23rd Jyvaskyla
Summer School
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COM8
Techno-economic Systems Institutional Innovation (6)

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COM8: Techno-economic Systems, Institutional Innovation

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AM: 10-12 am PM: 13-15pm

1. **7 Aug (W) AM Technological innovation, growth, diffusion and consumption**
2. **PM Productivity, technological progress, competitiveness**

3. **8 Aug (T) AM Diffusion of technology, Effects of learning**
4. **PM Technology spillover, Rate of return to R&D investment**

5. **9 Aug (F) AM Basic concept of institutional innovation**
6. **PM New Stream for institutional innovation**

Identity: SEARCH Systems approach, **Empirical** approach, **Analytical** approach, challenge to **Rationale, Comprehensive** approach, with **Historical** perspective

Institutional Innovation

1. Basic Concept of Institutional Innovation

2. New Stream for Institutional Innovation

2.1 New Stream of Inst. Innov. toward Post-excessive Cons. Soc.

2.2 Acclimatization

2.3 Innovation-Consumption Co-emergence

2.4 Dynamism of Innovation – Consumption Co-emergence

2.5 Supra-functionality beyond Economic Value

2.6 A Way to Supra-functionality

2.7 Growth Option

- Supra-functionality Seeking or Economic Functionality Oriented

2.1 New Stream of Inst. Innov. twd Post-excessive Consp. Socit.

(1) Shift of Growth Engine

1) Strategy for Substitution

Table 1 Concept of Imitator Substitutes for Innovator

Innovator	Imitator
Leader	Follower
Supplier	Customer
Producer	Consumer
Fear to new products	Gratification of consumption

Sustainable Functionality Development (FD)

⇕

***q* (imitator) substitutes for *p* (innovator)** ⇔ **Assimilation of spillover technology**

⇔ **Customer substitutes for supplier**

⇔ **Open innovation**

⇔ **Coopetiotion (Cooperation and competition)**

⇔ **Co-evolutionary domestication**

⇕

Knowledge transfer

⇕

⇔ **Hybrid management of technology**

2) Chronology of the Shift of Growth Engine

$$Y = F(X, T) \quad \Rightarrow \quad \frac{\Delta Y}{Y} = \sum \left(\frac{\partial Y}{\partial X} \cdot \frac{X}{Y} \right) \frac{\Delta X}{X} + \frac{\partial Y}{\partial T} \cdot \frac{R}{Y}$$

$$\frac{\partial Y}{\partial T} = aY\left(1 - \frac{1}{FD}\right)$$

Increase in

X

R → by R&D invest.
R → through T substitution for X

$\frac{\partial Y}{\partial T}$ → by Y increase
$\frac{\partial Y}{\partial T}$ → by FD increase

FD → by sustainable FD self-propagating FD
FD → by open innovation

Supply — **Production func.**

Diffusion — **Innofusion func.**

Consumption — **Innofumption func.**

Chronology of the Shift of Growth Engine.

(2) Shifting from Production to Innofusion and to Innofumpsion

1) Innovation at Production Cite

2) Innovation through Diffusion - *Innofusion*

3) Innovation by Gratification of Consumption - *Innofumption*

⇩

Co-emergence of Innovation and Consumption

Integration of Production, Diffusion and Utility Functions - *Innofumption*

(i) Production Function

$$Y = F(X,T) \Rightarrow \frac{\Delta Y}{Y} = \sum\left(\frac{\partial Y}{\partial X}\cdot\frac{X}{Y}\right)\frac{\Delta X}{X} + \frac{\partial Y}{\partial T}\cdot\frac{R}{Y}$$

(ii) Diffusion Function (Cumulative Y diffuses as a function of T)

$$\frac{\partial Y}{\partial T} = aY\left(1-\frac{Y}{N}\right) = aY\left(1-\frac{1}{FD}\right) \qquad \frac{\partial N}{\partial T} = a' N\left(1-\frac{N}{N_k}\right)$$

(iii) Production Diffusion Integration — *Innofusion*

Growth rate — Traditional production factors — **TFP** increase rate

$$\frac{\Delta Y}{Y} = \sum\left(\frac{\partial Y}{\partial X}\cdot\frac{X}{Y}\right)\frac{\Delta X}{X} + \frac{\partial Y}{\partial T}\cdot\frac{R}{Y}$$

MPT — R&D intensity

$$\frac{\partial Y}{\partial T} = aY\left(1-\frac{1}{FD}\right)$$

Functionality development

In order to maintain sustainable FD, further integration of utility function is indispensable.

(iv) Production, Diffusion and Utility Integration — *Innofumption*

Technology substitution for constrained production factors

$$\sigma_{TX} = \frac{\ln T/X}{\ln\frac{\partial Y}{\partial X} - \ln\frac{\partial Y}{\partial T}}$$

σ_{TX}: Elasticity of technology substitution (ETS) for X, and c: coefficient.

$$\frac{\Delta Y}{Y} = \sum\left(\frac{\partial Y}{\partial X}\cdot\frac{X}{Y}\right)\frac{\Delta X}{X} + \frac{\partial Y}{\partial T}\cdot\frac{R}{Y}$$

$$\frac{\partial Y}{\partial T} = aY\left(1-\frac{1}{FD}\right)$$

Utility function

$$U(FD) \rightarrow C \rightarrow Y \rightarrow R \rightarrow T \rightarrow N \rightarrow FD$$

1. ***FD* enhances utility which induces *C*** (consumption) **leading to *Y* increase.**
2. **Increased *Y* induces *R*** (R&D) **leading to *T*** (technology stock) **increase.**
3. **Increased *T* enhances *N*** (carrying capacity) **leading to *FD*** (= N/Y) **increase.**
4. **Increased *FD* increases MPT which induces higher ETS.**
5. **Higher ETS induces *X* productivity increase** ($\frac{Y}{T}\cdot\frac{T}{X} = \frac{Y}{X}$)

(3) Shifting from Competition to Coopetition and to Actipetition

(1) Competition - *Sources of Japan's Vigorous R&D Efforts*

(2) Cooperation and Competition – *Coopetition* (A. Brandenburger and B. Nalebuff, 1996)

(3) Activate and Competition – *Actipetition* (C. Watanabe, 2009)

Acclimatization

Co-emergence of innovation and consumption

M. Porter (2011)**: Creating Shared Value (CSV)**

A business needs a healthy, educated workforce, sustainable resources and adept government to compete effectively.

For society to thrive, profitable and competitive business must be developed and supported to create income, wealth, tax revenues, and opportunities for philanthropy.

2.2 Acclimatization

(1) Concept of Acclimatization

Domestication

Process whereby a population of animals or plants, through a process of artificial selection, becomes accustomed to human provision and control.

Acclimatization

1. **To get used a new place, situation or climate**
2. **The process in a individual organism adjusting to a gradual change in its environment**
   (in temperature, humidity, photoperiod, pH)

1. **Artificial selection based on humans experiences,**
2. **Multi-functionalities (economic, social, cultural, aspirational, emotional, and spiritual),**
3. **Instills in humans an exciting story with their own initiative as heroes and thrills them with gratification**

(2) Concept of Co-evolutionary Acclimatization

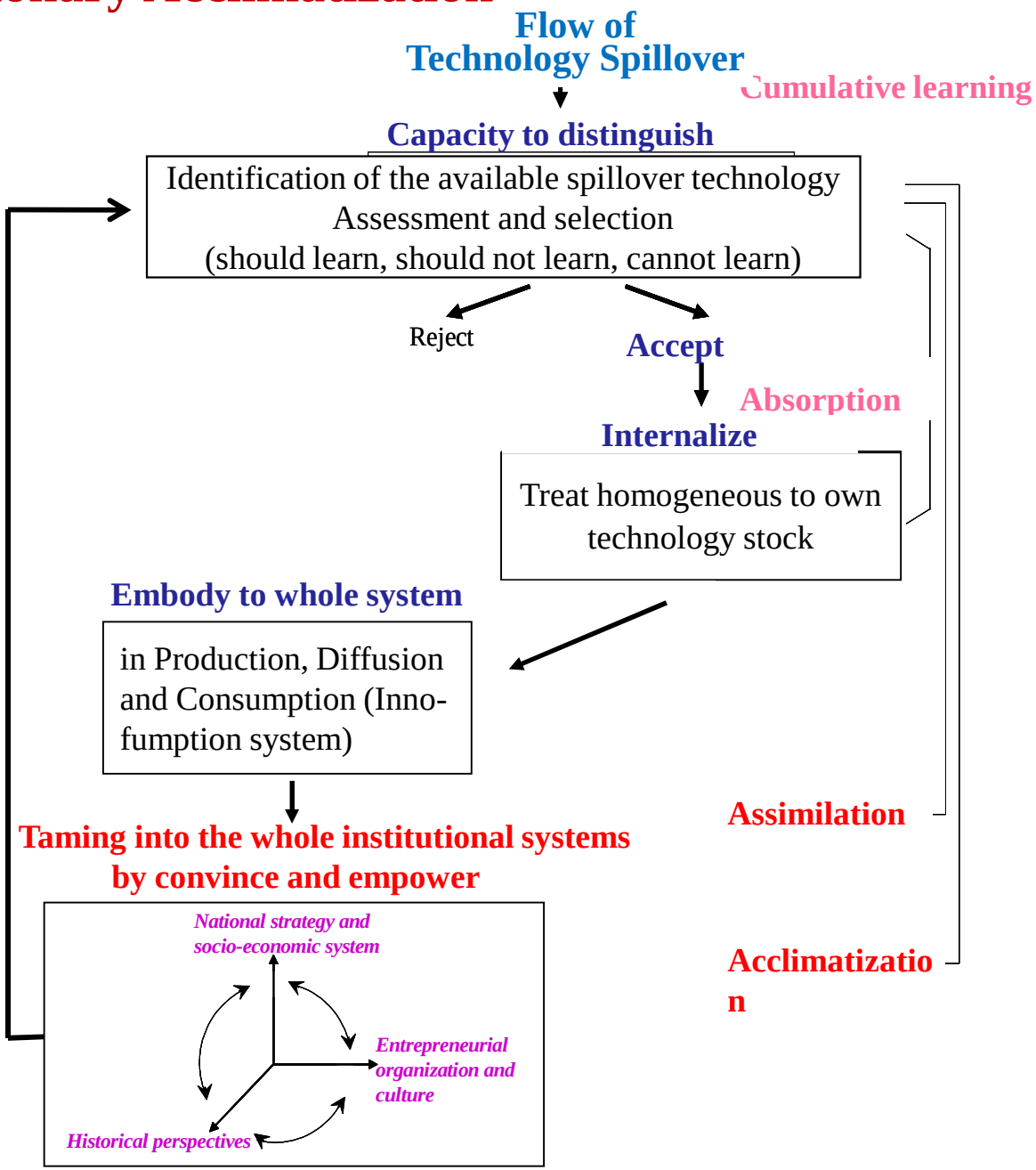
1. **Cumulative learning** cultivate the capacity of distinguishing technology spillover flows by assessing and selecting them into
   (i) Should learn,
   (ii) Should not learn, and
   (iii) Can not learn

   leading to **absorptive capacity** to be able to treat accepted spillover technologies homogeneous to own technology stock.

2. Through co-evolutionary exercise of absorption **assimilation capacity** can be developed thereby to be able to embody absorbed technology to whole system in
   (i) Production,
   (ii) Diffusion, and
   (iii) Commercialization.

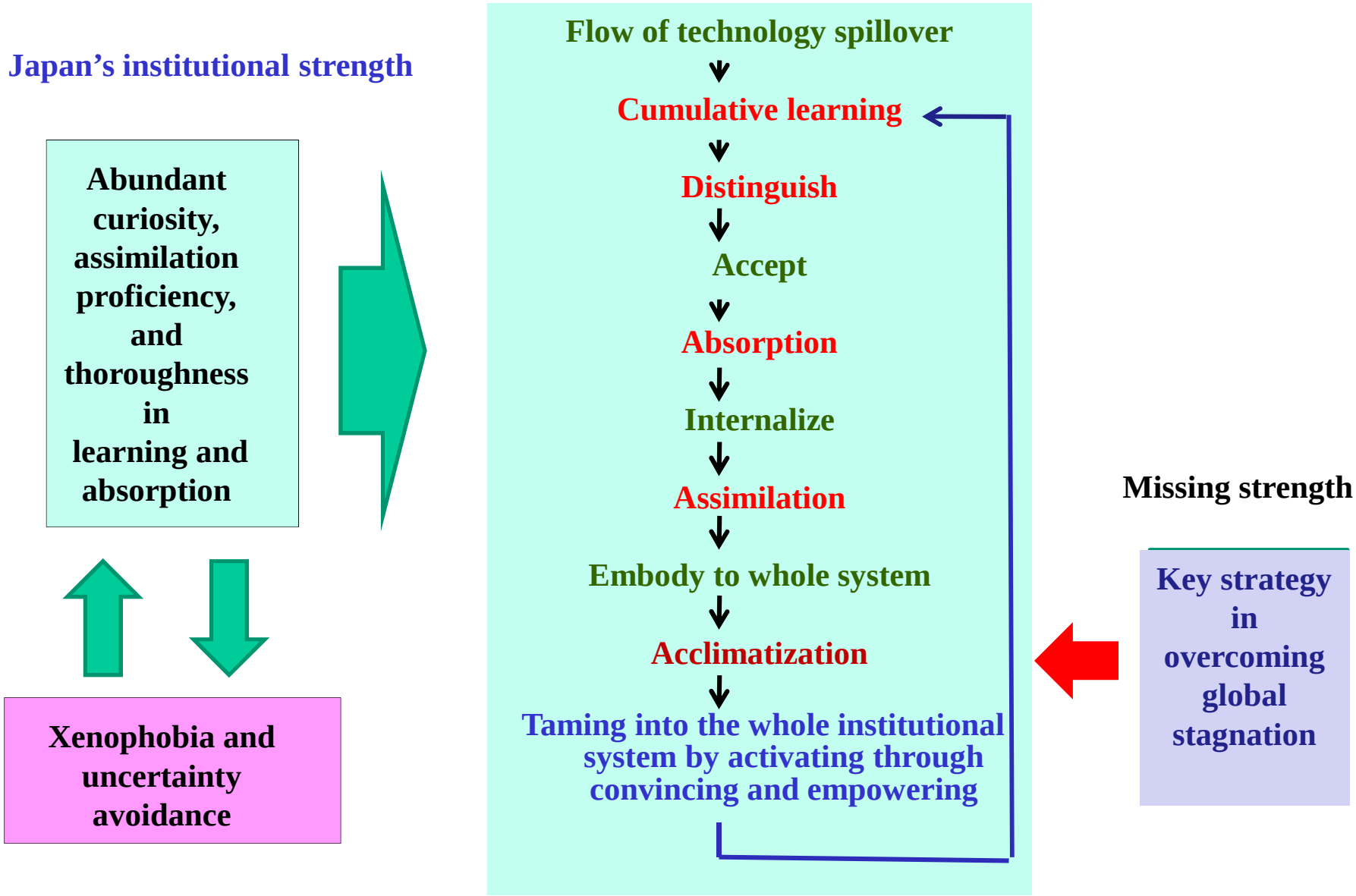
3. This ability then develop to **acclimatization** thereby **taming** assimilated spillover technology into the whole institutional system **by activating it through convincing and empowering**.

4. Accimatized technology/knowledge in turn further improve distinguishing capacity, absorption, assimilation and domestication ability in a co-evolutionary way



The Concept of Co-evolutionary Acclimatization.

