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## 2C01　Dynamic interaction between diffusion process and learning effect of plasma TVs between Japan, Korea and Taiwan's companies

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### 1. Introduction

The objective of this research attempts to elucidate dynamic interaction between diffusion process and learning effect of plasma TVs between Japan, Korea and Taiwan's companies.

The plasma TV industry recently achieved conspicuous development within Japan, Korea and Taiwan. As of 2005, Japan and Korea occupied an enormous 90% market share of plasma TVs. It was initially Japan that developed and launched the plasma TVs into the global market. However, in the fourth quarter of 2004, the total shipment of plasma TVs was reversed for the first time. On the basis of comparative analysis about plasma TVs, this research is focusing on identifying factors contributing to the co-evolution within the institutions. Through an empirical analysis, the unique institutional structures will be demonstrated. Comparing with LCD (Liquid Crystal Display) industry, PDP (Plasma Display Panel) industry has no distinct competitor because of the short period of commercialization and restrictive demand. It was early simplified through the withdrawal of PDP business of Fujitsu, the undertaking of NEC's PDP business sector by Pioneer and market expansion of aggressive investment of Korea's companies. Therefore, a market competition's structure was reorganized among Matsushita, Samsung SDI and LG electronics since the end of 2004, and then is expected to be more intensive competition.

In case of Matsushita, its capability concentrates on the PDP business and makes full use of the production of most of PDP panels into the own PDP TV. On the other hand, such as Korea's companies, they undergo a difficulty for security of a source of major supply comparing with Matsushita.

Fig. 1 demonstrates that the characteristics of plasma TV from 2002 to 2005. We can also observe the unique plasma TV industry among Japan, Korea and Taiwan by measuring the cumulative shipment.
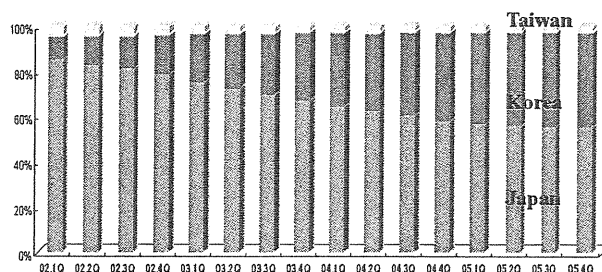


Fig. 1. Total Ration of Cumulative Shipment of Plasma TV in Japan, Korea and Taiwan (2002-2005; 16 quarters).

### 2. Diffusion Trajectory

### 2.1 Analytical Framework

In this research, the diffusion trajectory can be analyzed with dynamic carrying capacity as illustrated in equation (1).

$$f(t) = \frac{K_K}{1 + a \exp(-bt) + \frac{b \cdot a_K}{b - b_K} \exp(-b_K t)} \quad (1)$$

When $a_K = 0$, equation (4) is a general function of the epidemic behavior encompassing a simple logistic growth function, and the ratio of $a_K$ and $a$ ($a_K/a$) indicates the degree of non-SLF (simple logistic growth function) structure (degree of functionality).

For data construction, depreciation rate ρ can be treated as a reverse of the life time and cumulative

shipment also can be measured by the following equation:

$$S_t = C_t + (1 - \rho)S_{t-1} \qquad (2)$$

$$S_0 = \frac{C_1}{(g + \rho)} \qquad (3)$$

$$\rho = \frac{1}{LT} \qquad (4)$$

$S_t$: cumulative shipment at time t; $C_t$: annual shipment at time t; $g$: increase rate of shipment in the initial period; $\rho$: depreciation rate and $LT$: life time.

Generally, life span is defined as the period until the brightness of the screen is diminished by 50%. With this application, the life time of plasma TV is over *60,000* hours. By means of the above equation and understanding, we can analyze the comparative study of each company among three countries.

Trends in cumulative shipment of plasma TV over the period 2002-2005 (16 quarters) classified by each company and based on the above approach are illustrated in Fig. 2.
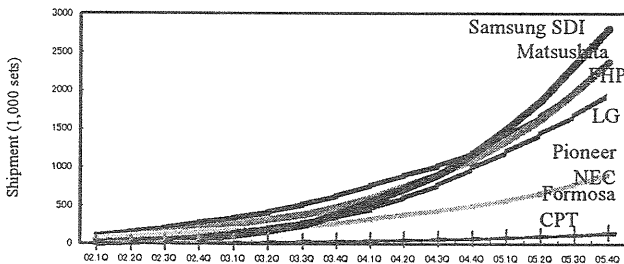


Fig. 2. Cumulative Shipment of Plasma TV in Japan, Korea and Taiwan's Companies (2002-2005; 16 quarters).

