

## R&D Competition and Innovation in the VCR Industry

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### ABSTRACT

This paper examines a significant example of accumulation of technology in post war Japan - the development process of the videocassette recorder (VCR) for home use, and the dynamic evolution process of the mass market. The purpose of analyzing the Japanese home VCR industry is to clarify how and why only the Japanese makers had succeeded in developing home VCR and dominated the global mass market and to make clear the dynamic process of industrial evolution. This study found out the following facts; 1) Japanese inter-firm interactions in the VCR have been carried out by the structure of "the competition and cooperation among the engaged players" from the initial stage, to growing, and maturing stage. 2) The process of competition and cooperation produced the revolutionary innovation through a continuous systematic development process in the R&D phase. 3) The process of competition and cooperation accelerated the speed of technological progress and the rapid growth of the industry in the growing and maturing stage.

## R&D Competition and Innovation in the VCR Industry

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### 1. Introduction

This paper examines a significant example of accumulation of technology in postwar Japan - the development process of the videocassette recorder (VCR) for home use, and the dynamic evolution process of the mass market. The purpose of the analysis of the Japanese home VCR industry is two fold. The first purpose of analyzing the Japanese home VCR industry is to clarify how and why only the Japanese makers had succeeded in developing home VCR and dominated the global mass market. The second purpose of analyzing the Japanese home VCR industry is to clarify the dynamic process of industrial evolution.

#### 1.1. Home VCR in Japan

The first purpose of analyzing the Japanese home VCR industry is to clarify how and why only the Japanese makers had succeeded in developing home VCR in the world and dominated the global mass market. Home VCR is the Japanese innovation of the 1970s: the Betamax introduced in 1975 by Sony Corporation, and the VHS (Video Home System)<sup>(1)</sup> introduced in 1976 by Vitor Company of Japan (Japan Victor, JVC). These innovations of home VCR were originated from broadingcast videotape recorder(VTR). Of course videorecording, like the transistor and color television, was an American innovation. VTR was first developed and commercialized for broadcasting in America and Europe in the 1950s. Japanese electronic makers, however, put lots of efforts in R&D and finally developed home VCR in the mid 1970s.

It is said that the development process of the home VCR is a typical pattern of Japanese technological development - equivalent to that of the semiconductor or automobile industry as for following reasons.

First, in the R&D phases, the Japanese makers had developed the home VCR evolutionary by a trial and error process of systematic innovation<sup>(2)</sup>. Also the home VCR had flourished on the basis of Japanese technological accumulations of consumer electronics such as color television and audio tape recorder<sup>(3)</sup>. Accordingly, both product and process technology of home VCR were developed nowhere else than in Japan. From the revolutionary innovation of home VCR in the mid 1970s, Japan had wielded the power as leader in the home VCR market from the very early stage of the industry's evolution.

Second, in the mass production phase, almost every Japanese consumer electronics maker entered the home VCR market and each firm had tried to solve a diverse set of technological challenges for a low-cost mass production and mass market. Especially, because two innovations, Beta and VHS, which were introduced by Sony and JVC respectively, were incompatible formats, the battles for industrial standardization were deployed in the market. Competition of standardization, however, was proceeded not only by Sony and Japan Victor but also by all member companies of each group. This competition of Japanese makers accelerated the technological development of the VCR as well as the rapid growth of the market<sup>(4)</sup>.

[ insert table 1 ]

As a result, Japanese makers monopolize the global home VCR market from the early stage of the industrial evolution to the

mature phase. As shown in Table 1, the production value of home VCRs in Japan had jumped from \$84 million in 1975 to \$7.9 billion in 1985, and held 73% and 86% of the world production respectively. Japanese exports also rose to \$6.6 billion in 1985 and marked 82% of world exports. These exports corresponded to 75% of the domestic production. In short, Japanese makers monopolized the global VCR market and Japan has been the center of supply for world demand as can be seen in the high rate of export ratio.

#### 1.2. Dynamics of Industrial Evolution

The second purpose of analyzing the Japanese home VCR industry is to clarify the dynamic process of industrial evolution. Traditionally, it has been considered that the market structure is determined externally by the initial conditions of that industry like technology, demand or factor condition. Looking at the present situation, however, the dynamic process of competition which is based on innovation and strategic behaviors among the participating firms, unlike the past theories of monopoly and oligopoly, has evolved in many industries<sup>(5)</sup>.

When we discuss the formation and evolution of market structure in that respect, the pattern of inter-firm interaction like the exchanging process of knowledge or information among firms is the key factor for the formation of market structure in the R&D phase as well as in the mass production stage. This is because the difference in the exchanging process of knowledge would produce a different market structure, market performance and technological development. Lots of examples are observed that the difference in the exchanging process of knowledge or information, and differences in corporate strategy, governmental policy, etc., at the stage of

R&D, have influence on the industry's market structure and market outcome throughout the developing stages of the industry.

I would like to analyze the patterns of inter-firm interaction by making use of the framework named 'competition and cooperation' for grasping the dynamics of industrial evolution.

### 1.3. Competition and Cooperation

There are two patterns of extreme inter-firm interaction; competition and cooperation process.

The competition process stands for that through the competition of performance of new products or prototypes in the market, the most superior product among them survives, and other firms acquire a new technological knowledge or information from the surviving products in the market. This process is represented typically in industrial evolution of America. In the competition process, only the firms which can assimilate the embodied technology of the product that has survived in the market as well as develop and shape its own technological base from the acquired technology in the market will remain in the market; otherwise the firm in the competition process will be forced out of the market, that is a natural selection process. The market structure which is formed by the competition process mentioned above, is an unstable oligopolistic structure characterized as many Schumpeterian companies<sup>(6)</sup> enter and exit the market.