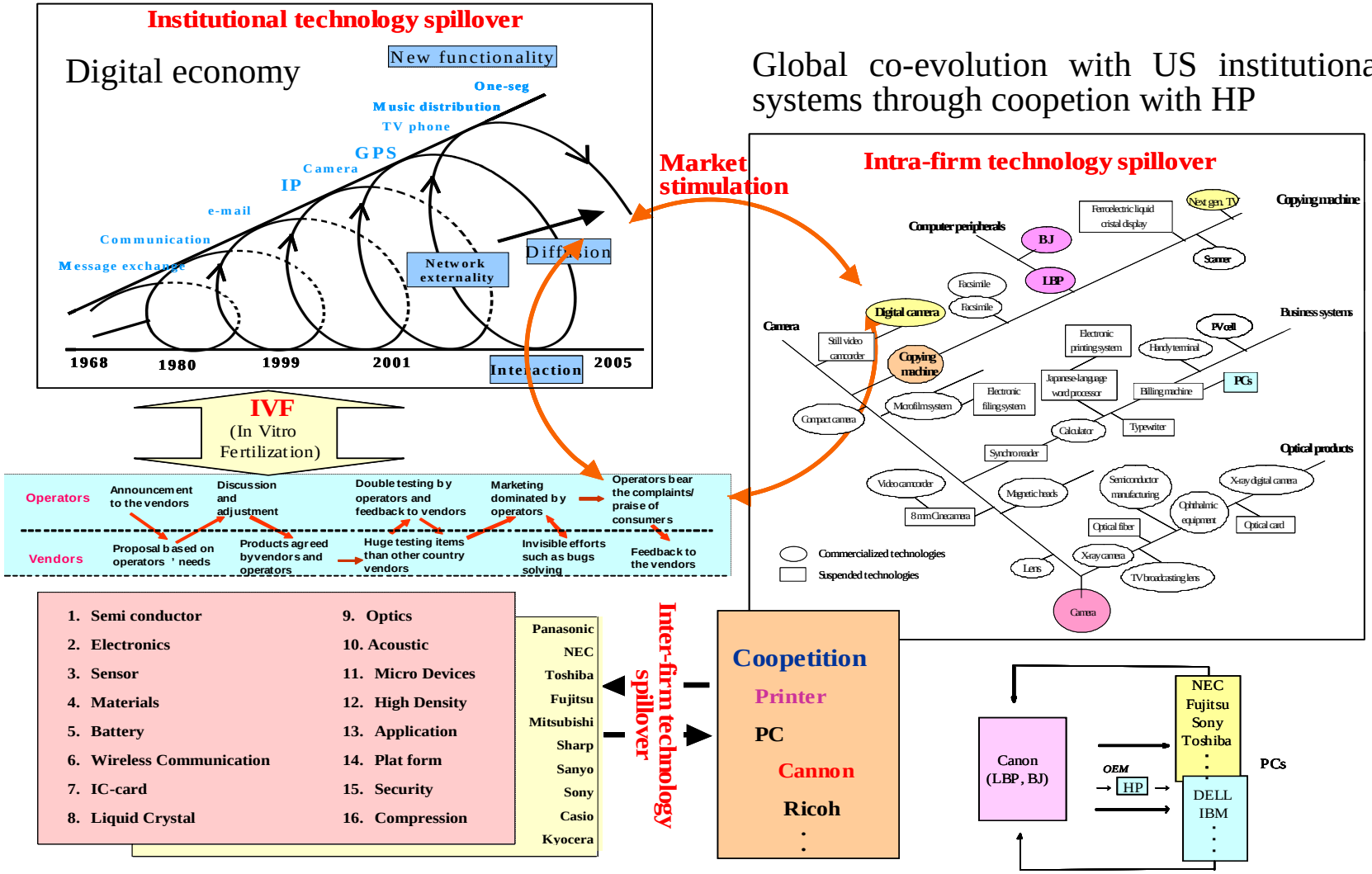
(3) Institutional Sources Leveraging Co-evolutionary Acclimatization



The Concept of Co-evolutionary Acclimatization.

(4) Co-evolutionary Acclimatization through Hybrid Management

Canon's hybrid management consists of (i) Market stimulation, (ii) Institutional technology spillover, (iii) In vitro fertilization, (iv) Acclimatization through coopetition, and (v) intra-firm technology spillove



Scheme of Canon's Co-evolutionary Acclimatization.

2.3 Innovation – Consumption Co-emergence

(1) Bi-polarization in High-technology Firms Profit: Net income *(2011/4-12/3)*

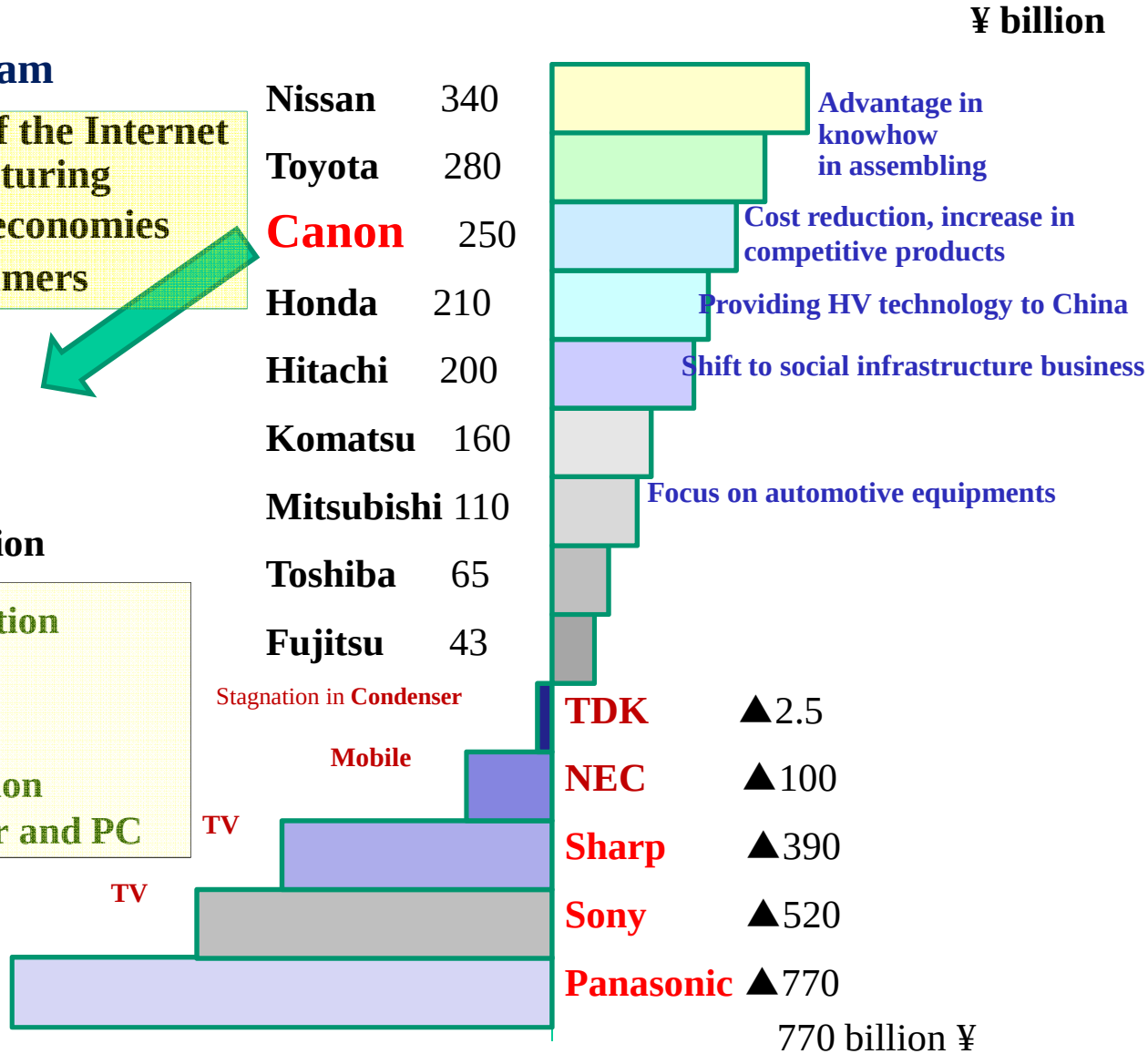
Beyond anticipation stream

(1) Dramatic advancement of the Internet
(2) Digitalization of manufacturing
(3) New stream of emerging economies
(4) Increasing anger of consumers

Canon's unique business model

Co-evolutionary acclimatization

1. Technological diversification strategy leveraging intra technology learning
2. Cooperation and competition (coopetition) between printer and PC

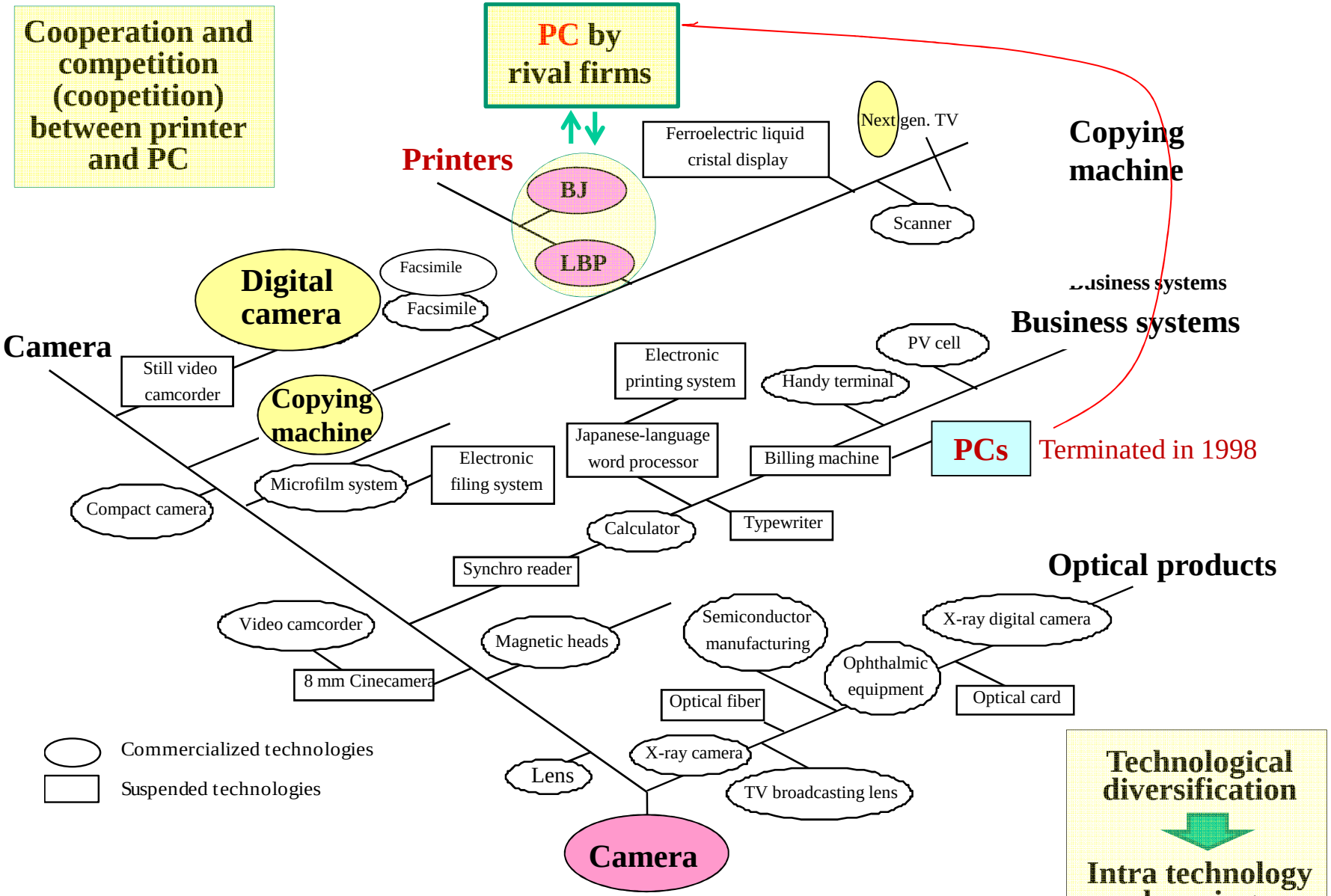


770 billion ¥
= 8 billion Euro

Co-emergence of Innovation and Consumption

(2) Canon's Unique Business Model

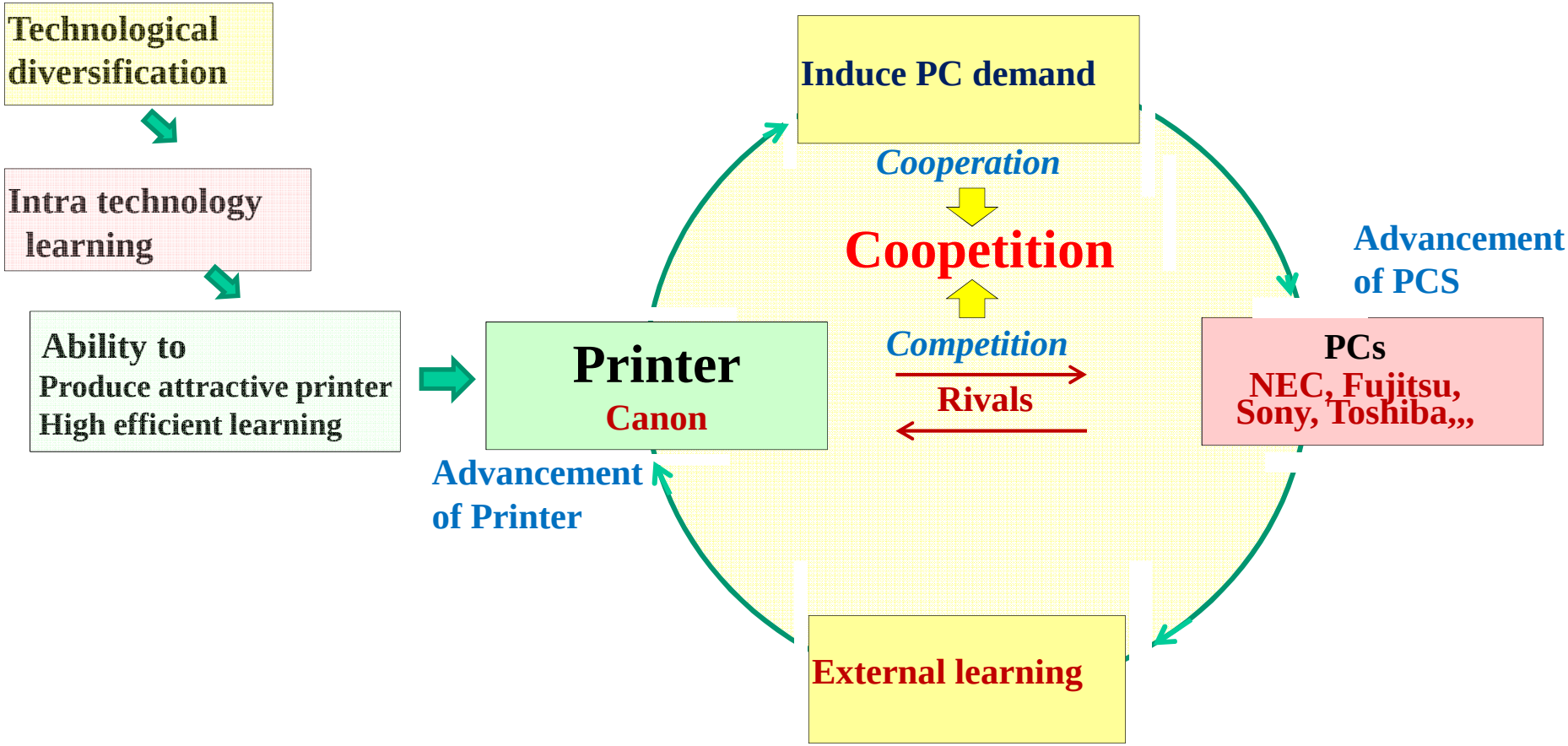
1) Technological Diversification Strategy



Canon's Identical Business Model.