Based on the above Fig. 2, Samsung SDI exceeded the cumulative shipment of that of Matsushita in the fourth quarter of 2004 for the first time. One of these results caused by the institutional uniqueness of Samsung SDI as follows: (i) very strong supply oriented; (ii) professional display oriented company; (iii) technology innovation by world's first glass cutting development

and world's largest size plasma TV development in 2004.

Results of the analysis on the trends in the diffusion process of plasma TV over the period 2002-2005 by using dynamic carrying capacity depicted by equation 1 are illustrated in Fig. 3.
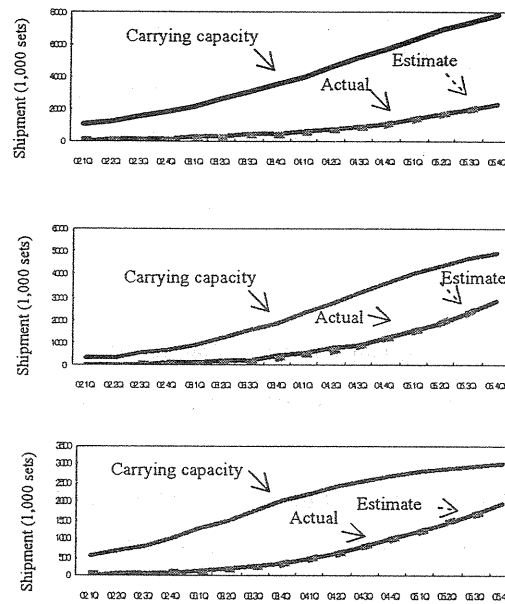


Fig. 3. Carrying Capacity of Plasma TV in Matsushita, Samsung SDI and LG (2002-2005; 16 quarters).

Through this result, cumulative shipment exhibited a dramatic increase among three companies and changed slow down, however maintains sustainable increase over the period examined. Table 1 compares the factors characterizing carrying capacity structure of plasma TV in three countries.

Table 1 Comparison of Factors Characterizing Carrying Capacity Structure of Plasma TV in Each Companies

| Country | Company | Velocity of Diffusion | Degree of Functionality | | Year to Reach |
|---|---|---|---|---|---|
| | | $b$ | $a_K/a$ | $b_K/b$ | $\ln a_K / b_K$ |
| Japan | Matsushita | 0.251 | 0.207 | **0.851** | 11 7 |
| | FHP | 0.313 | 0.595 | 0.516 | 23.6 |
| | Pioneer | 0.179 | 0.089 | 0.603 | 25 8 |
| | NEC | 0 487 | 0.229 | 0.233 | 33.9 |

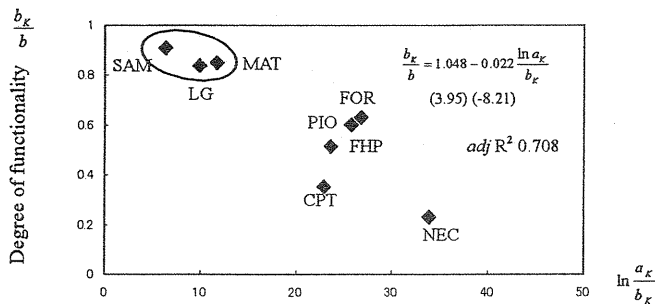| Korea | Samsung SDI | 0.387 | 0.739 | 0.840 | 9.9 |
|---|---|---|---|---|---|
|  | LG | 0.344 | 0.329 | 0.911 | 6.4 |
| Taiwan | Formosa | 0.187 | 0.009 | 0.663 | 26.8 |
|  | CPT | 0.507 | 0.256 | 0.354 | 22.9 |



**Fig. 4. Degree of Functionality of Plasma TV in Each Companies (2002-2005; 16 quarters).**

Table 1 interprets institutional structure affecting the differences of these carrying capacity structures in Japan, Korea and Taiwan. And also Fig. 4 demonstrates the highest degree of the functionality ($b_K/b$) and the lowest degree of the year to reach ($t^{\#}$) among top three companies such as Matsushita, Samsung SDI and LG electronics. These top three companies have also common technology innovation as follows: (i) glass cutting technology; (ii) the effort of reduction of glass thickness from 2.8mm to 1.8mm; (iii) technology innovation through world's largest size plasma TV development year by year, respectively.

In addition to that, they show their mutual inspiration through the patent litigation and technology innovation.

