1D02　日本型技術経営システムのダイナミズム

―イノベーション創出サイクルとインスティテューションとの共進ダイナミズムの時代的検証分析

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1. Introduction

Innovation generation cycle that leads to emerging innovations to market is highly dependent on institutional systems.

Here, institutional systems are constituted by (i) National strategy and socio-economic system, (ii) Entrepreneurial organization and culture, and (iii) Historical perspectives.

MOT (Management of Technology) is a management of a cycle of technological innovation from its emergence to utilization (**Fig. 1**).

Activation of the innovation cycle depends largely on the co-evolution with the institutions and change in innovation also changes in institutions (**Fig. 2**).

The co-evolutionary dynamism between the emergence of innovation and the advancement of institutional systems is thus decisive for an innovation-driven economy.

It may stagnate if institutional systems cannot adapt to evolving conditions. Current Japan's economy is one such example.

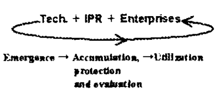

Fig. 1. Innovation Generation Cycle.

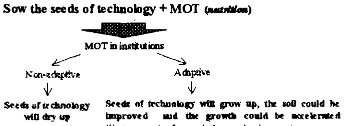

Fig. 2. Adaptivity between Innovation and Institutions.

While Japan's system of MOT indigenously incorporates an explicit function to induce this co-evolutionary dynamism, current stagnation can be attributed to the systems conflict.

This can be attributed to a conflict of the co-evolutionary dynamism due to the organizational inertia of the success story in the growth economy in an industrial society binding the two axes of the institutions (national strategy and socio-economic system, as well as entrepreneurial organization and culture) while historical perspective has shifted to a new paradigm characterized by mature economy in an information society.

This paper, on the basis of an empirical analysis focusing on the dynamism and its developing trajectory of Japan's system of MOT, attempts to demonstrate this postulate.

2. Co-Evolutionary Dynamism between Innovation and Institutional Systems

2.1 Co-Evolutionary Dynamism

The innovation generation cycle that leads to emerging innovations to market is highly dependent on institutional systems. While institutional systems strongly shape emerging innovation, innovation may also change the underlying institutions leading to a self-propagating development trajectory as demonstrated in the upper side of **Fig. 3.**

Co-evolutionary dynamism between emergence of innovation and advancement of institutional systems is thus decisive for an innovation-driven economy. It may stagnate if institutional systems can not adapt to evolving innovations as illustrated in the lower part of Fig. 3 and system of MOT in most countries is suffering including current Japan's system.

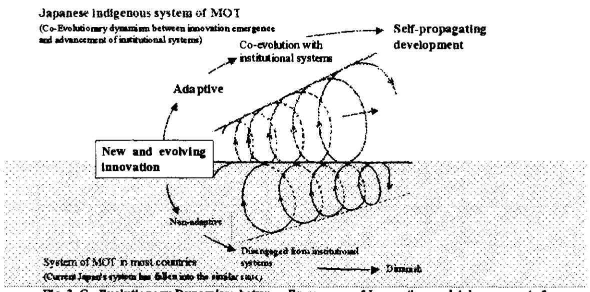

Fig. 3. Co-Evolutionary Dynamism between Emergence of Innovation and Advancement of Institutional Systems.

2.2 Contrast between Co-Evolution and Disengagement

2.2.1 Japan-US Comparison

(1) Contrast in TFP and Marginal Productivity of Technology

Japan's current stagnation can be attributed to the systems conflict impeding this co-evolutionary dynamism.

Consequently, contribution of technological improvement to economic growth, or contribution of TFP (total factor productivity) growth to GDP growth has dramatically declined in the 1990s resulting in the clear contrast between the 1980s and 1990s with respect to Japan's level in international competitiveness as demonstrated by its TFP decrease (**Fig. 4**).

Growth rate of TFP is simply a product of marginal productivity of technology ($\partial V/\partial T$) and R&D intensity (R/V). Since Japan's R&D intensity is the highest level in the world (**Fig. 5**), its marginal productivity of technology changed from top level in the 1980s to the lowest level in the 1990s (**Fig. 6**).

