phenomenon in which R&D expenditure exceeds capital investment is generally focused in the fabrication industry. We can probably read into this the occurrence of structural changes in which corporate operations are placing greater emphasis on R&D, which is looked upon as investment in future product development, than on capital investment.

Figure 8 Company Cumulative Distribution - R&D / Capital Investment

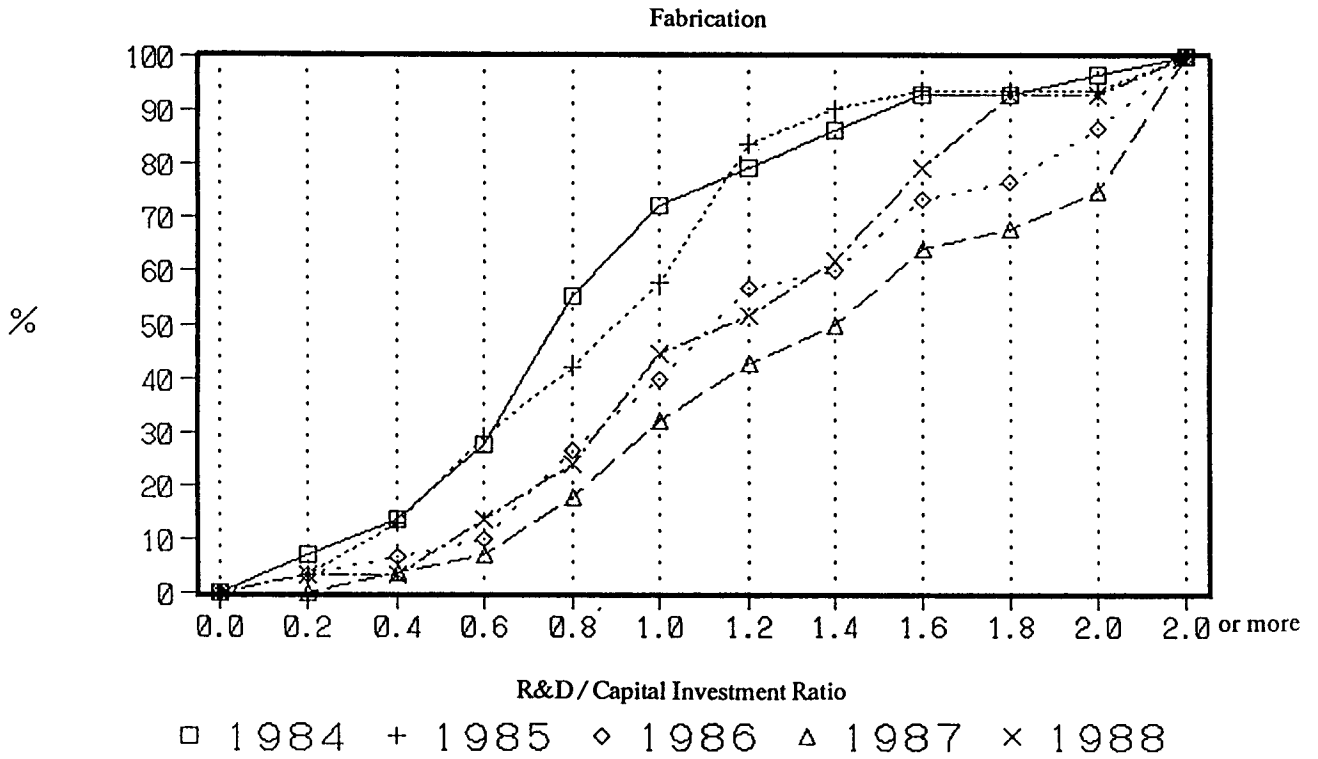
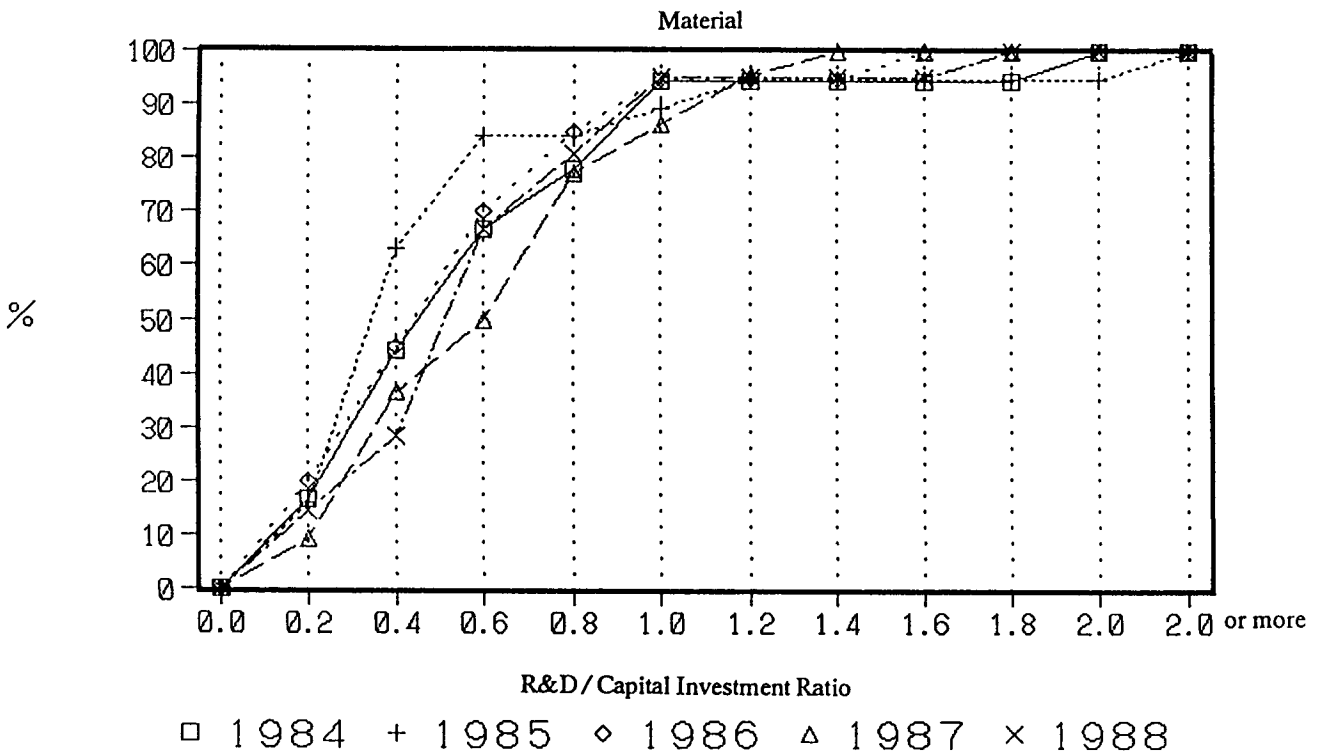


Figure 9 Company Cumulative Distribution - R&D / Capital Investment



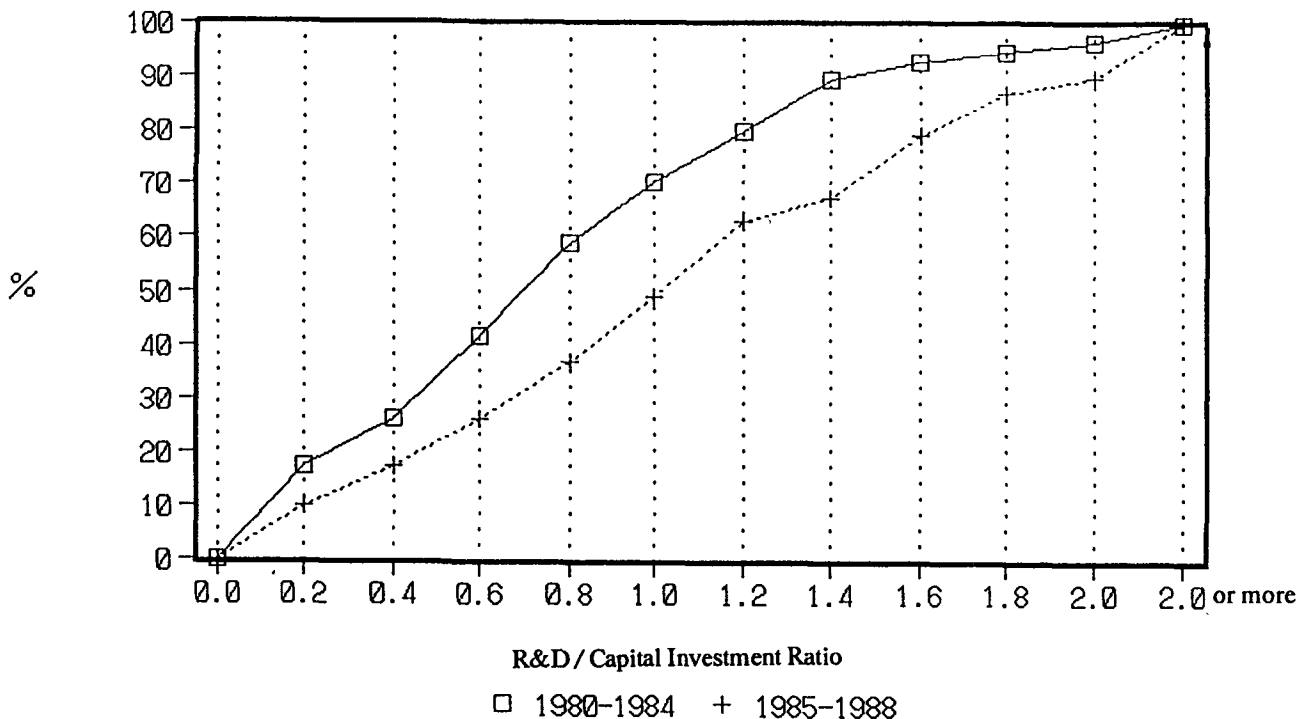
(3) Analysis of the Reverse Phenomenon in which R&D Expenditure Exceeds Capital Investment

When did this phenomenon first appear? To answer this question, at twenty-three companies (sixteen fabrication companies and seven material) whose post-FY1980 data could be used were examined (Figure 10).

With regard to the cumulative average value of the R&D expenditure / capital investment ratio for the twenty-three companies between fiscal 1980 and fiscal 1984, the value of 1.0 is 70.4%; in contrast, the value of 1.0 for fiscal 1985-88 has dropped to 48.9%. It can be said that the phenomenon in which R&D expenditure exceeds capital investment appeared in more than half of the companies for the first time in 1985.

From the above point, we can say that from about 1985 companies in Japan's manufacturing industry, which were formerly "producing organizations", evolved into "thinking organizations", or 'organizations that give thought to what should be produced' rather than just 'how to' produce, centering on the fabrication industry. In the next section we shall look at why this transformation has taken place, focusing on the analysis of the survey results.

Figure 10 Company Cumulative Distribution - R&D / Capital Investment
(Twenty-three companies)



3-2 Effect of FMS Introduction on Capital Investment

When conducting this survey, we hypothesized that one of the factors behind the increasing tendency of companies to spend more on R&D than on capital investment was that companies were putting a curb on the growth of capital investment owing to a reduction of the need to expand facilities for new product manufacture as a result of the introduction of FMS (Flexible Manufacturing System). And to analyze this phenomenon from the capital investment side, we examined the effect of FMS introduction.