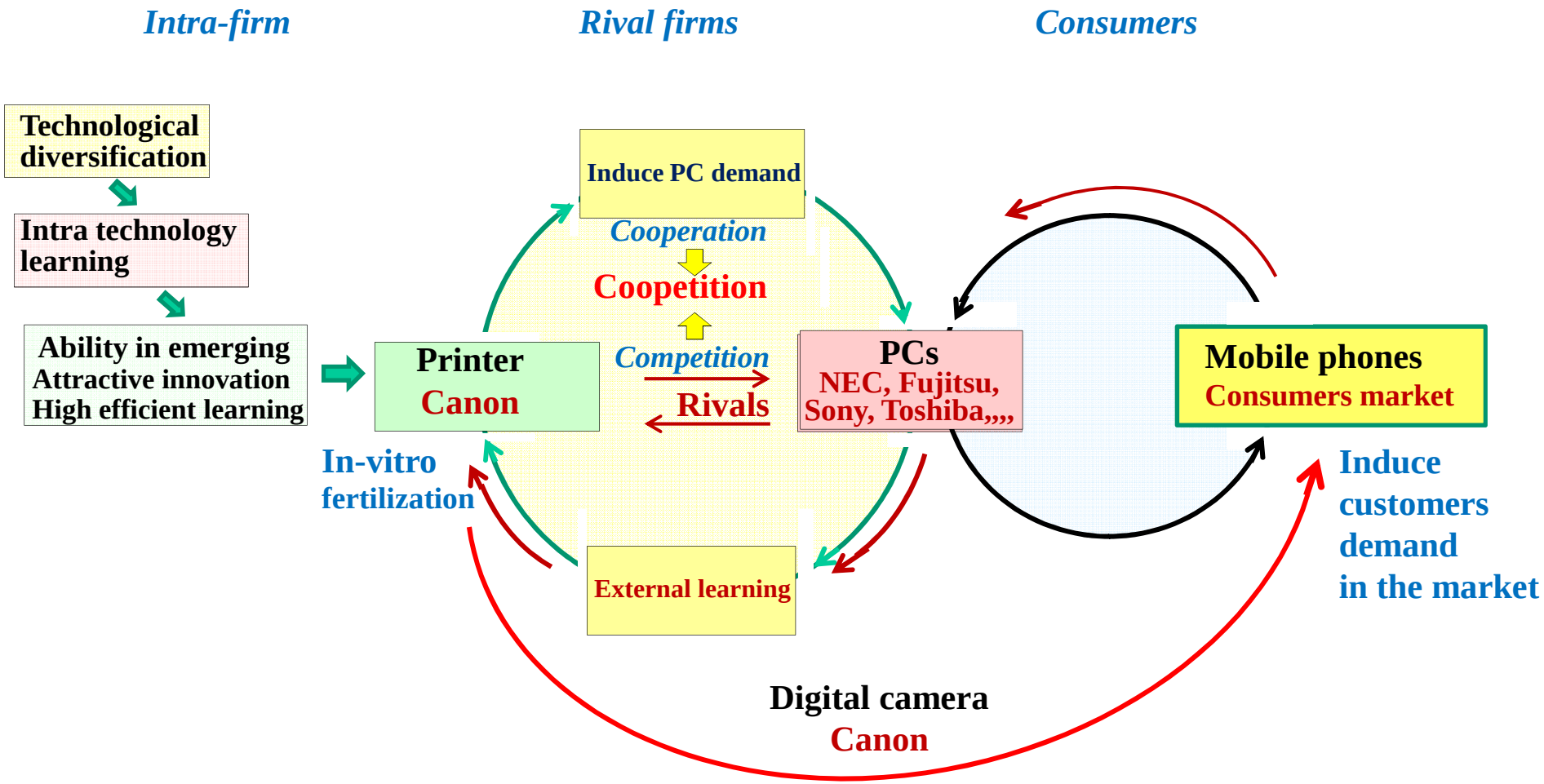
2) Virtuous Cycle between Printers and PCs

- Learning by Inspiring Competitors - Coopetition



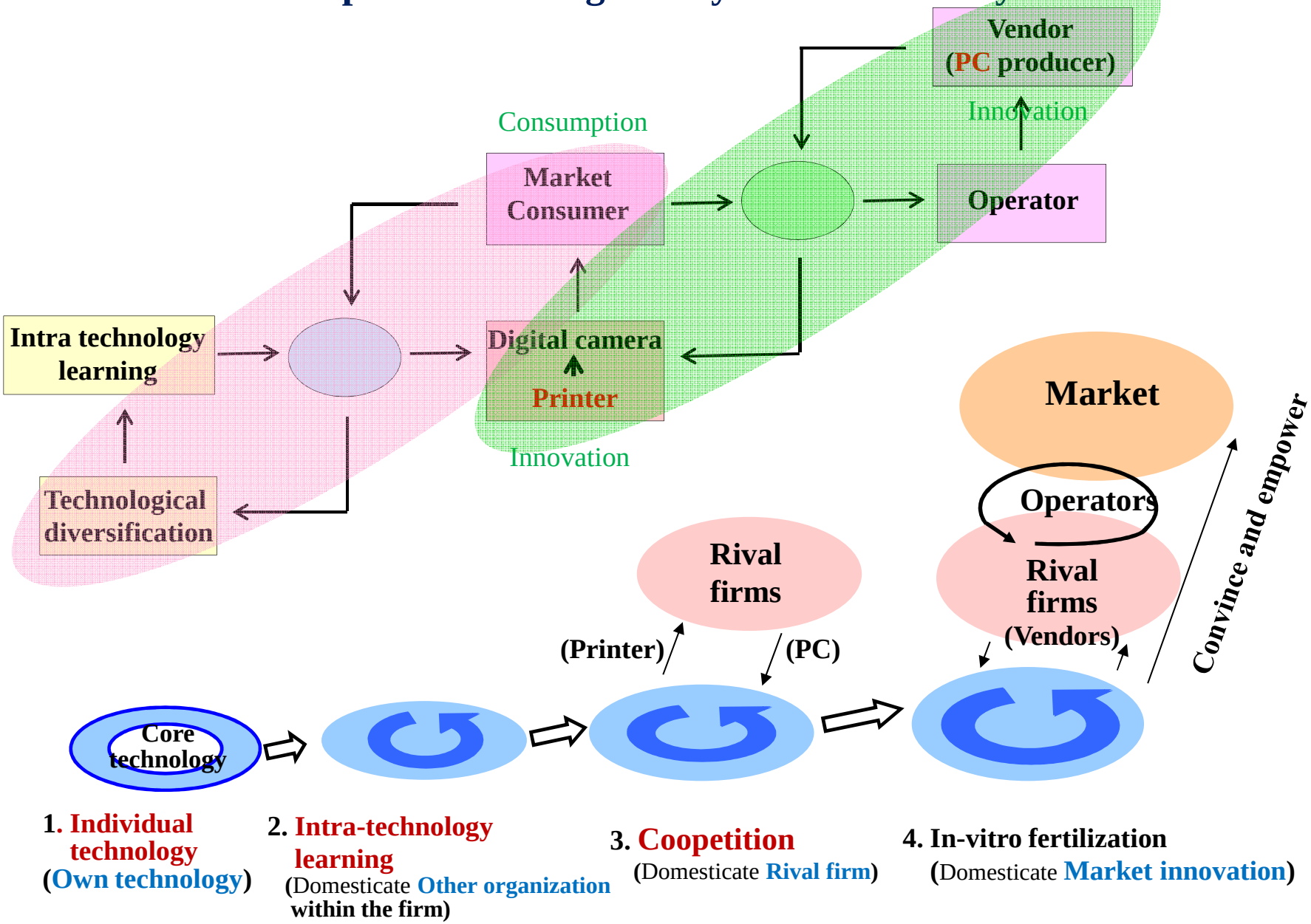
Virtuous Cycle between Canon Printers and PCs.

3) Acclimatization of Consumers Demand



Dynamism in Co-emerging Innovation and Consumption - In-vitro fertilization.

4) Innovation-Consumption Co-emergence by Co-evolutionary Acclaimatization



Canon's Business Model in Co-emerging Innovation and Consumption.

2.4 Dynamism of Innovation - Consumption Co-emergence

(1) From Innofusion to Innofumption

1) Limit of co-evolutionary domestication by firm level

(i) Bi-polarization
(ii) Stagnation of IT
(iii) Consumption haters

→ **Vicious cycle** → **Limit of co-evolutionary domestication by firm level**

↓

Construct this dynamism between Tech. and Cons.

↓

Integration of Consumption Function → **2) Innofumption**

↓

3) Co-emergence of Tech. and Cons. → **Spirally developing virtuous cycle**
→ **Supra-functionality beyond economic value**

4)Tech. and Cons. Co-emergence can be triggered by Resonance between signals emitted by Tech. and Cons. : *Affordance* (Gibson, 1977)

→ **Resonance theory**

5) Resonance is induced by Learning of Tech. and Cons. → Learning theory

(2) Integration of Production, Diffusion and Utility Functions: Innofumption

(i) Production Function

$$Y = F(X,T) \Rightarrow \frac{\Delta Y}{Y} = \sum\left(\frac{\partial Y}{\partial X}\cdot\frac{X}{Y}\right)\frac{\Delta X}{X} + \frac{\partial Y}{\partial T}\cdot\frac{R}{Y}$$

MPT

R&D intensity

(ii) Diffusion Function (Cumulative Y diffuses as a function of T)

$$\frac{\partial Y}{\partial T} = aY\left(1-\frac{Y}{N}\right) = aY\left(1-\frac{1}{FD}\right)$$

$$FD = N/Y \quad = 1 + be^{-at}$$

Functionality development

Declining nature

(iii) Production Diffusion Integration — *Innofusion*

Growth rate

Traditional production factors

TFP increase rate

$$\frac{\Delta Y}{Y} = \sum\left(\frac{\partial Y}{\partial X}\cdot\frac{X}{Y}\right)\frac{\Delta X}{X} + \frac{\partial Y}{\partial T}\cdot\frac{R}{Y}$$

$$\frac{\partial Y}{\partial T} = aY\left(1-\frac{1}{FD}\right)$$

Functionality development

In order to maintain **sustainable FD**, **self-propagating FD cycle** should be constructed by means of **integration of utility function**

(iv) Production, Diffusion and Utility Integration — *Innofumption*

Technology substitution for constrained production factors

ETS

$$\sigma_{TX} = \frac{\ln T/X}{\ln\frac{\partial Y}{\partial X} - \ln\frac{\partial Y}{\partial T}}$$

σ_{TX} : Elasticity of technology substitution (ETS) for X, and c: coefficient.

$$\frac{\Delta Y}{Y} = \sum\left(\frac{\partial Y}{\partial X}\cdot\frac{X}{Y}\right)\frac{\Delta X}{X} + \frac{\partial Y}{\partial T}\cdot\frac{R}{Y}$$

$$\frac{\partial Y}{\partial T} = aY\left(1-\frac{1}{FD}\right)$$

MPT

Utility function

$$U(FD) \rightarrow C \rightarrow Y \rightarrow R \rightarrow T \rightarrow N \rightarrow FD$$

Co-emergence of T and C

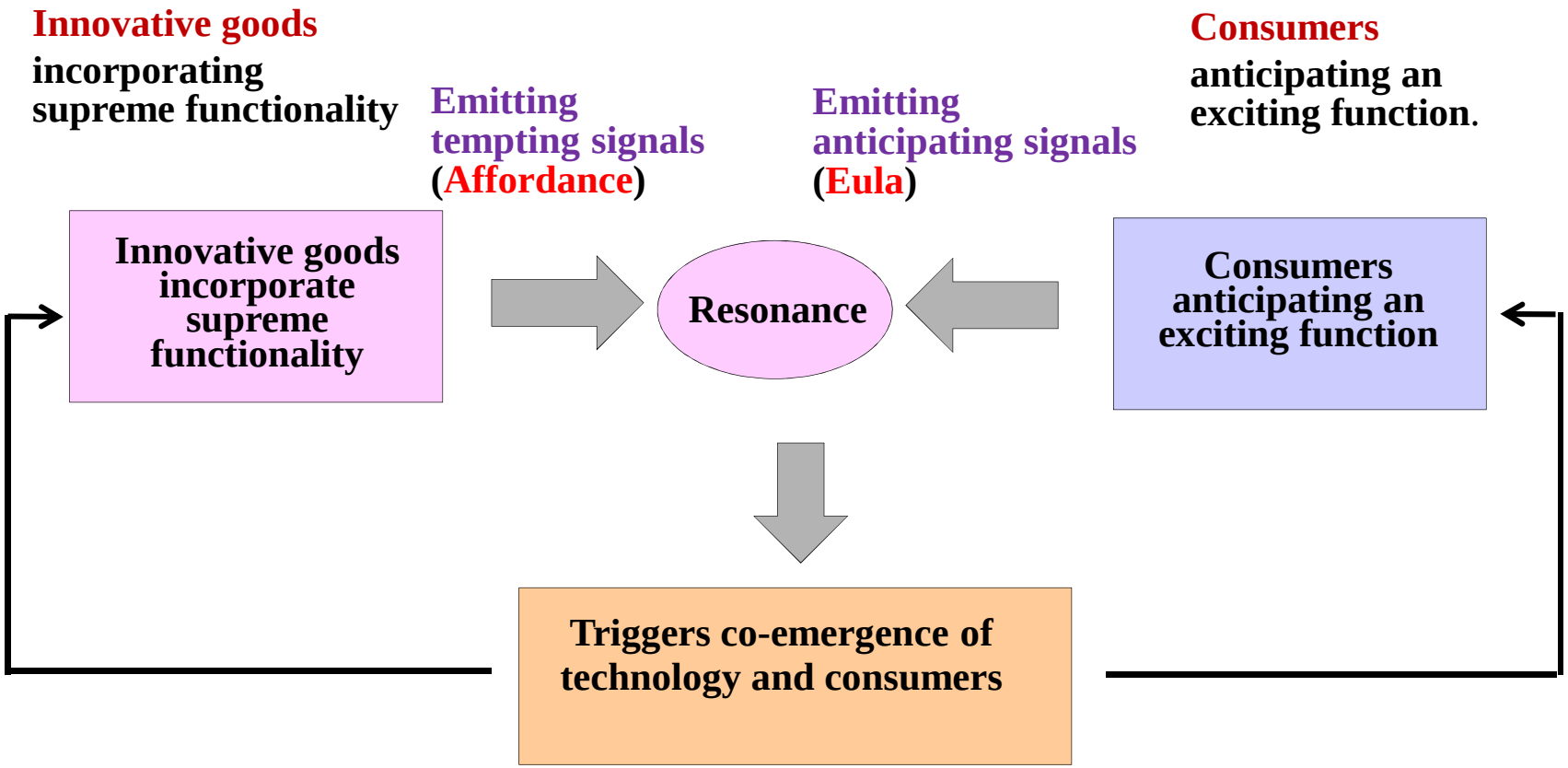
1. ***FD*** **enhances utility which induces *C*** (consumption) **leading to *Y* increase.**
2. **Increased *Y* induces *R*** (R&D) **leading to *T*** (technology stock) **increase.**
3. **Increased *T* enhances *N*** (carrying capacity) **leading to *FD*** (= *N/Y*) **increase.**
4. **Increased *FD* increases MPT which induces higher ETS.**
5. **Higher ETS induces *X* productivity increase** ($\frac{Y}{T}\cdot\frac{T}{X} = \frac{Y}{X}$)
6. **Increased productivity increases *Y* leading to self-propagating FD**

Integration of Production, Diffusion and Utilization Functions: *Innofumption*.

(3) Resonance between Innovation and Consumption

1) Resonance of Signals Emitted by Innovative Goods and Consumers

Innovative goods incorporating supreme function emit tempting signals, while consumers anticipating exciting function emit anticipating signals. Both resonates each other and triggers co-emergence of technology and consumers.



Resonance of Signals Emitted by Innovative Goods and Consumers.

2) Resonance between Technology and Consumption in Mobile Phones

(i) T and C Resonance

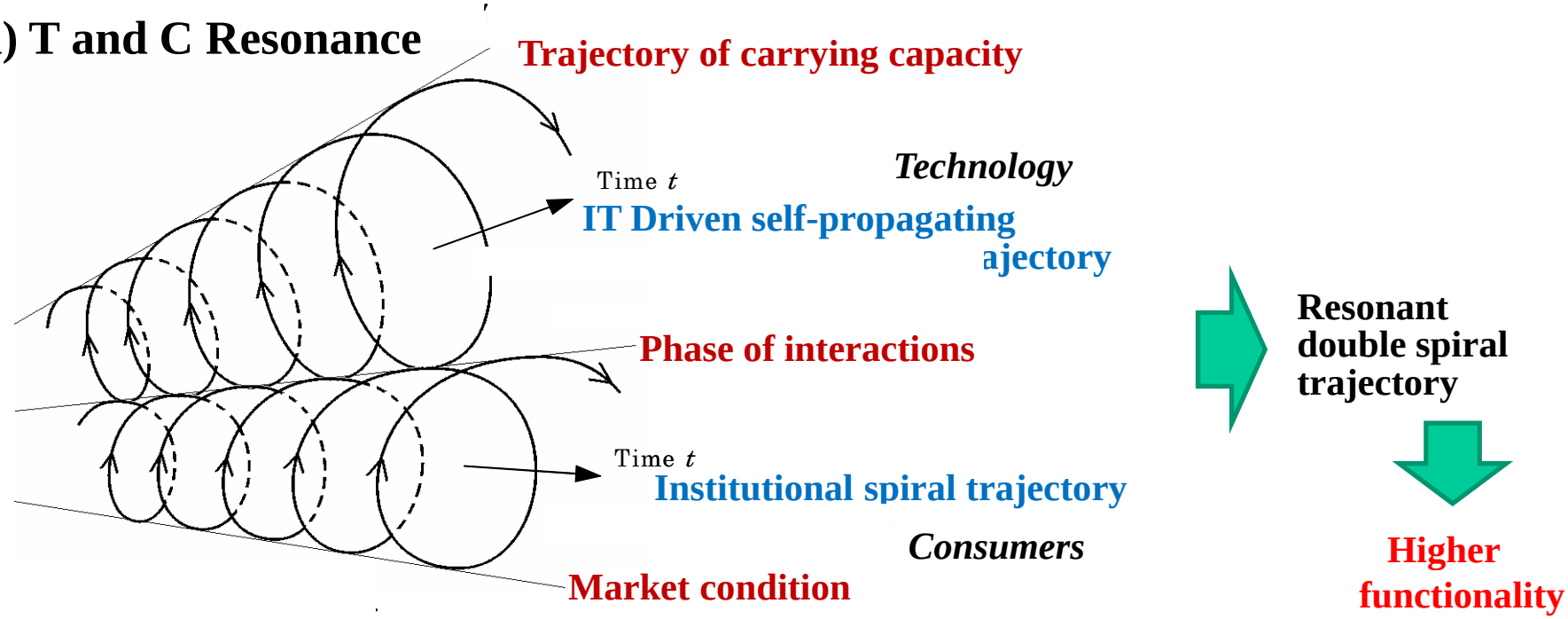
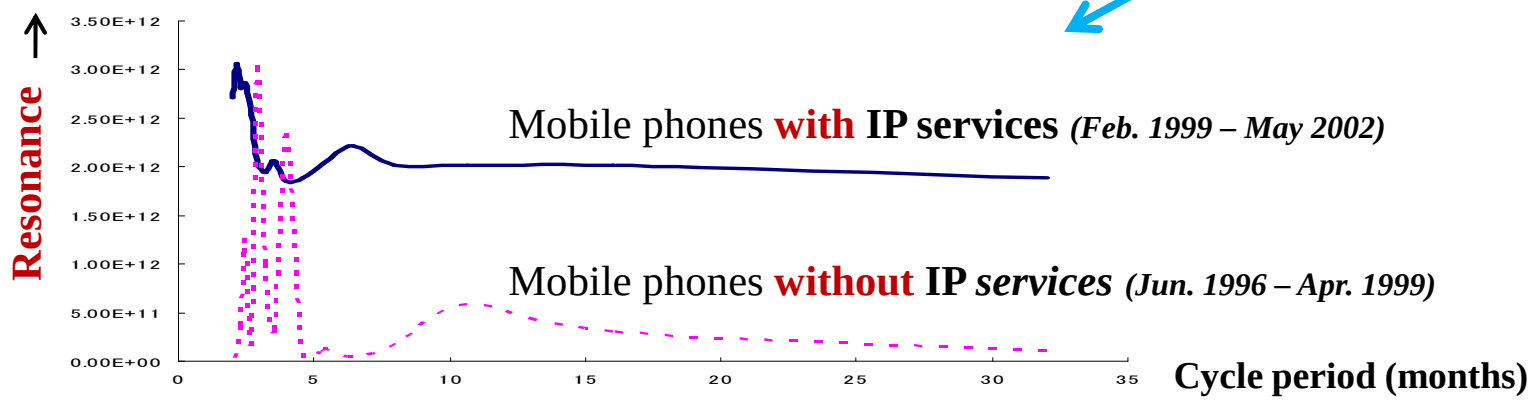


Fig. 11. Resonant Double Spiral Trajectory.