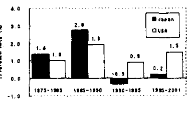

Fig. 4. Comparison of TFP Growth Rate between Japan, the US *(1960-2001)*.

a TFP for Germany in 1960-1990 depends on that of FRG and for EU in 1975-2001 depends on that of the average of Germany, France and the UK.
Sources: 1960-1973 OECD Economic Studies (1988); and 1975-2001 European Competitiveness Report (2001)

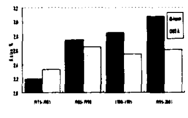

Fig. 5. Trends in R&D Intensity in Japan and the US *(1975-2001)*.

Source: White Paper on Japan's Science and Technology (annual issue)

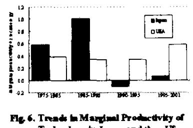

Fig. 6. Trends in Marginal Productivity of Technology in Japan and the US *(1960-2001)*.

a Marginal productivity of technology = Growth rate of TFP/R&D intensity.
Sources: European Competitiveness Report (2001) White Paper on Japan's Science and Technology (annual issue)

(2) Sources of Japan's Low Level of MPT in the 1990s

1) Systems Conflict of Manufacturing Technology in an Information Society

$$V = F(L, K, T) \quad (1)$$

$$\ln V = A + \alpha \ln L + \beta \ln K + \gamma 1 \ln T + \gamma 2\, Dx \ln T \quad (2)$$

$$D_x = \frac{1}{1+e^{-at-b}} = \frac{1}{1+e^{-\frac{\ln((1-\eta)/\eta)}{\varepsilon}t + \ln\frac{1-\eta}{\eta}\left(1+\frac{t_0-\varepsilon}{\varepsilon}\right)}} \quad (3)$$

A: scale factor; α、β、γ: elasticity of labor, capital, technology.

Dx: Coefficient dummy variable corresponding to a shift from an industrial society to an information society and represents adoption of IT.

where t: time period; t_0: turning point; ε: time span; η: margin to the carrying capacity

Table 2 Comparison of the Contribution Orbits of Manufacturing Technology to GDP in Japan and the US *(1975-1999)*

$$\ln V = A + \alpha \ln L + \beta \ln K + \gamma_1 \ln T + \gamma_2 D_x \ln T$$

	α	β	γ_1	γ_2	adj R^2	DW
Japan	0.586 (5.77)	0.370 (3.00)	0.367 (3.39)	-0.009 (-4.08)	0.995	1.42
USA	0.667 (6.87)	0.312 (7.36)	0.357 (10.31)	0.005 (1.65)	0.990	1.17

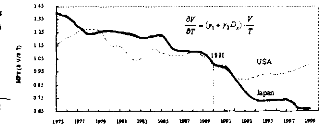

Fig. 7. Trends in Marginal Productivity of Manufacturing Technology in Japan and the US *(1975-1999)* **- Index: 1990=1.**

2) Wrong Choice of a Development Trajectory Options

$V = F(X, T)$　　*V*: *GDP*; *X*: labor (*L*) and capital (*K*); *T*: technology stock

$$\frac{dV}{dt} \equiv \Delta V,\ \frac{dX}{dt} \equiv \Delta X,\ \frac{dT}{dt} \equiv \Delta T \approx R \qquad \text{(R \& D expenditure)}$$

$$\frac{\Delta V}{V} = \sum_{X=L,K}\left(\frac{\partial V}{\partial X}\cdot\frac{X}{V}\right)\frac{\Delta X}{X} + \left(\frac{\partial V}{\partial T}\cdot\frac{T}{V}\right)\frac{\Delta T}{T} \approx \sum_{X=L,K}\left(\frac{\partial V}{\partial X}\cdot\frac{X}{V}\right)\frac{\Delta X}{X} + \underbrace{\frac{\partial V}{\partial T}\cdot\frac{R}{V}}_{\text{TFP growth rate}} \quad (4)$$

Economic growth dependent model: Depend on V - *Growth-Oriented Trajectory*

Contribution to labor and capital; TFP growth rate (technological progress)

$$\frac{\Delta V}{V} = \sum_{X=L,K}\left(\frac{\partial V}{\partial X}\cdot\frac{X}{V}\right)\frac{\Delta X}{X} + \frac{\partial V}{\partial T}\cdot\frac{R}{V}, \qquad \frac{\partial V}{\partial T} = aV\left(1-\frac{1}{FD}\right)$$

