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Sustainability of Competitive Advantage: Accumulated Experience and Discontinuous Technological Change

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Abstract: A discontinuous technological innovation destroy the existing technological systems and alter the regular competitive balance even in a stable mature industry. In the color TV set industry, a discontinuous technological change from vacuum tubes to transistors and ICs was observed in the 1970's. The effect of a discontinuous change in the color TV set industry is analyzed through comparative study of Japanese and American firms.

Keywords: discontinuous technological change, refraction of experience curve, color TV, homogeneous competitive behavior

1. Introduction

After World War II, many Japanese industries were started up by introducing advanced technologies developed in the U.S. In due course, Japanese firms, which have acquired the capability to produce competitive products at low cost, began to export their products. Remarkable increase of Japanese exports caused trade friction between the U.S. in the textile industry in the 1950's, as well as in the steel industry in the 1960's, the color TV set industry in the 1970's, and the automobile and electronics industries in the 1980's.

According to Vernon's product life cycle theory, exports from developing countries to the U.S. increase in mature industries where the focus of competition is not technological innovations but manufacturing cost (Vernon, 1966). In fact the Japanese wage was much lower than in America but the cost advantage of Japanese firms have been undermined due to raising wage and strong yen since

the 1970's. Competitiveness of Japanese industries after the 1970's cannot be ascribed only to cheap labor but also to other factors such as discontinuous technological innovations (Shusa & Kuwada, 1988).

Followers rarely surpass the leaders in the phase of incremental innovations based on traditional technological systems. The leaders are able to sustain their competitive advantage because they have longer experiences and more cumulative resources than the new entrants or the small share firms. Such situation is clearly exemplified by the experience curve effect. Once a firm gained a large share, its strong cost position would be secure.

However, a discontinuous technological innovation which destroy the existing technological systems often alter the regular competitive balance. Even in a stable mature industry, competition would again become fierce by a discontinuous change. For example, in the 1970's, the watch and color TV set industries experienced competitive turbulence by applying semiconductors.

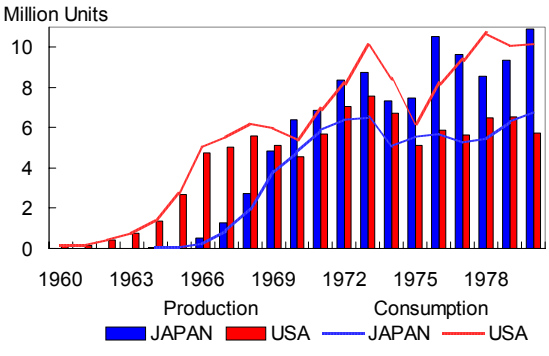
In the color TV set industry, a discontinuous technological change from vacuum tubes to transistors and ICs was observed in the 1970's. Japanese TV producers which lead this discontinuous change gained competitive advantage over pioneering American producers (Baba, 1989; Peck & Wilson, 1982; Sciberras, 1982). In the following sections, the effect of a discontinuous change in the color TV set industry was analyzed through comparative study of Japanese and American firms.

II. Color TV Industry in the U.S. and in Japan

In Japan, production of color TVs and broadcasting of full-color programs started in 1960, which was six years behind the U.S. Figure 1 shows the consumption and production of color TV in the U.S. and in Japan. Japanese product life cycle lagged behind the American one. However, Japanese production volume increased rapidly in the late 1960's and exceeded the U.S. in 1970. This was ascribed not only to the growth of Japanese market but also to the increase of exports especially to the U.S.

Most Japanese TV producers except Sony were licensed for the basic TV technologies from RCA. RCA developed a color picture tube called shadow mask and introduced the color TV set to the market for the first time. Many of the other American firms as well as the Japanese firms were licensed for the shadow mask technologies from RCA. Shadow mask became the dominant design of color picture tube both in the U.S. and in Japan. Each firm made an effort to improve the quality of TV set and to reduce

Figure1. Color TV Industry in U.S. and Japan



production cost based on this dominant design in the 1960's.

