

Changes in Research Activities in the Fields of Electronics and Information & Communications in Japan

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1 Introduction

The World Competitiveness Yearbook 2010 Ranking^[8] of International Institute for Management Development (IMD) states that Japan ranked 2nd in science and technology infrastructure. However, some say that “Japan’s science and technology capability has not led to an increase in its industrial competitiveness and growth potential” and that “Japan, despite its technical strength, has been losing ground in business competition.” In most cases, these arguments are based on the current situation of the Japanese electronics and information & communications industries.

When making such arguments, how much are we aware of changes in Japan’s research activities in the fields related to electronics and information & communications? The National Institute of Science and Technology Policy has been conducting a bibliographic survey of periodicals published by the Institute of Electrical and Electronics Engineering Inc. (IEEE) and, from the survey results made available so far^[1,2], we have come to see changes in the world trends and the characteristics of Japan’s research in the fields of electronics and information & communications.

In this report, we would like to show in quantitative terms how the situation of Japanese research activities in the fields of electronics and information & communications has changed by examining trends in the number of articles in IEEE periodicals. Specifically, we first show sector-by-sector research trends since 1992 and then compare changes in universities’ and enterprises’ research trends in 1992 and 2007. Finally, we present researchers’ opinions on the results of our analyses.

A change in the number of articles is only one of the indicators of research results and it does not reveal the entire picture of an R&D activity. Still, changes in the number of articles in IEEE periodicals can be viewed as data reflecting an industrial trend. It is well known that IEEE publications account for a large proportion of the whole of engineering research papers^[3] and such a large professional association like the IEEE does not exist in other fields. The professional literature published by the IEEE includes literature produced by affiliated academic societies (for instance, the Optical Society of America) that share IEEE Xplore (literature database) with the IEEE. Moreover, with respect to industrial utilization and application, IEEE literature is the most frequently referenced in U.S. patents.^[4] Since IEEE literature covers a very wide range of the engineering field both in terms of quality and quantity, it is the best data for learning the situation of research and development in the fields of electronics and information & communications.

2 Characteristics of Japan in the World

Simply put, research on electronics and information & communications in Japan is in a very peculiar situation compared with global trends. To begin with, Japan is the only one among high-ranked countries that has seen the number of articles on electronics and information & communications published in the country remain almost unchanged, while research in the same fields in other countries has become very active. (for details, see References^[1,2])

Figure 1 shows the number of articles by area (vertical scale) and the total number of articles by society (horizontal scale) and compares the numbers