On the other hand, cooperation process means that through the institutions or places of interaction which is formed intentionally by the government or companies in the same line of business, every company who participate in that institution exchanges the common-based technological knowledge which was acquired from its own R&D

activities. The typical case of the cooperation process might be like this; at first, the government selects the research agenda and subsidizes the R&D outlays, and then all the firms who are related to the selected research agenda participate in the joint research, next they launch a new business form the same start-line with the outcome of this joint-research.

The cooperation process, however, doesn't continue consistently throughout all the R&D phase, or from the R&D stage to the growing, and maturing stage. In reality, inter-firm interaction like the acquisition and diffusion of technological knowledge, usually occurs by the competition process under some context, and by the cooperation process in the other context, that is, by the combination of competition and cooperation process. In the case of Japan, various institutions of inter-firm interaction like kondankai (study group), council, committee, and research association had been established and dissolved under the social-economic context, which shows the combination of the competition process and the cooperation process. Many companies, sometimes including potential entrants, that participate in those inter-firm interaction institutions exchange their knowledge or information with each other, which offers not only the basis for creating new knowledge, but also provides the chance for participants to attend the next stage of the competition process. For example, VTR Kondankai (study group) and VTR Research Committee in the consumer electronics industry, LD Council in the steel industry, VLSI Research Association in the semiconductor industry which had been established and dissolved in the initial stage of industrial evolution, might be typical cases.

Comparing the market structure, which is formed by the

combination of cooperation and competition process, with the structure that is formed only by the competition process, the fact is that the same unstable oligopolistic structure has been formed by each process. The difference is that in the case of the former process, only if the Schumpeterian companies once entered the market, they few exit the market. In the case of cooperation the process, whether the new prototype of a product which was developed under the basis of the past accumulated knowledge win or lose in the market, has little meanings, because regardless of winning-or-losing they have the chance to participate in the next market process. As a result, almost every company enters the market easily and only a few exits the market. In short, the market structure which is formed by the cooperation process is an unstable oligopolistic structure characterized as lots of Schumpeterian companies enter into and a few exit from the market.

The merits of the cooperation process for technological development is as follows; The cooperation process can raise the possibility of innovation occurrences, because it diffuses the technological knowledge to all the companies, whether they have the capabilities to assimilate and to improve the technology or not. That is, it's process provide firms with the incremental and continuous basis of technological development. On the other hand, the cooperation process, however, has the following demerits; to protect the technological appropriability as well as to exclude the free-rider dilemma is extremely difficult, because of the sharing of knowledge among firms. The more difficult problem, however, is that if all the participating members will proceed toward a false direction, there is no adjustment mechanism.

#### 1.4. Technological Development and Industrial Evolution

Until now, I pointed out two separate purposes. First is how did the "imitative" Japanese seize the innovative leadership in the large, important and lucrative industry of the home VCR? Second is how to grasp industrial evolution and on what process Japanese home VCR industry had evolved?

Now, I ask another question combining these two separate purposes. What relation is there between technological development and industrial evolution? To answer this question we have to take a careful look at the history of VCR innovation (section 2) and further we have to examine how a handful of Japanese makers interact with each other in the growing and maturing stage, and began to dominate the major world market (section 3), and then grasp the dynamic evolution of the VCR industry (section 4).

## 2. Research and Development Process of VCR<sup>(7)</sup>

### 2.1. The Birth of VTR for Broadcasting

The idea of videorecording was generated immediately by the invention of television and audio tape recorder. A major innovation, the introduction of television after the Second World War, created a need for a way to make videorecording that would offer high fidelity on playback and ease of use that radio broadcaster had attained with magnetic tape recorders. Firms already in the broadcast equipment business had attempted to invent a device suitable for this well-defined application.

In the early 1950s, before anyone had solved the problem of



inventing a practical videotape recorder(VTR), fertile technical work was underway in the laboratories of Radio Corporation of America (RCA), Bing Crosby Enterprise in the United States and in British Broadcasting Corporation(BBC) in the U.K. After continuing the studies on the principles of videorecording technology and subsequent manufacturing of prototype applications, they finally developed and released the videorecording applications. Those applications, however, fell short of commercial success because they had so many technological problems such as too short available recording time and excessive visual scars during the playback.

The model of 'VR-1000' for broadcasting was developed by Ampex Corporation in the United States in 1956, and nicely cleared all of the technological shortcomings mentioned above. This VR-1000 became the dominant design of VTR for broadcasting. Since then almost all competitive American makers like RCA stopped their R&D activities for video recording and immediately exited from the VTR market because Ampex machine was so predominant at that time. After that, Ampex machine monopolized the VTR for broadcasting in the world market.

## 2.2. Improvement process of Ampex's VTR

Japan started to import the VTR model of VR-1000 for broadcasting in 1958, two years after the commercial introduction by Ampex. Even though the importing price of the Ampex VTR was 25 million yen, the Japanese VTR market for broadcasting had a flood of imports because of the boom of opening new TV broadcasting stations. The Japanese central government, or to be more precise the Ministry of International Trade and Industry (MITI), came to make a serious consideration about this trend of excessive demand.

For the development of domestic versions of Ampex's VTR and eventually import substitution, MITI encouraged the Japanese electronic makers to research and develop the VTR by subsidizing R&D expenses. Along with the Japanese government's policy, VTR Kondankai (study group) was established in July 1958 by those who came from such broadcasting companies as Japan National Broadcasting Corporation (NHK), Radio Tokyo, and from electronics companies like Sony, Matsushita, Shiba Electric, Toshiba, Shinnihon Electric. The participants in the VTR Kondankai actively exchanged the technological information of the Ampex type VTR.