Major reason for the increase of Japanese exports in the late 1960's was low labor cost. Labor cost was the crucial factor for TV production at that time because much labor was needed to assemble the electronics circuit and the final product. An average wage in Japanese TV industry was $0.5 per hour compared with $2.72 in the U.S. in 1968 (Peck & Wilson, 1982). Most of the Japanese color TVs exported to the private label market in the U.S. where low price was regarded as important.

However, Japanese advantage in labor cost became smaller in the 1970's. American TV producers started foreign production in cheap labor countries such as Taiwan and Mexico around 1970. Yet the cost advantage of Japanese TV sustained and exports to the U.S. rapidly increased to 2.96 millions in 1976. Many American firms exited from TV business or were acquired by foreign firms after 1974. The share of American producers in the U.S. market declined to 56% in 1980.

III. Discontinuous Technological Change and Refraction of Experience Curve

Color TV industry faced a discontinuous technological change around 1970. Core electronic parts changed from vacuum tubes to transistors and ICs. Accordingly, assembly line of the printed circuit boards shifted from labor intensive to automated. These change affected both product and manufacturing processes.

Performance of TV was drastically improved, under which consumption of electricity reduced to one third and field call rate reduced to a quarter. The quality of pictures also improved.

The change in process improved reliability of color TVs and reduced cost. First, the cost of parts was reduced because cost reduction rates of transistors and ICs were much higher than the rate of vacuum tubes. Second, the number of parts reduced to one third. Third, the labor productivity was remarkably improved due to the automated insertion machines and the inspection machines.

With these drastic changes, a significant part of the past experience became obsolete, which had a great impact on the cost structure. Figure 2 shows the experience curves for the color TV industry in the U.S. and in Japan. Both two curves are refracted but the refracted point and the learning rate in each

Figure 2. Experience Curve for Color TV

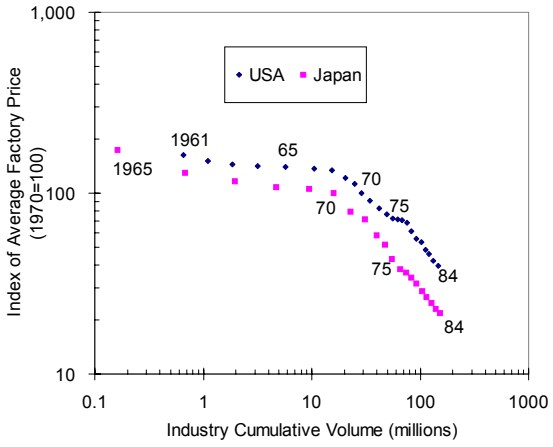
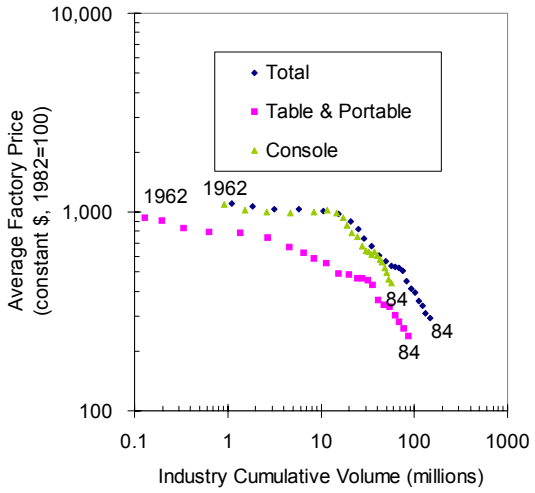


Table 1. Learning Rate of Color TV

	1st period	2nd period
USA	96.4% (1961-1967)	96.4% (1968-1984)
Japan	92.4% (1962-1970)	61.1% (1971-1984)

Figure 3. Experience Curve by TV Type in U.S.



period are different as shown in Table 1. The second learning rate is much lower than the first one in each country. And the learning rate in Japan is slightly lower than the one in the U.S. in either period. These refraction and differences are statistically significant at 1% level.

