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COM8
Techno-economic Systems Institutional Innovation (5)

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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

1.1 Basic Concept

1.2 Three Dimensional Structure of Institutional Systems

1.3 Co-evolution between Innovation and Institutional Systems

1.4 Success and Failure of Institutional Innovation

1.5 Sources of Failure

1.6 Sources of Success

2. New Stream for Institutional Innovation

1.1 Basic Concept

1.1.1 Chronology of Key Concepts and Discipline

1. **「Nature can be managed only by following」** (F. Bacon, 1600)
2. **「Creative Destruction」** (J. Schumpeter, 1942)
3. **「Economic Biology rather than Economic Mechanics」** (A. Marshall, 1948)
4. **「Induced Bias in Innovation and the Theory of Distribution」** (C. Kennedy, 1964)
5. **「Induced Innovation: Technology, Institutions and Development」** (H. Binswanger and V. Ruttan, 1978)
6. **「Role of Institutional System」** (D.C. Norm, 1994)
7. **「Techno-metabolism」** (C. Watanabe, 1997)
8. **「Institutional Elasticity」** (C. Watanabe and C. Griffy-Brown, 2000)
9. **「Co-evolution of Technology Impacting Society and Industry」** (C. Watanabe and IIASA, 2000)
10. **「Co-adaptation and Co-evolution」** (G.G. Marten, 2001)
11. **「Institutional Innovation」** (V. Ruttan, 2001)
12. **「Resilience as a Source of Survival Strategy」** (C. Watanabe and M. Kishioka, 2002)
13. **「Co-evolutionary Dynamism between Innovation and Institutions」**（SIMOT, Tokyo-tech, 2004)

1.1.2 Key Concepts

(1) Resilience

The ability of an ecosystem or social system to continue functioning despite occasional and severe disturbance *(G.G. Marten, 2001)*

The capability of sustained body to recover from or adjust smoothly to external changes, shocks or crises *(C. Watanabe and M. Kishioka, 2002)*

(2) Co-evolution

Co-existence (existing together),
Co-adaptation (fitting together),
Co-evolution (changing together)

(G.G.Marten, 2001)

(3) The significant role of co-evolution in complex circumstances

- *Comparing an ecosystem and TV sets* *(Marten, 2001)*

1. Both systems are similar in incorporating a selection of parts that function together.

2. A TV has a large number of electronic components, each precisely suited to the other components in the set.

3. There are, however, some important differences between an ecosystem and TV sets. An ecosystem has a higher level of redundancy than TV sets, and this gives it greater reliability and resilience.

4. Because TV sets are designed to be constructed as economically as possible, there is only one component for every function.

5. Each important function in an ecosystem is normally performed by several different species.

6. An ecosystem and TV sets are different in another important way. The biological components of themselves complex adaptive systems with the ability to change as circumstance demands.

7. In contrast to TV sets, an ecosystem, depending upon what is happening at a particular time, plants and animals can change the way in which they interact with other species.

1.1 Institutional Systems

(1) Definition of Institutions (Wikipedia)

(i) Institutions are structures and mechanisms of social order and cooperation governing the behavior of set of individuals within a given human collectively.

(ii) Institutions are identified with a social purpose and performance, transcending individual human lives and intensions, and with the making and enforcing of rules governing cooperative human behavior.

(iii) The term "institution" is commonly applied to customs and behavior patterns important to society, as well as to particular formal organizations of government and public service.

(iv) As structures and mechanisms of social order among humans, institutions are one of the practical objects of study in the social sciences, including sociology, political science, and economics.

(v) Institutions are central concern for law, the formal mechanism for political rule-making and enforcement.

(vi) The creation and evolution of institutions is a primary topic for history

(2) Fundamental Viewpoints of SIMOT (Science of Institutional MOT)

1) Basic Understanding

Emergence of innovation is critically dependent on the co-evolutionary dynamism *(a mutually inspiring virtuous cycle)* **with institutional systems** *(similar to soil in that they cultivate emerging innovation)* **which are realized by means of a three-dimensional system consisting of**

(i) National Strategy and Socio-Economic System,

(ii) Entrepreneurial Organization and Culture, and

(iii) Historical Perspectives.

2) Three Dimensional Structure of Institutional Systems

Institutional systems are similar to soil in that they cultivate emerging innovation realized by means of 3 dimensional system.

1. National strategy and socio - economic system

9 factors

1.1 National strategy

- 1.1.1 Democracy
- 1.1.2 Constitution, Law, Regulation, Standard, Manner
- 1.1.3 Separation of the three powers of *Administration, Legislation*, and *Judicature*

1.2 Social system

- 1. 2.1 Education system
- 1.2.2 Employment system
- 1.2.3 Infrastructure investment

1.3 Economic system

- 1.3.1 GDP and GDP per capita
- 1.3.2 Trade- based nation, Export and Import
- 1.3.3 Tech- based nation, ICT and Government ICT

2. Entrepreneurial organization and culture

12 factors

2.1 Strategy and Business model

- 2.1.1 Vision and Business strategy
- 2.1.2 Business model and Market policy
- 2.1.3 R&D and ICT

2.2 Employment, Promotion and Training

- 2.2.1 Appointment
- 2.2.2 Promotion
- 2.2.3 Training

2.3 Structure

- 2.3.1 Entrepreneurial organization
- 2.3.2Affiliated firms
- 2.3.3 Foreign capital

2.4 Doctrine, Philosophy and Ethics

- 2.4.1 Business doctrine and Culture
- 2.4.2 Philosophy and Ethics
- 2.4.3 Corporate governance

3. Historical perspectives

12 factors

3.1 Geographical structure

- 3.1.1 Geopolitical environment
- 3.1.2 Population
- 3.1.3 Homogeneous/Heterogeneous, Gini index

3.2 Culture and Tradition

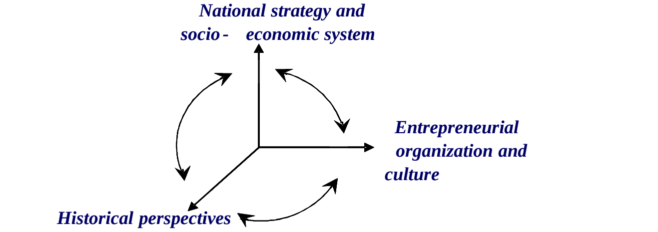
- 3.2.1 Culture, Custom and Common idea
- 3.2.2 National spirit, Moral ethic, Manners and Customs
- 3.2.3 Religion

3.3 State of development

- 3.3.1 Rapid economic growth
- 3.3.2 Mature economy
- 3.3.3 Diminishing population and Aging trend

3.4 Paradigm and phase of industrial society

- 3.4.1 Indust . society, Inform. society, Post- inform. society
- 3.4.2 Heavy and chemical industrial structure
- 3.4.3 Knowledge- intensified industrial structure

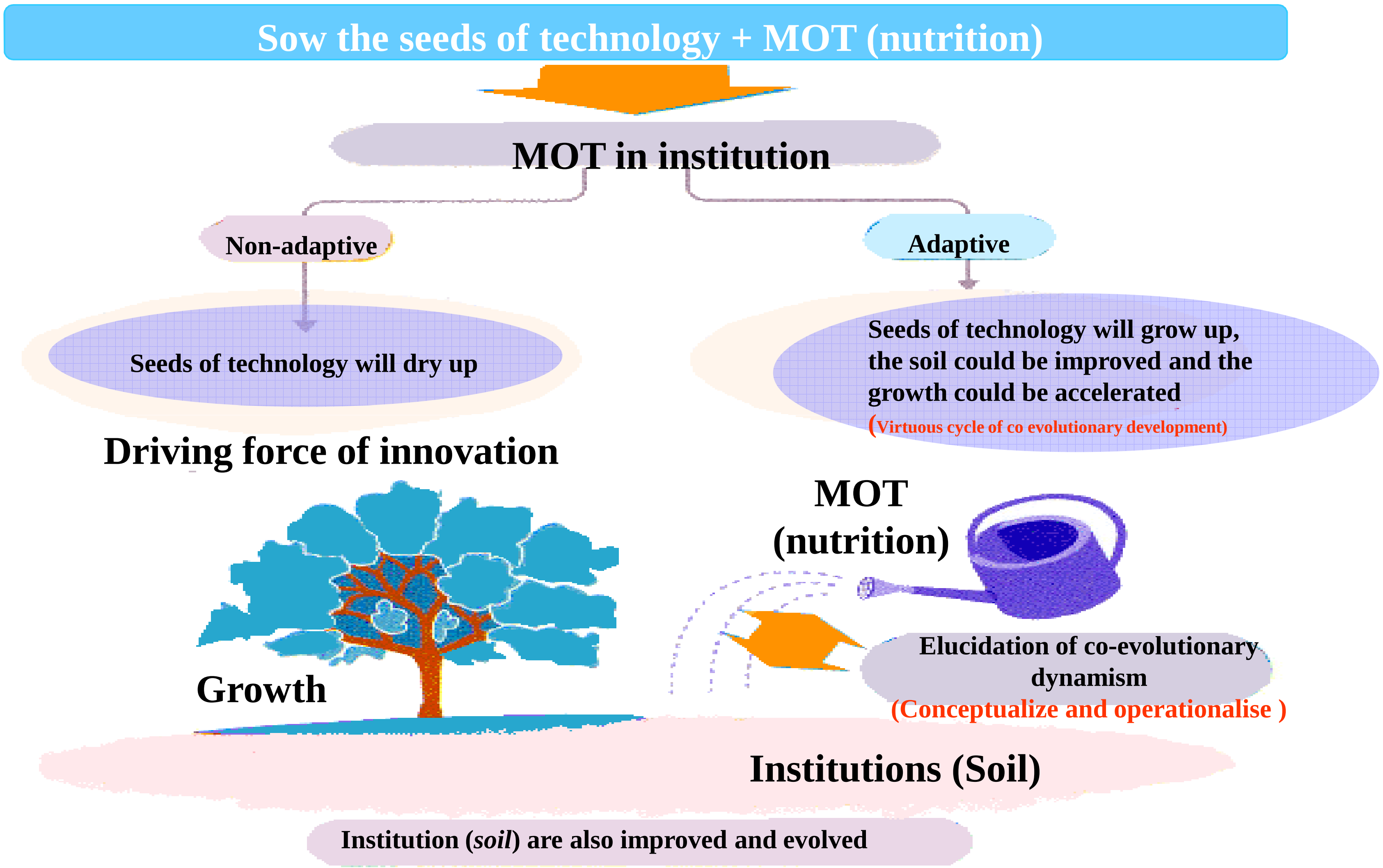


3 Dimensions of Institutions

Source: Watanabe and Zhao et al. *(2006).*

3) Co-evolution between Innovation and Institutional Systems

Co-evolutionary dynamism between innovation and institutional systems is decisive for an innovation driven economy.
It may stagnate if institutional systems cannot adapt to evolving conditions



(3) Postulate of SIMOT

1. **Japan's system of Management of Technology (MOT) indigenously incorporates explicit function which induces this co-evolutionary dynamism.**

2. **However, it changed to an opposite in the very last decade of the last century.**

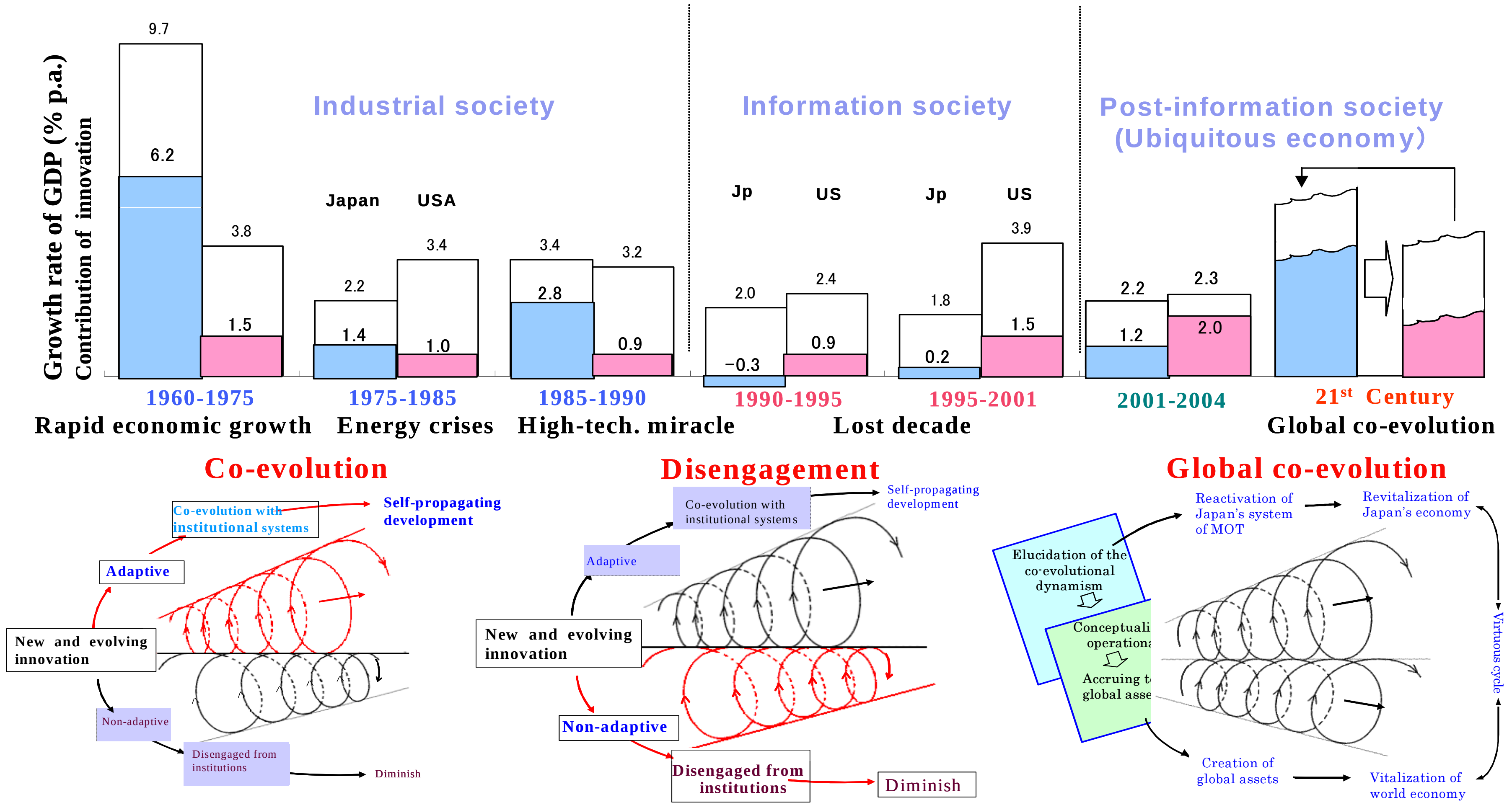
3. **This can be attributed to a conflict of the co-evolutionary dynamism due to the organizational inertia of the success story in the growth economy in an industrial society binding the two axes of the institutions (national strategy and socio-economic system, as well as entrepreneurial organization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

4. **Although Japan's dynamism shifted to the opposite in the 1990s, resulting in a lost decade, a swell of reactivation emerged in the early 2000s.**

5. **This can largely be attributed to hybrid management fusing the "East" (indigenous strength) and the "West" (lessons from an IT driven new economy).**

(4) What has Learned

1. The co-evolutionary dynamism between innovation and institutional systems is decisive for an innovation-driven economy. Rise and fall of the Japanese economy over the last 3 decades can be attributed to the consequence of the co-evolution and disengagement between innovation and institutional systems as illustrated in the **Figure.**



2. Successful co-evolution in an industrial society by manufacturing technology substitution for labor and energy leading to high-technology miracle changed to disengagement in an information society in the 1990s resulting in the lost decade.

3. Noteworthy surge in new innovation in leading edge activities in certain high-technology firms can be attributed to **the hybrid management of technology by fusing indigenous strength developed in an industrial society ("East") and the effects of learning of the global best practice in an information society ("West").**

4. This surge suggests a possibility of reactivation of Japan's system of MOT leading to revitalizing its economy. This can be enabled by constructing a virtuous cycle with vitalized world economy.

5. In addition, the foregoing surge suggests a significance of the hybrid system in a global context aiming at fusing indigenous strength and learning from partners with comparative advantage in certain fields.

Hybrid Management - *Fuses East and West*

1. Japan is emerging from years of sluggish growth.
2. Its firms appear to have produced something.
3. Management method that incorporates lessons from US firms while preserving the practices that once made Japanese firms famous.

International Herald Tribune
Thursday, August 31, 2006

Made in corporate Japan: New approach to business

Hybrid management fuses east and west

by Patrick L. Smith

TOKYO: Now that Japan is emerging from years of sluggish growth, its corporations appear to have produced something few executives or analysts expected even a few years ago: a management method that incorporates lessons from American companies while preserving the practices that once made Japanese companies famous.

Even a few years ago, it was widely expected that recession and the mounting pressures of global competition would force corporate Japan to surrender such traditions as loyalty to employees and suppliers, responsibility to stakeholders and the like. Prominent analysts in the Tokyo offices of firms like Goldman Sachs and Merrill Lynch were among the most enthusiastic exponents of this view.

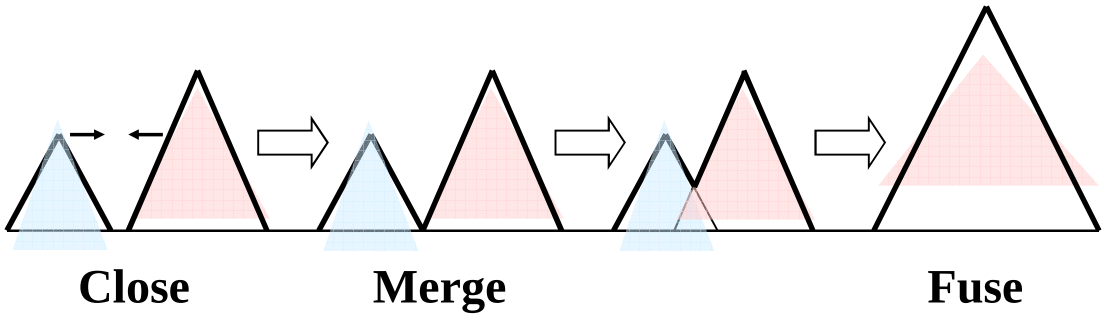
But a funny thing happened on the way to the Japanese recovery. What was almost universally written off as Japan's "lost decade" has left this nation's leading companies stunningly competitive while still holding to the corporate ethos for which they have long been known.

"A lost decade? Nonsense. A painful transition? Yes," said James Abegglen, chairman of the Asia Advisory Service and an expert on Japanese corporate organization. "Companies have done what had to be done to redesign themselves. They've retained basic values while changing what had to be changed."

With Japan now recovering, what is emerging here is a hybrid management strategy that is partly Japanese and partly Western, or a kind of "third way" in the corner office. Executives, management experts and consultants say this is producing a reinvigorated corporate sector that is more focused on primary businesses, better able to maximize human capital, more dedicated to advanced technologies such as robotics and second to none in cost-effectiveness.

The corporate ideal as this hybrid takes hold here is Toyota, Japan's leading auto maker. Company executives, notably the chairman, Hiroshi Okuda, have long been known for their cutting-edge management methods even as

JAPAN, Continued on Page 14



Scheme of Fusion

1.2 Three Dimensional Structure of Institutional Systems

1.2.1 Basic Structure of Institutional Systems

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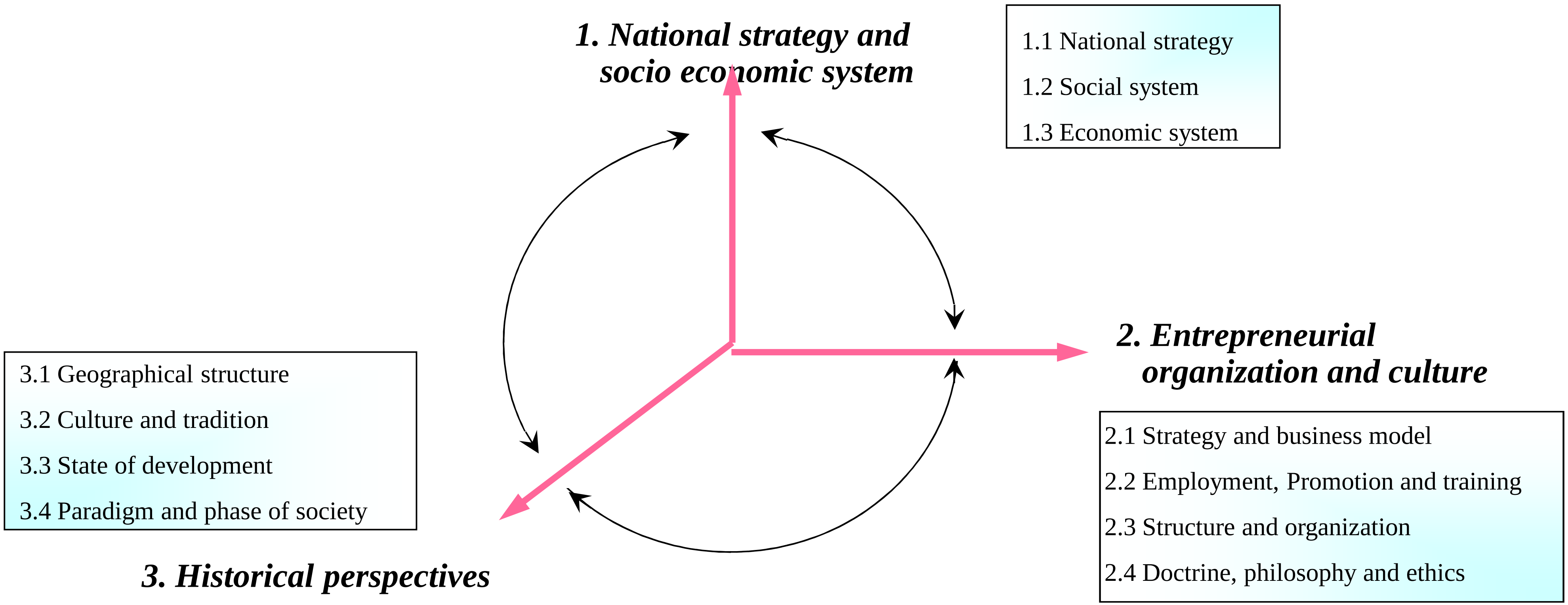
(2) Role of Institutional Systems for Innovation

(i) Institutional systems are similar to soil in that they cultivate emerging innovation realized by means of 3 dimensional system.



(ii) Each respective 3 dimension interacts each other with remaining 2 dimensions thereby, with institutional elasticity, resilience against external changes can be maintained.

Fig. 1. Three Dimensional Structure of Institutional Systems.

(3) Three Dimensional Structure of Institutional Systems

Institutional systems are similar to soil in that they cultivate emerging innovation realized by means of 3 dimensional system.

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2. Entrepreneurial organization and culture

2.1 Strategy and Business model
- **2.1.1 Vision and Business strategy**
- **2.1.2 Business model and Market policy**
- **2.1.3 R&D and ICT**

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3. Historical perspectives

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- **3.1.1 Geopolitical environment**
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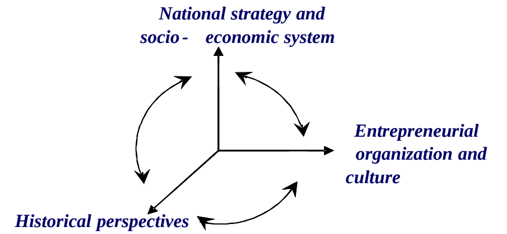


3 Dimensions of Institutions

Source: Watanabe and Zhao et al. *(2006)*.

Fig. 2. Composition of Three Dimensional Structure of Institutional Systems.

(4) Socio-cultural Systems Enabled Japan's Technology Assimilation

1. Socio-cultural foundation cultivated through the Edo period *(1603-1867)*

[a] Homogeneity of the nation, [b] High educational level, [c] Regional technology exchange, [d] Active information flow by "Sankin Kotai"

Cultural elasticity, Adopt and internalize ability, Pragmatism

2. Flood of western civilization and culture triggered by

[a] Unexpected call by the US vessel in 1853 → [b] Meiji Restoration in 1868

3. Japan's basic policy against the flood

Introduce and adopt a new civilization while being based its selection on

[a] Examination of traditional values, customs and institutions previously thought to have absolute value,

[b] Objective appreciation of the excellence of western civilization and culture from efficiency/higher quality of life view

4. Meiji Government's *(1868-1912)* **policy**

(1) Nat. targets/principle: [a] Japanese spirit and western learning, [b] Increase ind. prod. [c] Wealth and military

(2) Policies:

(i) Cultivating Japanese spirit: [a] Educational system, [b] Moral ethic

(ii) Western learning: [a] Literature, [b] Advisers, [c] Model factories, [d] Advanced machinery, [e] Sending youth

Introd., adopt., assimilat. and develop. of western tech. selectively into Japanese social and cultural system without spoiling indig. culture

Fig. 3. Socio-cultural Systems Enabled Japan's Smooth and Effective Technology Assimilation.

(5) Foundation of Japan's Economic Development after WW Ⅱ

External factor

1. **Free trade system**
2. **Stable exchange rate**
3. **Cheap and stable energy supply**

⇒ Grave Situation → Stiff repulsive power
(External shocks and crises)

Internal factor

1. **High level of education**
   - Social mobility
   - Fair income distribution
   - High quality used demand
   - Competitive nature of the society
2. **Diligence/commitment of workers/managers**
   - Zero defect, QC, TQC, CWQC
   - Active improve imported tech.
3. **Highly organized systems and customs**
   - **(1) Seniority system**
   - **(2) Life time employment**
   - **(3) Enterprise unions**
   - Gaining consensus and trust
   - Smooth assimilation
4. **Enlightened manage-ment strategy**
   - Long-term consideration
   - Active and flexible approach
   - Dependency on Government policy

⇒

Severe competition

User demand for high quality

Active inter- industry stimulation

Mutual stimulation between dynamic change in industrial structure and R&D

Political stability *(1955-1993-2009)*
Successive trends in catch-up and growth *(1945-1990)*

Fig. 4. Foundation of Japan's Economic Development after World War Ⅱ.

Landslide victory for DPJ

30 Aug. 2009

DPJ leader Hatoyama (centre) pinning a red rosette on the name of a winning candidate, while observing election results at the party's election centre in Tokyo yesterday. The 62-year-old grandson of a former prime minister is slated to become Japan's next premier. PHOTO: ASSOCIATED PRESS

LDP voted out after nearly 50 continuous years in power in Japan

By Kwan Weng Kin
JAPAN CORRESPONDENT

TOKYO: Japanese voters eager for change yesterday handed an overwhelming victory to the opposition Democratic Party of Japan, opening a new chapter in the nation's political history.

DPJ leader, 62-year-old Mr Yukio Hatoyama, is slated to become Japan's next prime minister.

"I am thankful for the support shown by the public....I think people felt an extreme sense of frustration with the government of the ruling party," he told reporters. At press time, projections by the Asahi Shimbun gave the DPJ 305 seats, a clear majority in the 480-seat Lower House. When all the results are in, the DPJ coalition is expected to clinch as many as 320 seats, giving it an absolute, two-thirds majority.

The DPJ's widely expected win rang down the curtain on over 50 years of almost uninterrupted rule by the Liberal Democratic Party (LDP), which had garnered only 116 seats at press time.

Yesterday's historic win was the first time in 62 years that an opposition party had ousted the ruling party, also with a clear majority. When the LDP lost power briefly in 1993, it was surpassed in numbers by a coalition of smaller anti-LDP parties, but remained the largest party.

The 11-year-old DPJ was formed through a merger of four opposition parties, some of them splinter LDP groups. Despite its relative inexperience, the party succeeded at presenting itself as a viable alternative to voters weary of an LDP government whose pro-business policies had widened the income gap in recent years.

The DPJ campaigned on a reform platform that promised to end wasteful government spending, remove cushy jobs for retired bureaucrats, review health care and provide more money for childcare and education. Its candidates, many newcomers, were jubilant over their defeat of veteran LDP politicians in many constituencies, while anguish and humiliation engulfed the LDP camp.