(ii) Trigger Co-emergence

Power spectral density

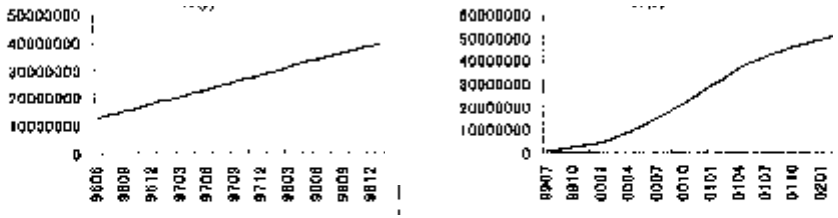


Comparison of Periodograms on the Development Trajectory of MP with and without IP Services.

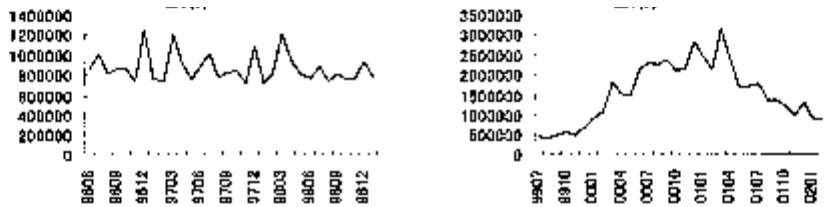
3) Spectrum Analysis of the Diffusion Trajectory of Japan's Mobile Phones

without IP services **with IP services**

Number of subscribers *N(t)*



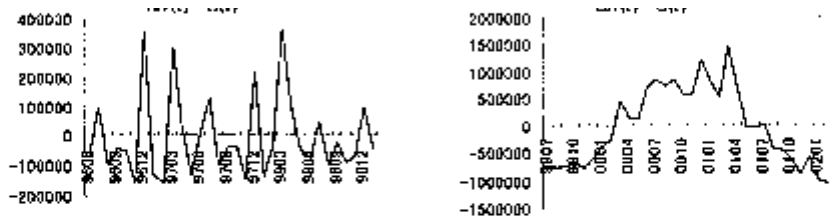
Difference: New purchase $\Delta N(t)$



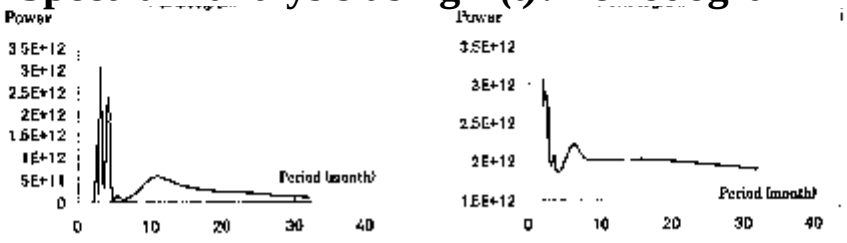
Resonance can be anticipated

Time trend

Trend in new purchase eliminating time trend $\Delta N(t) - G(t) \equiv F(t)$



Spectrum analysis using *F(t)*: Periodogram

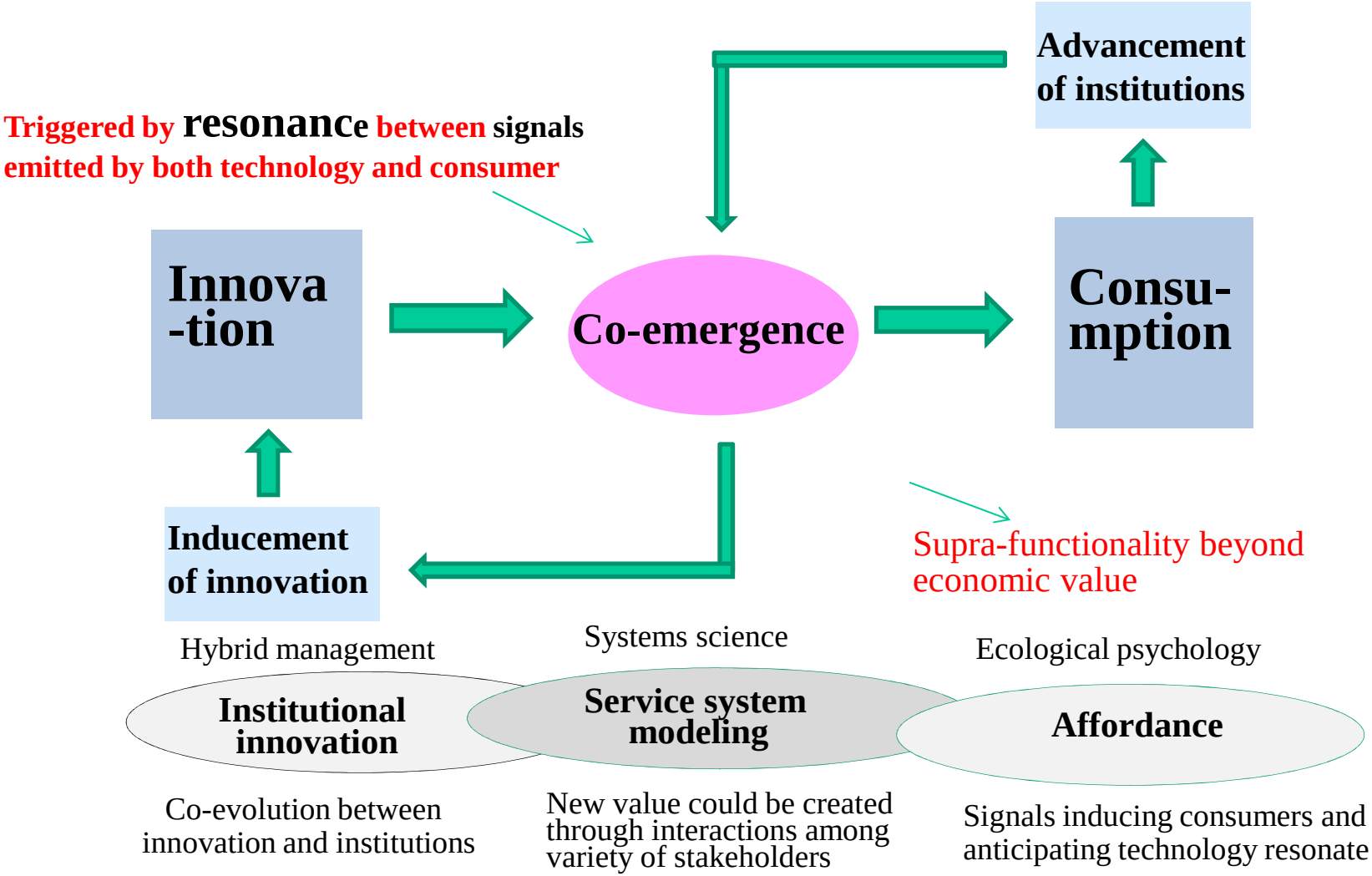


$$f(t) = \frac{c_0}{2} + \sum_{n=1}^{\infty} \left[a_n \cos \frac{2\pi n}{T} t + b_n \sin \frac{2\pi n}{T} t \right]$$

Fourier Transform

(4) Co-emergence of Innovation and Consumption

Correspondence of consumers' demand and innovation emerges new value which in turn enhances demand and innovation, and leverages learning leading to spirally developing virtuous cycle.



Dynamism Co-emerging Supra-functionality beyond Economic Value.

2.5 Supra-functionality beyond Economic Value

(1) Significance of FD for Sustainable Growth

(2) Declining Nature of FD and Significance of Sustainable FD

(3) Earlier Emergence of Functionality Development

(4) Role of Learning in Innovation Dynamism

(5) Requirement for Earlier Functionality Development Emergence

(6) Sustainability of Functionality Development in Major Innovation

(7) Functionality of Sustainable Functionality Development

(8) Innofumption enabled by Supra-functionality

(1) Significance of FD for Sustainable Growth

As paradigm shifts to an information society, spot where innovation takes place shifts from production site to diffusion process leading to the significance of production diffusion integration: innofusion function.

Y : Prod. of innovative goods
K : Capital
R : R & D investment
N : Carrying capicity
b : Diffusion at the initial stage
L : Labor
T : Technology
FD: Functionality development
a: Diffusion velocity

(i) Production Function

$$Y = F(X,T) \quad \Rightarrow \quad \frac{\Delta Y}{Y} = \sum \left(\frac{\partial Y}{\partial X} \cdot \frac{X}{Y} \right) \frac{\Delta X}{X} + \frac{\partial Y}{\partial T} \cdot \frac{R}{Y}$$

(ii) Diffusion Function (Cumulative Y diffuses as a function of T)

$$\frac{\partial Y}{\partial T} = aY\left(1 - \frac{Y}{N}\right) = aY\left(1 - \frac{1}{FD}\right), \quad FD = \frac{N}{Y} \quad \Rightarrow \quad Y = \frac{N}{1 + be^{-aT}}$$

- **Growth**
  - **Traditional production factors** (Labor, Capital)
  - **TFP**
    - **R&D intensity**
    - **Marginal productivity of technology (MPT)**
      - **GDP**
      - **Diffusion velocity**
      - **FD**

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

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

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

$$\frac{\Delta Y}{Y} = \sum_{X=L,K,M,E} \left(\frac{\partial Y}{\partial X} \cdot \frac{X}{Y} \right) \frac{\Delta X}{X} + \frac{\partial Y}{\partial T} \cdot \frac{R}{Y}$$

$$\frac{\partial Y}{\partial T} = aY\left(1 - \frac{1}{FD}\right)$$

Marginal productivity of technology

$$\frac{\Delta Y}{Y} = \sum_{X=L,K,M,E} \left(\frac{\partial Y}{\partial X} \cdot \frac{X}{Y} \right) \frac{\Delta X}{X} + \frac{\partial Y}{\partial T} \cdot \frac{R}{Y}$$

$$\frac{\partial Y}{\partial T} = aY\left(1 - \frac{1}{FD}\right)$$

Japan (1980s, 1990s) **US (1980s)** → **US (1990s)**

System conflict **System match**

Contrast of Growth Option.

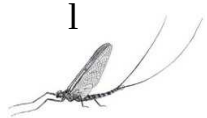
(2) Declining Nature of FD and Significance of Sustainable FD

1. FD incorporates declining nature as follows:

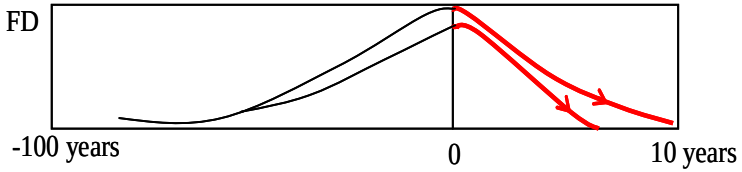
$$Y = \frac{N}{1+be^{-aT}} \qquad FD = \frac{N}{Y} = 1+be^{-aT}$$

2. Therefore, attaining sustainable FD is firms critical strategy.

ephemera
l



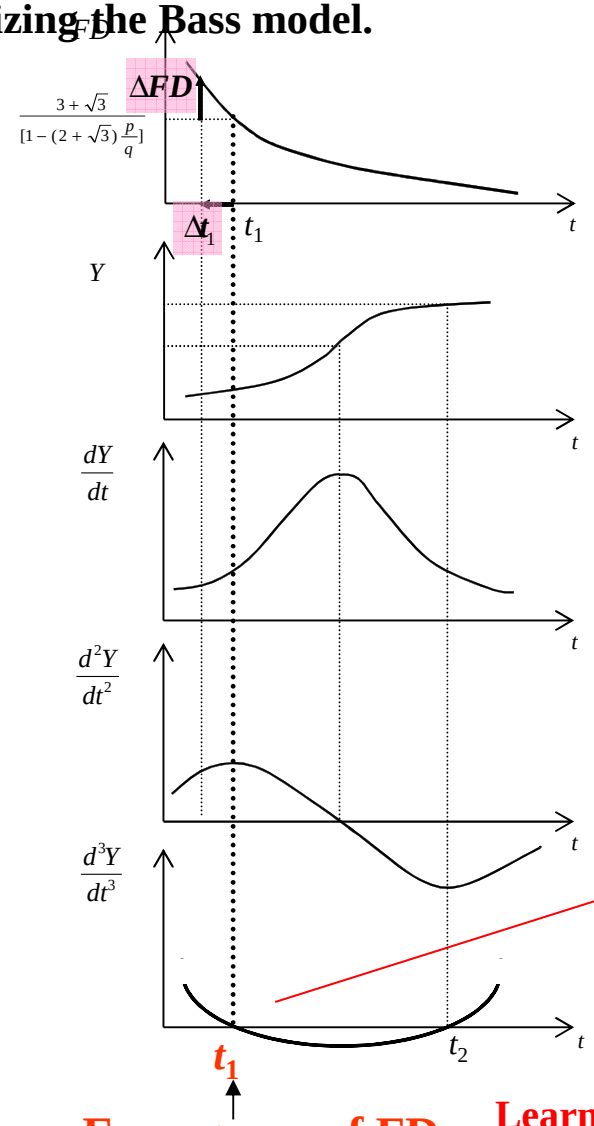
1. While emergence of innovation creates new functionality, it obsolesces "immediately."
2. Given the lengthy years of efforts for emerging an innovation (e.g. 100 years from its origin), life time of newly created functionality is an ephemeral existence.
3. Firms sustainable development effort corresponds to the effort to prolong this ephemeral existence.



New functionality development
(Potential capacity before reaching obsolescent stage)

(3) Earlier Emergence of Functionality Development

Aiming at identifying conditions enabling "learning from preceding innovation," dynamic game between follower (imitator *q*) and leader (innovator *p*) in the diffusion process is analyzed by utilizing the Bass model.



$$FD = \frac{1+\frac{q}{p}e^{-(p+q)\cdot t}}{1-e^{-(p+q)\cdot t}}$$

$$Y = \frac{N(1-e^{-(p+q)\cdot t})}{1+\frac{q}{p}e^{-(p+q)\cdot t}}$$

Earlier Emergence of FD

$\Delta t_1 \downarrow$ → $\Delta FD \uparrow$

$$\frac{d^3Y}{dt^3} = 0$$

Timing of FD emergence

$$t_1 = -\frac{1}{(p+q)}\ln\left[\left(2+\sqrt{3}\right)\frac{p}{q}\right]$$

***p, q* relation decreasing *t₁* (earlier FD emergence)**

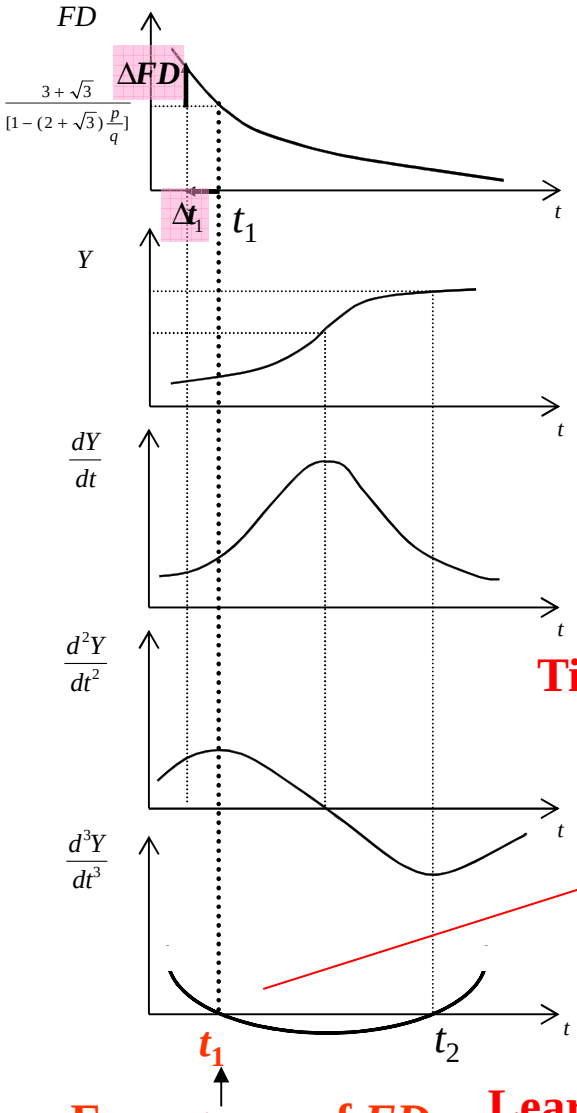
Emergence of FD

Learning from preceding innovation conditions leading to sustainable FD

Timing of the Emergence of Functionality Development.