FMS is a system that makes qualitative improvements to the production process by introducing flexibility, efficiency and timeliness into the process, taking into account the product cycle, small-volume multi-product production and so on, so that the company can better meet the diversifying needs of the consumers, as well as its own needs. It is thought that possession of this flexibility, efficiency and timeliness will not only give rise to qualitative improvements, but also enable companies to avoid the establishment of new facilities that normally goes hand-in-hand with a diversification of needs.

(1) Introduction of FMS

Being aware of the degree to which this system has been introduced is very beneficial in the sense that one is aware of its effectiveness, and knows how the company is responding to the diversifying needs of consumers.

Table 2 Introduction of FMS

Response	Overall	Fabrication	Material
I Has been introduced	78.0%	100.0%	47.1%
II Has not been introduced	22.0	0.0	52.9

Overall 78% of companies have introduced FMS. By categories, 100% of companies in the fabrication industry and 47.1% of companies in the material industry have introduced the system.

We can see that 100% of companies in the fabrication industry have introduced FMS to meet the diversifying needs of consumers, for theirs is an industry which is

connected directly with consumers. In contrast, the introduction of FMS into the large-scale mass-production system of the material industry is taking much longer.

(2) Year of Introduction

Table 3 Year of Introduction

Year of Introduction	Overall	Fabrication	Material
Before fiscal 1979	20.0%	22.2%	14.3%
Fiscal 1980	8.0	11.1	0.0
1981	0.0	0.0	0.0
1982	12.0	16.7	0.0
1983	8.0	11.1	0.0
1984	8.0	0.0	28.5
1985	18.0	11.1	28.6
1986	4.0	5.6	0.0
1987	4.0	0.0	14.3
1988	4.0	5.6	0.0
1989	12.0	16.6	0.0
1990	4.0	0.0	14.3

The majority of companies in the manufacturing/ assembly industry introduced FMS before fiscal 1984; in contrast, less than half of the companies in the material industry introduced FMS before 1984. In the fabrication industry 20% of companies had introduced FMS by 1979, and the speed with which they responded is eye-opening.

The fabrication industry must respond accurately to consumers tastes which are increasingly demand variety and quality, and its introduction of FMS has led the way for other industries .

(3) Does FMS Curb Capital Investment ?

We are aware that many companies introduced FMS to give their production processes the flexibility, efficiency and timeliness needed to respond to the tastes of consumers who are increasingly demanding variety and quality, but we shall now examine whether its introduction has curbed capital investment (see Figure 4).

Table 4 Has FMS Curbed Capital Investment?

Response	Overall	Fabrication	Material
I Has curbed	31.2%	33.3%	25.0%
II Has not curbed	46.9	50.0	37.5
III Cannot say either way	21.9	16.7	37.5

One-third of the companies in the fabrication industry and one-quarter in the material industry responded that their capital investment has been curbed. However half of the companies in the fabrication industry responded that their capital investment has not been curbed.

Reasons given for this are that curbing capital investment is not an aim of FMS, and that the introduction of FMS itself is costly. Another factor that can be considered is the cost of developing software for FMS, but we cannot determine from the survey whether this cost has been included in capital investment or in R&D expenditure. If it has been included in capital investment, this can be regarded as the main reason that it has not curbed capital investment.

We can generally see from the above that the introduction of FMS does not, by itself, fully explain the reverse phenomenon of R&D expenditure and capital investment. It appears that this reverse phenomenon is caused not only by the negative factor of a decrease in capital expenditure, but also by the positive factor of an increase in R&D activities.

3-3 Characteristic of R&D Activities

What are the companies' views on R&D? How are they tackling it? We shall now look at the background to and reasons for the expansion of R&D, and factors behind the increase in expenditure weight?

(1) Future Changes in the Reverse Phenomenon of R&D Expenditure and Capital Investment

First we asked about future changes to the relationship between R&D and capital investment. Until a few years ago it was good sense for companies (manufacturing industry) to spend more on capital investment than on R&D, but in the past several years this relationship has tended to move in the opposite direction. Here we asked the companies how they thought this reversal would effect their operations(see Table 5).

Table 5 Future Changes in the Relationship Between R&D and Capital Investment

Responses	Overall	Fabrication	Material
I R&D expenditure will continue to grow larger.	16.7%	16.0%	17.7%
II R&D expenditure will grow larger, but will become sluggish at a certain point.	23.8	28.0	17.7
III R&D expenditure and capital investment will keep pace with each other	30.9	36.0	23.5
IV Others	28.6	20.0	41.2

If we combine I and II, 40% of the forty-three companies that responded believe that R&D expenditure will continue to exceed capital investment in the future. If we add III to this, we can see that 70% of the companies do not believe that R&D expenditure will drop below capital investment, even if it becomes sluggish at a certain point in the future.

Companies believe that R&D will have an effect on their future, and indicated that strategically they will continue to put their effort into R&D. Thus we can read from this that the phenomenon of R&D expenditure exceeding capital investment will continue.

(2) Background to the Expansion of R&D Expenditure

Companies were asked why R&D expenditure has expanded, whether it could not do anything but expand, against this background what kind of changes have occurred to the flow of R&D, how they are tackling R&D and in what direction are they aiming (see Table 6).

Table 6 Background to Expansion of R&D Expenditure

Responses	Overall	Fabrication	Material
I Diversification etc. continued and wide-ranging R&D became necessary	32.6%	38.5%	23.5%
II In-depth R&D, including basic research, became necessary.	0.0	0.0	0.0
III Both I and II.	67.4	61.5	76.5

Nearly 70% of companies responded with III, namely that wide-ranging and in-depth R&D became necessary. The remaining 30% all responded with I, namely the necessity for wide-ranging R&D. No company responded with II - the necessity for in-depth R&D. From this we can consider that although companies put an effort into in-depth R&D, including basic research, the core of their overall R&D programme is the wide-ranging R&D for the purpose of diversification.

Although in recent years a shift towards basic research has been talked about, in reality even the major companies surveyed do not start simply with basic research; rather it is said that companies undertake basic research as a part of their overall R&D operations, and based on a requirement within applied or developmental research.

Therefore, although companies are carrying out basic research, it is thought that, considering its importance, the government and such establishments as universities should take the lead in this area.

(3) Reasons for Expansion of R&D Expenditure

In the preceding section we learned that most companies focus on wide-ranging and in-depth R&D, from basic research to broad R&D for the purpose of diversification. What are the reasons for this?

Table 7 Reason for Expansion of R&D (Multiple responses possible)

Responses	Overall	Fabrication	Material
I Introduction of technology from overseas has become difficult	14.0%	11.5%	17.7%
II Intensification of competition with other companies (domestic, overseas)	93.0	92.3	94.1
III Additional funds were available	4.7	3.9	5.9
IV To keep pace with other companies in the same industry	9.3	15.4	0.0
V For taxation advantages	0.0	0.0	0.0
VI Others	30.2	23.1	41.2

More than 90% of all companies responded with II, 'Intensification of competition with other companies', indicating that their R&D effort is aimed at ensuring their survival. This was followed by I, 'Introduction of technology from overseas has become difficult' because of problems with intellectual property rights. Reasons given in VI, 'Others', include 'expansion into new fields of business', and 'to diversify the business'. Increasing R&D expenditure because of competition or because of an expansion into new fields is a good indication of the intensity with which companies will fight to survive. Another reason was given as 'to establish the company's own technology so that it can respond to social issues such as the environment'. The response suggests the overall line of thought was that 'R&D expanded because we became more aware that R&D will have an effect on the future of the company'.

Companies are tackling R&D not just because of competition with other companies in the same industry, but also because of their expansion into other industries, and this they are doing to ensure their own survival. (Much research has been conducted on this trend. (see Bibliography; Niwa, Hirooka, and others)).

(4) Areas of R&D Expenditure That Have Increased in Weight

Table 8 shows the areas of R&D expenditure that have increased in weight.

Table 8 Areas of R&D Expenditure That Have Increased in Weight (Multiple responses possible)

Responses	Overall	Fabrication	Material
I Increase of R&D personnel	85.7%	84.0%	88.2%
II Rationalisation of R&D facilities *	47.6	64.0	23.5
III Establishment of new R&D facilities **	81.0	68.0	94.1
IV Acquisition of R&D-related information	4.8	4.0	5.9
V Expenditure related to intellectual property rights	14.3	12.0	17.7
VI Increase of external R&D commission payments	19.0	12.0	29.4
VII Trial manufacture expenses	26.2	20.0	35.3
VIII Others	4.8	4.0	5.9

* . . . : Labour-saving due to introduction of computer systems, preparation of a joint data base, etc.

** . . . : Research institutes, R&D departments, etc.

More than 80% of the companies responded with I, 'Increase of R&D personnel'. The main reason for this is an increase of personnel in special fields owing to the expansion of the range of R&D - the importance of displaying originality in R&D gives rise to the need for more R&D staff. An increase in personnel costs is also a factor, but emphasis is placed on recruiting and training R&D staff.

This was followed by III, 'Establishment of new R&D facilities', with 80%. One reason for this is that new research institutes were established as pillars for new business activities in the next era - as R&D became more advanced, the need for modern well-equipped facilities grew.

Next was II, 'Rationalization of R&D facilities' with 45%. Whereas more than 60% of companies in the fabrication industry gave this response, only slightly more than 20% of companies in the material industry did so; or about one-third of the fabrication

industry response. The companies appear to be responding to the need for rationalization by introducing highly advanced technology such as computers. Furthermore, the fabrication industry has led the field in R&D in Japan from the beginning and therefore probably has more scope to rationalise its R&D facilities; the material industry set out on the R&D path much later so there is not the same pressing need to rationalise its R&D facilities. This can also be seen from the high 94% response from the material industry to the previous item, 'Establishment of new R&D facilities'.

Fourth was VII, 'Trial manufacture expenses'. This can be attributed to the increase of trial and test expenditure resulting from an expansion of the scale of R&D. More companies in the material industry gave this response than in the fabrication industry. This is because companies in the material industry (here, more appropriate to be called 'equipment industry') have a greater need to construct pilot plants. When this occurs, these companies commission the external production of instrumentation such as meter casings, so we can see that there was also a higher response from companies in the material industry for the next item, 'Increase of external R&D commission payments' than companies in the fabrication industry.

This was followed by VI, 'Increase of external R&D commission payments', and then V, 'Expenditure related to intellectual property rights'. The increase in external R&D commission payments accounted for slightly less than 20%, and the response rate was higher in the material industry than in the fabrication industry.

Some reasons for increased R&D expenditure given in VIII, Others, include 'to expand the product base so as to become less dependent on a single item', 'to facilitate entry into new business areas', 'to deal with safety and pollution control in product development so as to strengthen strategically R&D', and 'to promote diversification because of the need to incorporate various forms of advanced technology such as electronics and new materials'.

(5) Future R&D Priorities (Fields, Stages, Etc)

Seeking to ensure their future survival, companies are tackling wide-ranging and in-depth R&D, not only because of competition with other companies in the same industry, but also because of their desire to make inroads into other industries. What do these companies see as their future R&D priorities?