The cumulative production volume in Japan caught up with the American one in 1978. The cost in Japan might have been higher before 1978 if the learning rate and the factor costs were the same. Labor cost in Japan increased in the 1970's but the learning rate has drastically decreased. This change gave a big chance to the Japanese firms.

It was for the discontinuous technological change as mentioned above that the experience curves were refracted. Of course, other factors might have affected this refraction because Figure 1 has used the price data at an industry level. For example, either the decrease of the number of competitors, the increase of the share of low price segment, or the intense price competition might refract the industry level experience curves.

First, the number of competitors was stable in Japan. The number of competitors began to decrease in the U.S. in 1974: several years passed 1967, that is, the refracted point. Second, price competition was consistently fierce in both countries through the 1960's to 1970's. Third, in the U.S., the production share of the table and portable type TVs, which were cheaper than the console type, increased from 15% in 1965 to 62% in 1974. If this increase was the major reason for the refraction of American experience curve, each experience curve by TV type would not be refracted. However, the experience curve of the console type is similarly refracted as shown in Figure 3. Most of all Japanese color TVs have been the table and portable types since the 1960's.

IV. Response of American and Japanese Firms to the Discontinuous Change

The response of the Japanese firms to this discontinuous change was quick and aggressive, while the response of the American firms was relatively negative. This difference led the Japanese

firms to gain a great competitive advantage.

Generally, a newly developed discontinuous technology is applied to a specific product segment by pioneering firms at first, because new technologies are immature and their possibilities are uncertain. After the possibilities of a new technology become clear and its performances are improved, the new technology is adopted by other firms and applied to wide range of products.

In Japan, Hitachi first introduced a fully transistorized color TV, which was a 15-inch model in 1968, and developed a complete line of fully transistorized models in 1969. Hitachi's market share suddenly increased from 10% in 1967 to 14% in 1969. Other Japanese firms quickly introduced fully transistorized models in 1970 and all models released in 1971 were this type of TV, some of which using ICs. This corresponds to the refracted point of the Japanese experience curve.

After the oil crisis in 1973, Japanese TV producers made efforts to reduce costs. Simplifying circuit design by using various ICs, they reduced the number of parts. Moreover, in the late 1970's, they automated the assembly line where 65% to 80% of components were assembled by automated machines. As a result, productivity drastically improved as shown in Table 2.

In the U.S., Motorola first introduced a fully transistorized color TV named Quaser in 1969 and all of its models changed to this type in 1969. However, its products were focused on the large console segment because Motorola regarded transistorized TV as high-price and high-performance product. 86% of its total sales was

Table 2. Productivity of Japanese TV Industry

year	1974	1975	1976	1977	1978
No. of Parts	750	645	465	443	430
Automated PCB Assembly	16%	43%	55%	57%	75%
Man-hours per Set	3.48	2.71	1.46	1.29	1.15

Source: Gregory (1985), p. 117.

Table 3. Comparison of Response in U.S. and Japan

	Japan	U.S.
Leader:	Hitachi (1968-69)	Motorola (1967-69)
Applied Product Line:	Full Line	High Grade
Overall Completion:	1971	1976
Speed of Improvement:	Quick	Slow
Design:	Integrated in a Few Parts	Module Design
Process:	Automation	Labor Intensive

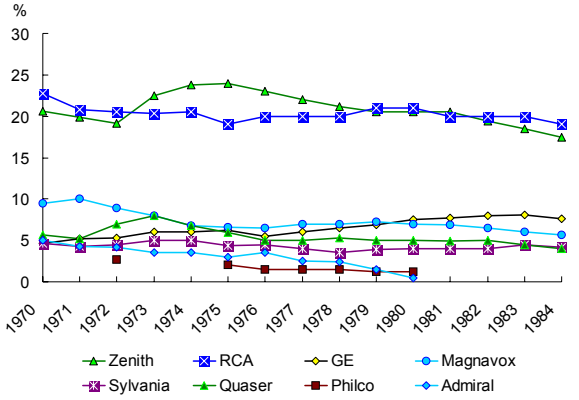
the sales of 23-inch models.