## 3. Learning Effect

### 3.1 Analytical Framework

By measuring dynamic learning coefficient, which represents market-learning effects, diffusion trajectory can be interpreted. Learning effects can be captured by the following equation.

$$P = AY^{-\lambda} \qquad (5)$$

Taking the logarithm of equation (5):

$$\ln P = \ln A - \sum_{i=0}^{n} a_i t^i \ln Y \qquad (6)$$

Since learning coefficient $\lambda$ is a function of successive coefficients during production, distribution and utilization phases in their dissemination process, these coefficients can be depicted as a function of time trend $t$ as:

$$\lambda(t) \approx \sum_{i=0}^{n} a_i t^i \qquad (7)$$

Stimulated by these understandings and prompted by a concept of learning effect, dynamic learning coefficient will be analyzed between Japan, Korea and Taiwan's companies as demonstrated in Table 2.

**Table 2 Comparison of Learning Coefficient of Plasma TV in Japan, Korea and Taiwan's companies**

$$\ln P = \ln A - \left(a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4 + a_5 t^5\right)\ln S$$

$P$: price; $S$: sales; $t$: time trend.

| Company | ln$A$ | $a_0$ | $a_1$ | $a_2$ | $a_3$ | $a_4$ | $a_5$ | DW | adj $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Matsushita | 1.89 | 0.418 | -0.122 | 0.035 | $-4.0*10^{-3}$ | $2.5*10^{-4}$ | $-4.9*10^{-6}$ | 2.71 | 0.974 |
|  | (3.81) | (2.79) | (-3.79) | (3.83) | (-3.61) | (3.23) | (-2.82) |  |  |
| FHP | 2.12 |  |  | $2.7*10^{-3}$ | $-3.3*10^{-4}$ | $1.1*10^{-5}$ |  | 2.26 | 0.700 |
|  | (2.61) |  |  | (4.36) | (-3.69) | (3.19) |  |  |  |
| Pioneer | 3.02 |  | 0.048 | $-5.9*10^{-3}$ | $1.9*10^{-4}$ |  |  | 1.69 | 0.887 |
|  | (24.8) |  | (3.81) | (-3.77) | (3.26) |  |  |  |  |
| NEC | 2.45 | 0.265 | -0.063 | 0.015 | $-1.3*10^{-3}$ | $3.4*10^{-5}$ |  | 1.51 | 0.840 |
|  | (7.82) | (2.61) | (-3.17) | (3.53) | (-3.58) | (3.39) |  |  |  |
| Samsung SDI | 1.02 | 0.813 | -0.133 | 0.016 | $-1.0*10^{-3}$ | $2.5*10^{-5}$ |  | 2.80 | 0.808 |
|  | (1.75) | (3.18) | (-2.95) | (2.53) | (-2.27) | (2.14) |  |  |  |
| LG | 2.09 | 0.199 | -0.002 | $-2.5*10^{-4}$ | $-6.5*10^{-5}$ | $3.9*10^{-6}$ |  | 2.39 | 0.700 |
|  | (0.26) | (2.49) | (-2.35) | (-2.42) | (-2.48) | (2.50) |  |  |  |
| Formosa | 1.98 | 0.871 | -0.279 | 0.077 | -0.011 | $6.3*10^{-4}$ | $-1.4*10^{-5}$ | 2.18 | 0.947 |
|  | (4.73) | (2.32) | (-2.93) | (2.58) | (-2.54) | (2.49) | (-2.43) |  |  |
| CPT | 2.44 | 0.567 | 0.235 | 0.063 | $-8.0*10^{-3}$ | $4.6*10^{-4}$ | $-9.6*10^{-6}$ | 2.72 | 0.947 |
|  | (15.61) | (2.59) | (-3.25) | (3.51) | (-3.51) | (3.36) | (-3.18) |  |  |