By and by the centers of the VTR development shifted from America and Europe to Japan, and Japanese makers concentrated on their efforts to compete in the development of VTR. At first, Japanese makers completely copied the Ampex machine by reverse engineering, but entering the 1960s, they started to put more efforts on the adaptation of the Ampex machine, by carrying out research on coloring and making it more compact by using transistors, experiencing lots of mistakes and failures.

As a result of these R&D activities, an open reel type compact VTR named 'CV-2000' was developed and began to show up in the market by Sony. Subsequently, Shiba Electric, Japan Victor, Matsushita, also developed and sold compact VTRs of that kind at the price around 200 thousand yen. This kind of compact VTRs, however, couldn't reach ordinary households. They were mainly bought by schools and firms. Moreover because of the lack in compatibility with tapes, the sales didn't reach the expected amount.

In 1967 eleven makers of VTR organized a meeting called 'Committee for VTR Research', and succeeded in reaching a uniform

standard named 'Standard I' after a two year reviewing process. What I want to focus on in this process of reaching a standard is the activities of a sub-committee named 'Committee for Technology Research'. Composed of staff members of each participating firm who were in charge of R&D and its implementation, the committee accomplished a standardization of VTR tapes through the following process; (1)opening his own technological contents, (2)sharing and comparing of each member firm's technologies, (3)discussing and selecting the best technologies for standardization. For this reason, the new technologies were well diffused to every member firm, which played a significant role to make a firm a technological base for revolutionary innovation. After this arrangement, following the eleven member firms, new entrants like Sanyo, General, Ikenoue Communication Appliances began to launch their own 'Standard I' type VTRs into the market.

### 2.3. Competition between Alternative Technologies

Even after the agreement to make a uniform standard, several problems such as picture quality, coloring, inconveniences caused by the use of open reel, too high price, etc, still remained in order to be fully accepted by home users. These problems caused suspicion towards the method of magnetic recording itself. In other words, a search was made for a technology to render possible an image playback by television terminals without relying on magnetic recording, and even a technology to make possible the packaging of the tapes as well as coloring, at a lower cost than using magnetic recording technology.

Finally in the course of the searching process, several new technologies had been born. They were; EVR(Electronic Video

Recording which applied a optical recording method) developed by CBS, U.S., in 1967; SV(Selecta Vision which applied a printing technology) by RCA, U.S., in 1969; EBR(Electron Beam Recording, an application of optical recording) by Nippon Electronics in 1971; and CVR(Cine Video Recording, an application of the cinema technology) by Fuji Film of Japan in 1971, all playback only machines.

On the other hand, targeting the home demand, color VTR of various types by packaging the tapes such as the cartridge type, the magazine type and the cassette type, had been developed and introduced to the market one after another by mainly Sony, Matsushita, and Japan Victor. Among these types that appeared during this period, special attention has to be paid to 'U-Matic' standard. 'U-Matic' standard was announced in 1971 as a request from the first developer Sony that asked for a standardization. Matsushita and Japan Victor had joined this and finally developed the U-Matic standard as a result of the joint research with Sony.

Though this type of VTR was a failure because of the fragility of the technology as well as market, it is considered a meaningful achievement in that those developers could have moved forward stepping on the failure. It was a valuable touchstone. As for Matsushita and Japan Victor, they were able to keep up to the best technology at that time through the joint R&D with Sony. Moreover they could make free use of Sony's patent at the next stage of R&D because they were on cross-licencing patent contract with Sony. Conversely Sony's gaining in terms of technology transfer was also considerable at the next stage of R&D. For one thing, while a low range transformation technology applied in the coloring of U-Matic type was the newest technology owned by Victor, Sony took advantage

of this technology in its development of the Beta system.

#### 2.4. The Choice of Magnetic Videorecording Technology

Throughout competition between alternative technologies like VCR, CVR, EVR, SV and EBR, VCR using the magnetic videorecording technology became accepted as a home use machine. Furthermore, home video appliance using the magnetic videorecording technology had transformed from open reel type to cassette type, that is from videotape recorder (VTR) to videocassette recorder (VCR). The reasons why magnetic videorecording technology was selected for home video appliance were the fact that Japanese consumers regarded as of great importance to the recording function, and the result of continuous trial and error development process of magnetic videorecording technology.

As of 1972 the spread rate of TV sets at home first surpassed 50% with the striking rate of 61.1%. As TV programs became diverse and interesting, more and more people wanted to record what they wished to keep as personal visual information, or wanted to enjoy their favorite programs later when it would be more convenient to them. Therefore the recording function was regarded as very useful and necessary. Among the competitive technologies, VCR using the magnetic videorecording technology was the only machine which had the recording function.

In 1972, among the fourteen players in video appliances industry ten makers--Sony, Matsushita, Japan Victor, Sanyo, Toshiba, Shiba Electrics, General, Nippon Columbia, Akai Electrics, and Ikenoue Communication Appliances-- were engaged in VCR. On the other hand, four firms--Hitachi, Mitsubishi, Toshiba(plan only), and Matsushita(plan only)-- were involved in EVR, while only one in

EBR (Nippon Electronics) and in CVR (Fuji Film). In other words, most of the Japanese makers continued their trial and error process of R&D only in VCR using the magnetic videorecording technology, not paying attention to other possible substitutes.