Other American firms did not take such a quick response as the Japanese. RCA and Zenith, which had a large market share, were four to five years behind Motorola. The share of fully transistorized color TVs in the U.S. market increased from 25% in 1972 to 100% in 1976. American firms that were six years ahead of the Japanese at the start of the industry lagged five years behind when shift to the new technology completed.

Moreover, American firms adhered to the traditional module-type design and labor-intensive process. Module-type design, in which several parts are installed as modules, is reasonable for products that are apt to malfunction. However, it became useless when the defect rate has drastically declined by ICs and automated assembly lines.

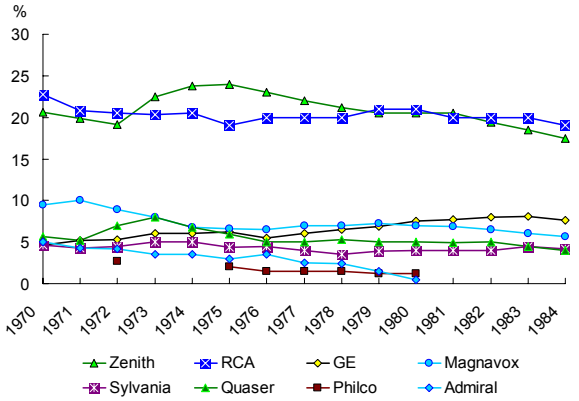
Table 3 summarizes the differences between Japanese firms and American firms.

Figure 4. Color TV Market Share in U.S.



Note: Market share by sales volume.
Sources: 1970-80: Peck and Wilson (1982), p. 199; 1981-84: Itagaki (1987), p. 50.

Figure 5. Color TV Market Share in Japan



Note: Figures based on monetary value of production.
Sources: *Nihon maketto shea jiten* (1970-1984).

V. Homogeneous and Heterogeneous Competitive Behavior

When existing firms face discontinuous change, the speed and scope of switching and the subsequent improvements as well as the timing of introduction are important to gain and sustain competitive advantage as mentioned above.

Nevertheless, existing firms tend to be cautious about switching because there are sunk cost of past resources and uncertainty in a new technology. This attitude is reasonable with regard to the risk if the firm monopolizes the industry. Competition will put pressure on firms to switch quickly in a large scale. Yet, not only the market structure but also the firm's perception of competition affects the behavior of each firms.

In the early 1970's, the concentration ratio of top three firms in the color TV market was about 50%, both in the U.S. and in Japan. But the relative

competitive situation was different as showed in Figure 4 and Figure 5.

In the U.S., RCA and Zenith had great share compared to other firms. RCA and Zenith had full line of products but differentiated themselves by picture tube and high reliability respectively. Other small share firms such as Motorola focused on the specific niche market to survive. Totally, each firm has differentiated itself and the heterogeneous structure was established. Under these situations, each firm could independently make a decision.

On the other hand, in Japan, shares were relatively close and most of the firms had similar line of products. Under such homogeneous structure, successful behavior of a certain firm is followed by the others because others feared to be shaken out of the industry. This accelerated the switching to new technologies and subsequent improvements.

The variety of products would be richer in heterogeneous markets than in homogeneous markets. Nevertheless, the speed of evolution in the industry toward a specific direction such as a change from vacuum tubes to ICs would be increased in homogeneous markets. The firms competing in homogeneous markets could gain competitive advantage over the firms in heterogeneous markets if their chosen direction is correct.

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