Prime Minister and LDP chief Taro Aso took responsibility for the drubbing, saying he would resign. "I will take the distrust toward myself seriously," he told NHK. Mr Aso's ratings had plunged to record lows for a Prime Minister, following a series of scandals and gaffes within his Cabinet since he took over less than a year ago. The LDP is due to elect a new

TIME FOR CHANGE

"It's too long for a single party to dominate national politics."

Pensioner Toshihiro Nakamura

16 Dec. 2012

FINANCIAL TIMES

ASIA Monday December 17 2012

Iraq's 'supergiant'
BP and the Rumaila oilfield. Analysis, Page 6

I'm not stressed: I merely have a lot to do
Lucy Kellaway, Page 12

- Result redraws political landscape
- Potential policy shifts at home and abroad

LDP landslide in Japan poll

By Michiyo Nakamoto, Mure Dickie and Jonathan Soble in Tokyo

Japan's Liberal Democratic party has crushed the ruling Democrats in an election landslide so emphatic that together with a smaller coalition partner it will be able to enact legislation even without approval by the Diet's upper house.

The victory redrew at a stroke the political landscape of the world's third-largest economy and signalled potentially far-reaching shifts in its fiscal and monetary policy and in its dealings with China and other regional neighbours.

State broadcaster NHK said the LDP had won at least 293 of the 480 seats in the Diet's lower house and that together with smaller ally Komeito had secured a two-thirds supermajority that would allow it to drive legislation through parliament even if the upper chamber – where they lack a majority – tries to block it.

By ending the upper house's effective veto, the supermajority gives the LDP and its leader Shinzo Abe an opportunity to rapidly implement campaign promises to boost the economy with a surge in spending on public works and to push the Bank of Japan to adopt more aggressive monetary easing to curb deflation. Mr Abe – who will become prime minister for a second time five years after he stepped down due to illness, policy setbacks and scandals – has also signalled a tougher line in a flaring territorial dispute with China and on frictions with South Korea over Japan's wartime history.

But the LDP leader last night responded cautiously to his party's dramatic revival from heavy defeat at the hands of the ruling DPJ just three years ago.

"This result doesn't mean that public support for the LDP has 100 per cent recovered," Mr Abe said. "It's a rejection of the last three years of political confusion. Now it's up to the LDP to live up to people's expectations."

Shigeru Ishiba, LDP secre-

LDP leader Shinzo Abe at the party's headquarters in Tokyo yesterday. The poll results board behind him shows the scale of victory

'This result doesn't mean public support ... has 100 per cent recovered. It's up to the LDP to live up to people's expectations'
Shinzo Abe

21 July 2013

Abe issues party rallying cry after poll win

By Jonathan Soble in Tokyo

Shinzo Abe, Japan's prime minister, exhorted his triumphant Liberal Democratic party yesterday to rally behind his plans for economic reform, a day after the LDP took full control of parliament in a sweeping victory in upper house elections.

"If we go back to being the old LDP that flees from reform, we will immediately lose the trust of the nation," Mr Abe said at a news conference at the party's headquarters. "We can no longer blame the opposition and use a hung parliament as an excuse. The stern gaze of the Japanese people will be on the LDP."

On Sunday, voters gave the party and its smaller partner, Komeito, enough seats for a majority in the House of Councillors, putting the coalition in charge of both chambers of parliament for the first time since 2007.

Many analysts believe Mr Abe's biggest challenge now will be convincing members of his own often fractious party to support his plans for freer trade and deregulation, as well as a planned increase in the national sales tax, known as the consumption tax, that is designed to address Japan's huge public debt.

"There is a need to monitor the emergence of 'opposition parties within the ruling camp'," said Kyohei Morita, an analyst at Barclays Capital. "In relation to the consumption tax, for example, some LDP lawmakers have already taken an explicitly cautious stance, which could lead to internal splits."

A significant number of LDP parliamentarians, many representing rural districts, are also unhappy about Mr Abe's decision to pursue membership in the US-led Trans-Pacific Partnership trade bloc, for fear that Japan will be forced to lower tariffs on imported farm products.

More than 200 LDP legislators from both chambers of parliament – a majority of the total – are members of a party subgroup whose original name translated to "group demanding immediate withdrawal from TPP negotiations".

Out of deference to Mr Abe, it changed its title to "group to protect the national interest in TPP negotiations" after the premier committed Japan to joining talks in March, but its aversion to the proposed trade deal remains.

Mr Abe, who advocates an expanded role for Japan's military and conservative cultural changes such as a more patriotic school curriculum, was explicit in linking an upturn in Japan's economy with what he hopes will be a broader kind of national revival.

"Economics is the source of national power. Without a strong economy, we cannot have diplomatic influence or dependable social security," he said. "I want to make Japan's presence felt in the world."

Still, he reiterated a pledge he made on election day that he would focus on the economy and defer for now his most controversial ambition – to revise the liberal, anti-war constitution imposed by the US after the second world war.

To do that, he would need a two-thirds majority in both houses of parliament, something he still does not have even after Sunday's victory.

"Even to propose a revision requires two-thirds of the legislature, so even if we wanted to move forward, we can't," he said. "Politics is about what is achievable and realistic."

In his speech, the prime minister touched on the personal nature of the victory.

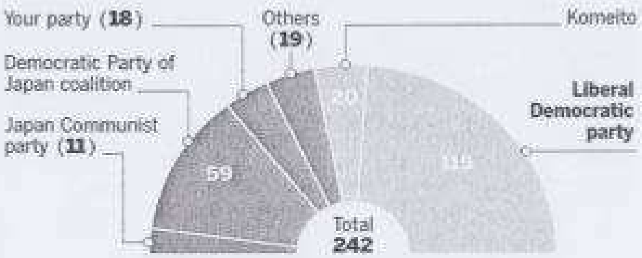
It was under Mr Abe's first and fleeting stewardship back in 2007 that the LDP lost control of the upper house.

That defeat marked the beginning of several years of party instability that included in 2009 its second ever general election defeat since it was established in 1955.

"I was the one who caused the split in parliament in the first place," Mr Abe said.

Japan House of Councillors (upper house) composition

Seats



Source: Japan ministry of internal affairs and communications

1.2.2 Institutional Elasticity

	1980s	*1990s*
Paradigm	**Industrial society**	**Information society**
Core technology	Manufacturing technology	IT
Key features	**Given, Provided by suppliers**	**To be formed during the course of interaction with institutions**
Actors responsible for features formation	Individual firms/organizations	Institutions as a whole
System structure	Optimization	Standardization

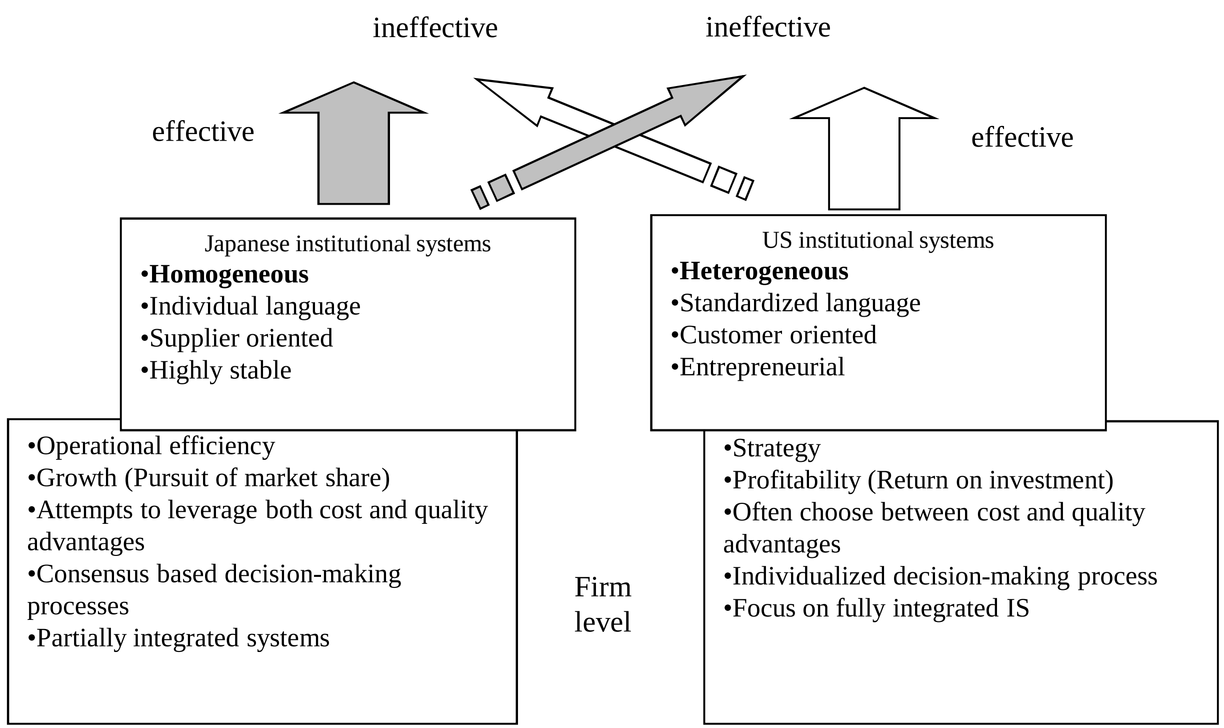


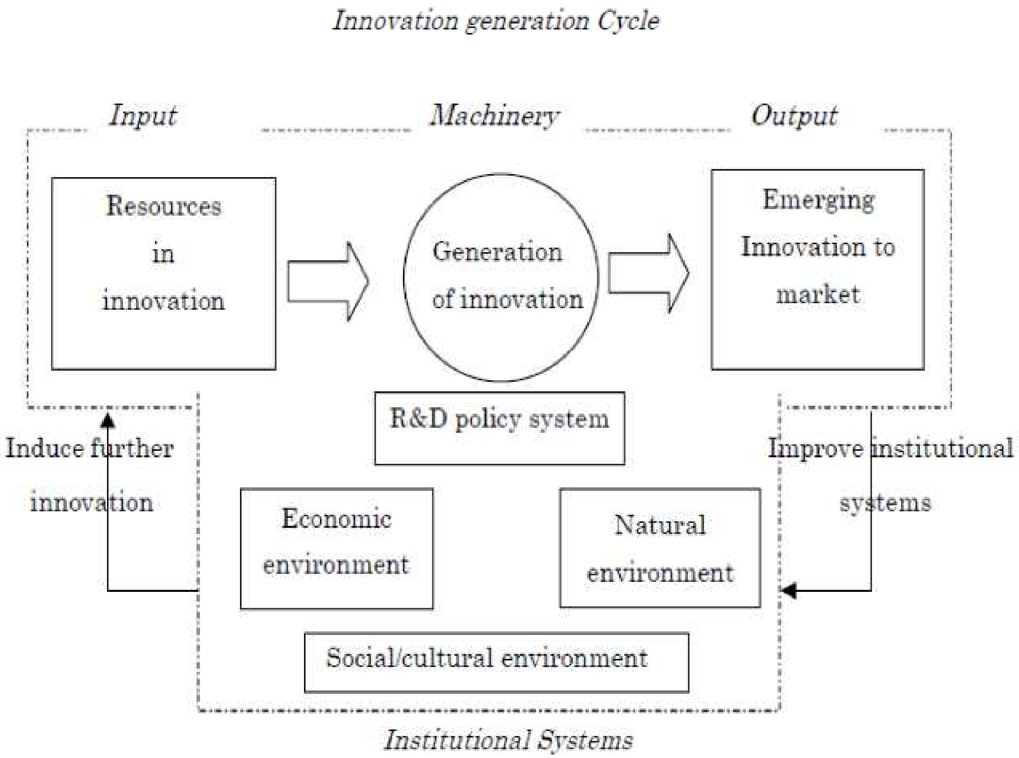
Fig. 5. Comparison of Institutional Elasticity between Japan and the US in the Paradigm Shift from an Industrial Society to an Information Society.

1.2.3 Horizontal and Vertical Interacting Structure

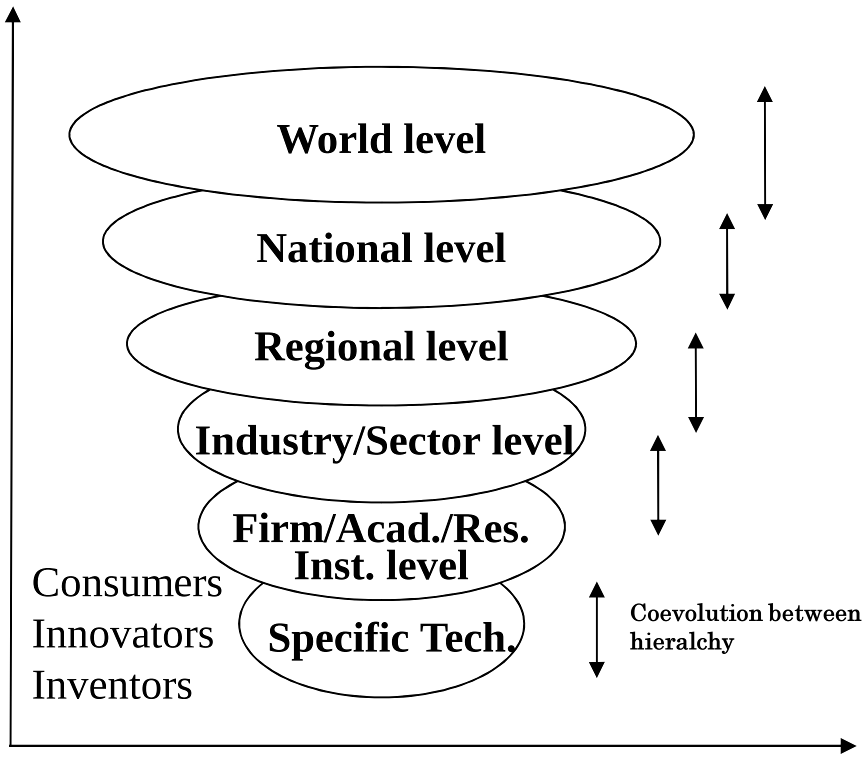
(i) Institutions incorporates both horizontal and vertical interacting structure.

(ii) This structure leads to institutions' co-evolutionary nature with interacting partners.

Horizontal interaction



Vertical interaction



Invention becomes **innovation** when the invention becomes a commercial product, which in turn becomes a successful product when **consumers** buy it in the market.

Fig. 6. Scheme of Institutional Systems for Innovation.

Fig. 7. Vertical Interaction of Institutions.

1.2.4 Global Technopreneurial Strategy in High R&D Profile Firms

Canon	Mitarai *initiative*	North America	HP	***Diversification*** ***Globalization*** ***Transformability***
Shin-Etsu	Kanagawa *initiative*	North America	Shintech	***New business*** ***Agility*** ***Globalization***
Toyota	Okuda *initiative*	North America	GM	***Self-exam.*** ***Improvement*** ***Globalization***

Global Techno -preneurial Strategy

1. **Fighting with the world strongest partner**
2. **Challenging innovation from the global perspective**
3. **Learning and absorbing by inspiring competitors**
4. **Preserving advantageous practices (e.g. employment, close ties to suppliers)**
5. **Fusing indigenous strength and lessons from learning**
6. **Thorough understanding of the indepth institutions of the partner**

Fig. 9. Global Technolopreneurial Strategy in High R&D Profitable Firms.

1.2.5 Japan’s System in Transforming External Crises into a Springboard for New Innovation

(i) Japan has constructed a sophisticated co-evolutionary dynamism between innovation and institutional systems by transforming external crises into a springboard for new innovation.

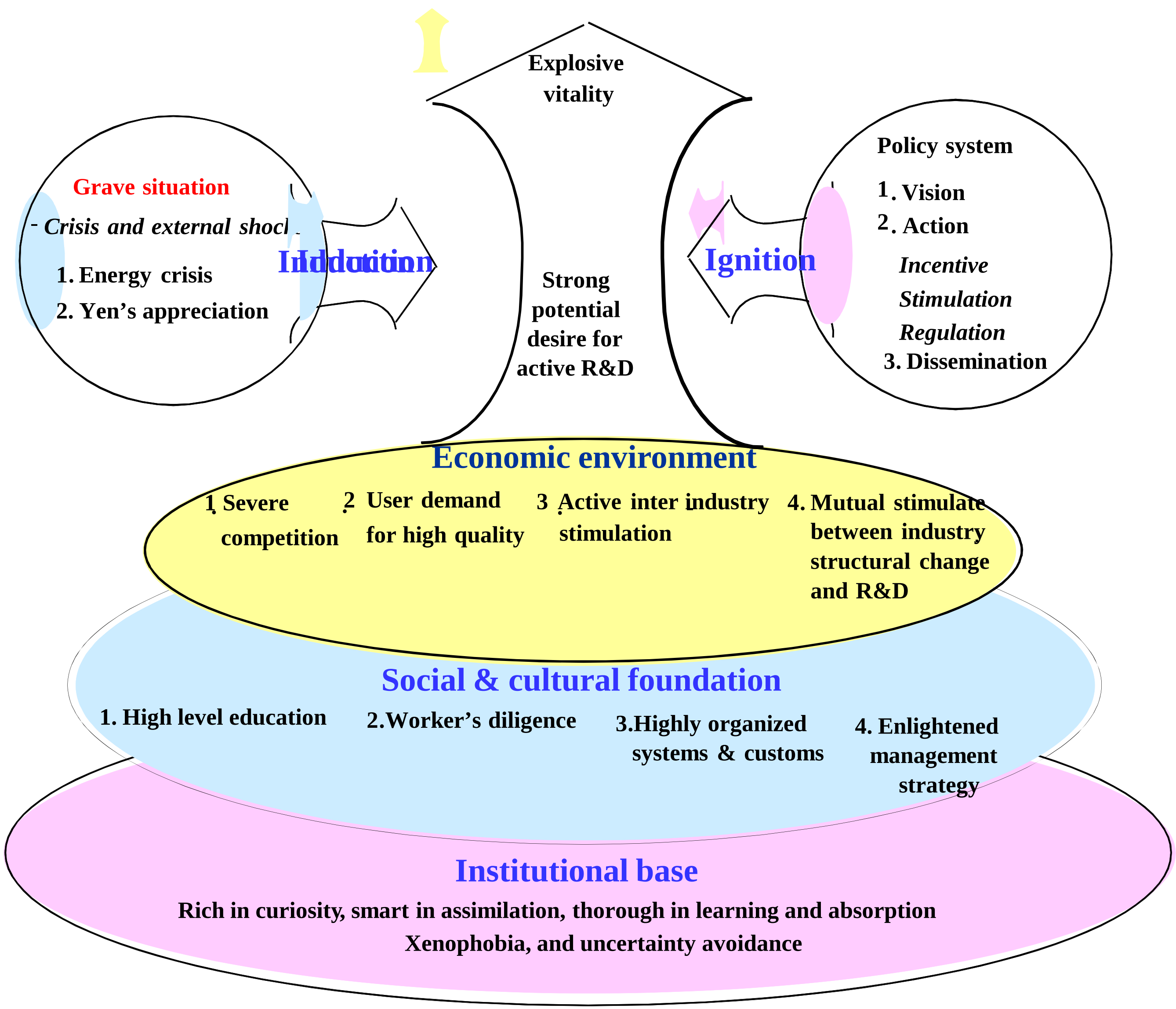
(ii) This can largely be attributed to the unique features of the nation such as

a. Having a strong motivation to overcoming fear based on xenophobia,
b. Uncertainty avoidance, and
c. Abundant curiosity, assimilation proficiency, thoroughness in learning and absorption.

Xenophobia is defined as the "hatred or fear of foreigners or strangers or of their politics or culture".It comes from the Greek words ξένος (*xenos*), meaning "stranger," "foreigner" and φόβος (*phobos*), meaning "fear."

1.2.6 Inducing Mechanism

Chain Reaction of the vitality of industry



1. Japan's institutional systems are characterized by the institutional base and the corresponding social and cultural foundation together with economic environment.
2. There exists a strong potential desire for active R&D similar to oxygen rich atmosphere in a chemical reaction sensitive to grave situation derived from xenophobia and uncertainty avoidance
3. Grave situation acts as induction to which policy system reacts timely as ignition inducing explosive vitality leading to chain reaction.
4. This chain reaction leveraged Japan's notable technology substitution for energy against the energy crises in the 1970s.
5. This was supported by the preceding endeavor against the labor shortage in the 1960s and corresponding innovation in automation and labor saving.

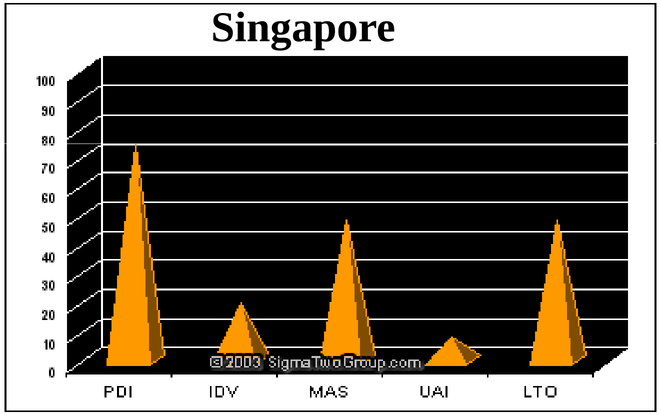
Fig. 10. Scheme of the Mechanism for Inducing Industry's Vigorous R&D Activities in Japan.

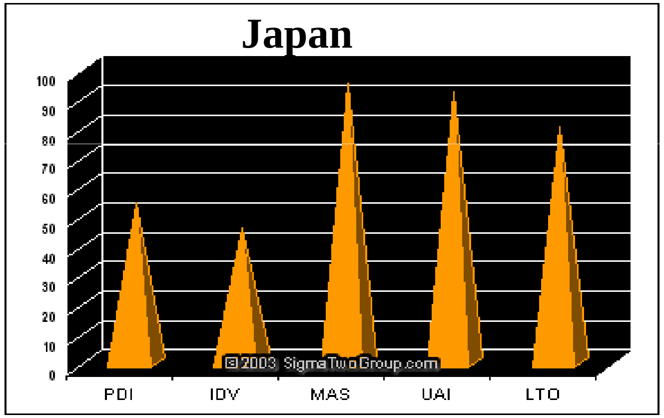
1.2.7 Hofstede's Cultural Dimensions of the Nations

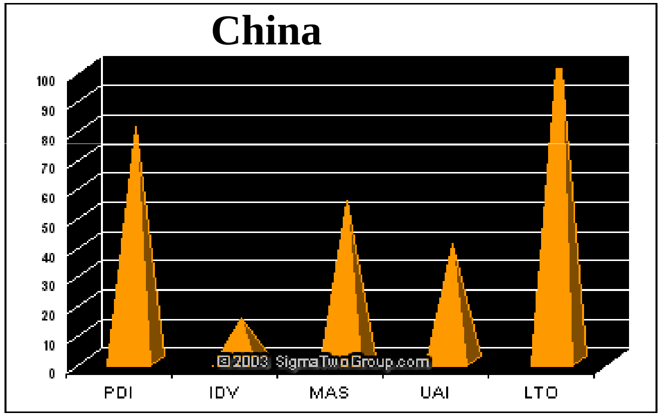
Geert Hofstede anlyzed a large data base of employee values scores collected by IBM between 1967 and 1973 covering more than 70 countries (G. Hofstede, Cultures and Organizations, McGraw-Hill International, London, 1991)

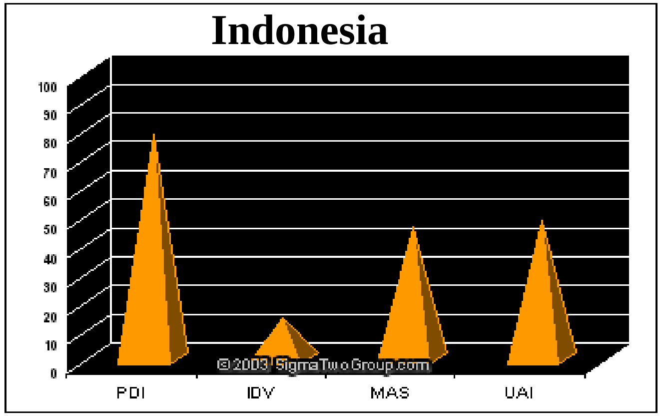
(1) Cultural Dimensions of 6 Nations.

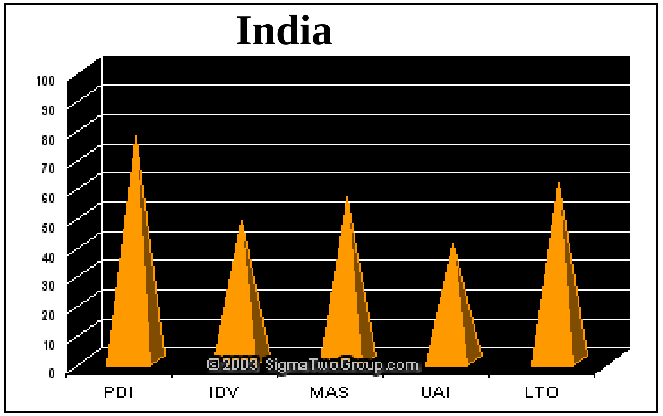
1. Japan demonstrates highest the highest **Uncertainty Avoidance** (UAI) and **Masculinity** (MAS: distribution of roles between genders)
2. China, together with Japan, demonstrates the highest **Long-term Orientation** (LTO).
3. Singapore, similar to China, Indonesia and India, demonstrates the highest **Power Distance** (PDI: Power and inequality).
4. US demonstrates the highest **Individualism** (IDV).