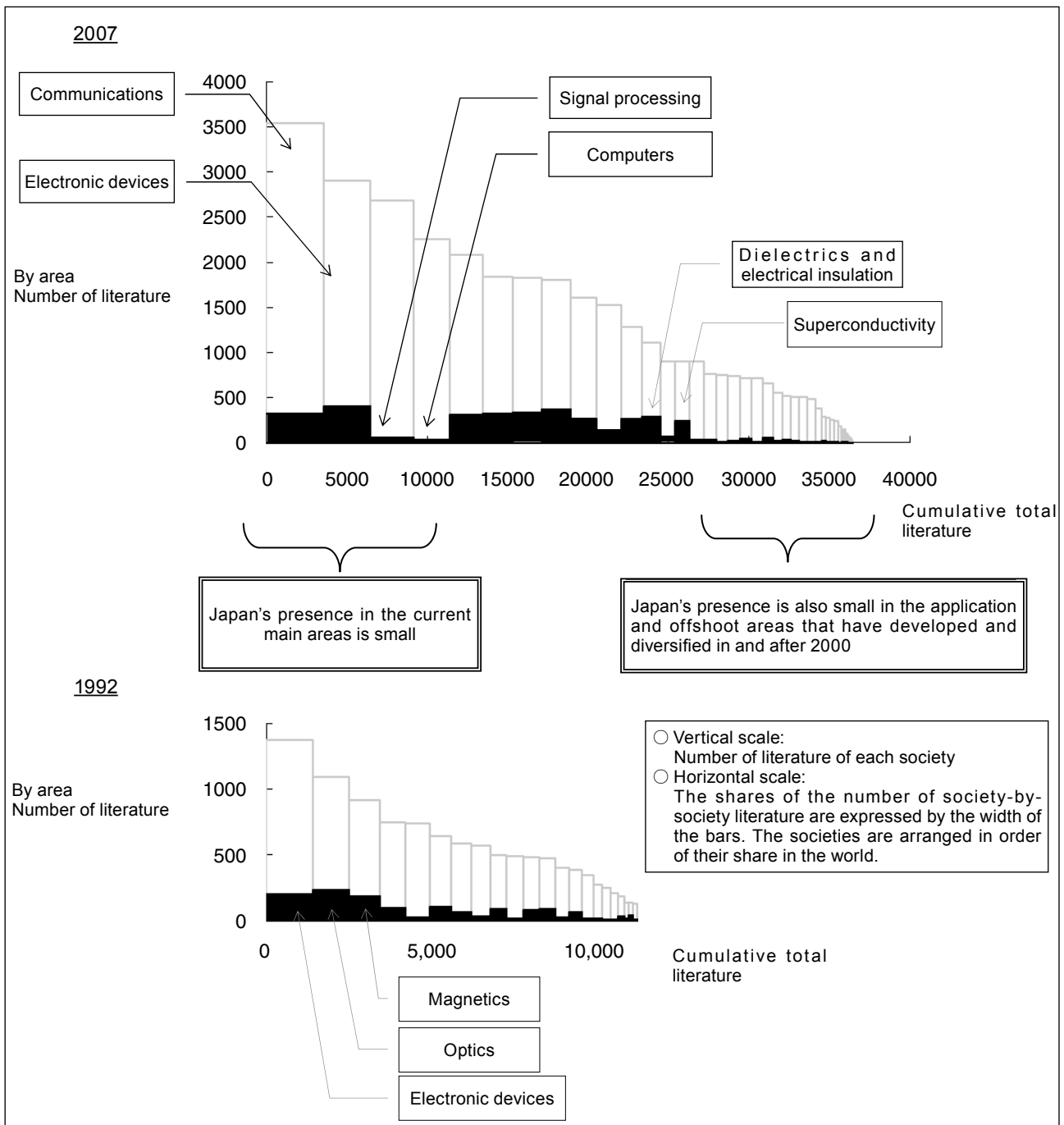


Figure 1: Comparison of the Numbers of Area-by-Area Literature Published in Japan and Other Countries (1992 → 2007)
Prepared by the STFC based on Reference^[2]

in 1992 and 2007. The white bar graphs show the global total number of articles by area and the black bars show those published in Japan. Incidentally, the term “area” here means the specialized area of each IEEE society. Japan’s area-by-area portfolio in 1992 was similar to that of the world, holding high shares in such areas as optics and electronic devices. However, in 2007, Japan showed almost no growth in the information and communications-related areas, such as communications, signal processing and computers (including applications; such as application to medicine or biotechnology), the areas that have posted

a sharp increase worldwide. Japan’s shares in its main areas, including electronic devices, also decreased. In particular, in the application and offshoot areas that have diversified and developed since 2000, Japan produced almost no articles. The comparison between 1992 and 2007 clearly reveals the anomaly of Japan’s trend in science and technology research, while other countries shifted their focus to the information and communications related fields during the period.

One of the characteristics of research articles in Japan, as compared with those in other countries, is that there are many articles on electronics but that the

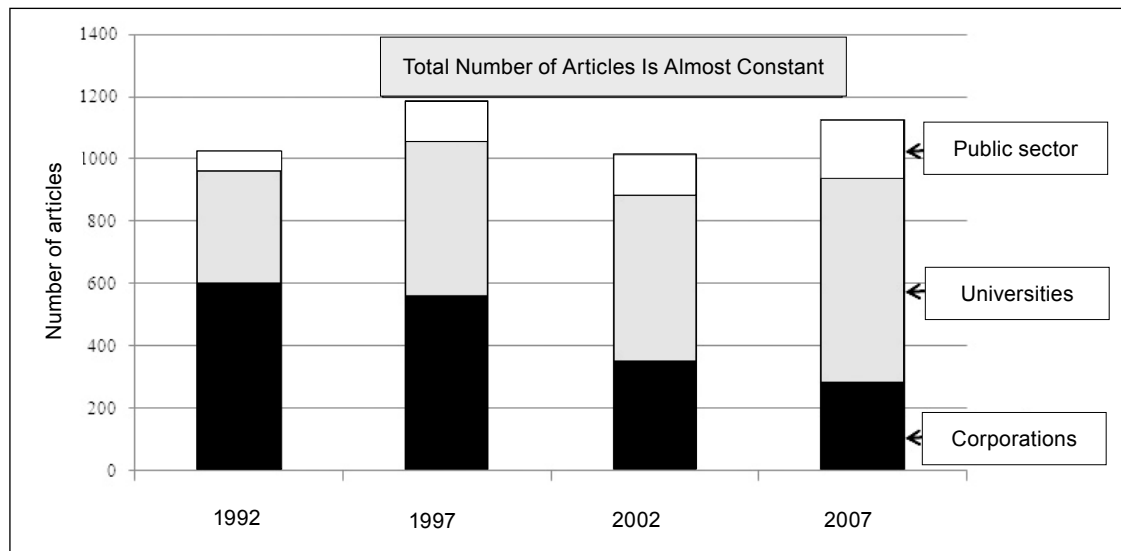


Figure 2: Total Number of IEEE Articles from Japan and Sector-by-Sector Changes
Prepared by the STFC based on Reference^[1]

number of information-related articles is extremely small. In particular, there is much literature in the electronics-related areas, such as magnetics, and the Japanese shares of literature on superconductivity and robotics are high (for details, see References^[1,2]).

In other words, it can be said that amid a sharp increase in the number of articles in the fields of information and communications in other countries, Japan has been carrying out research based on its own “selection and concentration.”

