23rd Jyvaskyla
Summer School
7-9 Aug.. 2013, University of Jyvaskyla, Jyvaskyla

COM8
Techno-economic Systems Institutional Innovation (1)

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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

Chihiro WATANABE

Chihiro Watanabe graduated from Tokyo University with a bachelor's degree in engineering (urban planning) in 1968 and received his Ph. D. (arts and science) in1992, also from Tokyo University.

Professor Watanabe joined Japan's Ministry of International Trade and Industry (MITI) in 1968 and spent most of his career there, chiefly working in the fields of energy and environmental policies, industrial policy, and industrial technology policy. He is former Deputy Director-General of Technology Development of the Ministry. His career includes overseas work experience in Indonesia (Second Secretary of the Japanese Embassy: 1973-1976)**, Australia** (Chief Representative of the Sydney Office of NEDO: 1984-1987) **and Austria** (IIASA: 1994-)**.**

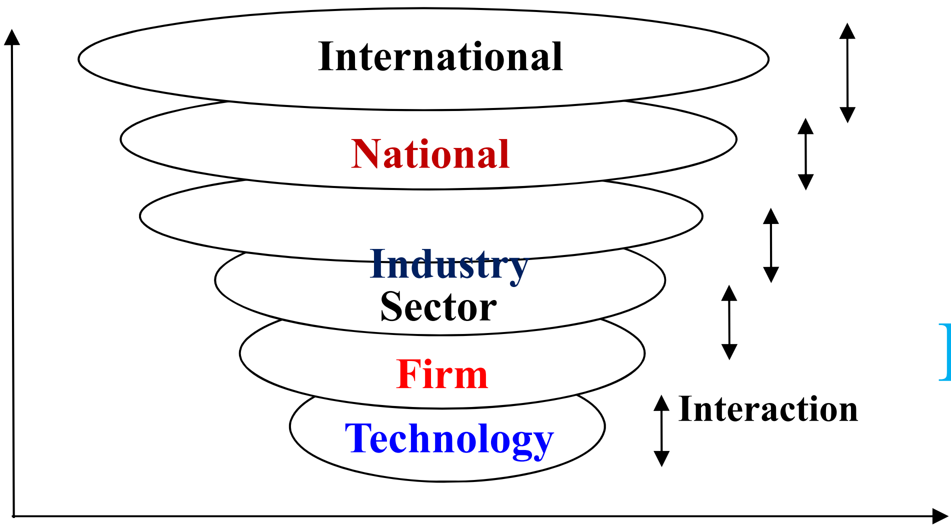
Professor Watanabe Joined Tokyo Institute of Technology in 1995 and worked as a Professor at Department of Industrial Engineering and Management of the Graduate School of Decision Science and Technology of the Institute. He is former Vice-Dean of the Graduate School and also a Councilor (member of the council) **of the Institute.**

He is currently a Professor Emeritus of Tokyo Institute of Technology, and Professor of the Department of Industrial Management of Tokyo Seitoku University. He is also Visiting Professor of D-ETM, NUS, Visiting Professor of University of Jyvaskyla, Finland, and also Guest Scholar of the International Institute for Applied Systems Analysis (IIASA).

He was a leader of Japan's Ministry of Education, Culture, Sport, Science and Technology's (MEXT) 21st Century Center of Excellence (COE) Project: *Science of Institutional Management of Technology (SIMOT)* in 2004, and was Director of the *Research Center for the Science of Institutional Management of Technology*, the research center for the project. He was ranked the world top researcher in the technology management field at IEEE IEEM (Dec. 2009, Hong Kong).

His research fields are technology innovation management, techno-economics, technology innovation, and technology policy. His research interest covers institutional innovation, energy and resource productivity, hybrid management of technology, and optimization of R&D investment. Professor Watanabe has published 150 refereed papers in the above fields.

Term Paper submit to watanabe.c.pqr@gmail.com by 31 Aug. 2013



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
	5. Analysis of the Tablet PC Industry & Market	Learning
Sector	6. Comparison of Technology Diffusion for Auto Manufacturing Industries	Diffusion
Firm	7. Rate of Return to R&D Investment Comparison between Huawei and Alcatel-Lucent	Rate of return to R&D
	8. Strategies Adopted by Apple and Samsung toward Smart Phone Innovation	Diffusion/learning
Technology	9.. Diffusion of Two Co-Existing Innovation: Cellular Phone vs Smart Phone	Diffusion
	10. Co-evolution Dynamism of Mobile Phone in Emerging and Developed Markets	Co-evolution
	11. Analysis of PV Technology Industry, Solar Technology Development in China	Diffusion/Learning

1. Technological Innovation, Growth, Diffusion and Consumption

1.1 Innovation, Growth, Diffusion and Consumption: *12 Key Features in Firm's Technopreneurial Strategy*

(1) Bi-polarization of Growth Trajectory

(2) Resilience against Beyond Anticipation

(3) Consequence of Dramatic Advancement Beyond Anticipation

(4) Innovation – Consumption Co-emergence

(5) Commodification of Experiences

1.2 Innovation and Growth: *Techno Economic Approach*

1.2.1 Production function
1.2.2 Growth rate
1.2.3 Elasticity
1.2.4 Cobb-Douglas type production function
1.2.5 Profit maximum condition
1.2.6 Implications of firms' profit maximum behavior
1.2.7 Elasticity of substitution

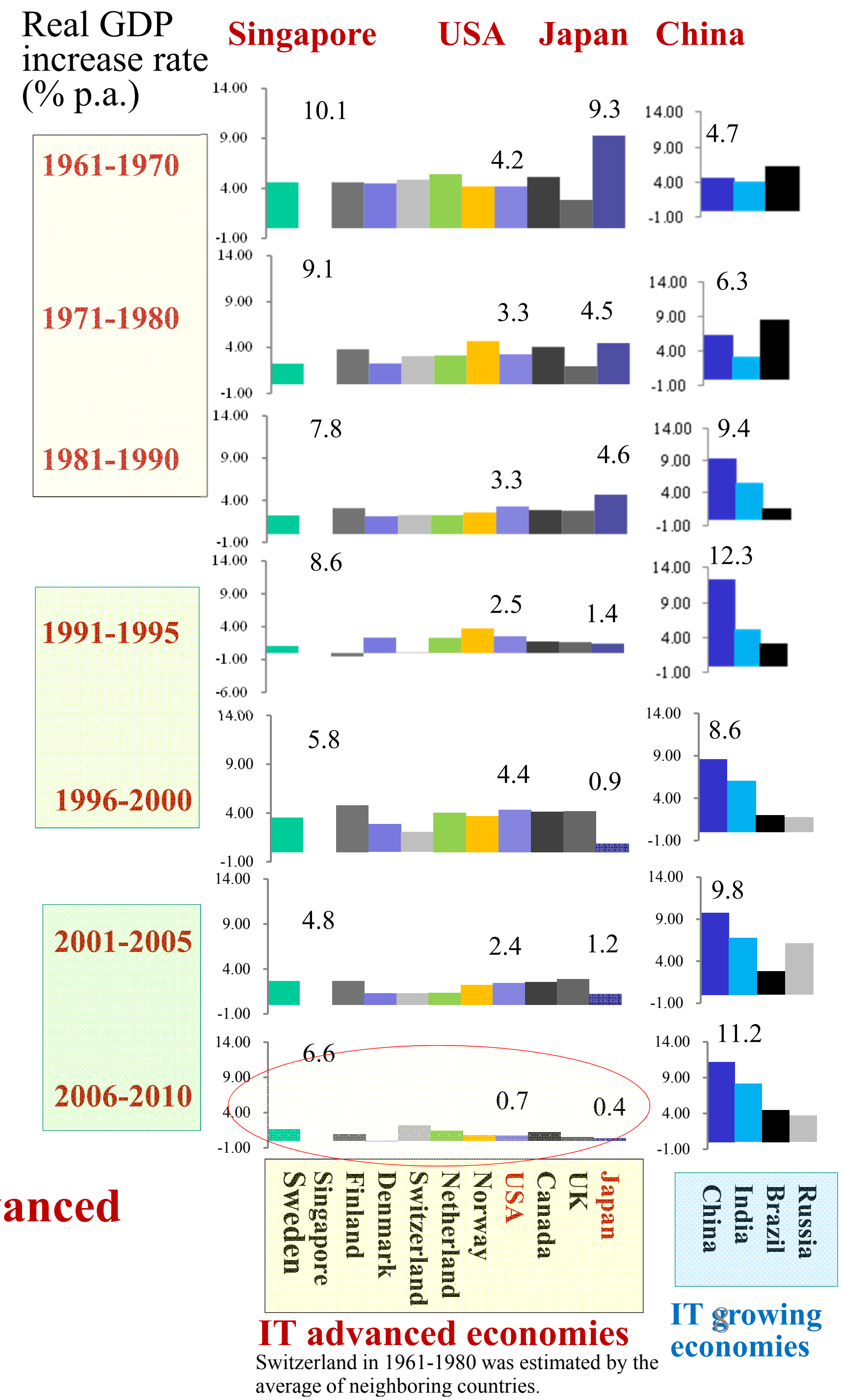
2. Productivity, Competitiveness
3. Knowledge stock
4. Diffusion
5. Learning
6. Spillover
7. Rate of Return to R&D

1.1 Innovation Growth, Diffusion and Consumption

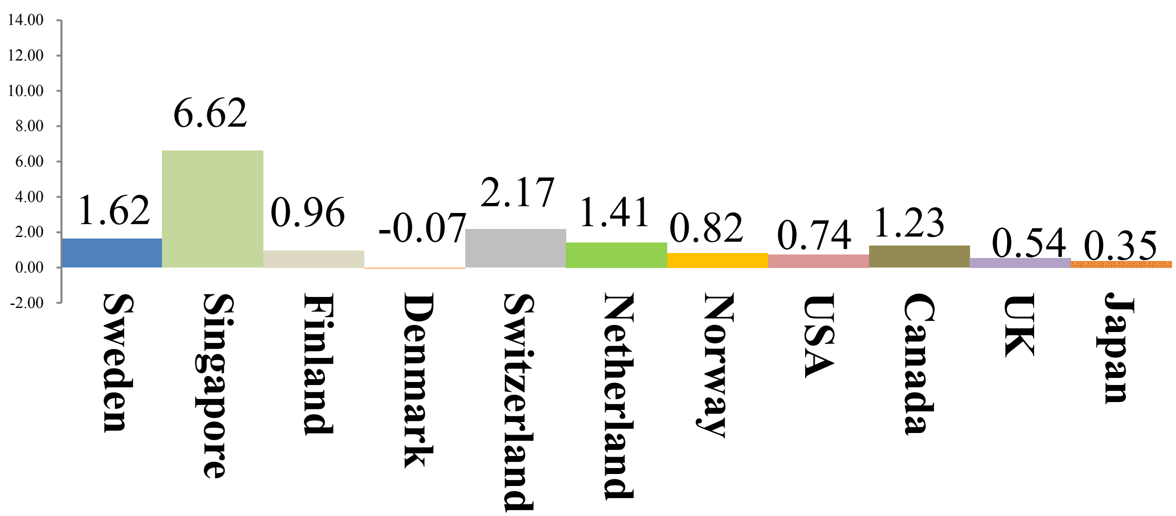
- *New Normal in Global System*

I. Bipolarization of Growth Trajectory

1. Bi-polarization of Growth Engine



Real GDP Increase Rate in 2006-2010 (% p.a.)



Contrary to IT growing economies, GDP increase in IT advanced economies has lost except Singapore.

2. Bi-polarization of Technopreneurial Trajectory
in Japan's High-tech Firms

IT driven business environment change

1.Digitalization of manufacturing process

No more Japan's indigenous knowhow

Unable to disseminate
No substantial differences in quality

2. Advancement of Internet beyond anticipation

No time differences in information dissemination
(Global simultaneous start-up)

Reverse in asymetory of information between S/D

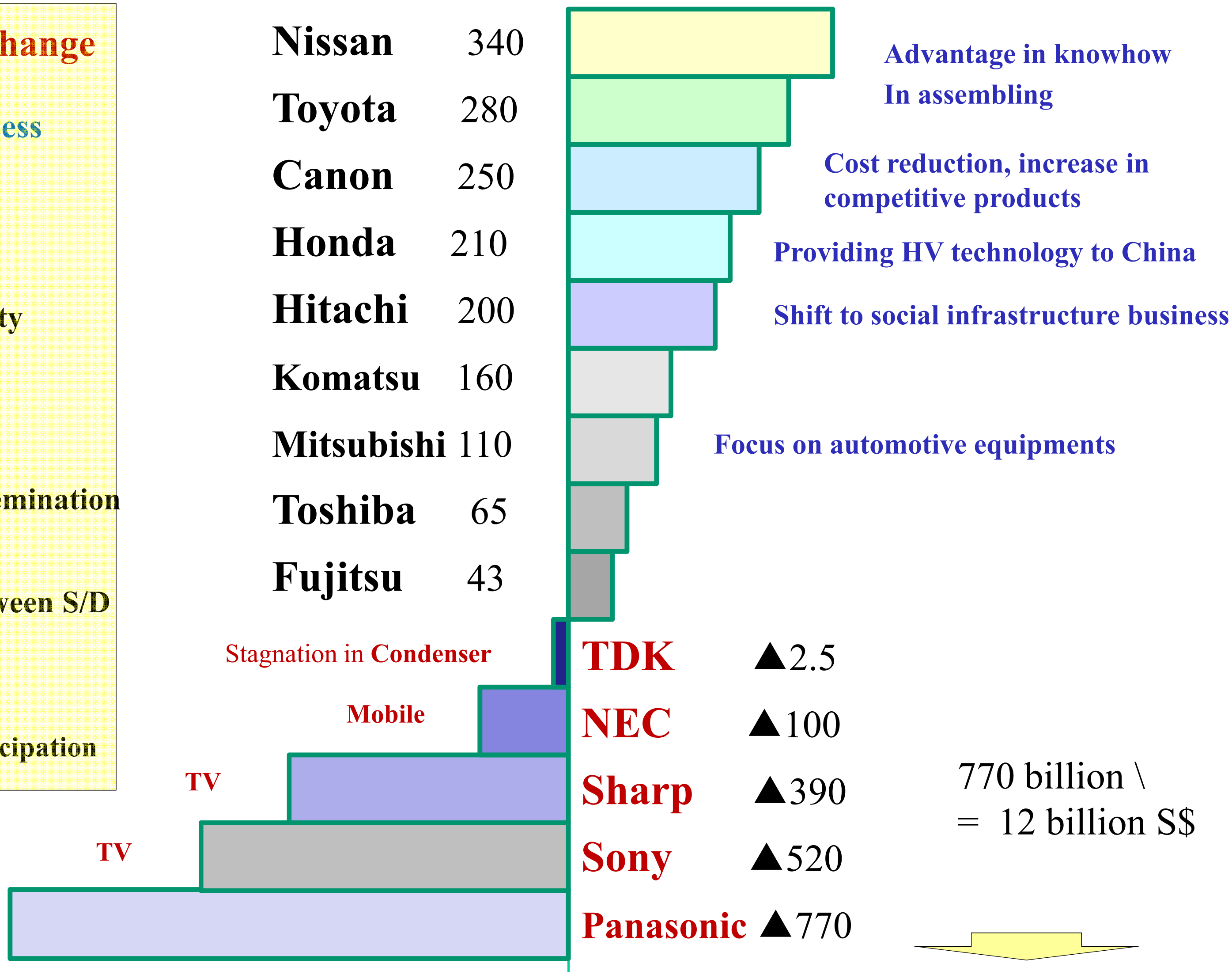
3. Rapid networking speed

Integration of multifunction faster than anticipation

As a consequence of efficiency oriented BM (business model)

1. **Misunderstand new stream**
2. **Non adaptive to env. change**
3. **Cling to traditional BM**
4. **Delay in structural change**

Net income ***(2011/4-12/3)*** **\ billion**



Reorganization of electronic machinery industry

New business model balancing efficiency and resilience

II. Resilience against Beyond Anticipation
- *Review*

1. President Soeharto's Postulate

President Soeharto in the early 1970s enlightened

Indonesia harus menjadi suatu bangsa yang tangguh

Indonesia should be a resilient nation

An ability (of a nation) to maintain original state in long term, and whenever change happens, the nation will be able to recover the situation to the original state

1973-1976 Japanese Embassy in Jakarta

2. Japan's Conspicuous Resiliency in the 1970s

- Transform Crises into a Springboard for Innovation: Technology Substitution

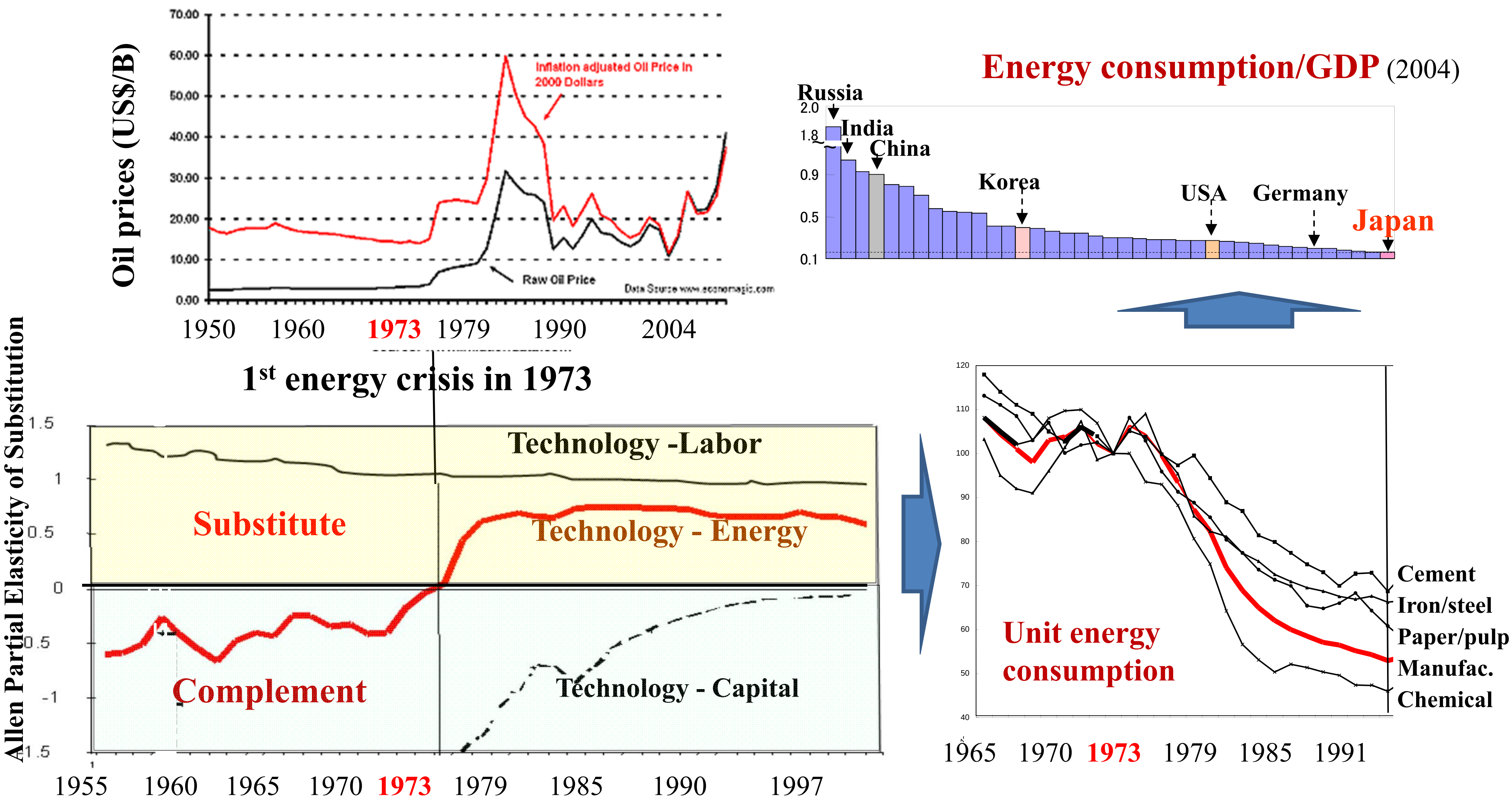


Fig. 1. Trends in Technology Substitution for Production Factors in Japan's Manufacturing *(1955-1997)*

3. System Conflict in an Information Society

- Complexity Mismatch: Dramatic Decrease in MPT resulting in Innovation Decrease

(i) Dramatic Decrease in Marginal Productivity of Technology

TFP: Total Factor Productivity

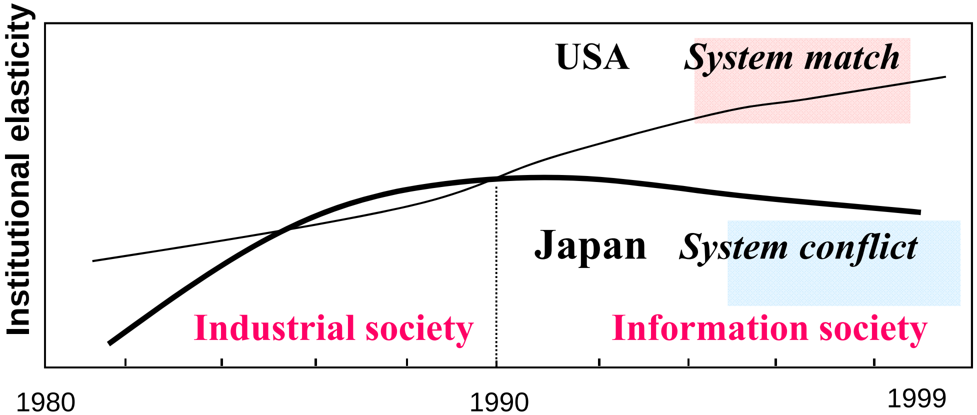


Fig. 2-1. Institutional Elasticity of Manufact.Technology

- Elasticity of the Shift to an Information Society to Marginal Productivity of Technology *(1980-1999) - Index : 1990 =100.*

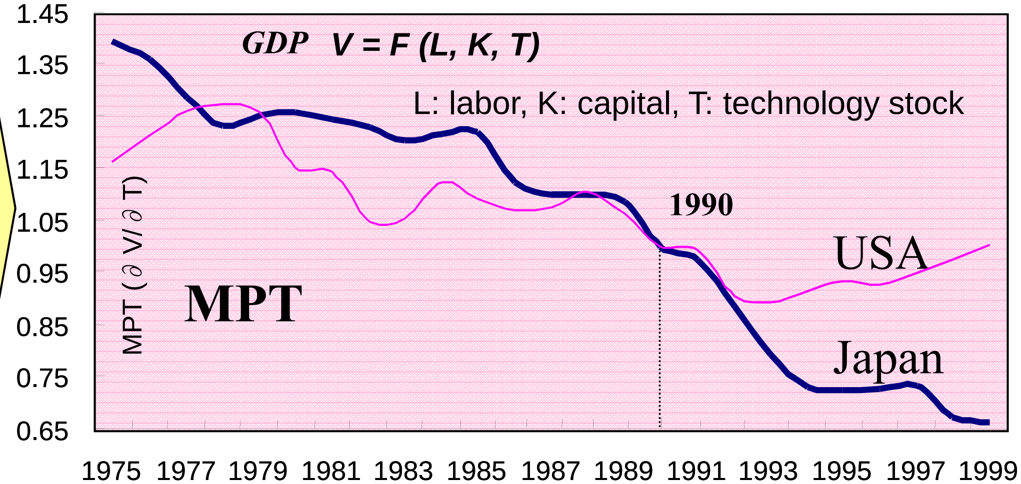


Fig. 2-2. Marginal Productivity of Manufact. Technology

(1975-1999) - Index: 1990 =1.