Earlier Emergence of Functionality Development (Supplement)

Aiming at identifying conditions enabling "learning from preceding innovation," dynamic game between follower (imitator *q*) and leader (innovator *p*) in the diffusion process is analyzed by utilizing the Bass model.



$$Y = \frac{N(1-e^{-(p+q)\cdot t})}{1+\frac{q}{p}e^{-(p+q)\cdot t}}$$

$$FD = \frac{N}{Y} = \frac{1+\frac{q}{p}e^{-(p+q)\cdot t}}{1-e^{-(p+q)\cdot t}}$$

Timing of *FD* emergence

*Appendix 2

$$* \ \frac{dFD}{d\,q/p} > 0, \quad \frac{dFD}{dt} < 0$$

$$\frac{dFD}{d\,q/p} = \frac{dt}{dq/p} \cdot \frac{dFD}{dt} > 0$$

$$\frac{dt}{d\,q/p} < 0 \longrightarrow \text{Sustainable FD condition}$$

$$\frac{d^3Y}{dt^3} = 0 \longrightarrow t_1$$

$$t_1 = -\frac{1}{(p+q)} \ln\left[\left(2+\sqrt{3}\right)\frac{p}{q}\right]$$

Early emergency of *FD*

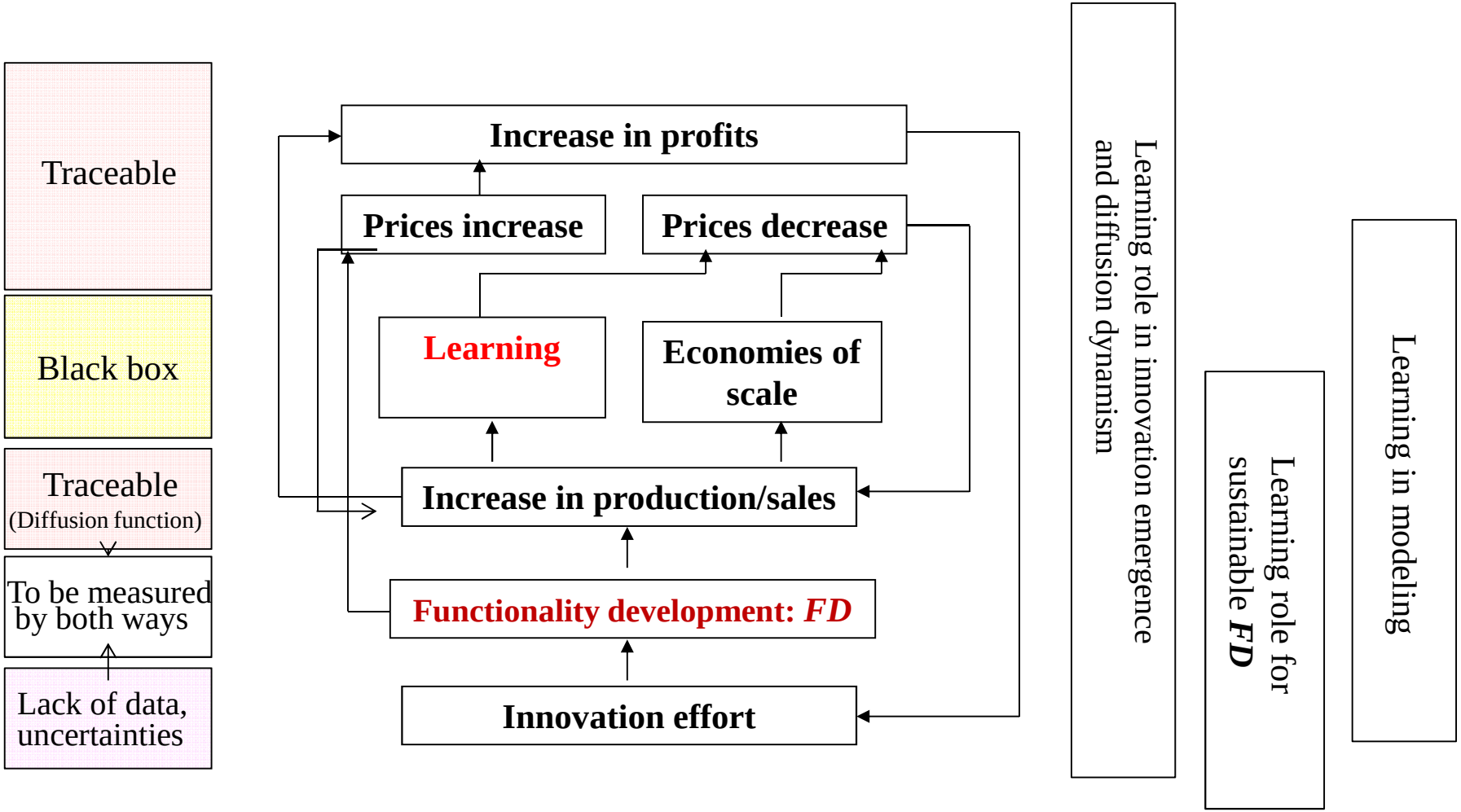
$\Delta t_1 \downarrow \Rightarrow \Delta FD \uparrow$

***p, q* relation decreasing t_1 (earlier *FD* emergence)**

Emergence of *FD* **Learning from preceding innovation conditions leading to sustainable *FD***

Timing of the Emergence of Functionality Development.

(4) Role of Learning in Innovation Dynamism



Role of Learning in Innovation Emergence and Diffusion Dynamism.

(5) Requirement for Earlier FD Emergence

$$\frac{d^3Y}{dt^3}=0 \Rightarrow t_1=-\frac{1}{(p+q)}\ln\left[\frac{1}{(2+\sqrt{3})}\frac{p}{q}\right]=y\ln[\frac{x}{(2+\sqrt{3})}]$$

where $q/p=x$ and $\frac{1}{p+q}=y$.

***p*: innovator**
***q*: imitator**

Learning from preceding innovation (*q/p*) ↑

Earlier FD emergence of FD (t_1) ↓

$$\frac{dt_1}{dq/p}=\frac{dt_1}{dx}=\frac{dy}{dx}\ln[\frac{x}{(2+\sqrt{3})}]+\frac{y}{x}$$

where $y=\frac{1}{p(1+x)}$, $\frac{y}{x}=\frac{1}{p(1+x)x}$, $\frac{dy}{dx}=\frac{-[(1+x)\frac{dp}{dx}+p]}{[p(1+x)]^2}$.

Therefore, $\frac{dt_1}{dq/p}$ can be developed as follows:

$$\frac{dt_1}{dq/p}<0$$

Necessary condition for earlier FD emergence

Sustainable FD

$$\frac{dt_1}{dq/p}=\frac{-[(1+x)\frac{dp}{dx}+p]}{[p(1+x)]^2}\ln[\frac{x}{(2+\sqrt{3})}]+\frac{1}{px(1+x)}=\frac{1}{px(1+x)}\left[1+\frac{[(1+x)\frac{dp}{dx}+p]\ln[\frac{(2+\sqrt{3})}{x}]x}{p(1+x)}\right]$$

In case when $W(x)=\frac{[(1+x)\frac{dp}{dx}+p]\ln[\frac{(2+\sqrt{3})}{x}]x}{p(1+x)}<-1$, $\frac{dt_1}{dq/p}<0$

Bi-Bass Model

– *Diffusion of successive innovation with leader and follower dynamism*

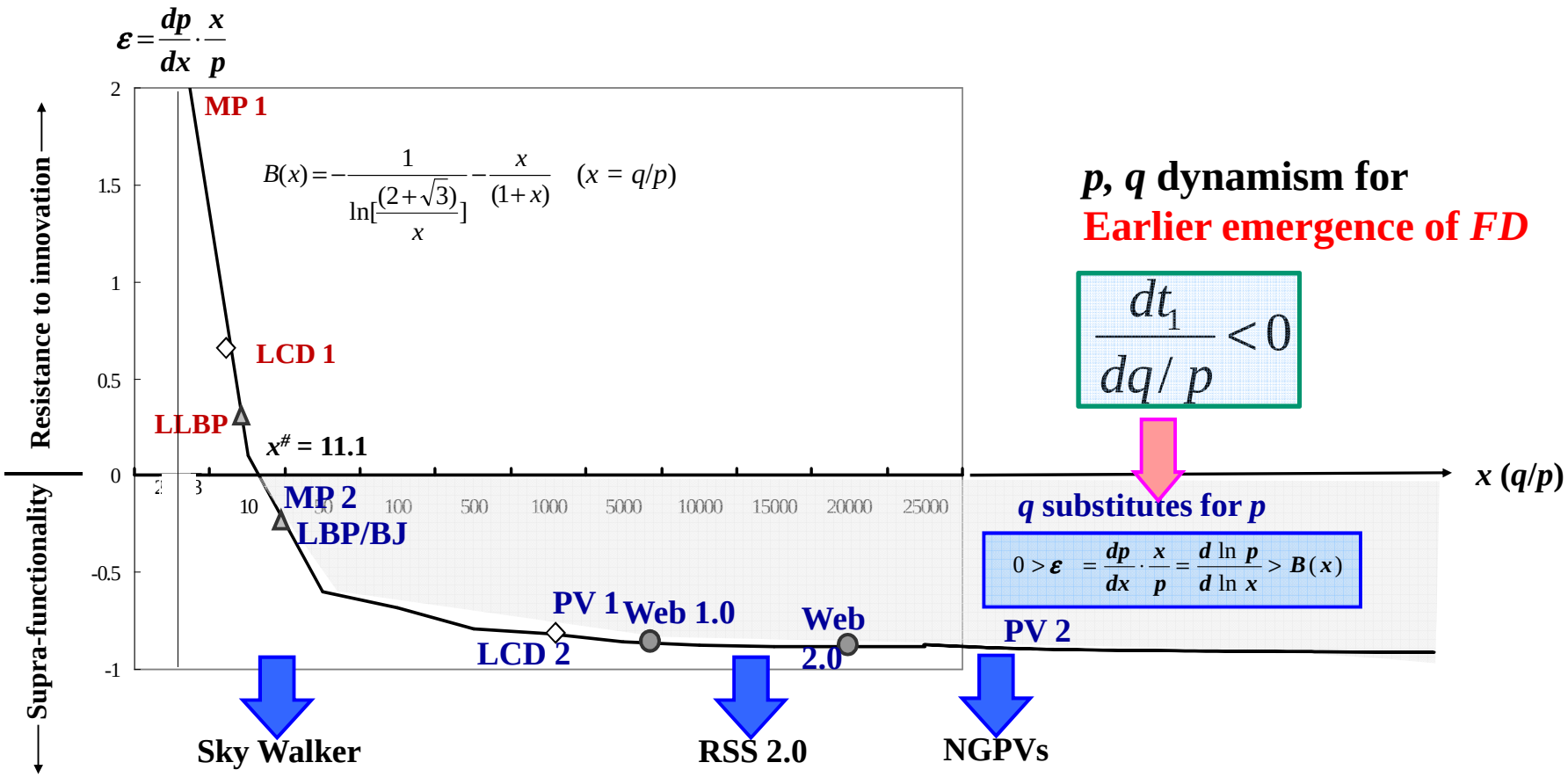
$$Y(t)=\frac{N_1(1-e^{-(p_1+q_1)t})}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)t}}+\frac{N_2(1-e^{-(p_2+q_2)t})}{1+\frac{q_2}{p_2}e^{-(p_2+q_2)t}}$$

Diffusion Parameters in Major Innovative Goods and Services

		N	*p*	*q*	*adj.* R^2	$x = q/p$	$\varepsilon = \frac{d\ln p}{d\ln x}$	Trigger of new innovation	*q/p* ratio increase
Printer [a]	**LLBP** (*1975-1994*)	1581 (19.33)	5.43×10^{-3} (15.13)	5.8×10^{-2} (9.94)	0.999	**10.7**	**0.03**	**LBP** (*1987*)	**1.8**
	LBP/BJ (*1987-2005*)	97205 (166.57)	1.47×10^{-3} (2.27)	2.9×10^{-2} (37.96)	0.999	**19.3**	**-0.35**		
MP (*1990-2006*)	**MP 1**	38216 (149.45)	0.12×10^{-1} (5358.9)	0.58×10^{-1} (2616.7)	0.999	**5.0**	**2.59**	**Sky Walker** (*1997/10*)	**3.1**
	MP 2	65741 (170.24)	0.22×10^{-2} (1270.1)	0.35×10^{-1} (438.3)		**15.6**	**-0.24**		
LCD (*2000-2008*)	**LCD 1**	2.4×10^{3} (1654.3)	0.3×10^{-2} (1654.3)	0.2×10^{-1} (1654.3)	0.999	**7.3**	**0.60**	**TFTAM** (2000)	**260**
	LCD 2	2.4×10^{3} (656.1)	0.4×10^{-4} (1654.3)	0.8×10^{-1} (1654.3)		**1.9×10^{3}**	**-0.83**		
Web (*1993-2006*)	**Web 1.0**	2.42×10^{5} (145.87)	1.38×10^{-5} (8.35)	1.08×10^{-1} (58.33)	0.999	**7.8×10^{3}**	**-0.87**	**RSS 2.0** (*2003/7*)	**2.8**
	Web 2.0	2.49×10^{5} (75.66)	0.25×10^{-5} (2.60)	0.55×10^{-1} (22.74)		**22.0×10^{3}**	**-0.89**		
PV (*1976-2007*)	**PV 1**	0.50×10^{5} (8.81)	19.36×10^{-5} (3.87)	2.66×10^{-1} (45.22)	0.999	**0.1×10^{4}**	**-0.83**	**NGPVs** (*2006*)	**1054**
	PV 2	12.71×10^{5} (8.82)	0.04×10^{-5} (5.72)	4.11×10^{-1} (47.89)		**105.4×10^{4}**	**-0.92**		

[a] Since the period of co-existence of LLDP and LBP/BJ was limited, simple Bas model was used for respective innovation.
[b] Figures in parentheses indicate *t*-value. All demonstrates statically significant at the 5% level.
[c] LLBP: Large-scale Laser Beam Printer; LBP: Laser Beam Printer; BJ: Bubble Jet Printer; LCD: Liquid Crystal Display; MP: Mobile phone; and Web: Internet dependency based on the number of co.jp domains.
[d] Sky Walker: Triggered e-mail transmission by mobile phone; TFTAM (Thin Film Transistor Active Matrix): Triggered interactive viewing system in TV; RSS 2.0 (Really Simple Syndication): Triggered publishing updated works in a standardized form as blog and video; NGPVs (Next Generation PV System): Triggered acceleration of customers initiative in PV development and introduction by means of highly advanced next generation technology.