With these basic situations in mind, we would like to continue our discussions.

3 Structural Change in Japan’s Research and Development

The fact that the corporate sector spends an overwhelming amount of research funds^[5] gives the impression that corporations are the main player in Japan’s R&D activities in the fields of electronics and information & communications. However, a sector-by-sector analysis reveals that the number of articles contributed by corporations has decreased drastically since the second half of the 1990s and, instead, the numbers of articles contributed by universities and public research institutions has increased sharply. It is clear that, while the total number of articles remains almost stable, the main player in the production of research articles has shifted “from industry to academia.”

Although the number of articles contributed by public research institutions has increased from 1992,

when the number was almost zero, it is still much smaller than those contributed by universities and corporations. Therefore, we omit public research institutions from our analyses.

There may be cases where corporations “carry out R&D activities but do not write articles.” In this report, however, we advance our discussions on the assumption that the relationship between R&D activities and the publication of articles remains unchanged.

4 Changes at Corporations

4-1 Trends in the number of articles published by corporate groups

Figure 3 shows trends in the numbers of research articles contributed by high-ranked Japanese corporations and their research institutes (NTT, Hitachi, Toshiba, NEC, and Mitsubishi Electric) and other Japanese corporations. Although the numbers decreased at all corporations under review, the decrease at the NTT group is conspicuous.

4-2 Analogy of changes in R&D activities by corporate group

Figure 4 shows changes in the number of area-by-area articles contributed by corporate groups in 1992 and 2007. As a whole, the number of articles contributed by Japanese corporations has decreased, centering on optics, electronic devices, consumer electronics and electric power engineering.

We analogize the changes in the contents of research

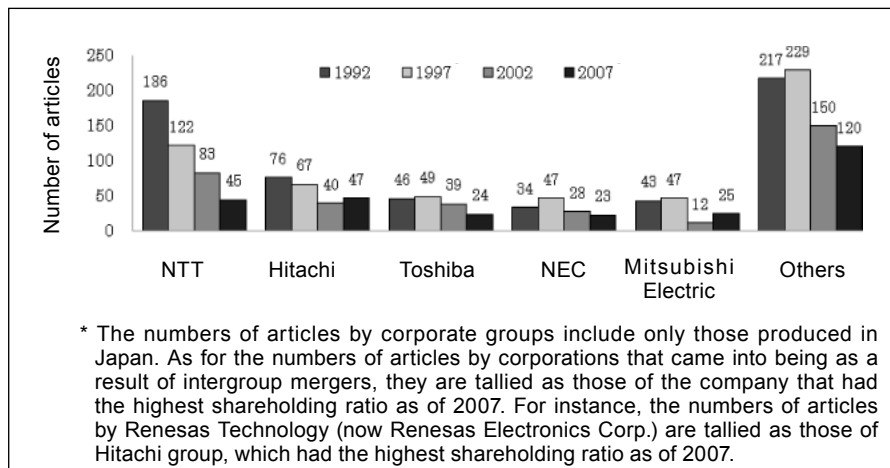


Figure 3: Changes in the Numbers of Articles by Corporate Groups

Prepared by the STFC based on Reference^[1]

and development by corporate groups by dividing them into (1) NTT group (1st), (2) Other high-ranked corporate groups (2nd~5th), and (3) Corporate groups ranked 6th or below.

(1) Changes at NTT group

As Figure 4 shows, the decrease in the number of articles by NTT group accounts for about half of the decrease in the number of articles contributed by the Japanese corporate sector. By area, the decrease in the number of optics-related articles came to about 100, accounting for nearly 10% of the total decrease in the number of articles in Japan. It can be said that the decrease in the number of NTT group's articles, including those on electronic devices, had a major impact on Japan as a whole.

Meanwhile, in the signal processing-related area, which has posted conspicuous growth on a global scale, NTT group remained the largest corporate group in terms of the number of articles in 2007. In the field related to communications and network, NTT group is still a leading research institution in Japan.

The change in the number of articles of NTT group should be viewed as a result of the group's positive action to change its business strategy in line with the establishment of optical communications technology and redefinition of the corporate business domain.

(2) Changes at other high-ranked corporate groups

The number of articles in the areas of electronic devices, magnetics, optics and home electronics, electric power engineering contributed by the four high-ranked corporate groups (Hitachi, Toshiba, NEC, Mitsubishi Electric) in Japan has decreased. However, a more characteristic change is that, as

Figure 5 shows, the number of articles contributed by their research institutes abroad or the companies they acquired abroad has increased. This represents a trend in the number of articles reflecting the global business strategies of the corporate groups. In particular, in the case of NEC group, the proportion of articles contributed by its research institutes abroad is high. By area, many articles are produced abroad in the areas related to information, communication and signal processing, areas where only a relatively small number of articles is produced in Japan. In other words, the corporate groups are strategically promoting research and development by compartmentalizing the contents of their research activities in Japan and abroad. Figure 5 also shows that there are many articles produced by the new companies that came into being as a result of domestic business reorganizations among the high-ranked corporate groups, such as Elpida Memory Inc. and Renesas Technology Corp. (now Renesas Electronics Corp.). Many of the high-ranked corporate groups keep the number of their articles constant by promoting global business deployment and reorganization.