(ii) Consequent Decrease in Innovation

TFP change rate (ΔTFP/TFP) = R&D intensity (R/V) × Marginal productivity of technology (MPT)

Innovation to GDP growth

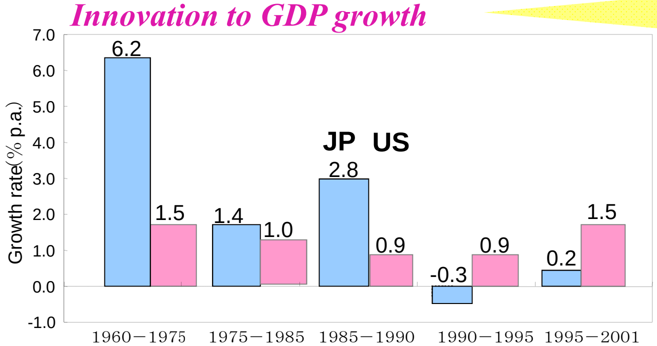


Fig. 2-3. TFP Growth Rate *(1960-2001).*

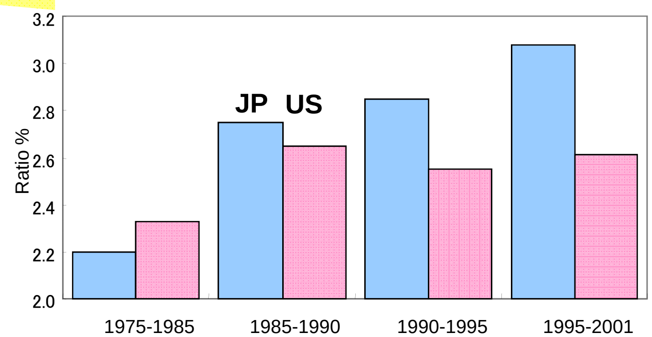


Fig. 2-4. R&D Intensity *(1975-2001).*

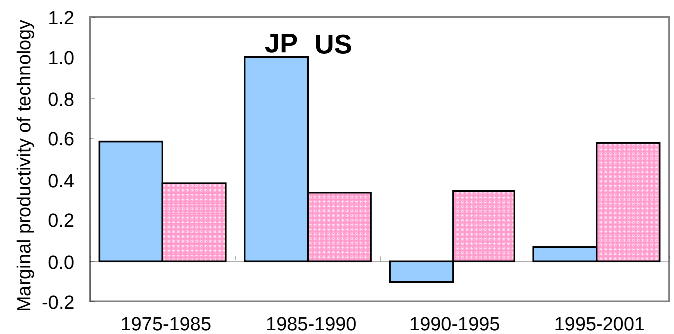


Fig. 2-5. Marginal Produc. of Tech. *(1960-2001).*

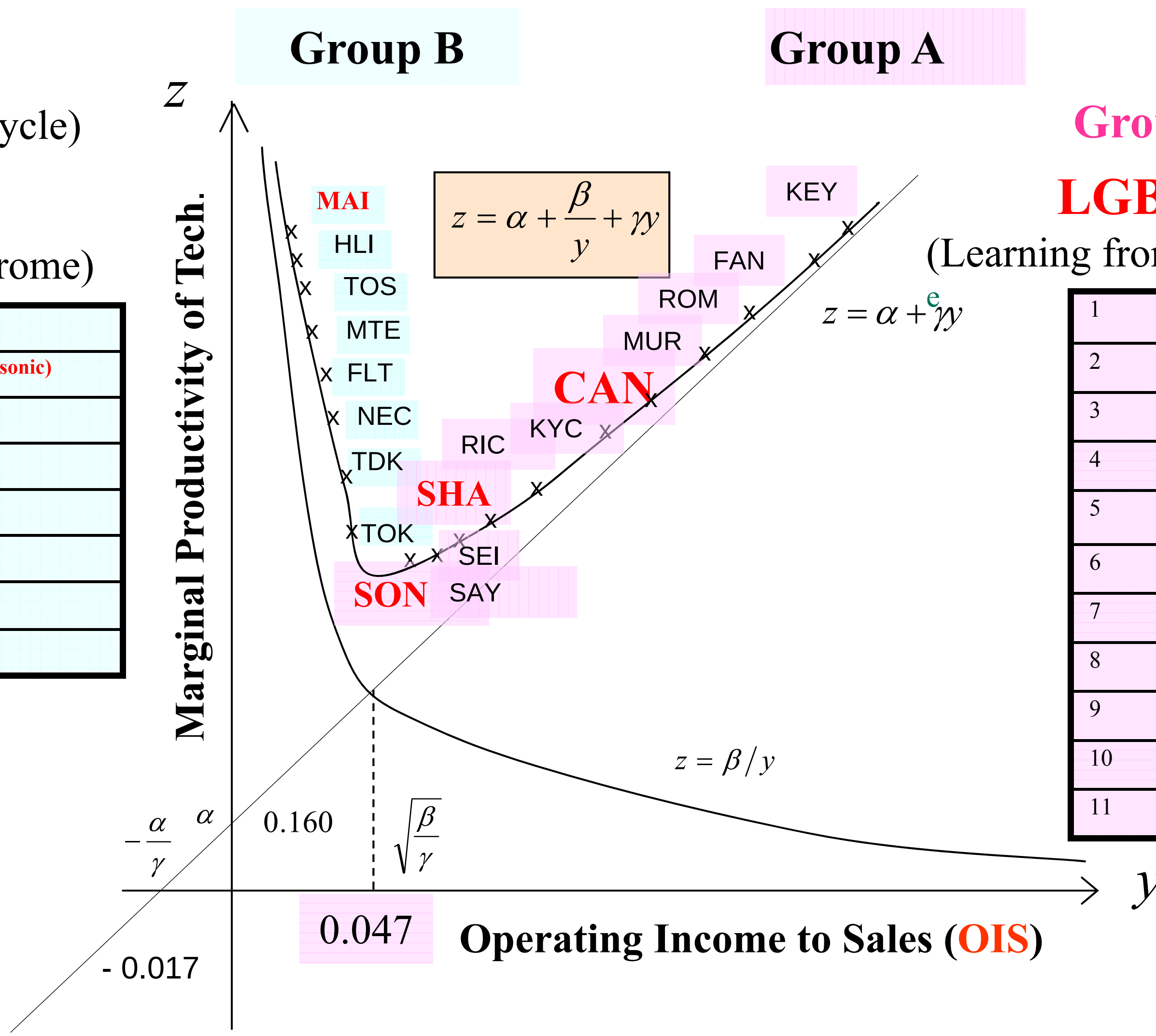
4. Bipolarization of Technopreneurial Trajectory

Group B (Vicious cycle)

NIH

(Not Invented Here syndrome)

12	HLT	**Hitachi**
13	**MAI**	**Matsushita (Panasonic)**
14	NEC	**NEC**
15	TOS	**Toshiba**
16	FLT	**Fujitsu**
17	MTE	**Mitsubishi**
18	TDK	TDK
19	TOK	Tokyo Electron



Group A (Virtuous cycle)

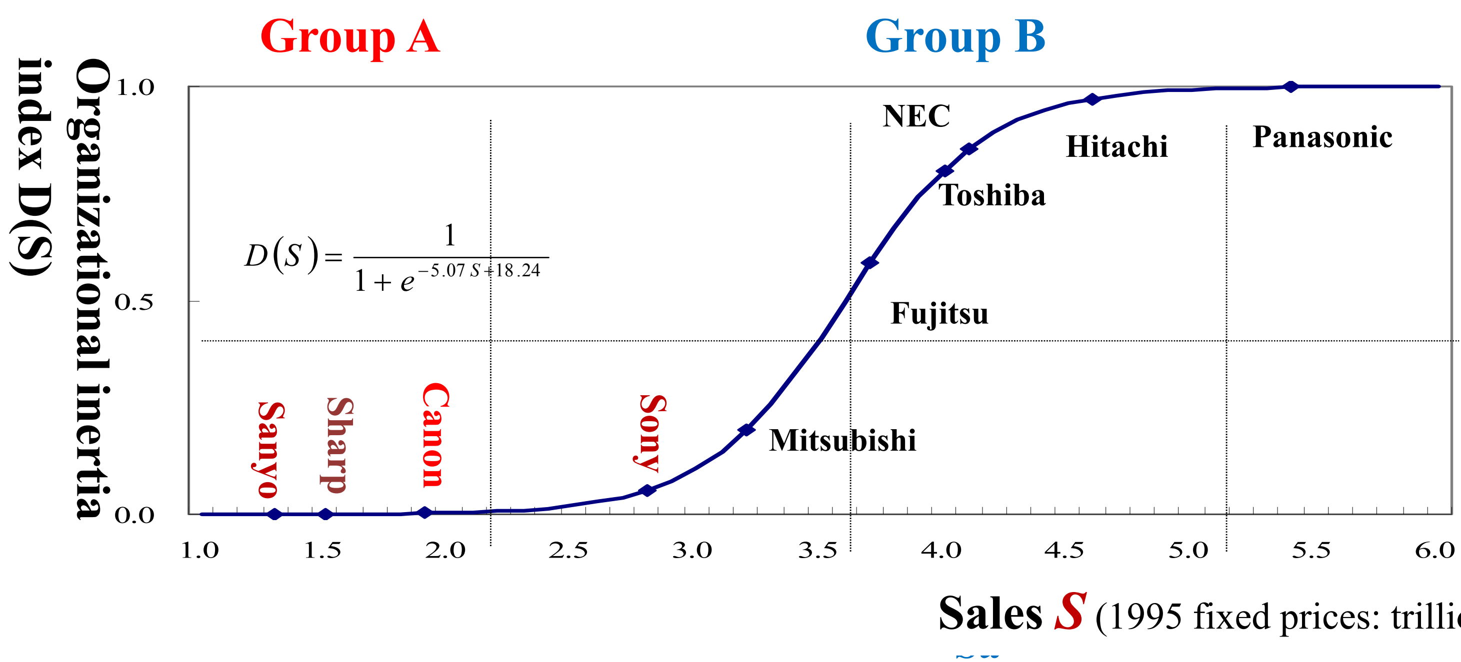
LGBP

(Learning from Global Best Practice)

1	**CAN**	**Canon**
2	**SHA**	**Sharp**
3	RIC	Ricoh
4	FAN	Fanuc
5	SEI	Seiko Epson
6	SAY	Sanyo
7	**SON**	**Sony**
8	MUR	Murata
9	ROM	Rohm
10	KYC	Kyocera
11	KEY	Keyence

Fig. 3. Technoprenurial Positions of 19 Electrical Machinery Firms *(2001-2004).*

Organizational Inertia by Firm Size



Organizational Inertia Index

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

$$=\frac{1}{1+e^{-5.07S+18.24}}$$

1995-1998

S_0: 2.7, S_1: 5.1, ε: 0.9, η: 0.0005

Fig. 4. Organizational Inertia Corresponding to Firm Size in Japan's Leading 10 Electrical Machinery Firms *(1995-1998).*

(i) Differences of the endeavor to technological diversification challenge due to organizational inertia by firm size

$$\ln TDI = \alpha + \beta_1 \ln R/S + \beta_2 D(S) \ln R/S$$

TDI : Technological diversification index, R/S : R&D intensity.

(ii) D(S) can be depicted by a logistic growth function.

5. Innovation and Institutional Systems

1. Innovation is highly dependent on the co-evolution with the institutional systems.

2. While institutions shape innovation, innovation also changes the institutions leading to a self-propagating dynamism

3. However, it may stagnate if institutional systems can not adapt to evolving conditions.

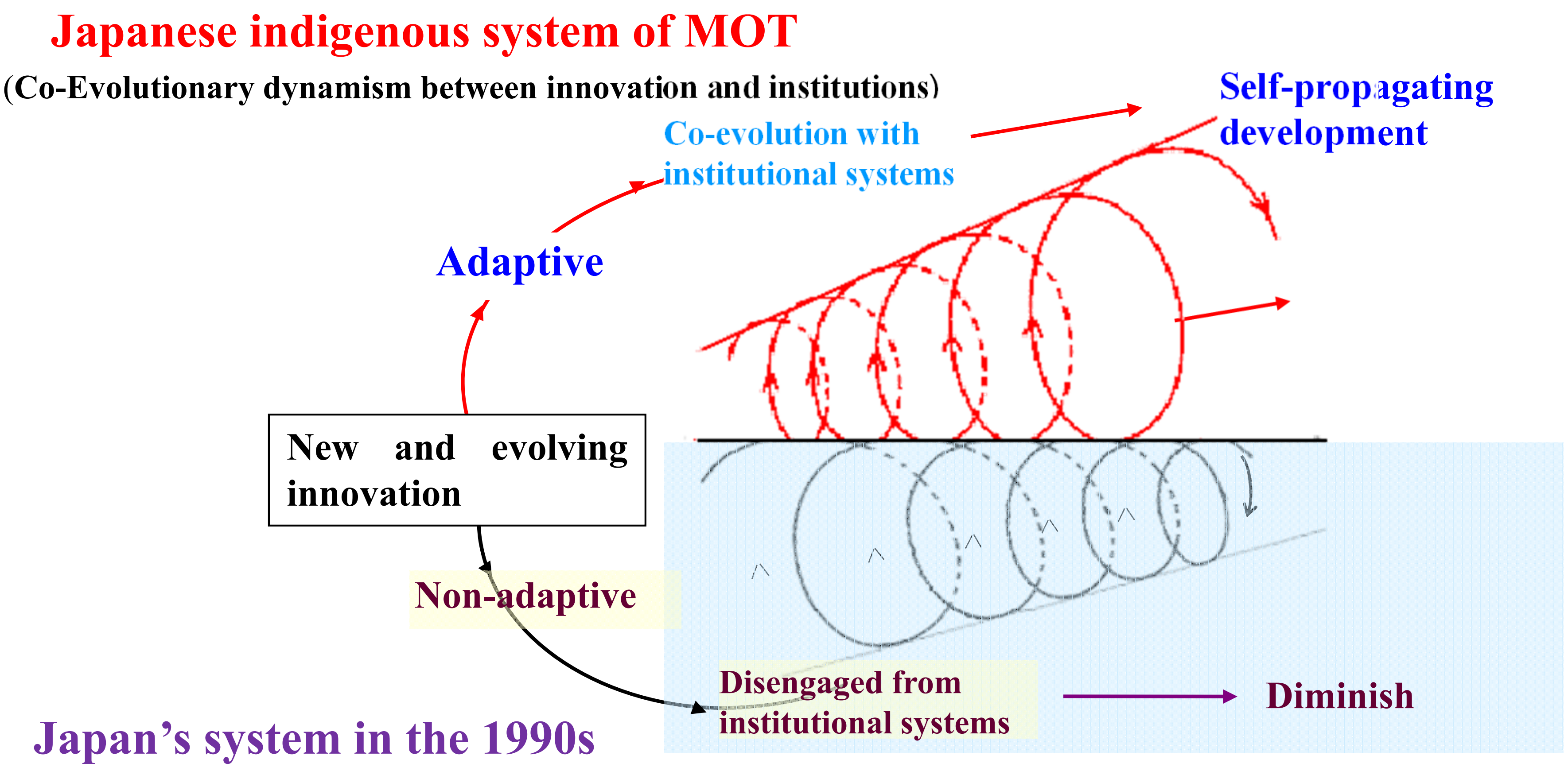
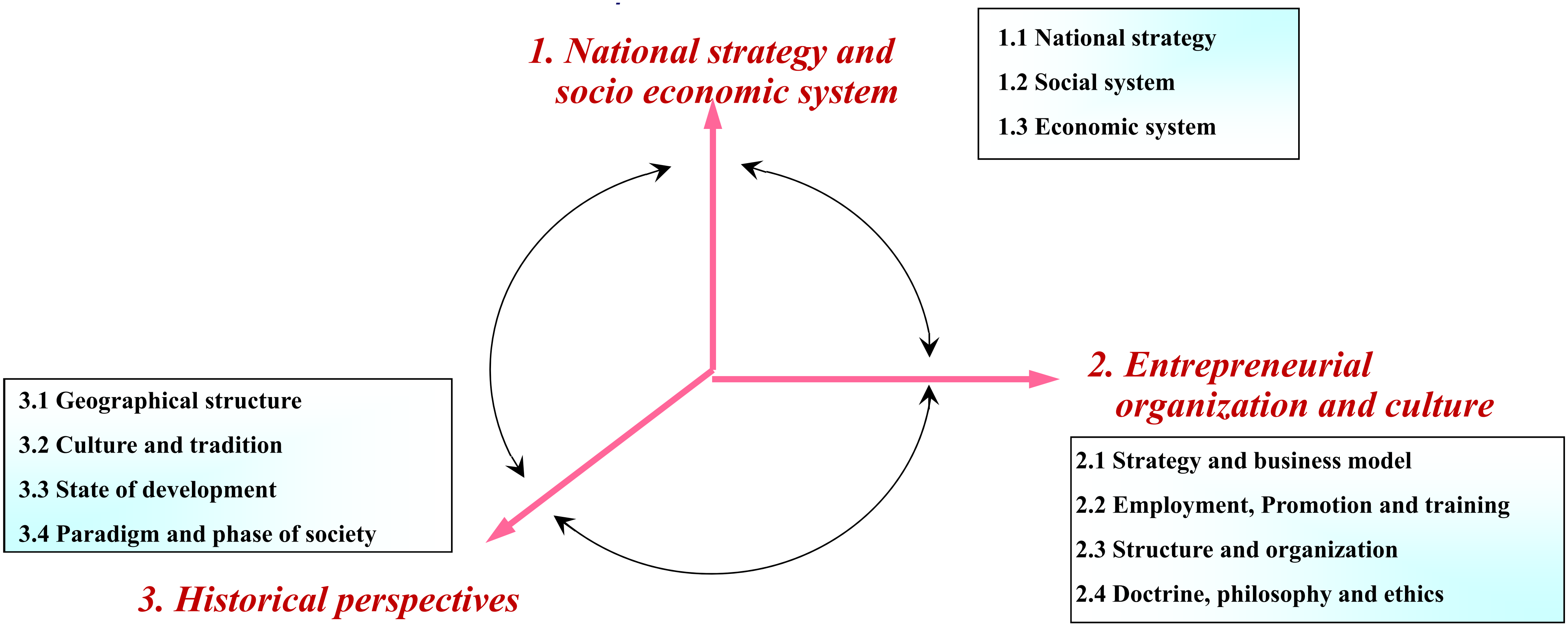


Fig. 5. Co-Evolutionary Dynamism between Innovation and Institutional Systems.

6. Role of Institutional Systems for Resilience

(i) Institutional systems consists of 3 dimensions and cultivate emerging innovation.



(ii) Resilience against external changes can be maintained by means of an elastic interaction between 3 dimensions.

Fig. 6. Three Dimensional Structure of Institutional Systems.

Suggestion

1. **External crises (due to beyond anticipation) can be transformed into a springboard for resilience.**

2. **Institutional less elasticity may decrease productivity dramatically.**

3. **Fusing indigenous strength with learning effects leads to sustainable virtuous cycle.**

4. **Innovation depends on the co-evolution with institutional systems while it changes to disengagement by loosing institutional elasticity.**

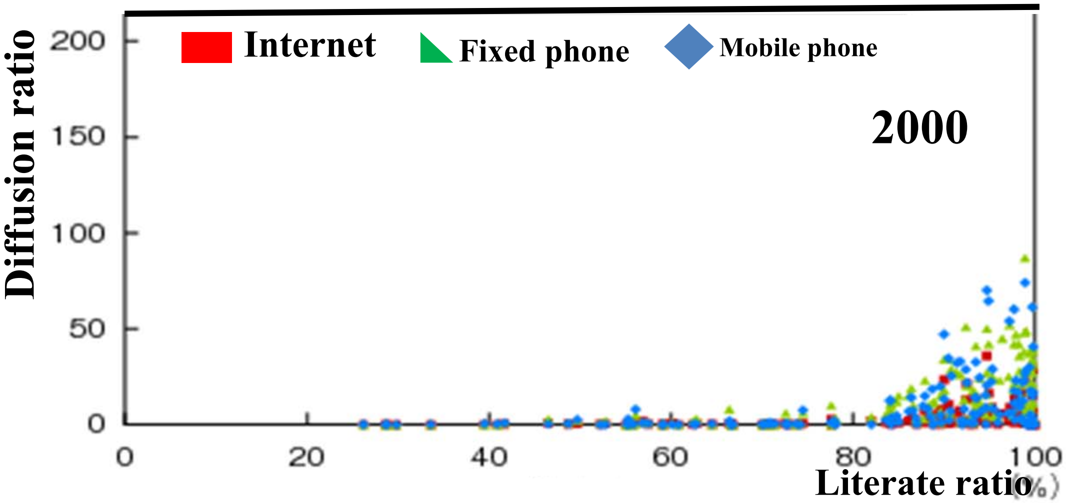
III. Consequence of Dramatic Advancement Beyond Anticipation: *A Case of the Internet*

III-1. Bi-polarization of IT Driven Global Economy

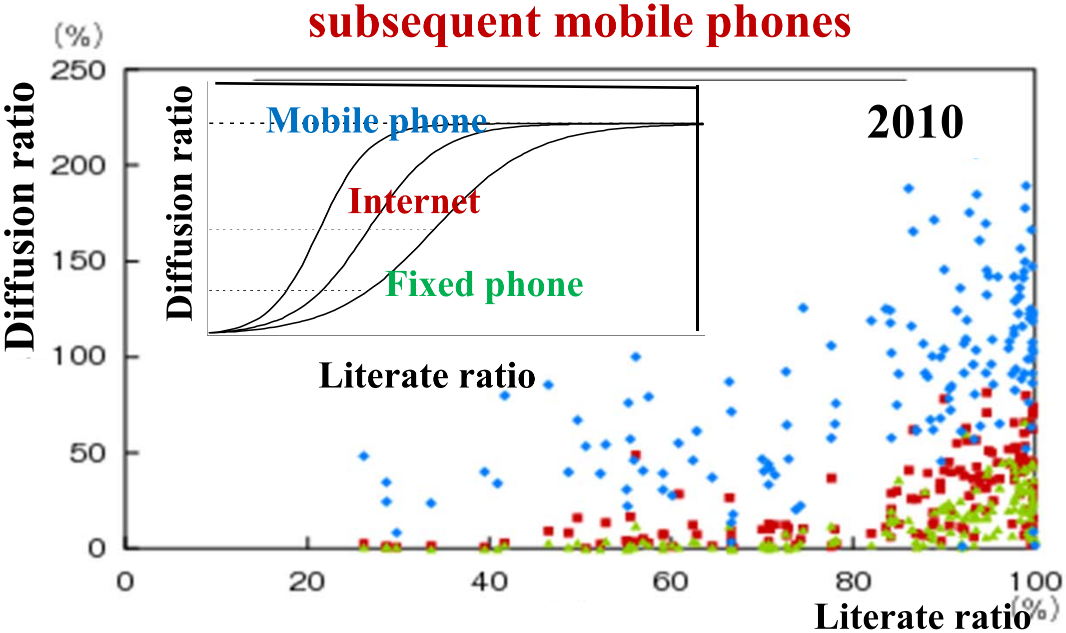
III-2. Increasing Complaints of Consumers

III-1. Bipolarization of IT Driven Global Economy

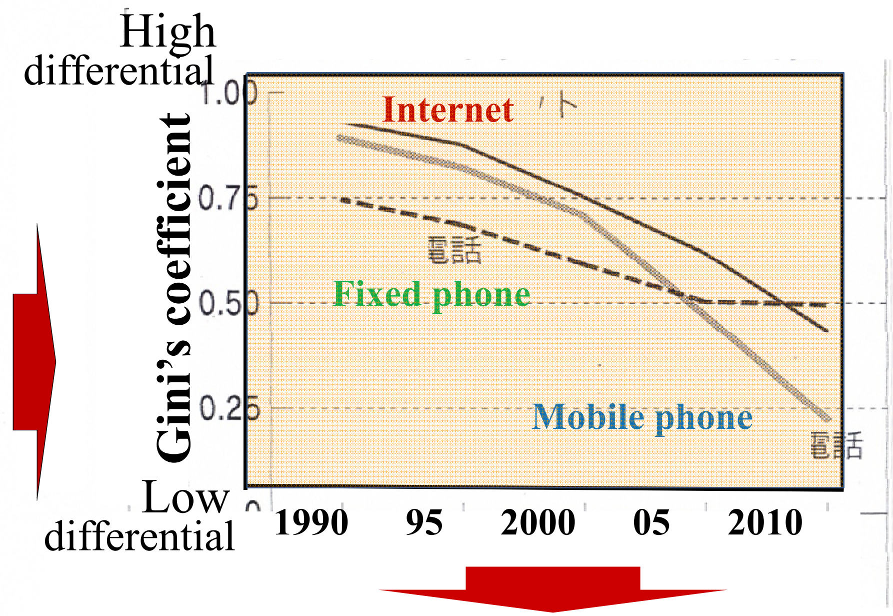
1. Global Simultaneous Dependency on IT



Dramatic advancement of Internet and subsequent mobile phones



Dramatic decrease in Digital Divide



Global simultaneous dependency on IT

Governing factor of GDP per capita in 100 countries (2011)

$$\frac{V}{P} = F(NRI)$$

V/P: GDP per capita, *NRI*: Network Readiness Index

$$\ln V/P = 3.47 + 4.25 \ln NRI + 1.03 D_1 - 1.12 D_2 \quad adj.R^2\ 0.876$$

(10.62) (19.47) (9.31) (-9.29)

D_1 *and* D_2: Dummy variables

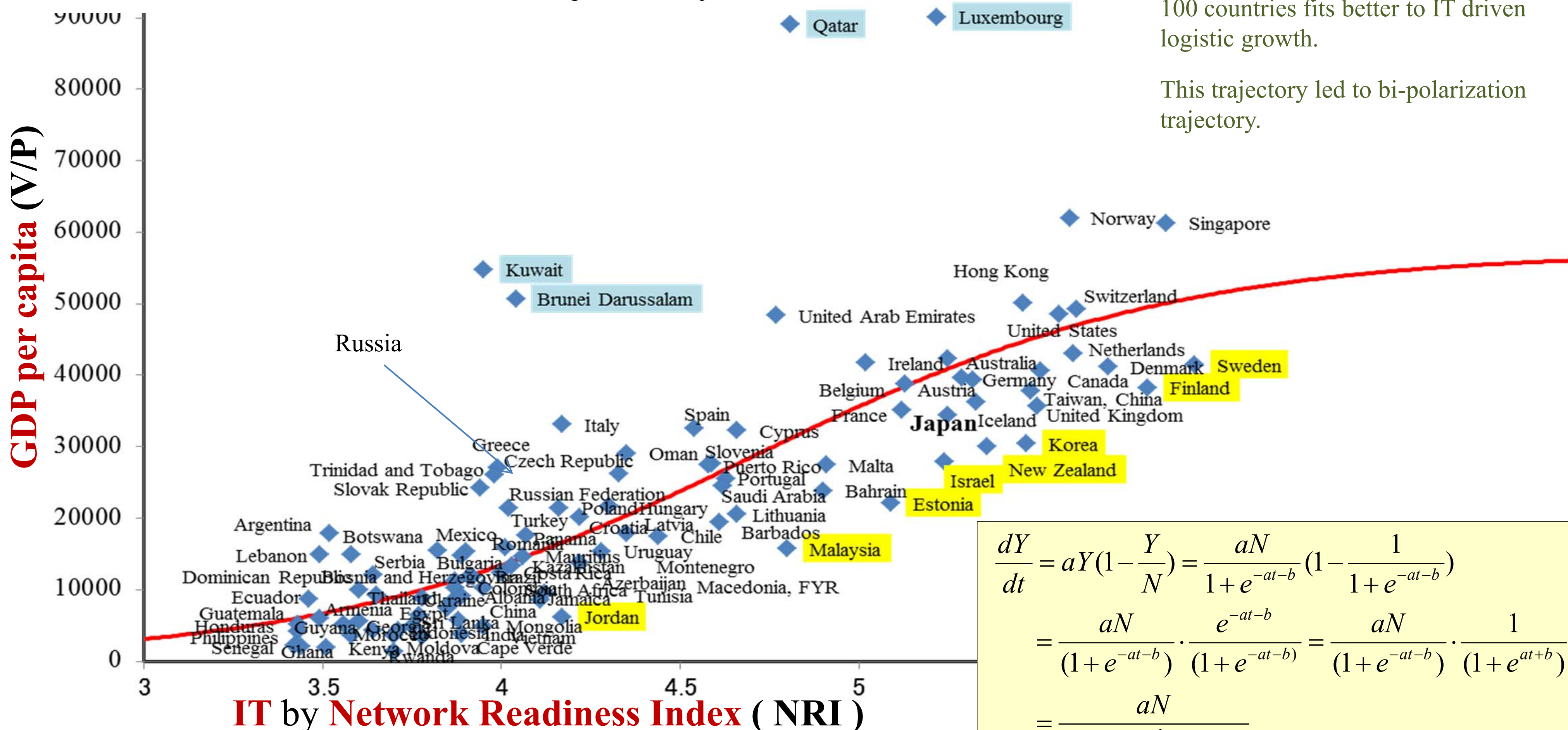
Fig. 7. Trend in Global Simultaneous Dependency on IT.