From 1974 VCR systems using a half inch tapes began to be introduced to the market one after another by Toshiba and Sanyo(V-Code I, V-Code II), Matsushita (VX2000), Sony (Beta), and Japan Victor (VHS). Among these, the V Code by Toshiba and Sanyo, and the VX2000 by Matsushita were excluded from the market because of shortcomings like a too high price and problems in picture quality (V-Code), and inconvenience in usage (VX2000). Eventually Beta by Sony and VHS by Japan Victor, the two major types came to constitute the basic design<sup>(8)</sup> of home VCR.

#### 2.5. The Development Process of Home VCR

The basic design of home VCR had been derived from the technological structure of the broadcasting VTR, and emerged to be light and compact, inexpensive and of high quality. This was made possible not only by the technological progress of magnetic videorecording technology itself, such as the helical scanning technology, but also progress in peripheral technology such as IC technology, magnetic tape technology, audio technology, TV technology, etc. To make it short, the technology of the broadcasting VTR was transferred, and applied by Japanese makers that already had audio and color TV technology. This led to the superior home VCR technology. This excellent result of R&D is attributable to productive corporate-level interactions of the all participating firms in the industry throughout the process of R&D stages.

[ insert table 2 ]

Table 2 is the summary of R&D process of Japanese home VCR industry from the viewpoint of corporate interactions. As shown by this table, it is clear that the patterns of interaction by Japanese makers at the industry level, are expressed by the repetition of cooperation and competition among the players. In addition, most of new entries were made in the course of the cooperation process and participated in the next competition. Even if a firm lost at the competition of new product development, it still could participate in the next competition making the best of the cooperation process. This would be the reason why no exit from the market had taken place. Eventually, every player is well informed of what's happening in the industry, basic knowledge, any new information, and technological development. Combined with the potential knowledge base available inside a corporation, this trial and error R&D process increased the possibility of innovation. Ultimately this was the basic source of the revolutionary innovations and made possible the launching of lots of new product with a variety of features like Beta, VHS and so on.

### 3. Dynamics of the Mass Market: Competition between Beta and VHS

#### 3.1. Networking Strategy: Battle for Industrial Standards

In the Japanese Manufacturers' competitive development of cassette-type VCR for home-use, such models as 'VX-2000' and 'VX-100' by Matsushita, 'V-Code I' and 'V-Code II' by Sanyo and by Toshiba were excluded through competition, while 'Beta' by Sony

and 'VHS' by Japan Vitor Corporation (JVC) had survived. At that moment, no one was sure which type would be the industrial standard with major share of the market aside from the technological aspect. Let me analyze the process of making the industry's standard and the formation of a new industrial structure on the basis of the basic designs of Beta and VHS type VCR system from the angle of inter-firm interactions of the involved firms.

Beta system, first introduced in 1975 by Sony Corporation, and VHS, introduced in 1976 by Japan Victor, were not compatible at all. Therefore VCR market consisted of two groups of makers being led by the two technological leaders, Sony and Japan Victor. Recognizing the technological opportunity and taking the concept of full lined commodities into account, those makers who had failed in launching their own models and potential entrants, namely followers, had to decide which type they should take, that is Beta or VHS. That was a networking process. Networking between the technological leaders and their followers had been carried out under the guidance of the technological leaders on account of the 'network externalities'<sup>(9)</sup> based on compatibility.

The leaders who had successfully developed their own exclusive type of VCR systems were supposed to make as much effort as possible in order to make their own types industrial standard. They were all committed to so called, 'family making'. If any side succeeded in making the majority group, more abundant supply of the software for the major type would be expected, which again might lead to a growing demand for the major type VCRs. Eventually the maker succeeded in hitting the market with the major type of VCR system, would possibly maximize his profit through the supply of the exclusive type of VCR system. For this reason Sony and Victor



entered competition with each other for making each family bigger than the other's, and eventually for making their own model the industrial standard. In the course of the rivalry, the strategies each competitor had taken were in big contrast.

The strategy taken by Sony throughout the competition of family making was 'keeping the stubborn stance without compromise'. Before its announcement of Beta system, Sony suggested the uniformity of the industrial standard to Matsushita and Japan Victor. The problem here was that the uniformity was to be based on Sony's Beta system. To this suggestion both Matsushita and Japan Victor showed little interest, because they considered themselves as already having accumulated enough technology not to be dependent upon Sony. Their own R&D efforts in the development of VCR had lasted more than 20 years until that time. In addition, Matsushita and Victor felt that it is hard for Sony to make another technological innovation because Sony was already too much involved in its Beta system. The fundamental VCR technology was said to already got matured at that time. These assessments made Matsushita and Victor realized that Sony's technological leadership was not considerable one. They believed that the small technological gap could be gotten over through their coming effort in terms of process innovation and synergy effect within their own technological groups. Another point to be mentioned is, when they reached making a uniform standard of U-Matic VCR, all three companies, Sony, Matsushita, and Victor, made a cross licensing contract on the basic patents of VCR. Therefore Matsushita and Victor were able to make free use of Sony's patents. For these reasons Sony's stubborn policy didn't work. To make matters worse, Sony didn't take any active measures on family making. For

example, nevertheless strengthening the original equipment manufacturing (OEM) policy is an effective measure for family making, Sony had consistently sold the products under its own brand.

On the other hand, Japan Victor's policy in family making took a different feature. Japan Victor were ready to accept other makers' technological alternatives at any time through cooperative R&D. Japan Victor's strategy was a very generous and flexible one including OEM production system. OEM policy offered by Japan Victor was very favorable bargaining condition for the other following makers, because OEM policy of Japan Victor was expected to provide the other followers with the product technology. As for followers, beside of the expected benefits of achieving full lined commodity strategy and receiving detailed market information, they could find a room for developing their own production system through the OEM production experience. Actually the participation of Mitsubishi, Sharp, Hitachi in the VHS system started with OEM production. Consequently in 1977, the market was divided by two groups: Beta group of Sony, Toshiba, and Sanyo, and VHS group of Japan Victor, Matsushita, Hitachi and Mitsubishi, and Sharp.