Marginal productivity of technology

New functionality development model: Stimulate FD - *New Functionality Development Initiated Trajectory*

$$\frac{\Delta V}{V} = \sum_{X=L,K}\left(\frac{\partial V}{\partial X}\cdot\frac{X}{V}\right)\frac{\Delta X}{X} + \frac{\partial V}{\partial T}\cdot\frac{R}{V}, \qquad \frac{\partial V}{\partial T} = aV\left(1-\frac{1}{FD}\right) \quad (5)$$

R: R&D investment; *a*: Diffusion coefficient; FD: New functionality development $= \bar{V}/V$ ($\bar{V}$: upper limit of *V*- *carrying capacity*)

Fig. 8. Development Trajectory Options.

2.2.2 Japan's High-Technology Firms

(1) R&D Option and Its Consequence

Rise and fall of the leading firms due to a choice of development trajectory can be clearly observed also in Japan's high-technology firms.

Firms which switched to new functionality development trajectory by accelerating technological diversification lead to high level of OIS (Operating Income to Sales) as demonstrated in **Fig. 9**.

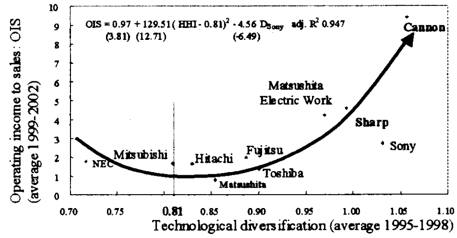

Fig. 9. Correlation between Technological Diversification and OIS in Japan's Top 10 Electrical Machinery Firms *(1999-2002).*

(2) Impediments by the Organizational Inertia

Larger firms incorporate strong organizational inertia cling to growth oriented trajectory resulting in lower level of OIS as demonstrated in **Fig. 10**.

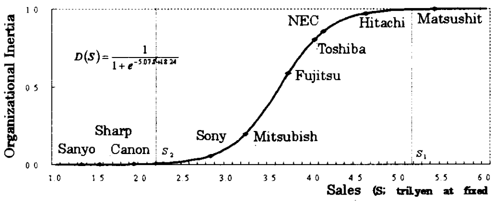

Fig. 10. Trajectory of Organizational Inertia in Japan's Top 10 Electrical Machinery Firms Corresponding to their Sales (1995-1998).

$$D(S)=\frac{1}{1+e^{\ln\left(\frac{\eta}{1-\eta}\right)\left(\frac{1}{S_1-S_0\pm\varepsilon}\right)S-\ln\left(\frac{\eta}{1-\eta}\right)\left(\frac{S_0\pm\varepsilon}{S_1-S_0\pm\varepsilon}\right)}}=\frac{1}{1+e^{-5.07S+18.24}}$$

1995-1998
S0: 2.7, S1: 5.1, ε: 0.9, η: 0.0005

2.3 Price Elasticity of Technology as a Source of Functionality Development

(1) Governing Factor of Co-Evolutionary Dynamism

Marginal productivity of technology (MPT)

$$\frac{\partial V}{\partial T}=aV\left(1-\frac{V}{\bar{V}}\right)=aV\left(1-\frac{1}{FD}\right)=P \qquad (6)$$

V: GDP, T: technology stock, a: Diffusion coefficient, $\bar{V}$: carrying capacity of V trajectory (upper limit); FD: New functionality development, P: Real technology price

Differentiated by time t

$$\frac{\Delta P}{P}=a\Delta T\left(1-\frac{2}{FD}\right) \qquad (7)$$

$$FD=\frac{2}{1-\frac{\Delta P/P}{a\Delta T}}=\frac{2}{1-\frac{\Delta P/P}{aT\frac{\Delta T}{T}}}=\frac{2}{1+\frac{1}{aT\lambda}} \qquad (8)$$

where $\lambda=\frac{\Delta T/T}{-\Delta P/P}$ price elasticity of technology.

(i) FD is governed by price elasticity to technology (λ) as well as technology stock (T) and increases as this elasticity and stock increase.