Sources: White Paper on Japan's ICT (2012), Shinozaki (2012).

2. IT Driven Economic Trajectory

Economic development trajectory in 100 countries fits better to IT driven logistic growth.

This trajectory led to bi-polarization trajectory.



Economic development trajectory fits better to IT driven logistic growth

$$Y \equiv \frac{V}{P} = \frac{N}{1+e^{-a\,NRI\,-b}} + cD_1 + dD_2$$

D_1 (*blue*), D_2 (*yellow*): Dummy

N	a	b	c	d	adj. R^2
57239	1.68	-7.90	46434	-12913	**0.885**
(9.62)	(7.58)	(-9.80)	(14.54)	(-5.25)	

Bi-polarization trajectory

$$\frac{dY}{dt} = aY\left(1-\frac{Y}{N}\right) = \frac{aN}{1+e^{-at-b}}\left(1-\frac{1}{1+e^{-at-b}}\right)$$

$$= \frac{aN}{(1+e^{-at-b})}\cdot\frac{e^{-at-b}}{(1+e^{-at-b})} = \frac{aN}{(1+e^{-at-b})}\cdot\frac{1}{(1+e^{at+b})}$$

$$= \frac{aN}{\left(2+e^{-at-b}+\frac{1}{e^{-at-b}}\right)}$$

$$\frac{aN}{\frac{dY}{dt}} = 2+e^{-at-b}+\frac{1}{e^{-at-b}}$$

$$y = (1+x)+\left(1+\frac{1}{x}\right) \qquad y \equiv \frac{aN}{\frac{dY}{dt}},\ x \equiv e^{-at-b}$$

Fig. 8. IT Driven Economic Development Trajectory in 100 Countries (2011).

3. Bi-polarization of IT Driven Economic Development Trajectory

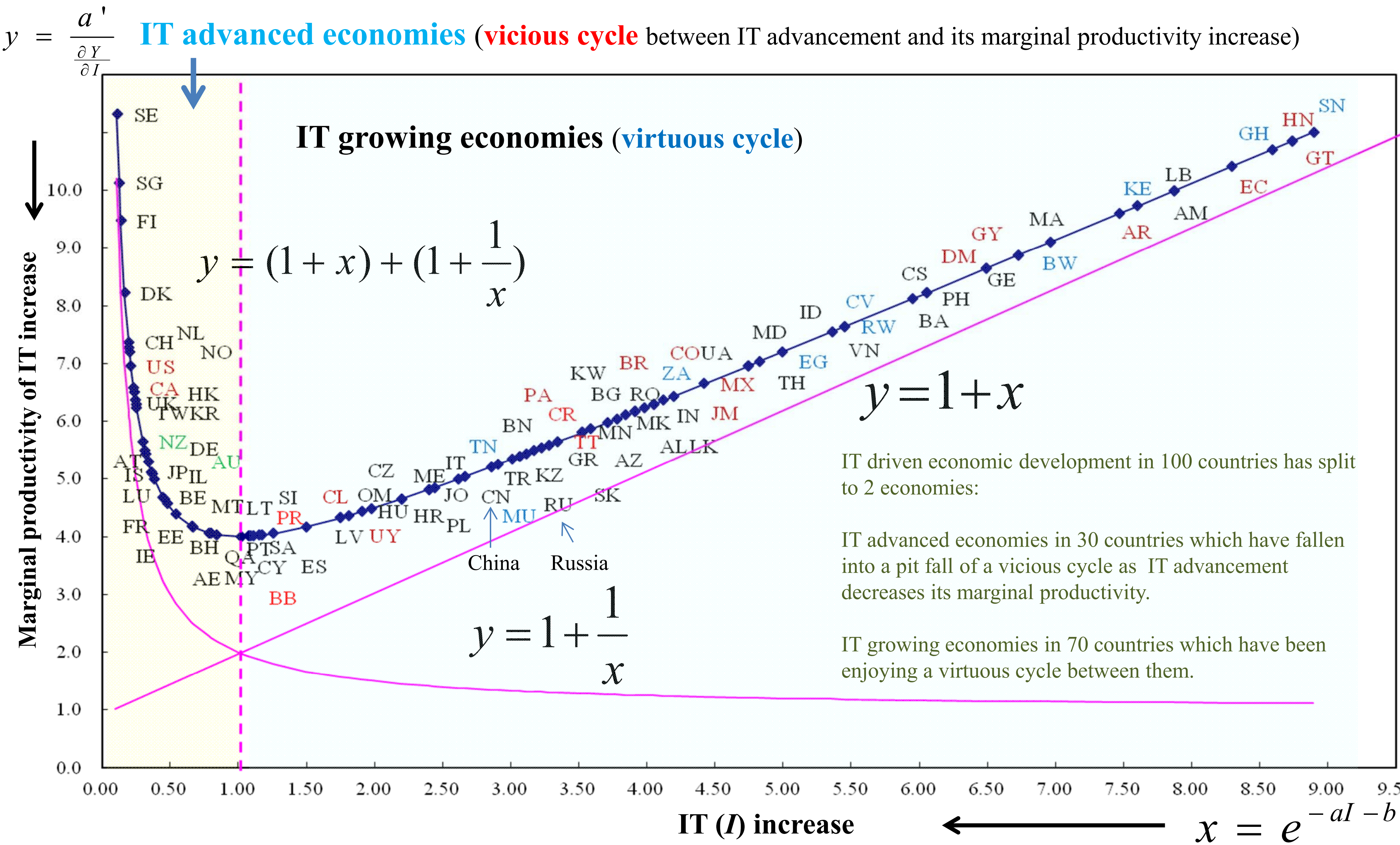


Fig. 9. Bi-polarization of IT Driven Economic Development Trajectory in 100 Countries (2011).

Table 1 The Networked Readiness Index 2012

N: Eurasian, N: Oceania, N: America, N: Africa

1 SE Sweden 5.94	26 MT Malta 4.91	51 CN China 4.11	76 MX Mexico 3.82
2 SG Singapore 5.86	27 BH Bahrain 4.90	52 TR Turkey 4.07	77 TH Thailand 3.78
3 FI Finland 5.81	28 QA Qatar 4.81	53 MU Mauritius 4.06	78 MD Moldova 3.78
4 DK Denmark 5.70	29 MY Malaysia 4.80	54 BN Brunei Darussalam 4.04	79 EG Egypt 3.77
5 CH Switzerland 5.61	30 AE United Arab Emirates 4.77	55 KZ Kazakhstan 4.03	80 ID Indonesia 3.75
6 NL Netherlands 5.60	31 LT Lithuania 4.66	56 RU Russian Federation 4.02	81 CV Cape Verde 3.71
7 NO Norway 5.59	32 CY Cyprus 4.66	57 PA Panama 4.01	82 RW Rwanda 3.70
8 US United States 5.56	33 PT Portugal 4.63	58 CR Costa Rica 4.00	83 VN Vietnam 3.70
9 CA Canada 5.51	34 SA Saudi Arabia 4.62	59 GR Greece 3.99	84 BA Bosnia and Herzegovina 3.65
10 UK United Kingdom 5.50	35 BB Barbados 4.61	60 TT Trinidad and Tobago 3.98	85 CS Serbia 3.64
11 TW Taiwan, China 5.48	36 PR Puerto Rico 4.59	61 AZ Azerbaijan 3.95	86 PH Philippines 3.64
12 KR Korea, Rep. 5.47	37 SI Slovenia 4.58	62 KW Kuwait 3.95	87 DM Dominican Republic 3.60
13 HK Hong Kong SAR 5.46	38 ES Spain 4.54	63 MN Mongolia 3.95	88 GE Georgia 3.60
14 NZ New Zealand 5.36	39 CL Chile 4.44	64 SK Slovak Republic 3.94	89 BW Botswana 3.58
15 IS Iceland 5.33	40 OM Oman 4.35	65 BR Brazil 3.92	90 GY Guyana 3.58
16 DE Germany 5.32	41 LV Latvia 4.35	66 MK Macedonia, FYR 3.91	91 MA Morocco 3.56
17 AU Australia 5.29	42 CZ Czech Republic 4.33	67 RO Romania 3.90	92 AR Argentina 3.52
18 JP Japan 5.25	43 HU Hungary 4.30	68 AL Albania 3.89	93 KE Kenya 3.51
19 AT Austria 5.25	44 UY Uruguay 4.28	69 IN India 3.89	94 AM Armenia 3.49
20 IL Israel 5.24	45 HR Croatia 4.22	70 BG Bulgaria 3.89	95 LB Lebanon 3.49
21 LU Luxembourg 5.22	46 ME Montenegro 4.22	71 LK Sri Lanka 3.88	96 EC Ecuador 3.46
22 BE Belgium 5.13	47 JO Jordan 4.17	72 ZA South Africa 3.87	97 GH Ghana 3.44
23 FR France 5.12	48 IT Italy 4.17	73 CO Colombia 3.87	98 GT Guatemala 3.43
24 EE Estonia 5.09	49 PL Poland 4.16	74 JM Jamaica 3.86	99 HN Honduras 3.43
25 IE Ireland 5.02	50 TN Tunisia 4.12	75 UA Ukraine 3.85	100 SN Senegal 3.42

Source: The Global Information Technology Report 2012 (World Economic Forum, 2012).

The Network Readiness Index; **Environment** (Political and regulatory environment, Business and innovation environment), **Readiness** (Infrastructure and digital content, Affordability), **Usage** (Individual usage, Business usage, Government usage), **Impact** (Economic impact, Social impact)

4. Co-emergence of Institutional Innovation

$$Y = F(X, I)$$

Y = ***V/P*** (GDP per capita), ***X***: labor and capital, ***I***: Level of IT by ***NRI***

IT advanced economies

$$\frac{\Delta Y}{Y} = \sum_{X=L,K} \frac{\partial Y}{\partial X} \cdot \frac{\Delta X}{X} + \frac{\partial Y}{\partial I} \cdot \frac{\Delta I}{Y}$$

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

$$FD \downarrow \;\rightarrow\; \frac{\partial Y}{\partial I} \downarrow \;\rightarrow\; \frac{\Delta Y}{Y} \downarrow$$

Harness the vigor of IT growing economies

$$Y \uparrow \;\rightarrow\; I \uparrow$$

IT advancement supported by IT advanced economies

IT growing economies

$$FD \uparrow \;\rightarrow\; \frac{\partial Y}{\partial I} \uparrow \;\rightarrow\; \frac{\Delta Y}{Y} \uparrow$$

$$\downarrow$$

$$Y \uparrow$$

Fig. 10. Basic Concept of Co-emergence of Institutional Innovation between IT Advanced Economies and IT Growing Economies.

FD (Functionality development): Ability to improve performance of production processes, goods and services by means of innovation. Potential capacity before reaching obsolescent stage degree of which can be measured by $\overline{Y}/Y$.

5. Global Change in Growth Engine

1. Growth oriented trajectory

GDP per capita increase rate — Contribution by traditional factors — TFP growth rate

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

Marginal productivity of technology

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

Functionality development

2. Functionality development initiated trajectory

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

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

3. Co-evolutionary acclimatization trajectory

IT advanced Economies (*IAE*)

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

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

Harness the vigor of *IGE*

IT growing Economies (*IGE*)

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

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

Advance IT supported by *IAE*

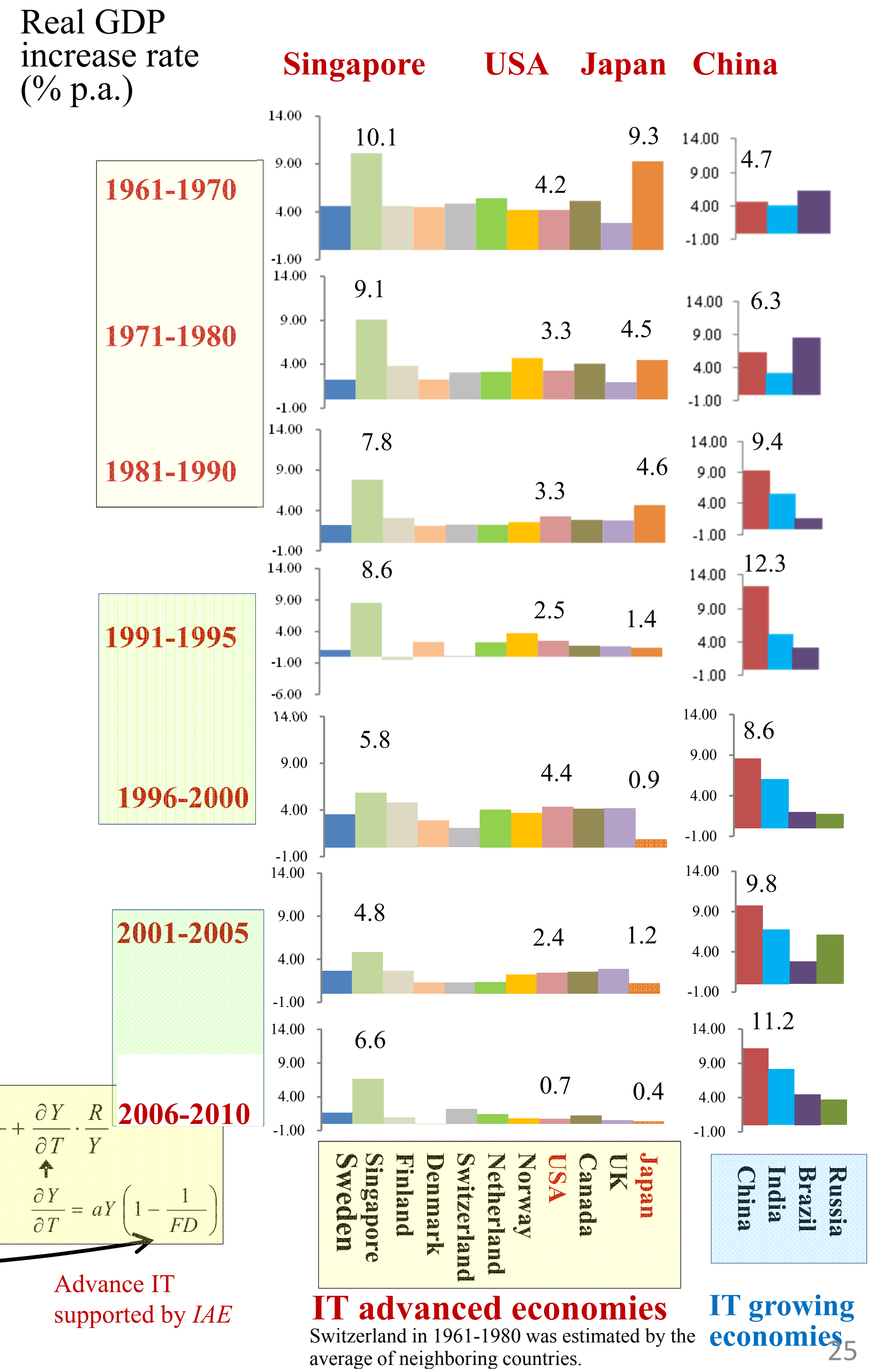


Fig. 11. Global Change in Growth Engine.

III-2. Increasing Complaints of Consumers

1. Maker Movement

Commodification of experience

Utmost gratification ever experienced has memorized in the brain

Experience/Learning

Complaints to
- Producers
- Being remained consumers

Anxiety

1. Supra-functionality beyond economic value
2. Shift from claimers to creators
3. Eco-contribution by own option

Wish to manufacture by own hand what anticipate

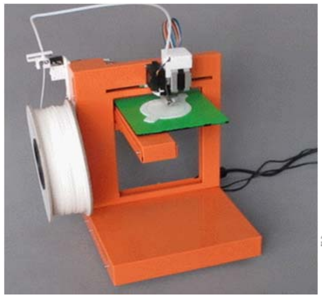
Dramatic advancement of the Internet → Knowledge

Consumers accumulate more knowledge than producers

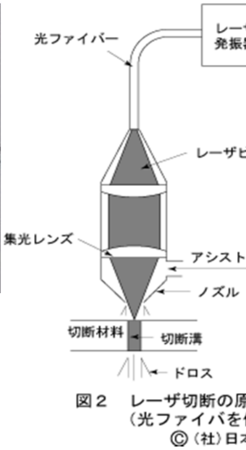
Technology

Digitalization of manf.

3D printer



Laser cutter



Funding →

Crowd funding

Maker Movement

Fig. 12. Maker Movement Paths.

2.Consumer's Instinctive Suppression against Consumption (CISAC)

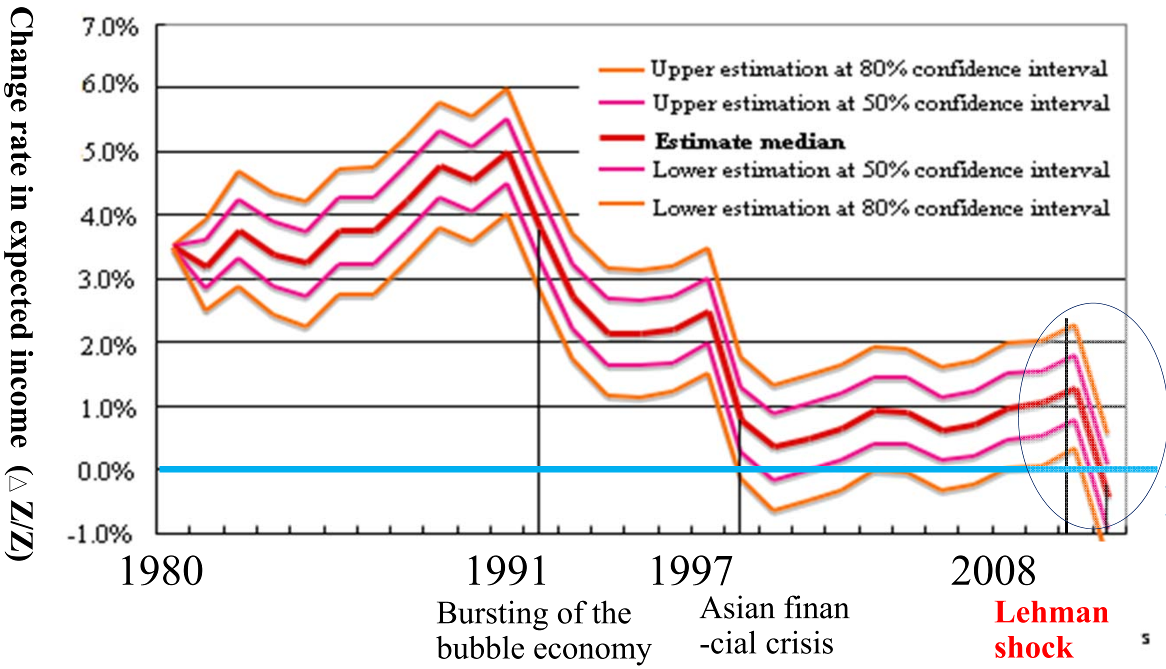


Fig. 13. Trend in Annual Increase Rate in Japan's Expected Income (1980-2008).

Dramatic decrease after the bursting of the bubble economy (1991) and further decreased due to Asian financial crisis((1997).
While slightly recovered, changed to dramatic decrease due to the Lehman shock (2008).

Dramatic decrease

Expected income / Actual income / CISAC

$$Z = Z(V, W)$$

$$\frac{\Delta Z}{Z} = \phi \frac{\Delta V}{V} - \lambda \frac{\Delta W}{W}$$

$$\Delta\left(\frac{C}{V}\right) = -\pi\left(\frac{\Delta V}{V} - \frac{\Delta Z}{Z}\right)$$

$$\Delta\left(\frac{C}{V}\right) = -\pi\left(\frac{\Delta V}{V} - \frac{\Delta Z}{Z}\right) = -\pi\left[\frac{\Delta V}{V} - \left(\phi \frac{\Delta V}{V} - \lambda \frac{\Delta W}{W}\right)\right] = -\pi\left[(1-\phi)\frac{\Delta V}{V} + \lambda \frac{\Delta W}{W}\right]$$

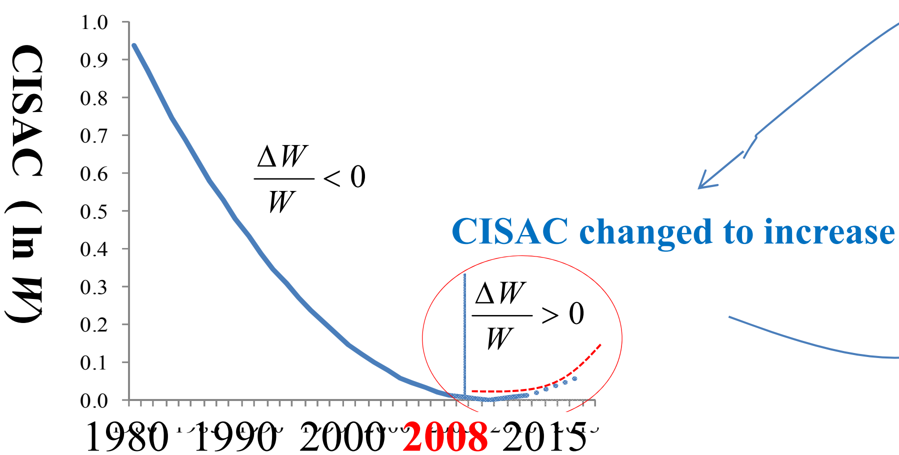


Fig. 14. Trend in CISAC in Japan (1980-2015).