### 3.2. The Impact of Market Process on Technological Progress

This competition of family making and industry standard making was proceeded not only by Sony and Japan Victor, but also by all member companies of each group. Member companies of each group were in good harmony sharing the main parts as holding research meetings for technological enhancement. The principle of cooperation worked so well that any technological improvement was spread over to the other members in the same group instantly. In order to win the

competition, least differentiation of products was carried out within a family group. In other words, based on the cooperation and harmonious power of the member companies, the two groups were involved in fierce competition in all aspects like price competition, world market penetration, providing additional functions, investment on facilities, etc.

The competitive movement of all makers in the two groups accelerated the technological development of VCR Industry as well as the quantitative growth of the market. In the head to head competition of family making and initiative taking, all of the Japanese makers paved their ways for mass production by making quick decisions of which type to follow. This quick structuring of the industry made it possible for Japanese makers to monopolize the world market of VCR production. Competitive launching of each system, Beta or VHS, by each group member company, was witnessed all over the world. In consequence the world's makers of electric goods came to belong to one of the system groups, Beta or VHS which was offered by the Japanese industrial leaders in a very short period of time. While this competitive structure of the industry facilitated the rapid growth of the industry, sooner or later it also led to decline of prices. For example, as a result of a regression analysis by linear algebra equation based on the data(1970-1987) derived from the accumulative amount of production(X) and production cost(Y)<sup>(10)</sup>, an experience curve as follows was found;

$$\ln Y = 15.776 - 0.260 \ln X \quad \bar{R}^2 = 0.948$$

$$(-16.997) \quad DW = 0.359$$

The 'experience rate' (the slope of experience curve) which was computed from the coefficient of the variable of accumulative

amount of production, became 83.6% ( $2^{-0.260}$ ). So the production cost decreased at 16.4% when the accumulative amount of production doubled. In case of VCR, because it took only a short period of time for accumulative amount of production to double, it was possible to cut prices from the very first phase of mass production.

Considering the fact that the industrial standard was eventually narrowed down to the two types from the angle of technological development, there was a high level of cooperation among the member companies through technological symmetry by means of incredibly complete technology transfer within a group. The two groups contended fiercely for the dominance of the market throughout the process of deciding the industrial standard. This intra-group cooperation and inter-group competition resulted in speeding the progress of the VCR technology. Taking the length of recording-hour, a great improvement was made in the course of competition:

1975	Beta(B-I)	: 1 hr	1976	VHS:	2 hrs
1977	Beta(B-II)	: 2 hrs	1977	VHS:	4 hrs
1978	Beta(B-III)	: 3 hrs	1979	VHS:	8 hrs

The important point here is that not all the technological progress was made by the first two technological leaders; Sony and Victor. For instance, B-II was developed by Toshiba and Sanyo, while the four-hour format of VHS was developed by Matsushita

This kind of balanced mechanism of technological progress had been experienced in many other aspects like Hi-fi systems for better sound or Hi-vision for better picture, etc.

### 3.3. Formation of New Market Structure

Moreover, interaction mechanism of inter-group competition based on the cooperative movement of member companies of each group formed a new structure of the VCR industry. Group-wise, VHS family who was in an advantageous stage in terms of complementary assets<sup>(11)</sup> came to occupy the market. Industry-wide, Matsushita

took the most advantageous position occupying the majority of the market, while several other group members shared the rest, which was showed a stable oligopoly.

As time passed the initial advantage of Beta group had reversed. The market share of Beta and VHS in 1976 was 70% to 30%. It changed to 40 to 60 in 1979 and ended up with 30 to 70 in 1984. VHS became the major industry standard with no doubt. This trend influenced not only the domestic makers but also most of the VCR manufacturers abroad. In 1984, Phillips of Netherlands joined the VHS group giving up concentrating on its own model 'V-2000'. At the same time Grundich of West Germany which had received technological instruction on the V-2000 system from Phillips also participated in VHS group. With this momentum, Toshiba, Sanyo, Shin-Nippon Electricity, and General which had belonged to the Beta family, shifted to VHS (At first they produced VHS systems only for the export, but later they ended up with VHS wholly withdrawing from Beta).

[ insert figure 1 ]

In addition, the only American maker of Beta system, Zenith, which had been on OEM contract with Sony for seven years turned to VHS at the end of the contract. Finally the mother of the Beta system, Sony acknowledged its defeat and took part in the VHS market by taking the OEM from Hitachi. Figure 1 shows the process of VHS's becoming the industry's standard by means of change in the market share.

#### 4. Dynamic Evolution of the VCR Industry

Based on the discussion so far, I tried to classify the evolutionary process of the industry (process of the industry's development) by period, and analyzed the relationship between the development process and market structure. Observing the data in table 3, showing the overall trend of compact VCR's production, export, and domestic shipment, we can divide the evolutionary process of the home-use VCR industry into three phases. The first phase is from 1956 to 1975 which represents the formation of the basic design of VCR for home use. The second phase is the 1975-1985 period of growth. The third phase is the period of the maturity after 1985.

[ insert table 3 ]

The growth period can be divided again into two phases; before and after 1980. The first growth period(1975-1979) started with revolutionary innovations, while the second growth period(1980-1984) with the establishment of the mass production system. In other words, interactions within the industry structure defined by the inter-group competition and intra-group cooperation accelerated the speed of technological progress, and led to price-cuts. Eventually this resulted in the fast growth of the industry. Throughout the growth period, domestic supply increased consistently and the diffusion rate of the home-use VCR reached almost 20% in 1984.