Besides individual companies' main product development, responses tended to center on the following fields:

- a. High-tech fields (electronics, semiconductors) - 15 companies.
- b. Data communications - 8 companies.
- c. Biotechnology fields - 7 companies.

Other fields listed include superconductivity, new materials, aviation and space, and global environmental issues..

With regard to the stages of R&D, most companies indicated that they intend to tackle R&D in its widest sense, from basic research to product development.

From the above we can see that companies are putting their effort into wide-ranging R&D, from basic research to product, with the aim of business diversification and, of course, improving their respective products.

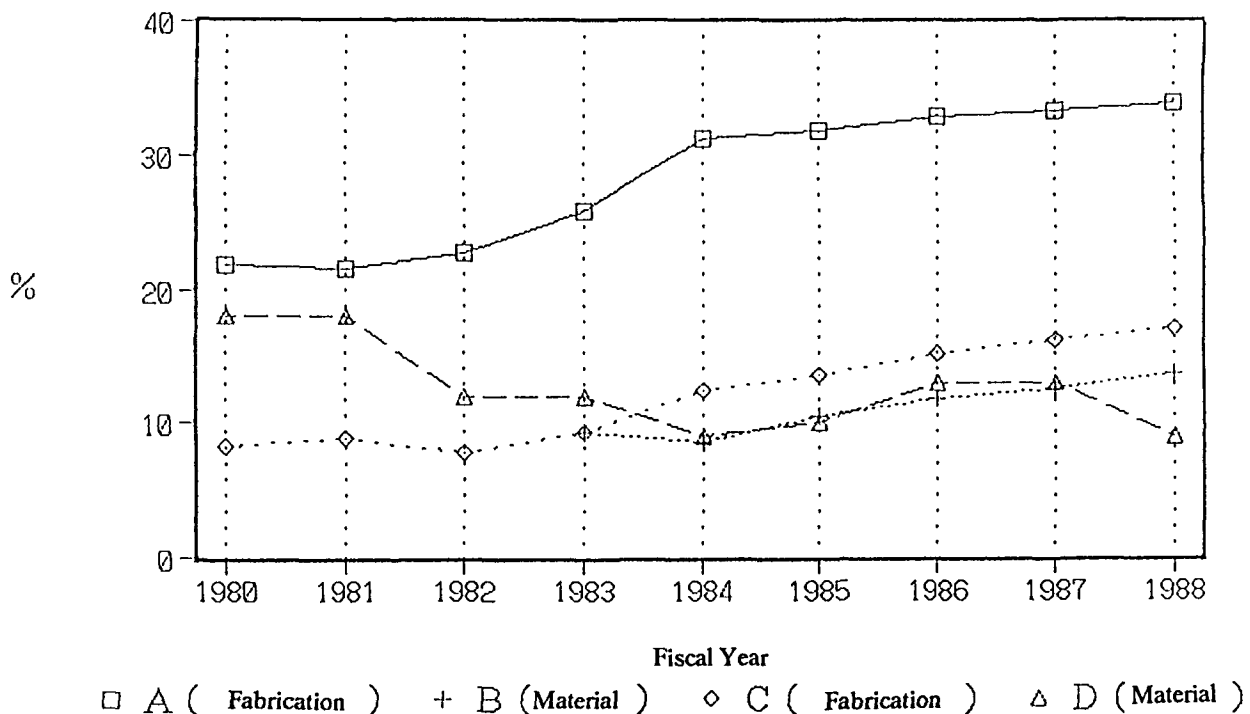
3-4 Shift to External Production

We began this survey with the belief that companies were transforming from “producing organizations” to “thinking organizations” because of the growing tendency for R&D expenditure to exceed capital investment, but in reality, to what extent have companies actually transformed? To find this out, we asked about changes in the production structure of the company, and its shift to external production, whereby rather than manufacturing a product itself, the company places external production orders with affiliated and associated companies.

The question we put to companies was: “What percentage of overall production (in terms of value) is placed on external order to affiliated or associated companies for production of goods to be sold under your company’s name?” (Figure 11).

Less than ten companies responded to this question. Looking at these responses, we can see that there is a definite shift towards external production, in these companies at least. However, the amount of data is limited, so we shall give the results purely as reference. This is one area we should like to examine in a future survey. (Of the companies that responded, we excluded those whose data did not extend back more than five years, and also those that merged during the period.)

Figure 11 Move to External Production or Production by Affiliated Companies



4. Conclusion and Future Issues

Focusing on the point that the number of private manufacturing companies whose R&D expenditure exceeds their capital investment is increasing, this research sought to explore the structural change in which companies in the manufacturing industry, exemplified as “producing organizations”, have evolved into “thinking organizations”.

In conducting the survey, we hypothesized that one of the factors behind this was that companies were putting a curb on the growth of capital investment owing to a reduction of the need to expand facilities for new product manufacture as a result of the introduction of FMS (Flexible Manufacturing System). However, we were unable to obtain results that supported this hypothesis. One reason we were unable to do this was that, as stated in 3-2 (3), we could not determine by the survey whether the cost of developing software for FMS has been included in capital investment or in R&D expenditure. If this is included in capital investment, we can view it as not being a factor behind companies' putting a curb on capital investment.

After putting the results of the survey together, we asked several companies about this point. They answered that they were unable to generalize about software development for FMS because of the diversity of their production lines.

At the time of FMS introduction, software costs were included in the capital investment, and with regard to comparative expenditure for hardware and software, in the past expenditure for hardware was greater than that for software, but for the past several years software expenditure has been increasing, and at times has even exceeded that for hardware. Furthermore, some companies said that after introducing FMS, they included any software development expenditure at the time of a production line change in development expenditure.

That being so, the introduction of FMS naturally becomes a factor behind an increase in capital investment at the time of its introduction. This survey did not conclude that FMS introduction does not, economically and over the long term, act to curb capital investment, but it can be viewed as becoming a factor behind the increase of R&D expenditure. We did not obtain numerical data as to exactly what extent it pushed up R&D expenditure, so this is an area that requires further examination, but it can be considered that the increase of R&D expenditure was not relative to the drop in capital

investment resulting from FMS introduction, but was an absolute increase for the purpose of software development. Thus there is a possibility that FMS has become a factor behind the reverse phenomenon of R&D expenditure's exceeding capital investment in a different sense from the hypothesis established at the beginning.

However, what is becoming clear through this research is that there is probably a greater change to R&D itself at the bottom of this phenomenon.

That is, because of the growing intensity of competition, companies are tackling R&D with the aim of raising their overall capability, not only in their own major products, but also in the diversification of their business operations into other industries, by lifting their technological capabilities over a wide area, from basic research to product development. In other words, the companies believe that R&D will influence their own future. Companies have evolved from "producing organizations" into "thinking organizations" that give consideration to what should be produced and how it should be produced.

From this, it is believed that companies will continue strategically to put their effort into R&D, and we may still be able to see the reverse phenomenon of R&D expenditure and capital investment.

In the future we should like further to clarify the changing nature of the manufacturing industry by undertaking a detailed analysis on the following points.

- a. A quantitative examination into the effect of FMS on capital investment by comparing the difference between capital investment before FMS introduction, which we were unable to do in this survey, and capital investment after FMS introduction.
- b. In relation to a., we cannot overlook software development. We should like to examine this point within R&D, along with the percentage accounted for by software development.
- c. In this survey we carried out an analysis from a comparison of the totals of R&D expenditure with capital investment per company. We should like to examine the differences through an industry-based comparative analysis of R&D expenditure and capital investment per employee.

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Supplementary Remarks

This research was conducted by special researcher, Yoshinari Kagita, under the guidance of Fumio Kodama, Professor of the Research Section, Policy Department, Saitama University Postgraduate College (former senior research supervisor of National Institute of Science and Technology Policy). Assistance was received from the Director-General, Masahiro Kawasaki, members of the Third Policy-oriented Research Group, and many other people within the Institute. Mention must also be made of the assistance and support from the following people.

Fumihiko Kakizaki, Senior Researcher, Second Research Group, National Institute of Science and Technology Policy.

For provision of data: Tadahiko Abe, Senior Economist, Industrial Research Division, LTCB Research Institute

Last, but not least, I should like to express my sincere thanks to all the companies that assisted us in this survey by responding to our questionnaire.

Attached Data

Questionnaire

Questionnaire results

- Simplified Results
- Expenditure of Top 50 Companies (sales base)
- Annual Ratio of R&D Expenditure / Capital Investment for the Top 50 Companies
- Reference graphs

Questionnaire

Confidential

This survey will not be used for any purpose other than that indicated in the separate sheet. Under no circumstances will individual tables be released to the public.

8 November 1990

Yoshinari Kagita

Third Policy-oriented Research Group

National Institute of Science and Technology Policy

Science and Technology Agency

Contact Telephone Number: (03)581-2391

Company Name

Address

Name of person filling in questionnaire: Position

Contact telephone number: Ext

1. Please complete the table below regarding your business performance for the period shown

Table:

(1) Fiscal Year

(2) Sales (million yen)

(3) R&D Expenditure (million yen)

(4) Capital investment (million yen)

(5) Notes: *Please fill in amounts using the base contained in the Company Quarterly Bulletin (Oriental Economist). Please use estimated figures for fiscal 1990, and if possible projected figures for 1991.

*Have these figures been announced publicly? (Yes; No)

2. In the manufacturing industry a trend has appeared in recent years in which R&D expenditure is exceeding capital investment; how do you think this will change in years to come?
- I R&D expenditure will continue to grow larger.
 - II R&D expenditure will grow larger, but will become sluggish at a certain point.
 - III R&D expenditure and capital investment will keep pace with each other
 - IV Others
3. What are your views on the hypothesis “The introduction of FMS (Flexible Manufacturing System) results in a reduction in the establishment of production facilities for new products, and therefore curbs increases in capital investment”? Has your company introduced FMS? If so, how many years ago was it introduced on a full scale?
- Regarding introduction:
- I Have not introduced
 - II Have introduced (Introduced ___ years ago)
 - III Plan to introduce (In fiscal ___)
- Regarding FMS:
- I Has curbed capital investment
 - II Has not curbed capital investment
 - III Others ()
4. What is the background to the expansion of R&D expenditure?
- I We have diversified and therefore R&D in a wide range of fields has become necessary.
 - II In-depth R&D, including basic research has become necessary.
 - III Both I and II.

5. What is the reason for the expansion of R&D expenditure? (Check more than one if applicable)
- I Introduction of technology from overseas has become difficult
 - II Intensification of competition with other companies (domestic, overseas)
 - III Additional funds were available
 - IV To keep pace with other companies in the same industry
 - V For taxation advantages
 - VI Others
6. What areas of R&D expenditure have been given more weight? What is the reason for this? (Check more than one if applicable).
- I Increase of R&D personnel (newly graduated recruits, new employees from other companies).
 - II Rationalization of R&D facilities (labour-saving due to introduction of computer systems, preparation of a joint data base).
 - III Establishment of new R&D facilities (research institutes, R&D departments, etc. In Japan; Overseas; Establishment in fiscal ____)
 - IV Acquisition of R&D-related information (access to Japanese and overseas data bases etc.)
 - V Expenditure related to intellectual property rights (various expense related to applications, patent registration and maintenance expenses, expenses for introduction of technology)
 - VI Increase of external R&D commission payments (Japan; Overseas)
 - VII Trial manufacture expenses
 - VIII Others
- Reasons:
7. It is believed that R&D expenditure will continue to increase; what kinds of R&D (areas and stages) will you place importance on in the future? (No restrictions on response; please include as many as you feel is appropriate)

Please answer the following questions if the relevant data is available.