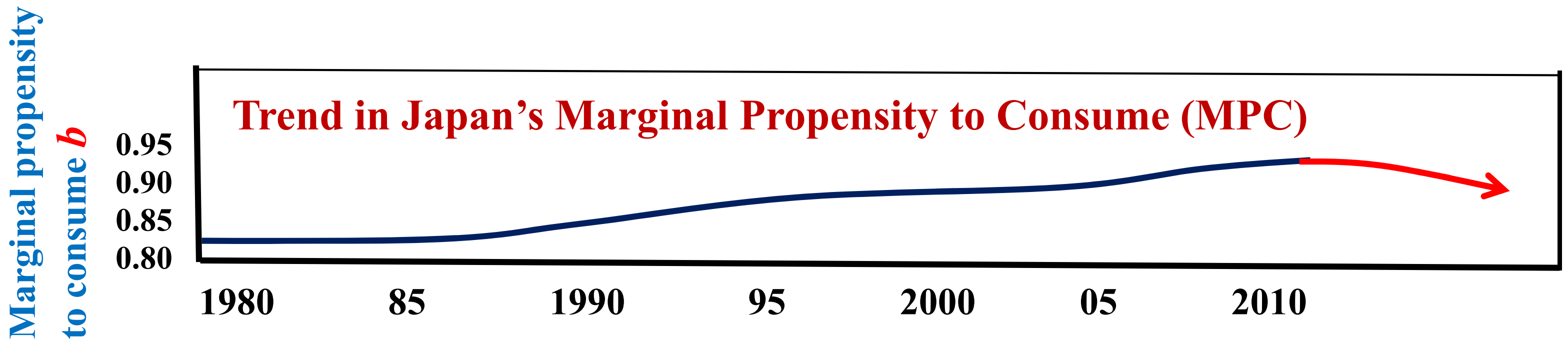
Marginal propensity to consume (MPC)

$$\frac{\Delta C}{\Delta V} = [\delta - \pi(1-\phi)] - \lambda\pi \cdot \frac{\Delta W / W}{\Delta V / V}$$

CISAC increase under income increase results in MPC decrease

3. Stagnation of Consumption

toward a Post-excessive Consumption Society



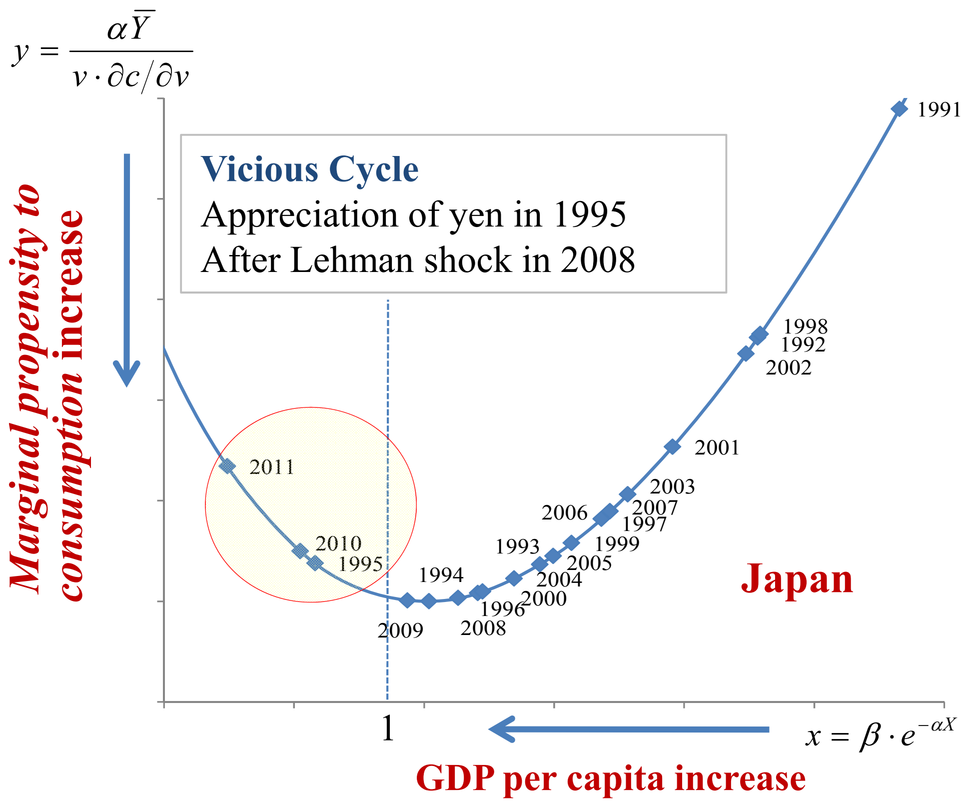
$$C = a + bV$$

C: Consumption
V: GDP

$$b = \frac{\partial C}{\partial V}$$

Y: Size of c; X: level of v
(X in logarithmic terms)

$$\frac{\partial X}{\partial Y} = \frac{\partial \ln v}{\partial c} = \frac{\partial v}{\partial c} \cdot \frac{1}{v} = \frac{1}{v \cdot MPc}$$



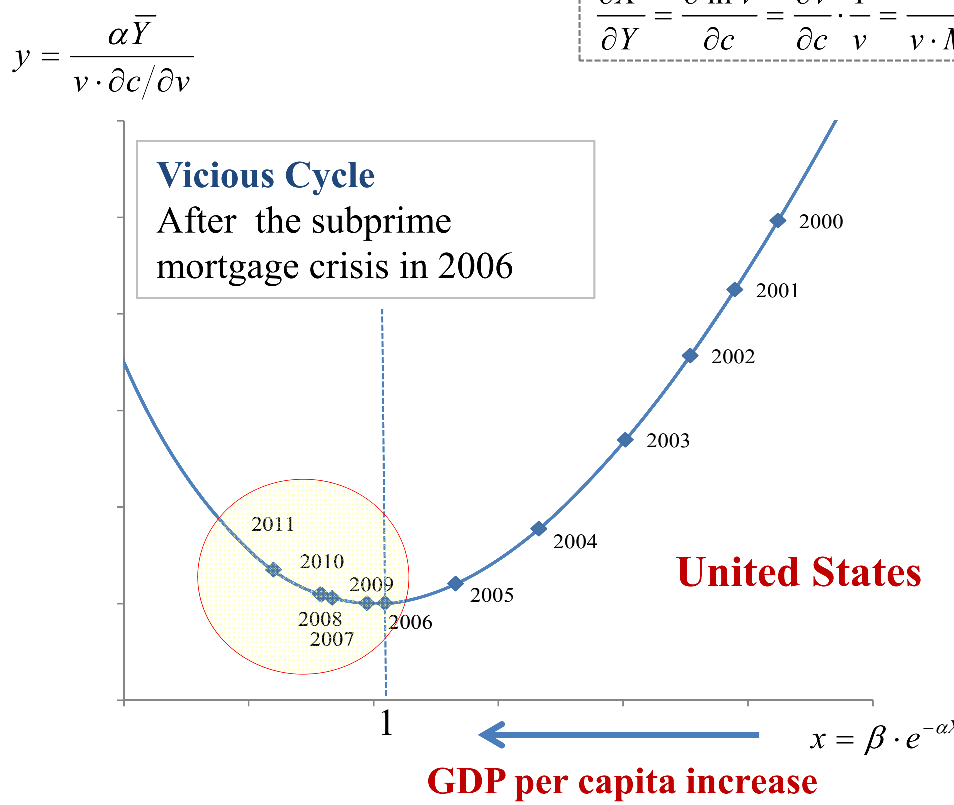


Fig. 15. Development Trajectory of MPC induced by GDP of Japan and the US *(1980-2011)*.

Source: Fukuda and Watanabe (2012.).

Suggestion

Dramatic advancement of the Internet beyond anticipation

Bipolarization of IT driven global economy

Co-evolutionary acclimatization trajectory for sustainability

Innovation – consumption co-emergence

Transform into a springboard for innovation

Increasing complaints of consumers

IV. Innovation-Consumption Co-emergence

1. Growth Engine in Co-evolutionary Acclimatization Trajectory

Trigger of co-emergence of such institutional innovation can be depicted as follows:

IT advanced economies

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

↑

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

↑

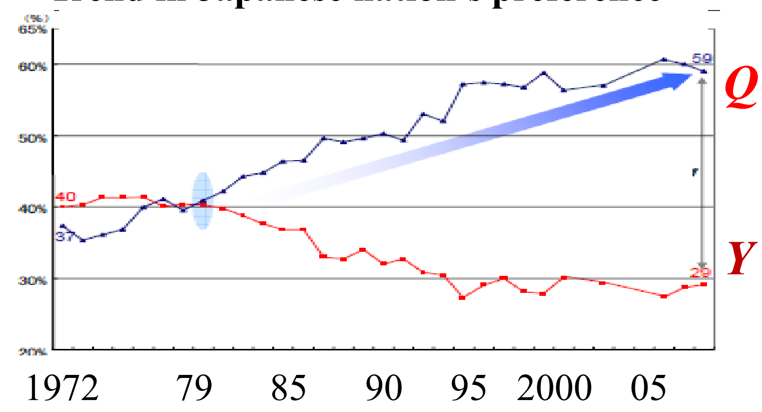
IT growing economies

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

↑

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

Trend in Japanese nation's preference



Source: Japan's Cabinet Office.

Utility function

$$U = U(FD) = U(Y,Q) = \frac{\partial U}{\partial Y}\cdot Y + \frac{\partial U}{\partial Q}\cdot Q = \left(\frac{\partial U}{\partial C}\cdot C\right)\left(\frac{\partial C}{\partial Y}\cdot\frac{Y}{C} + \frac{\partial C}{\partial Q}\cdot\frac{Q}{C}\right) = \left(\frac{\partial U}{\partial C}\cdot C\right)\left[\frac{\partial C}{\partial Y}\cdot\frac{Y}{C} + \left(\frac{\partial C}{\partial I}\cdot\frac{I}{C}\right)\left(\frac{\partial I}{\partial Q}\cdot\frac{Q}{I}\right)\right]$$

Income elasticity to consumption — IT elasticity to consumption — Q elasticity to IT

$$U = U(FD) = U(Y,Q) = \left(\frac{\partial U}{\partial C}\cdot C\right)\left[\frac{\partial C}{\partial Y}\cdot\frac{Y}{C} + \left(\frac{\partial C}{\partial I}\cdot\frac{I}{C}\right)\left(\frac{\partial I}{\partial Q}\cdot\frac{Q}{I}\right)\right]$$

Y **Economic functionality**

Q **Supra-functionality** beyond economic value encompassing social, cultural and emotional value

IT induce consumption ← **Increase IT dependency** ← **IT support by IT advanced economies**

Fig. 16. IT Driven Innovation-Consumption Co-emergence Dynamism.

2. Dynamism Inducing Innovation-Consumption Co-emergence

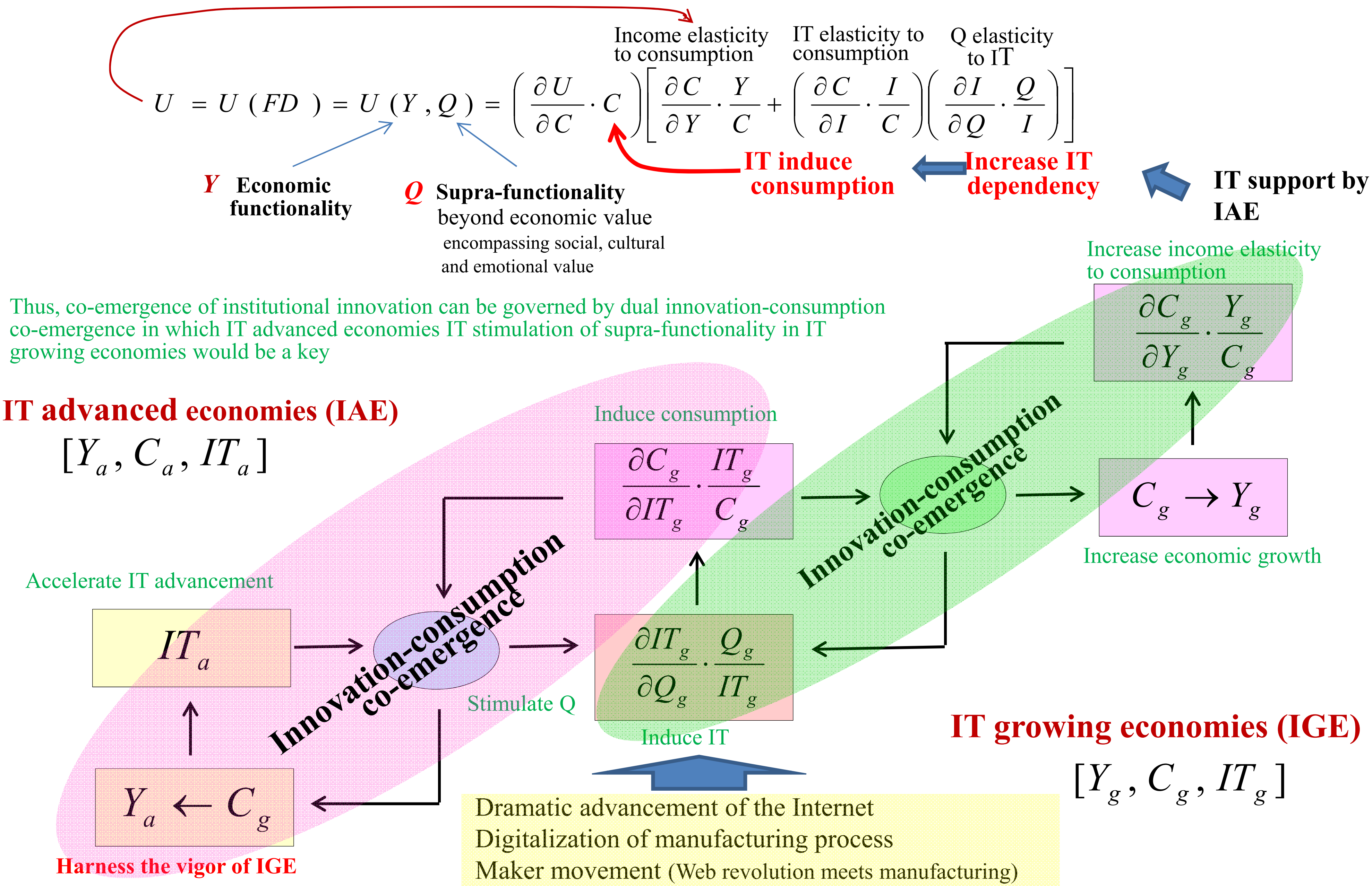
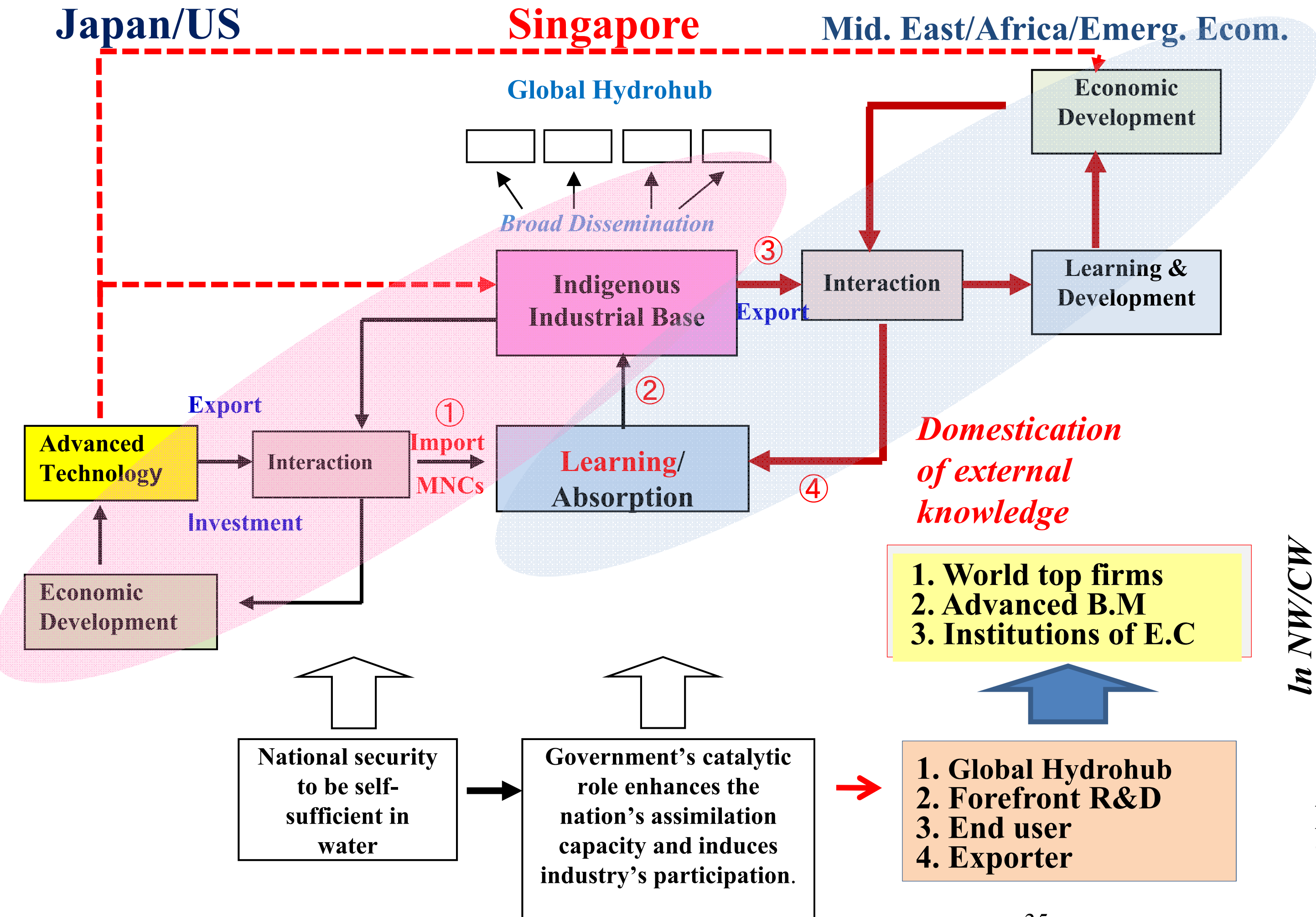


Fig. 17. Dynamism Inducing Innovation-Consumption Co-emergence.

3. Success in Singapore by Innovation-Consumption Co-emergence

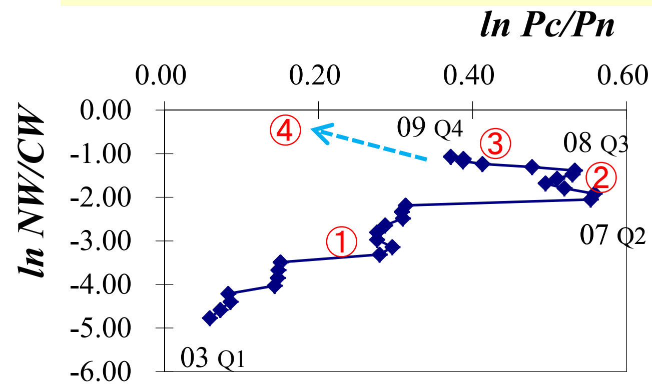


Phase 1 (2000 - 2007 Q1)
Imported technology dependent

Phase 2 (2007 Q2 – 2008 Q2)
Transition from learning to indigenous technology development

Phase 3 (2008 Q3 – 2010)
Export acceleration

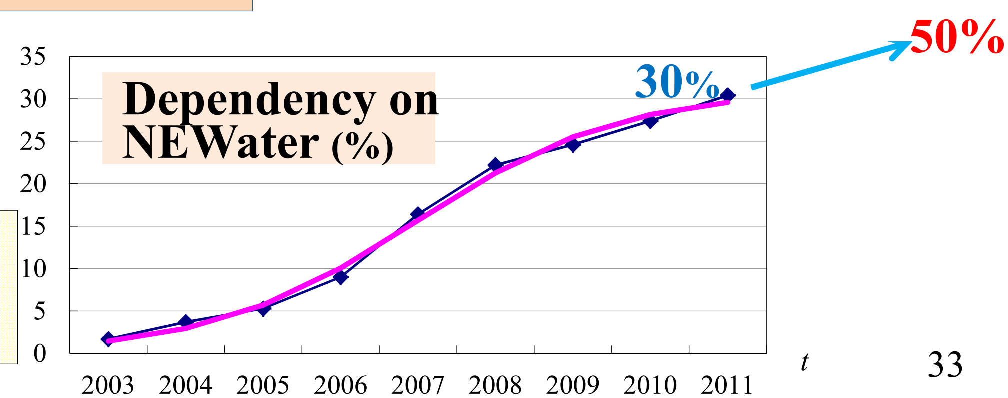
Phase 4 (2010 -)
Co-evolutionary acclimatization



NEWater (NW) Substitution for Conventional Water (CW)

Fig. 18. NEWater Develop. Dynamism in S'pore.

NEWater		Desalination	Total (Technology-driven water)
2011	30%	10%	40%
2061	50%	30%	80%



4. Success in Canon by Co-evolutionary Acclimatization

(1) Co-evolutionary Acclimatization

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 spillover.

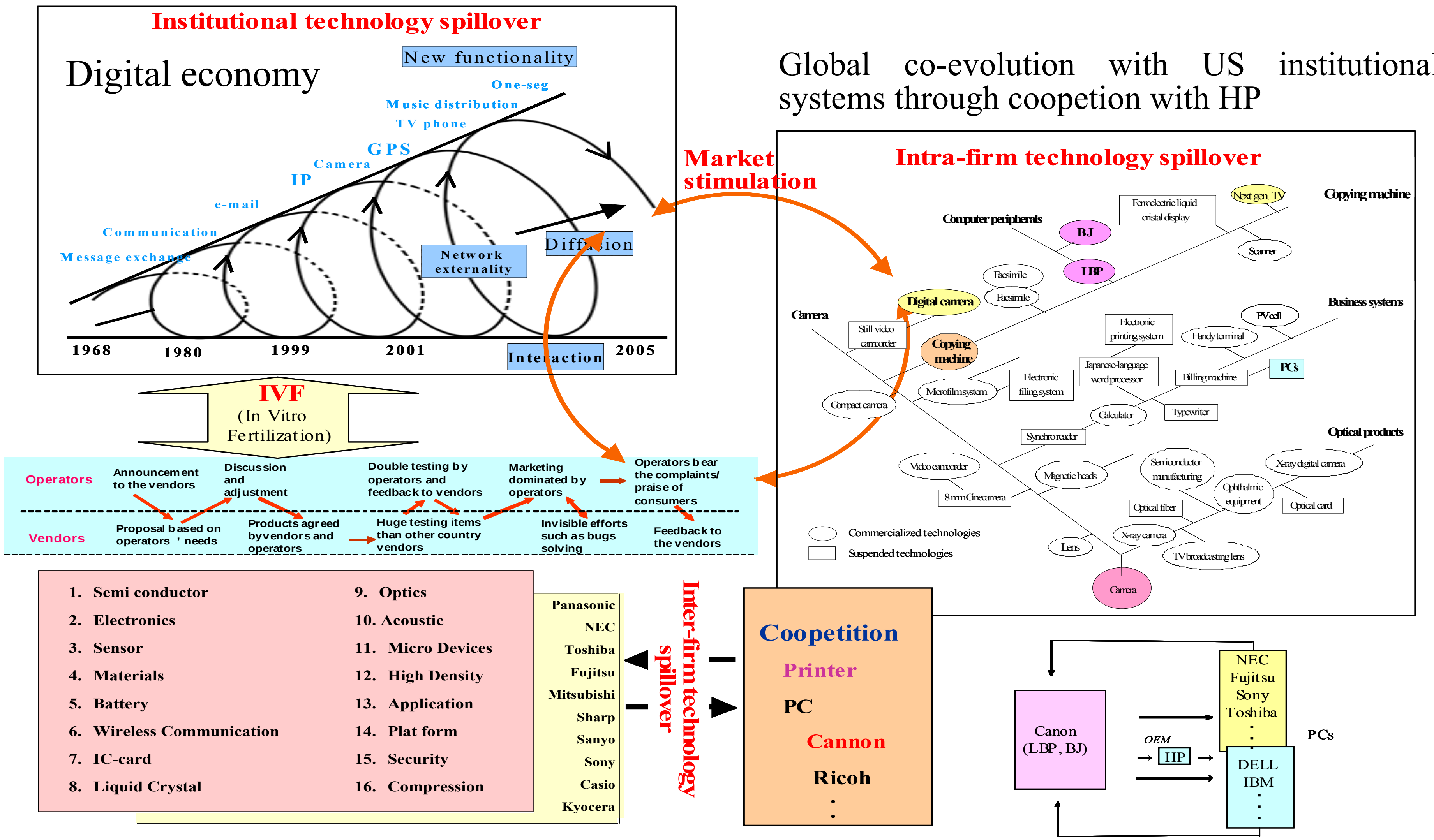


Fig. 18-2. Scheme of Canon's Co-evolutionary Acclimatization.

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(2) Technological Diversification Strategy

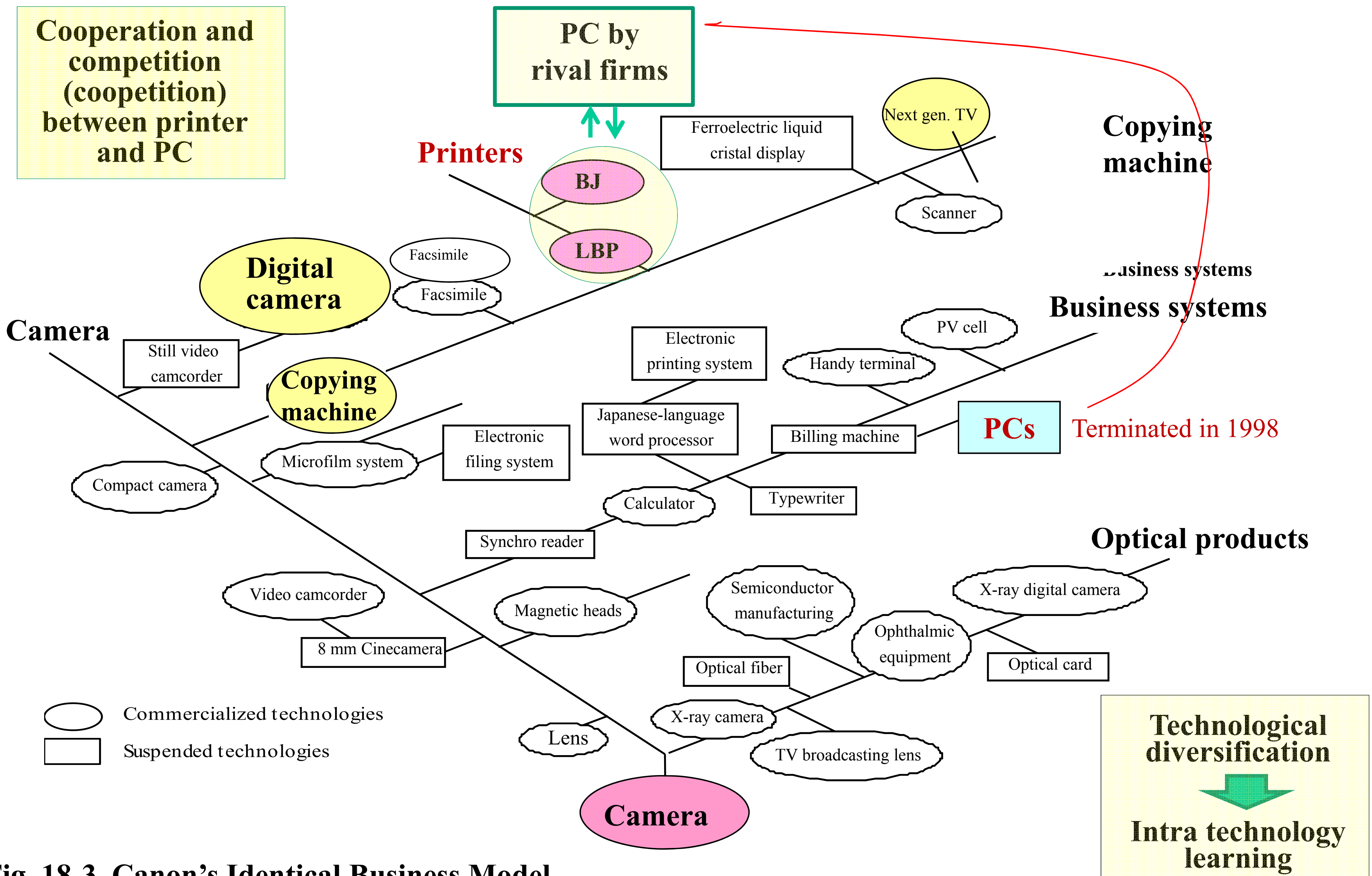


Fig. 18-3. Canon's Identical Business Model.