The global business operations being like this means that the corporate groups are promoting not only the overseas transfer of their production activities but also their R&D activities in pursuit of "overseas brains." This suggests that "hollowing out of intelligence" may be under way in Japan.

(3) Changes in corporate groups ranked 6th or below

At corporations ranked 6th or below, the number of articles in the area of electronic devices, mainly home electronics and electric power engineering,

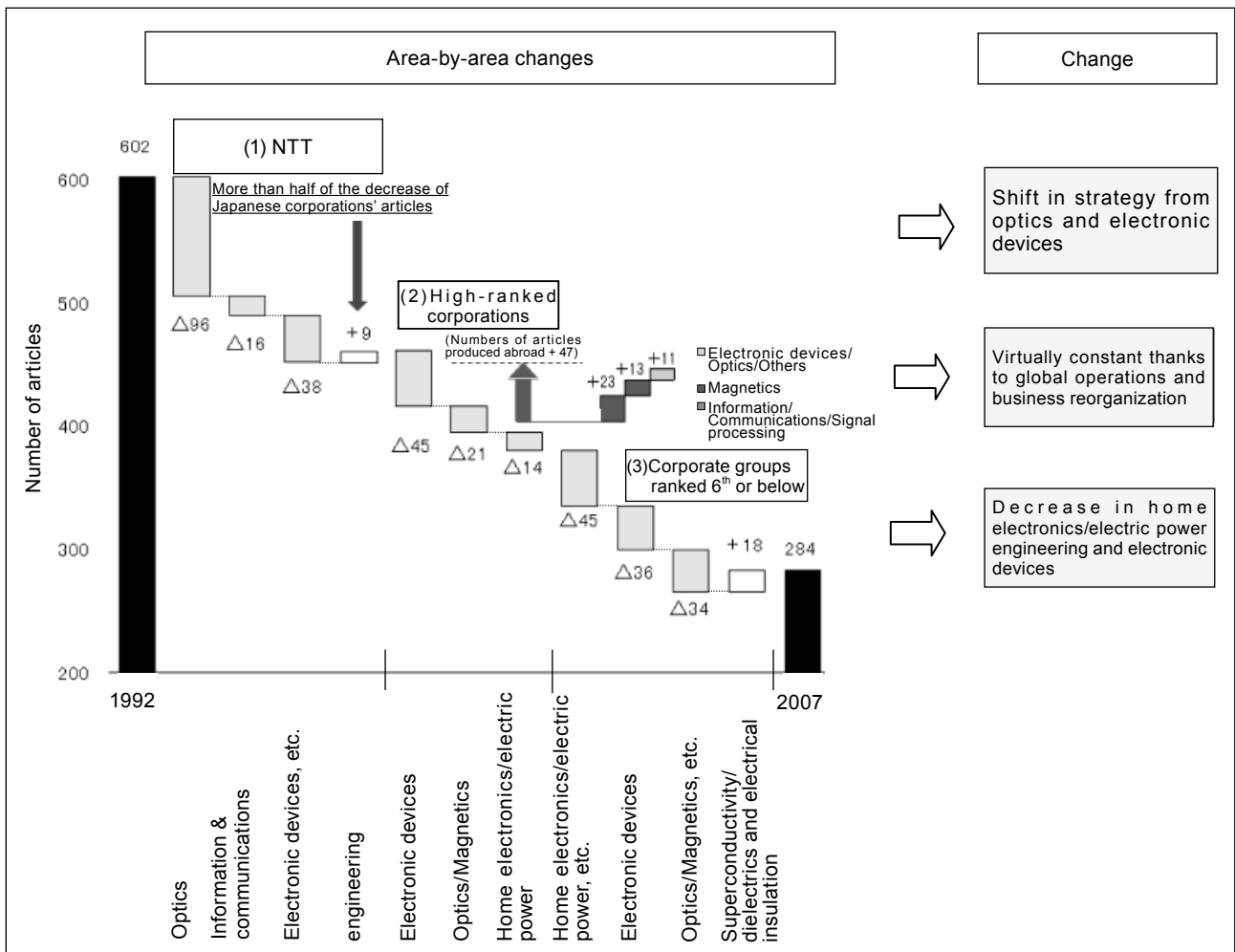


Figure 4: Area-by-Area Changes at Corporate Groups from 1992 to 2007

Prepared by the STFC

has decreased. On the other hand, in the areas where Japan makes a strong showing in the world, such as superconductivity and dielectrics and electrical insulation, the number of articles has slightly increased. This can be seen as a trend in the number of articles reflecting the restructuring of business operations by the corporations. At the same time, however, it suggests that the corporations may have shifted their focus from publishing R&D results to securing patents and other intellectual properties.