8. As indicated in Question 3, we believe that the introduction of FMS in the manufacturing industry brings about a reduction of capital investment, mainly in production facilities, and that as a result, companies have transformed from “producing organizations” to “thinking organizations”. We can therefore conceive that production divisions will break away from the head office or business division and become independent, and that production will then be entrusted to affiliated or associated companies. As it is difficult to obtain data to verify or otherwise this hypothesis, please answer the following questions.

I What percentage of overall production (in terms of value) is placed on external order to affiliated or associated companies for production of goods to be sold under your company’s name?

II What are annual indices based on a 1980 value of 100?

Fiscal year: External production (%)

9. An R&D component is included in capital investment (part of capital investment that is allocated purely for R&D purposes, e.g. establishment of new research institutes, establishment of testing facilities, etc.), and appropriation of this component is duplicated in R&D investment, so it is preferable to separate this from capital investment. By doing this, we can make a clear comparison of R&D investment and capital investment, and we believe that this, in turn, will facilitate discussions that are based on facts. Listed below are the R&D component percentages of capital investment based on the “Capital Investment Programme Study”, researched by banking organizations etc. Please indicate the corresponding percentages for your company.

Fiscal year; R&D component (%); Your company (%)

Thank you very much for your cooperation.

Simplified Results

Survey results

Overall

2		
1	7.00	16.28
2	10.00	23.26
3	13.00	30.23
4	12.00	27.91
No response	1.00	2.33
Total	43.00	

3 Regarding introduction (not introduced)		
1	9.00	15.00
No response	2.00	3.33
	60.00	11.00

2	
Year of introduction	
not available	7.00
Before 1980	5.00
1980	2.00
1981	
1982	3.00
1983	2.00
1984	2.00
1985	4.00
1986	1.00
1987	1.00
1988	1.00
1989	3.00
1990	1.00
	32.00

3	
Planned introduction	
1990	
1991	
1992	
1993	
1994	
1995	
1996	
1997	
1998	
1999	
2000	

4		
Regarding FMS		
1	10.00	31.25
2	15.00	46.88
3	7.00	21.88
No response		0.00
Total	32.00	

4		
1	14.00	32.56
2		0.00
3	29.00	67.44
No response		0.00
Total	43.00	

5		
1	6.00	9.23
2	40.00	61.54
3	2.00	3.08
4	4.00	6.15
5		0.00
6	13.00	20.00
No response		0.00
Total	65.00	

6		
1	36.00	30.00
2	20.00	16.67
3	34.00	28.33
4	2.00	1.67
5	6.00	5.00
6	8.00	6.67
7	11.00	9.17
8	2.00	1.67
No response	1.00	0.83
Total	120.00	

Simplified Results Fabrication

2		
1	4.00	15.38
2	7.00	26.92
3	9.00	34.62
4	5.00	19.23
No response	1.00	3.85
Total	26.00	

3 Regarding introduction (not introduced)		
1		0.00
No response	2.00	3.33
	60.00	2.00

2	
Year of introduction	
not available	6.00
Before 1980	4.00
1980	2.00
1981	
1982	3.00
1983	2.00
1984	
1985	2.00
1986	1.00
1987	
1988	1.00
1989	3.00
1990	
	24.00

3	
Planned introduction	
1990	
1991	
1992	
1993	
1994	
1995	
1996	
1997	
1998	
1999	
2000	

4		
Regarding FMS		
1	8.00	33.33
2	12.00	50.00
3	4.00	16.67
No response		0.00
Total	24.00	

4		
1	10.00	38.46
2		0.00
3	16.00	61.54
No response		0.00
Total	26.00	

5		
1	3.00	7.89
2	24.00	63.16
3	1.00	2.63
4	4.00	10.53
5		0.00
6	6.00	15.79
No response		0.00
Total	38.00	

6		
1	21.00	30.88
2	16.00	23.53
3	17.00	25.00
4	1.00	1.47
5	3.00	4.41
6	3.00	4.41
7	5.00	7.35
8	1.00	1.47
No response	1.00	1.47
Total	68.00	

Simplified Results

Material

2		
1	3.00	17.65
2	3.00	17.65
3	4.00	23.53
4	7.00	41.18
No response		0.00
Total	17.00	

3 Regarding introduction (not introduced)		
1	9.00	15.00
No response		0.00
	60.00	9.00

2	
Year of introduction	
not available	1.00
Before 1980	1.00
1980	
1981	
1982	
1983	
1984	2.00
1985	2.00
1986	
1987	1.00
1988	
1989	
1990	1.00
	8.00

3	
Planned introduction	
1990	
1991	
1992	
1993	
1994	
1995	
1996	
1997	
1998	
1999	
2000	

4		
Regarding FMS		
1	2.00	25.00
2	3.00	37.50
3	3.00	37.50
No response		0.00
Total	8.00	

4		
1	4.00	23.53
2		0.00
3	13.00	76.47
No response		0.00
計	17.00	

5		
1	3.00	11.11
2	16.00	59.26
3	1.00	3.70
4		0.00
5		0.00
6	7.00	25.93
No response		0.00
Total	27.00	

6		
1	15.00	29.41
2	4.00	7.84
3	16.00	31.37
4	1.00	1.96
5	3.00	5.88
6	5.00	9.80
7	6.00	11.76
8	1.00	1.96
No response		0.00
Total	51.00	

Expenditure of Top 50 Companies

Capital Investment

	1 9 8 4	1 9 8 5	1 9 8 6	1 9 8 7	1 9 8 8
Top 10 companies	1,424,300	1,588,600	1,212,282	1,118,300	1,665,913
Top 20 companies	2,238,642	2,427,777	2,012,785	1,821,466	2,438,992
Top 30 companies	2,588,304	2,885,681	2,408,014	2,236,319	2,941,301
Top 40 companies	2,913,802	3,250,381	2,704,645	2,502,698	3,299,369
Top 50 companies	3,133,502	3,499,781	2,931,987	2,812,106	3,712,156

R&D Expenditure

	1 9 8 4	1 9 8 5	1 9 8 6	1 9 8 7	1 9 8 8
Top 10 companies	1,400,917	1,640,570	1,730,083	1,907,842	2,062,083
Top 20 companies	1,886,418	2,169,803	2,325,246	2,450,069	2,749,414
Top 30 companies	2,108,782	2,449,082	2,596,985	2,746,707	3,098,335
Top 40 companies	2,311,714	2,692,442	2,866,637	3,028,963	3,376,324
Top 50 companies	2,431,641	2,860,672	3,003,831	3,214,776	3,633,178
R&D / Capital Investment	0.78	0.82	1.02	1.14	0.98

Annual Ratio of R&D Expenditure / Capital Investment for Top 50 Companies

R&D Expenditure / Capital Investment

Fiscal 1980

		8 1			8 2			
Industry category; R&D / Cap			Industry category; R&D / Cap		Industry category; R&D / Cap			
1	A	0.396	1	A	0.783	1	A	0.842
2	B		2	A	0.675	2	A	0.643
3	A	0.667	3	B		3	B	
4	A	2.169	4	A	1.786	4	A	3.238
5	A		5	A		5	A	
6	A	1.386	6	A	1.250	6	A	1.144
7	B	0.321	7	A		7	A	0.763
8	A	0.735	8	B	0.188	8	A	
9	A		9	A	0.883	9	B	0.151
10	B	0.190	10	B	0.196	10	A	
11	A		11	A		11	B	0.154
12	B		12	B		12	A	1.300
13	B	0.000	13	B		13	B	0.290
14	A	0.376	14	A	0.350	14	A	0.463
15	A	1.538	15	A	1.264	15	B	
16	A	0.985	16	A	0.631	16	A	0.687
17	B		17	B		17	B	
18	B		18	A		18	A	1.064
19	A	0.377	19	A		19	A	
20	A		20	B	0.556	20	A	
21	A		21	A		21	B	0.567
22	B		22	A	0.414	22	A	0.633
23	A		23	A	1.083	23	A	
24	B		24	B		24	A	1.103
25	A	1.100	25	B		25	A	0.639
26	B		26	A	0.606	26	B	
27	A		27	A	0.583	27	B	
28	A		28	A	0.914	28	A	0.661
29	B		29	B		29	A	0.207
30	A	0.464	30	A	0.183	30	B	0.136
31	A	1.015	31	A		31	B	
32	A	0.479	32	A		32	A	
33	B	0.049	33	B	0.089	33	A	0.175
34	B		34	A		34	B	
35	A		35	B		35	B	
36	A	0.190	36	A		36	A	
37	B		37	A		37	A	
38	B	1.608	38	A		38	A	
39	B	0.420	39	B		39	B	
40	A		40	B	1.143	40	B	1.119
41	B		41	B	0.485	41	B	0.027
42	B		42	B	0.361	42	B	
43	B	0.189	43	B		43	A	
44	B		44	B		44	B	0.573
45	B		45	B	0.018	45	A	
46	B		46	B		46	A	
47	B	0.565	47	A		47	B	0.525
48	A		48	B		48	B	0.595
49	A		49	A		49	B	
50	A		50	A		50	B	

A = Fabrication

B = Material

8 3		8 4		8 5	
Industry category; R&D/Cap		Industry category; R&D/Cap		Industry category; R&D/Cap	
1 A	0.994	1 A	0.788	1 A	0.574
2 A	1.167	2 A	1.260	2 A	1.129
3 A	3.923	3 A	3.855	3 A	3.483
4 B		4 A	1.086	4 A	1.457
5 A		5 B		5 B	0.355
6 A	0.981	6 A	0.808	6 A	1.071
7 A		7 A	1.507	7 A	1.147
8 A	1.262	8 A	1.480	8 A	1.095
9 A		9 A	0.952	9 A	1.292
10 A	1.322	10 A	0.866	10 A	0.955
11 A	0.947	11 B	0.267	11 A	0.800
12 B	0.142	12 A	0.986	12 A	1.078
13 B	0.293	13 A	0.628	13 A	0.848
14 A	1.574	14 A	1.243	14 B	0.343
15 B		15 B	0.441	15 B	0.294
16 B	0.216	16 B	0.314	16 B	0.395
17 B		17 B	0.368	17 B	0.361
18 A	0.844	18 B	0.345	18 B	0.341
19 A		19 A	0.592	19 A	0.402
20 A	0.493	20 A	0.647	20 A	1.101
21 A	0.652	21 A	2.000	21 A	0.857
22 B	0.679	22 B	0.846	22 A	0.590
23 B	0.566	23 A	0.716	23 B	0.966
24 A	0.739	24 A	0.593	24 A	2.586
25 A	0.807	25 B	0.647	25 B	0.589
26 A	0.413	26 A	0.668	26 A	0.577
27 B		27 B	0.846	27 A	0.209
28 B	0.149	28 B	0.109	28 B	0.173
29 B		29 A	0.313	29 A	0.635
30 A	1.185	30 A	0.640	30 B	0.350
31 A	0.244	31 B	0.334	31 B	0.568
32 A		32 B	0.450	32 B	1.170
33 A		33 A	0.737	33 B	0.354
34 B		34 A	0.362	34 A	1.229
35 B		35 A	1.188	35 B	0.597
36 A		36 B	0.079	36 A	0.119
37 A	0.188	37 B	0.957	37 A	1.180
38 A		38 A	1.000	38 A	0.970
39 A		39 B	0.665	39 A	0.846
40 B	0.064	40 A	0.553	40 B	0.062
41 B	1.871	41 A	0.117	41 A	0.232
42 A		42 B	0.479	42 A	0.474
43 B	0.566	43 A	0.780	43 A	0.670
44 B		44 A	0.551	44 B	0.600
45 B		45 B	0.413	45 B	0.387
46 B		46 B	1.903	46 A	0.773
47 B	0.458	47 B		47 B	0.595
48 B		48 A		48 B	2.251
49 A		49 B	0.048	49 A	1.199
50 B	0.681	50 A	0.132	50 B	0.203