(3) Virtuous Cycle between Printers and PCs: *Learning by Inspiring Competitors - Coopetition*

Satisfaction of (i) two factors learning and (ii) technology inducement by PC can be enabled not only by its own technology stock but also by inspiring competitors. This is called **coopetition**.

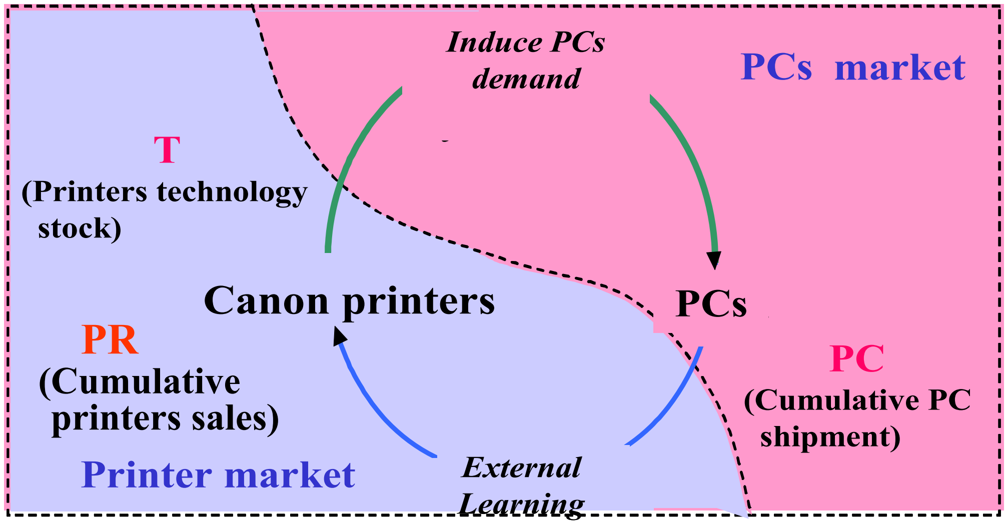
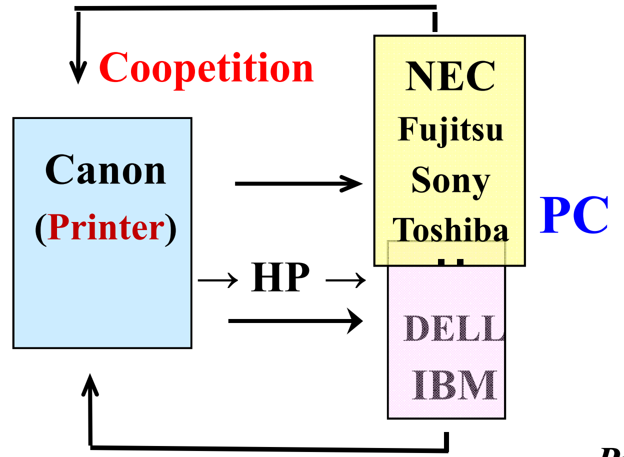
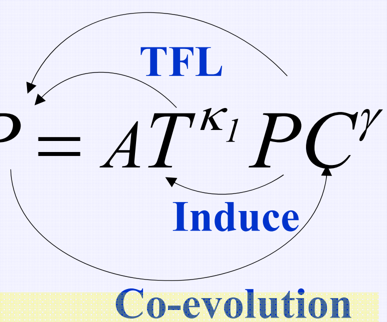


Fig. 18-4. Virtuous Cycle between Canon Printers and PCs *(1986-2005)*.



Pv: Price of printers
P: Relative technology prices of printers

$$P = AT^{\kappa_1} PC^{\gamma}$$



Two factors learning and technology inducement by PC in printers development

$$\ln P_v = 4.85 - 0.62 \ln T - 0.26 \ln PC - 0.16 D \quad adj.R^2 \; 0.997 \quad DW \; 1.42$$

(12.70) (-6.44) (-6.27) (-2.52) *D*: 2003-05 = 1, other years - 0

$$\ln P = 3.34 + 0.08 \ln T + 0.40 \ln PC - 0.25 D \quad adj.R^2 \; 0.997 \quad DW \; 1.60$$

(165.75) (67.66)) (67.66) (-8.14) *D*: 1986, 2000-05 = 1, other years = 0

$$\ln T = 8.99 + 0.26 D_1 \ln PC + 0.40 D_2 \ln PC + 0.40 D_3 \ln PC + 0.30 D_4 \ln PC - 1.92(D_2 + D_3) \quad adj.R^2 \; 0.997 \quad DW \; 1.00$$

(27.63) (10.20) (12.77) (14.13) (17.20) (-3.22)

$$\ln PC = -7.06 + 1.71 D_1 \ln P + 1.77 D_2 \ln P + 1.82 D_3 \ln P + 1.81 D_4 \ln P \quad adj.R^2 \; 0.994 \quad DW \; 1.62$$

(-22.62) (16.10) (24.83) (28.54) (29.67)

D1: 1986-1990 = 1, *D2*: 1991-1997 = 1, *D3*:1998-2000 = 1, *D4*: 2001-2005 = 1, other years = 0

(4) Assimilation of Spillover Technology

While Canon has not involved in mobile business, it fully enjoys the advancement of mobile technologies.

This can be attributed to spillover effect through coopetition.

	Involved in mobile phones (20)	Not involved in mobile phones (19)
Large firms	A Panasonic NEC Hitachi Toshiba MELCO Fujitsu Sony	
Medium firms	B Sharp Sanyo Rohm TDK NIDEC Casio Murata Other 6	C Canon D Ricoh Fanuc Keyence Pioneer Daikin Other 13

Fig. 18-5. Japan's leading 39 Electric Machinery Firms and their Relevance to Mobile Phones.

Table 2 Contribution to OIS in 39 Firms.

$$OIS = \underset{(1.89)}{0.097} + \underset{(5.18)}{0.563}D_{mb} + \underset{(10.87)}{0.287}D_{kf} - \underset{(-2.44)}{0.571}D_{gi} + \underset{(3.36)}{0.039}D_t$$
$$+ \underset{(1.76)}{0.030}\ln R/S + \underset{(4.76)}{0.164}D_{mb}\ln R/S - \underset{(-1.94)}{0.160}D_{gi}\ln R/S$$
$$+ \underset{(6.20)}{1.528\times 10^{-4}}\sum R/R + \underset{(2.40)}{0.005}D_{ca}\sum R/R$$
$$adj.R^2 = 0.782$$

D_{mb}: Mobile firms = 1, non-mobile firms = 0; D_{gi}: Large firms = 1, medium firms = 0; D_t: 2003-2005 = 1, 2000-2002 = 0; D_{ca}: Canon = 1, other firms = 0; D_{kf}: Fanuc, Keyence = 1 (Non-mobile but high OIS: over 25%), other firms = 0.

Own R&D intensity — Spillover effect

$$OIS = a + b\ln R/S + c\sum R/R + dD$$

	Constant	$\ln R/S$	$\sum R/R$
A	0.534	**0.156**	-5.8E-03
B	0.534	**0.156**	0.2E-03
C	0.104	0.033	**6.0E-03**
D	0.104	0.033	0.2E-03

(5) Co-emergence of Innovation and Consumption

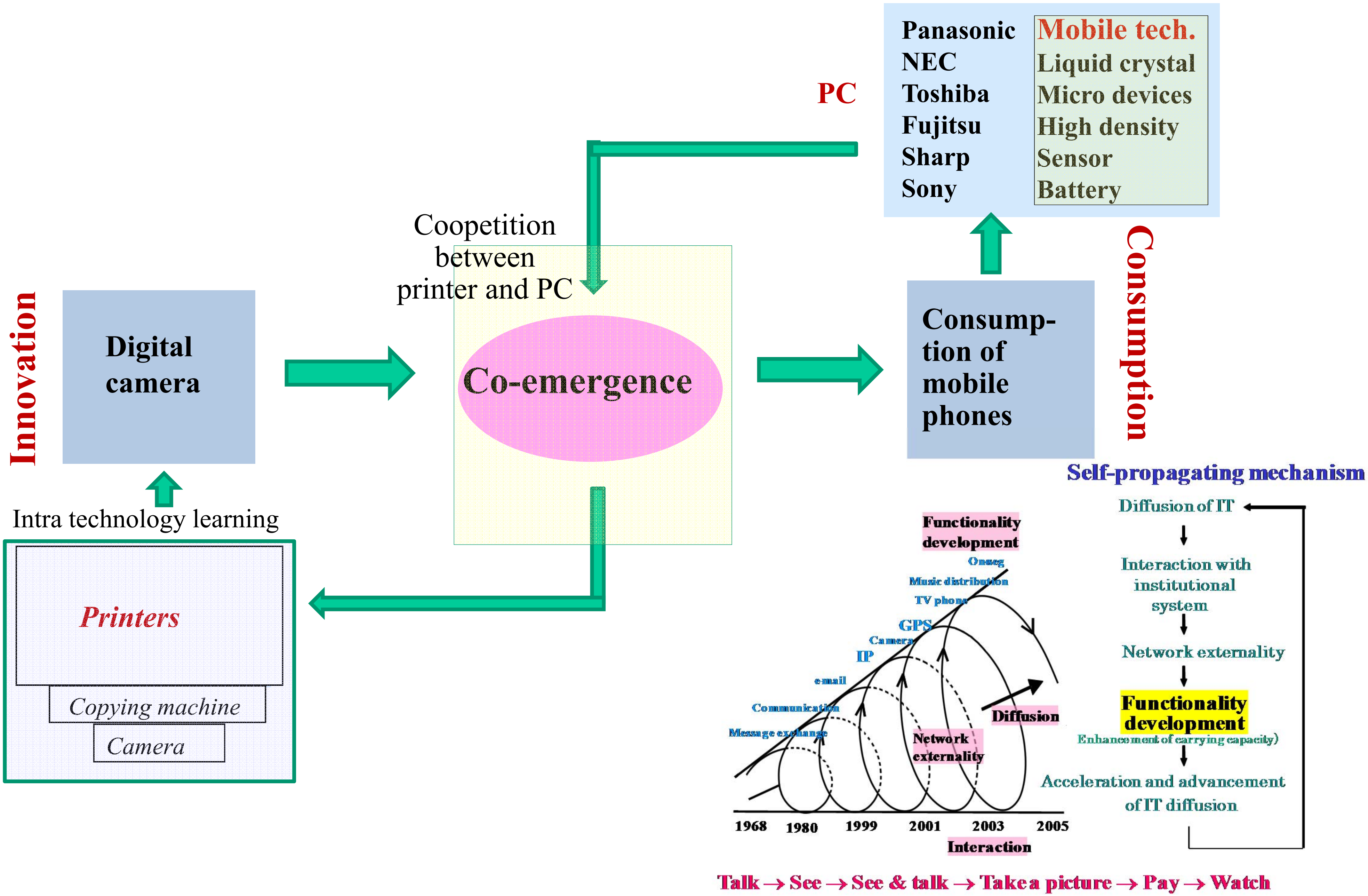


Fig. 18-6. Canon’s Unique Business Model in Co-emerging Innovation and Consumption.

(6) Canon's Way of Innovation-Consumption Co-emergence

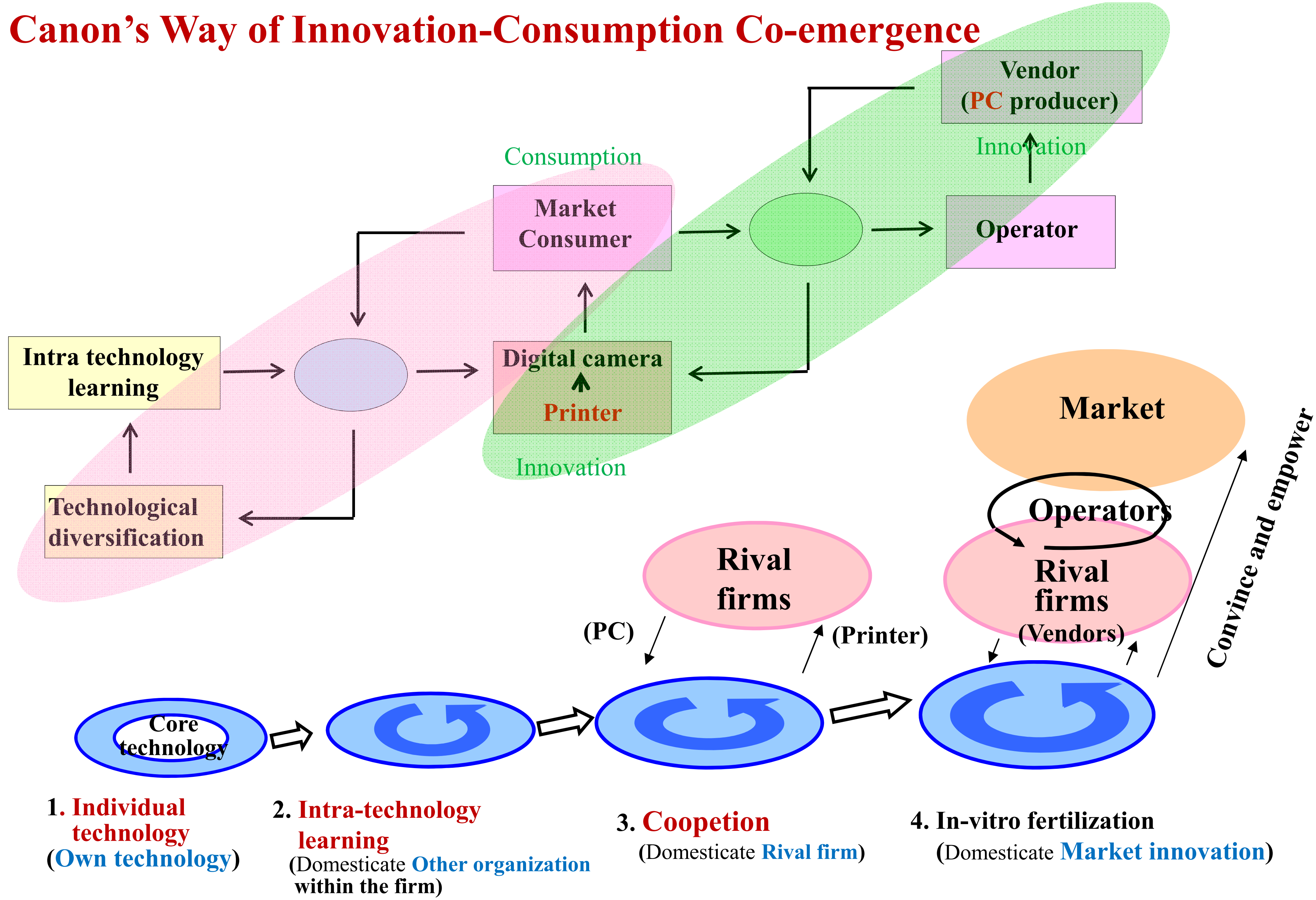
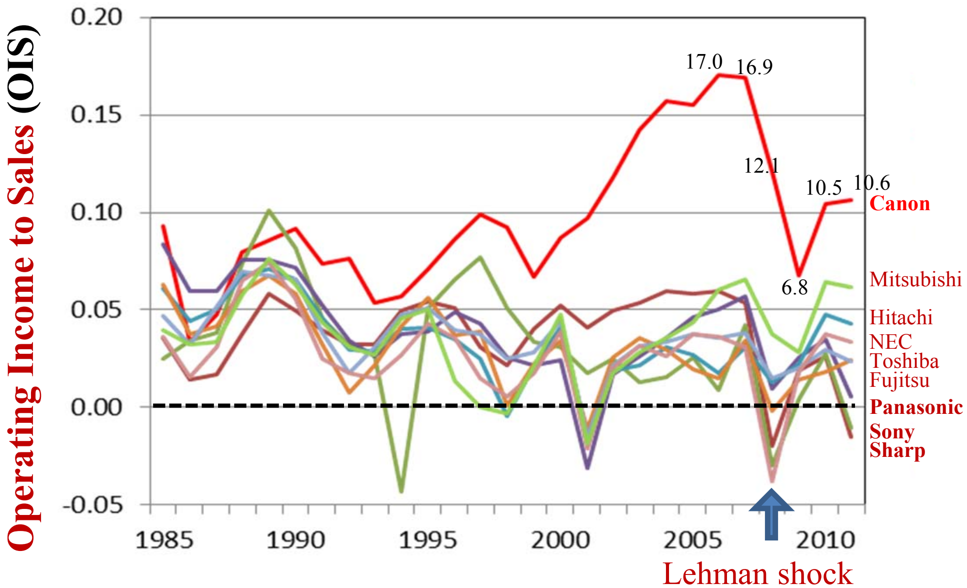
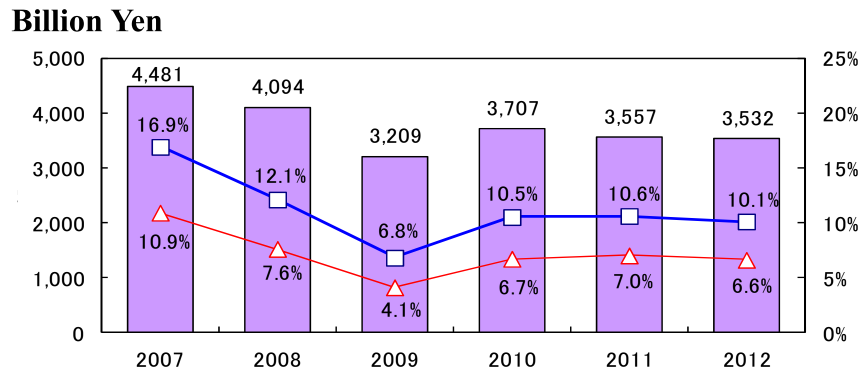


Fig. 18-7. Canon's Business Model in Co-emerging Innovation and Consumption.

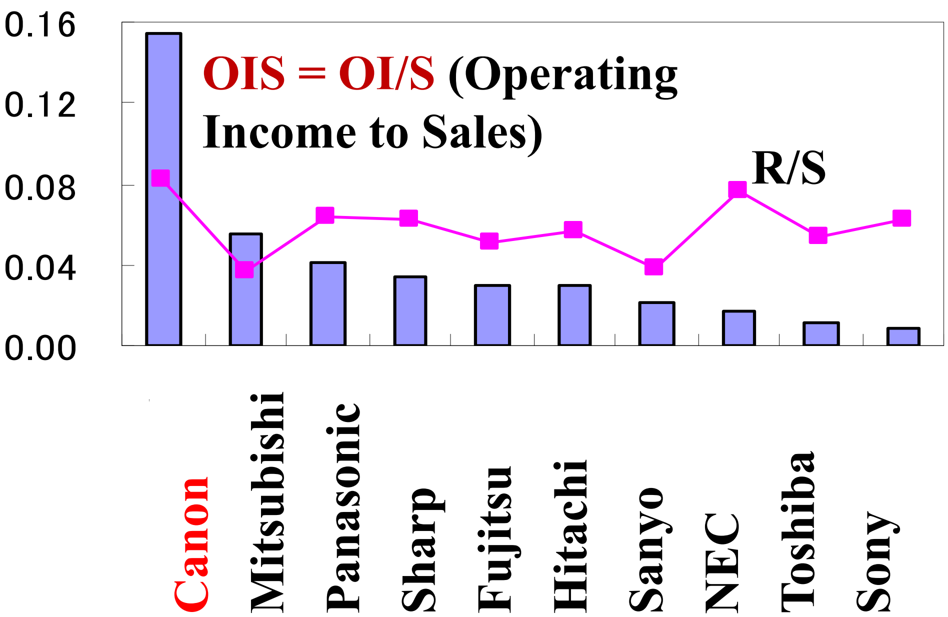
(7) Canon's Conspicuous R&D Profitability





Canon's sales, OIS and NPR (2007-2012)

NRP: Net Profit Ratio



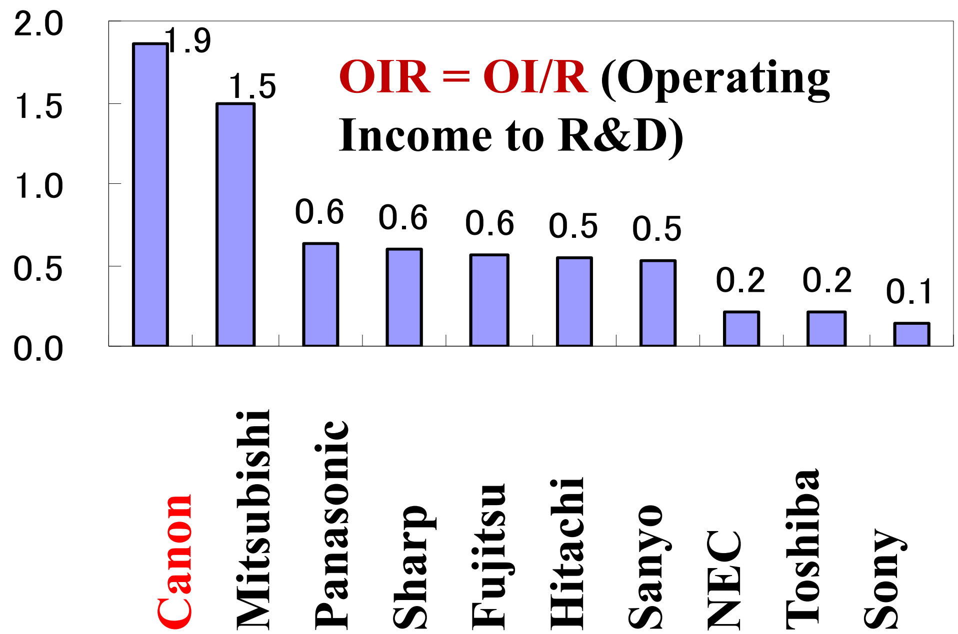


Fig. 18-8. OIS, R/S, OIR in Japan's 10 Leading Electric Machinery Firms *(average 2006-2008).*

5. Firm's Technopreneurial Strategy (1) R&D Profitability

Shipment (Production: *Y*) = Sales (*S*) + Inventory (*Iv*)

||

IMI (Intermediate input): Materials (*M*) and energy (*E*)

\+

Value added (GDP: *V*)

||

Labor (*L*) cost

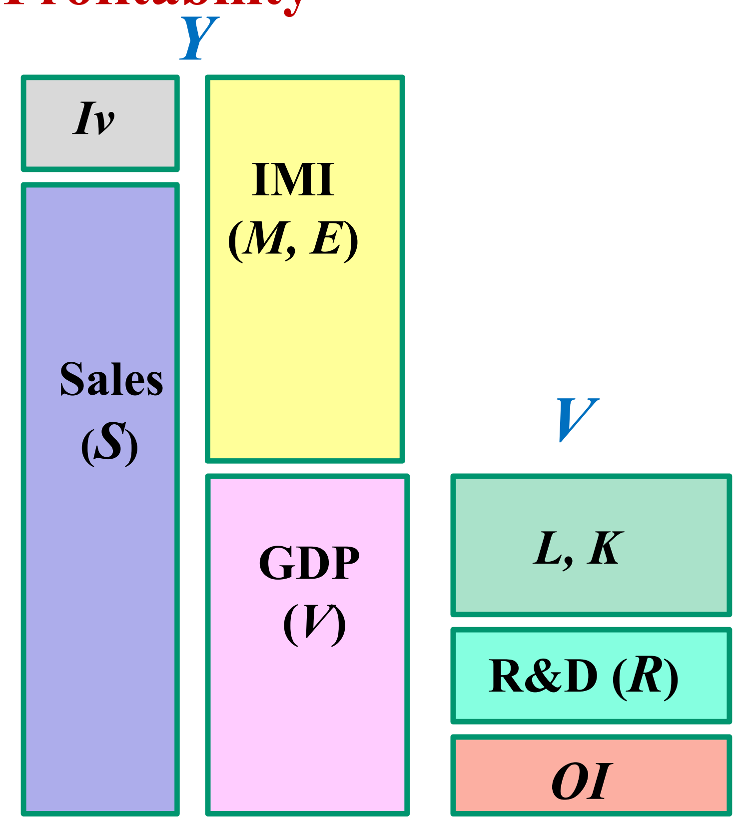
Capital (*K*) cost

\+

R&D (*R*), Advertisement

\+

Operating income (*OI*)



