Micromachines and Business Models

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Introduction

Thank you for the introduction. I am Fumio Kodama. Today I would like to focus my discussion on two topics: micromachines and business models. You are probably thinking that I am drawing a connection between two wholly unrelated terms. Well, I believe I have been associated with the Micromachine Center now more than five years, where experts in many fields are tackling various technical issues related to micromachines, and questions on demand forecasts, economic effects, and so forth have eventually found their way to me.

If you think back to five years ago, it was extremely difficult at that time to scientifically analyze potential markets for this type of technology. At first we tried to predict new markets, and by doing so came up with some sort of statistics, but the grounds for these numbers were somewhat dubious. We wondered if considering only new markets was enough. Then we wondered if we should consider the creation of new industries and begin to look at the relationships of these new industries, which became a popular buzzword at that time. While all this seemed to look good on paper, in fact it was extremely difficult to analyze.

While I realize that there are many types of micromachines, I believe that by considering them as basically element technologies we can look at their various uses, particularly new uses. Therefore, we considered the development of new uses, even though we did not know whether they would actually be used as such. Essentially it is necessary to link these uses with a system of use that can be established as a business. Or assuming this micromachine technology is of tremendous proportions, we must create a separate business model. However, the term business model sounded very small. We wanted a business model for establishing an industry. So ultimately we began creating peculiar terms, such as "industrial business model," resulting in the title of my presentation, "Micromachines and Business Models." This information is described in much more detail in our report, which is the result of experts in various fields joining forces to analyze each sector of the market. But rather than describing that here, I think you would understand it much quicker by reading the report.

Today I would like to talk about the background and process at which we arrived at the conclusion described earlier, through much trial and error, namely that it is necessary to create a business model. As one might expect, great changes in the direction of technological innovation occurred during this process. We see many changes particularly in technological innovation and the generation of industries, or the industrial structure. Alternatively, the creation of industries changes the industrial structure, causing the direction of technological innovation to change. I believe there is a strong interaction between innovation and the industrial structure. Today I would like to tell you about our research findings and views on this topic.

Micromachine Systems

The reasons why Japan could create a new industry and take control of its creation, and why Japan is regarded as the home of micromachines is due to the "mechatronics revolution" in the background. In fact, the word "mechatronics" was coined by a Japanese, which leads one to believe that Japan seized the initiative in this technological revolution. The essence of mechatronics and optoelectronics is the skillful combination of technologies thought to be of completely different types belonging to different fields for the purpose of exhibiting effects greater than the combination of its parts. In this sense, we created a new concept called "technology fusion," meaning the combining of different technologies.

Hence, technologies have advanced in this pattern. While industries had been progressing in a direction that emphasized total integration, the PC revolution brought about a state in which a manufacturer supplying a single element called a microprocessor unit, specifically Intel, has taken complete control of all industries. By looking at this situation, however, I believe a major change has occurred in technologies; in other words, a phenomenon called digital convergence has progressed. Digital convergence is a phenomenon peculiar to the PC industry. With the advance of modularization, module suppliers seized leadership in technological development, and final products are obtained by combining these modules. This is what has occurred in the PC industry.

While there are varied opinions on whether this phenomenon has occurred in the mechanical industry as well, indeed we can find the same phenomenon by looking at the automotive industry and the like. There are some differences in how the progression of this phenomenon is occurring in the automotive industry from how it is progressing in the PC industry, but modularization is also taking hold in mechanical systems. Accordingly, the term micromachine-based system was coined when considering the micromachine market to mean a new system based on micromachines. Much research has been conducted under the belief that it would be better to consider things under that system.

Hence, the idea is to predict the future. For example, if we tried to predict what will occur in the year 2010 and the year 2025, we know that while the current pattern may hold through 2010, it is almost impossible to predict what will happen in 2025 without considering a completely different type of usage pattern. Business models are used to consider new industries that use micromachines.