(ii) Therefore, FD can be interpreted as "**Generate new products with higher value by smaller expenses.**"

(iii) Given that $\lambda > 0$, equation (8) indicates FD < 2 which means $\Delta P/P < 0$ by equation (7). This indicates that marginal productivity of technology diminishes as far as depending on the same trajectory.

(2) Virtuous Cycle Initiated by Price Elasticity to Technology

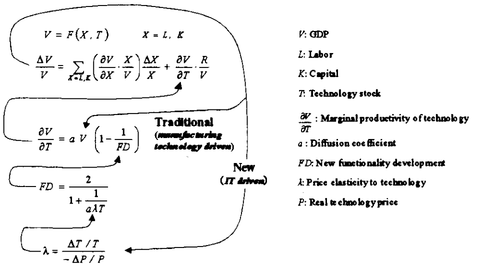

Fig. 11. Virtuous Cycle Leading to New Functionality Development Driven Trajectory.

(3) Self-Propagating Dynamism initiated by Price Elasticity to Technology

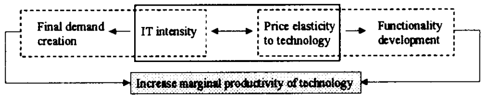

Fig. 12. Correspondence between Self-propagating Nature of IT and New Functionality Development Initiated Development Trajectory.

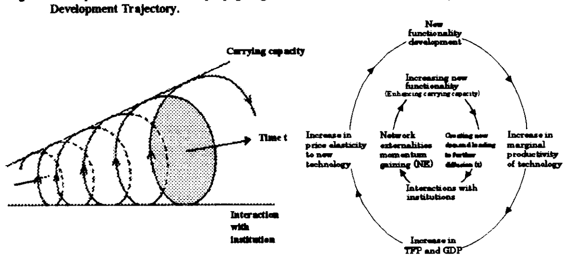

Fig. 13. Self-propagating Mechanism of IT in its Diffusion Process and Corresponding New Functionality Development Initiated Development Trajectory.

3. Co-Evolutionary Dynamism by Learning

3.1 Co-Evolutionary Development of Japan's System of MOT

In the past, Japan's system of MOT successfully achieved a co-evolutionary development as well as the assimilation of advanced innovation primarily from the US as well as Europe and advancement of own institutional systems.

This co-evolutionary development can be traced by the projected trajectory of self-propagating mechanism as demonstrated in **Fig. 14**.

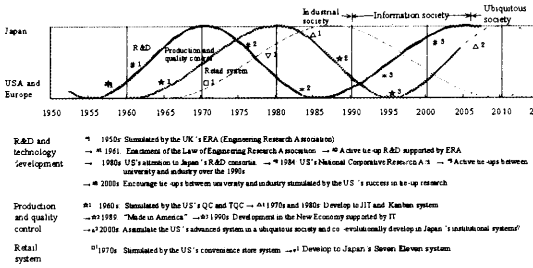

Fig. 14. Trajectory of Co-Evolutional Development of Japan's System of MOT.

3.2 Effects of the Cumulative Learning

While Japan experienced a lost decade in the 1990s due to a system conflict with an information society, it sustained intensive efforts in learning and absorbing advanced technologies and systems from competitors. These efforts included to learning and absorbing from the US initiatives linking university and industry.

As a consequence of this learning, primarily of US's IT driven new economy over the last decade, Japan has been developing into a new phase assimilating cumulative learning as it did in preceding periods and its competitiveness has been improving (**Fig. 15**).

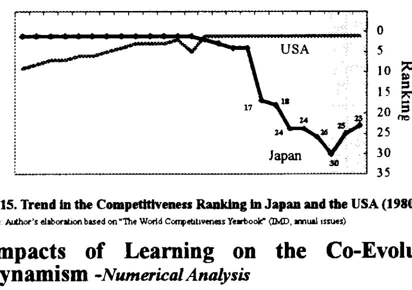

Fig. 15. Trend in the Competitiveness Ranking in Japan and the USA (1980-2004).