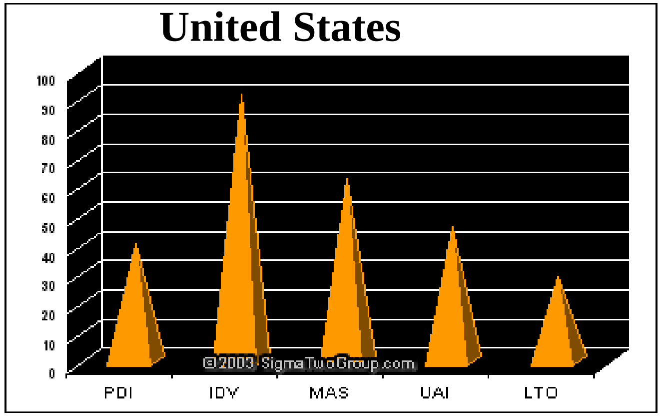






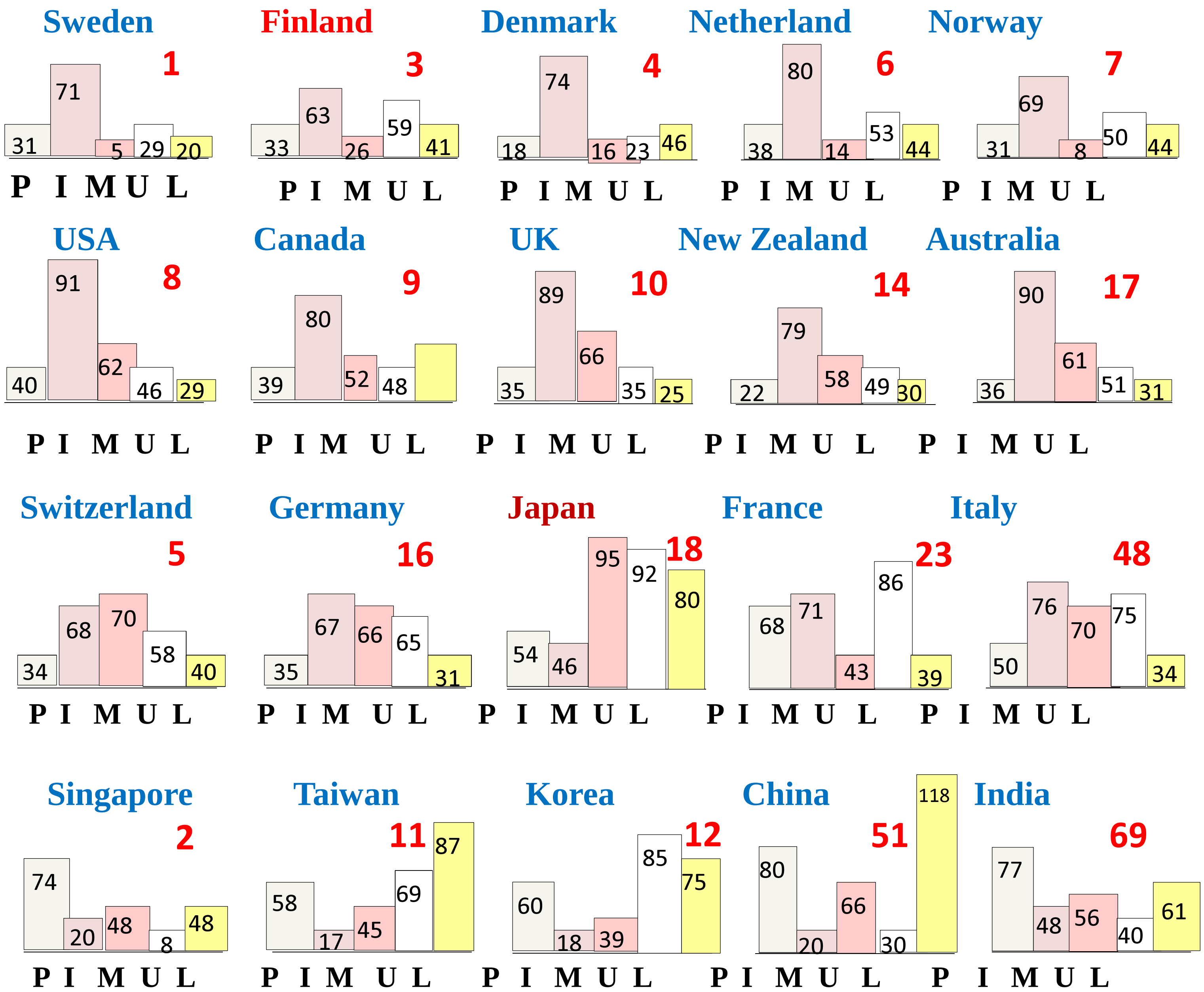






(2) Institutional Structure in 20 Nations by Cultural Dimension

Figures in red indicate Net Work Readiness Index ranking in 2011



P: Power distance
China, India, Singapore, France

I: Individualism
US/Europe, Australia, New Zealand

M: Masculinity
Japan, Switzerland, Italy. Germany, China

U: Uncertainty avoidance
Japan, France, Korea, Italy, Taiwan

L: Long term orientation
China, Taiwan, Japan, Korea

Power Distance Index (PDI) that is the extent to which the less powerful members of organizations and institutions (like the family) accept and expect that power is distributed unequally. This represents inequality (more versus less), but defined from below, not from above. It suggests that a society's level of inequality is endorsed by the followers as much as by the leaders. Power and inequality, of course, are extremely fundamental facts of any society and anybody with some international experience will be aware that 'all societies are unequal, but some are more unequal than others'.

Individualism (IDV) on the one side versus its opposite, collectivism, that is the degree to which individuals are inte-grated into groups. On the individualist side we find societies in which the ties between individuals are loose: everyone is expected to look after him/herself and his/her immediate family. On the collectivist side, we find societies in which people from birth onwards are integrated into strong, cohesive in-groups, often extended families (with uncles, aunts and grandparents) which continue protecting them in exchange for unquestioning loyalty. The word 'collectivism' in this sense has no political meaning: it refers to the group, not to the state. Again, the issue addressed by this dimension is an extremely fundamental one, regarding all societies in the world.

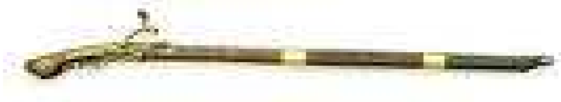
Masculinity (MAS) versus its opposite, femininity, refers to the distribution of roles between the genders which is another fundamental issue for any society to which a range of solutions are found. The IBM studies revealed that (a) women's values differ less among societies than men's values; (b) men's values from one country to another contain a dimension from very assertive and competitive and maximally different from women's values on the one side, to modest and caring and similar to women's values on the other. The assertive pole has been called 'masculine' and the modest, caring pole 'feminine'. The women in feminine countries have the same modest, caring values as the men; in the masculine countries they are somewhat assertive and competitive, but not as much as the men, so that these countries show a gap between men's values and women's values.

Uncertainty Avoidance Index (UAI) deals with a society's tolerance for uncertainty and ambiguity; it ultimately refers to man's search for Truth. It indicates to what extent a culture programs its members to feel either uncomfortable or comfortable in unstructured situations. Unstructured situations are novel, unknown, surprising, different from usual. Uncertainty avoiding cultures try to minimize the possibility of such situations by strict laws and rules, safety and security measures, and on the philosophical and religious level by a belief in absolute Truth; 'there can only be one Truth and we have it'. People in uncertainty avoiding countries are also more emotional, and motivated by inner nervous energy. The opposite type, uncertainty accepting cultures, are more tolerant of opinions different from what they are used to; they try to have as few rules as possible, and on the philosophical and religious level they are relativist and allow many currents to flow side by side. People within these cultures are more phlegmatic and contemplative, and not expected by their environment to express emotions.

Long-Term Orientation (LTO) versus short-term orientation: this fifth dimension was found in a study among students in 23 countries around the world, using a questionnaire designed by Chinese scholars It can be said to deal with Virtue regardless of Truth. Values associated with Long Term Orientation are thrift and perseverance; values associated with Short Term Orientation are respect for tradition, fulfilling social obligations, and protecting one's 'face'. Both the positively and the negatively rated values of this dimension are found in the teachings of Confucius, the most influential Chinese philosopher who lived around 500 B.C.; however, the dimension also applies to countries without a Confucian heritage.

1.2.8 Japan's Assimilation Proficiency, Thoroughness in Learning and Absorption

- Battle of Nagashino *(1575)*



With learning | **Without learning**

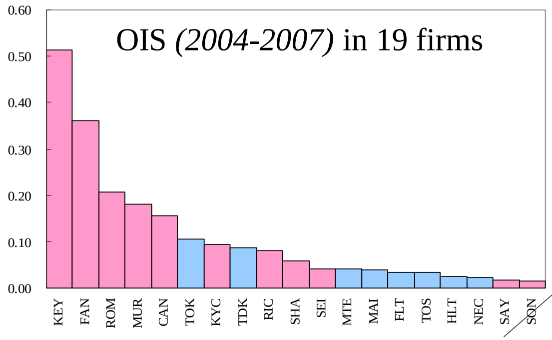
Japan's import of Gun from Portuguese (1543) → Battle of Nagashino (1575)

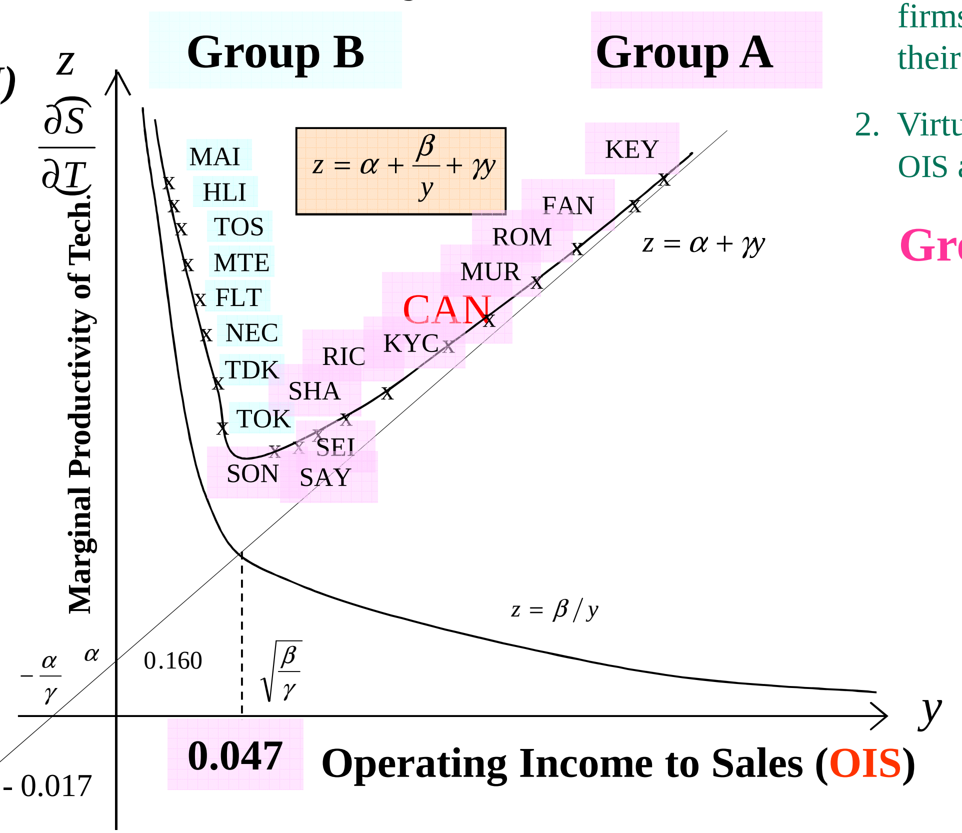
Only 30 years learning changed Japan's history.

1.2.9 Bi-polarization of Technopreneurial Trajectory due to Learning
- *A Case of Electrical Machinery*

Group B ***(No-learning: NIH)***

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





1. Japan's leading electrical machinery firms demonstrate bi-polarization in their technopreneurial trajectories.
2. Virtuous cycle in Group A between OIS and MPT, while vicious in Group B.

Group A ***(Intensive Learning)***

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

Firms technology progress W depends on the ratios of (i) R&D and operating income X and (ii) operating income and sales Y.

$W = F(X, Y)$ Taylor expansion to the secondary term, $\ln W = a + b \ln X + c \ln Y + d \ln X \cdot \ln Y$ （a, b, c, d: coefficients）

$\ln W, \ln X, \ln Y$ → *growth rate of TFP*, *R/OI*（R&D expenditure to OI）, *OI/S* (operating income to sales)

$$\frac{\Delta TFP}{TFP} = a + b\frac{R}{OI} + c\frac{OI}{S} + d\frac{R}{OI}\cdot\frac{OI}{S} = a + b\frac{1}{OI/R} + c\frac{OI}{R}\cdot\frac{R}{S} + d\frac{R}{S} \Rightarrow \frac{\partial S}{\partial T} = \alpha + \frac{\beta}{OI/S} + \gamma\frac{OI}{S}$$

1.3 Co-evolution between Innovation and Institutional Systems

1.3.1 Basic Concept of Co-evolution

(1) Definition of Co-evolution

1) Biological Co-evolution *(Wikipedia)*

(i) The change of a biological object triggered by the change of a related object.

(ii) Each party in a co-evolutionary relationship exerts selective pressures on the other, thereby affecting each others' evolution.

(iii) Two or more <u>species</u> having a close ecological relationship evolve together such that one <u>species</u> adapt to the changes of the other, thereby affecting each other's <u>evolution</u>.

2) Ecosystem Concept *(Marten)*

(i) Co-existence existing together

(ii) Co-adaptation fitting together

(iii) Co-evolution changing together

3) MOT Concept *(Watanabe)*

(i) Constructing a mutually inspiring virtuous cycle.

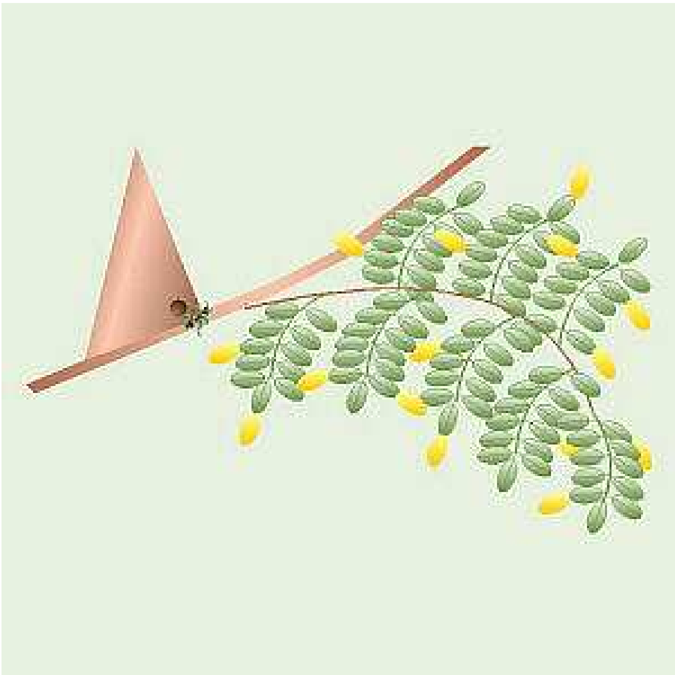
(ii) In that innovation improves institutional systems, which in turn induce further innovation.

(2) Examples of Co-evolution

1) Biology *(Sources: Google)*

(i) Yucca moths and yucca plants

1. Yucca flowers are a certain shape so only that tiny moth can pollinate them.
2. The moths lay their eggs in the yucca flowers and the larvae (caterpillars) live in the developing ovary and eat yucca seeds.



(ii) Acacia ants and acacia trees

1. Acacias are small, Central American trees in the Leguminosae.
2. They have large, hollow thorns. The acacia ants live in the thorns. On the tips of its leaflets, the plant makes a substance used by the ants as food.
3. The ants defend the tree from herbivores by attacking/stinging any animal that even accidentally brushes up against the plant.
4. The ants also prune off seedlings of any other plants that sprout under “their” tree

34

(iii) Plants and animals

1. Many plants depend on animals to spread their pollen.
2. This is a mutualistic relationship where the plant and the pollinator benefit each other.
3. The plant expends less energy on pollen production and instead produces showy flowers, nectar, and/or odors.
4. Some plants/flowers are more general, while others are more specific.

(iv) Regular part of the life activities

1. For pollination to work, to be effective, a relationship must be established between the pollinator and the blossom to be pollinated, involving: The pollinator should visit this particular blossom regularly.
2. These visits (whatever the cause) should constitute a regular part of the life activities of the animal.
3. The visitor must perform or at least try to perform certain tasks that are tied in with the structure and function of the blossom.

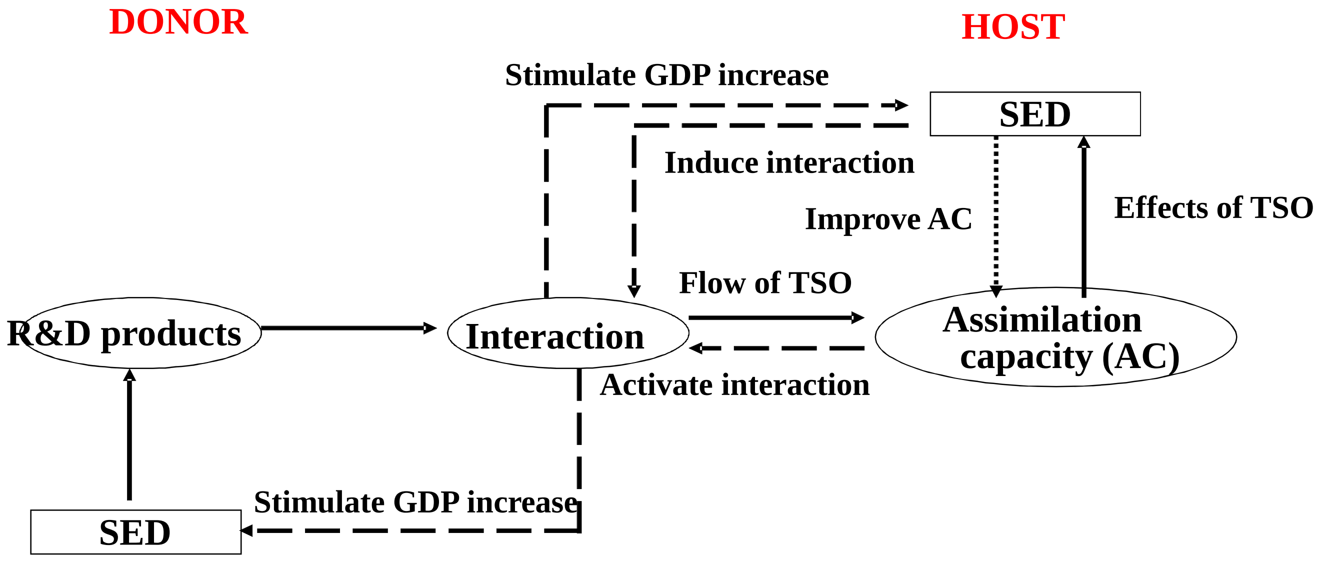
2) Economy

(i) R&D → Economic growth → Further R&D

(ii) Medicare → Increase life expectancy → Increase consumption → Economic growth → Further medicare

(iii) Suburbs rail development → Suburbs development → Increase passengers

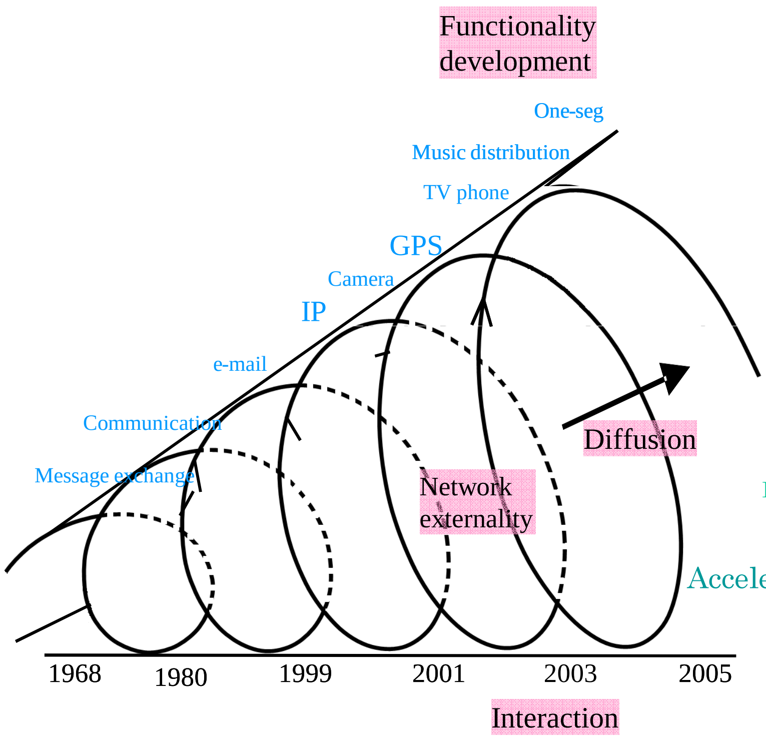
(iv) Global technology spillover



SED: Socio economic development ; TSO :Technological spillovers; AC: Assimilation capacity

3) Innovation - *Self-propagating Functionality Development in IT*

In mobile driven innovation, new functionality emerged in a self-propagating way in a process of diffusion, not at development stage, as from *talk* to *see*, *see & talk*, *take a picture*, *pay* and *watch*.



Talk → See → See & talk → Take a picture → Pay → Watch

Self-propagating mechanism

Diffusion of IT

↓

Interaction with institutional system

↓

Network externality

↓

Functionality development
Enhancement of carrying capacity)

↓

Acceleration and advancement of IT diffusion

FD (Functionality development): Ability to improve performance of production processes, goods and services by means of innovation.

Self-propagating Dynamism in Functionality Development of Japan's Mobile Phones.

1.3.2 Enablers for Co-evolution

(1) Japan's Indigenous Strength (1980s-)

(i) Japan's system of Management of Technology (MOT) indigenously incorporates explicit function which induces co-evolutionary dynamism between innovation and institutions.

(ii) Its sophisticated co-evolutionary dynamism between innovation and institutional systems in transforming external crises into a springboard for new innovation enabled this explicit function.

(iii) This can largely be attributed to the unique features of the nation such as

a. Having a strong motivation to overcoming fear based on xenophobia,
b. Uncertainty avoidance, and
c. Abundant curiosity, assimilation proficiency, thoroughness in learning and absorption.

(2) Hybrid Management of Technology Fusing East and West (early 2000s)

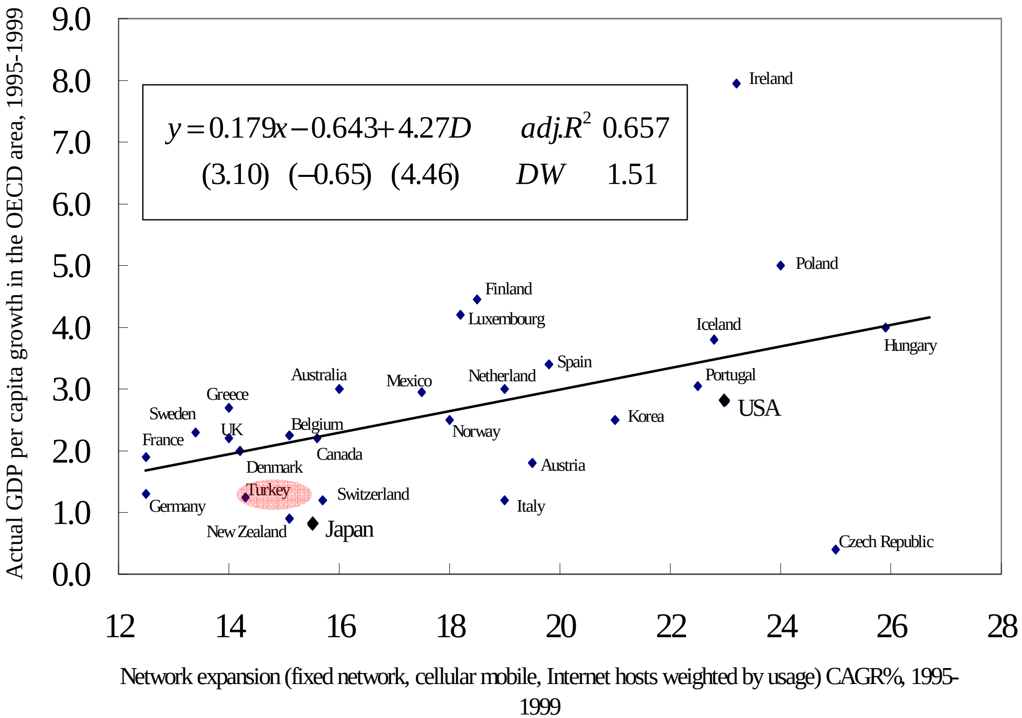
(i) Although Japan's dynamism shifted to the opposite in the 1990s, resulting in a lost decade, a swell of reactivation emerged in the early 2000s.

(ii) This can largely be attributed to hybrid management fusing the "East" (*indigenous strength*) and the "West" (*lessons from an IT driven new economy*).

(3) From Cooperation to Coopetition *(Cooperation and Competition)* and to Actipetition *(Activate and Competition)*

1.3.3 Impediments to Co-evolution
- *Systems Conflict in a Paradigm Change to an Information Society*

(1) Inefficiency in IT Innovation and Its Utilization



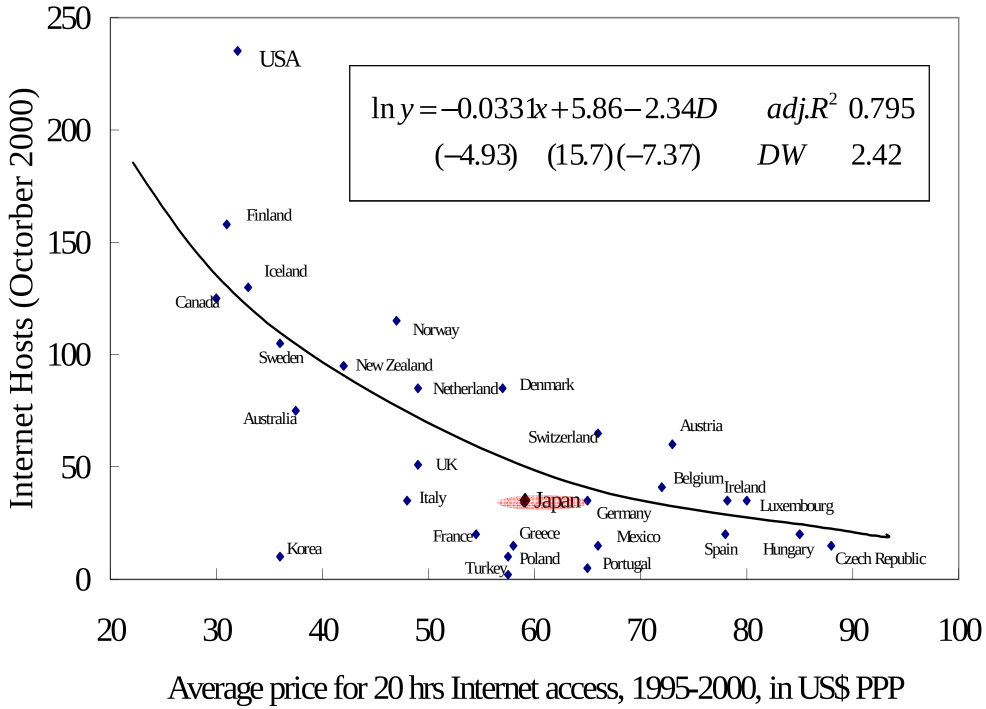
Network Expansion and GDP Growth **(1995-1999).**

a Korea, Czech Republic, Hungary, Mexico, and Poland were excluded from the analysis since these countries joined OECD relatively recently.

b D in regression indicates dummy variables: Ireland = 1, other countries = 0.

c Figures in parentheses indicate t-value.

Sources: Reproduced from OECD's report on the OECD Growth Project (OECD, (2001), Kondo and Watanabe (2001)).



Access Costs and Uptake of the Internet.

a Korea, Czech Republic, Hungary, Mexico, and Poland were excluded from the analysis since these countries joined OECD relatively recently.

b D in regression indicates dummy variables: Turkey, Greece, Portugal = 1, other countries = 0.

c Figures in parentheses indicate t-value.

Sources: Reproduced from OECD's report on the OECD Growth Project (OECD (2001), Kondo and Watanabe (2001)).

(2) Mis-selection of Development Trajectory Options

GDP, Technology stock

$$V = F(X, T)$$

Labor, capital

Growing economy

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

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

$$\frac{\partial V}{\partial T} = a\,V\left(1-\frac{1}{FD}\right)$$

Marginal productivity of technology

R: R&D investment

***a*: Diffusion coefficent**

FD: New functionality development

Mature economy

Economic growth dependent model: Depend on V

- Growth Oriented Trajectory

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

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

New functionality development model: Stimulate FD

- New Functionality Development initiated Trajectory

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

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

Development Trajectory Options.

(3) The Role of Institutional Elasticity for IT's Self- propagation and Functionality Development

1) New Policy Trajectory Corresponding to the New Paradigm in an Information Society

(i) The systems conflict with manufacturing industry has been experiencing in an information society can be attributed to the structural differences between manufacturing technology and IT as contrasted in the Table.

(ii) While shifting to an information society in the 1990s, there remains in Japan strong **organizational inertia** in an industrial society in the 1980s.