Technology Fusion

To begin with, "mechatronics revolution" is a term coined by a Japanese person in 1975. There was another significant movement occurring at this time. Despite a steady increase in Japan's competitiveness in the international market, doubts were raised at this time concerning what original contributions Japan had made. The U.S. administration in particular initiated several comparative studies to determine which country had the most technological innovativeness. The first study, called the Gellman Survey, evaluated the innovativeness of each country. The method of this survey was to list one hundred examples of radical breakthroughs in technology over the period from 1953 to 1973 and determine which countries brought about these breakthroughs. America was responsible for 65, Japan for a mere 2, and England for 25. Hence, although Japan's competitiveness in the market was strong, from the viewpoint of radical breakthroughs it was responsible for only 2 of 100, leading to the conclusion that Japan is merely a country that imitates.

With the purpose of conducting a slightly more objective survey, Francis Narin was commissioned to conduct a survey in which he stored all patents registered in America between 1975 and 1985 in a database. When checking the percentage of patents for each country, Japan's share had increased steadily during this period. Japan clearly demonstrated enormous strength in high-tech oriented patents. When looking at the quality of patents at this time, it was found that the U.S. carefully manages citations of patents. All citations were fully listed on the front page of each patent. By using this data, it was possible to determine how many patents cite a particular patent. If a patent is cited numerous times, that patent can be viewed as a basic technology. The chance of patents submitted by Americans being in the most cited patent group, for example the top ten percent, was completely random. It turns out that, rather than being completely random, patents published by Japanese had a higher probability, by 37 percent, of belonging to the most cited patent group. Hence, many patents filed by Japanese belonged to the patent group that is most frequently cited, thereby making them basic technologies. As a result, in only ten years, Japan jumped from the bottom rung in the Gellman Survey to the very top rung in the Narin Survey.

It is conceivable here that this came about due to a new technological concept. I think this is basically due to the mechatronics revolution. For example, Japan began in fourth place in the number of machine tools manufactured and jumped to an overwhelming first place in just ten years. As you are aware, such a large change in only ten years was brought about by the great progress made in the numerical control of machine tools. Hence, Japan made this great jump due to the advance of the mechatronics revolution.

Optoelectronics is a term for a similar technology, also formed by fusing different technologies. In 1986 Fortune magazine published a scoreboard indicating which countries were the strongest in various fields. As you can imagine, the U.S. was the top in most fields, but Japan was stronger in one: optoelectronics. Japan had 9.5 points to America's 7.8, a difference that cannot be ignored. While we found a major change over a ten-year period when evaluating the quality of patents earlier, behind this change there has emerged new technological concepts called mechatronics and optoelectronics that conceivably brought about this change. I propose that we combine these conceptions into the term "technology fusion." Technology fusion is not simply the combination of different technologies, but rather the addition of one technology to another to provide a solution greater than the sum of its parts. In other words, one plus one equals three. This I have cited from the Harvard Business Review, a magazine written for business managers, which emphasized in rather severe language that this is a new concept.

Modularization

Subsequently, considerable changes occurred. Around 1980, for example, the computer industry was composed of vertically integrated firms. Companies like IBM, TEC, Fujitsu, and NEC were competing with each other making their own chips, their own platforms, their own software, and their own applications, and selling them at their own distribution outlets. Hence, the industry had an extremely vertically integrated structure.

Around 1995, the industry shifted to a horizontal competition. Intel and Motorola were competing in the silicon industry; Sharp, NEC, and DTI in the matrix display field; and so on. Great changes in the industrial structure occurred when computer manufacturers began to obtain various components and combine them. In 1999 Newsweek magazine did a feature asking experts what they felt the major changes of the next century would be. I was also interviewed, at which time I commented that it is not easy to link things in the analog world, while things can be joined in every possible combination in the digital world, demonstrating results greater than the sum of their parts. Hence, digitization has come charging into the current age, I commented, and we will see a change from technology fusion to digital convergence.

In my laboratory, we attempted to measure how much modularization had developed. While there may be several methods for measuring this, ours was to search patent applications on a patent database called PATORIS for four different computer fields: CPUs, memory, discs, and I/O devices. We measured the percentage of patent applications filed to determine how much leadership the assemblers (not component suppliers) had seized in the technological development of each field. The assembler shares in each field had all dropped, indicating that modularization has progressed in the personal computer field, shifting control of technological development to the individual module providers. This shift reflects the change in industrial structure indicated above from a vertical to a horizontal structure.