A = Fabrication
B = Material

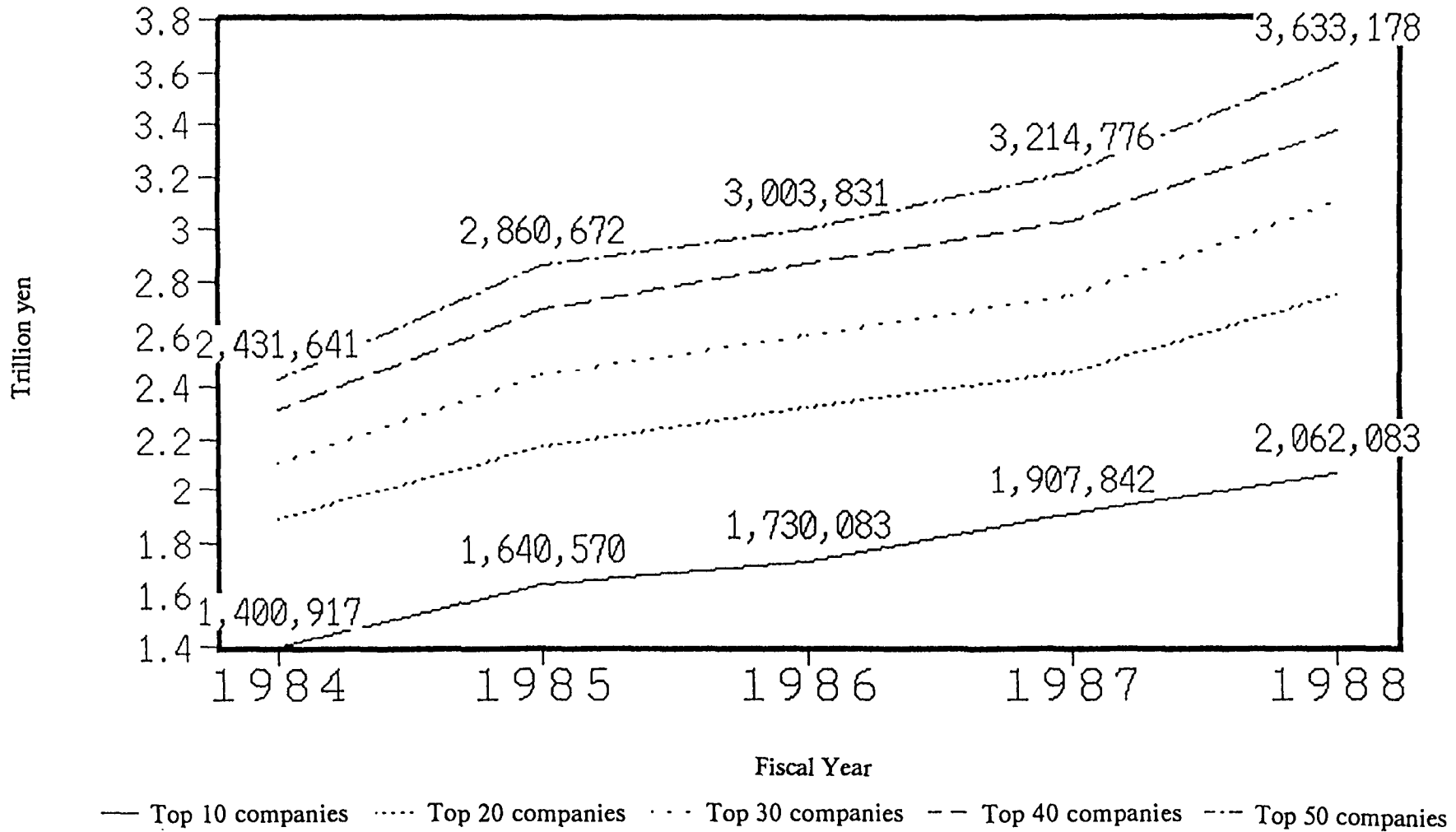
8 6		8 7		8 8	
Industry category;	R&D/Cap	Industry category;	R&D/Cap	Industry category;	R&D/Cap
1 A	0.854	1 A	1.050	1 A	0.838
2 A	1.632	2 A	2.095	2 A	3.317
3 A	5.200	3 A	4.125	3 A	1.668
4 A	2.495	4 A	2.536	4 A	1.425
5 A	1.436	5 A	1.741	5 A	1.471
6 A	1.504	6 A	1.955	6 A	1.481
7 B	0.410	7 A	1.453	7 A	1.130
8 A	1.500	8 B	0.650	8 B	0.550
9 A	1.806	9 A	2.068	9 A	1.453
10 A	1.231	10 A	1.549	10 A	0.659
11 A	0.692	11 A	1.532	11 A	1.542
12 A	1.866	12 A	0.682	12 A	1.379
13 A	1.163	13 A	0.960	13 A	0.875
14 B	0.367	14 B	0.550	14 A	1.206
15 B	0.408	15 B	0.276	15 B	0.498
16 A	1.179	16 A	0.928	16 B	0.288
17 B	0.433	17 B	0.710	17 B	0.486
18 A	0.711	18 B	0.291	18 A	0.746
19 B	0.293	19 A	1.248	19 B	0.422
20 B	0.350	20 A	1.184	20 B	0.473
21 A	1.143	21 B	0.407	21 A	1.677
22 A	0.613	22 A	1.239	22 A	0.930
23 A	2.563	23 A	2.383	23 A	0.881
24 B	0.272	24 B	0.720	24 B	0.135
25 A	0.200	25 A	0.296	25 B	0.700
26 B	0.648	26 B	0.629	26 B	0.587
27 A	0.432	27 A	0.524	27 A	0.181
28 B	0.476	28 B	0.190	28 A	0.563
29 A	0.801	29 B	0.936	29 A	0.919
30 B	0.993	30 A	0.898	30 B	0.962
31 B	0.842	31 B	0.298	31 B	0.081
32 B	0.104	32 B	1.031	32 B	0.236
33 A	2.438	33 A	0.879	33 A	2.487
34 A	1.072	34 A	1.811	34 A	0.433
35 A	1.420	35 A	1.556	35 B	0.826
36 A	0.917	36 A	2.228	36 A	1.652
37 A	0.845	37 A	0.753	37 A	0.597
38 B	0.887	38 B	1.103	38 A	0.702
39 B	0.603	39 B	0.360	39 A	1.381
40 A	1.128	40 B	0.929	40 B	1.003
41 B	0.686	41 B	0.413	41 B	0.789
42 B	0.751	42 B	1.219	42 A	0.974
43 B	0.370	43 A	2.168	43 B	1.783
44 B	1.581	44 B	0.760	44 A	1.680
45 A	1.939	45 B	0.291	45 B	0.799
46 A	0.717	46 B	0.048	46 B	0.516
47 B	0.243	47 B	0.366	47 B	0.016
48 B	0.132	48 A	1.155	48 A	1.070
49 B	0.006	49 A	0.772	49 B	0.352
50 B	0.137	50 B	0.694	50 B	0.479