5 Changes at Universities

Figure 6 shows a list of universities that produced at least 5 articles a year and changes in the annual number of articles produced. The number of universities producing at least 5 articles a year has steadily increased, standing at 13 in 1992, 28 in 1997, 30 in 2002 and 34 in 2007. This suggests that the research has expanded with a very broad base.

Figure 7 shows changes in the proportions of area-

by-area articles at universities. In 1992, a majority of research papers related to electronics and information & communications produced by Japanese universities were dominated by three areas, magnetics, optics and electronic devices. The proportions of articles on electronic devices and information & communications remained stable from 1992 to 2007. On the other hand, articles in the areas of superconductivity, dielectrics and electrical insulation and robotics increased sharply. Articles on signal processing and remote sensing have also increased. The proportions of articles on magnetics- and optics-related research have decreased sharply. Although articles in other areas have been on an increasing trend, their shares of the total number of articles have decreased.

Figure 8 shows quantitative changes from 1992 to 2007 in the number of articles in distinguishing areas. It shows that articles in the areas of superconductivity, dielectrics and electrical insulation, and robotics increased sharply. These are areas where Japan makes a strong showing in the world. The growth

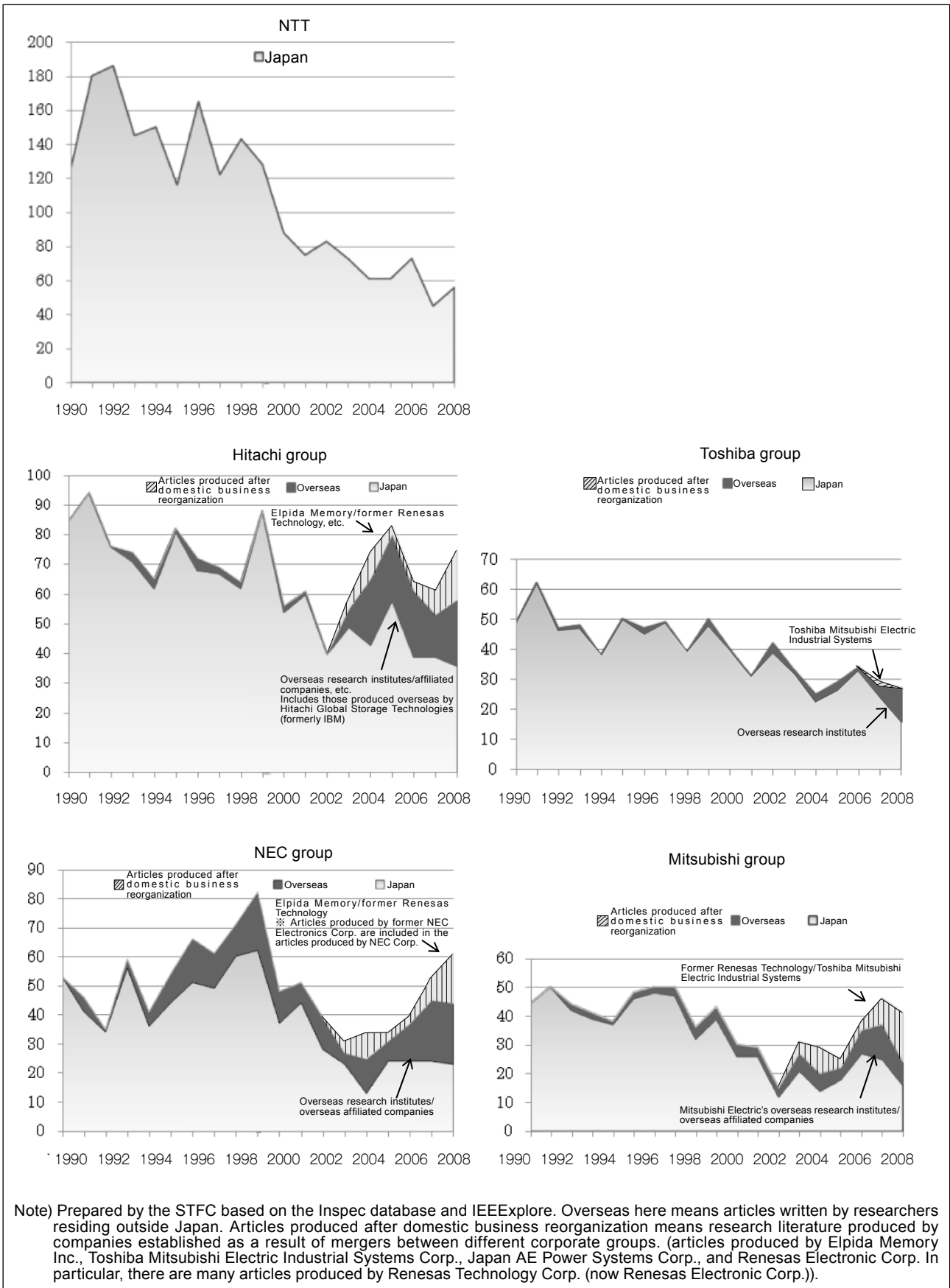


Figure 5: Changes in the Number of Articles by High-Ranked Corporate Groups (5 top-ranked corporate groups in the number of articles in 2007)