Fig. 5 demonstrates the decreasing trend of dynamic learning coefficient among top three companies. On the basis of own empirical analysis, correlation between sales of plasma TV and prices in Samsung SDI as illustrated in Fig. 6.
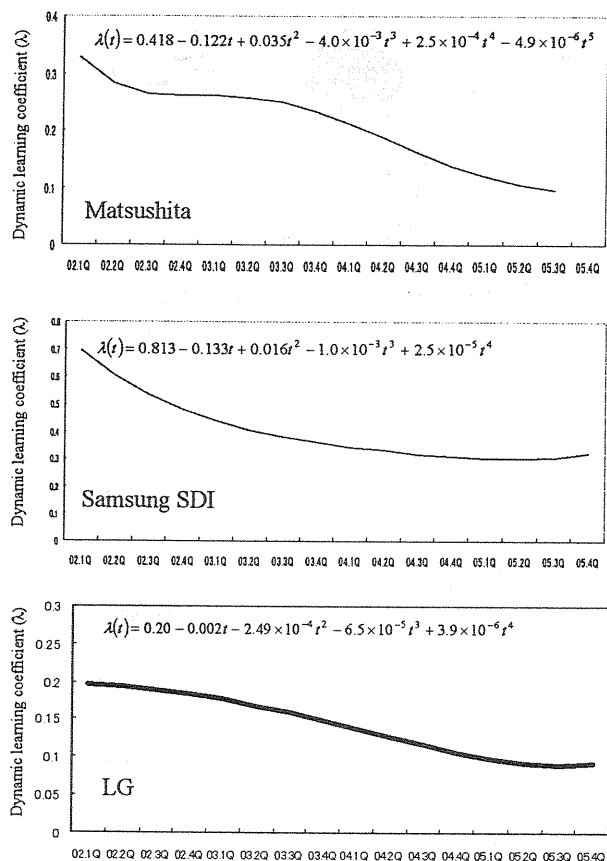


$$\lambda(t) = 0.418 - 0.122t + 0.035t^2 - 4.0 \times 10^{-3}t^3 + 2.5 \times 10^{-4}t^4 - 4.9 \times 10^{-6}t^5$$

Matsushita

$$\lambda(t) = 0.813 - 0.133t + 0.016t^2 - 1.0 \times 10^{-3}t^3 + 2.5 \times 10^{-5}t^4$$

Samsung SDI

$$\lambda(t) = 0.20 - 0.002t - 2.49 \times 10^{-4}t^2 - 6.5 \times 10^{-5}t^3 + 3.9 \times 10^{-6}t^4$$

LG

Fig. 5. Trend in Dynamic Learning Coefficient of Plasma TV among Top Three Companies.



$$\lambda(t) = 0.813 - 0.133t + 0.016t^2 - 1.0 \times 10^{-3}t^3 + 2.5 \times 10^{-5}t^4$$
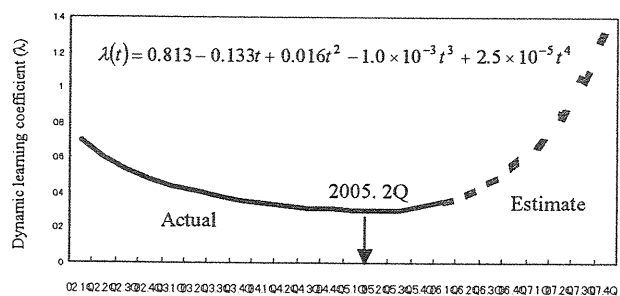
Actual     2005. 2Q     Estimate

Fig. 6. Trend in Dynamic Learning Coefficient of Plasma TV in Samsung SDI (2002-2007; 24 quarters) - Actual *(2002-2005; 16 quarters)* and extended estimate *(2006-2007; 8 quarters)* by the above learning effect equation.

In case of Samsung SDI, learning effect supports this result and it induces the broad opportunity of diffusion process and then accelerates the dramatic increase in cumulative shipment of plasma TV.

## 4. Conclusion

(i) Samsung SDI can be attributed to rapid diffusion and market learning effects comparing with other companies originated from increasing the level of cumulative shipment and accelerating learning effect.

(ii) Samsung SDI's co-evolutionary virtuous cycle due to co-evolution between activation in plasma TV development and dynamic carrying capacity accelerated enhancing functionality development with learning effect.

(iii) Samsung SDI's conspicuous figures can be attributed to unique dynamic interaction between diffusion and learning.

## References

[1] C. Watanabe and B. Asgari, "Impacts of Functionality Development on Dynamism between Learning and Diffusion of Technology," Technovation 24, No. 8 (2004) 651-664.

[2] C. Watanabe, J. Y. Hur and S. Lei, "Converging Trend of Innovation Efforts in High Technology Firms under Paradigm Shift-A Case of Japan's Electrical Machinery," Omega 34, No. 2 (2006) 178-188.

[3] Y. H. Hahn and P. I. Yu, "Towards a New Technology Policy: The Integration of Generation and Diffusion," Technovation 19, No. 3 (1999) 177-186.

[4] J. D. Choi, "A Menace to Status of Korea's Display Industry," LG Economic Research Institute Weekly Economy (2006), http://www.lgeri.com

[5] Y. Nakane, "LCD Industry Outlook," Deutsche Bank (2004).