The market structure was to some extent monopolistic around 1976 when the revolutionary innovations were put through. After this, in the first growth period a lot of strategic entry into either the Beta or VHS group took place. Thus the industry shifted from the first growth period's state of unstable oligopoly

to the second growth period's stable oligopoly state. The market structure went on being stable with the predominance of VHS. Taking the number of equivalent firms<sup>(12)</sup> in the industry as an example (refer to the table 4 and figure 2), in 1977, just after the drastic innovations were made, the market was rather in a monopolistic structure with 2.4 equivalent firms. This had changed to 5.5 until 1981. This big change denoted a quite unstable market structure. After 1982 the figure converged to '7' showing a stable market structure.

[ insert table 4 and figure 2 ]

On the other hand, taking the level of market share (refer to the figure 3) for one of the indicators showing the level of a corporation's achievement, in the initial period the market shares of Sony and Japan Victor who first carried out the innovations were high. Especially Sony's share was the highest thanks to the earliest introduction of the innovation. As for the followers, it made a big difference which group they had participated in, Beta or VHS. VHS group was showing a better accomplishment.

[ insert figure 3 ]

It becomes clear when we compare these two electric appliances makers, Toshiba and Hitachi, for an example. These two makers show little difference in terms of their complementary assets. Concerning the VCR technology, however, at the early stage of the industry's development, Toshiba was a technological leader while Hitachi lagged far behind. But in 1983 Toshiba's market share dropped to 2.2% from 8.1% in 1978. On the contrary, Hitachi's share grew up to 15% by 1986 from 2% in 1977. This considerable growth of Hitachi is attributable to the synergy effect emerged from the cooperation of the VHS group members. Moreover, Sony and Matsushita

have shown the most striking contrast. Sony Corporation who first introduced innovative products dominated the market with a share of 60.1% in 1976. This fell to 12.5% by 1987. Meanwhile, Matsushita recorded a share of 30.1% in 1981, having kept the leading post since 1979, from 12.2% in 1976.

#### 5. Concluding Remarks

The facts that Japanese VCR makers who lagged behind America in magnetic videorecording technology could develop the home use VCR and dominated the world market owe to the inter-firm interactions of the technological knowledge exchanging process in the R&D phase. The technological knowledge exchanging process of Japanese VCR makers in the R&D phase was the repetition of a competition process characterized as new product or prototype competition in the market and cooperation process. In the case of the VCR industry, the cooperation process was proceeded by the VTR Kondankai, VTR Committee, Joint Research. Through this process, many Schumpeterian companies entered and few exit the market, which stimulated the process of product invention and learning effects in the R&D phase. Moreover that process served as a basis for the formation of the industrial structure, which enhanced the technological effect in the stages of growth and maturity. Because no withdrawal was recorded in the R&D phase, the possibility of innovation was heightened from the existence of various types of companies possible even throughout the stages of the industry's growth and maturity.

On the other hand, inter-group competition of Beta versus VHS for industrial standardization and intra-group cooperation within



the Beta or VHS group occurred in the growing and maturing stage. The process of competition and cooperation in the stage of growth and maturity accelerated the speed of the technological progress and made the rapid growth of the industry possible. At the same time, there had been dynamic changes in the concentration rate and market share which emerged in a new market structure.

Concludingly, Japanese inter-firm interactions in the VTR industry have been carried out consistently by the structure depicted by 'the competition and cooperation among the engaged players' throughout the industry's history from the initial stage, to growing, and maturing stage, which produced the revolutionary innovation through a continuous systematic development process, and accelerated the speed of technological progress and the rapid growth of the industry.

## Notes

- (1) Betamax is a trademark of the Sony Corporation, and VHS is that of the Japan Victor.
- (2) See Y. Baba and K. Imai [1990].
- (3) See H. Itami [1989].
- (4) See H. Itami [1989], J. Seo [1991].
- (5) The dynamic process of industrial evolution is discussed in the following books and paper; R. Nelson and S. Winter [1982], G. Dosi [1984], A. Sakuma, Y. Matsui, and M. Horiuchi [1987].
- (6) Schumpeterian company means that the firm will pursue the entrepreneurial profits from a series of innovations in the temporary oligopolistic market structure. See in detail in G. Dosi [1984], pp.93-111.
- (7) The case analysis of Japanese home VCR history is mainly based on the following materials; Almanac: Electronics Industry, Y. Nakagawa [1984], Y. Nakagawa [1987], H. Itami [1989], R. Rosenbloom and M. Cusumano [1987].
- (8) The meaning of 'basic design' is the same as 'dominant design' used in W. J. Abernathy, Productivity Dilemma: Roadblock to Innovation in the Automobile Industry, 1978, the Johns Hopkins University Press.
- (9) 'Network externalities' is discussed in M. Katz and C. Shapiro [1985].
- (10) The sources of data used in the regression refer to table 3.
- (11) The meaning of 'complementary assets' is discussed in D. Teece [1986].

(12) Roughly speaking, the number of equivalent firms is a measure of the number of firms that would populate an industry if all participant had the same share of the market as did the larger firms. The number of equivalent firms is calculated as the inverse of the Herfindahl index.