Firms targets
- **Sales increase** → **Price maker, Market appeal, R&D increase**
- **Operating income increase** → **Dividend, MVE** (Market Value of Equity) **increase**

Key indices ***S, OI, V, R*** ***OI/S, R/S, R/V*** → **R/S contribution to OI/S increase** → **OI/R (R&D profitability)**

Trade off between *OI/S* and *S* increase *R* and *OI*

$$\frac{\Delta OI/S}{OI/S} = \frac{\Delta OI}{OI} - \frac{\Delta S}{S}$$

→ **Decrease in *M, E, L, K*** → **Productivity increase** / **Technology substitution**

→ **Utiliz of external resources** → **Learning/Assimilation**

(2) Profitability Structure in Global R&D Firms

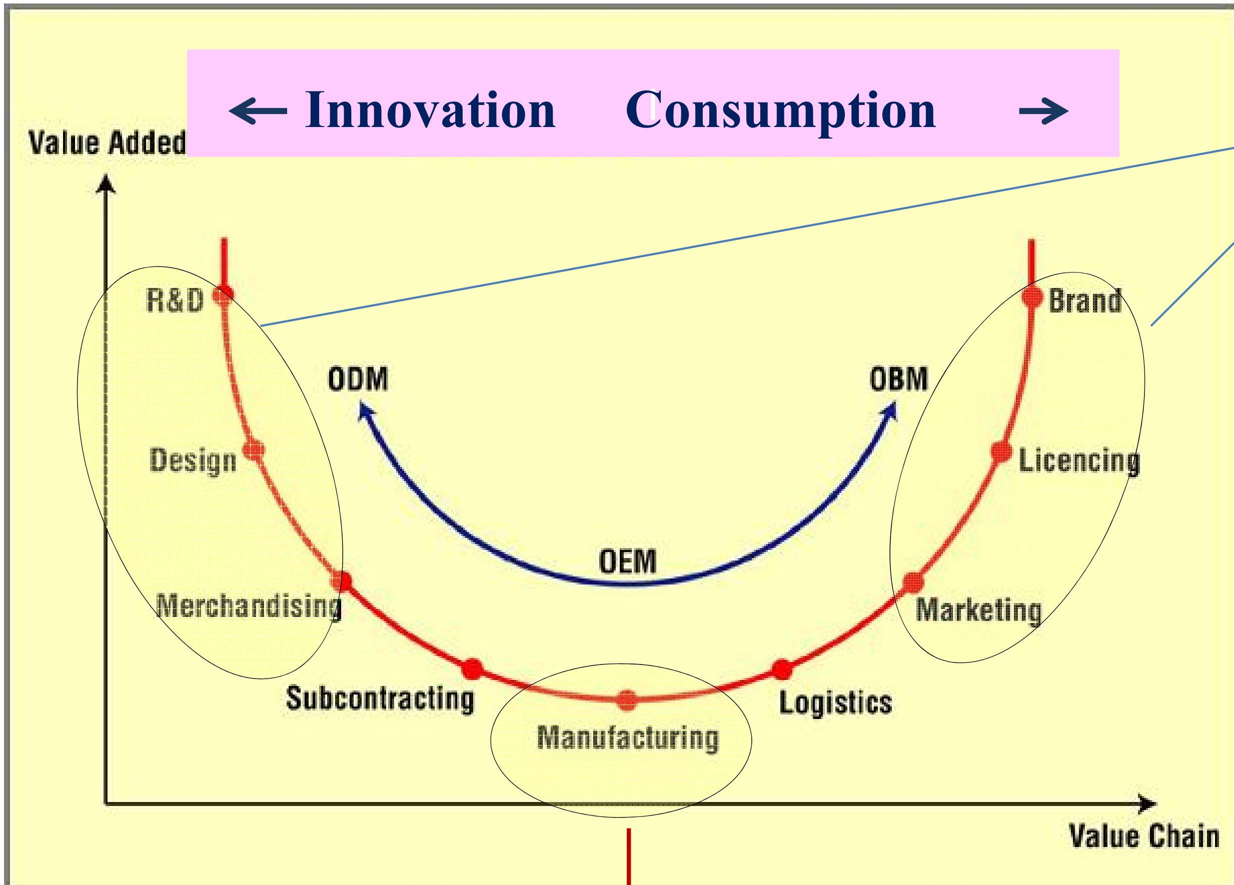
	2010			2007		
	OI/S	R/S	OI/R	OI/S	R/S	OI/R
Apple	0.28	0.03	10.23	0.18	0.04	5.09
Samsung	0.13	0.06	2.07	0.10	0.06	1.56
Nokia	0.04	0.12	0.38	0.12	0.10	1.13
Microsoft	0.39	0.13	3.00	0.38	0.14	2.78
Google	0.35	0.13	2.76	0.31	0.13	2.42
Dell	0.06	0.01	5.28	0.06	0.01	5.56
HP	0.09	0.02	3.88	0.08	0.03	2.42
Intel	0.36	0.15	2.39	0.21	0.15	1.40
Hitachi	0.01	0.04	0.25	0.02	0.04	0.54
NEC	0.01	0.08	0.17	0.03	0.07	0.35
Fujitsu	0.01	0.05	0.17	0.04	0.05	0.85
Mitsubishi	0.02	0.04	0.53	0.05	0.03	1.38
Canon	0.10	0.09	1.22	0.17	0.08	2.09
Sharp	0.01	0.06	0.09	0.05	0.06	0.79
Kyocera	0.04	0.05	0.96	0.11	0.05	2.59
Siemens	0.07	0.06	1.30	0.07	0.04	1.75
Lenovo	0.02	0.01	1.21	0.03	0.02	1.64
ZTE	0.07	0.11	0.60	0.06	0.09	0.66

OI/S: Operating income to sales, R/S: R&D intensity (R&D expenditure per sales). **OI/R**: Operating income to R&D (figures in red indicate above 1)

2010: After Lehman shock in 2008
2007: Before Lehman shok

Fig. 18-9. Comparison of R&D Profitability Structure in Global R&D Firms in 2010 and 2007.

6. Apple's Way of Innovation-Consumption Co-emergence



Apple's focus

Bridging innovation and consumption by leveraging coordinating role of EMS

Innovation-consumption co-emergence

Japan clings to this focus
Should transfer to EMS
(Electronics Manufacturing Service)

Fig. 18-10. Apple's Business Model in Co-emerging Innovation and Consumption.

Suggestion

Innovation → **Co-emergence** → **Consumption**

Innovation value chain

Production → **Diffusion** → **Consumption**

from "**Invisible hand of God**" to "**Voiceless voice of consumers**"

Complaints to
- **Producers**
- **Economic value oriented market**
- **Being remained consumers**

Conceptualize invisible voice of consumers

People can never forget utmost gratification of consumption ever experienced which affects lifetime consumption
(Modgiliani et al.)

Commodification of experiences

V. Commodification of Experiences

1. Conceptualization of Invisible Voice of Consumers
- Facial Temperature Feedback Hypothesis

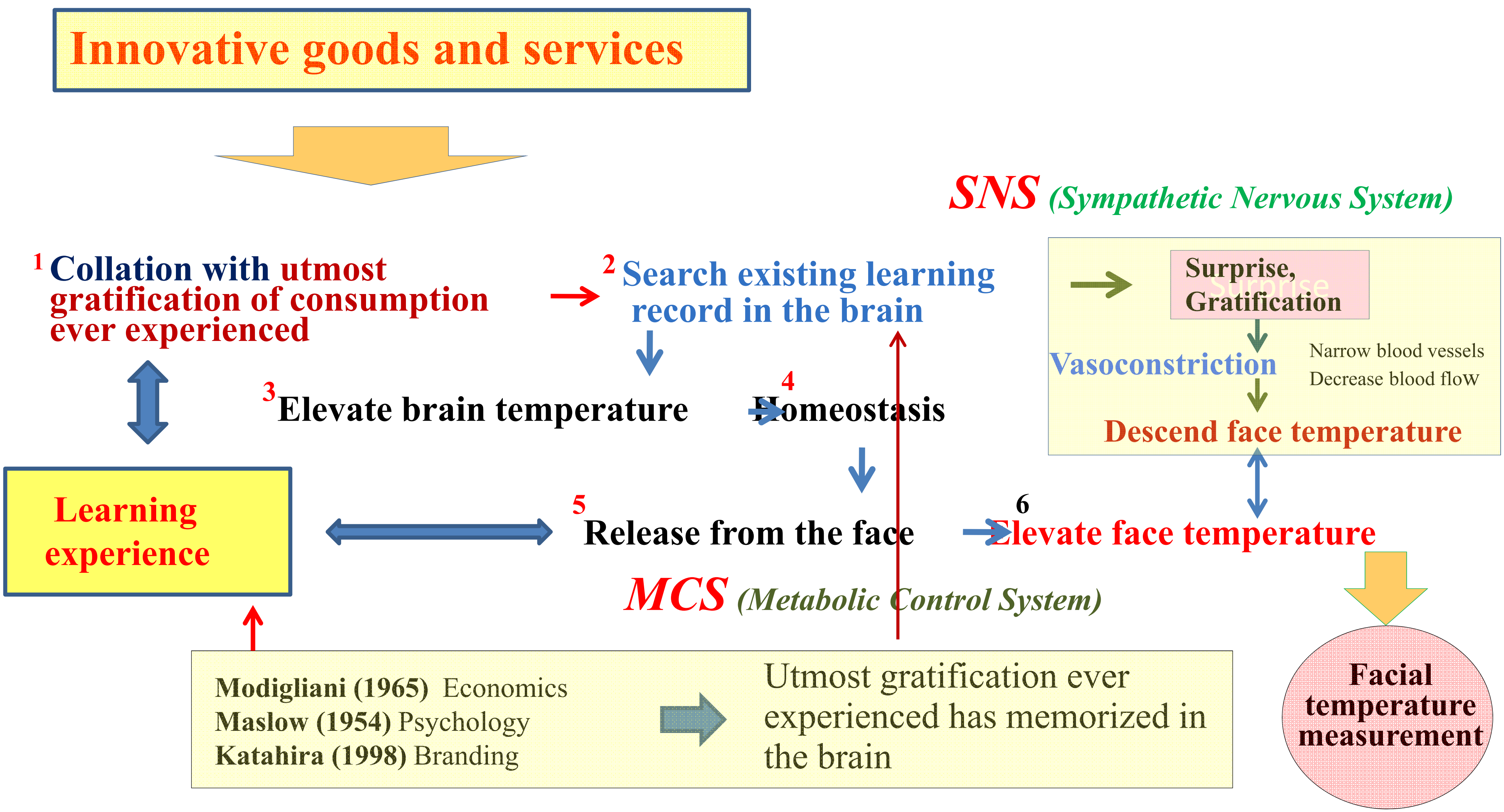


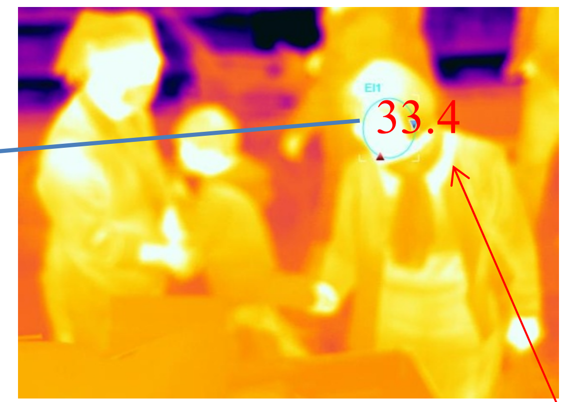
Fig. 19. Scheme of Facial Feedback Hypothesis.

2. Demonstration by Experiment Utilizing Thermography

(a) With the measurement of the **relationship between attractive goods and consumers' temperature elevations** at the leading supermarkets in Japan and Finland.

(b) Demonstrate a hypothesis that "*There exists a resonance between attractive goods and consumers constructing a spiral cycle with energy leading to elevating consumers' facial temperature.*"

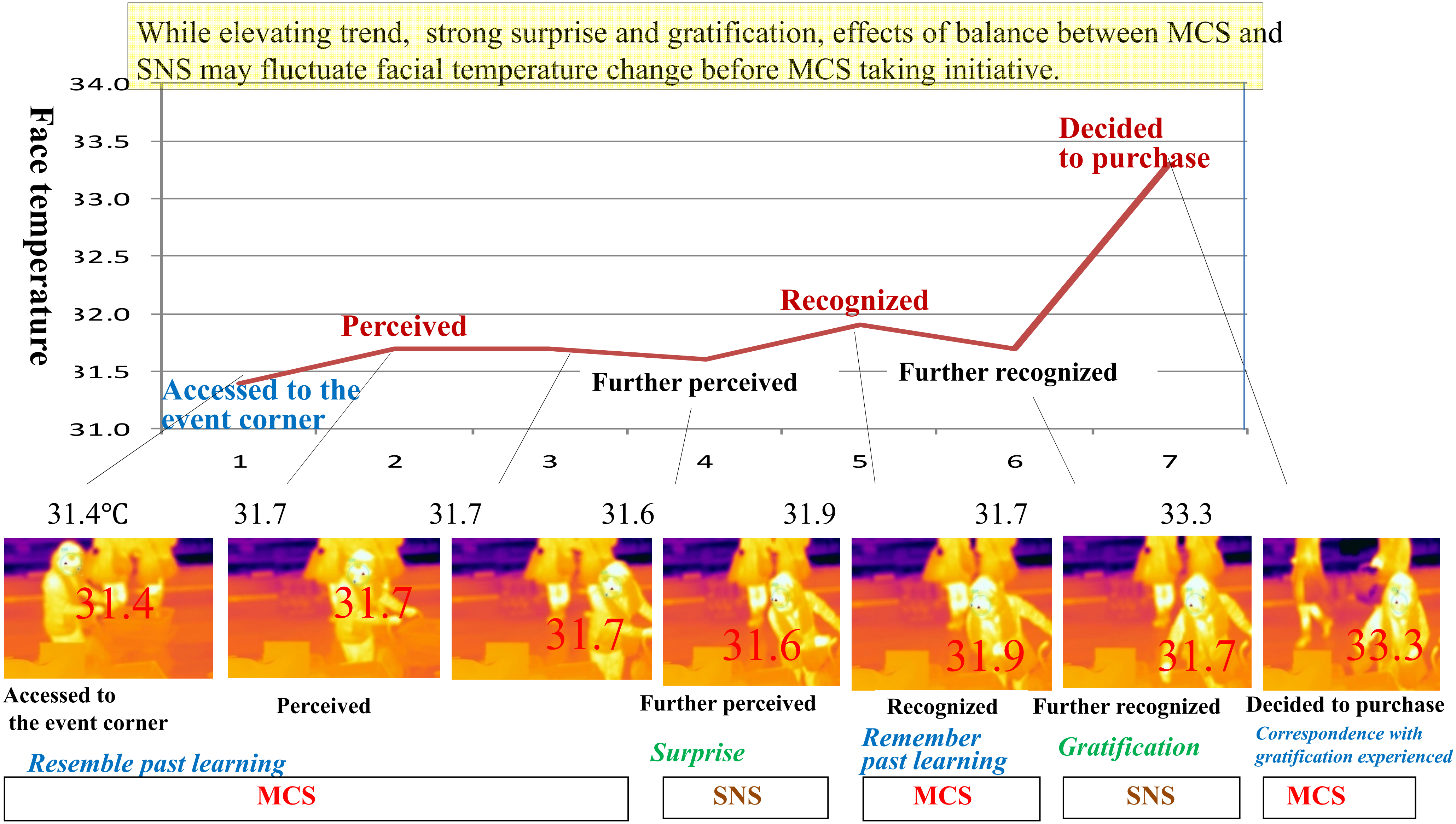
Monitor the consumers' facial temperature by the thermography: novel psychophisiological measuring technique enables observation in the objective circumstances without providing any cautions to examinees.



Record in a PC

Analyze the recorded data by the exclusive software
"FLIR Research IR" (able to identify a pin-point temperature)

3. Empirical Results



MCS: Metabolic Control System (elevate temperature), SNS: Sympathetic Nervous System (descend temperature)

Fig. 20. Standard Pattern of Facial Temperature Change in Shoppers Decided to Purchase.

4. Evidences in Silver Consumption

Since 1990s significant contribution of silver consumption (age above 60s) to average consumption propensity has been observed which can be attributed to calling back of consumption in their 20s

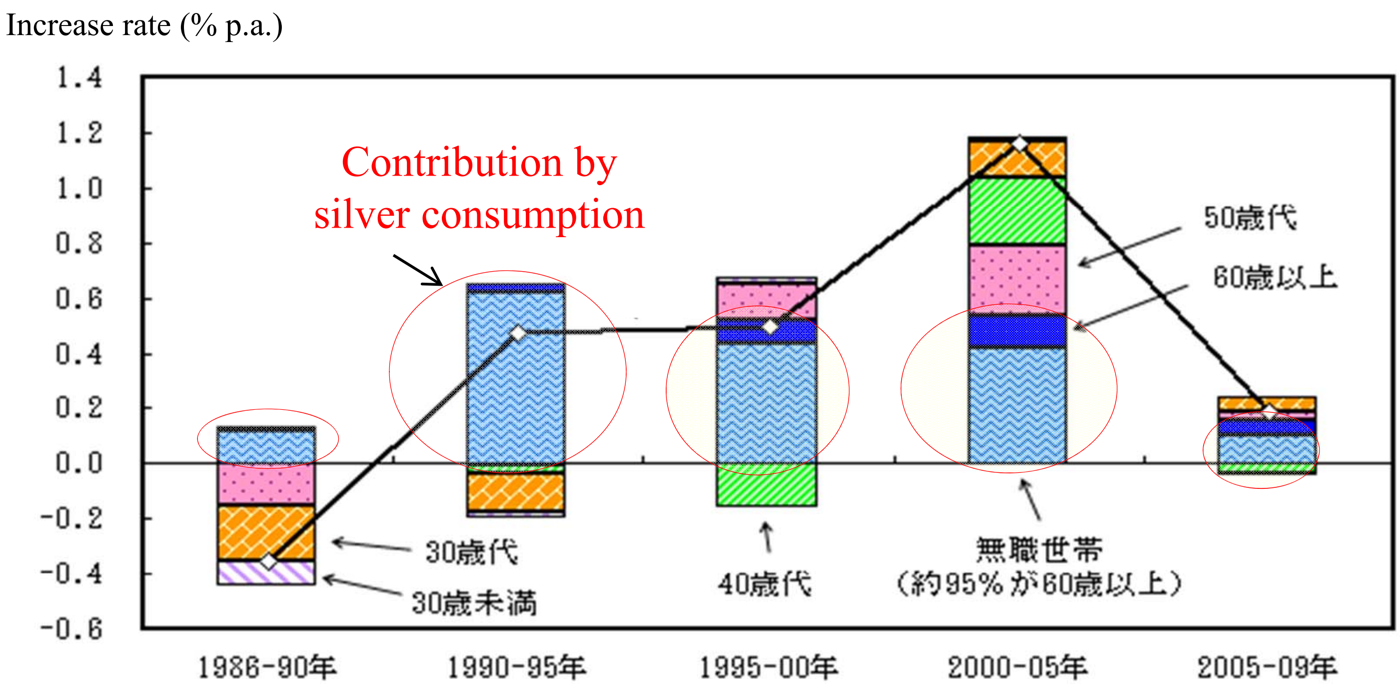
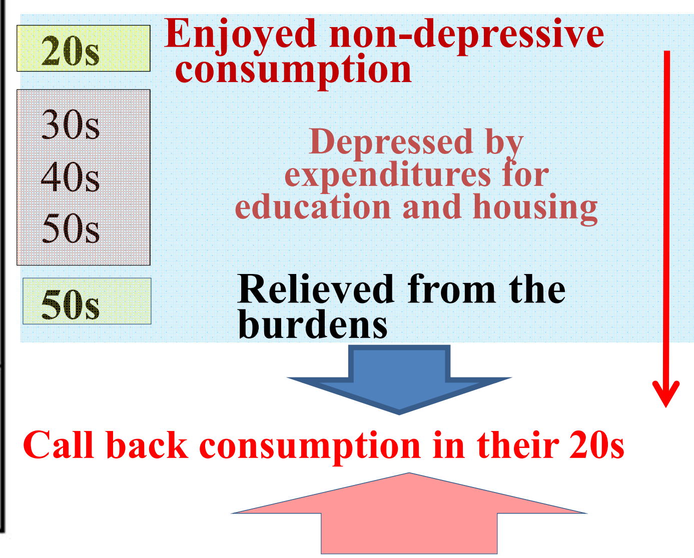


Fig. 21. Contribution to Average Consumption Propensity by Ages.

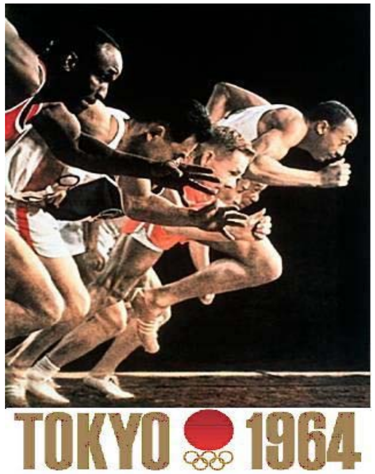


People can never forget utmost gratification of consumption ever experienced which affects lifetime consumption (Modgiliani et al.)

Source: White Paper on Japan's Economy and Finance 2010 (2010).

5. Unforgettable Impressive Memory Experienced in their 20s

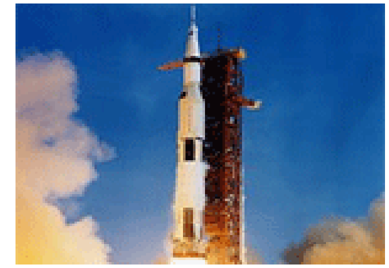
Roman holiday
(1953)



Tokyo Olympic Game
(1964)

Giants
(1965-1973 V9)

Beatles
(1966)



Apollo
(1969)

Bowling
(1970-)

Haiseiko
(1970-)

MacDonald
(1971)

Sapporo Olympic Game
(1972)

Panda
(1972)

Fig. 22. Major Impressive Memory Never Forget Experienced in their 20s.

6. Platform for Commodification of Experiences for Innovation-Consumption Co-emergence

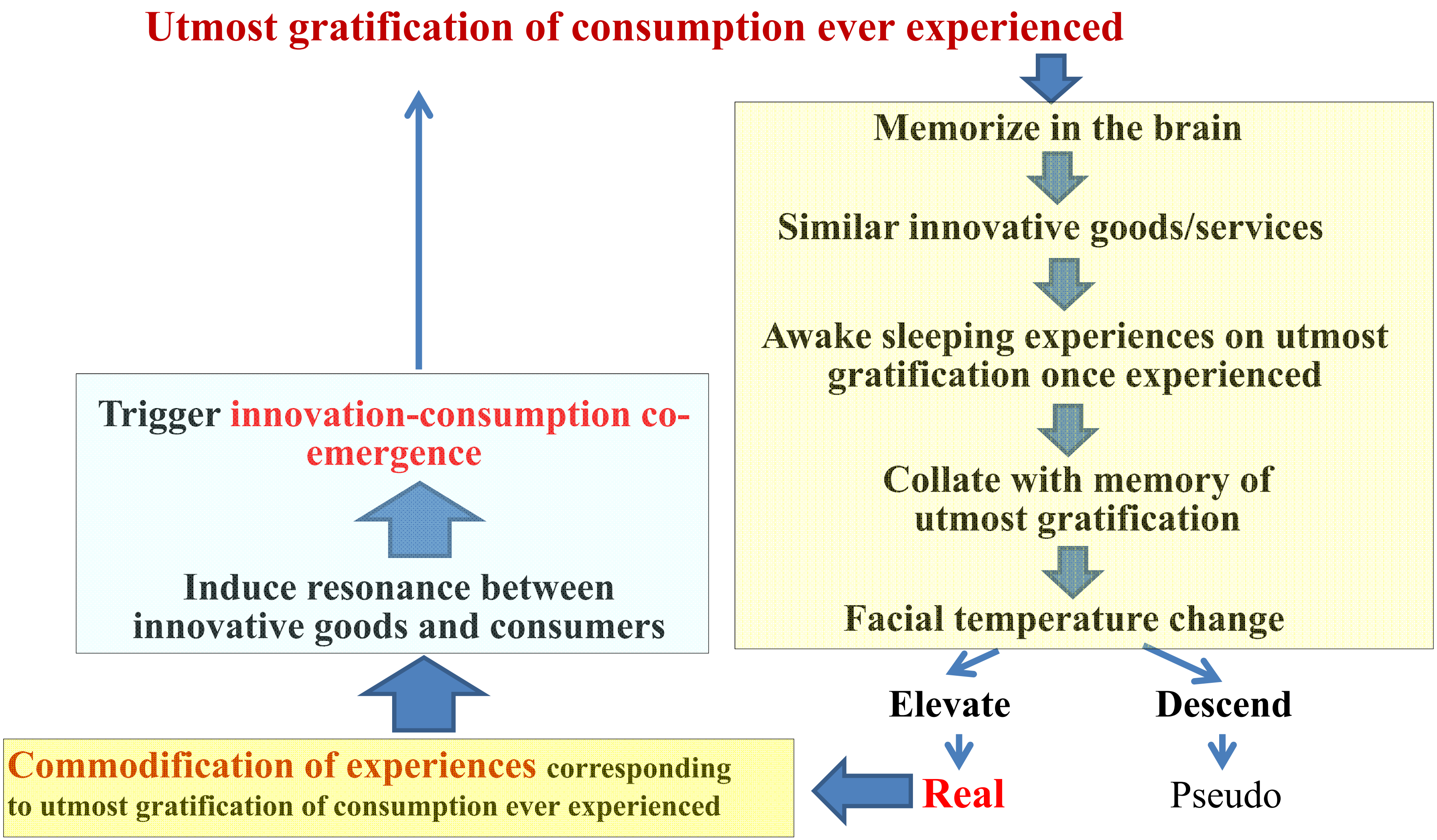


Fig. 23. Platform for Commodification of Experiences.