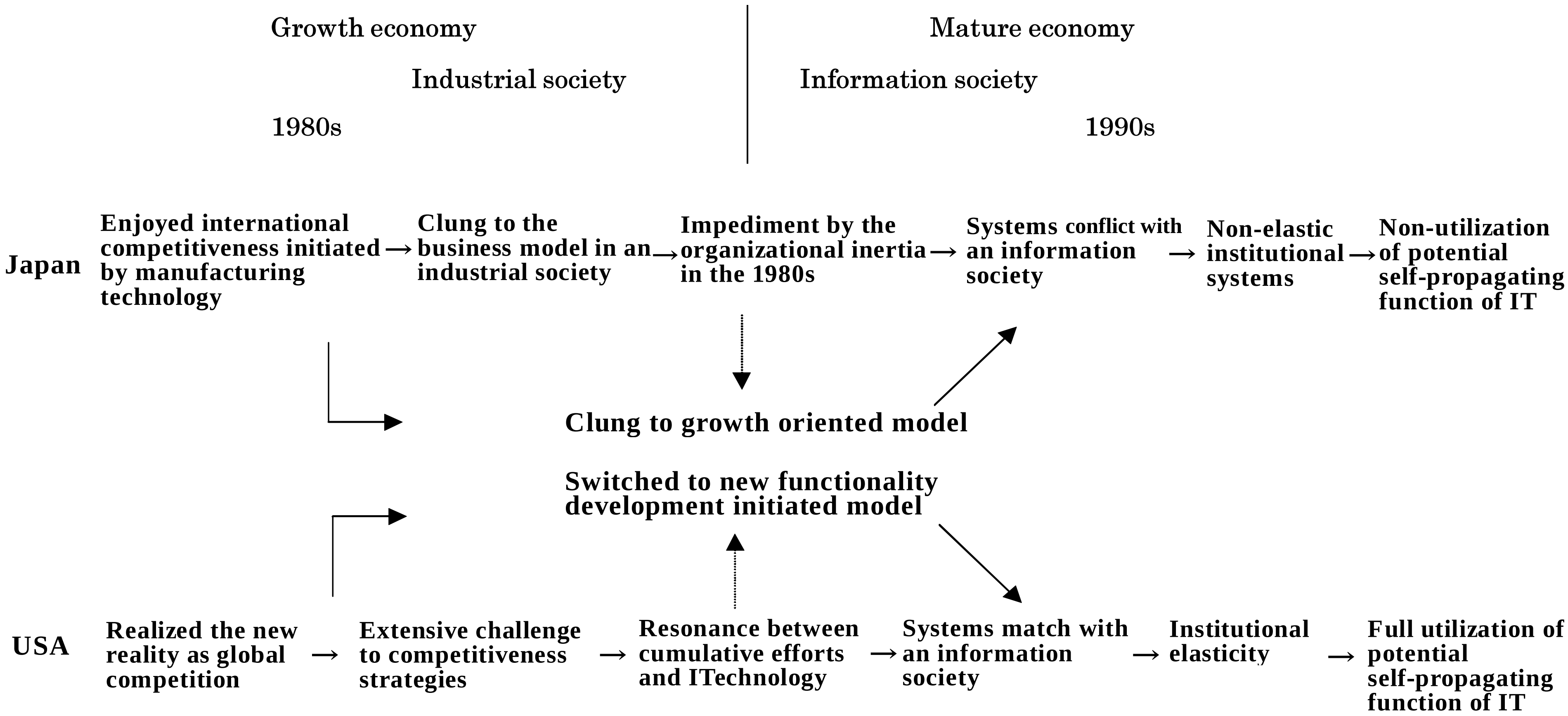
(iii) This inertia impedes Japan's institutions correspond to an information society and compels to a dual vicious cycle leading to institutional elasticity.

Comparison of Features between Manufacturing Technology and IT

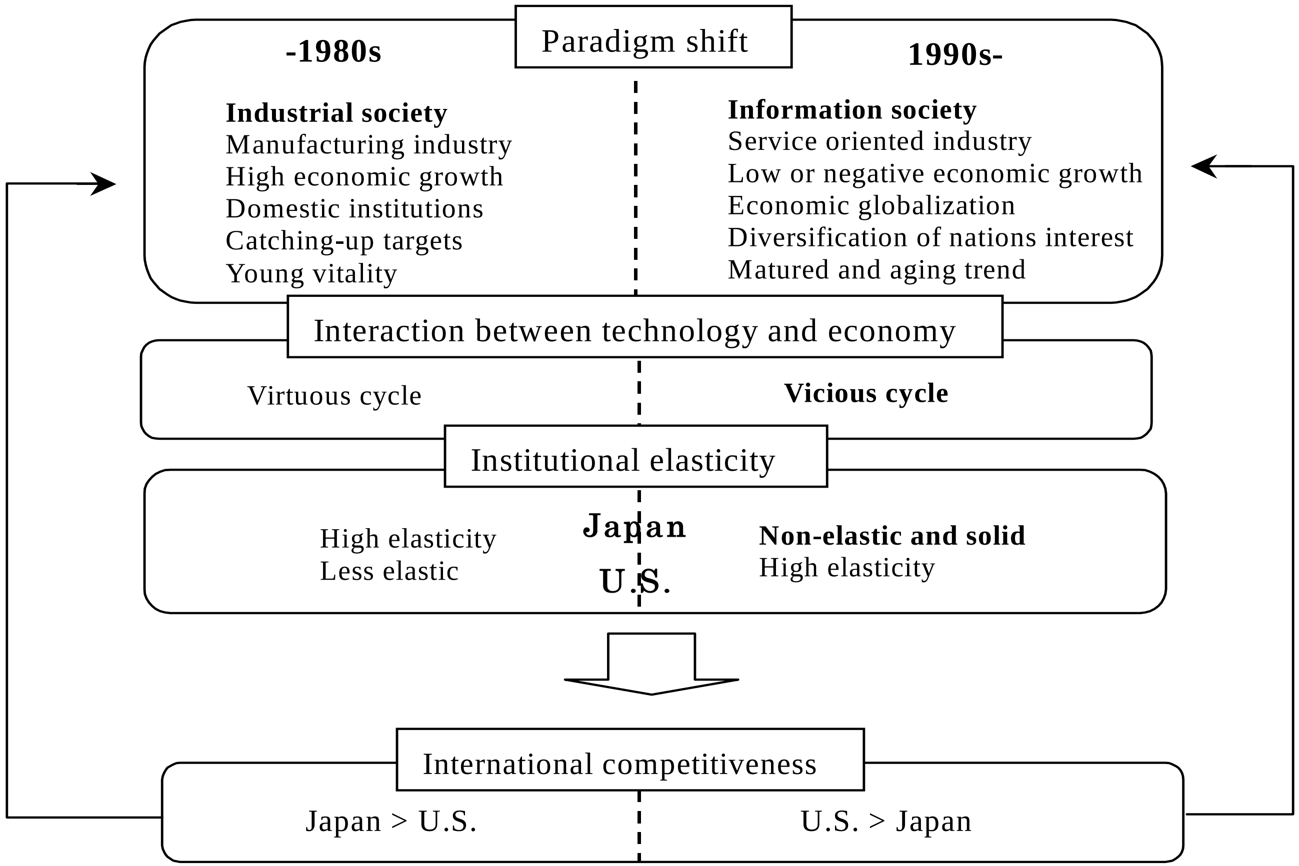
	1980s	1990s
Paradigm	**Industrial society**	**Information society**
Core technology	Manufacturing technology	IT
1. Optimization	Within firms/Organizations	In the market
	i. Asymmetry of information ii. Steady change iii. Conservation of indigenous technology iv. Mass production v. Stable management through non-risk seeking	i. Decrease of asymmetric information cost ii. Dramatic change iii. Globalization iv. Modularization v. Diversification of risk
2. Key features formation process	Provided by suppliers	To be formed during the course of interacting with institutions
3. Fundamental nature	As given	Self-propagating
4. Actors responsible for formation of features	Individual firms/organizations	Institutions as a whole

Source: Watanabe et al. (2003).

2) Development Trajectory and Adaptability to an Information Society



3) Scheme Leading Japan Losing Its Institutional Elasticity



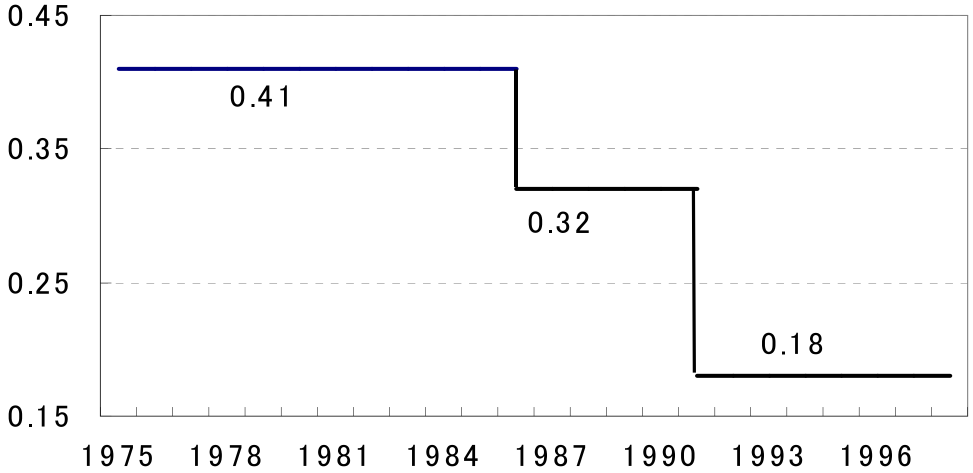
(i) During the period of an industrial society initiated by manufacturing industry, Japan's domestic institutions, based on young vitality, functioned efficiently towards "catching up" target leading to high economic growth.

(ii) In the 1990s, Japan's economy clearly contrasted with preceding decades.

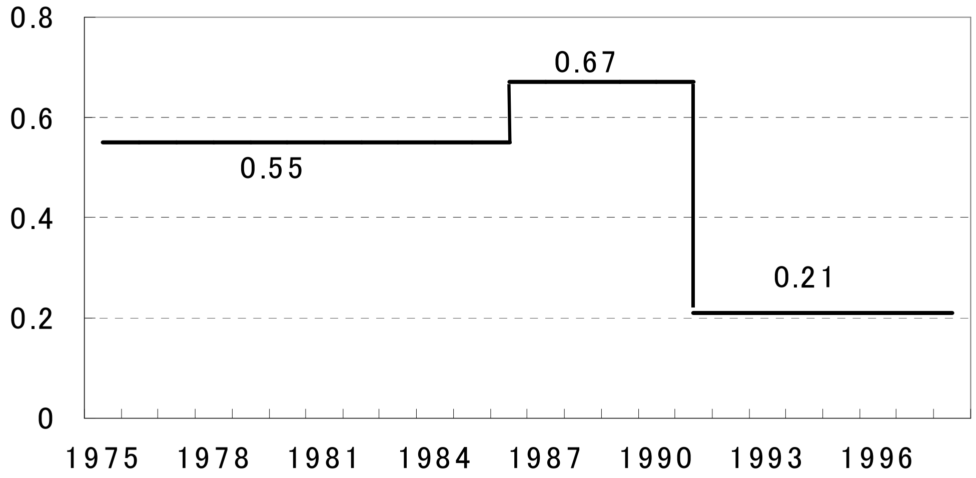
(iii) Facing a new paradigm characterized by a shift to an information society, Japan's traditional institutions did not function efficiently as they did in the preceding decades.

4) Decrease in Japan's Institutional Elasticity

(Manufacturing as a whole)



(Electrical machinery)



Trend in Institutional Elasticity by Measuring Wages Elasticity to Labor Productivity in Japan's Manufacturing Industry *(1975-1998)*.

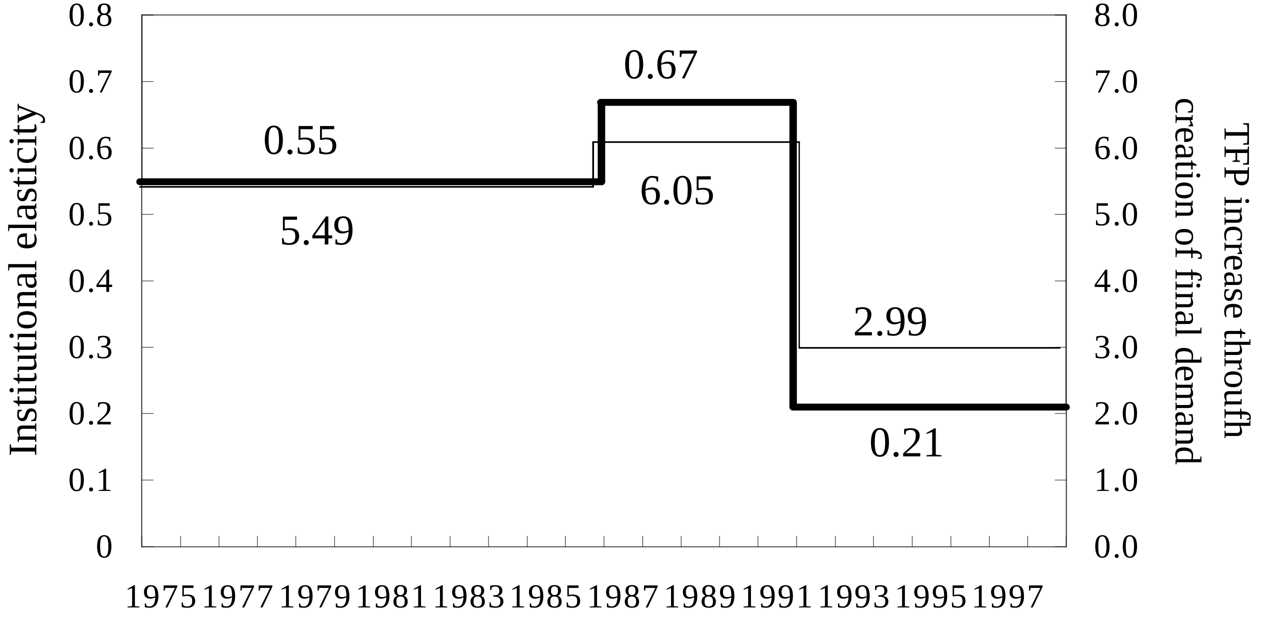
a Institutional elasticity in terms of wage elasticity to labor productivity (*Φpl,V/L*) is measured by developing the following technology incorporated CES (constant elasticity of substitution) type production function:

$$V = F(t, L(T), K(T))$$

where *V*: GPD; *t*: time trend; *L:* labor*; K:* capital*;* and *T:* technology stock.

$$\Phi_{Pl,V/L} = \frac{\partial(V/L(T))}{\partial P_l}\cdot\frac{P_l}{V/L(T)} = \frac{\partial \ln(V/L(T))}{\partial \ln P_l} = \sigma\cdot\frac{1}{\left[\frac{1-\delta}{\delta}\right]^{\sigma}\cdot\left[\frac{P_l}{P_k}\right]^{1-\sigma}+1}$$

where *Pl*: labor prices (wages); *Pk*: capital prices; σelasticity of *K(T)* substitution for *L(T)*; and *δ*: capital distribution.



Comparison between "TFP Increase through Creation of Final Demand" and "Institutional Elasticity" in Japan's Electrical Machinery *(1975-1996)*

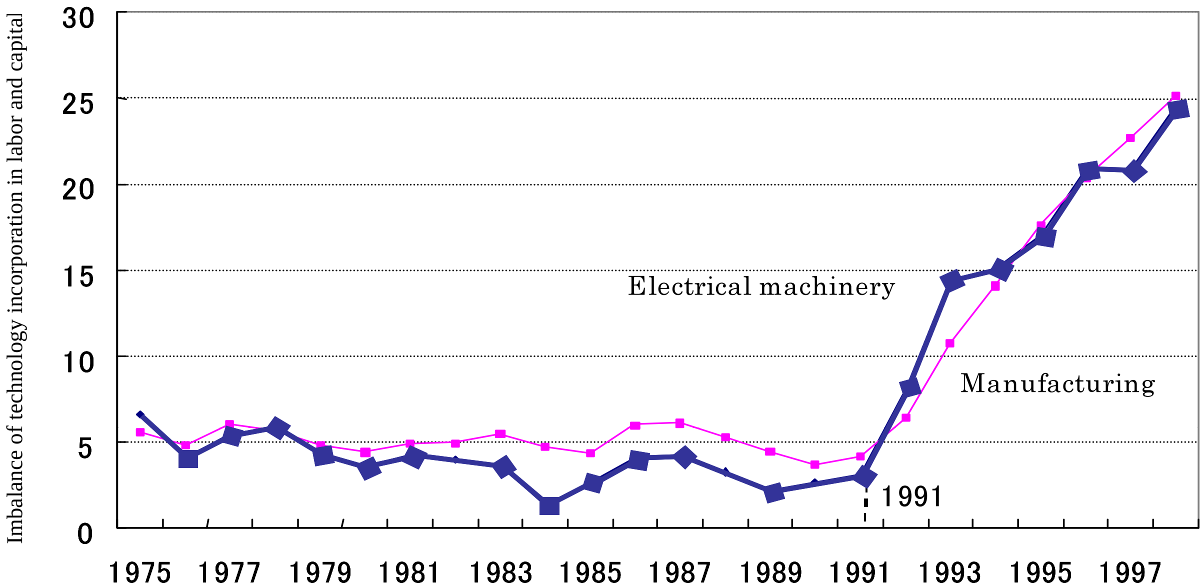
	1975-1986	1987-1990	1991-1996
TFP increase through creation of final demand (% p.a.)	5.49	6.05	2.99
Institutional elasticity	0.55	0.67	0.21

a TFP increase through creation of final demand is measured by contribution of exogenous shift of product demand to TFP increase rate

b Institutional elasticity is measured by institutional elasticity indicator in terms of wage elasticity to labor productivity

(4) Impediments by Organizational Inertia

1) Imbalance of IT Incorporation in Labor and Capital: *The Source of the Decrease in Institutional Elasticity*



Trend in Imbalance of Technology Incorporation in Labor and Capital in Japan's Manufacturing Industry *(1975-1998).*

(i) Imbalance of technology incorporation in labor and capital is measured by taking1 balance between lead time of technology incorporation into labor and capital.

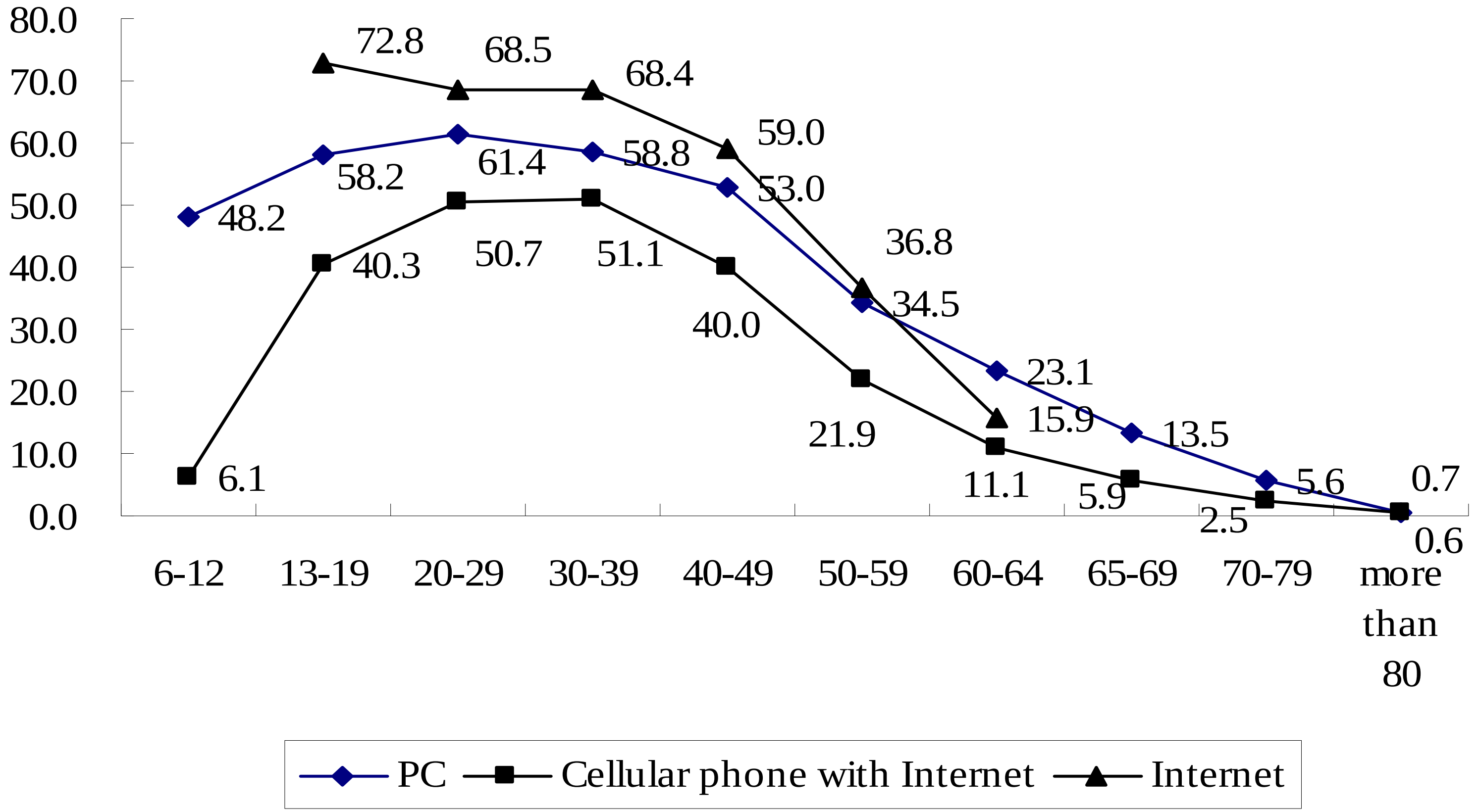
(ii) Lead time of technology incorporation into production factor *X(=L, K)* is measured by the following equation:

$$e^{mr} = \frac{\partial V / \partial X(T)}{\rho + r}$$

where *m:* lead time of technology incorporation into *X; r:* discount rate; and ρ: rate of obsolescence of technology.

Sources: *Annual Report on National Accounts, Monthly Labor Statistics, Cross Capital Stock of Private Enterprises, and Annual Report on Industrial Production.*

2) Structural Source of the Imbalance: *Impediments by Organization*



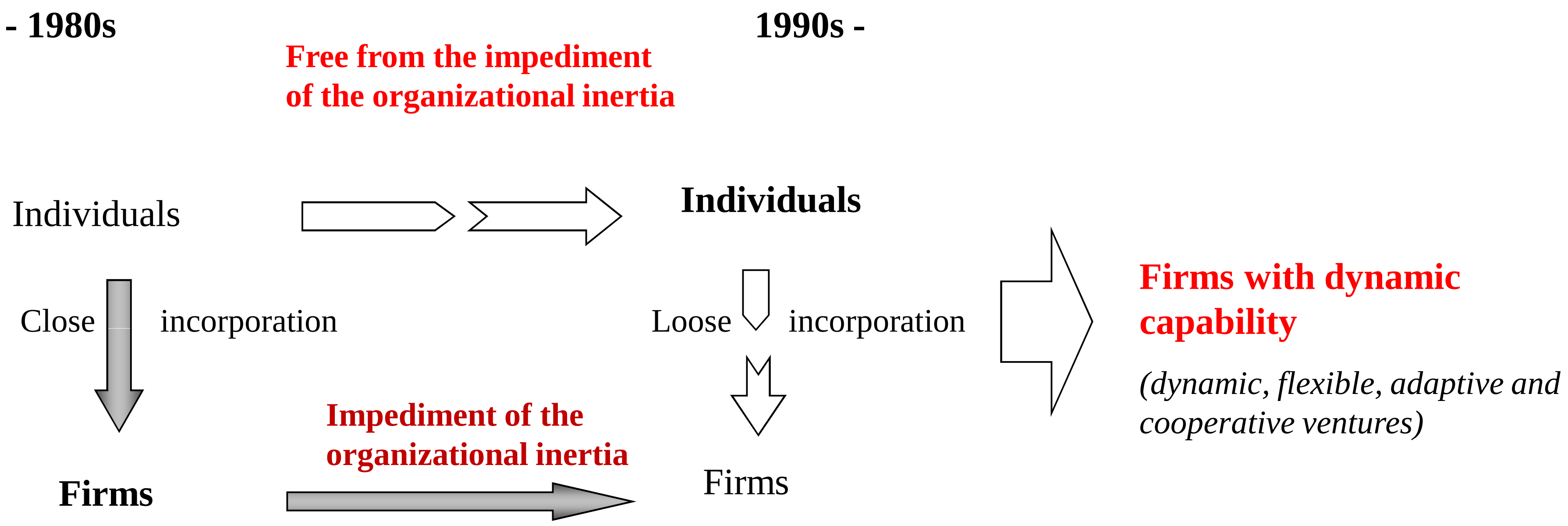
Trends in the Diffusion of IT Goods by Age in Japan (2002).

Sources: White Paper 2002 on Information and Communications in Japan, MPHPT (2003), Communications Usage Trend Survey, MPHPT (2003).

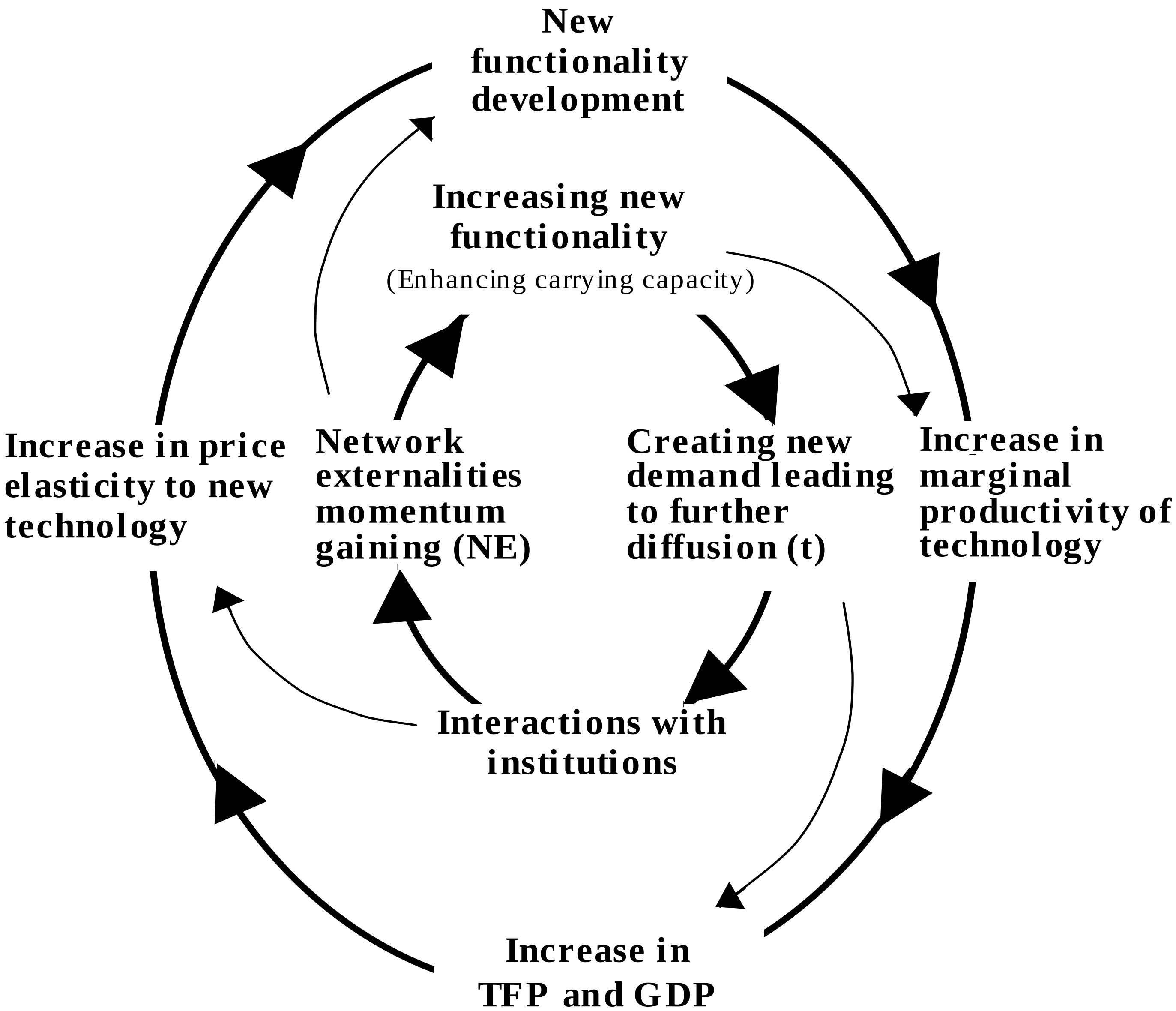
a For the penetration rate of the Internet, age 13-19 corresponds to teenagers and age 60-64 corresponds to age 60-69.

1.3.4 Resonance between IT's Self-propagating Trajectory and New Functionality Initiated Trajectory

(1) Transition of the Role of the Organization in the Japanese Institutions: Relationship between Individuals and Firms



(2) Resonance between Self-propagating Diffusion Trajectory of IT and a New Functionality Development Initiated Trajectory



1.3.5 Pseudo Co-evolution

(1) Japan's Bubble Economy

(2) Net Bubble

(3) Sub-prime Loan

(4) EMU (European Monetary Union) ?