Source: Author's elaboration based on "The World Competitiveness Yearbook" (IMD, annual issues)

3.3 Impacts of Learning on the Co-Evolutionary Dynamism *-Numerical Analysis*

(1) Dynamic Behavior of Learning Coefficient

1) Learning Coefficient

Learning effects can be captured by the following equation:

$$P=B\cdot Y^{*-\lambda} \qquad (9)$$

where P: prices (unit cost); B: scale factor; $Y^* = \Sigma SY$: cumulative production (Y: production); and λ (> 0): learning coefficient.

$$\ln P = \ln B - \lambda \ln Y^* \tag{10}$$

$$-\lambda = \frac{\frac{d}{dt}\ln P}{\frac{d}{dt}\ln Y^*} \tag{11}$$

Prices can be depicted by a function of time t, generally proportional to t as follows:

$$P = B' e - \eta t \quad \text{where B': scale factor; } \eta\text{: coefficient; and t: time trend.} \tag{12}$$

$$\frac{d \ln P}{dt} = -\eta \tag{13}$$

2) Trajectory of Diffusion Process

Trajectory of diffusion process of Y* can be depicted by the following epidemic function:

$$\frac{dY^*}{dt} = bY^*(1 - \frac{Y^*}{K}) \quad \text{where b: coefficient; and K: carrying capacity.} \tag{14}$$

$$\frac{d \ln Y^*}{dt} = b(1 - \frac{Y^*}{K}) \tag{15}$$

Y* can be depicted by a following logistic growth function within a dynamic carrying capacity (LFDCC):

$$Y^* = \frac{K_k}{1 + ae^{-bt} + \frac{a_k}{1 - b_k/b} e^{-b_k t}} \tag{16}$$

where $K = \frac{K_k}{1 + a_k e^{-b_k t}}$; K_k: ultimate carrying capacity; and a, a_k and b_k: coefficients.

3) Trajectory of Learning Coefficient

Therefore, learning coefficient λ can be depicted by the following general equation:

$$\lambda = \alpha - \beta \cdot e^{-\gamma t} \quad \text{where } \alpha, \beta, \text{ and } \gamma \text{ are positive coefficients.} \tag{17}$$

Equation (17) suggests that a coefficient γ is a following function:

$$\gamma = \gamma\left((a, b), \left(\frac{a_k}{1 - b_k/b}, b_k\right)\right) \tag{18}$$

The second term in equation (18) is a function of factors governing dynamic carrying capacity and reflecting functionality of the innovation examined.

Since this functionality changes in long run, γ is a function of time t and provide that fluctuation of λ is not so significant as has been empirical observed, λ can be expressed as follows:

$$\lambda = \alpha - \beta \cdot e^{-\gamma(t)t} \cong \alpha - \beta e^{-(b_1 t + b_2 t^2 + b_3 t^3)} \approx (\alpha - \beta) + \beta \cdot b_1 \cdot t + \beta \cdot b_2 \cdot t^2 + \beta \cdot b_3 \cdot t^3$$

Fig. 16 provides a conceptual illustration of the trajectory of learning coefficient.

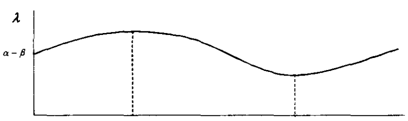

Fig. 16. Trajectory of Learning Coefficient – ***Conceptual Illustration.***

3.4 Effects of the Cumulative Learning to the Reactivation of the Co-Evolutionary Dynamism - *A Case of Japan ' s Leading Electrical Machinery Firms*

(1) Trends in Learning Coefficient: Empirical Analysis

Taking techno-sales trajectory of Japan's leading electrical machinery firms over the period 1980-2003, an empirical analysis is conducted.