A = Fabrication
B = Material

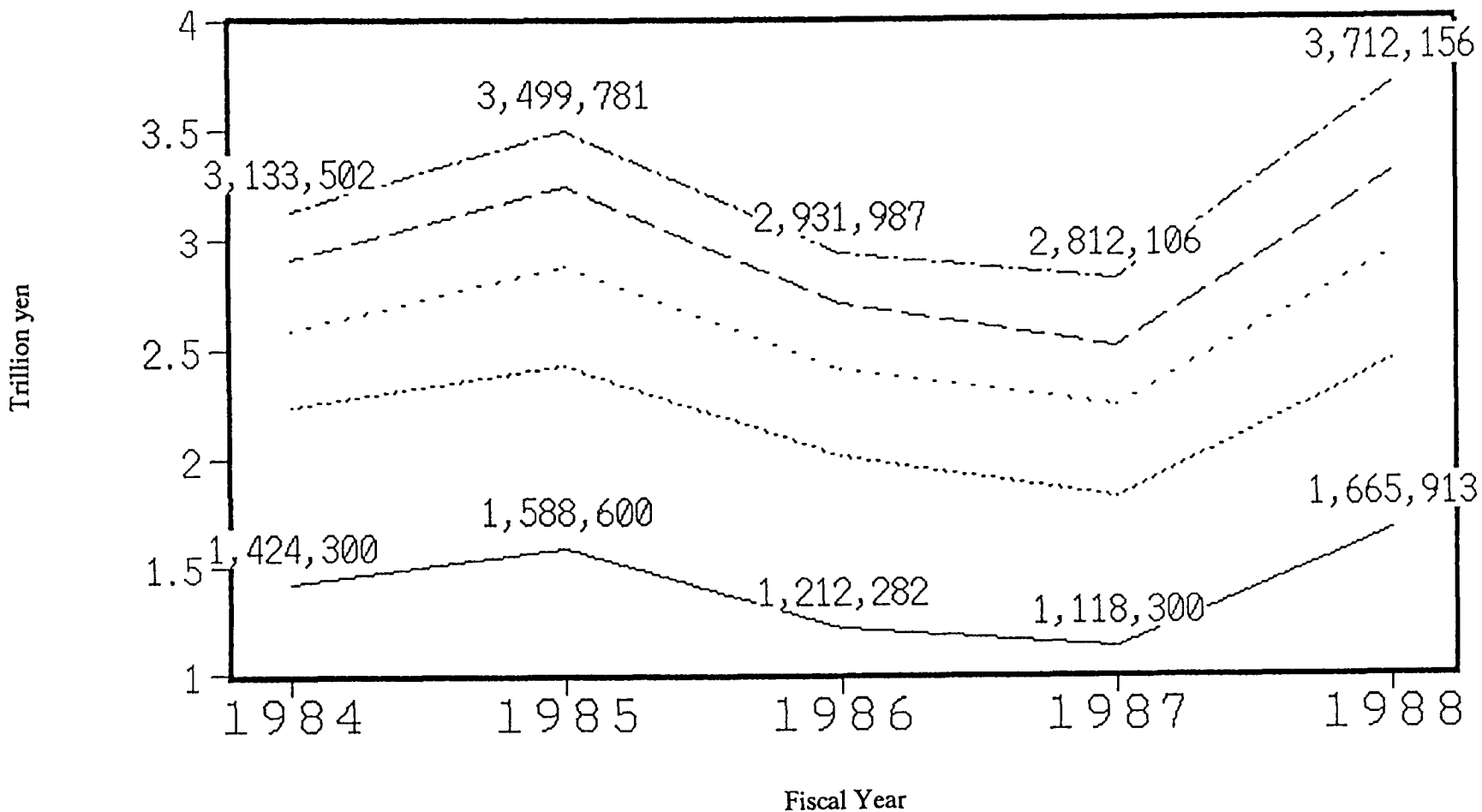
Ratio of 23 Companies

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1980-1984	1985-1988
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.2	17.39	21.74	21.74	17.39	8.70	8.70	8.70	8.70	13.04	17.39	9.79
0.4	34.78	30.43	21.74	21.74	21.74	21.74	17.39	17.39	13.04	26.09	17.39
0.6	56.52	47.83	34.78	34.78	34.78	34.78	26.09	21.74	21.74	41.74	26.09
0.8	65.22	65.22	65.22	43.48	56.52	43.48	39.13	26.09	39.13	59.13	36.96
1.0	69.57	73.91	69.57	65.22	73.91	60.87	43.48	39.13	52.17	70.44	48.91
1.2	78.26	82.61	86.96	73.91	78.26	86.96	60.87	47.83	56.52	80.00	63.05
1.4	82.61	95.65	95.65	86.96	86.96	91.30	60.87	60.87	56.52	89.57	67.39
1.6	91.30	95.65	95.65	91.30	91.30	91.30	78.26	73.91	73.91	93.04	79.35
1.8	95.65	100.00	95.65	91.30	91.30	91.30	82.61	78.26	95.65	94.78	86.96
2.0	95.65	100.00	95.65	95.65	95.65	91.30	91.30	82.61	95.65	96.52	90.22
2.0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

R&D Expenditure by the Top Companies (Sales base) - 1984-88

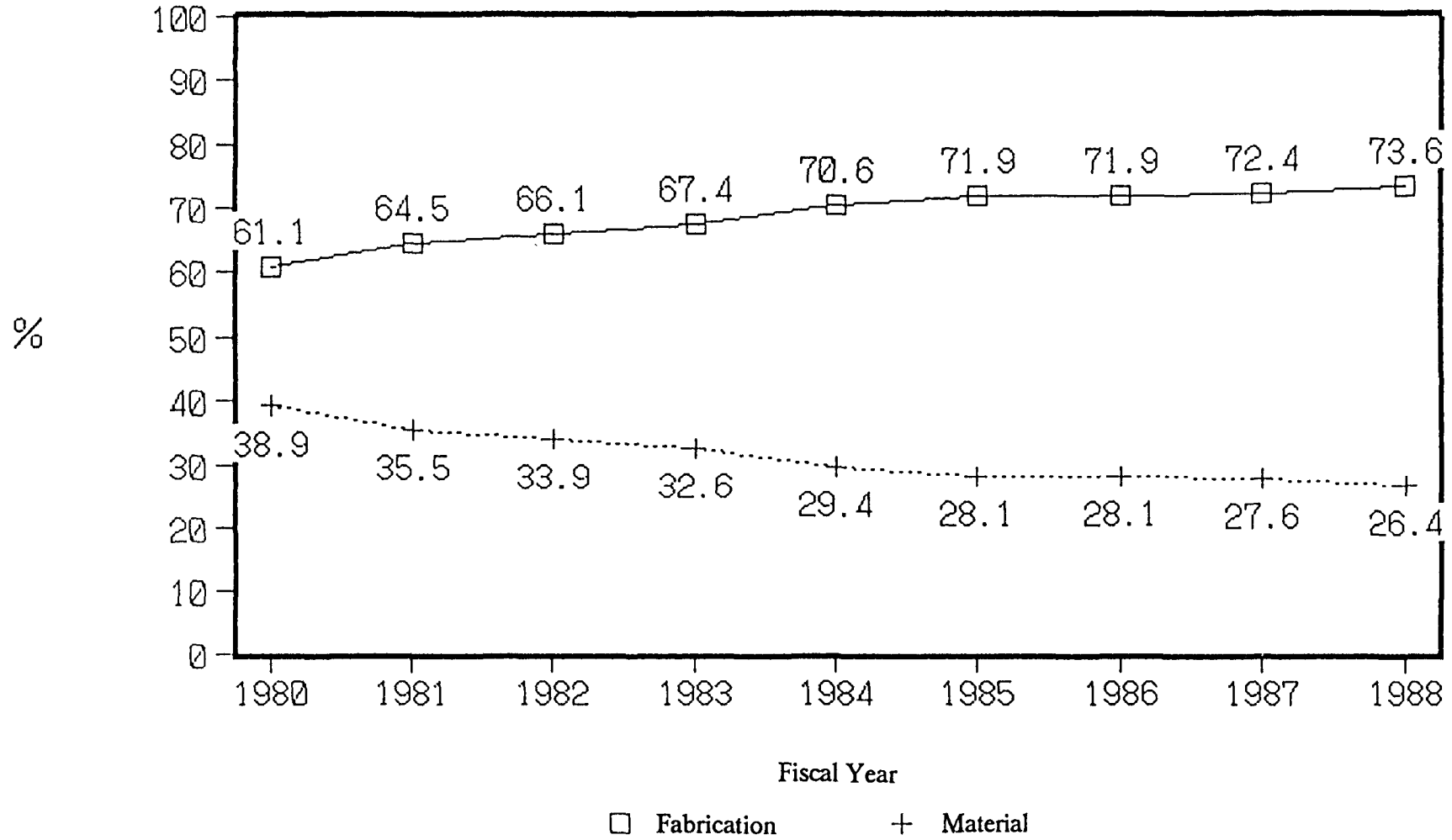


Capital Investment by the Top Companies (Sales base) - 1984-88

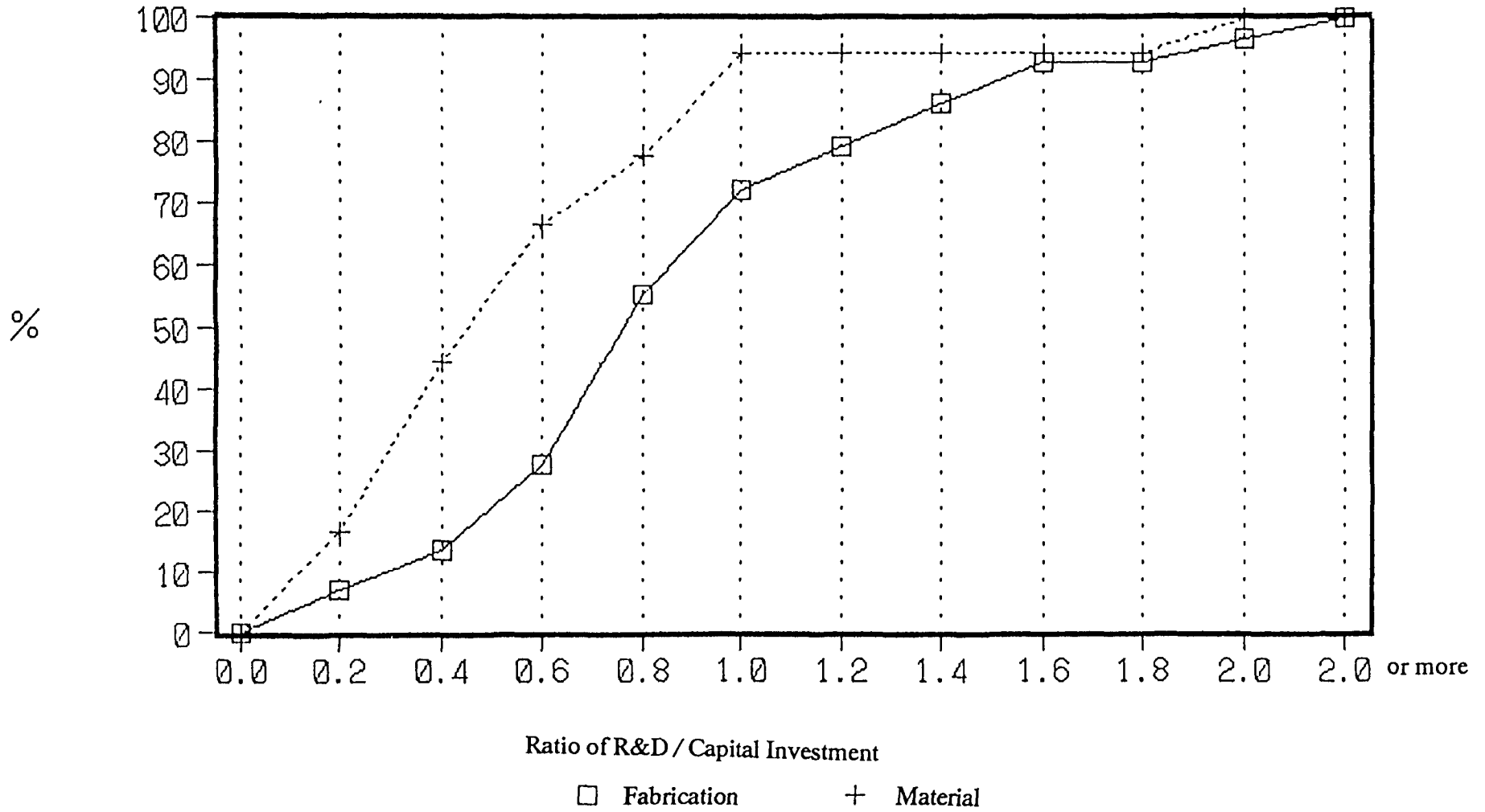


— Top 10 companies ····· Top 20 companies ····· Top 30 companies - - - Top 40 companies - - - Top 50 companies