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Table 1. Japanese and World Production and Export in Home VCRs

thousand units, million dollars, %

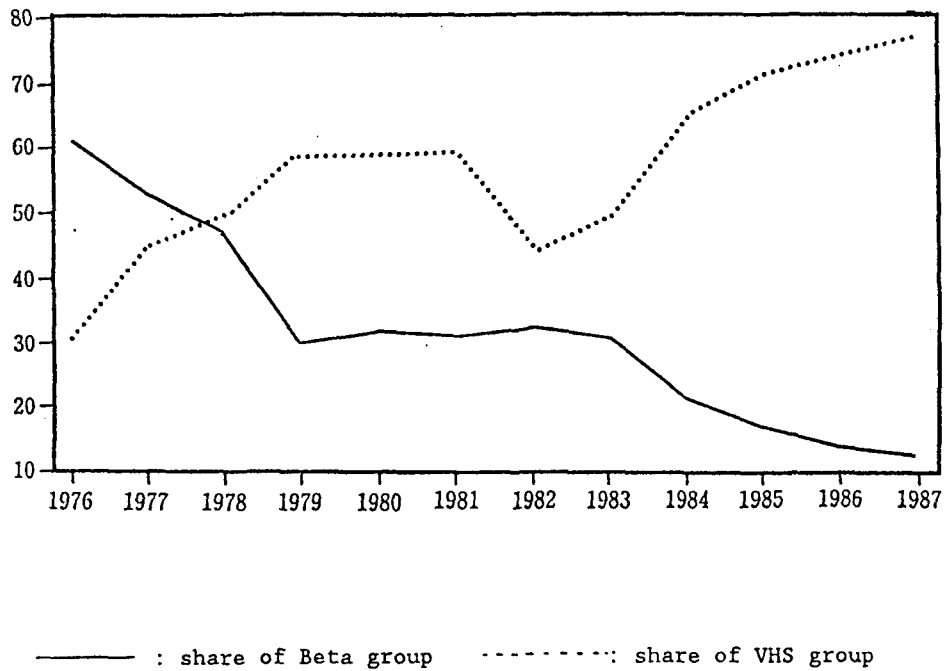
year	Production					Export				
	Volumes		Amounts			Volumes		Amounts		
	World	Japan	World	Japan	%	World	Japan	World	Japan	%
1975	165	119	115	84	73.0	118	70	162	75	46.3
1976	343	288	240	193	80.4	215	139	206	104	50.5
1977	844	762	531	468	88.1	499	402	380	245	64.5
1978	1,610	1,470	1,078	970	90.0	1,118	973	834	599	71.8
1979	2,514	2,199	1,675	1,352	80.7	1,908	1,671	1,394	1,015	72.8
1980	4,754	4,441	2,971	2,482	83.5	3,754	3,444	2,379	1,957	82.3
1981	9,902	9,489	5,435	4,928	90.7	7,687	7,355	4,293	3,870	90.1
1982	13,769	13,134	5,875	5,159	87.8	11,468	10,652	4,964	4,344	87.5
1983	19,242	18,217	7,172	6,374	88.9	16,381	15,237	5,946	5,308	89.3
1984	30,019	28,611	9,743	8,799	90.3	24,484	22,071	7,814	6,823	87.3
1985	33,192	30,581	9,214	7,920	86.0	29,984	25,475	8,094	6,641	82.0

Source; Japanese Industrial Association of Electronics, *Statistics Major Items in World Electronic Industry*, 1986

Table 2. Inter-firm Interaction of the Industry Level

Period	Patterns of Interaction	Contents	New Entries
1956 -	Cooperation	Subsidies by MITI VTR <i>Kondankai</i> (VTR Study Group)	Sony, Shiba Elec, Toshiba, Matsushita, Shin-nihon Elec.
1958 - 1966	Competition	Prototype VTR for broadcasting  Trial and error process in home VTR development  Developing business use VTR	Japan Victor (JVC)
1967 - 1969	Cooperation	VTR Research Committee (Sub-committee on technology)	Mitsubishi, Hitachi, Ikenoue T., Toshiba-Ampex, Japan-Columbia Co.
1969 -	Competition	'Standard I type'  Business use VTR	Sanyo
1971 -	Cooperation	Joint Research on VCR (U-Standard)  Cross Licensing Contracts	(Sony, Matsushita, JVC)
-1976	Competition	Home VTR	

Figure 1. Production Share of Beta versus VHS Group



Sources: Yano Economic Institute, *Dictionary of Japanese Market Share*.

Note: The share of the Beta group is the sum of Sony, Toshiba, Sanyo, and the VHS group is the sum of JVC, Matsushita, Hitachi, Sharp. However, the shares of Toshiba from 1985, and that of Sanyo from 1986 are added to the VHS group.