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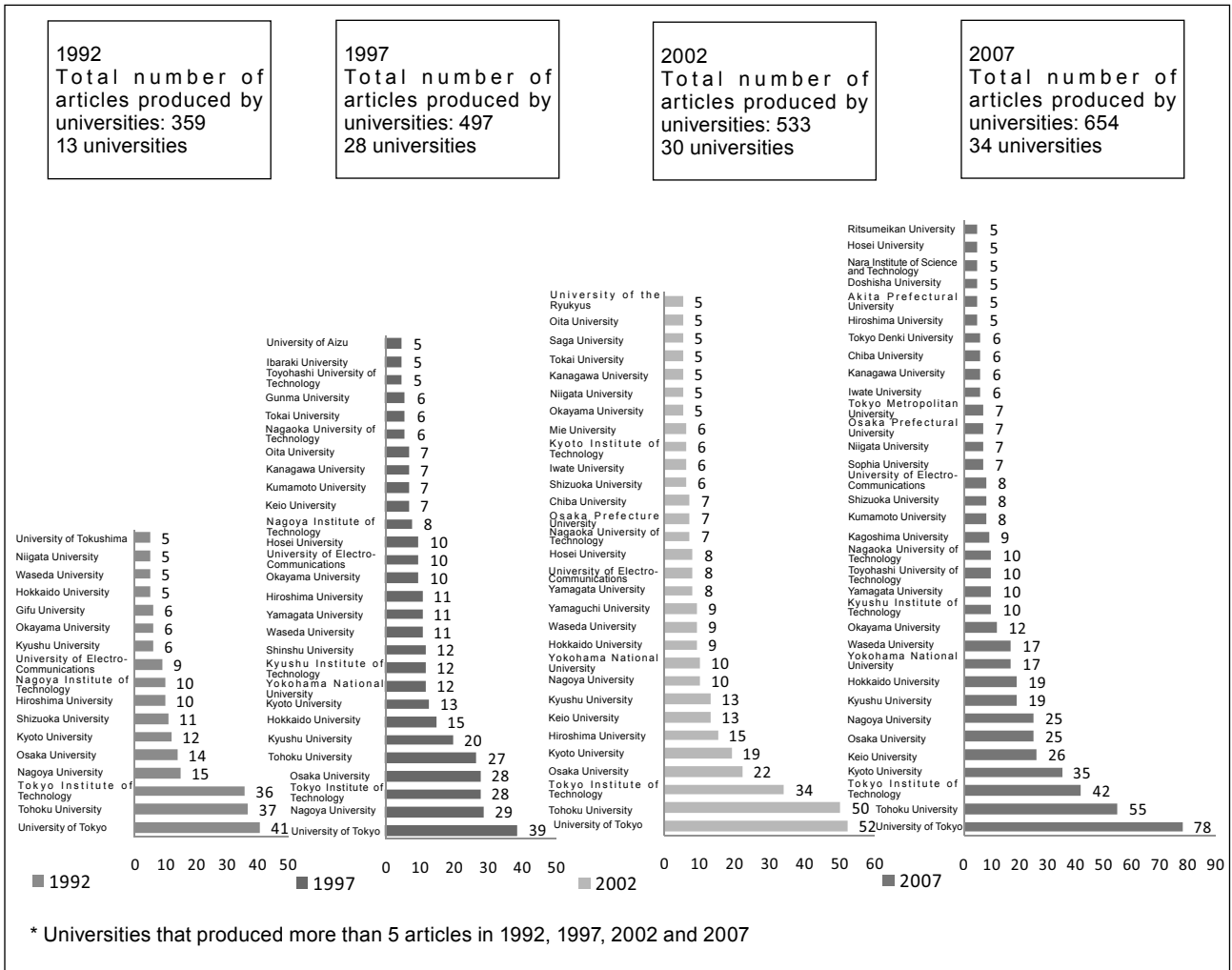


Figure 6: Changes in the Number of Articles Produced by Japanese Universities (Universities producing more than 5 articles a year)

Source: Reference^[6]