Given the competition condition, relative (real) technology price (P) can be measured by the following equation:

$$\frac{\partial S}{\partial T} = P \tag{19}$$

S: sales at fixed prices S = S(X, T) *where X: L (labor) and K (capital); T: technology stock*

Given the logistic growth function within a dynamic carrying capacity (LFDCC), techno-sales trajectory can be depicted as follows:

$$S = \frac{S_K}{1 + e^{(-aT - b)} + \frac{a}{a - a_K} e^{-a_K T - b_K}} \tag{20}$$

Marginal productivity of technology can be measured as follows:

$$\frac{\partial S}{\partial T} = \frac{S_K\left(e^{(-aT-b)} + \frac{aa_K}{a - a_K} \cdot e^{(-a_K T - b_K)}\right)}{\left(1 + e^{(-aT-b)} + \frac{a}{a - a_K} e^{(-a_K T - b_K)}\right)^2} = a\,S\left(1 - \frac{S}{\bar{S}}\right) \tag{21}$$

where $\bar{S}$ is carrying capacity of S trajectory and depicted as follows:

$$\bar{S} = \frac{S_K}{1 + e^{(-a_K T - b_K)}} \quad S_K\text{: ultimate carrying capacity.} \tag{22}$$

Leaning coefficient λ can be computed by the following equation:

$$\ln P = \ln B' - \lambda \ln T$$
$$\lambda = (\alpha - \beta) + \beta \cdot b_1 \cdot t + \beta \cdot b_2 \cdot t^2 + \beta \cdot b_3 \cdot t^3 \tag{23}$$

Table 3 summarized the result of the correlation analysis.

Table 3 Correlation between Price of technology and Governing factors of Learning Coefficients in Japan's Leading Electrical Machinery Firms (1980-2003)

$$\ln P = \ln B' - \left[(\alpha - \beta) + \beta \cdot b_1 \cdot t + \beta \cdot b_2 \cdot t^2 + \beta \cdot b_3 \cdot t^3\right] \ln T$$

	lnB	$(\alpha - \beta)$	$\beta \cdot b_1$	$\beta \cdot b_2$	$\beta \cdot b_3$	adj. R^2	D W	$1980 + \left\lvert \frac{b_2}{2 \cdot b_3} \right\rvert$
Matsushita	-9.94	1.45	-0.030	0.0008	$-4.2 \cdot 10^{-6}$	0.994	2.81	1999
	(-5.61)	(4.92)	(-5.01)	(4.66)	(-1.13)			
Hitachi	-7.47	1.11	-0.024	0.0006	$7.9 \cdot 10^{-6}$	0.997	2.34	2000
	(-3.43)	(2.99)	(-2.73)	(3.64)	(2.13)			
Canon	-7.95	1.47	-0.045	0.0019	$-3.4 \cdot 10^{-5}$	0.989	1.98	1992
	(-3.00)	(2.31)	(-2.05)	(2.62)	(-3.37)			
Sharp	-11.80	2.15	-0.034	0.0010	$-2.5 \cdot 10^{-5}$	0.989	2.01	1997
	(-2.53)	(-2.07)	(-11.42)	(10.95)	(-2.57)			

Table 3 suggests that the 4th term of equation (23) ($\beta \cdot b_3$) is relatively small and learning coefficient can be represented by the quadratic equation for Japan's leading electrical machinery firms examined over the period of 1980-2003.

Fig. 17 demonstrates the trend in learning coefficient in Japan's 4 leading electrical machinery firms examined over the period 1980-2003.

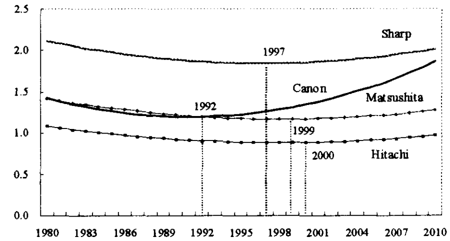

Fig. 17. Trend in Learning Coefficient in Japan's 4 Leading Electrical Machinery Firms *(1980-2003).*

Fig. 17 suggests that while learning coefficient in 4 firms continued to decline, they change to increasing trends in 1992 (Canon), 1997 (Sharp), 1999 (Matsushita), 2000 (Hitachi), respectively reflecting the sustained intensive efforts in learning and absorbing advanced technologies and system from competitors during the period of the lost decade in the 1990s.

(2) Effects of Cumulative Learning to Technology Diffusion

Empirical analysis in the preceding section demonstrates that learning coefficients in Japan's leading electric machinery firms display a quadric curve which suggest the following diffusion trajectory:

$$Y^*(t) = \frac{K_k}{1 + ae^{-bt} + \frac{a_k}{1 - b_k/b} e^{-b_k t} + a_h e^{b_h t^2}} \tag{24}$$

While the last term in the denominator in equation (24) ($a_h e^{b_h t^2}$) represents the effects of the change in the learning coefficient through cumulative learning efforts, this value for firms examined recent years demonstrate negative ($b_2 > 0 \rightarrow a_h < 0$) which indicate a positive contribution of learning effects to accelerate technology diffusion.