Share of the Top 50 Companies (Sales Base) by Industry Type

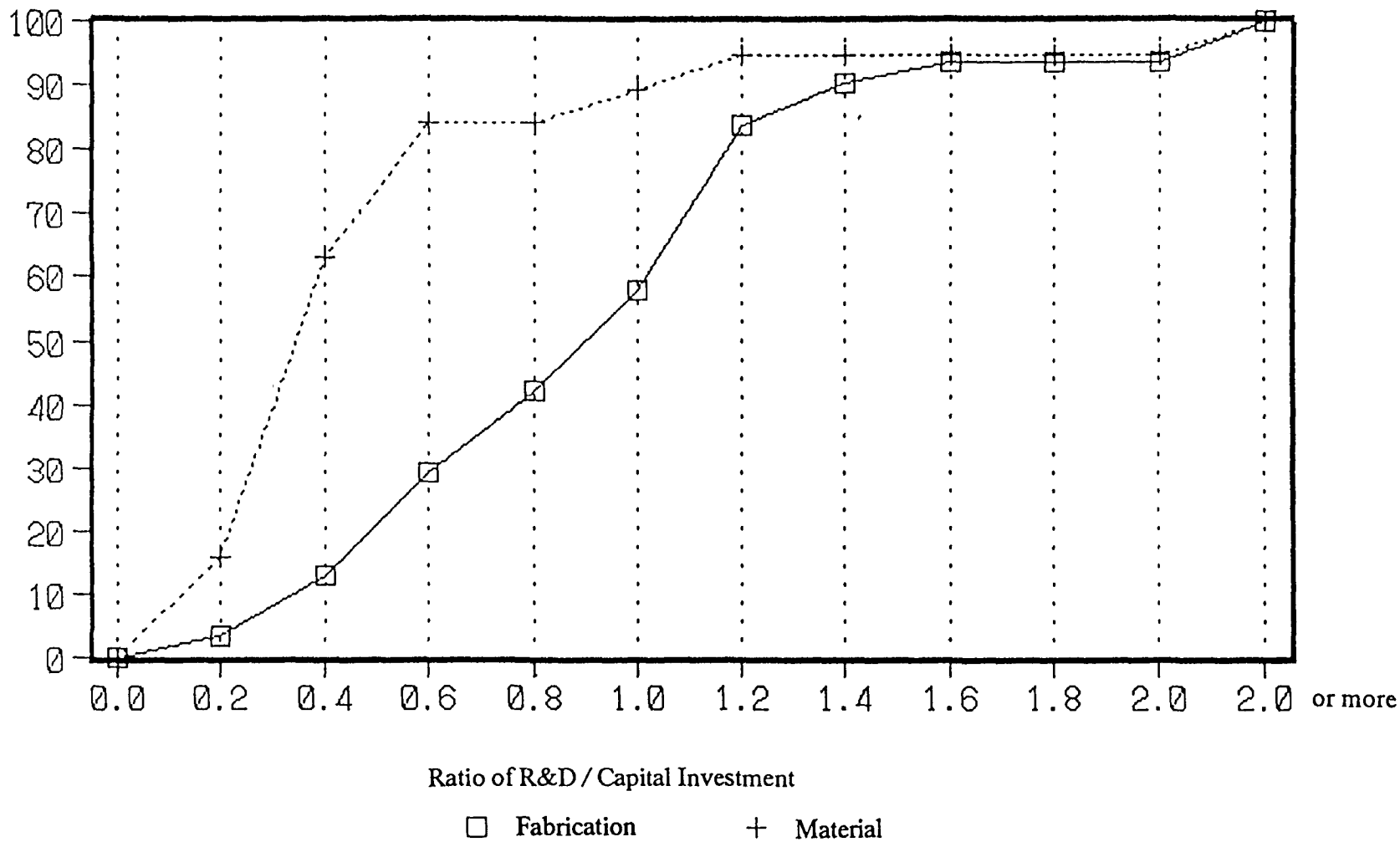


Company Cumulative Distribution - R&D / Capital Investment (1984)



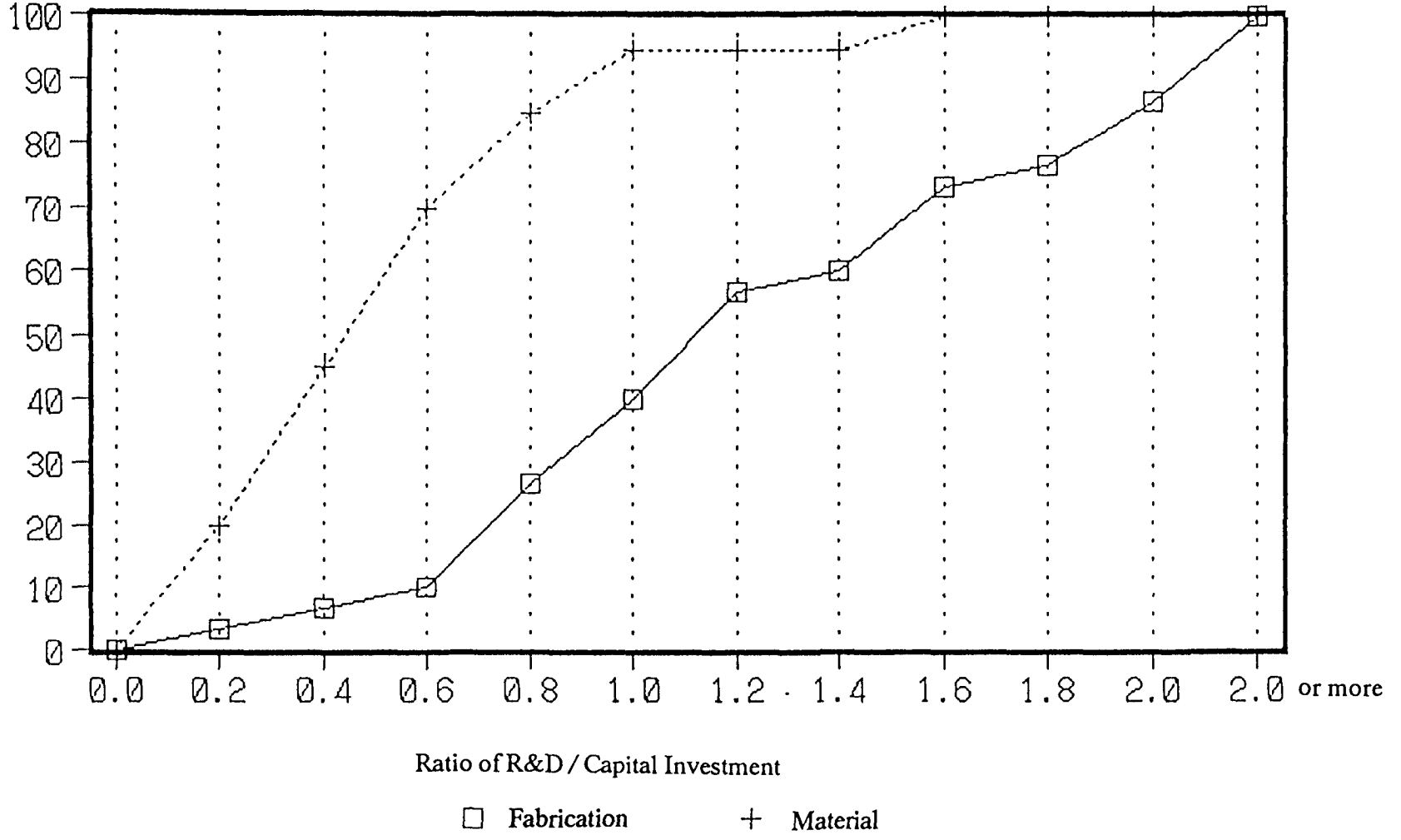
Company Cumulative Distribution - R&D / Capital Investment (1985)

— 44 —
%



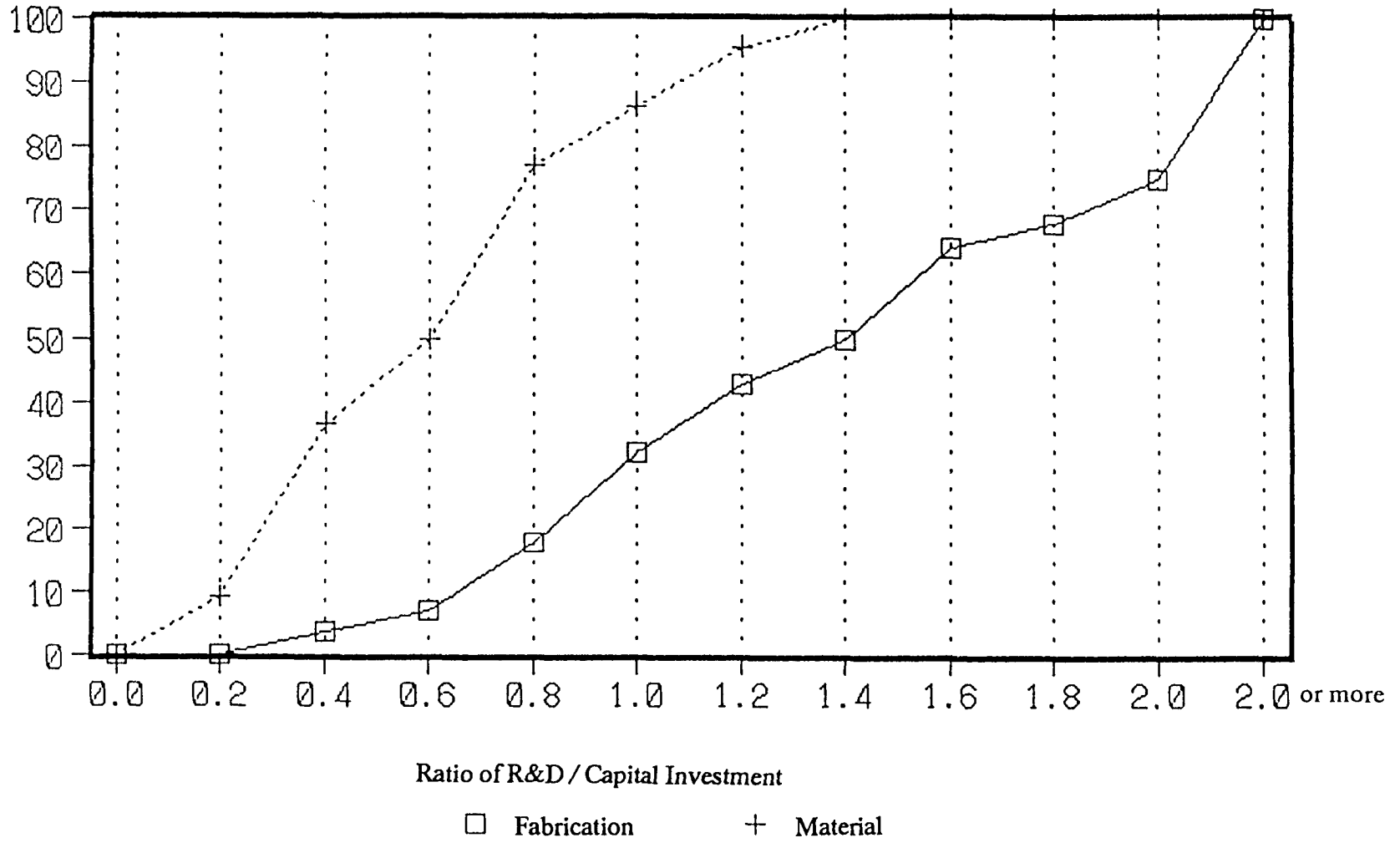
Company Cumulative Distribution - R&D / Capital Investment (1986)