(5) Japan's Home Electric Appliances in the face of Digitalization of Manufacturing

(6) Apples Business Model in inducing customers substitution to new products with higher prices?

1.4 Success and Failure of Institutional Innovation: Co-evolution and Disengagement

1.4.1 Japan's Notable Co-evolutionary Dynamism

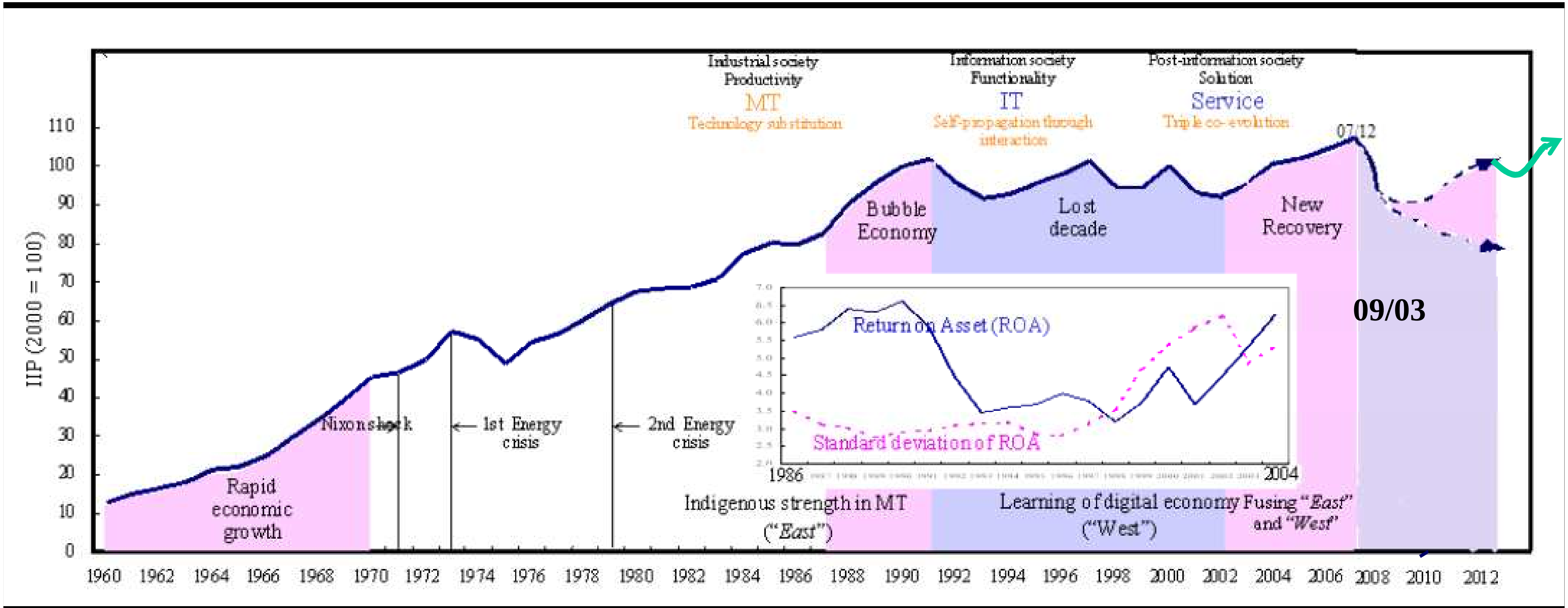
(1) General Postulate

(i) Japan has successfully developed a sophisticated co-evolutionary dynamism between innovation and institutional systems by transforming external crises into a springboard for new innovation.

(ii) This can largely be attributed to the unique institutional features of the nation as having

a. Strong motivation to overcoming fear based on xenophobia,
b. Uncertainty avoidance,
c. Abundant curiosity, assimilation proficiency, and thoroughness in learning and absorption.

(2) Japan's Development Path: Crises and Transformed Innovation *(1960-2012)*

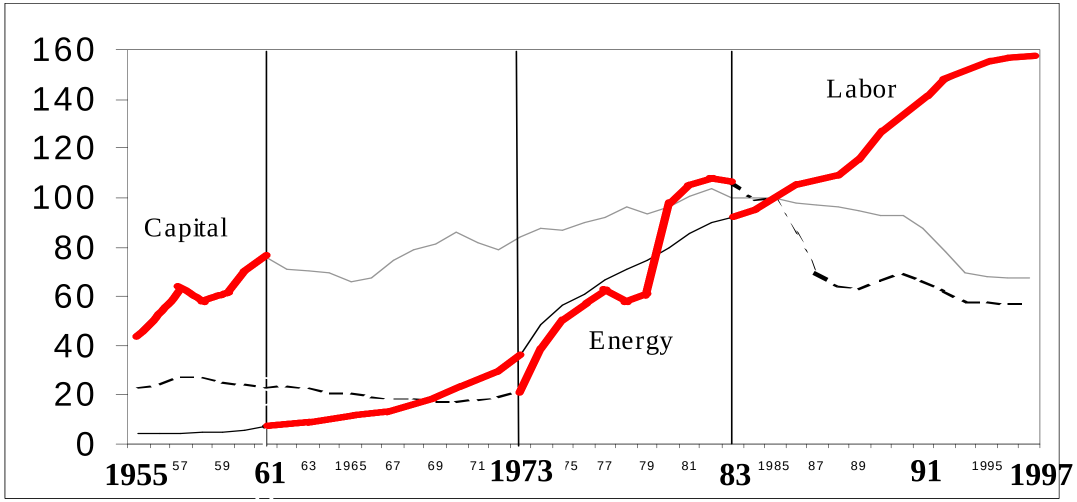


Crisis	Innovation	Singapore
1960s Labor shortage **1970s Energy crises** **1980s Intl. trade conflict** **1990s Systems conflict in IT**	**Labor saving, automation tech. Robotics** **Energy saving, oil-alternative tech.** **High-technology** **High-functional MP driven innovation**	**Turbulence and economic uncertainty** **Skills-intensive industries** **Capital-intensive /high-tech ind.** **Technological and service ind.** **Innovation, knowledge and R&D**
2000s Once-in-a century crisis 2000 Net bubble crisis 2001 9.11 attack 2008 Lehman shock 2011 3.11 Catastrophe	**Hybrid management of technology (MOT)** **CSV (Creating Shared Value)** **Supra-functionality beyond economic value ?**	**Research, innovation & enterprise**

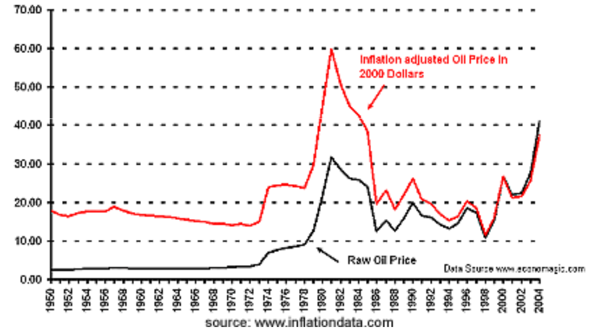
(3) External Crises, Constraints in Production Factors, Productivity Increase

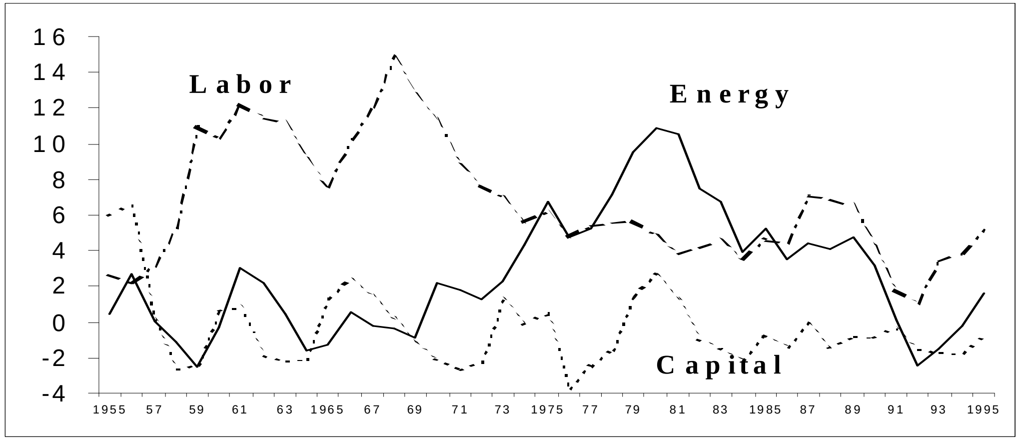
External crises → Constraints in production factor → Prices increase → Productivity increase

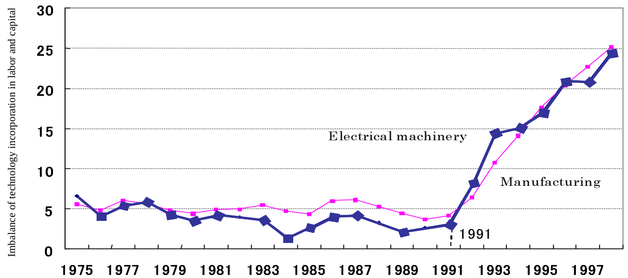
Trends in Prices of Prod. Factors in the Japanese Manf. Ind. *(1955-1997)*
– Index: 1985=100.



Recovery from WWII	**1950s**	**Capital**
Rapid growth	**1960s**	**Labor**
Energy crises	**1973-1982**	**Energy**
Oil glut – High-tech miracle	**1983-**	**Labor**







Trends in Change Rate of Productivity of Prod. Factors in JMI *(1955-1997)* – 3 years moving average (%). JMI: Japanese Manf. Ind.

1.4.2 Technology Substitution for Constrained Production Factors

(1) Ecosystem Principle

1) Basic Principle of 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) *(Odum, 1963).*

2) Suggestions for Constrained Economy in Japan

Labor (1960s) **and energy** (1970s) **are constrained production factors and technology is the unlimited production factor.**

→ **Technology substitution for labor/energy**

(2) Japan's Accomplishments

1960s	**Labor shortage**	**Labor saving, automation technology, robotics**
1970s	**Energy crises**	**Energy saving, oil-alternative technology**
1980s	**Intl. trade conflict**	**High-technology**
1990s	**Systems conflict in IT**	**High-functional MP driven innovation**

(3) 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.

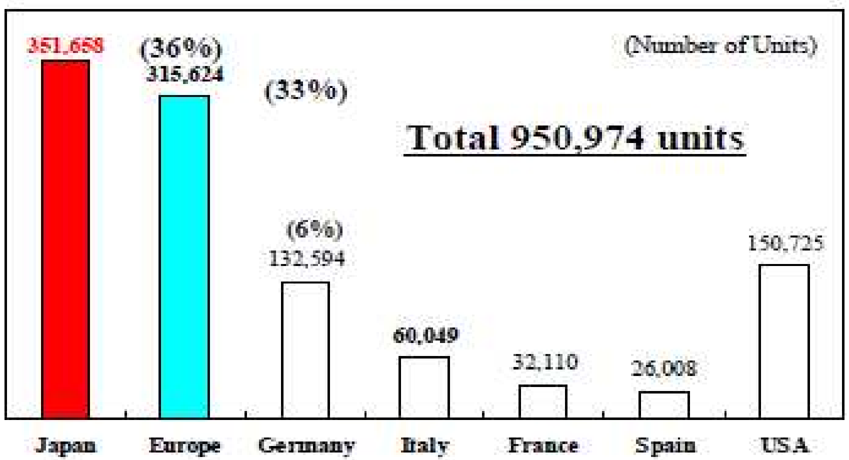
How many robots will it need to invest in to replace the labor power of one worker?

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

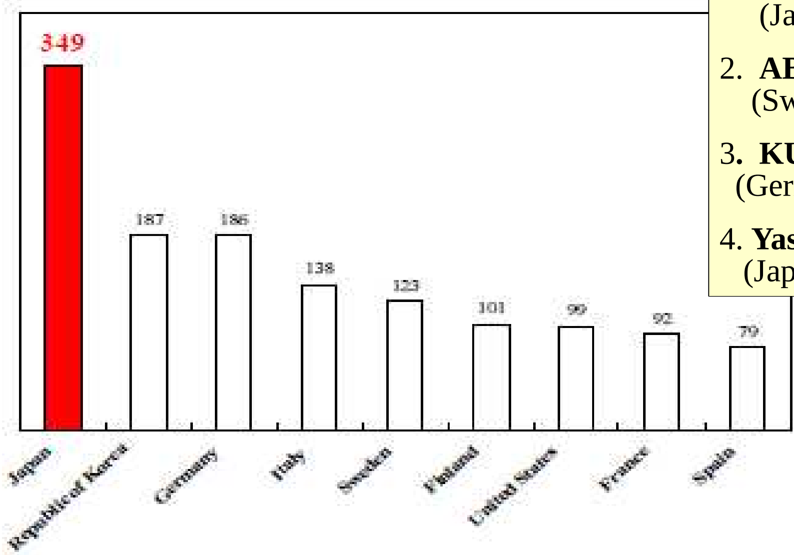
Shift to EEs | **Stay at HCs** (Home countries)

Technology substitution for labor → Reshoring

Operating Stock of Multi-purpose Industrial Robots in 2006



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



Articulated robot share in the world market (2011)

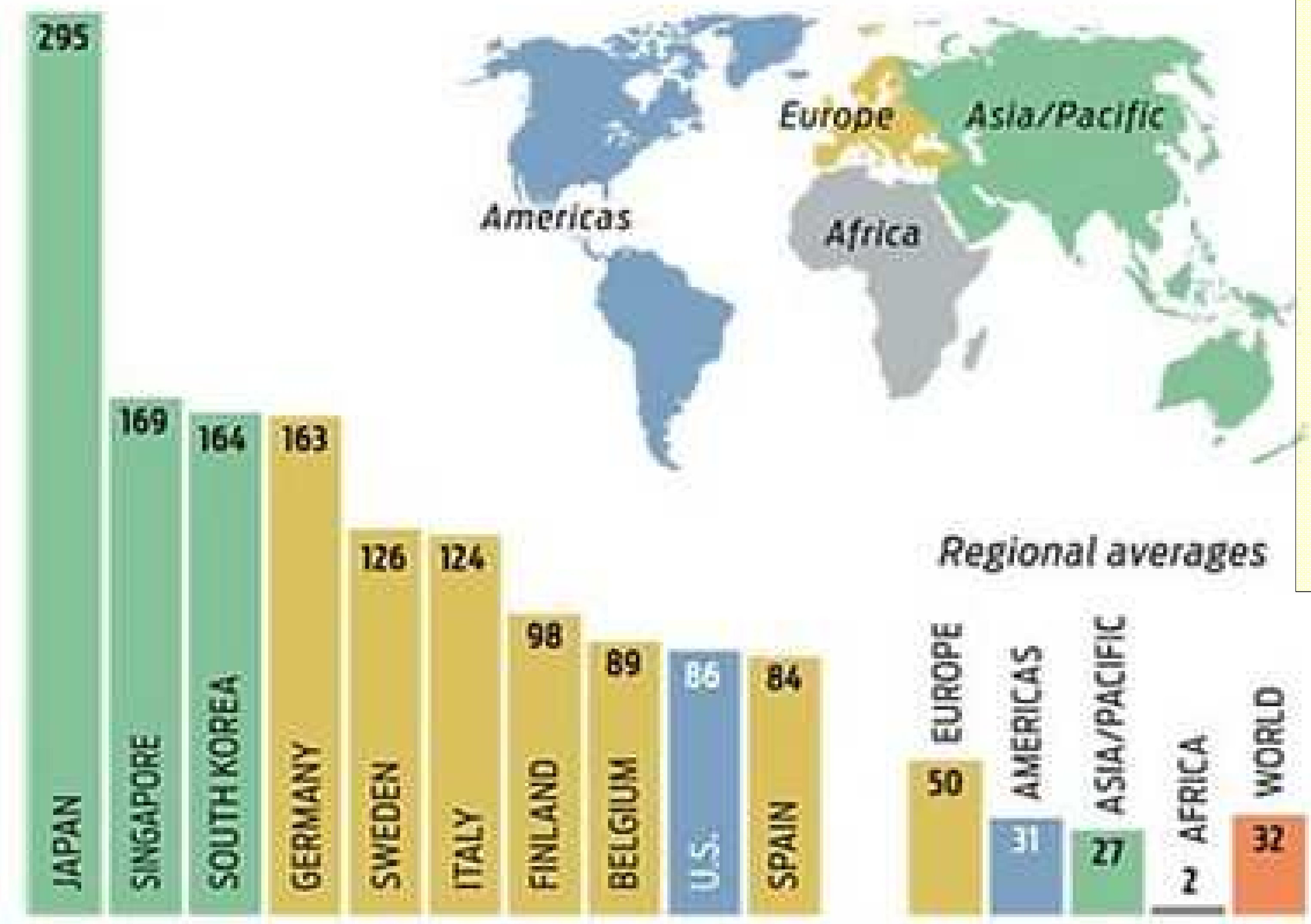
1. **Fanuc** (Japan) **18.0 %**
2. **ABB** (Switzerland) **12.8 %**
3. **KUKA** (Germany) **11.5 %**
4. **Yasukawa** (Japan) **11.5 %**

International Comparison of Industrial Robotics *(2006).*

Source: International Federation of Robotics (2009).

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

- Industrial robots per 10,000 manufacturing workers.



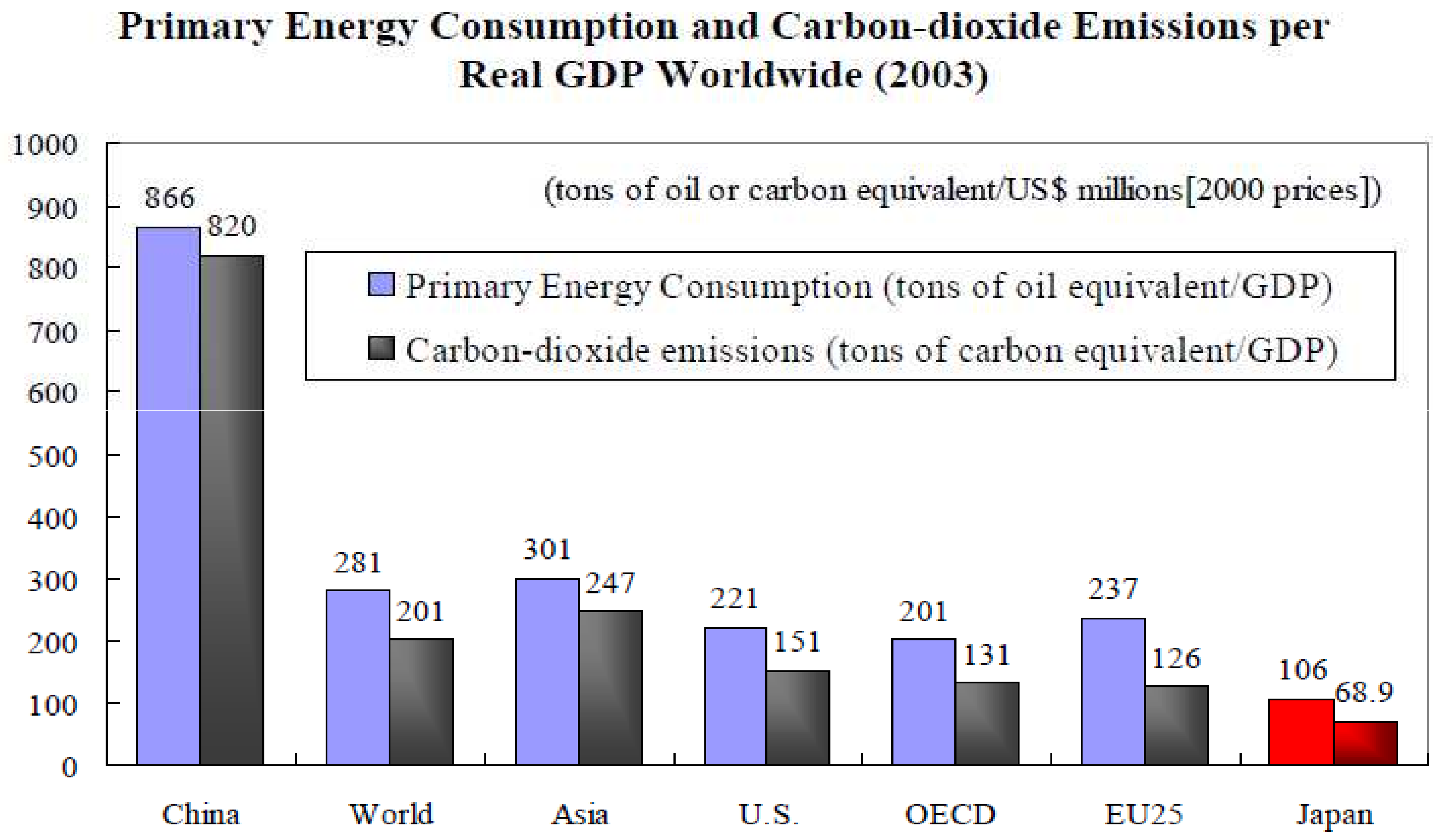
Comparative Advantages in Robots by Field

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

3) Historical Trends

1970s

Energy Efficient and Eco-friendly Society



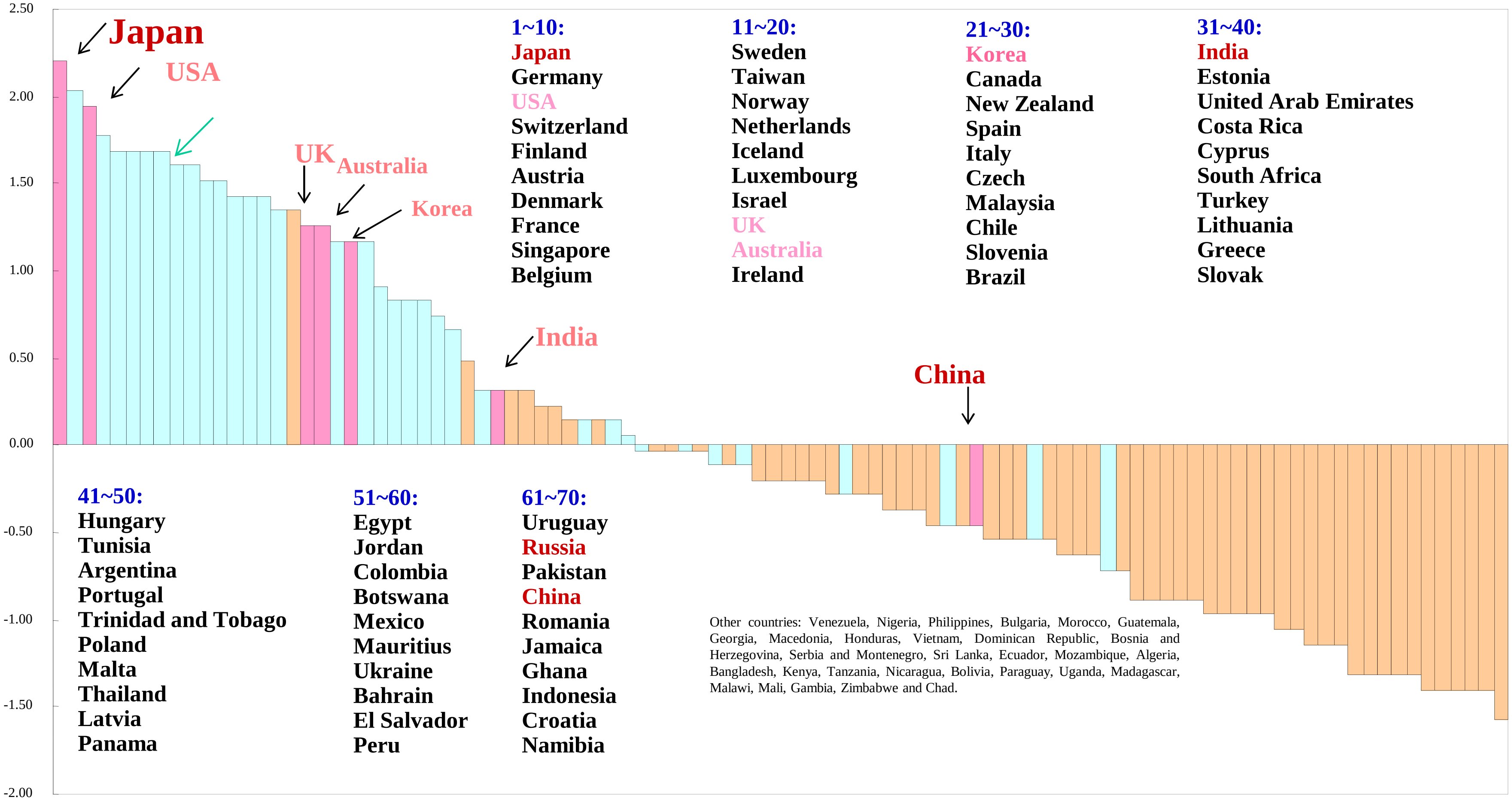
Source: IEA and The Institute of Energy Economics

Tsukamoto (2009).

World Top Level in Manufacturing Technology (*MT*)

1980s

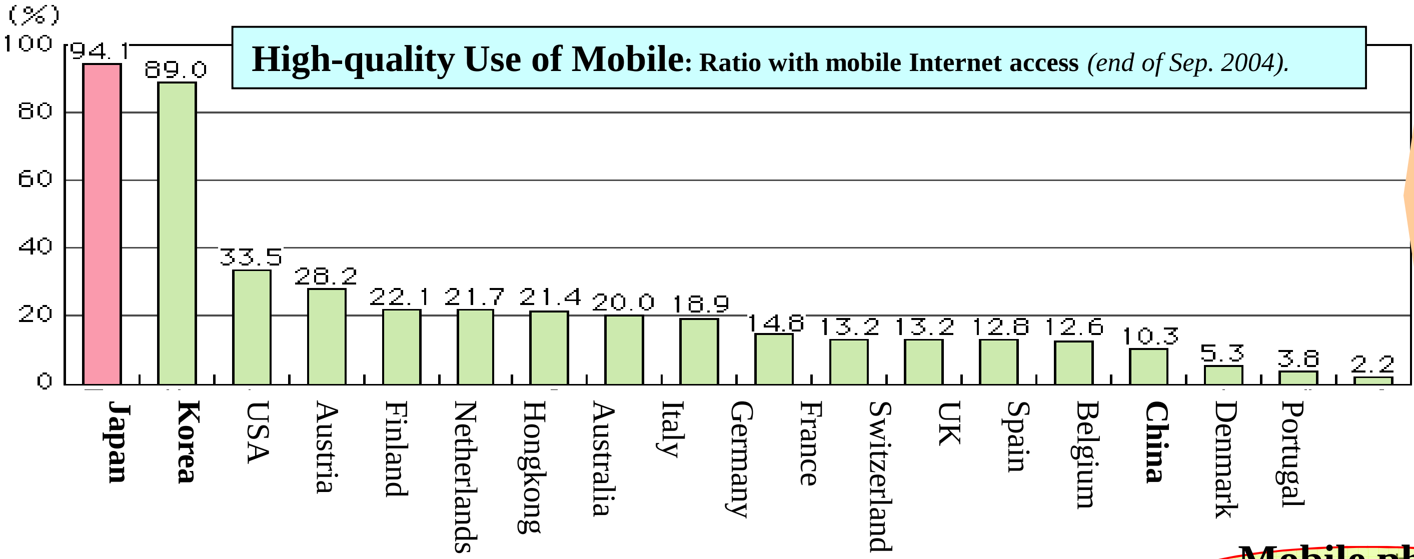
Technology substitution for scarce resources led Japan demonstrates world top level of manufacturing technology.



Level of Manufacturing Technology in 100 Countries *(2004).*

Source: The Global Competitiveness Report (2005-2006).