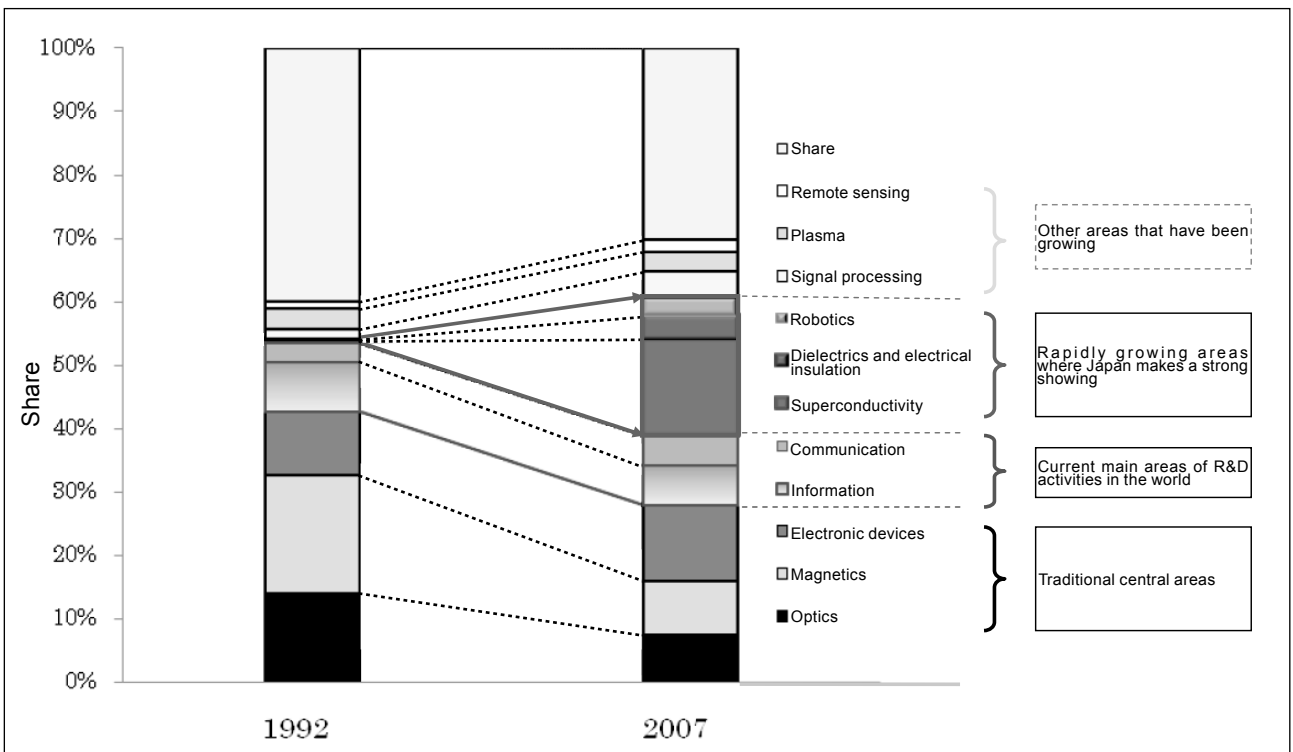


Figure 7: Composition of Area-by-Area Research Articles published by Universities

Prepared by the STFC based on Reference^[2]

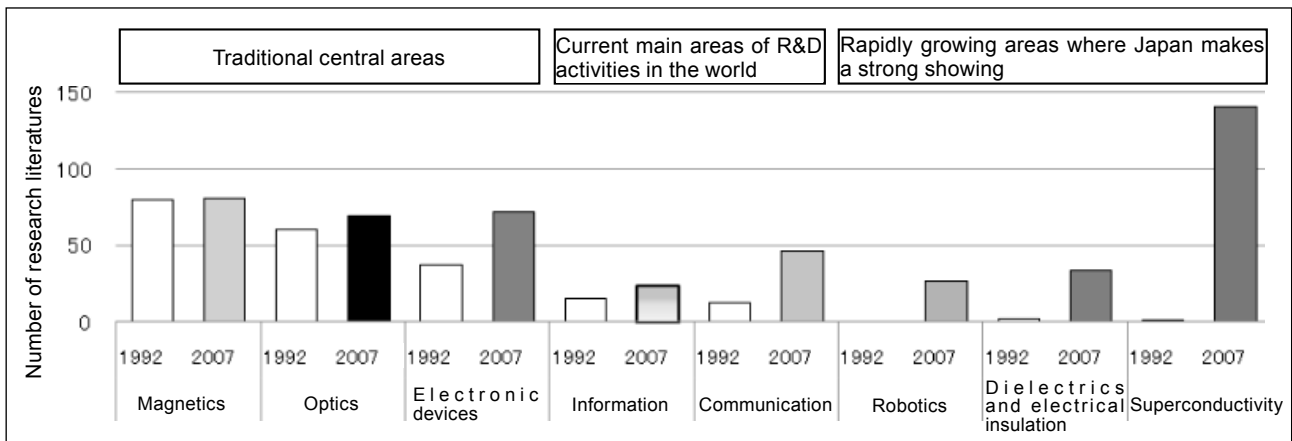


Figure 8: Changes in the Number of Area-by-Area Research Articles published by Universities

Prepared by the STFC based on Reference^[2]

in the number of articles produced by universities has directly led to Japan’s increased presence in the world in these fields. Articles in the information and communications related areas have also increased, but the growth is not particularly fast. The number of articles in the areas of magnetics and optics has remained almost at the same level.

Although the foundation of research on electronics and information & communications at universities has expanded on the whole, the number of articles in the field of information and communications, which is a global trend, is small and the articles are predominantly those on particular areas, such as superconductivity and dielectrics and electrical insulation. There are no data suggesting the diversification of research at universities as a whole.