(6) Sustainability of FD by Major Innovation



***p*, *q* dynamism for**
Earlier emergence of *FD*

$$\frac{dt_1}{dq/p} < 0$$

q* substitutes for *p

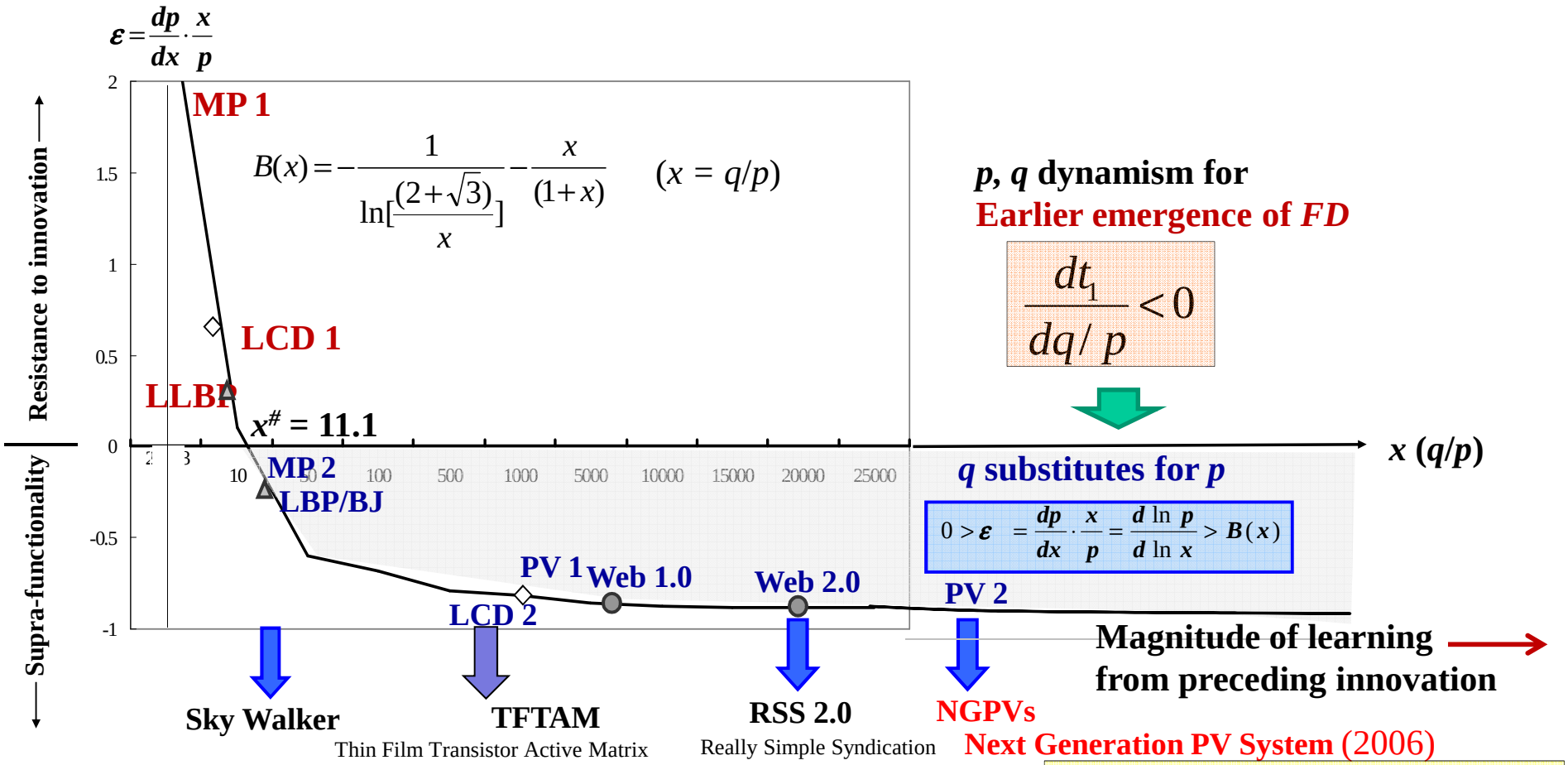
$$0 > \varepsilon = \frac{dp}{dx} \cdot \frac{x}{p} = \frac{d \ln p}{d \ln x} > B(x)$$

Sustainable Functionality Development Condition.

1. **While latest high-technology products as LBP/BJ, MP 2, LCD 2, Web 1.0, Web 2.0, PV 1 and PV 2 satisfy conditions for sustainable functionality development, LLBP (1976), MP 1 (1996) and LCD 1 do not satisfy these conditions resulting in being substituted by LBP, BJ, MP 2 and LCD 2.**

2. **This can be considered as substitution from 'resistance to innovation' in the early introduction to market, to supra-functionality with customers own initiative.**

Sustainable *FD* by Major Innovation (Supplement)



***p, q* dynamism for**
Earlier emergence of *FD*

q* substitutes for *p

	Sky Walker	TFTAM (Thin Film Transistor Active Matrix)	RSS 2.0 (Really Simple Syndication)	NGPVs (Next Generation PV System (2006))
q/p ratio increase	3.1	260	2.8	1054

Broad inter-sectoral learning

1. Highest magnitude of learning from preceding innovation
2. Conspicuous broad inter-sectoral learning

Sustainable Functionality Development Condition.

1. While latest high-technology products as LBP/BJ, MP 2, LCD 2, Web 1.0, Web 2.0, PV 1 and PV 2 satisfy conditions for sustainable functionality development, LLBP (1976), MP 1 (1996) and LCD 1 do not satisfy these conditions resulting in being substituted by LBP, BJ, MP 2 and LCD 2.

2. Among high-technology products with sustainable FD, **PV2 (NGPVs) demonstrated conspicuously high level of learning from preceding nnovation.**

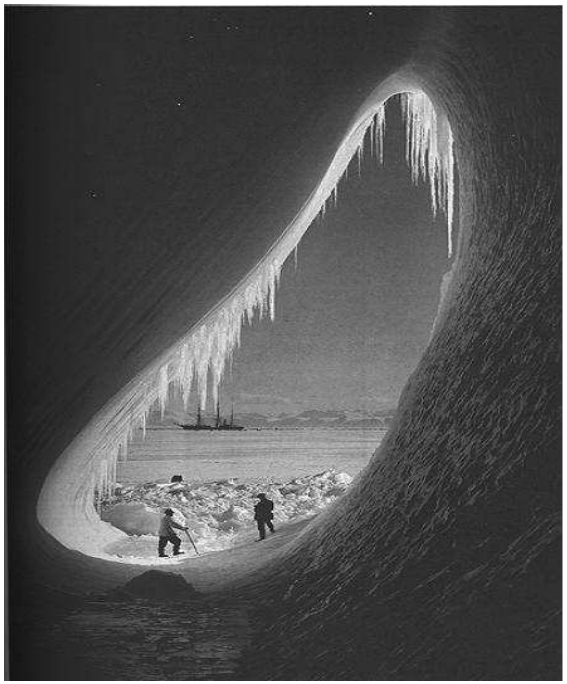
(7) Functionality of Sustainable FD

Printers	Mobile phone	LCD	Web	PV
Depend on **Print office**	**Communication** only	**Watch** only	**Passive information** dependent	Purchase from **Electric power company**

Explore new FD frontier

Resistance to new innovation

Supra functionality



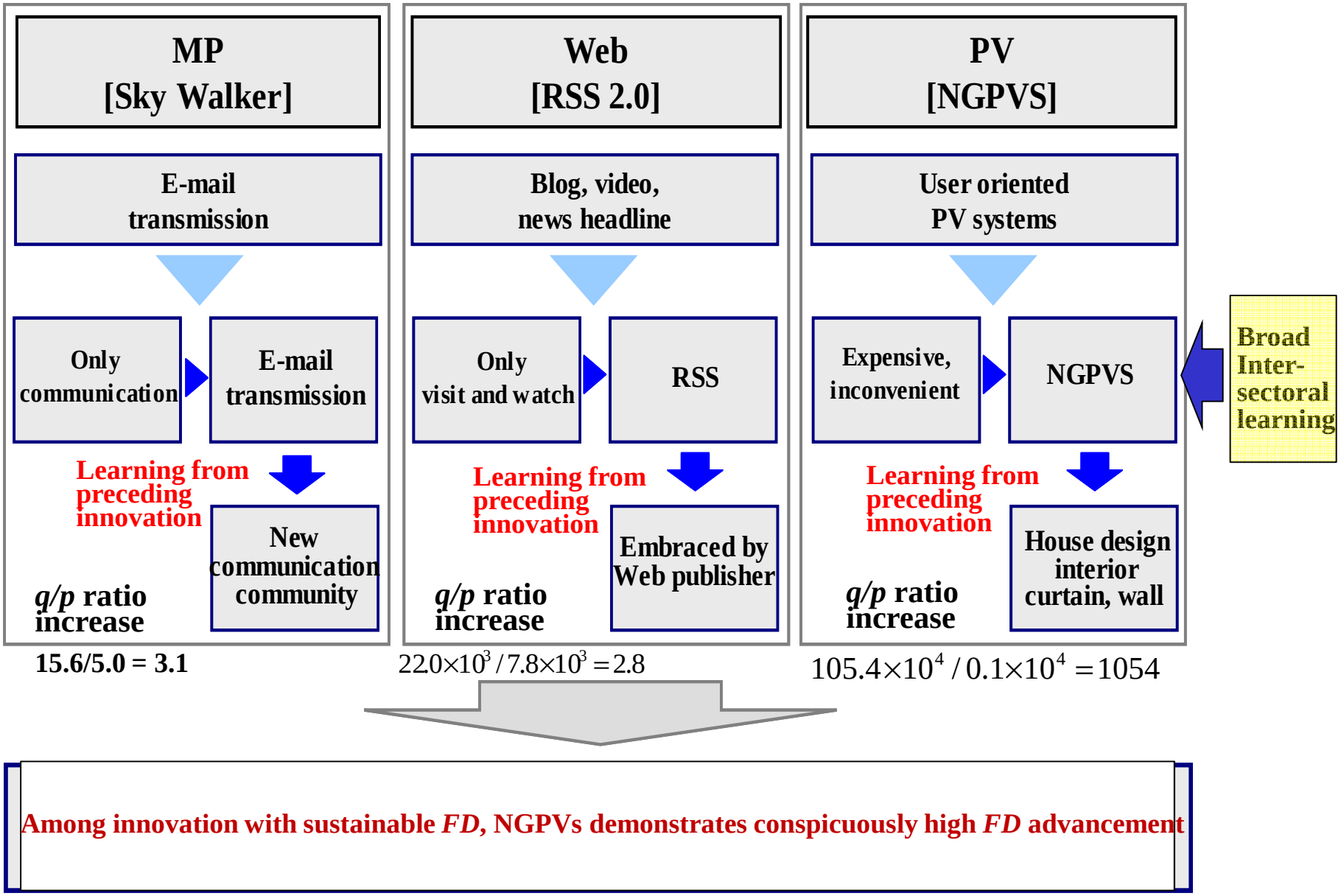
Instills customers "*exciting story with their initiative as heroes/heroines*" and thrills them gratification

Incorporates innovation new social cultural and aspirational value beyond economic value

Home print	Explore new world Internet	multimedia services IPTV	Blog	Clean energy
by own design	with as preferred	interactivity	as hero/heroines	by own interior design

New Functionality Development Frontier Leading to Supra-functionality

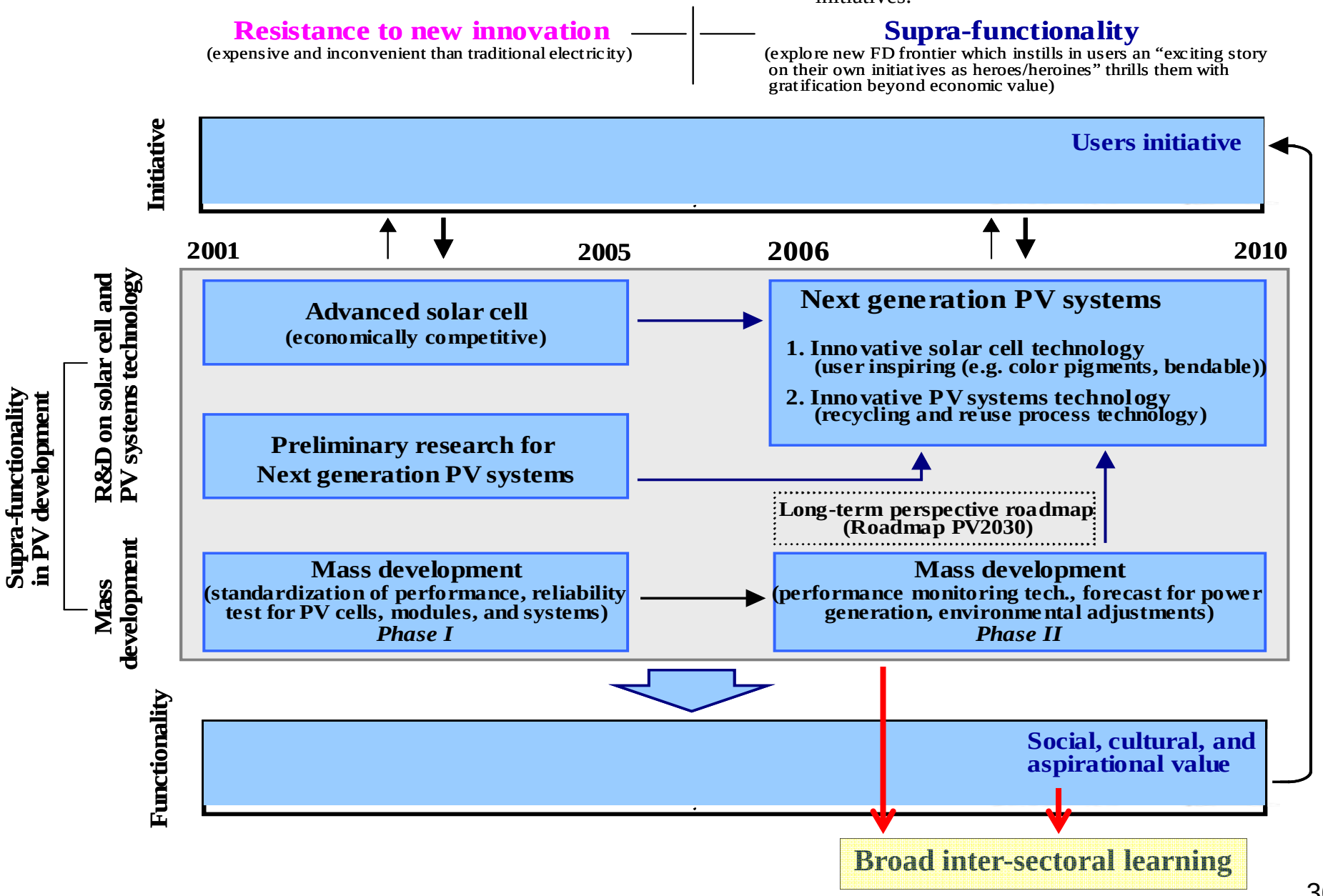
1) Sustainable *FD* by Learning from Preceding Innovation in MP, Web and PV



Dynamism in Creating Sustainable *FD* by Learning from Preceding Innovation.

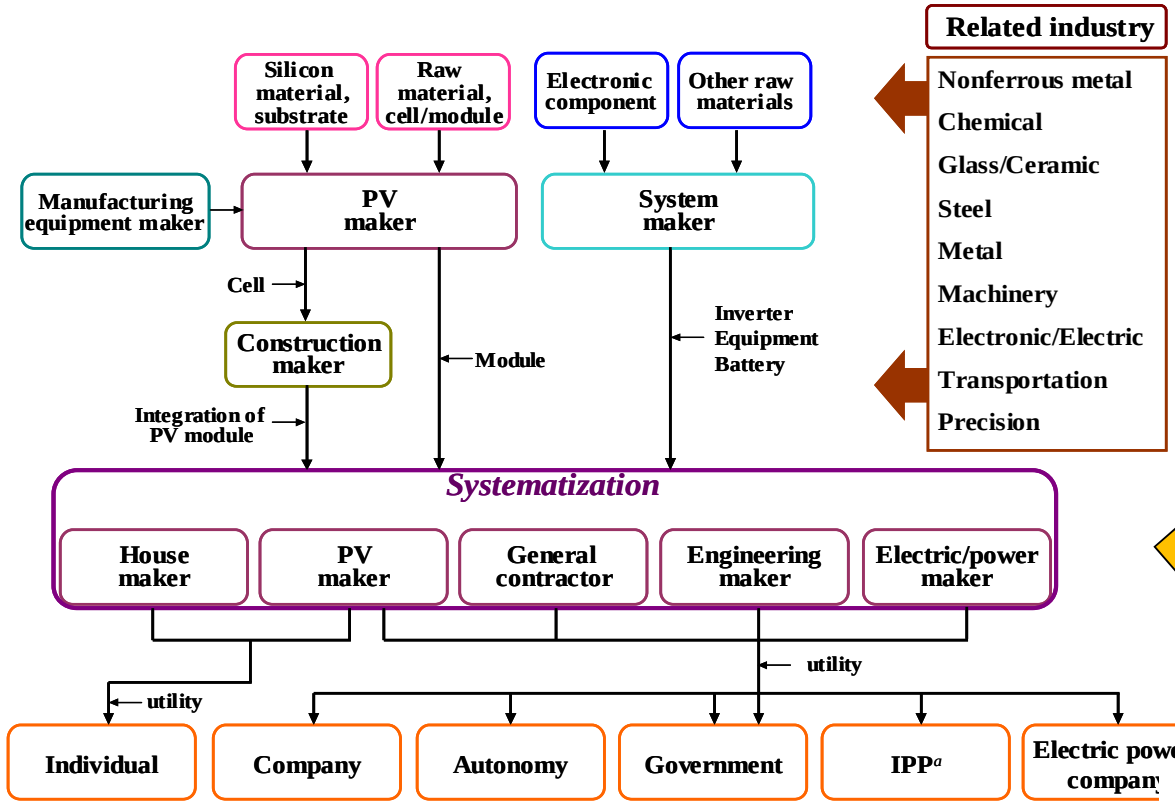
2) Sources Enabling High-intensity Learning

Broad inter-sectoral learning in NGPVs can be attributed to its strong mass development and user initiatives.