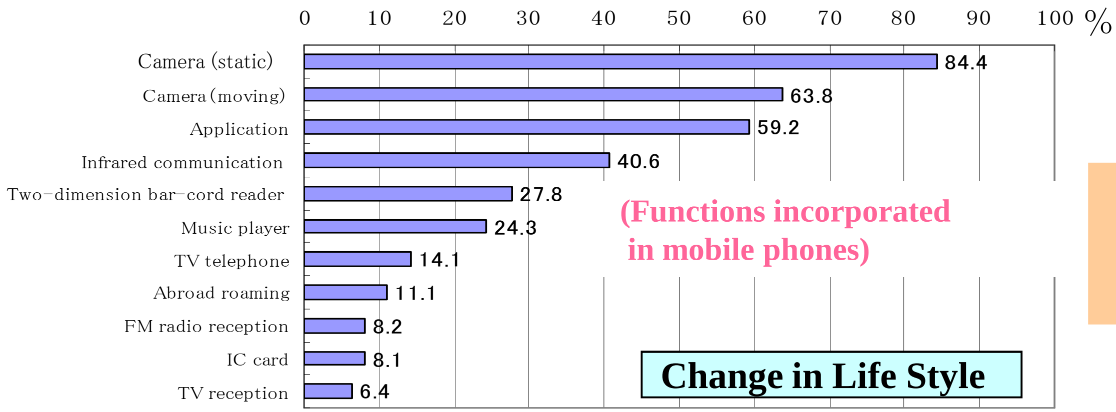
Co-evolutionary Dynamism Leading to Functional Mobile Phone Driven Innovation.

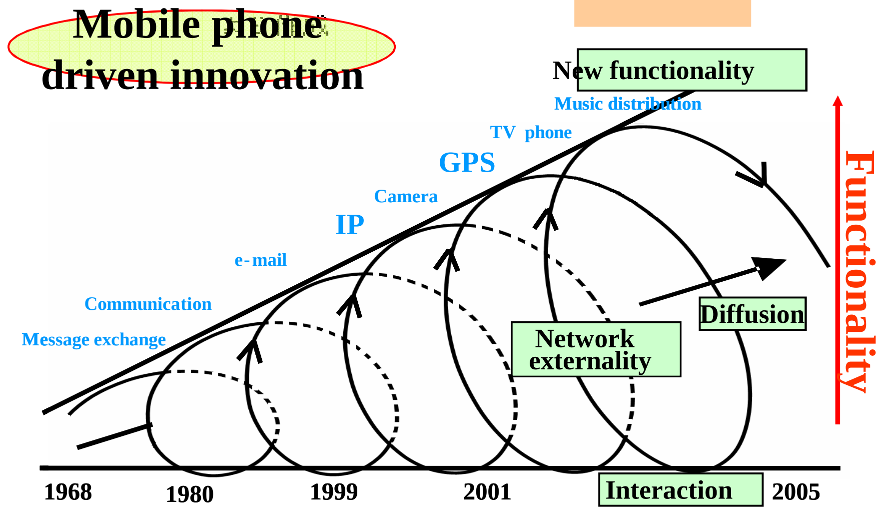


Dual Co-evolution

Demand structure
(i) Rich in curiosity,
(ii) Smart in assimilation,
(iii) Thorough in learning,
(iv) Demanding enhanced functionality.

Supply structure
Operators-vendors interaction





Functionality Development

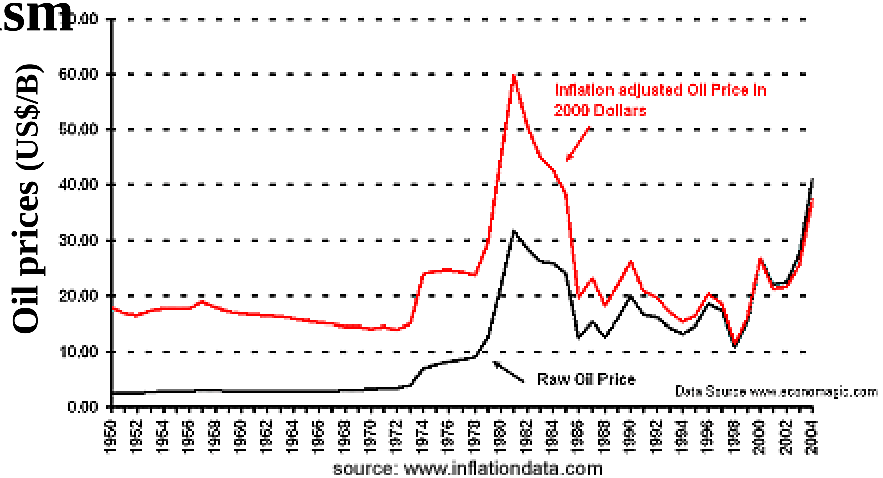
Talk → See → See & Talk → Listen → Take a picture → Pay → Watch

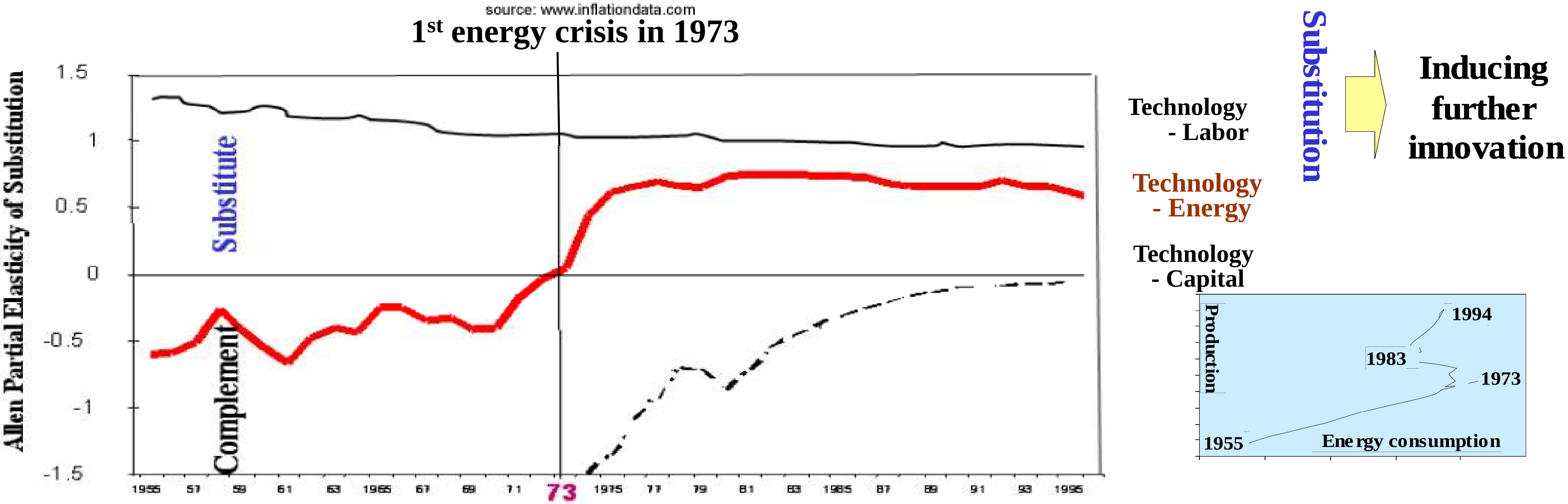
Co-evolution of Mobile Phone Driven Innovation.

1.4.3 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



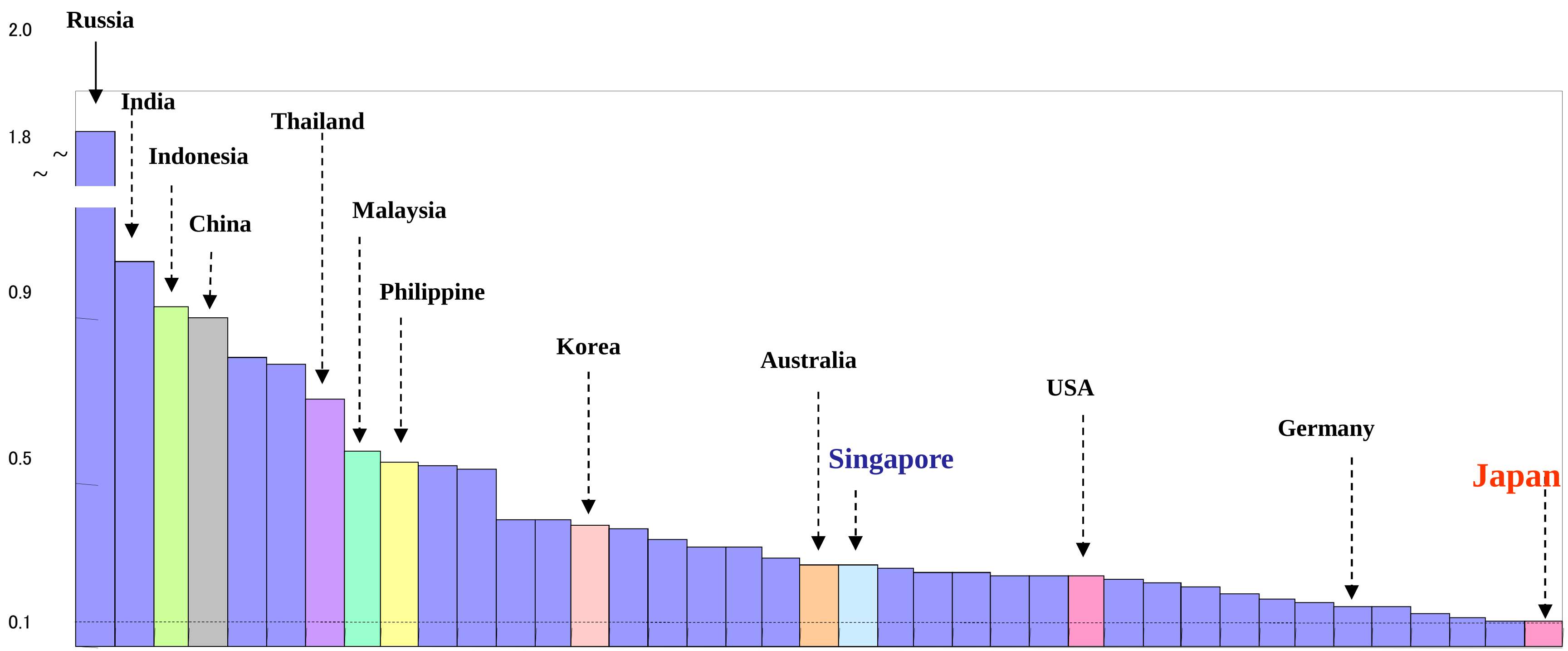


Trends in Technology Substitution for Production Factors in the Japanese Manufacturing Industry ***(1955-1997)***

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

(2) Conspicuous Energy Efficiency

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.

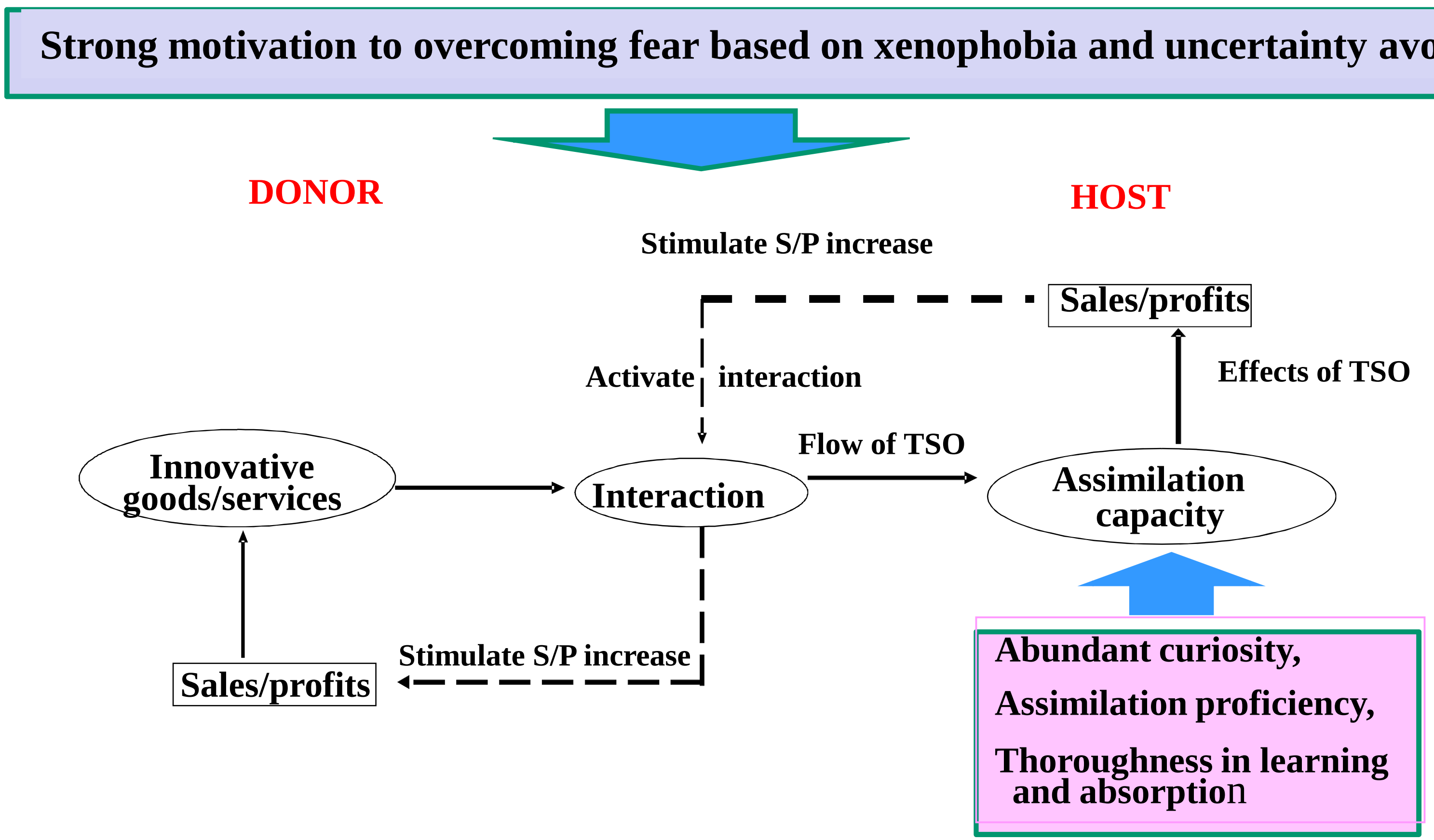


Energy Consumption per GDP in 40 Countries ***(2004).***

1.4.4 Learning and Assimilation of Spillover Technology

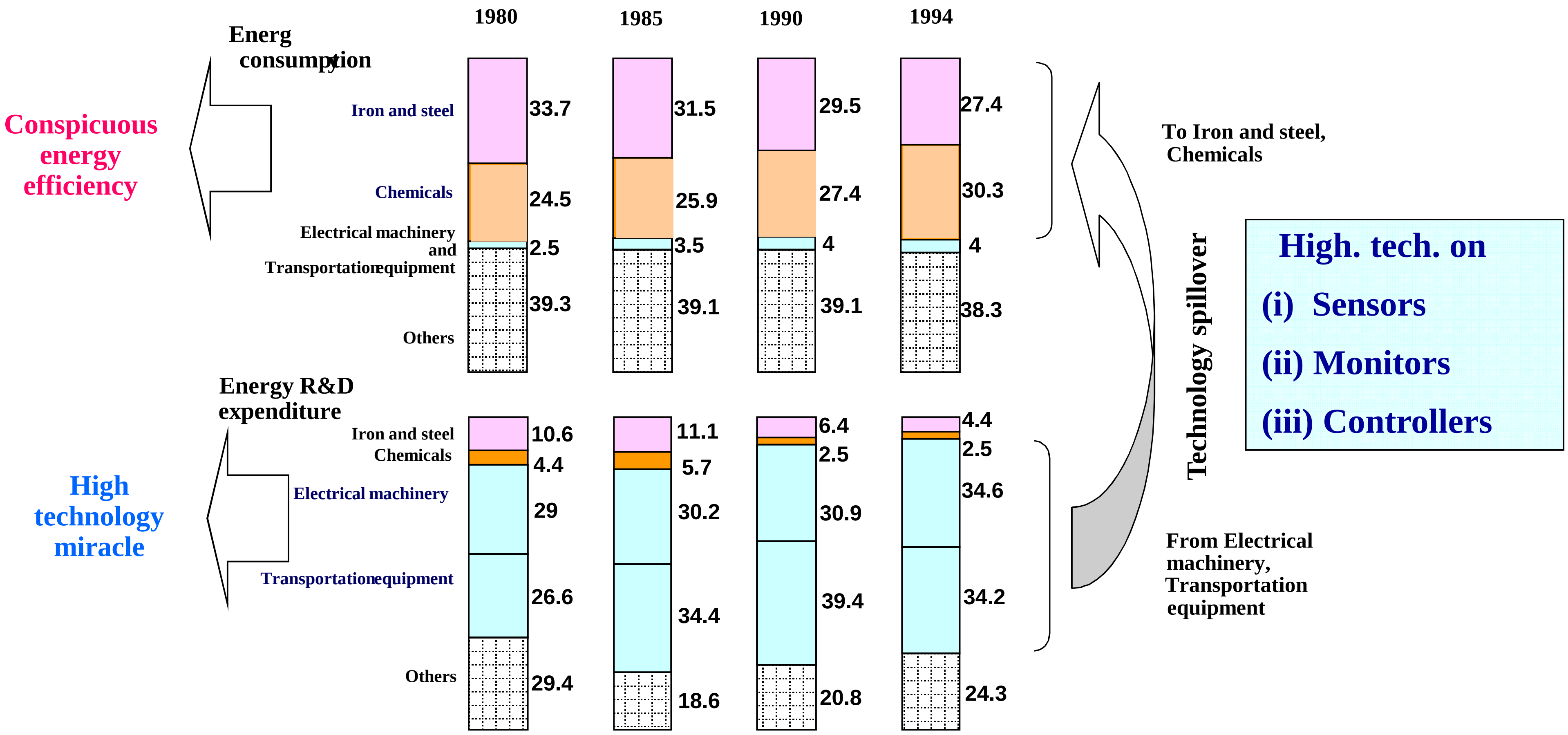
Japan's explicit technology substitution for energy can largely be attributed to broad trans-sectoral assimilation of spillover technology based on its assimilation proficiency and thoroughness in learning and absorption.

(1) Dynamism of Trans-sectoral Assimilation of Spillover Technology



S/P: Sales and profits ; TSO :Technological spillovers

(2) Trans-Sectoral Technology Spillover Leading to Broad Dissemination of Core Technologies



Technology Spillover from Electrical Machinery and Transportation Equipment to Iron and Steel and Chemicals in Japan ***(1980-1994).***

(3) Sophisticated Combination of Industry Efforts and Government Stimulation

1)Trends in Japan's Industrial Structure Policy and Chronology of MITI Initiated R&D Programs

1960s Heavy and chemical industrial structure

1963 MITI's Vision for the 1960s

1966-	The Large Scale R&D Project	Leading technology

1970s Knowledge-intensive industrial structure

1971 MITI's Vision for the 1970s

1974-	**The Sunshine Project** (R&D on New Energy Technology)	**Oil-substituting energy Technology**
1976-79	The VLSI Project (Very large scale integrated circuit)	Innovative computer Technology
1976-	The R&D Program on Medical & Welfare Equipment Technology	Medical and welfare Technology
1978-	**The Moonlight Project** (R&D on Energy Conservation Technology)	**Technology for improving energy productivity**

1980s Creative knowledge-intensive industrial structure

1980 MITI's Vision for the 1980s

1981-	The R&D Program on Basic Technologies for Future Industries	Basic and fundamental Technology
1982-91	Fifth Generation Computer Project	Innovative computer Technology
1985-	Key Technology Center Project (Industrial R&D on Fundamental Technology)	Fundamental technology initiated by industry

1990s Creation of Human-values in the global age

1990 MITI's Vision for the 1990s

1990-	The R&D Program for Global Environment Industrial Technology	Global environmental technology

2) R&D Consortia Initiated by MITI (1961-1997) [a]

I. Research Association

No.	Name	Period
1	*High Polymer Raw Materials*	1961-1977
2	*High Grade Alcohol Industrialization*	1961-1972
3	*Tenchi Research Institute*	1962-1967
4	*Creep Test*	1962-1977
5	*Optical Industry*	1962-1969
6	*Preferential Steel Refining*	1962-1981
7	*Electronic Computer*	1962-1973
8	*Wool Product Solvent Dyeing*	1962-1964
9	*Naniwa Casting*	1963-1974
10	*Insulator*	1964-1979
11	*Heavy Oil Kiln with Lime*	1965-1983
12	*Aluminum Surface Treatment*	1965-1980
13	*Automobile Equipment*	1971-exist
14	*General Automobile Safety and Pollution*	1971-exist
15	*Light Metals Composite Material*	1971-1976
16	*Super-high Performance Computer Development*	1972-1984
17	*New Computer Series*	1972-1984
18	*Super-high Performance Electronic Computer*	1972-1984
19	*Medical Equipment Safety*	1973-1985
20	*Steel Manufacturing by Atomic Energy*	1973-1981
21	*De-Nox Technology for the Iron and Steel Industry*	1974-1980
22	*Software Module for Design and Calculation*	1974-1991
23	*Software Module for Office Work*	1974-1991
24	*Calculation for Operation Research*	1974-1986
25	*Software Module for Business Management*	1974-1991
26	*Software Module for Automatic Control*	1974-1991
27	*Automatic Measurement*	1974-1993
28	*High Temperature Safety*	1974-1985
29	*Automobile General Control*	1974-1980
30	*Vinyl Chloride Environment*	1975-1983
31	*Heavy Oil Chemical Materialization*	1975-1983
32	*Jet Engines for Aircraft*	1976-1989
33	*Super LSI*	1976-1990
34	*Technology Research Association of Medical and Welfare Apparatus*	1976-exist
35	*New House Supply System*	1977-1979
36	*Pattern Information Processing System*	1977-1982
37	*Electric Car*	1978-1990
38	*Subsea Oil Production System*	1978-1985
39	*Flexible Manufacturing System Complex Provided with Laser*	1978-1991
40	*Advanced Gas Turbine*	1978-1988
41	*Research Association for Residual Oil Processing (RAROP)*	1979-1996
42	*Electronic Computer Basis*	1979-1991
43	*Research Association for Petroleum Alternatives Development (RAPAD)*	1980-1996
44	*Application of High Polymer*	1980-1985
45	*Wastewater Treatment Machinery System for Permanent Residential Area*	1980-1987
46	*C1 Chemical*	1980-1988
47	*Optics Applied System*	1981-1987
48	*Mini Gas Air-conditioning*	1981-1991
49	*Synthetic Dye*	1981-1998
50	*Fine Ceramics Research Association*	1981-exist
51	*Research Association for Biotechnology*	1981-exist
52	*High Polymer Basis*	1981-1992
53	*Scientific Computer System*	1981-1990
54	*Technology Research Association of Ocean Mineral Resources Mining System*	1982-1998
55	*Research Institute for Industrial Furnace Technology*	1982-exist
56	*New Basis of Steel Refining*	1982-1992
57	*Combustion using Oxygen Enrichment Film*	1982-1992
58	*Paper Manufacturing*	1982-1991
59	*Secondary and Tertiary Recovery from Crude Oil*	1982-1996
60	*Surfactant for Energy Development*	1982-1989
61	*Technology Research Association of Automated Sewing System*	1982-1991
62	*Coal Opencast Machinery*	1983-1995
63	*Advanced Aluminum Refining*	1983-1987
64	*New Application Development for Light Ingredient from Oil Refinery*	1983-1996
65	*High Efficiency Synthesis of Textiles*	1983-1995
66	*Advanced Manufacturing Technology for Chemical Product using Vital Function*	1983-1995
67	*Conductive Inorganic Compound*	1983-1995
68	*Advanced Technology for Manufacturing Resin with High Performance*	1983-1995
69	*Aluminum Power Metallurgy*	1983-1995
70	*Shape Memory Alloy*	1983-1993
71	*Fuel Alcohol Development*	1983-1994
72	*Advanced Robot Technology Research Association ARTRA*	1984-1991
73	*Alkaline Battery*	1984-1987
74	*Resources Remote Sensing*	1985-1989
75	*Super Heat Pump Energy*	1985-1993
76	*Advanced Material and Machinery for Apartment Buildings*	1985-1996
77	*Research Institute for Development of New Generation Equipment for Atomic Power Plant*	1985-exist
78	*Toyama Prefecture Regional System Development*	1985-1991
79	*Aqua Renaissance*	1985-1991
80	*Coal Based Hydrogen Production*	1986-1995
81	*Coal Gasification Combined Cycle Generation*	1986-1997
82	*Improvement of Practical Performance of Gas Turbine*	1986-exist
83	*Hokkaido Advanced Wood Use*	1986-1992
84	*Textiles Manufacturing System*	1986-exist
85	*Advanced Material Processing and Machining System*	1987-1995
86	*Laser Concentration*	1987-exist
87	*Advanced Cogeneration*	1987-1998
88	*Engineering Research Association for Superconductive Generation Equipment and Materials (Super-GM)*	1987-exist
89	*Composite Material Product Development System*	1987-1999
90	*Molten Carbonate Fuel Cell*	1988-exist
91	*Artificial Clay Synthesis*	1988-1993
92	*International Fuzzy Engineering Research Institute*	1989-1995
93	*Technology and System Development of New Industrialized House*	1989-exist
94	*Engineering Research Association for Super Transport Propulsion System*	1990-exist
95	*Photovoltaic Power Generation Technology Research Association (PVTEC)*	1990-exist
96	*Advanced Chemical Processing Technology Research Association*	1990-1997
97	*Phosphoric Acid Fuel Cell*	1991-1998
98	*Improvement of Small Articles Plating Environment*	1991-exist
99	*Real World Computing Partnership RWCP*	1992-exist
100	*Lithium Battery Electric Power Storage*	1993-exist
101	*Angstrom Technology Partnership*	1993-exist
102	*Water Plastic Casting of Ceramics*	1993-1999
103	*Association for Research and Development of House Technology*	1994-exist
104	*Ibaraki Prefecture General Information System for Support of the Aged*	1995-1998
105	*Nippon CALS Research Partnership (NCALS)*	1995-1998
106	*Femtosecond Technology Research Association*	1995-exist
107	*TRAMET*	1996-exist
108	*Association of Super-Advanced Electronics Technologies (ASET)*	1996-exist
109	*Solar Cell Material*	1996-exist
110	*Fixing Acid Gases by High Pressure*	1998-exist

II. Incorporated foundation, etc.

No.	Name	Period
111	*R&D Institute of Metals and Composites for Future Industries*	1981-exist
112	*Japan High Polymer Center* [b]	1949-exist
113	*Research and Development Association for Future Electron Devices*	1981-exist
114	*Information-Technology Promotion Agency*	1970-exist
115	*International Superconductivity Technology Center*	1988-exist
116	*Micromachine Center*	1992-exist
117	*Research Institute of Human Engineering for Quality Life*	1991-exist
118	*Engineering Advancement Association of Japan (ENAA)*	1978-exist
119	*Marine Biotechnology Institute Co., Ltd.*	1988-exist
120	*The Japan Research and Development Center for Metals*	1985-exist
121	*Japan Fine Ceramics Center (JFCC)*	1985-exist
122	*Japan Bio-Industry Association*	1983-exist
123	*Laboratories of Image Information Science and Technology (LIST)*	1992-exist
124	*Institute for New Generation Computer Technology (ICOT)*	1982-1992
125	*Interoperability Technology Association for Information Processing, Japan (INTAP)*	1985-exist
126	*Manufacturing Science and Technology Center Institute for Photonics Engineering*	1997-exist

[a] In addition to the above, seven consortia participated in MITI initiated R&D projects over the period 1998-2000. They consist of six foundations: Manufacturing Science and Technology Center, Optoelectronic Industry and Technology Development Association, Materials Process Technology Center, Ishikawa Sunrise Industries Creation Organization, Japan Information Processing Development Center, and Osaka Science & Technology Center; and one private corporation: Semiconductor Technology Academic Research Center.

[b] Japan High Polymer Center (No. 112) was restructured and renamed into Japan Chemical Innovation Institute.