Conclusion

1. **Resilience against beyond anticipation issues can be maintained by elastic institutional systems.**

2. **Given the bipolarization of IT driven global economy that revealed the limit of individual challenge, and increasing complaints of consumers, innovation-consumption co-emergence by transforming such complaints into a springboard for new challenge could lead a resilient business.**

3. **This co-emergence can be triggered by commodification of experiences that govern lifetime consumption.**

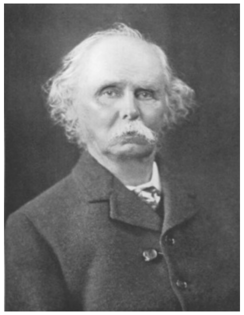
4. **This approach is beyond mechanical analogy and necessitates interdisciplinary endeavor paying special attention to Marshall's warning.**

5. **International network for the X-Center endeavors is expected to make a significant contribution to this endeavor.**

From Mechanical Analogy to Biological Analogy in economics.

Develop an extremely sophisticated mathematical model utilizing numerically measurable factors while neglecting factors difficult to measure

Beyond Mechanical Analogy



(Alfred Marshall, 1842-1924)

1.2 Innovation and Growth: *Techno-economic Approach*

1.2.1 Production function

1.2.2 Growth rate

1.2.3 Elasticity

1.2.4 Cobb-Douglas type production function

1.2.5 Profit maximum condition

1.2.6 Implications of firms' profit maximum behavior

1.2.7 Elasticity of substitution

1.2.1 Production function

(1) Basic concept

Output Input

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

GDP Labor Capital

V: GDP, *L*: Labor, *K*: Capital stock, *IMI* (Intermediate input: Materials and Energy)

$V + IMI = Y$ (Output)

= **Sales + Inventory**

Nation

A country developing its GDP (*V*) by increasing employees (*L*) and capital stock (*K*) + innovation

Firm

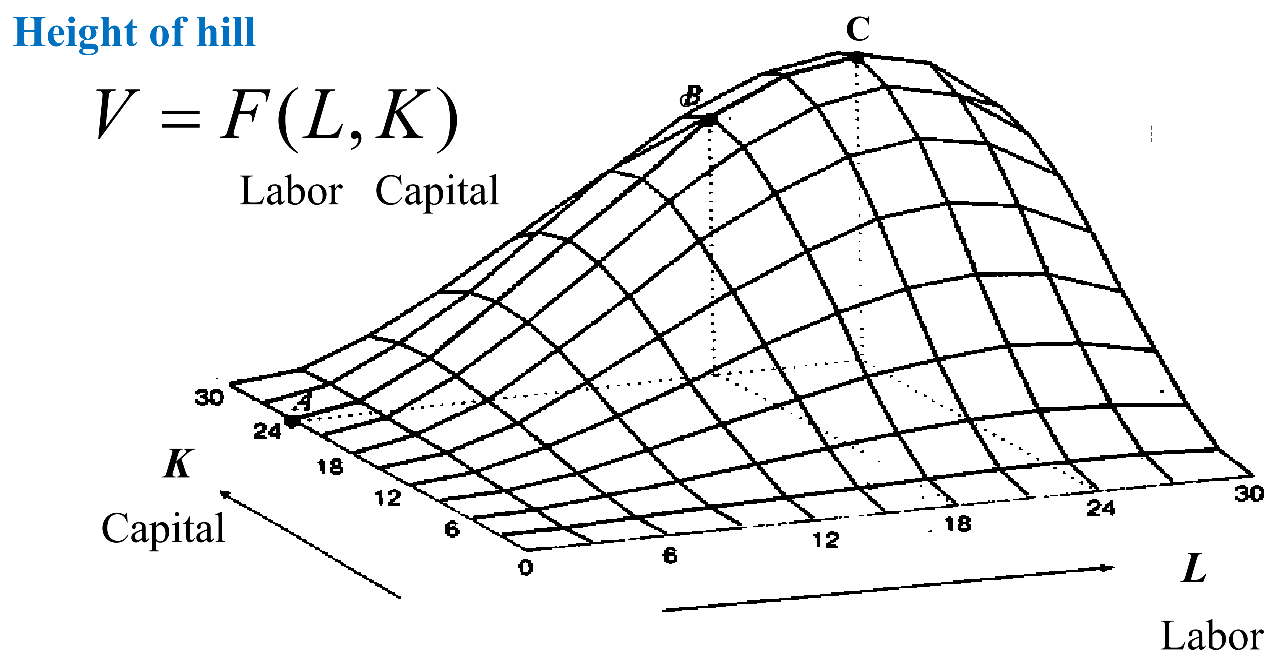
A firm increasing semiconductor (*V*) by employing humans (*L*) and/or robots (*K*) + innovation

Organization

A laboratory contemplating patents (*V*) by increasing students (*L*) and/or PC (*K*) + innovation

Number of employed person x **Working hour** **Cumulative stock of machines** x **Operating rate**

Graphical Image of Two Factors Production Function: *Total Product Hill*



This concept can be developed to multi-factors production functions.

e.g., LKMET production function (Watanabe, 1991)

$Y = f(L, K, M, E, T)$

Y: output; *L*: labor, *K*: capital; *M*: materials; *E*: energy; and *T*: technology

C. Watanabe, "Trends in the Substitution of Production Factors to Technology," *Research Policy* 21, No. 6 (1992) 481-505.

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

(1) Basic concept

(2) Productivity

V/L: (Labor) Producitvity, ***V/K***: Capital productivity, ***K/L***: Capital intensity

∂V/∂L: **Marginal productivity** of labor, ∂V/∂K: **Marginal productivity** of capital

V: GDP, ***L***: Labor, ***K***: Capital stock, *IMI* (Intermediate input: Materials and Energy)

V + ***IMI*** = ***Y*** (Output)

= **Sales + Inventory**

$$\frac{V}{L} = \frac{Total\ \ product}{Quantity\ \ of\ \ labor}$$

$$\frac{\partial V}{\partial L} = \frac{Change\ \ in\ \ total\ \ product}{Change\ \ in\ quantity\ of\ \ labor} = \frac{\Delta V}{\Delta L}|_{K\ is\ held\ cons\tan t} \equiv \frac{\Delta V_L}{\Delta L}$$

Marginal productivity of labor

$$\frac{\partial V}{\partial L} = \frac{Change\ \ in\ \ total\ \ product}{Change\ \ in\ quantity\ of\ \ labor} = \frac{\Delta V}{\Delta L}|_{K\ is\ held\ cons\tan t} \equiv \frac{\Delta V_L}{\Delta L}$$

The rate of total product changes when the firm changes the quantity of one unit of labor input, holding capital input constant.

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

(1) Basic concept

(2) Productivity

(3) Necessary requirements for production function

$\partial V/\partial L > 0,\ \partial V/\partial K > 0$ Marginal productivities of L and K are positive.

$\partial^2 V/\partial L^2 < 0,\quad \partial^2 V/\partial K^2 < 0$ Marginal productivities will decrease.

$\lambda V = F(\lambda L, \lambda K)$ Constant returns to scale: linear homogeneous.

V: GDP, L: Labor, K: Capital stock, IMI (Intermediate input: Materials and Energy)

$V + IMI = Y$ (Output)

$= \mathbf{Sales + Inventory}$

$$\frac{V}{L} = \frac{Total\ \ product}{Quantity\ \ of\ \ labor}$$

$$\frac{\partial V}{\partial L} = \frac{Change\ \ in\ \ total\ \ product}{Change\ \ in\ quantity\ of\ \ labor} = \frac{\Delta V}{\Delta L}\Big|_{K\ is\ held\ constant} \equiv \frac{\Delta V_L}{\Delta L}$$

e.g., Cobb-Douglas type production function

$$V = A \cdot L^{\alpha} \cdot K^{\beta} \quad (\alpha, \beta > 0,\ \alpha + \beta = 1)$$

$$\ln V = \ln A + \alpha \ln L + \beta \ln K$$

1. Partial differentiation with respect to $\ln L$

$$\frac{\partial \ln V}{\partial \ln L} = \frac{\partial V}{\partial L} \cdot \frac{L}{V} = \alpha, \quad \frac{\partial V}{\partial L} = \alpha \frac{V}{L} > 0$$

2. Partial differentiation with respect to L

$$\frac{\partial^2 V}{\partial L^2} = \alpha \left[\frac{\partial \frac{V}{L}}{\partial L} \right] = \alpha \left[-\frac{V}{L^2} + \frac{\frac{\partial V}{\partial L}}{L} \right] = \alpha \left[-\frac{V}{L^2} + \frac{\alpha \frac{V}{L}}{L} \right] = \alpha \frac{V}{L^2}(\alpha - 1) = -\alpha\beta \frac{V}{L^2} < 0$$

3. $A \cdot (\lambda L)^{\alpha} (\lambda K)^{\beta} = A \cdot \left(\lambda^{\alpha} \lambda^{\beta}\right)\left(L^{\alpha} K^{\beta}\right) = A \cdot \lambda^{\alpha+\beta} L^{\alpha} K^{\beta} = A \cdot \lambda L^{\alpha} K^{\beta} = \lambda V$

1.2.1 Production function

$$V = F(L, K) \qquad (1)$$

(1) Basic concept
(2) Productivity
(3) Necessary requirements for production function

1.2.2 Growth rate

Singapore GDP (bil. S$) *at 2005 market prices (MTI Annual Statistics)*

	2009	2010	2011	2012
GDP (bil. S$)	**249.6**	**286.4**	**301.2**	**305.2**
Change volume (bil. S$)		286.4. – 249.6 = **36.8**	301.2 - 286.4 = **14.8**	305.2 – 301.2 = **4.0**
Change rate		$\frac{286.4-249.6}{249.6}=0.148$ **14.8%**	$\frac{301.2-286.4}{286.4}=0.052$ **5.2%**	$\frac{305.2-301.2}{301.2}=0.013$ **1.3%**

Growth rate *(dV/dt)/V* of production function (1) can be computed as follows:

$$\frac{dV}{dt} = \frac{\partial V}{\partial L}\cdot\frac{dL}{dt} + \frac{\partial V}{\partial K}\cdot\frac{dK}{dt}$$

$$\Delta V = \frac{\partial V}{\partial L}\cdot\Delta L + \frac{\partial V}{\partial K}\cdot\Delta K = \frac{\Delta V_L}{\Delta L}\cdot\Delta L + \frac{\Delta V_K}{\Delta K}\cdot\Delta K = \Delta V_L + \Delta V_K$$

L contrib. ***K*** contribution

$$\frac{\Delta V}{V} = \frac{\partial V}{\partial L}\cdot\frac{1}{V}\cdot\Delta L + \frac{\partial V}{\partial K}\cdot\frac{1}{V}\cdot\Delta K = \frac{\partial V}{\partial L}\cdot\frac{L}{V}\cdot\frac{\Delta L}{L} + \frac{\partial V}{\partial K}\cdot\frac{K}{V}\cdot\frac{\Delta K}{K}$$
$$\equiv \alpha\times\frac{\Delta L}{L} + \beta\times\frac{\Delta K}{K} \qquad (2)$$

$$\alpha \equiv \frac{\frac{\partial V}{\partial L}}{\frac{V}{L}} = \frac{\partial V}{\partial L}\cdot\frac{L}{V} \qquad \beta \equiv \frac{\frac{\partial V}{\partial K}}{\frac{V}{K}} = \frac{\partial V}{\partial K}\cdot\frac{K}{V} \qquad (3)$$

[Reference]

Euler's theorem

$$V = F(L, K) = \frac{\partial V}{\partial L}\cdot L + \frac{\partial V}{\partial K}\cdot K$$

Change volume

$$\frac{dV}{dt} = V_t - V_{t-1} \equiv \Delta V_t$$

Change rate (growth rate)

$$\frac{\frac{dV}{dt}}{V} = \frac{V_t - V_{t-1}}{V_{t-1}} = \frac{\Delta V}{V}$$

Contribution to change

$$\frac{\partial V}{\partial L} = \frac{\Delta V}{\Delta L}\Big|_{K \text{ is held constant}} \equiv \frac{\Delta V_L}{\Delta L}$$

$$\alpha = 0.4 < \beta = 0.6,$$
$$\frac{\Delta L}{L} = 5\%, \frac{\Delta K}{K} = 10\%,$$
$$\frac{\Delta V}{V} = 0.4\times 5 + 0.6\times 10 = 8\%$$

1.2.3 Elasticity

Equation (3) indicates that 1% increase in labor and capital induces α and β % increase in GDP, respectively. These coefficients are called **elasticity of labor and capital.**

$$\alpha \equiv \frac{\frac{\partial V}{\partial L}}{\frac{V}{L}} = \frac{\partial V}{\partial L} \cdot \frac{L}{V}$$

$$\beta \equiv \frac{\frac{\partial V}{\partial K}}{\frac{V}{K}} = \frac{\partial V}{\partial K} \cdot \frac{K}{V}$$

1.2.4 CobbDouglas type production function

C.W. Cobb and P.H. Douglas, 1928

$$V = A \cdot L^{\alpha} \cdot K^{\beta} \quad (\alpha, \beta > 0,\ \alpha + \beta = 1) \qquad (4)$$

A: Scale factor

$$\ln V = \ln A + \alpha \ln L + \beta \ln K \qquad (4')$$

$$\ln \frac{V}{L} = \ln A + \beta \ln \frac{K}{L} \quad (\because\ \alpha = 1 - \beta)$$

Differentiate equation (4’) with respect to time t,

$$\frac{\frac{dV}{dt}}{V} = \alpha \frac{\frac{dL}{dt}}{L} + \beta \frac{\frac{dK}{dt}}{K} \qquad \frac{\Delta V}{V} = \alpha \frac{\Delta L}{L} + \beta \frac{\Delta K}{K}$$

$$\frac{d \ln X}{dt} = \frac{\frac{dX}{dt}}{X} \equiv \frac{\Delta X}{X}$$

ln: (natural) logarithm

$$\frac{\partial \ln Y}{\partial \ln X} = \frac{\partial Y}{\partial \ln X} \cdot \frac{1}{Y} = \frac{\partial Y}{\frac{\partial X}{X}} \cdot \frac{1}{Y} = \frac{\partial Y}{\partial X} \cdot \frac{X}{Y}$$

Partial differentiation of equation (4’) with respect to ln *L* and ln *K*, respectively,

$$\alpha = \frac{\partial \ln V}{\partial \ln L} = \frac{\partial V}{\partial L} \cdot \frac{L}{V} \qquad \beta = \frac{\partial \ln V}{\partial \ln K} = \frac{\partial V}{\partial K} \cdot \frac{K}{V}$$

1.2.5 Profit maximum condition

There exists **Cost function** (5) corresponding to **Production function** (1).

Production and its factors	V	L	K
Cost	GC	GLC	GCC
Prices	Pv	Pl	Pk

$$V = F(L, K) \qquad (1)$$

$$GC = C(V, Pl, Pk) \qquad (5)$$

Given that prices are decided in a competitive way, **profit maximum under the cost constrains** (5) corresponds to **maximum condition of equation (6)** as depicted in equation (7).

$$W = V + \Gamma\,[GC\ C(V, Pl, Pk)] \qquad (6)$$

where Γ: Lagrange Multiplier

$$\therefore \partial W/\partial \Gamma = \partial W/\partial V = \partial W/\partial L = \partial W/\partial K = 0 \qquad (7)$$

Given the linear homogeneity conditions of production function, cost function (5) can be depicted by the following linear function:

$$GC = C(V, Pl, Pk) = Pv*V = Pl*L + Pk*K \qquad (8)$$

$$\partial W/\partial V = 1 + \Gamma[\partial GC/\partial V\ \ \partial C/\partial V] = 1\ \ \Gamma\partial C/\partial V = 1\ \ \Gamma Pv = 0\ \ \therefore \Gamma = 1/Pv$$

$$\partial W/\partial L = \partial V/\partial L\ \ \Gamma\partial C/\partial L = \partial V/\partial L\ \ \Gamma Pl = 0\ \ \ \partial V/\partial L = \Gamma Pl = Pl/Pv$$

$\therefore \partial V/\partial L = Pl/Pv$ Similarly, $\partial V/\partial K = Pk/Pv$ (9)

$$\alpha = \frac{\partial V}{\partial L}\cdot\frac{L}{V} = \frac{P_l}{P_v}\cdot\frac{L}{V} = \frac{GLC}{GC},\ similarly,\ \beta = \frac{GCC}{GC} \qquad (10)$$

$$\alpha + \beta = (GLC + GCC)/GC = GC/GC = 1$$

V: Quantity of output (GDP,: value added), L: Labor, K: Capital stock

GC: Gross Cost
GLC: Gross Labor Cost,
GCC: Gross Capital Cost

Pv: Price of product
Pl: Price of labor (wage)
Pk: Price of capital

W: Profit

Identify the optimal combination of V, Pl and Pk maximizing W under given gross cost GC.

↓

GC is fixed thus $\frac{\partial GC}{\partial V} = 0$

$$C = P_v \cdot V,\ \frac{\partial C}{\partial V} = P_v$$

$$C = P_l \cdot L + P_k \cdot K,\ \frac{\partial C}{\partial L} = P_l$$

Marginal productivity corresponds to relative prices

Elasticity corresponds to cost share

1.2.6 Implications of firms' profit maximum behavior

$$\frac{\partial V}{\partial L} = \frac{P_l}{P_v}, \quad \frac{\partial V}{\partial K} = \frac{P_k}{P_v}$$

Marginal productivity corresponds to relative prices

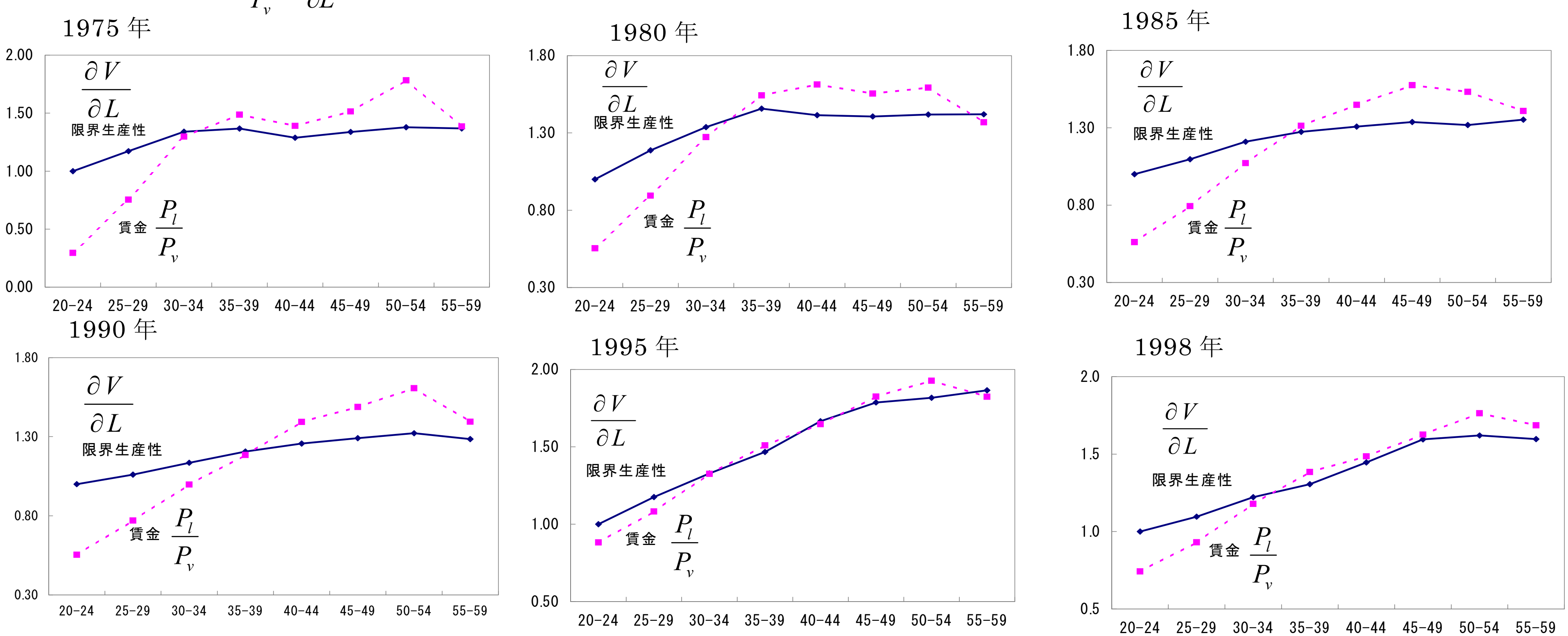
$$\alpha = \frac{\partial V}{\partial L}\cdot\frac{L}{V} = \frac{P_l}{P_v}\cdot\frac{L}{V} = \frac{GLC}{GC}, \quad \beta = \frac{\partial V}{\partial K}\cdot\frac{K}{V} = \frac{P_k}{P_v}\cdot\frac{K}{V} = \frac{GCC}{GC}$$

Elasticity corresponds to cost share

(1) Invisible investment based on lifetime employment: Japan's unique risk investment system

Younger age $\frac{P_l}{P_v} < \frac{\partial V}{\partial L}$ → **Securing risk investment fund for future development.**

Elder age $\frac{P_l}{P_v} > \frac{\partial V}{\partial L}$ → **Facilitate welfare for securing loyalty to the firm.**



Trends in Marginal Productivity of Labor and Wage by Age in Japan's Electric Machinery *(1975-1998).*

(2) Productivity increase criteria for wage management: Guideline for inflation avoidance

$$\alpha = \frac{\partial V}{\partial L} \cdot \frac{L}{V} = \frac{P_l}{P_v} \cdot \frac{L}{V}$$

Elasticity of labor

$$P_l = \alpha \cdot \frac{V}{L} \cdot P_v$$

Nominal wage

$$\frac{\Delta P_l}{P_l} = \frac{\Delta V/L}{V/L} + \frac{\Delta P_v}{P_v}$$

Increase in nominal wage (α is stable in short term, $\frac{\Delta \alpha}{\alpha} \approx 0$)

$$\frac{\Delta P_v}{P_v} = \frac{\Delta P_l}{P_l} - \frac{\Delta V/L}{V/L}$$

Increase in prices of production (Deflator)

$$\frac{\Delta P_l}{P_l} > \frac{\Delta V/L}{V/L} \Rightarrow \frac{\Delta P_v}{P_v} > 0$$

If wage increase is higher than productivity increase, inflation is apprehended.

$$\frac{\Delta XY}{XY} = \frac{\Delta X}{X} + \frac{\Delta Y}{Y}$$

$$\frac{\Delta X/Y}{X/Y} = \frac{\Delta X}{X} - \frac{\Delta Y}{Y}$$

1.2.7 Elasticity of substitution (EOS)

(1) Firms perplexity in investment decision: *Employment or replacement by robots?*

A semiconductor firm that is contemplating investments in advanced robotics would naturally be interested in the extent to which it can replace employees with robots.

How many robots will it need to invest in to replace the labor power of one worker?