Given the LFDCC incorporating learning as enumerated by equation (24), its dynamic carrying capacity is enumerated as follows:

$$K(t) = \frac{K_k}{1 + a_k e^{-b_k t} + [b(b + 2b_h t)] a_h e^{b_h t^2}} \tag{25}$$

Equation (25) suggests that the impacts of the additional term derived from learning effects reveal significantly in enhancing carrying capacity as time runs by in long run as illustrated in **Fig. 18**.

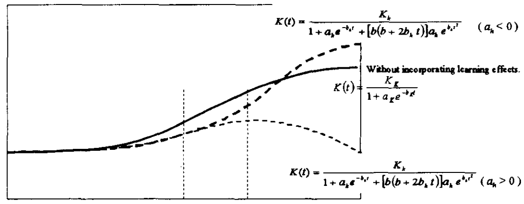

Fig. 18. Estimated the Trajectory of Dynamic Carrying Capacity in Japan's Leading Electrical Machinery Firms ***– Conceptual Illustration.***

Fig. 18 demonstrates a reactivation trajectory as increase in learning coefficient induces functionality development leading to increase in marginal productivity of technology, TFP growth and GDP growth rate.

$$\lambda\uparrow \rightarrow FD\uparrow \rightarrow \frac{\partial V}{\partial T}\uparrow \rightarrow \frac{\Delta TFP}{TFP}\uparrow \rightarrow \frac{\Delta V}{V}\uparrow$$

4. Reactivation of Japan's System of MOT

4.1 Technological Diversification, Assimilation and Learning

In mature economy, in order to increase firms operating income, their R&D should shift from quantitative increase to qualitative elaboration. Noteworthy efforts can be observed in Canon's technological diversification strategy.

This strategy endeavors to develop new functionality by stimulating inter-fields technology spillovers, thereby leveraging co-evolution between indigenously developed or assimilated core technologies and application of these technologies to new fields leading to maximizing the return of R&D investment.

This can be typically observed in wide-ranging application of core technologies to diverse fields as camera and optical technologies to copying machine, facsimile, laser beam printer (LBP) and bubble jet printer (BJ).

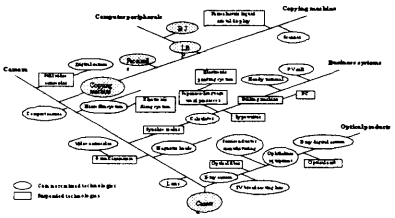

Figure 19. Canon's Technological Diversification Paths Demonstrated by its Inter-Technology Web.

Similar efforts can be observed also in Sharp as illustrated in **Fig. 20**. Sharp also endeavored in wide ranging application of core technologies as liquid crystal in the early 1970s to desk calculator, PC and liquid crystal TV, and also device technology in the early 1990s as flash memory and image sensor to mobile phone carrying liquid crystal, carrying camera, carrying 3D liquid crystal and carrying 2M pixel camera.

Furthermore, both stream of diversified technologies merged to more qualified technologies as game machine, car navigation system, video camera and PDA (Personal Digital Assistance).

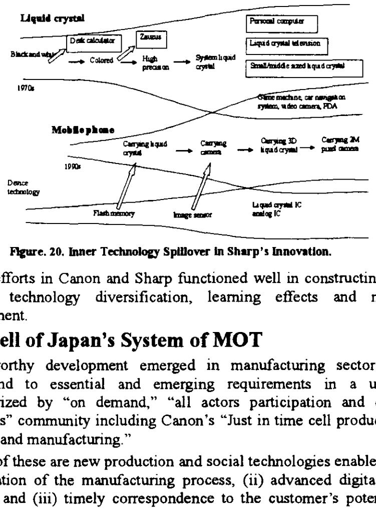

Figure. 20. Inner Technology Spillover in Sharp's Innovation.