3) Firms Participating in the Sunshine and Moonlight Project *(1992)*

The Sunshine Project (61)

Chemicals (15)	24 Asahi Chemical Industry Co., 29 Mitsubishi Kasei Co., Mitsui Toatsu Chemicals Inc., Kaneka Co., Daito Hoxan Inc., Japan Catalytic Chemicals, Nippon Steel Chemical Co., Idemitsu Oil Co., Tonen Co., Nippon Oil Co., Cosmo Oil Co., Nikko Kyoseki Oil Co., Oil Resouries Development, Sumitomo Coal Mining Co., Mitsui Coal Liguefaction
Ceramics (4)	33 Asahi Glass Co., Kyocera Co., NGK Spark Plug Co., Shinagawa Refractories Co.
Iron & steel (7)	Nippon Steel Co., 33 Sumitomo Metal Industries Ltd., 26 Kobe Steel Ltd., NKK Co., 28 Kawasaki Steel Co., Japan Steel Works Ltd., Japan Metal & Chemicals Co.
Non-ferrous metals and products (5)	Sumitomo Electric Industries, Ltd., Sumitomo Metal Mining Co., Hitachi Cable Ltd., Mitsui Mining & Smelting Co.,Osaka Titanium Co.
Machinery (20)	3 Hitachi Ltd., 6 Toshiba Co., 35 Ishikawajima-Harima Heavy Industris Co., 12 Mitsubishi Heavy Industries Ltd., 10 Mitsubishi Electric Co., 38 Fuji Electric Co., 32 Oki Electric Industry Co., 15 Sharp Co., 17 Sanyo Eectric Co., Ebara Co., Misui Engineering & Shipbuilding Co., 2 Matsushita Electric Industrial Co., Yuasa Battery Co., Japan Storage Battery Co., Matsushita Battery Co., Bab & Cock Hitachi Co., Yamatake-Honeywell Co., Koto Electric Co., 1 Toyota Motor Co., 8 Nissan Motor Co.
Public utilities (4)	EPDC, Tohoku Electric Power Co., Okinawa Electric Power Co., Tokyo Gas Co.
Construction (6)	JGC Co., TEC Electrics Co., Chiyoda Co., Kandenko Co., Ohte Development Co. Geothermal Technology Development,

The Moonlight Project (54)

Chemicals (3)	24 Asahi Chemical Industry Co., 29 Mitsubishi Kasei Co., Ube Industries Ltd.
Ceramics (4)	33 Asahi Glass Co., Kyocera Co., NGK Spark Plug Co., NGK Insulators Ltd.
Iron & steel (3)	33 Sumitomo Metal Industries Ltd., 26 Kobe Steel Ltd., NKK Co.
Non-ferrous metals and products (5)	Sumitomo Metal Industries Ltd., Hitachi Cable Ltd., Fujikura Ltd., Showa Electric Wire & Cable Co., Furukawa Electric Co.
Machinery (23)	3 Hitachi Ltd. 6 Toshiba Co., 35 Ishikawajima-Harima Heavy Industries Co., 12 Mitsubishi Heavy Industries Ltd., Kawasaki Heavy Industries Ltd. 10 Mitsubishi Electric Co., Fuji Electric Co., 17 Sanyo Electric Co., Ebara Co., Mitsui Engineering & Shipbuilding Co., Kubota Co., Yokogawa ElectricCo., Murata MFG. Co., Maekawa Manufacturing, Aishin Seiki Co., Daikin Industries Ltd., Sumitomo Precision Products Co., Hitachi Zosen Co., Niigata Engineering Co., Yammer Diesel, Yuasa Battery, Japan Storage Battery Co., Matsushita Battery
Public utilities (11)	Hokkaido Electric Power Co., Tohoku Electric Power Co., 19 Tokyo Electric Power Co., Chubu Electric Power Co., Hokuriku Electric Power Co., Kansai Electric Power Co., Chugoku Electric Power Co., Shikoku Electric Power Co., Kyusyu Electric Power Co., EPDC, Osaka Gas Co.
Construction (5)	JGC Co., TEC Electrics Co., Chiyoda Co., Shimizu Co., Obayashi Co.

a Figures heading firms indicate orders of R&D expenditures in 1992 out of top 40 firms (19 firms out of 40 participated)

b Figures in parentheses indicate number of firms in respective sectors.

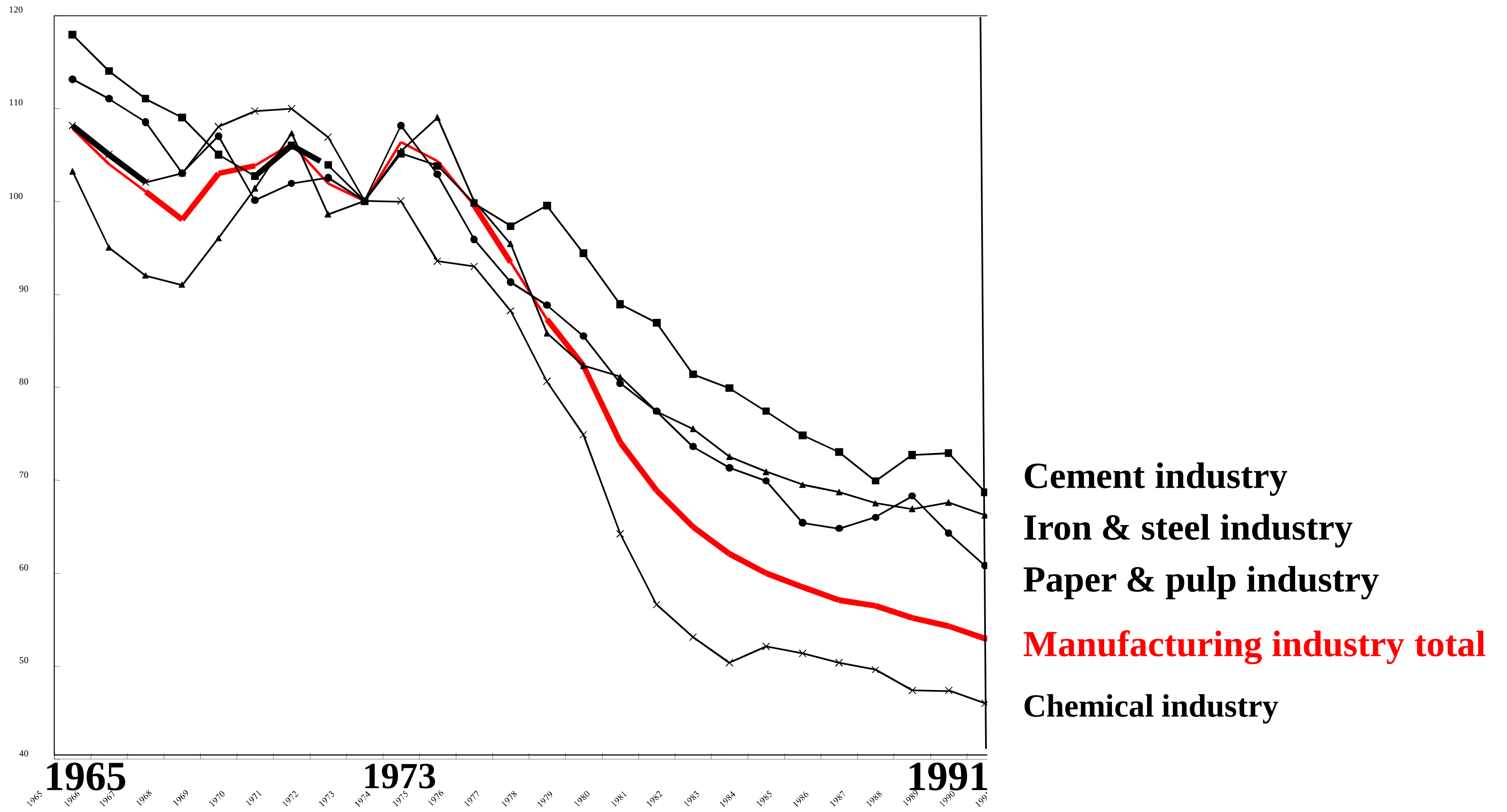
4) Firms Participating in PV Development under the Sunshine Project *(1997)*

Textiles	Teijin	
Chemicals	**Kanegafuchi Chemical Industry** Mitsui Toatsu Chemicals Shinetsu Chemical Daido– hoxan Matsushita Battery	Mitsubishi Chemical
Petroleum and coal products	Showa Shell Sekiyu Tonen Japan Energy	
Ceramics	**Kyocera** Asahi Glass Nippon Sheet Glass	
Iron and steel	Kawasaki Steel	Japan Steel Works
Non– ferrous metals and products	Mitsubishi Materials Sumitomo Sitix Hitachi Cable	
General mach.		Kubota
Electrical machinery	**Sanyo Electric** **Sharp** **Fuji Electric C. R&D** **Hitachi** **Mitsubishi Electric** **Sumitomo Electric Industries** Matsushita Electric Industrial Oki Electric Industry	Sony Canon Anelva
Other manf.		YKK
Public institutes	Japan Measurem. and Inspect. Inst. Central Res. Inst. of Elec. Power Ind.	Japan Quality Asurance Org. Shikoku Elec. Power Res. Inst. Jap. Elec. Safety & Env. Tech. Lab. Jap. Weather Forcast Assoc.
Electric power		Okinawa Electric Power Kashima North Joint Elec. Power
Housing and construction		Misawa Homes National House Industry YKK Architectual Products Kajima

Firms enclosed in [box] indicate members of PVTEC.

(4) Accelerated Effects of Joint Efforts

As a consequence of joint efforts by industry and government, learning and assimilation of spillover technology were accelerated leading to dramatic decline in unit energy consumption.



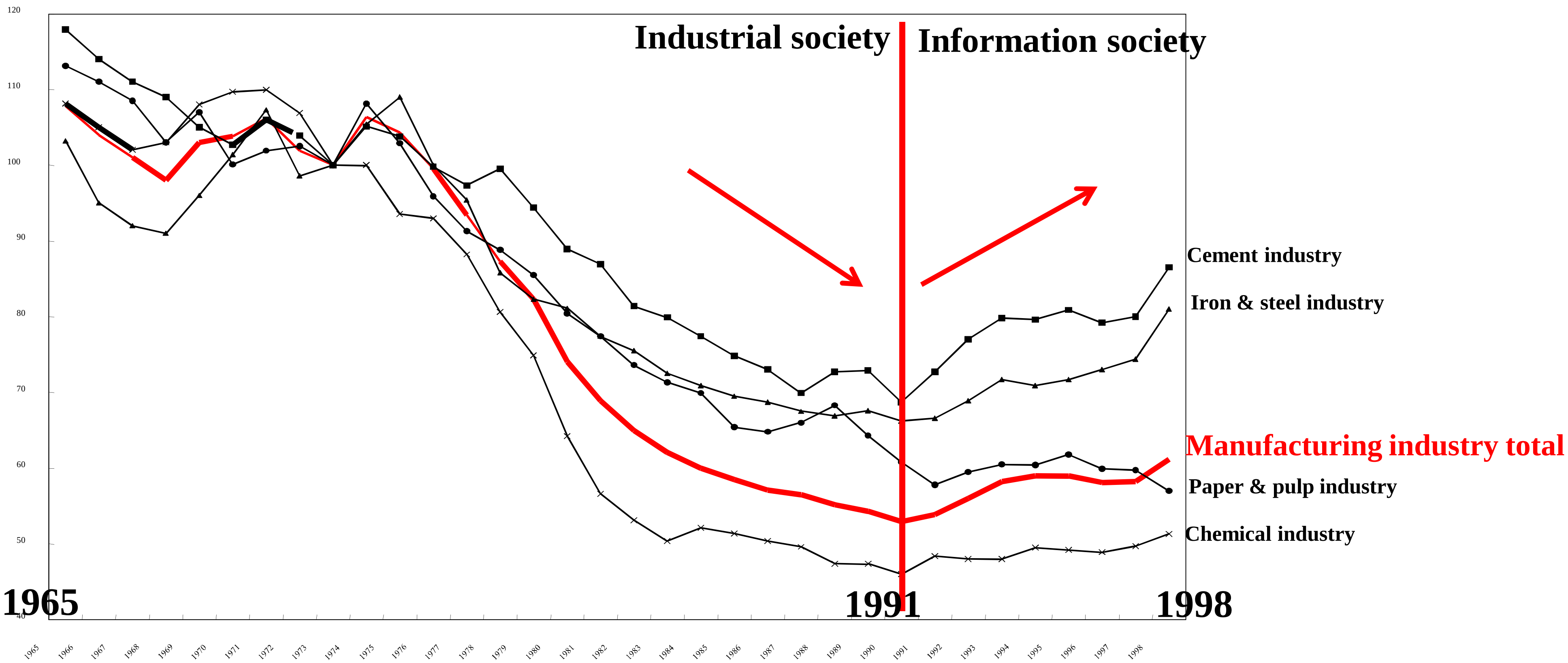
Trend in Unit Energy Consumption in the Japanese Manufacturing Industry *(1965-1991)* – Index: 1973 = 100.

1.4.5 Limit of Substitution Model

(1) Limit of Substitution Model in a Production Function

1. **Due to features differences between MT and IT,   Japan's notable dynamism in the 1980s moved in the opposite direction in an information society in the 1990s.**

2. **This reveals the limit of substitution model in a production function.**



Trend in Unit Energy Consumption in the Japanese Manufacturing Industry
(1965-1998) **– Index: 1973 = 100.**

(2) Sources Leveraging Substitution: Elasticity of Substitution

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

Y: Production, ***X***: Production factor (labor, capital, materials and energy), ***T***: Technology

Elasticity of substitution: Firm's input substitution opportunity

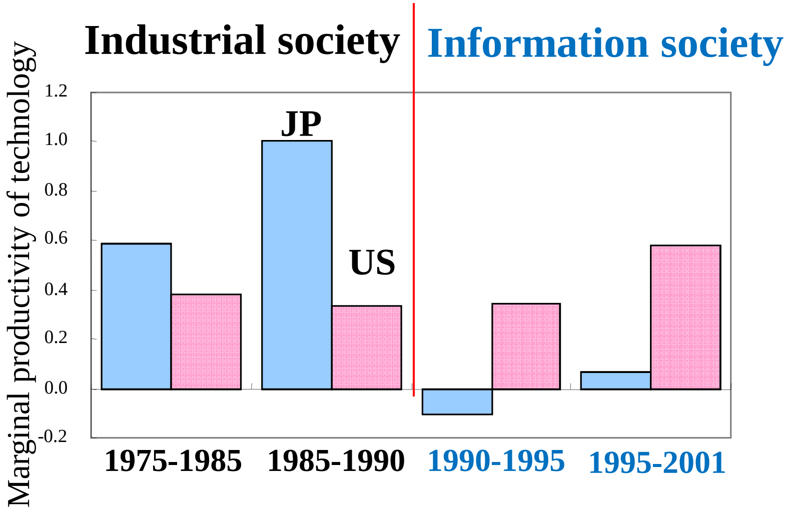
$$\sigma_{TX} = \frac{d \ln \frac{T}{X}}{d \ln \frac{MPX}{MPT}} = \frac{d \ln \frac{T}{X}}{d \ln MPX - d \ln MPT}$$

MPT: Marginal Productivity of X
MPT: Marginal Productivity of Technology

Higher MPT induces higher elasticity of technology substitution for X

$$MPT = \frac{\partial Y}{\partial T} = \frac{\Delta Y}{\Delta T} \Big| \ X \text{ is held constant}$$

While Japan maintained conspicuous MPT in an industrial society, it changed to dramatic decline in an information society resulting in stagnation of technology substitution.

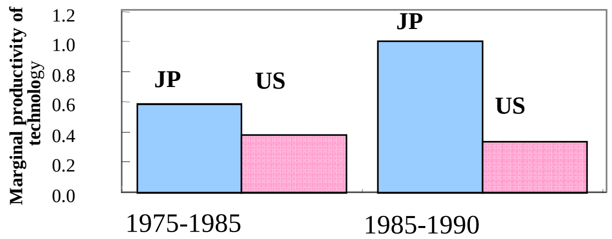


(3) Substitution Mechanism

Japan's high level of Marginal Productivity of Technology: MPT

1960s Labor	**Labor saving, automation**
1970s Energy	**Energy saving, oil-alternative**
1980s Trade	**High-technology**

→ **High level of MPT**



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

Production

Labor, Capital, Energy, Materials

Technology stock

Sustain Y

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

T* substitutes for *X

Constraint of X supply

External crises

***Y/X* increase**

Induce R (R&D investment)

$\frac{\partial Y}{\partial T}$ → IRR (Internal Rate of Return to R&D) $\uparrow \rightarrow R\uparrow \rightarrow T\uparrow \rightarrow T/X\uparrow$

$$\left[\ln\frac{\partial Y}{\partial X} - \ln\frac{\partial Y}{\partial T}\right]\downarrow \longrightarrow \frac{\ln\frac{T}{X} - c}{\ln\frac{\partial Y}{\partial X} - \ln\frac{\partial Y}{\partial T}} = \sigma_{TX} \rightarrow \frac{T}{X}\uparrow$$

Elasticity of technology substitution (ETC) for X c: coefficient

Technology productivity $\frac{Y}{T}\uparrow$

Y/X increase $\frac{T}{X}\cdot\frac{Y}{T} = \frac{\boldsymbol{Y}}{\boldsymbol{X}}\uparrow$

Growth dependent trajectory in an industrial society

Japan constructed a sophisticated co-evolutionary dynamism between innovation and institutional systems by transforming external crises into a springboard for new innovation.

Abundant curiosity, assimilation proficiency, and thoroughness in learning and absorption

Xenophobia and Uncertainty avoidance

This transformation ability can largely be attributed to Japan's unique features of the nation such as having

(i) a strong motivation for overcoming fear based on xenophobia and uncertainty avoidance,
(ii) while abundant curiosity, assimilation proficiency, and thoroughness in learning and absorption.

Such a unique institutional system led to a high level of MPT leveraging a conspicuously high level of

(i) elasticity of technology substitution for energy leading to a shift from energy to technology (T/E), and
(ii) increased technology productivity (Y/T) which generated
(iii) a notable energy productivity as a multiplier effect of these accomplishments ($\frac{Y}{E} = \frac{T}{E}\cdot\frac{Y}{T}$).
leading to sophisticated substitution mechanism.

Japan's System in Transforming Crises into a Springboard for New Innovation.

1.4.6 Significance of Functionality Development in an Information Society

(1) New Policy Trajectory Corresponding to the New Paradigm in an Information Society

(i) The systems conflict with manufacturing industry has been experiencing in an information society can be attributed to the structural differences between manufacturing technology and IT as contrasted in Table 5.

(ii) While shifting to an information society in the 1990s, there remains in Japan strong organizational inertia in an industrial society in the 1980s.

(iii) This inertia impedes Japan's institutions correspond to an information society and compels to a dual vicious cycle leading to institutional elasticity.

Comparison of Features between Manufacturing Technology and IT

	1980s	1990s
Paradigm	**Industrial society**	**Information society**
Core technology	Manufacturing technology	IT
1. Optimization	Within firms/Organizations	In the market
	i. Asymmetry of information ii. Steady change iii. Conservation of indigenous technology iv. Mass production v. Stable management through non-risk seeking	i. Decrease of asymmetric information cost ii. Dramatic change iii. Globalization iv. Modularization v. Diversification of risk
2. Key features formation process	Provided by suppliers	To be formed during the course of interacting with institutions
3. Fundamental nature	As given	Self-propagating
4. Actors responsible for formation of features	Individual firms/organizations	Institutions as a whole

Source: Watanabe et al. (2003).

(2) Mis-option Resulting in a System Conflict

However, Japan's organizational inertia impeded its institutions correspond to paradigm shifts to an information society and clung to "Growth oriented trajectory" rather than "Functionality development trajectory" resulting in a system conflict.

Comparison of Features between Manufacturing Technology and IT

	1980s	1990s
Paradigm	**Industrial society**	**Information society**
1. Core technology	**Manufacturing technology**	**IT**
2. Optimization	Within firms	In the market
3. Objectives	Productivity	Functionality
4. Development trajectory	Growth oriented trajectory	Functionality development trajectory

Growth Oriented Trajectory

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

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

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

(MPT)

Functionality Development Trajectory

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

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

V: GDP
L: Labor
K: Capital
T: Technology stock
R: R&D investment
FD: New functionality development
α: Diffusion coefficient

Japan (1980s, 1990s) → **System conflict**

US (1980s) → **US (1990s)** → **System match**

MPT: Marginal productivity of technology

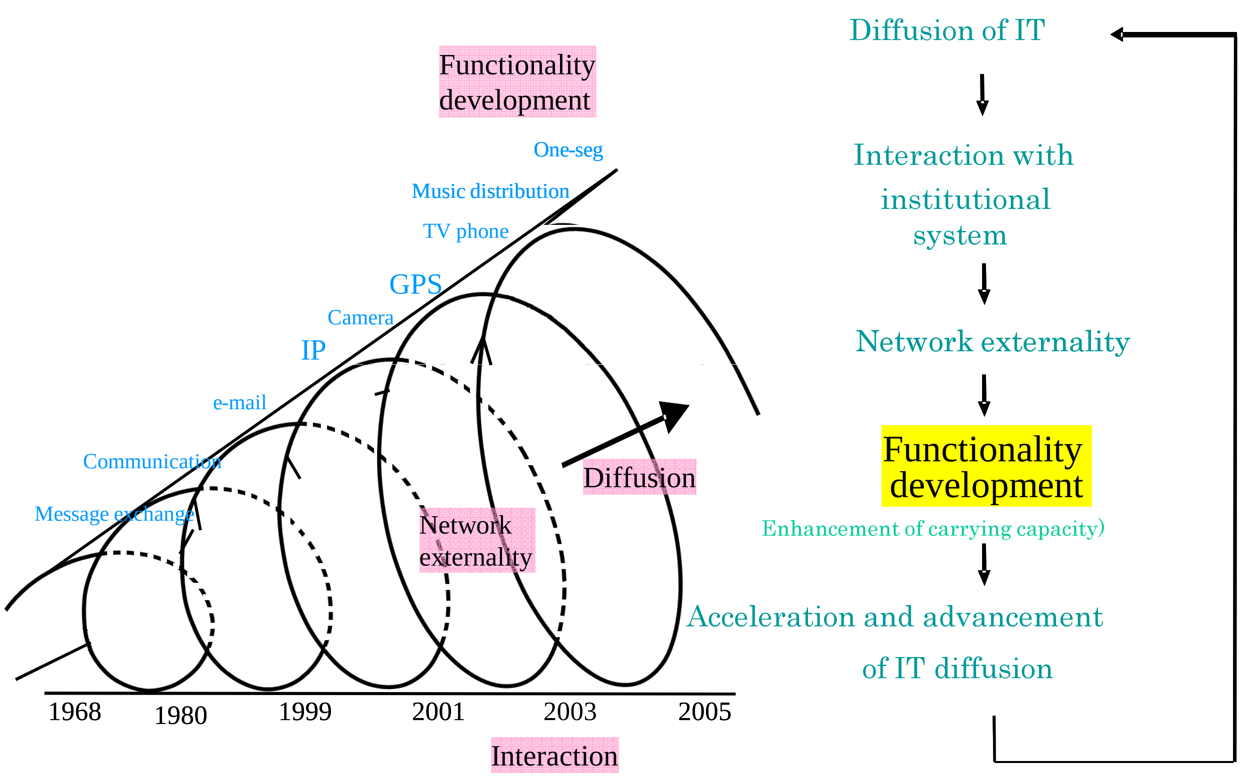
Scheme Leading Japan to Lose Its Institutional Elasticity.

Source: Watanabe et al. (2003).

(3) Self-propagating Functionality Development in IT

In mobile driven innovation, new functionality emerged in a self-propagating way in a process of diffusion, not at development stage, as from *talk* to *see*, *see & talk*, *take a picture*, *pay* and *watch*.

Self-propagating mechanism



Talk → See → See & talk → Take a picture → Pay → Watch

Self-propagating Dynamism in Functionality Development of Japan's Mobile Phones.

(4) Functionality Development for Sustainable Growth

1) Integration of Production Function and Diffusion Function - *Innofusion*

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)

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

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

2) FD for Sustainable Growth

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

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

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

$$\uparrow$$

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

Marginal productivity of technology

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

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

$$\uparrow$$

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

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

System conflict — **System match**

Contrast of Growth Option.

3) Options for Growth

GDP growth rate | Traditional production factors | TFP

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

Marginal Productivity of Technology (MPT) | R&D intensity

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

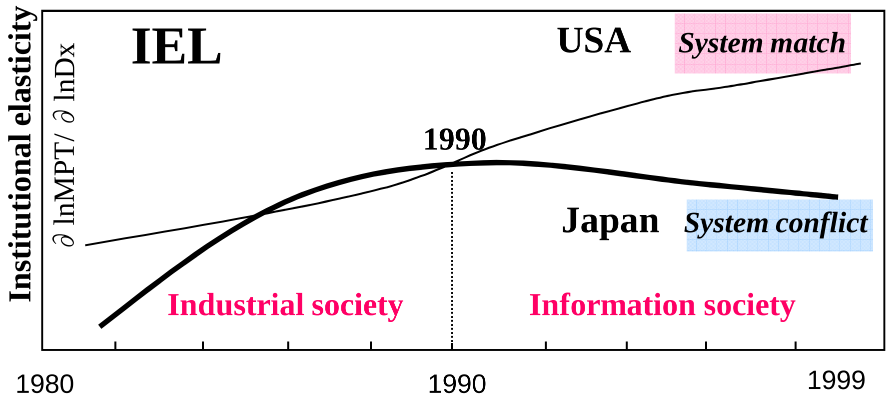
Diffusion velocity | GDP | Functionality development

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

1.4.7 System Conflict and Subsequence FD Decline (1) System Conflict

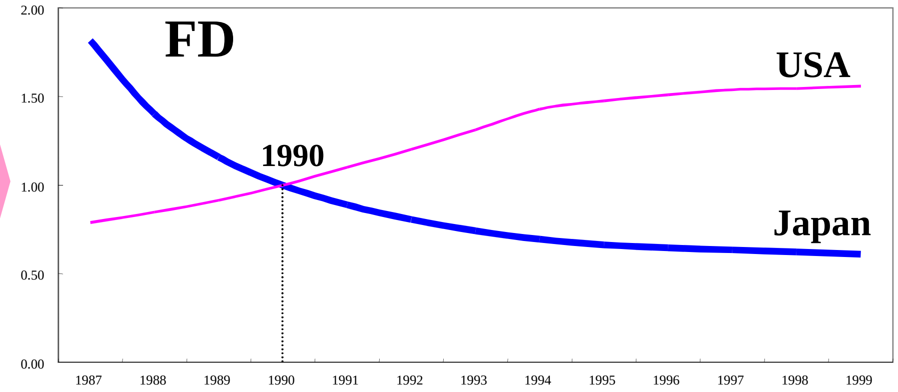
1. **System conflict** led to an **institutional less-elasticity** in an information society resulting in a **dramatic decrease in Japan's FD**.
2. FD decrease led to a **decrease in MPT** (Marginal Productivity of Technology).