Many in the mechanical industry felt that compromise between companies was necessary and that modularization would not be easy to implement. We attempted the same analysis on the automotive industry. We divided up control-related areas of the automotive industry into four fields, checked the patent filing percentage for each and measured the ratio of automotive assembly manufacturers, or so-called automobile manufacturers, therein. While the trends here were slightly complex, we divided the industry into four fields: engines, chassis, safety systems, and communication systems including navigation. Although the share of automotive assemblers rose in most fields up to around 1980, they all dropped in the 1990s. Hence, we must acknowledge that modularization had progressed. While all fields in personal computers dropped, there were some differences in the mechanical industries. Only one field, engines, rose in the automotive field. We can say that the proportion of automotive manufacturers in engine control increased, that is, their leadership strengthened - a trend different from the personal computer manufacturers.

In general terms, I believe that the promotion of modularization is electronification. Determining the share of production volume for electronic control units in the overall production of parts of each automotive field and determining how much weight each has in terms of monetary value is one index for indicating how much digitization and electronification has advanced in each field. Based on this index, we learned that digitization in the field of engine control has not advanced, or rather is in a declining trend. Since the ratio of patent applications supplied from automotive manufactures has risen slightly in the category of engines only, the strategy of automobile manufacturers is being watched. This strategy is reflected in the pattern of concentrating all efforts in developing engines and outsourcing parts in other fields as much as possible. As a result, modularization in the automotive industry is advancing.

Generally speaking, modularization is also advancing in mechanical industries. Hence, if micromachines are provided in modules, it is sufficient to simply consider the design of the overall system. So what type of strategy do we use? Two scholars that popularized the term "core competence" say this strategy comes in the form of first acquiring the necessary technologies, integrating these technologies, and then competing for the core intermediate product. Ultimately the intention is to maximize shares in the final end product. An example of this strategy was adopted by Canon, and maybe some of the people related to this project are here today. Canon even sells laser printer engines to its competitors, including Apple. Ultimately they sold their core product to competitors in order to obtain a larger market share in the field. "Virtual market share" is a term being used today. This is a competitive strategy for controlling the entire market by seizing the initiative in module development, as modularization increases.

Creating a Business Model

So what strategies will be used for micromachine technology? Micromachines should be thought of as core components of systems rather than core products. Therefore, I think that the problem lies not in the end product, but in how systems can skillfully use inventive micromachines, in other words, how micromachines can be used in a virtual system. Hence, we considered micromachine-based systems or systems of use that are only possible with micromachines. Actually, two years ago I spoke at this very symposium on "Micromachines and the Market," and today I am talking to you about "Micromachines and Business Models," so I have progressed a little. This table lists the ideas that we came up with at our research conference (see Table 1). Experts in various fields came up with the details, so I believe the table is reliable. We considered, for example, data storage systems, printing systems, optical communication systems, wearable systems, and micro-inspection systems. Regarding printing systems, we

Industries	Micromachine-based systems
Information Technology	Data-storage system Printing system
IT Infrastructure	Optical communication system
Precision Instrument	Wearable system
Measurement Instrument	Micro inspection system
Micro Factory	Micro factory system
Maintenance	Maintenance system
Medical and Health	Medical Endoscope and catheter system Personal health support system
Bio Technology	Genetic and DNA analysis system
Environment	Environmental inspection system
Automotive applications	Automotive related system
Life and Household	Electric household appliances system

Table 1 Micromachine-based Systems

viewed the development of new printers as an opportunity. We could come up with various wearable systems, but here we will take up cellular telephones. Therefore, we selected printers and cellular phones and then quantitatively analyzed what form of market had been created, what industries had been created, their differences, whether they were a new type of usage, or what part they played in the creation of a business model.

Specifically, while the facsimile machine was a substitute for conventional communication means, a liquid crystal display (LCD) expanded the number of applications. As you know, the PC of today began from a computer and later a word processor, and then was developed with a new use as an Internet terminal. Clearly, we can say that a business model had been developed. I would like to study each of these technologies in more detail. As you know, a logistic model is used to determine how large a new market has grown. Over time, the size of the market (production volume) approaches an upper limit, that is, an ultimate potential demand. This is a substitute market, wherein a new product is used as a substitute for an existing conventional function.