These efforts in Canon and Sharp functioned well in constructing a virtuous cycle between technology diversification, learning effects and new functionality development.

4.2 Swell of Japan's System of MOT

Noteworthy development emerged in manufacturing sector in recent years correspond to essential and emerging requirements in a ubiquitous society characterized by "on demand," "all actors participation and cooperation," and "seamless" community including Canon's "Just in time cell production" and Sharp's "On demand manufacturing."

Most of these are new production and social technologies enabled by (i) increasing digitalization of the manufacturing process, (ii) advanced digital infrastructure or alliance, and (iii) timely correspondence to the customer's potential desire in the digital economy.

All can be attributed to the resonance between indigenous strength in the Japanese firms developed and incorporated during the course of an industrial society and the effects of cumulative learning actively absorbed from their competitors in an information society and assimilated in their business model.

This suggests that Japan's indigenous MOT is again responding to a co-evolutionary dynamism between the emergence of innovation and advancement of institutional systems, and is adopting to new requirements in a ubiquitous society.

Given that the foregoing swell could be incorporated in Japan's institutional systems, reactivation of Japan's system of MOT can be expected and may provide additional demonstrations of the significance of the co-evolutionary dynamism between the emergence of innovation and advancement of institutional systems demonstrated by the Japanese indigenous system of MOT up until the end of the 1980s.

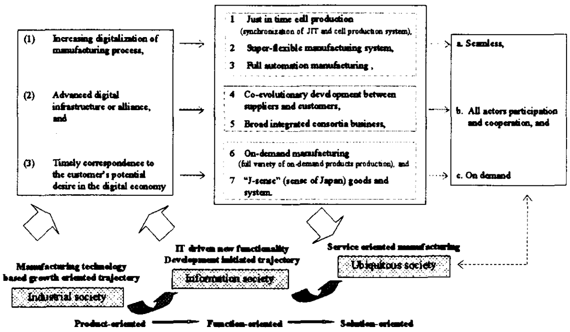

Fig. 21. Swell of Japan's New Innovation.

4.3 Accruing Japan's System of MOT to Global Assets

Therefore, identifying the source of the impeding function of Japan's indigenous system of MOT and demonstration of the significance of the co-evolutionary dynamism up until the end of the 1980s is important.

This is useful for conceptualizing and operationalizing the co-evolutionary dynamism accruing to global knowledge assets in a ubiquitous society.

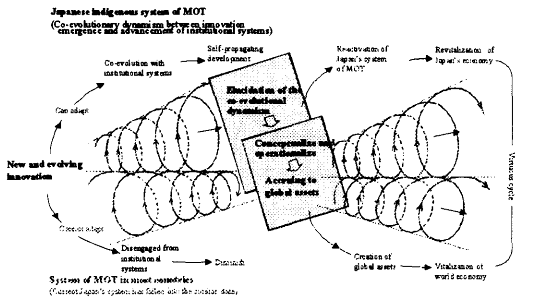

Fig. 22. Co-Evolutionary Dynamism between Emergence of Innovation and Advancement of Institutional Systems.

5. Conclusion

Prompted by a postulate that the innovation highly depends on institutional systems and that Japan's system of MOT indigenously incorporates an explicit function to induce this co-evolutionary dynamism, this dynamism was examined. Noteworthy findings and consequent suggestions include:

(i) While Japan's system of MOT indigenously incorporates an explicit function to induce the foregoing co-evolution, current stagnation can be attributed to a system conflict between a new paradigm shifting from an industrial society to an information society and its traditional institutional systems.

(ii) On the basis of cumulative learning efforts over the last decades and assimilation of the global knowledge suggests the possibility that Japan's MOT is shifting to a new phase.

(iii) Japan's institutional systems incorporates the potential capability in adapting and corresponding better to a ubiquitous society rather than to the current information society characterized by functionality driven self-propagation.

(iv) Thus, the foregoing cumulative learning effects suggest that Japan's system of MOT could reactivate toward a ubiquitous society.

(v) Identification of the source impeding the function of Japan's indigenous system of MOT and elucidation of the mechanism of its co-evolutionary dynamism is useful for conceptualizing and operationalizing the co-evolutionary dynamism accruing to global knowledge assets in a ubiquitous society.

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