Now that the main player in the production of research papers in Japan has shifted to the academic sector, we should think about whether the R&D activities at universities, which influence the direction of Japanese research and development as a whole, should remain as they are.

6 Opinions from Researchers

We have collected opinions and comments from researchers on the results of our analysis by conducting interviews with them and holding symposiums. Their opinions and comments are organized from the following five perspectives: (1) resource allocation, (2) target setting, (3) research diversity, (4) academia’s attitude, (5) science and technology human resources.

(1) Resource allocation

- With research budgets limited due to the slow

growth of the economy, it is no longer possible for Japan to promote research and development in all directions. Japan has no choice but to boldly narrow down R&D areas, rather than diversifying them.

- Due to a cut in operating subsidies to national universities, research at universities has become increasingly dependent on competitive funds. This has resulted in promoting the grading of universities, loss of diversification of research and homogenization of university research.
- Since budgets and the number of personnel at universities and other public research institutes are constrained, the allocation of resources to existing research fields and areas is fixed and a shift of resources to new research areas is constrained.

(2) Target setting

- Researchers constantly grapple with the problem of whether they should concentrate their research on areas closely related to industry or focus on fundamental research. In view of the rapid progress of technological innovation in recent years, it has become very difficult to set a proper target in the first place.
- Even if a target is set and focused investment and funding are made available under the initiative of the government, it does not necessarily mean the research and development activities in the targeted area become more active than in other countries. For instance, it is hard to say that the 2nd and 3rd Basic Plan for Science and Technology, which focused on research and development in the fields of information and communications, have brought about desired results.
- Japan is not good at developing computers. It is

important for Japan to devise measures to make innovation happen in the areas in which Japan is strong, such as superconductivity and robotics.

(3) Research diversity

- It comes as no surprise that universities have lost diversity in their research. If Japan simply continues research in the existing areas, it will be marginalized in global competition in the ever-growing science and technology field in terms of both quantity and quality.
- Since researchers in existing areas overly insist on the importance of their areas, what researchers in new areas say tends to go unheeded.
- We should give consideration to the fact that Japan is not participating in competition in the globally-growing areas of information and communications. We should discuss if it is enough for Japan to simply focus on the areas of its specialty and develop them.

(4) Academia’s attitude

- Researchers have become intimated and conservative, as pressure on their research performance has increased due to the incorporation of national universities and the introduction of competitive funds. They seem to specialize in the areas where they can easily produce results in the form of research papers.
- If the trend in the number of research articles has something to do with researchers’ thinking that they can get away with simply announcing their research results at a conference or similar, without publishing them in a journal, then it is a question of researchers’ fundamental attitude toward research.
- Although universities are allowed to conduct studies freely, engineering research should not be irrelevant to social needs and trends, as they are basically aimed at implementing scientific and technological research results in the society. It’s time for researchers to ask themselves how their electronics- and information & communication-related research should be and clarify their research direction.

(5) Science and technology human resources

- In order for Japan to lead a global trend in a specific area of research, there must be researchers who can be the leader in the area. If things remain as they are, there will be no Japanese researchers who can take the leadership in the area and Japan’s presence

may further decline.

- University researchers who came from private corporations are supposed to engage in research that meets social needs. However, it seems they have been continuing the same research in which they were engaged at their former corporations without regard to social trends and needs.
- If Japan continues to develop human resources by providing conventional engineering education that is removed from global trends, it may result in reproducing outdated human resources far removed from the technical needs of corporations and society.

7 | Conclusion

We have seen one aspect of the changes in Japanese research and development in the field of electronics and information & communications. However, it is unreasonable to draw a conclusion on Japanese research trends from the change in the number of articles in periodicals alone. Therefore, we intend to continue multifaceted analyses of the situations by expanding the scope of study to trends in major IEEE-related international academic conferences.

Still, we can roughly see changes in Japanese research and development from trends in the number of articles in IEEE periodicals alone.

Japan’s presence is small in the main research areas in the world, such as information and communications, and in the application and offshoot areas that have rapidly diversified and developed since 2000. It is clear that Japanese research activities have developed independently from the global trend. Furthermore, although the main player in the production of research papers in Japan has shifted from corporations to universities, the universities tend to specialize in specific areas, such as superconductivity. They show no signs of diversifying their research areas.

Meanwhile, corporations located in Japan are no longer the main producer of research papers, reflecting a shift in business strategy and an increase in global research activities. In order to make up for a small number of research articles in the field of information and communications produced in Japan, some major corporate groups have begun to increase research activities abroad. There are also concerns that if more Japanese corporations shift their R&D activities to other countries, it may result in “hollowing out of Japanese intelligence.”

It is necessary to promote discussions among the parties concerned in industry, academy and government on the relevance of the output of research activities to actual business conditions and consider the future direction of research activities in Japan as a whole.

Acknowledgement

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Profile



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Mr. Shirakawa has been in the current position since September 2008, after working as a staff of the Hiroshima Prefectural Government. His specialty is public management and evaluation.

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