%

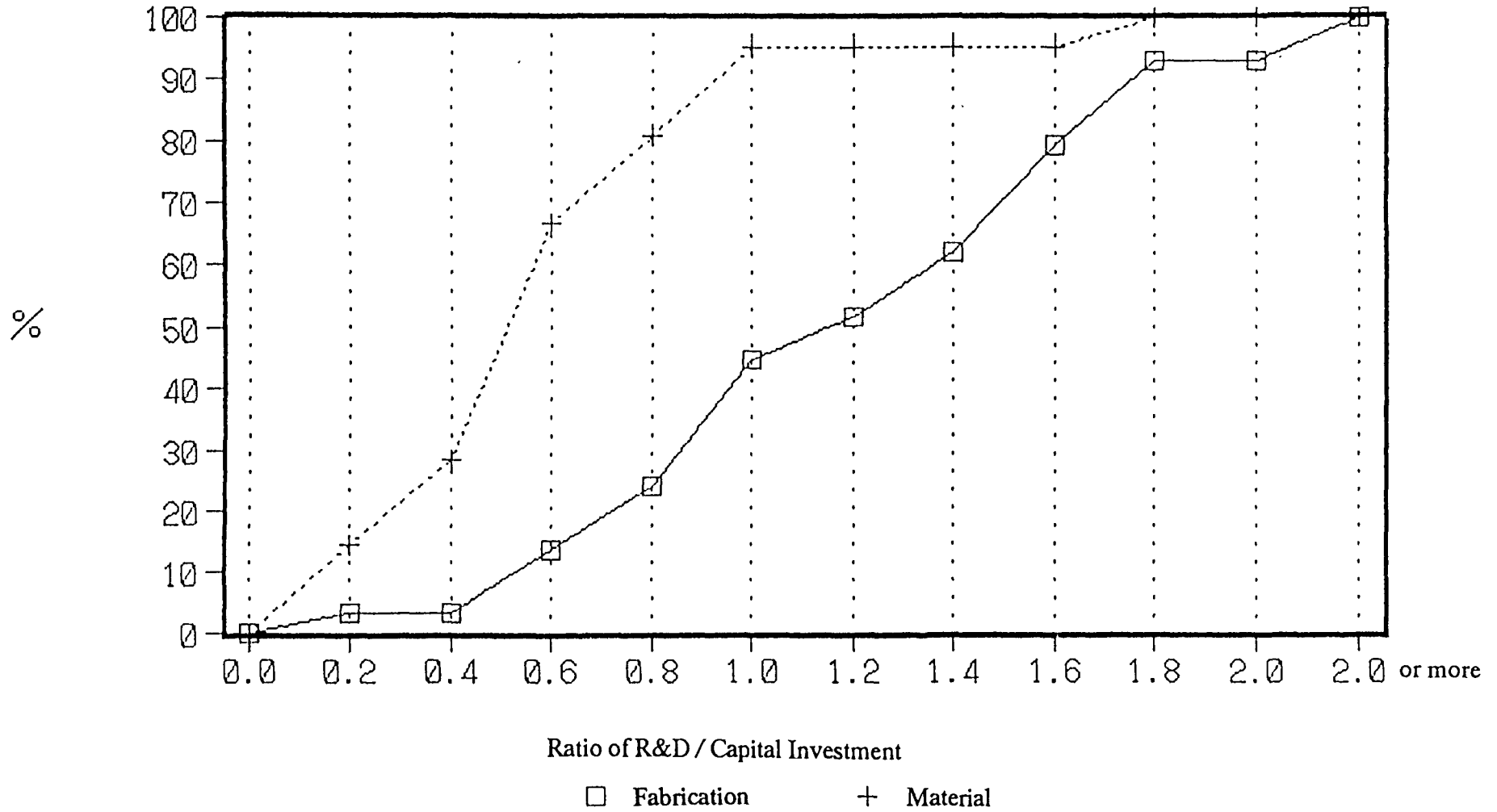


Company Cumulative Distribution - R&D / Capital Investment (1987)

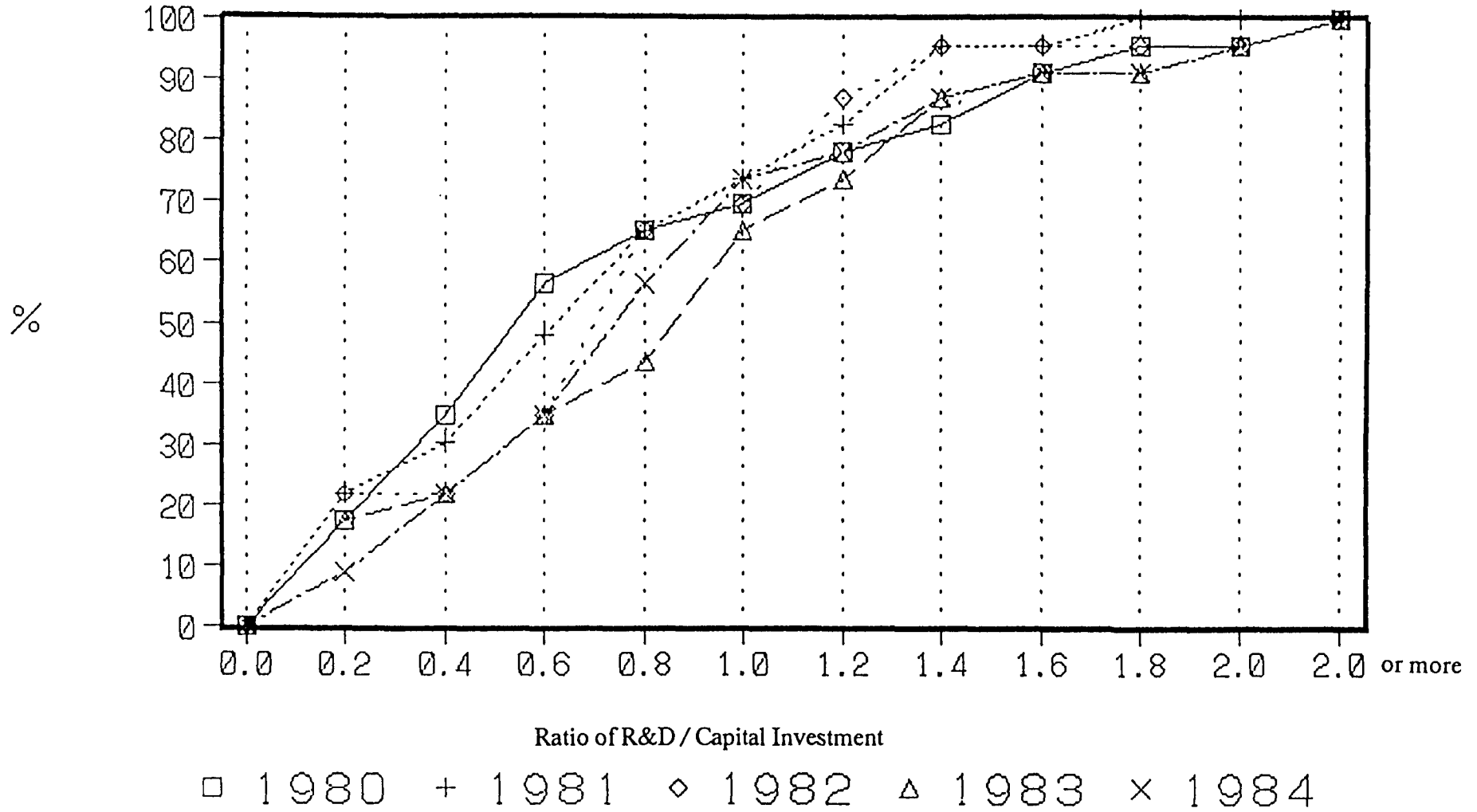
%



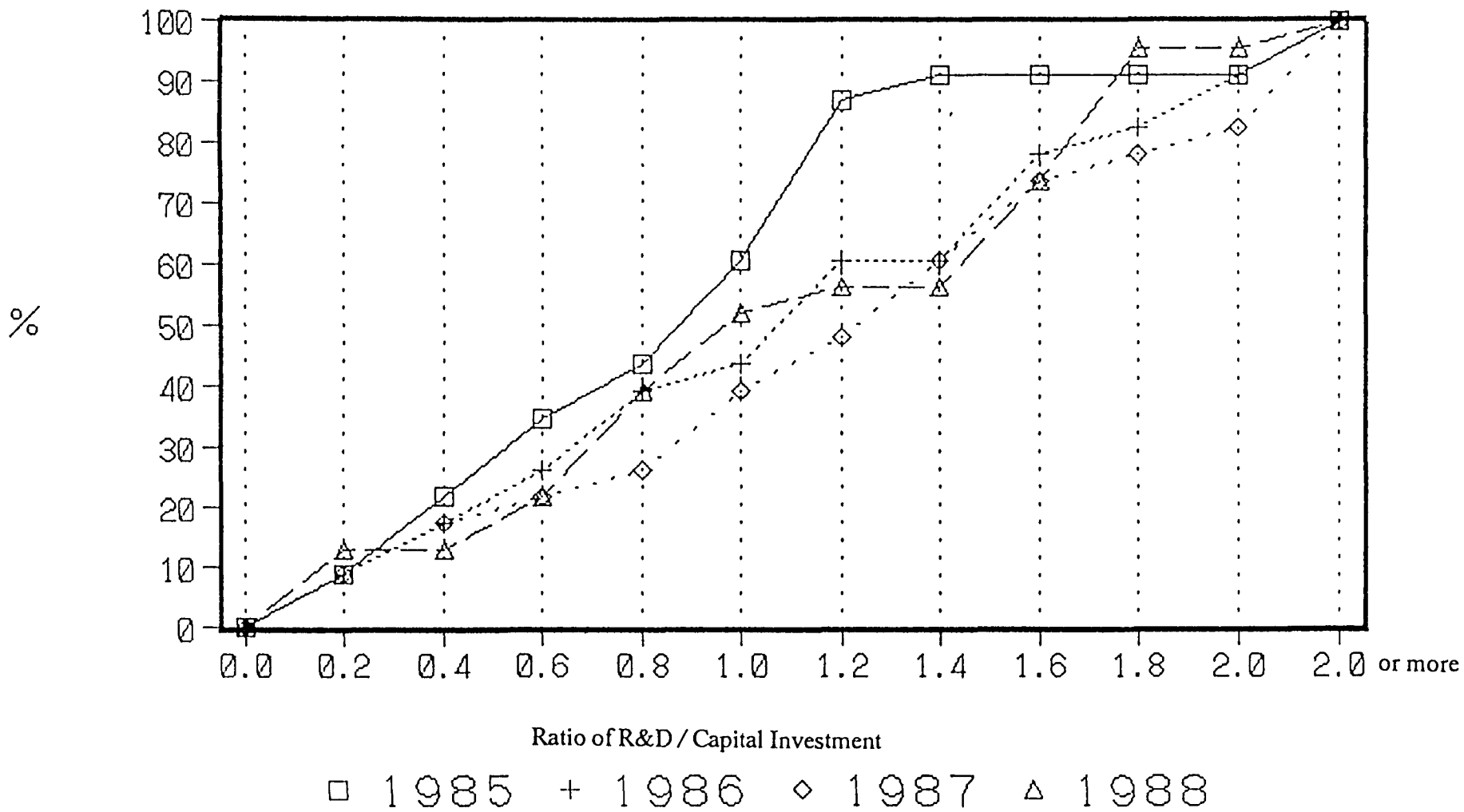
Company Cumulative Distribution - R&D / Capital Investment (1988)



Company Cumulative Distribution - R&D / Capital Investment (23 Companies)



Company Cumulative Distribution - R&D / Capital Investment (23 Companies)



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