Dynamism Inducing Broad Inter-sectoral Learning in NGPVs.

3) Inter-sectoral Learning Accelerating Full Utilization of Learning from Preceding Innovation

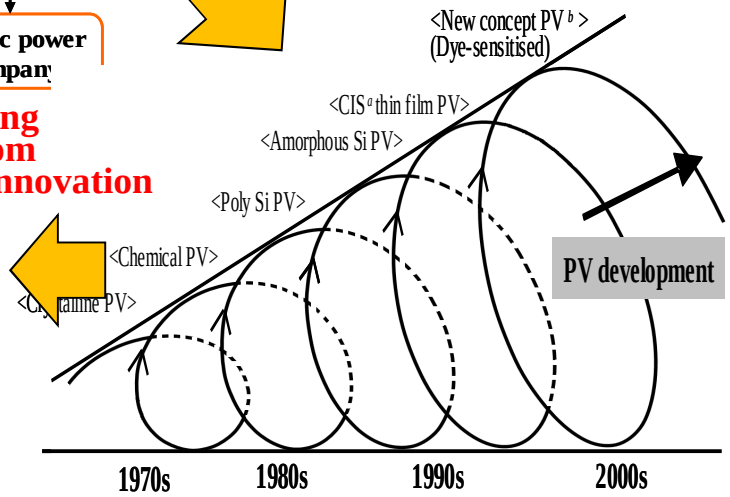


Broad inter-sectoral learning together with self-propagating diffusion dynamism under strong users initiatives accelerates full utilization of learning from preceding innovation.

Broad inter-sectoral learning

[a] IPP: Independent Power Producer

Fully utilizing learning from preceding innovation

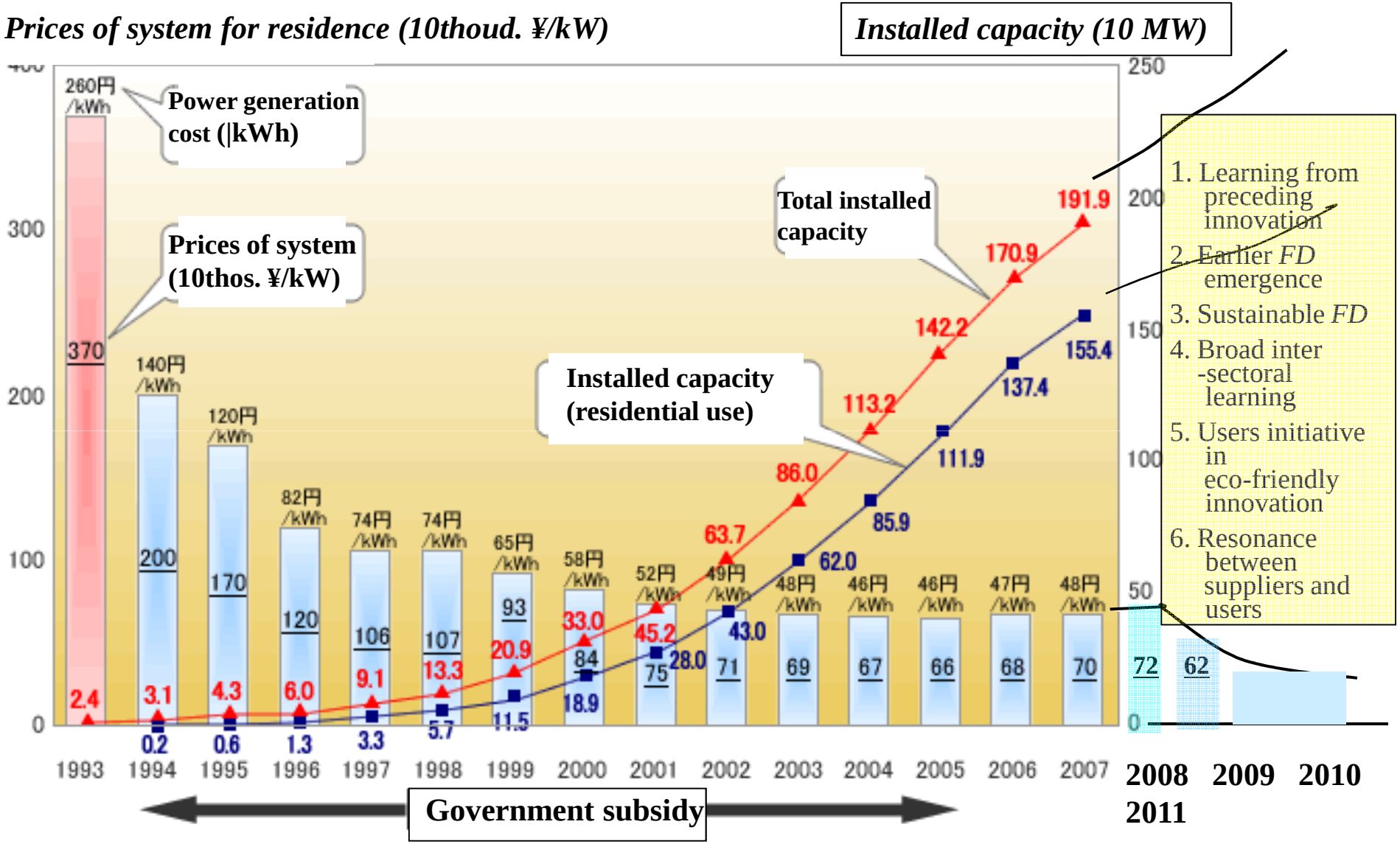


1. Innovative solar cell technology inspiring users (e.g., color pigments, bendable).
2. Innovative PV system technology (e.g., recycling, reuse process technology)
3. Mass development (performance monitoring, forecast for power generation, environmental adjustment).
4. Users initiative inducing social, cultural, emotional and aspirational value.

Industrial Network Induced by PV Development.

4) PV Development Dynamism in Japan

Japan maintains institutional advantages in PV development as technology-driven energy and endeavors maximum utilization of learning potentials.



Trends in PV Development in Japan (1993-2011).

(8) Innofumption enabled by Supra-functionality

1. Co-evolution between innovation (*FD*) and institutional systems (*C*)

σ_{TX} : Elasticity of technology substitution (ETS) for X,

Technology substitution for constrained production factors

$$\sigma_{TX} = \frac{\ln T/X}{\ln\frac{\partial Y}{\partial X} - \ln\frac{\partial Y}{\partial T}}$$

$$\frac{\Delta Y}{Y} = \sum\left(\frac{\partial Y}{\partial X}\cdot\frac{X}{Y}\right)\frac{\Delta X}{X} + \frac{\partial Y}{\partial T}\cdot\frac{R}{Y}$$

$$\frac{\partial Y}{\partial T} = aY\left(1-\frac{1}{FD}\right)$$

Utility function

$$U(FD) \rightarrow C \rightarrow Y \rightarrow R \rightarrow T \rightarrow N \rightarrow FD$$

Production function

Diffusion function

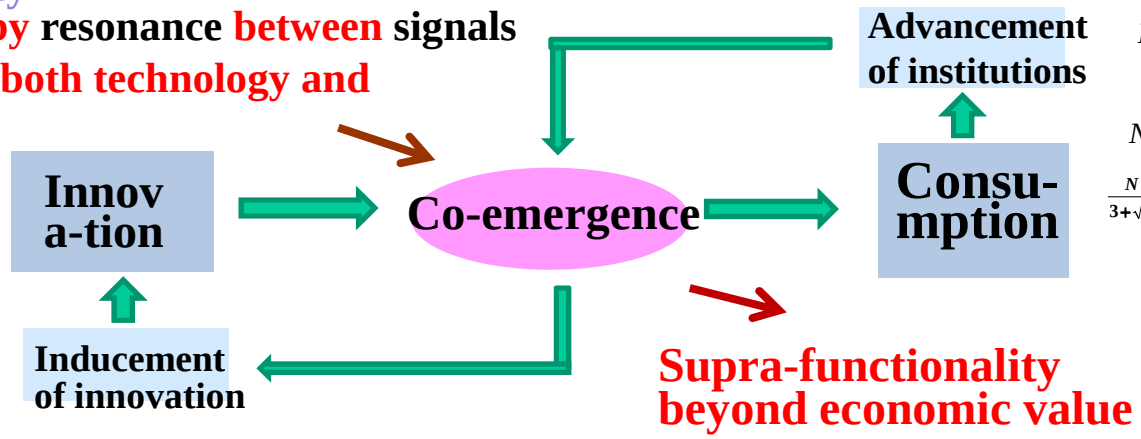
Utility function

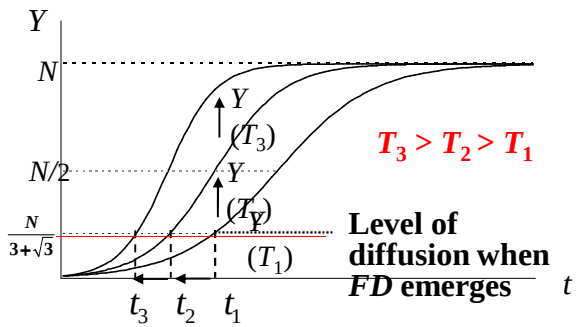
Inno -fusion

Innofu-mption

2. Co-emergence of innovation and consumption enabled earlier emergence of FD leading to supra-functionality

Triggered by resonance between signals emitted by both technology and consumer





3. Earlier emergence of FD

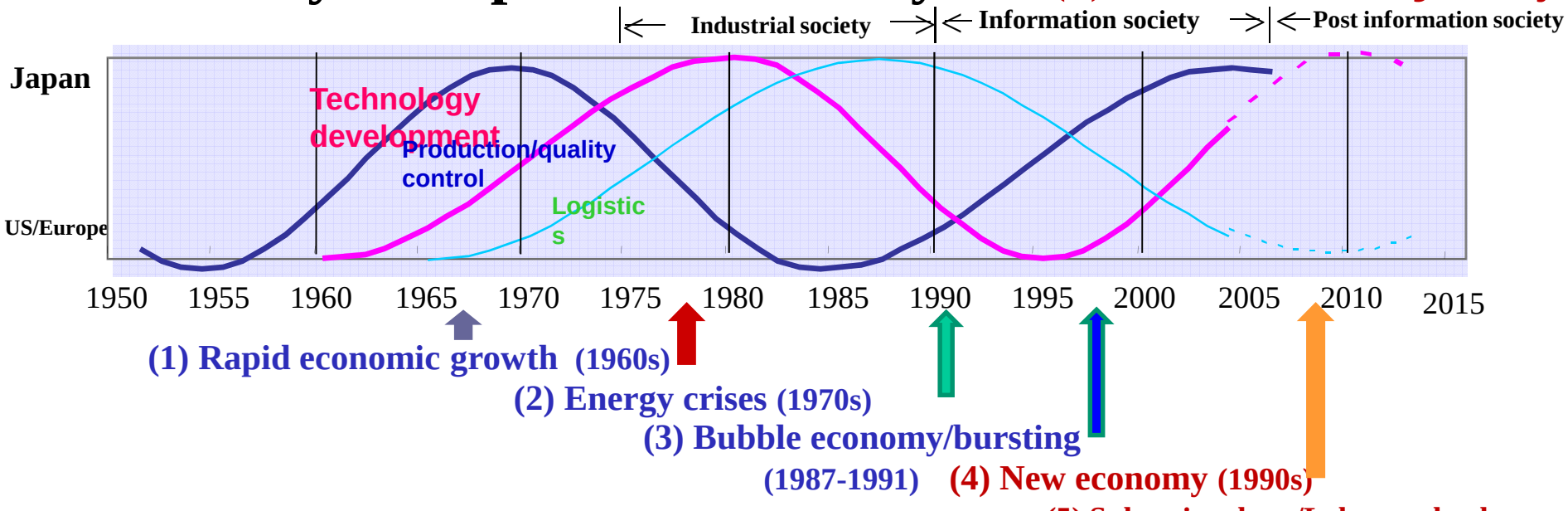
4. Sustainable FD

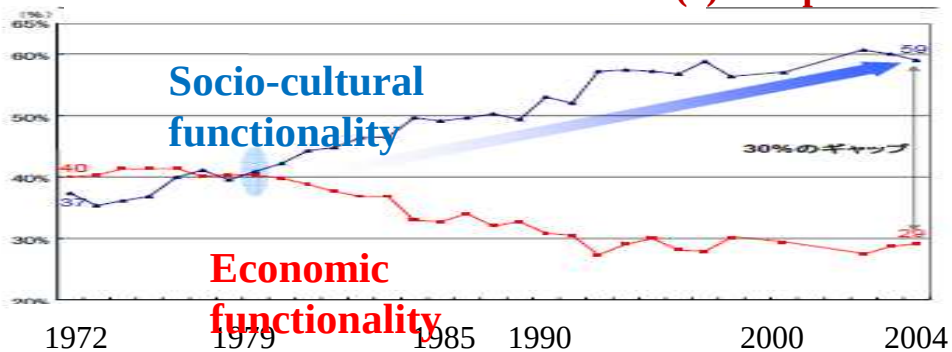
5. Supra-functionality

6. Supra-functionality functions Innfusion

2.6 A Way to Supra-functionality

(1) Historical Trajectory



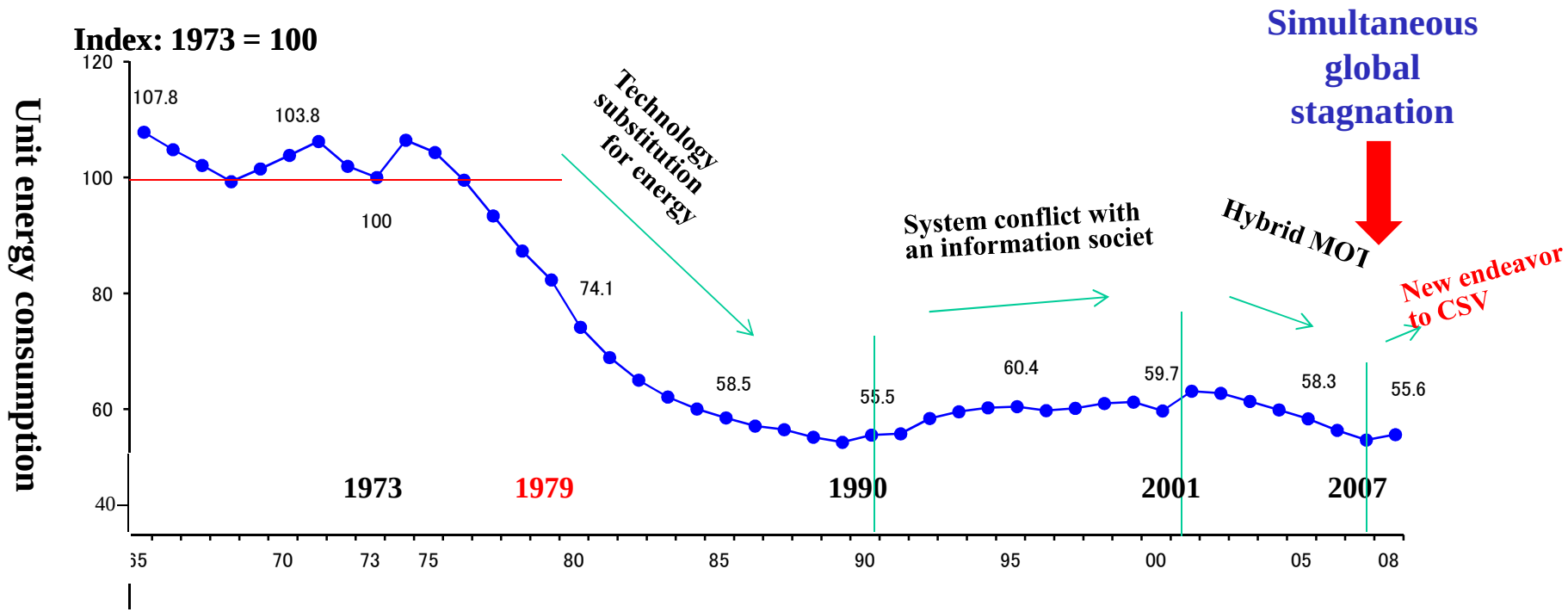


Energy conservation
Small is beautiful
Eco
Cool
Sensitiveness
Private brand
Community service
"Wabi, sabi"

(Aesthetic sense in Japanese art emphasising **quiet simplicity**)