Increasing competitiveness in emerging economies (EEs) based on cheap labor

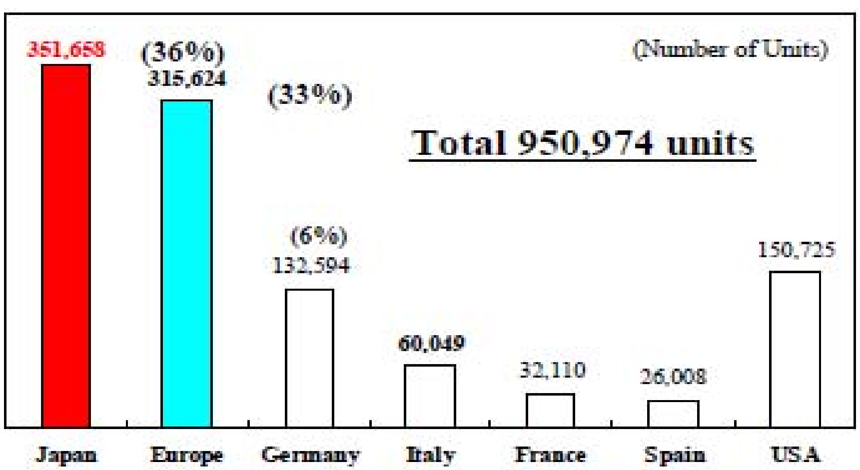
Shift to EEs | **Stay at HCs** (Home countries)

Technology substitution for labor → Reshoring

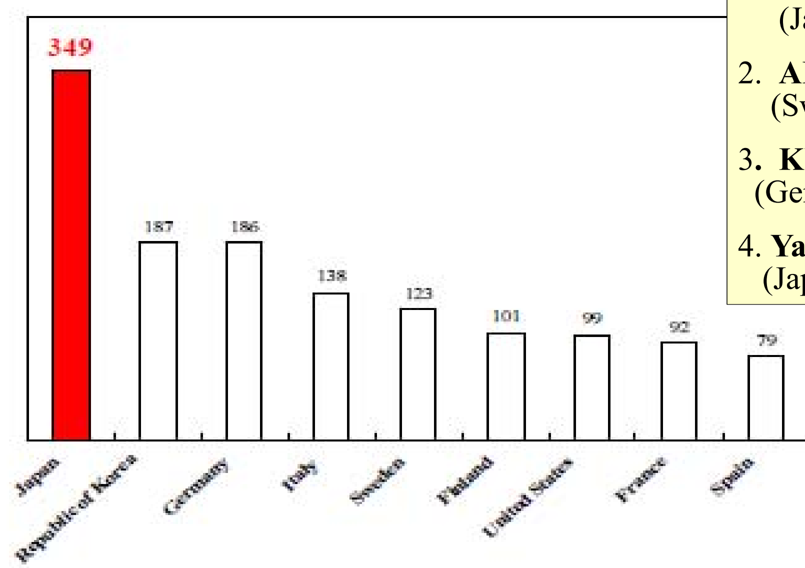
Articulated robot share in the world market (2011)

1. **Fanuc** (Japan) **18.0 %**
2. **ABB** (Switzerland) **12.8 %**
3. **KUKA** (Germany) **11.5 %**
4. **Yasukawa** (Japan) **11.5 %**

Operating Stock of Multi-purpose Industrial Robots in 2006



Robots in operation per 10,000 person employed in the manufacturing industry

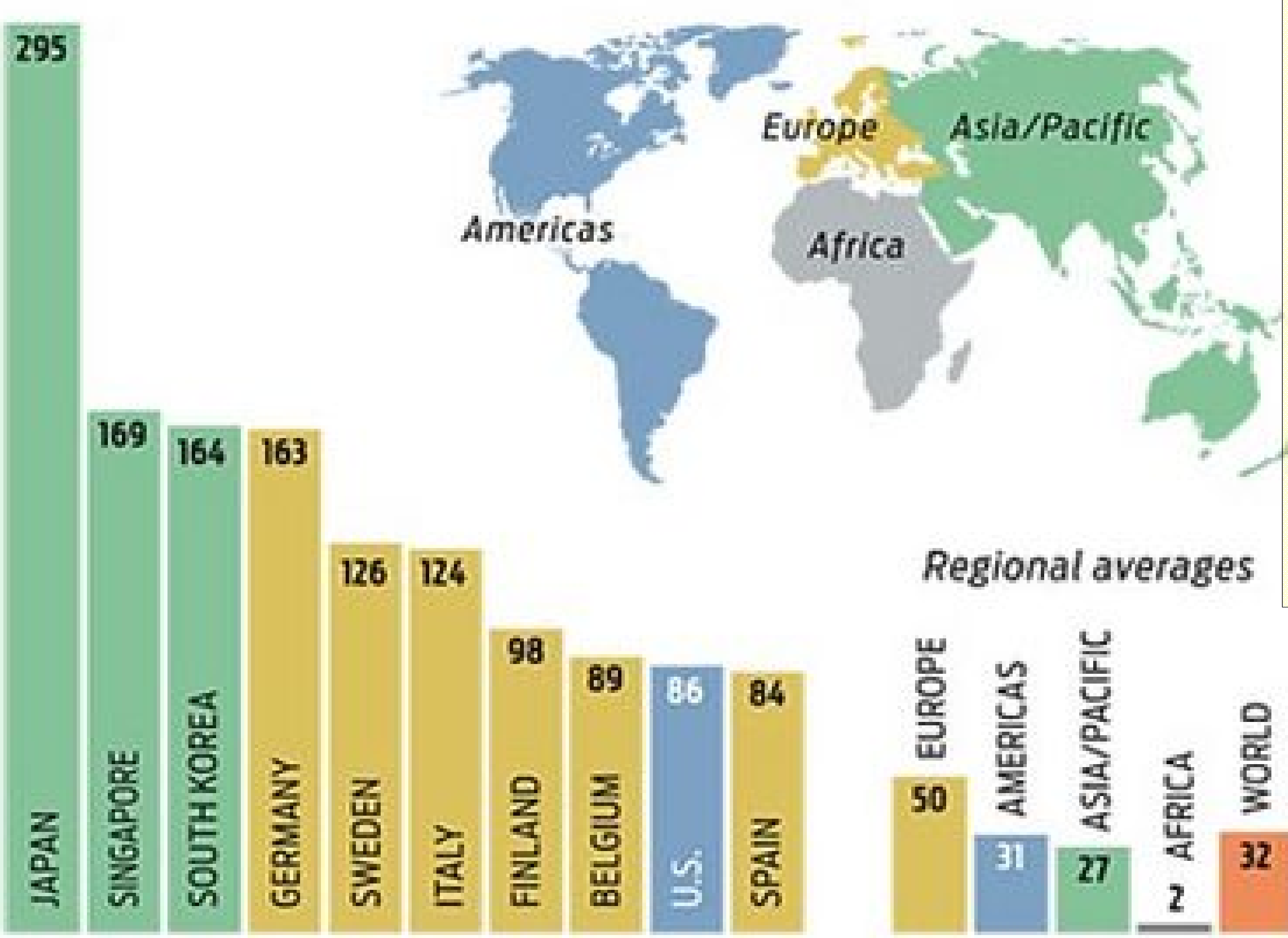


International Comparison of Industrial Robotics *(2006).*

Source: International Federation of Robotics (2009).

Top 10 Countries by Manufacturing Robot Intensity *(2007)*

- Industrial robots per 10,000 manufacturing workers.



Comparative Advantages in Robots by Field

	Jp	US	EP
Manufacturing	O	Δ	Δ
Medical	×	Δ	×
Nuclear	Δ	O	O
Space	Δ	O	Δ
Construction	O	×	×
Entertainment	O	O	×

1.2.7 Elasticity of substitution (EOS)

(1) Firms perplexity in investment decision: *Employment or replacement by robots?*

A semiconductor firm that is contemplating investments in advanced robotics would naturally be interested in the extent to which it can replace employees with robots.

How many robots will it need to invest in to replace the labor power of one worker?

1) Contribution to output increase

$$\frac{dV}{dt} = \frac{\partial V}{\partial L} \cdot \frac{dL}{dt} + \frac{\partial V}{\partial K} \cdot \frac{dK}{dt}$$

$$\Delta V = \frac{\partial V}{\partial L} \cdot \Delta L + \frac{\partial V}{\partial K} \cdot \Delta K$$

$$= \frac{\Delta V_L}{\Delta L} \cdot \Delta L + \frac{\Delta V_K}{\Delta K} \cdot \Delta K$$

$$= \Delta V_L + \Delta V_K$$

2) Marginal Rate of Technical Substitution (MRTS): Input substitution without affecting output

$$\Delta V = \frac{\partial V}{\partial L} \cdot \Delta L + \frac{\partial V}{\partial K} \cdot \Delta K = 0 \rightarrow \quad -\frac{\Delta K}{\Delta L} = \frac{\frac{\partial V}{\partial L}}{\frac{\partial V}{\partial K}} = MRTS$$

K **(robots) increase → *L* (employees) decrease**

⇒ Robots substitute for labor power

i.e., MPL = 10, MPK = 2, MRTS = 10/2 = 5, the firm can substitute 1 unit of labor by 5 units of robots without affecting output.

(2) Elasticity of substitution (EOS): *Describe firm's input substitution opportunities by measuring how quickly MRTS changes*

$$\text{EOS } \sigma = \frac{\text{Change rate of } K/L \text{ ratio}}{\text{Change rate of MRTS (MPL/MPK ratio)}} = \frac{\text{Change rate of } K/L \text{ ratio}}{\text{Change rate of } P_l/P_k \text{ ratio}}$$

MPL: Marginal Productivity of labor
MPK: Marginal Productivity of capital

P_l: Prices of labor
P_k: Prices of capital

$$\sigma = \frac{\left(\frac{d(K/L)}{K/L}\right)}{\left(\frac{d(f_L/f_K)}{f_L/f_K}\right)} = \frac{d\ln\frac{K}{L}}{d\ln\frac{f_L}{f_K}} \qquad f_X = \frac{\partial Y}{\partial X} = \frac{P_x}{P_y}\ (X = L,\ K)$$

$$\sigma = \frac{\left(\frac{d(K/L)}{K/L}\right)}{\left(\frac{d(P_L/P_K)}{P_L/P_K}\right)} = \frac{d\ln\frac{K}{L}}{d\ln\frac{P_L}{P_K}} \qquad (11)$$

$$\sigma > 1 \quad \rightarrow \quad d\ln\frac{K}{L} > d\ln\frac{P_l}{p_k} \quad \rightarrow \quad \textit{Elastic}$$

Equation (12) can be obtained by integrating equation (11).

$$d\ln\frac{K}{L} = \sigma \cdot d\ln\frac{P_l}{P_k}$$

$$\ln\frac{K}{L} = \int \sigma \cdot d\ln\frac{P_l}{P_k} = c + \sigma\ln\frac{P_l}{P_k}$$

$$\ln\frac{K}{L} = c + \sigma\ln\frac{P_L}{P_K} \qquad (12)$$

c: constant term.

$$\ln\frac{K}{L} = c + \sigma\ln\frac{P_L}{P_K}$$

$$\chi = \frac{Capital \quad \exp enditure}{Labor \quad \exp enditure} = \frac{P_k \cdot K}{P_l \cdot L}$$

$$\ln\chi = \ln\frac{K}{L} - \ln\frac{P_l}{P_k} = c + \sigma\ln\frac{P_l}{P_k} - \ln\frac{P_l}{P_k} = c + (\sigma - 1)\ln\frac{P_l}{P_k}$$

When elastic $(\sigma > 1)$, wage increase reacts to χ increase (increase in capital expenditure) enabling capital substitution for labor.

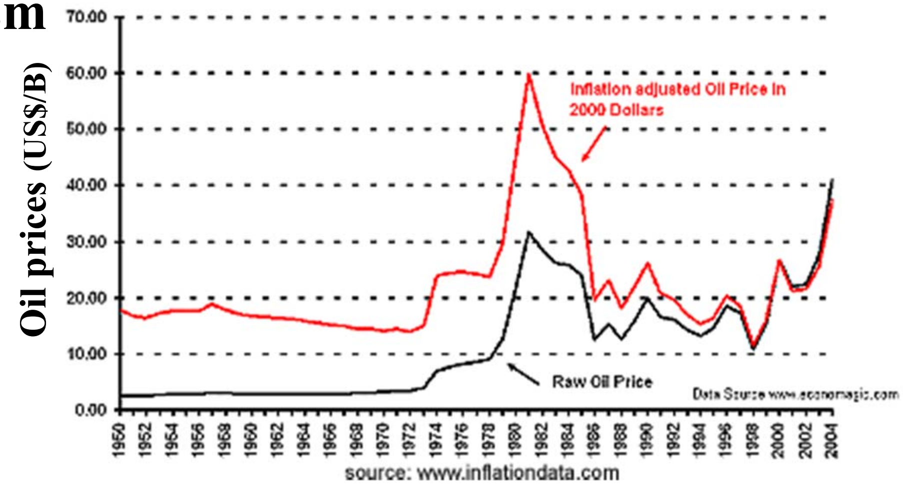
Implication of substitution in an ecosystem

In an ecosystem, in order to maintain homeostasis (checks and balances that dampen oscillations), when one species slows down, another speeds up in a compensatory manner in a closed system (**substitution**), while depending on supplies from an external system leads to dampen homeostasis (**complement**).

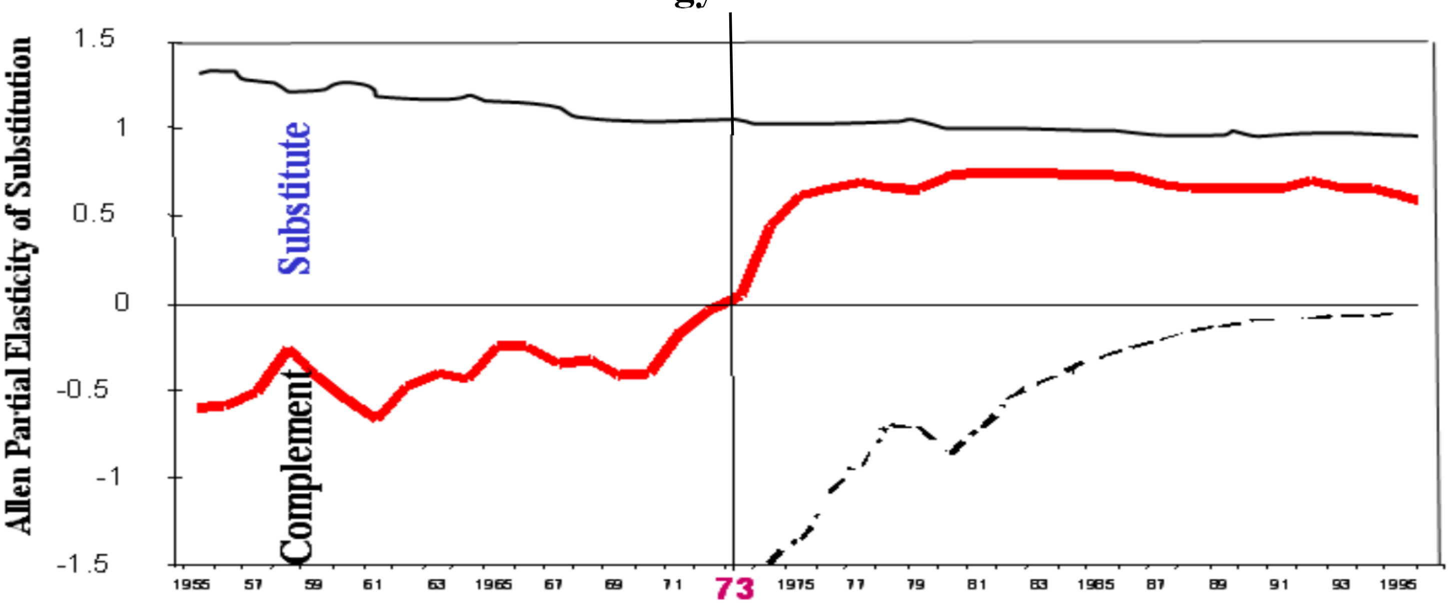
Technology Substitution for Energy

Japan's explicit co-evolutionary dynamism between innovation and institutional systems by transforming external crises into a springboard for new innovation was typically demonstrated by technology substitution for energy in the 1970s.

1) Dynamism



1st energy crisis in 1973

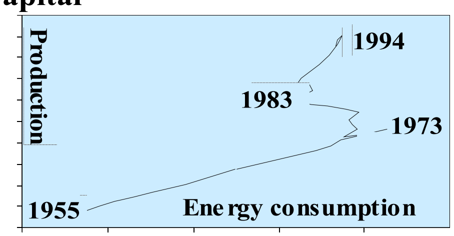


Technology - Labor

Technology - Energy

Technology - Capital

Substitution ⇒ **Inducing further innovation**



Trends in Technology Substitution for Production Factors in the Japanese Manufacturing Industry

(1955-1997) - Allen Partial Elasticity of Substitution. Source: Watanabe (1999).

2) Conspicuous Energy Efficiency *(2004)*

1. **Japan accomplished the highest GDP growth in a decade after the 2nd energy crisis in 1979.**
2. **This can be attributed to its conspicuous energy efficiency enabled by technology substitution for energy.**
3. **Consequently, Japan demonstrates the world's highest energy efficiency.**

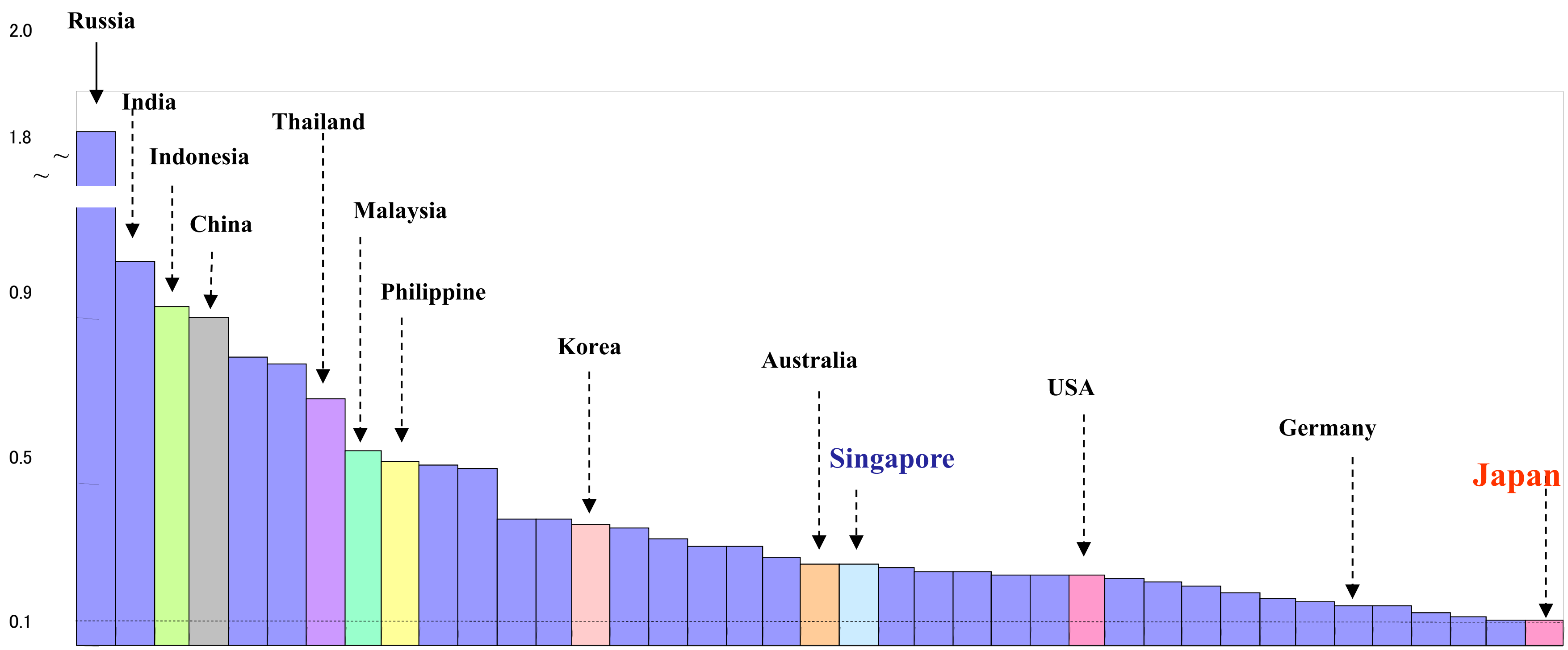
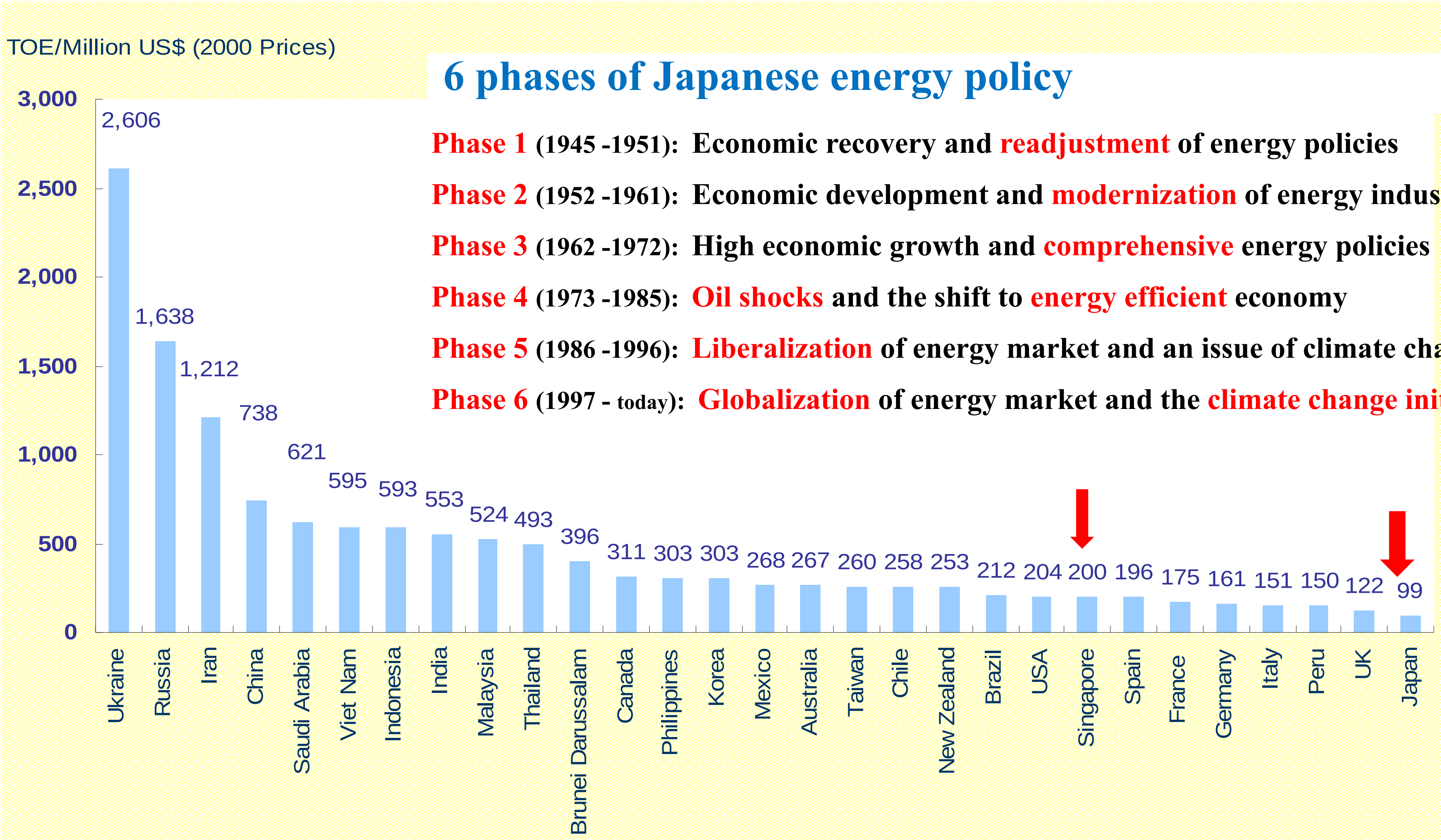


Fig. 9. Energy Consumption per GDP in 40 Countries ***(2004).***

3) Conspicuous Energy Efficiency *(2007)*
- Japan by far leads the world in energy efficiency



6 phases of Japanese energy policy

Phase 1 (1945 -1951): Economic recovery and readjustment of energy policies

Phase 2 (1952 -1961): Economic development and modernization of energy industry

Phase 3 (1962 -1972): High economic growth and comprehensive energy policies

Phase 4 (1973 -1985): Oil shocks and the shift to energy efficient economy

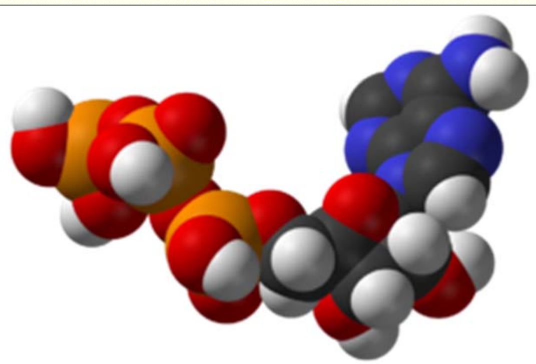
Phase 5 (1986 -1996): Liberalization of energy market and an issue of climate change

Phase 6 (1997 - today): Globalization of energy market and the climate change initiative

Sources: GDP : World Bank (2009), World Development Indicators, and Total Primary Energy: IEA(2009), Energy Balances of OECD and Non-OECD Countries

References: David Besanko and Ronald R. Braeutigam,
Micro Economics, John Wiley & Sons (Asia) Pte Ltd
(2006). ISBN: 0-471-69679-X

Chihiro Watanabe, Managing Innovation in Japan
- The Role Institutions Play in Helping or Hindering
How Companies Develop Technology, Springer,
Berlin (2009) ISBN: 978-3-540-89271-7



COM8: Techno-economic Systems, Institutional Innovation

Chihiro Watanabe (watanabe.c.pqr@gmail.com)

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** **S**ystems approach, **E**mpirical approach, **A**nalytical approach, challenge to **R**ationale, **C**omprehensive approach, with **H**istorical perspective