We can also consider the occurrence of an extremely major technological invention that greatly expands the scope of users. Since the logistics of this scenario take place in two stages, its model is called a two-stage logistic model. As the market size of the product nears an upper limit during a certain time period, a major technological innovation occurs, causing the market size to leap suddenly. The printer is one example that comes to mind immediately. Inkjet, bubble jet, or laser printers and particular inkjet are a good example of a product designed for office use that suddenly became useful in the home, and moreover could print photos or other pictures. Instead of just printing conventional text, it is now conceivable to print pictures.

Next is an example of the upper limit itself growing according to a logistic function. This is called a double logistic model. In short, new usages are being created constantly, increasing the production volume more and more. The cellular telephone fits this description, in which new business models were created continuously.

We talked about analyzing each one individually. The facsimile is a simple logistic model in which the production number approaches a fixed value. Printers follow more of a two-stage logistic curve. As you know, printers were used to print characters and were limited to use in the office. However, laser and inkjet printers came out around the mid-80s. At the same time, printing precision improved and the ability to print in color was also added, clearly causing production to jump a step.

If we assert that micromachine-based systems will create new business models, I think they must continually create new business models. A very recent example that follows the double logistic curve can be seen if we look at the actual production data for cellular telephones. In other words, the upper limit is increasing constantly and the market size is continually expanding. In a sense, I suppose business models are also constantly being created.

Conclusion

At the research conference, we studied various micromachine-based systems, such as printers using micromachines. We considered a business model of on-demand printer systems that can be used in the home and print when the user requests it (see Fig. 1). Next, we considered a business model for order made printer systems in 2025, wherein users can custom order printers with a desired design and shape and the capability of printing on anything, not just paper. The members at the research conference considered what systems would be necessary to achieve this and what technologies must be developed. When considering future technological development, the members concluded that it would be beneficial to promote the development of micromachine technology in particular, which is capable of changing the world. Such being the case, if you can imagine an industrial business model, such as that shown in Fig. 2, extract the technological issues from this model and attempt to resolve them, I believe that there is potential and validity in taking that future direction. Thank you all for your attention today.

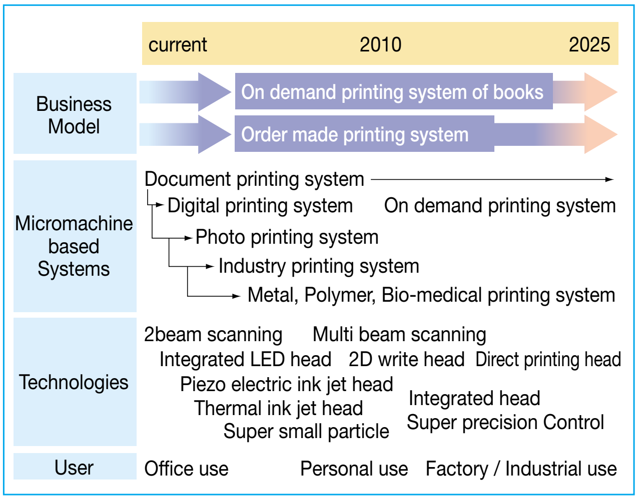

Fig.1 Micromachine Technologies for Printer Systems

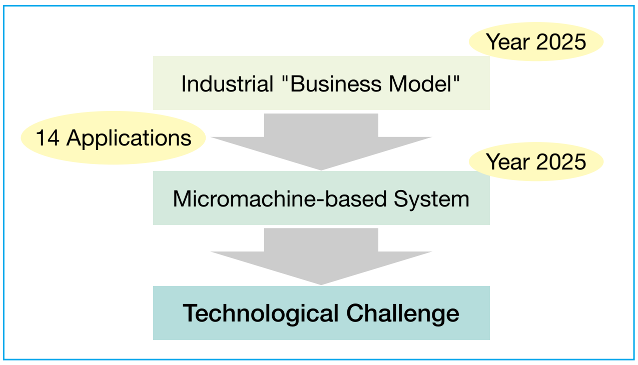

Fig.2 What is technological innovation in future?