Table 3. Japanese Production, Export, and Domestic Shipment of Home VCRs

100 million yen, thousand units, thousand yen, %

year	production			export			domestic shipment		price		export ratio	spread rate
	amount	unit	growth rate	amount	unit	growth rate	unit	growth rate	production	export		
1970	86	50	na	na	na	na	na	na	172	na	na	na
1971	75	49	0.0	na	na	na	na	na	153	na	na	na
1972	155	114	132.7	na	na	na	na	na	136	na	na	na
1973	236	137	20.2	na	na	na	na	na	165	na	na	na
1974	286	124	(- )9.5	na	72	na	52	na	206	na	na	na
1975	248	119	(- )4.0	na	70	(- )2.8	49	(- )5.8	208	na	na	na
1976	571	288	142.0	310	139	98.6	149	204.1	198	223	48.3	na
1977	1,260	762	164.6	659	402	189.2	360	141.6	165	164	52.6	na
1978	2,041	1,470	92.9	1,261	973	142.0	400	11.1	139	130	66.0	1.3
1979	2,962	2,199	49.6	2,224	1,671	71.7	480	20.0	135	133	75.9	2.0
1980	5,628	4,441	102.0	4,436	3,444	106.1	925	120.1	127	129	77.5	2.4
1981	10,868	9,498	113.9	8,535	7,355	113.6	1,548	59.6	114	116	77.5	5.1
1982	12,850	13,134	38.3	10,794	10,652	44.8	2,344	51.4	98	101	81.2	7.5
1983	15,140	18,217	38.7	12,608	15,237	43.0	3,659	56.1	83	83	83.6	11.8
1984	20,900	28,611	57.1	16,207	22,071	44.9	4,272	16.7	73	75	77.1	18.7
1985	18,893	30,581	6.9	15,841	25,475	60.8	4,007	(- )6.2	62	62	82.6	27.8
1986	16,594	33,879	10.8	12,429	27,689	8.7	4,853	21.1	49	45	81.7	43.0
1987	12,427	30,563	-9.8	8,583	22,801	-17.7	6,331	30.5	41	37	74.6	53.0

Source: J. Seo, 1991, Cooperation and Competition in the Industrial Evolution.

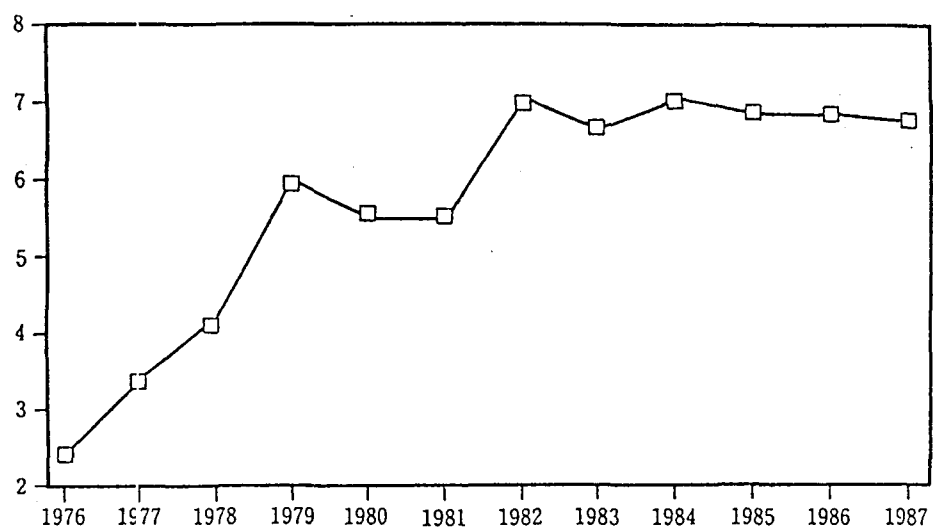
Table 4. Concentration Index in the Japanese Home VCR Industry

year	CR3	CR5	Herfindahl Index	Number of Equivalent Firms
1976	90.8	90.8	0.4245	2.4
1977	86.9	95.7	0.2916	3.4
1978	80.4	93.3	0.2375	4.2
1979	65.5	80.2	0.1654	6.0
1980	68.6	83.1	0.1805	5.5
1981	69.3	83.0	0.1823	5.5
1982	58.6	70.4	0.1411	7.1
1983	61.3	72.9	0.1484	6.7
1984	56.6	76.7	0.1403	7.1
1985	56.5	79.2	0.1448	6.9
1986	55.9	79.9	0.1446	6.9
1987	56.5	80.5	0.1467	6.8

Source: Yano Economic Institute, *Dictionary of Japanese Market Share*.

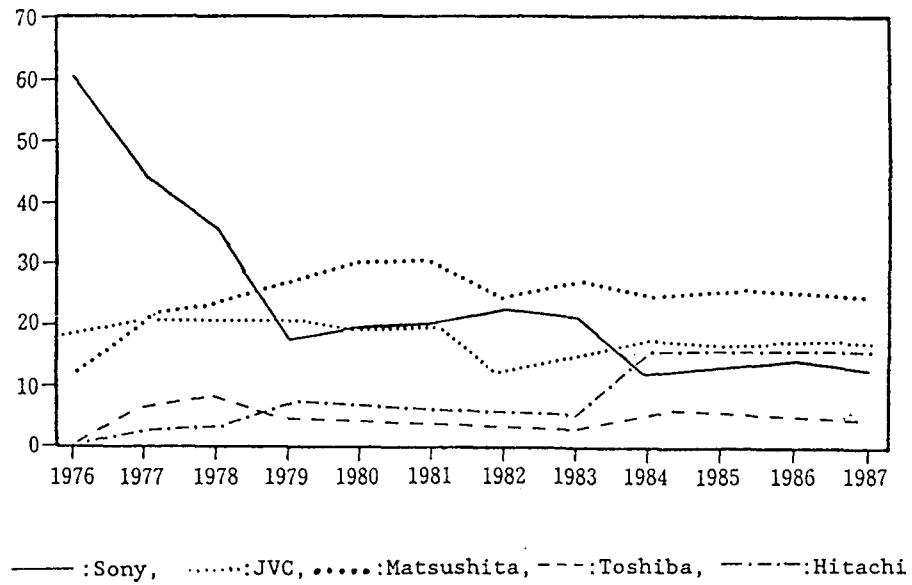
Note: CR3 is the concentration ratio of the three largest firms, and CR5 is that of the five largest firms

Figure 2. Trend in the Number of Equivalent Firms



Source: Depicted from table 4.

Figure 3. Trend of Market Share by Japanese VCR Makers



Source: Yano Economic Institute, *Dictionary of Japanese Market Share*.