→ Supra-functionality

(2) Trend in Energy Consciousness Corresponding to Economic Environment



Trend in Unit Energy Consumption in Japan's Manufacturing Industry *(1965-2008).*

(3) Sublimation to Supra-functionality beyond Economic Functionality

Energy conservation	① Social value	Distance between firms and society → Creating Shared Value (CSV) Social welfare、Support of social disability Social communication
Small is beautiful Eco	② Cultural value	Brand, Private brand (PB) “Wabi, sabi.” Cool, Cute, J-sense
Cool	③ Aspiration value	Aspiration to traditional beauty Genuine, real thing
Sensitiveness Private brand	④ Tribal value	Cognitive sense Tribal sense Love of home province
Community service Wabi/sabi	⑤ Emotional value	Perceptional value Appeal to senses Sensitiveness

Customers decision making

Behave as rational based on economic value → Private psychology, social mood → Socio-psychological factor

2.7 Growth Option: Supra-functionality Seeking or Economic Functionality Oriented

- Similarity and Disparity between Singapore and Finland

(1) Similarity

1) High Competitiveness

	Singapore	Finland
High level of economic development	49.3 1000US$	48.8
High level of Network develop/depend	NRI No. 2	NRI No. 3
Highly organized institutional systems	Efficiency of legal framework Transparency of governm. Policy making Ethical behavior of firms Quality of the educational system	

High level of competitiveness	No. 2	No. 3 in the world

2) Sources of Competitiveness in Finland and Singapore
in Comparison to Japan, US and China

	Finland	Singapore	Japan	USA	China		
Global competitive ranking	3	2	10	7	29	2012	WEF (2012)
Population (mil.)	5.4	5.3	127.9	312.0	1347.4	2011	IMF (2012)
GDP/capita (1000US $: actual)	48.8	49.3	45.9	48.3	5.4	2011	IMF (2012)
Networked Readiness Index ranking	3	2	18	8	51	2011	WEF (2012)
R&D intensity (per GDP %)	3.1	2.2	3.3	2.7	1.8	2011	Battelle, Chinese Bureau of Statistics (2012)
Energy intensity (Mtoe/mil. US$)	230	140	100	190	810	2009	IEA (2010)
Efficiency of legal framework	6.0	6.2	5.3	4.9	3.9	2009	WEF (2010)
Transparency of government policy makin	5.7	6.3	5.1	4.9	4.5	2009	WEF (2010
Ethical behavior of firms	6.6	6.6	5.6	5.2	4.2	2009	WEF (2010)
Quality of the educational syste	6.2	6.2	4.5	5.0	3.8	2009	WEF (2010)
Population density (/Km²)	16	7428	338	32	140	2011	IMF (2012)
Income disparity (GINI index)	26	52	38	45	47	2002-07	CIA (2002-07)
World happiness index ranking	2	33	44	11	112	2011	UN (2012)

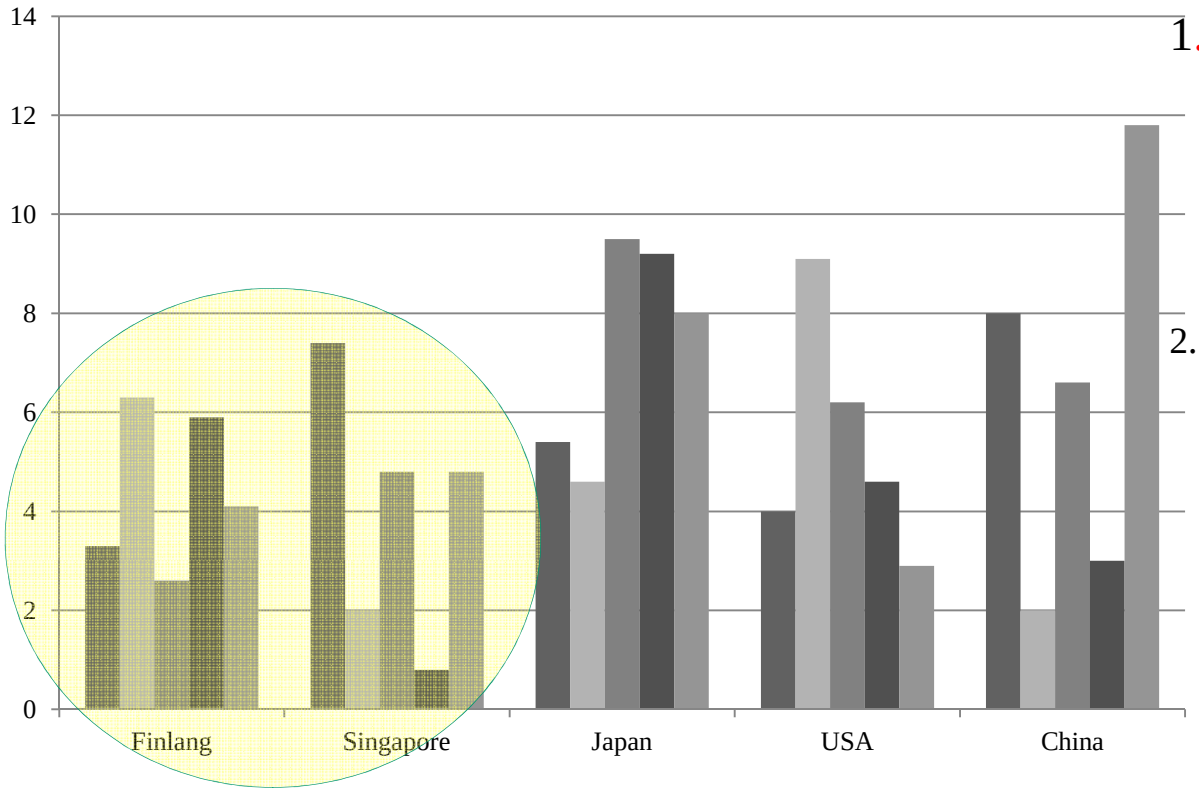
(2) Disparity

1) Disparity and Its Sources

	Singapore	Finland
Cultural dimension of the nations	Higher Power Distance (PDI: Power and inequality) and Masculinity (MAS: distribution of roles between genders)	Higher Individualism (IDV) and Uncertainty Avoidance (UAI)
Economic development strategy	Home attracting	Abroad exploring
Economic growth	Sustainably conspicuous	Stagnating
Unemployment	Low	High
Income disparity	High	Low
Birth rate	Low	High
Happiness	Low	High

Supra-functionality beyond economic value?

2) Cultural Dimensions of the Nations in 5 Countries



1. Finland demonstrates higher **Individualism** (IDV) and **Uncertainty Avoidance** (UAI) than Singapore.

2. Singapore demonstrates higher **Power Distance** (PDI: Power and inequality) and **Masculinity** (MAS: distribution of roles between genders) than Finland.

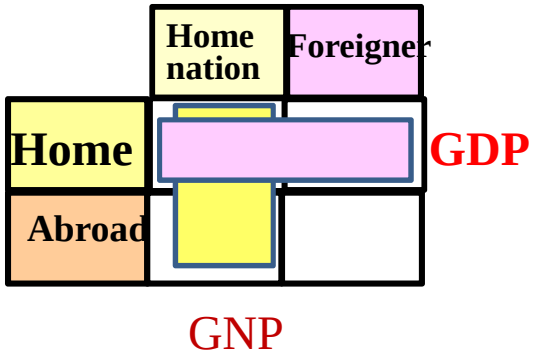
	Finland	Singapore	Japan	USA	China
PDI	3.3	7.4	5.4	4	8
IDV	6.3	2	4.6	9.1	2
MAS	2.6	4.8	9.5	6.2	6.6
UAI	5.9	0.8	9.2	4.6	3
LTO	4.1	4.8	8	2.9	11.8

Source: G. Hofstedo, *Cultures and Organizations*, McGraw-Hill International, London (1991).

3) Comparison of GDP and GNP per capita in 5 Countries in 2009-2012

Clear contrast between Home attracting (Singapore) and Abroad exploring (Finland).

	Singapore	Finland	Japan	USA	China
GDP/GNP	1.02	0.99	0.97	0.99	1.00
	Home attracting	Abroad exploring			



4) Unemployment rate in 3 Countries in 2012

Singapore	Finland	Japan
2.13	7.64	4.51 %

5) Birth rate in 3 Countries in 2010

Singapore	Finland	Japan
1.3	1.9	1.4

6) Economic Growth Trajectory

1961-1970
(Ind. society)

1971-1980
(Energy crises In 1973,79)

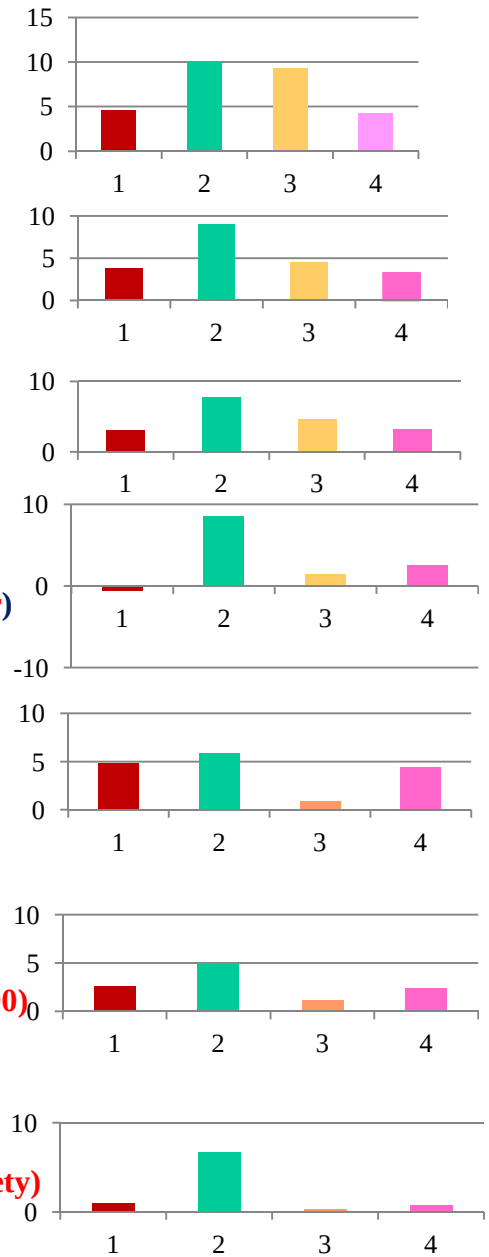
1981-1990
(bubble economy in Ind. society)

1991-1995
(Inform. Society, Relax. of cold war)
.

1996-2000
(Inform. Society Asian financial ct¥risis in 1997)

2001-2005
(Post inform. Sociereyy after the IT bursting in 2000)

2006-2010
(Post-excessive consumption society)



Finland Singapore Japan US

Economic Development Trajectories in 5 Countries (1961-2010):
-
Real GDP increase rate (% p.a)

	1961 -1970	1971 -1980	1981 - 1990	1991 -1995	1996 -2000	2001 -2005	2006 - 2010
Finland	4.62	3.81	3.07	-0.54	4.81	2.63	0.96
Singapore	10.12	9.08	7.81	8.57	5.84	4.83	6.62
Japan	9.3	4.5	4.64	1.42	0.85	1.2	0.35
USA	4.21	3.27	3.25	2.54	4.35	2.41	0.74

Industrial society **Information society** **Post-infm society**

1991 Bursting of Japan's bubble economy
Commercialization of the Internet
Collapse of USSR

1998 Asian financial crisis

2000 Bursting of the Net bubble

2006 US sub-prime loan issue

2008 Lehman shock

2010 Euro crisis

7) Comparison of Education Policy between Singapore and Finland

	Singapore	Finland
Basic principle	Score-oriented Competition Efficiency	Individual, Self, Harmony Equal opportunity Redundancy
Teacher's social status	Medium	High social status High level expertise
Stance of the state	Control	Support

Economic functionality oriented

Supra-functionality seeking

References

1. C. Chen and C. Watanabe, "Competitiveness through Co-evolution between Innovation and Institutional Systems: New Dimensions of Competitiveness in a Service-oriented Economy," *Journal of Services Research* 7, No. 2 (2007) 27-55.
2. J.J. Gibson, "The Theory of Affordances," in R. Shaw and J. Bransford (eds.), *Perceiving, Acting and Knowing*, Erlbaum, Hillsdale, NJ (1977).
3. R. Kondo, C. Watanabe and K. Moriyama, "A Resonant Development Trajectory for IT Development: Lessons from Japan's i-mode," *International Journal of Advances in Management Research* 4, No. 2 (2007) 7-27.
4. V. Mahajan, E. Muller and F.M. Bass, "New Product Diffusion Models in Marketing: A Review and Directions for Research," *Journal of Marketing* 54 (1990) 1-26.
5. D. McDonagh, Satisfying Needs beyond the Functional: The Changing Needs of the Silver Market Consumer, *Proceedings of the International Symposium on the Silver Market Phenomenon*, Tokyo (2008).
6. M. Polanyi, *Knowing and Being*, University of Chicago Press, Chicago (1969).
7. C. Watanabe, *Managing Innovation in Japan: The Role Institutions Play in Helping or Hindering How Companies Develop Technology*, Springer, Berlin (2009).
8. C. Watanabe, K. Moriyama and J. Shin, "Functionality Development Dynamism in a Diffusion Trajectory: A Case of Japan's Mobile Phone Development," *Technological Forecasting and Social Change* 76, No. 6 (2009) 737-753.
9. C. Watanabe and J. Shin, "Co-evolutionary Dynamism between Innovation and Institutional Systems: The Rise and Fall of the Japanese System of Management of Technology," in C. Watanabe (ed.), *The Science of Institutional Management of Technology*, Tokyo Institute of Technology, Tokyo (2009) 21-34.
10. C. Watanabe, W. Zhao and M. Nasuno, "Resonance between Innovation and Consumers: Suggestion to Emerging Market Consumers," Journal of Technology Management for Growing Economies 3, No. 1 (2012) 7-31.
11. C. Watanabe G. Kanno, and Y. You, "Inside the Learning Dynamism Inducing the Resonance between Innovation and High-demand Consumption: A Case of Japan's High-functional Mobile Phones," *Technological Forecasting and Social Change* 79, No.7 (2012) 1292-1311.

Term Paper

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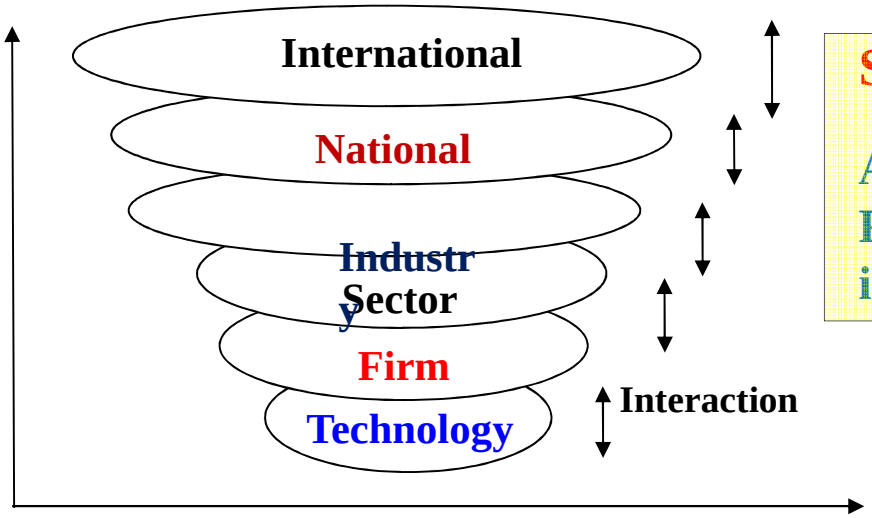

Subject

Analyze noteworthy business model From the view of Institutional innovation

Examples

		Primal analytical dimension
International	1 **A Comparison of Competitive Economic Growth between Finland and Singapore**	Growth
National	2. **Technology Diffusion and Spillover through foreign direct investment (FDI) in Singapore**	Diffusion/spillover
	3. **Co-evolutionary Dynamism for Sustainable Innovation: Green Growth Policy Creates New Development Economics**	Co-evolution
Industry	4. **Strategic Opportunities for the Oil and Gas Industries in India**	Spillover Learning
Sector	5. **Analysis of the Tablet PC Industry & Market**	Diffusion
Firm	6. **Comparison of Technology Diffusion for Auto Manufacturing Industries**	Rate of return to R&D
	7. **Rate of Return to R&D Investment Comparison between Huawei and Alcatel-Lucent**	Diffusion/learning
Technology	8. **Strategies Adopted by Apple and Samsung toward Smart Phone Innovation**	Diffusion
	9.. **Diffusion of Two Co-Existing Innovation: Cellular Phone vs Smart Phone**	Co-evolution
	10. **Co-evolution Dynamism of Mobile Phone in Emerging and Developed Markets**	Diffusion/Learning
	11. **Analysis of PV Technology Industry, Solar Technology Development in China**	