FD: Ability to improve performance of production processes, goods and services by means of innovation



Institutional Elasticity of Manufacturing Technology

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



Functionality Development *(1987-1999) - Index: 1990 =1.*

$$V = F(L, K, T)$$

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

where A: scale factor; α, β, γ_1, and γ_2: elasticities; D_x: coefficient dummy variable representing the trend in shifting from an industrial society to an information society ($D_x = \frac{1}{1+e^{-at-b}}$, a, b: coefficients).

$$MPT = \frac{\partial V}{\partial T} = \frac{\partial \ln V}{\partial \ln T} \cdot \frac{V}{T} = (\gamma_1 + \gamma_2 D_x) \cdot \frac{V}{T}$$

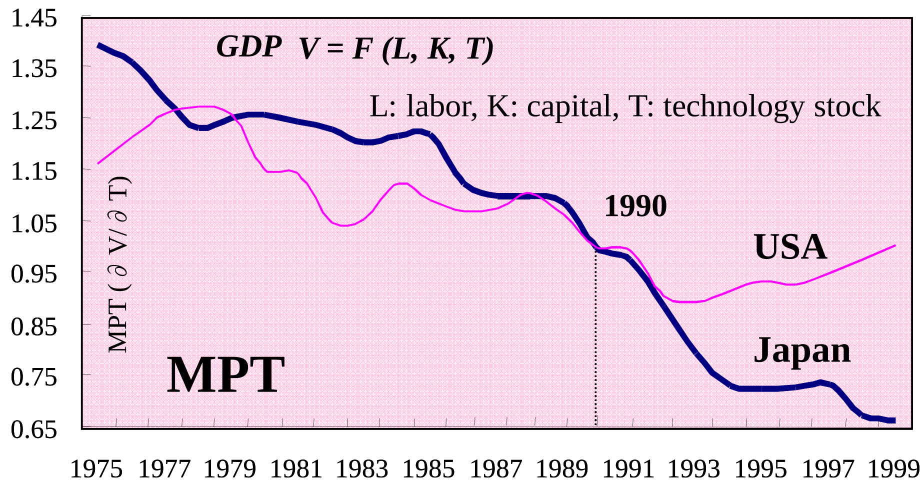
$$MPT = F(V, T, D_x)$$

$$\ln MPT = B + \alpha_1 \ln V + \alpha_2 \ln T + \alpha_3 \ln D_x + \beta_1 \ln V \cdot \ln T + \beta_2 \ln V \ln D_x + \beta_3 \ln T \ln D_x$$

where B: scale factor; α_i and β_i (i = 1~3): elasticities.

$$IEL \text{ (Institutional Elasticity)} = \frac{\partial \ln MPT}{\partial \ln D_x}$$

$$MPT = aV\left(1 - \frac{1}{FD}\right), \quad FD = \frac{1}{1 - \left(MPT/aV\right)}$$



Marginal Productivity of Manufacturing Technology

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

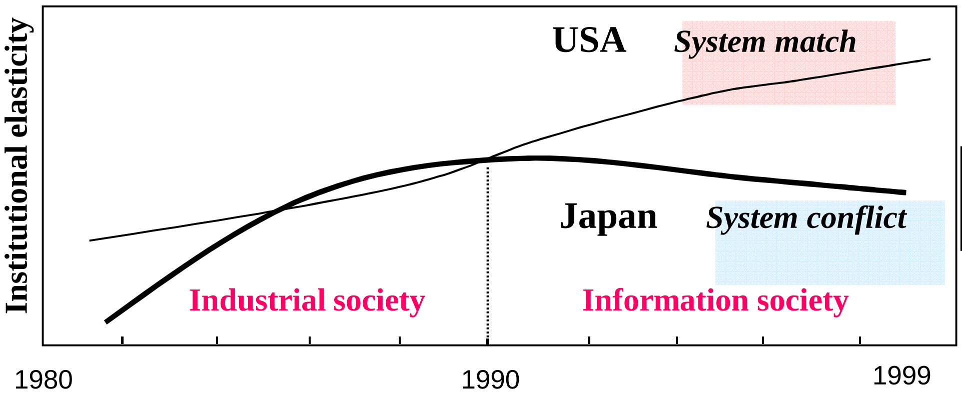
(2) Dramatic Decrease in MPT and Consequent Innovation Decrease

1. **System conflict** led to an **institutional less-elasticity** in an information society resulting in a **dramatic decrease in MPT**.
2. MPT decrease led to **TFP decrease** resulting in a **decrease in innovation contribution to growth**.
3. Thus, **co-evolution changed to disengagement** in an information society.

MPT: Marginal Productivity of Technology

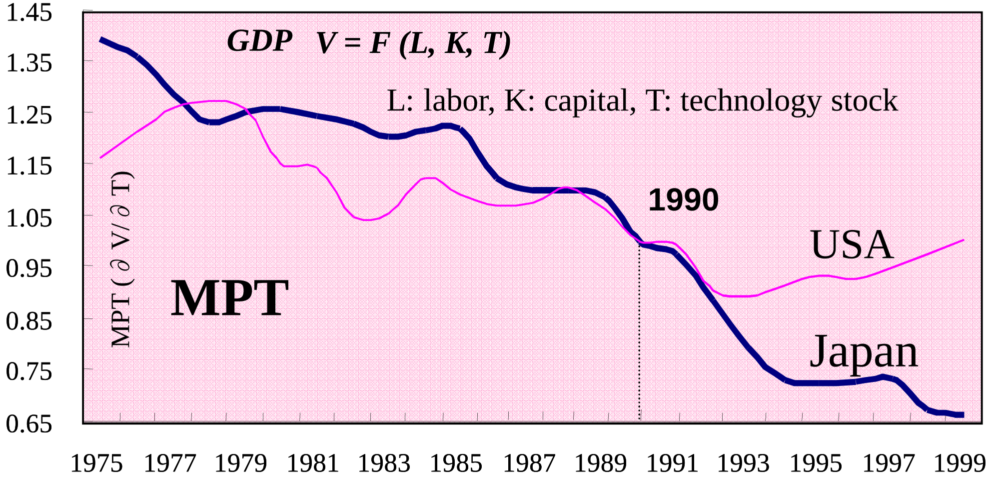
(i) Dramatic Decrease in Marginal Productivity of Technology

TFP: Total Factor Productivity



Institutional Elasticity of Manufacturing Technology

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

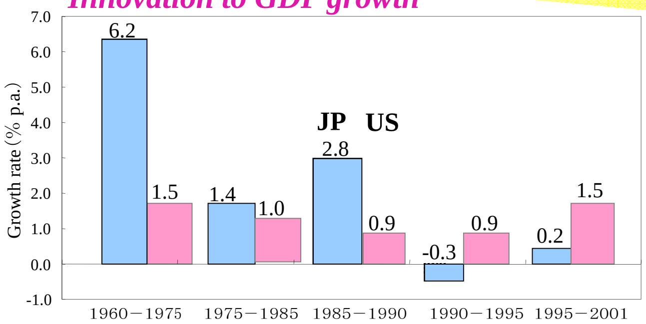


Marginal Productivity of Manufacturing Technology
(1975-1999) - Index: 1990 =1.

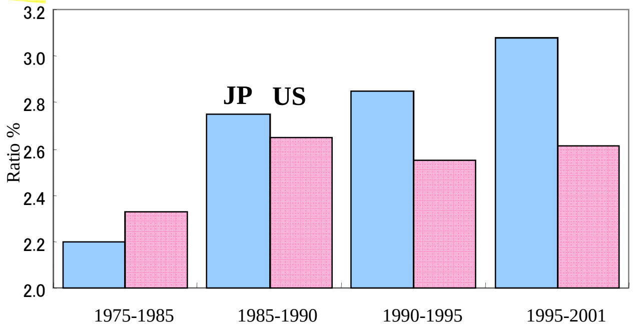
(ii) Consequent Decrease in Innovation

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

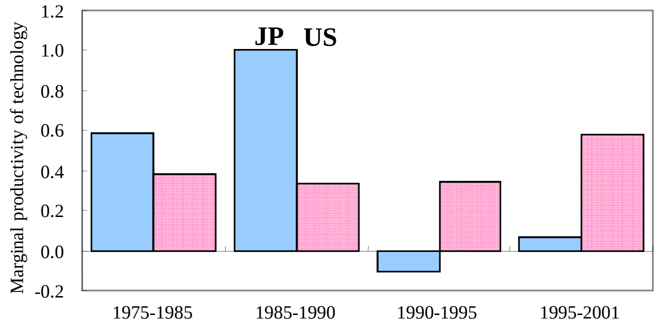
Innovation to GDP growth



TFP Growth Rate *(1960-2001).*



R&D Intensity *(1975-2001).*



Marginal Productivity of Technology
(1960-2001).

1.4.8 Loosing Institutional Elasticity: Sources of the Failure

(1) Development Trajectory and Adaptability to an Information Society

Growth economy | Mature economy

Industrial society | Information society

1980s | 1990s

Japan: **Enjoyed international competitiveness initiated by manufacturing technology** → **Clung to the business model in an industrial society** → **Impediment by the organizational inertia in the 1980s** → **Systems conflict with an information society** → **Non-elastic institutional systems** → **Non-utilization of potential self-propagating function of IT**

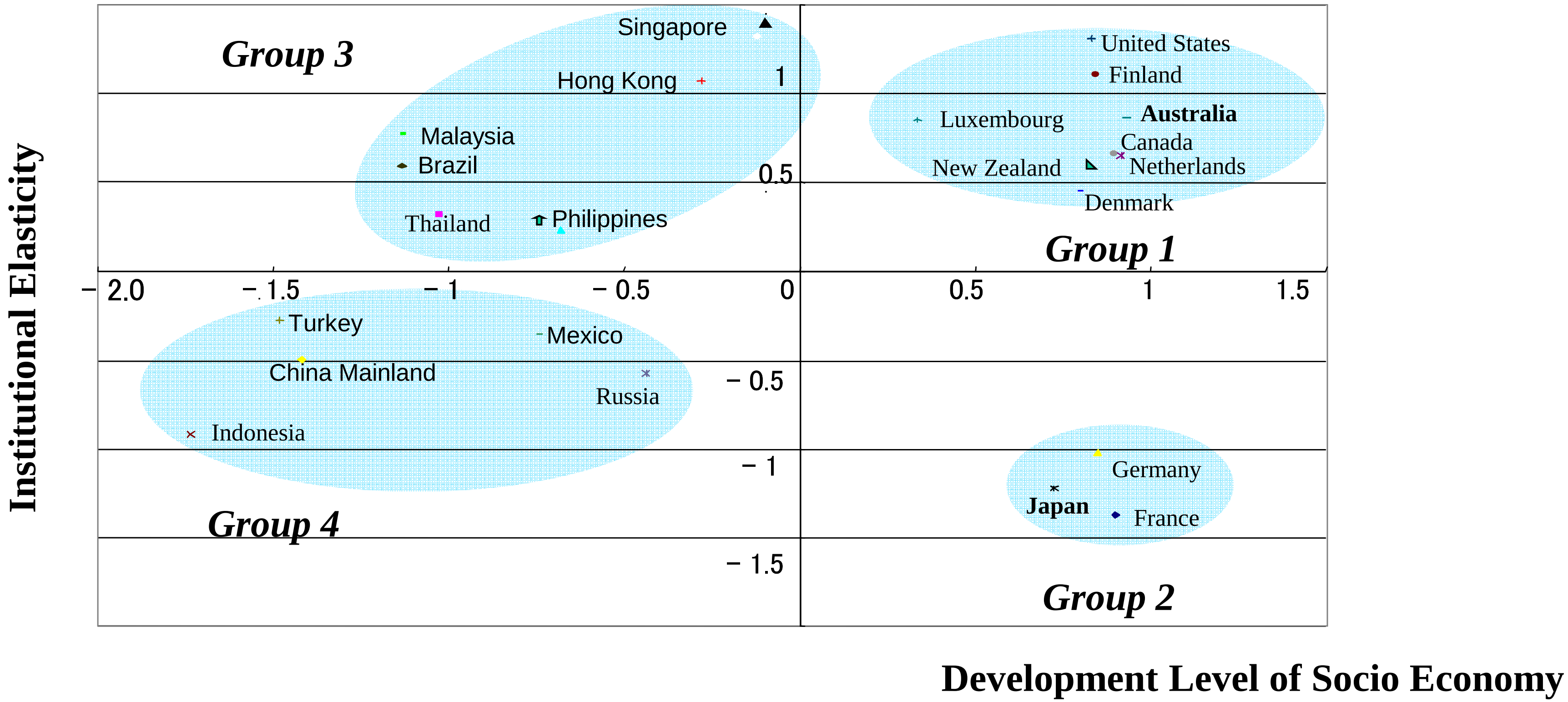
Clung to growth oriented model

Switched to new functionality development initiated model

USA: **Realized the new reality as global competition** → **Extensive challenge to competitiveness strategies** → **Resonance between cumulative efforts and ITechnology** → **Systems match with an information society** → **Institutional elasticity** → **Full utilization of potential self-propagating function of IT**

(2) State of Institutional Elasticity

However, possibility of constructing a virtuous cycle depends on elasticity of institutions.
Japan has lost its institutional elasticity in an information society.



Development Level of Socio Economy and Institutional Elasticity in Selected 20 Countries in an Information Society (2000): *Factor Analysis*.

1.4.9 Implication

1. Japan constructed function in transforming crises into a springboard for new innovation.

Crisis	New innovation
1960s Labor shortage	Labor saving, automation tech. Robotics
1970s Energy crises	Energy saving, oil-alternative tech.
1980s Intl. trade conflict	High-technology
1990s Systems conflict in IT	High-functional MP driven innovation
2000s Once-in-a century crisis	Supra-functionality incorporating new social, cultural and aspirational value beyond economic value
Group of consumers with disability	More demanding to supra-functionality

2. Sources of this notable function can be attributed to a technology substitution for constrained factors based on high level of marginal productivity of technology (MPT).

3. Such high level of MPT can be enabled by high level of labor productivity in the 1960s which led to growth oriented trajectory in an industrial society.

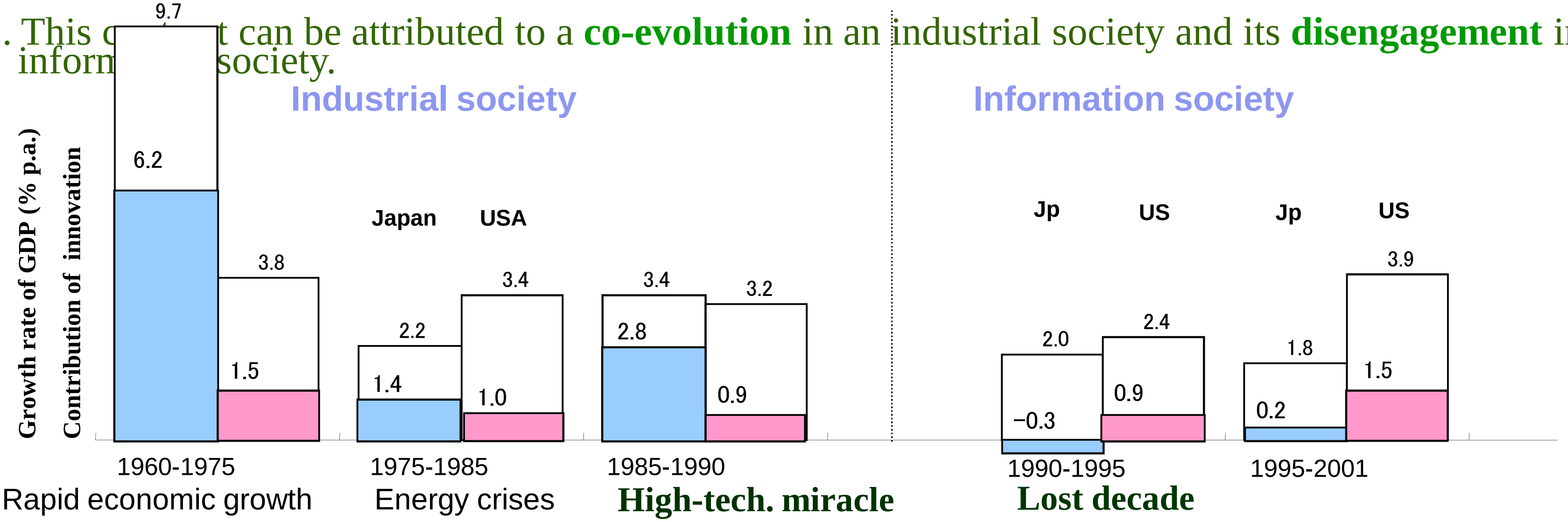
4. High level of MPT in an information society can be enabled by shifting to functionality development trajectory.

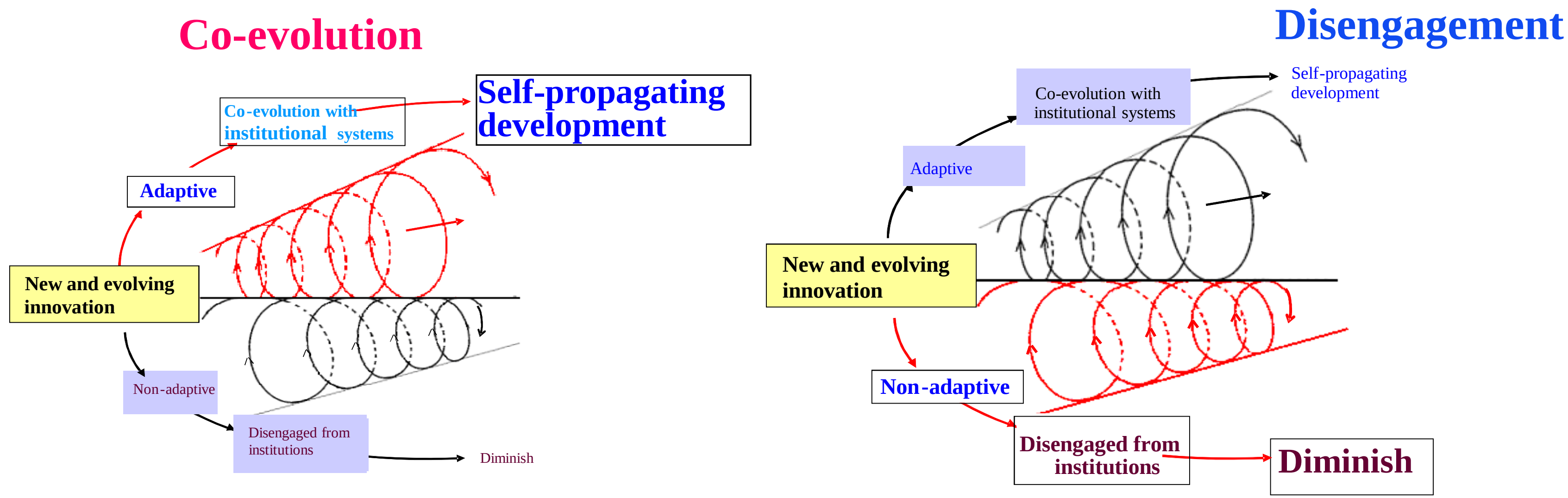
5. However, due to organizational inertia in an industrial society, Japan clung to growth oriented trajectory.

1.4.10 Lost Decade in the 1990s

- *Japan's Contrast between Co-evolution and Disengagement*

1. Contrary to the high technology miracle in the 1980s, Japan experienced a long-lasting economic stagnation in the 1990s.
2. This c t can be attributed to a **co-evolution** in an industrial society and its **disengagement** in an inform society.

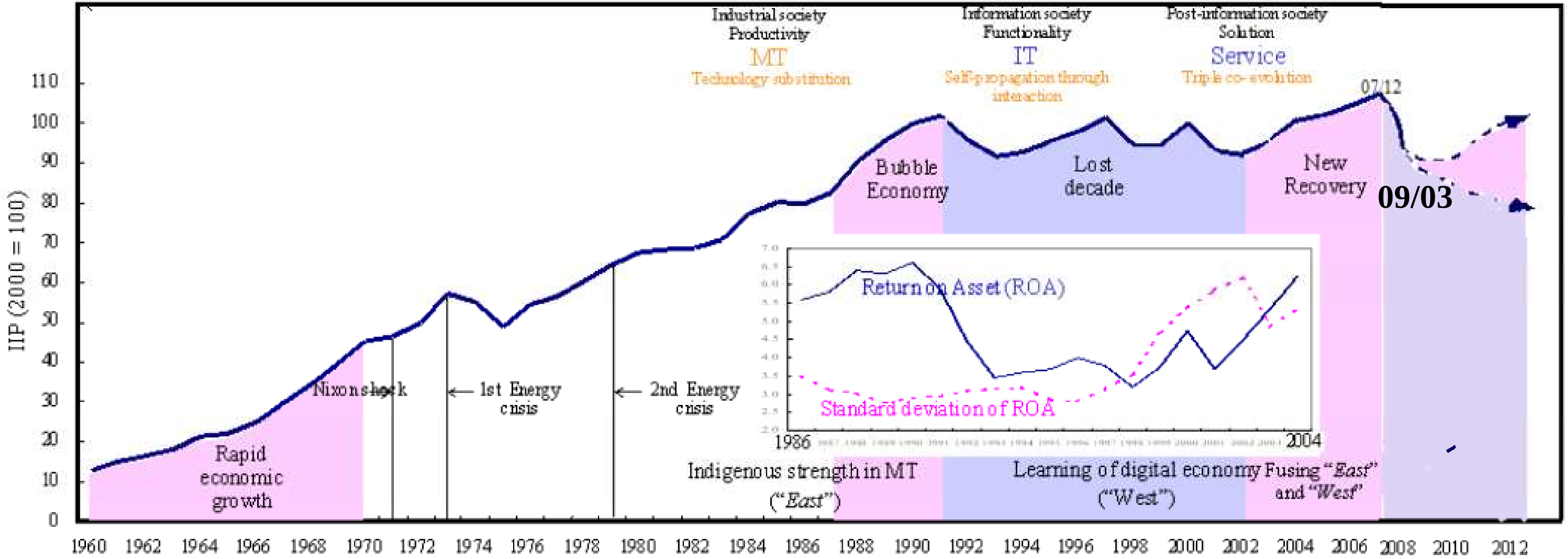




Contrast of the Co-evolution and Disengagement between Innovation and Institutional Systems in Japan.

1.5 Sources of Failure

1.5.1 Japan's Development Path: Crises and Transformed Innovation *(1960-2010)*

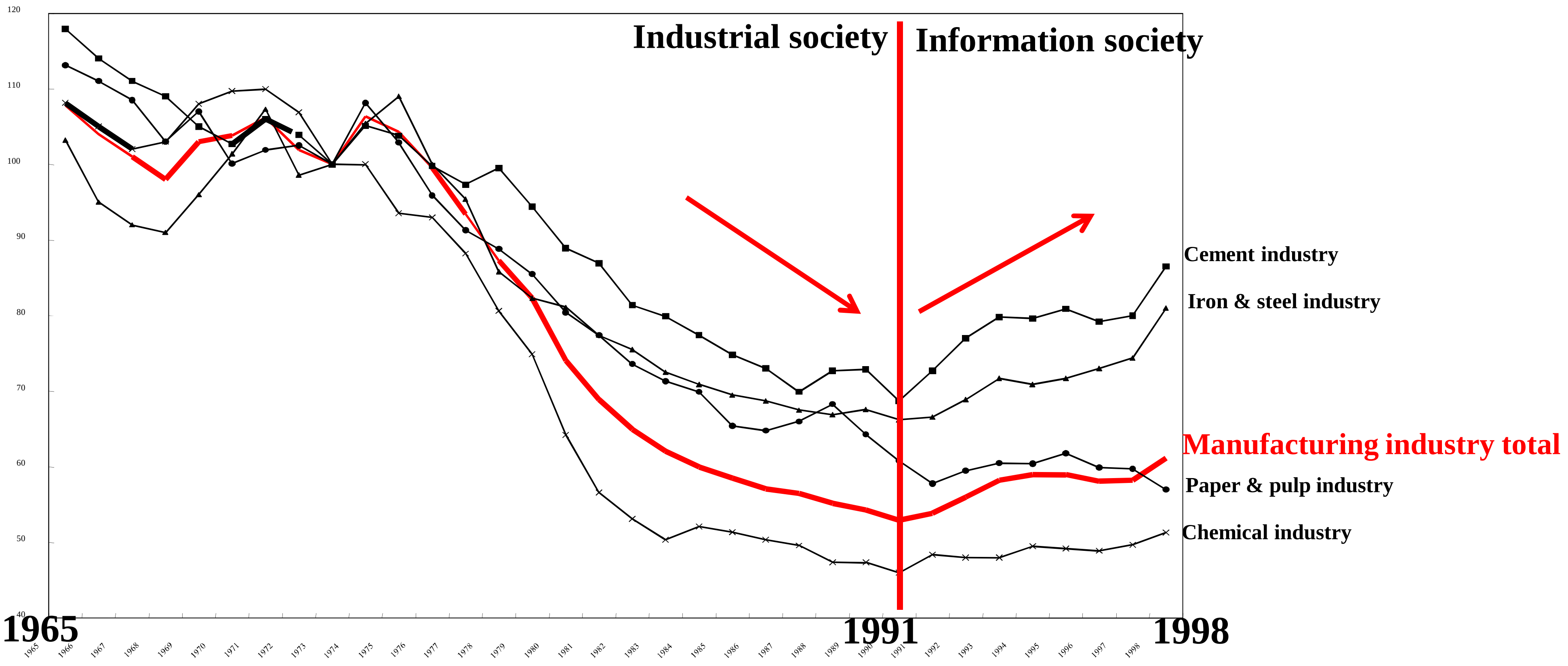


Crisis	Innovation	Contribution
1960s Labor shortage	Labor saving, automation tech. robotics	Productivity increase
1970s Energy crises	Energy saving, oil-alternative tech.	Cross sectoral tech. spillover
1980s Intl. trade conflict	High-technology	Advancement of MT
1990s Systems conflict in IT	High-functional MP driven innovation	Hybrid MOT
2000s Once-in-a century crisis	Supra-functionality beyond economic value	

1.5.2 Limit of Substitution Model

1. Due to features differences between MT and IT, Japan's notable dynamism in the 1980s moved in the opposite direction in an information society in the 1990s.

2. This reveals **the limit of substitution model in a production function** and leverages **the significance of production, diffusion and consumption integration**.



Trend in Unit Energy Consumption in the Japanese Manufacturing Industry

(1965-1998) **– Index: 1973 = 100.**

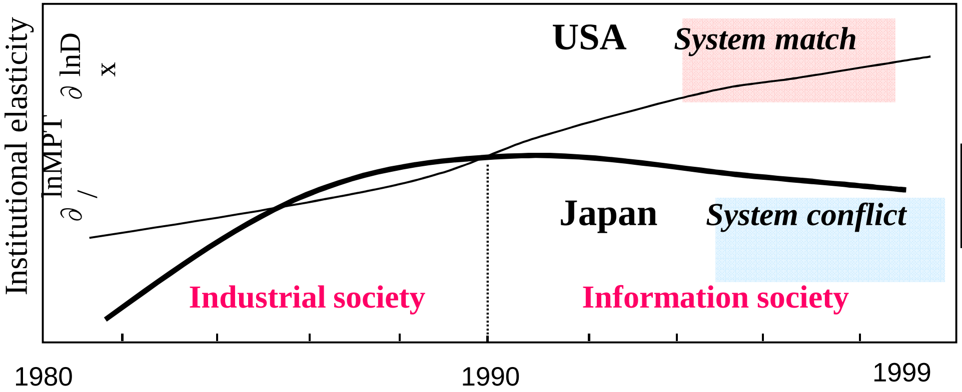
1.5.3 Dramatic Decrease in MPT and Consequent Innovation Decrease

1. **System conflict** led to an **institutional less-elasticity** in an information society resulting in a **dramatic decrease in MPT**.
2. MPT decrease led to **TFP decrease** resulting in a **decrease in innovation contribution to growth**.
3. Thus, **co-evolution changed to disengagement** in an information society.

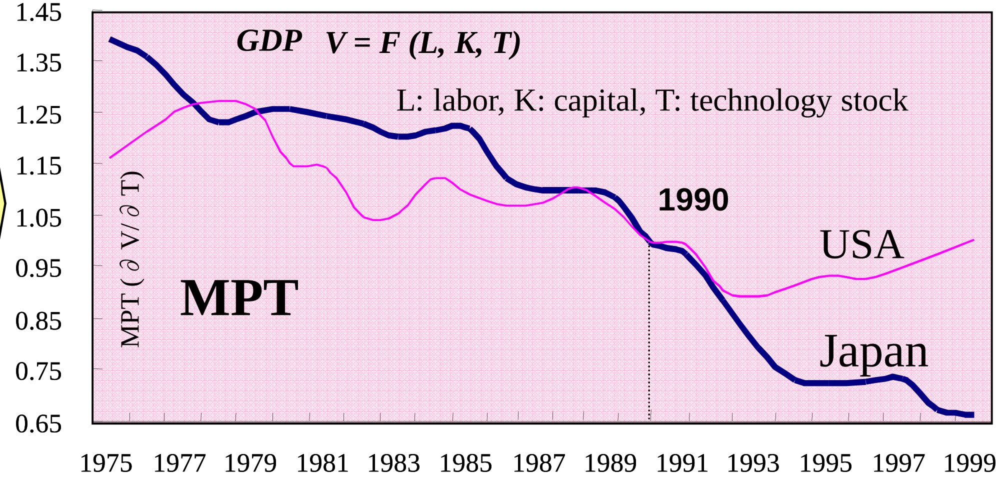
MPT: Marginal Productivity of Technology

(i) Dramatic Decrease in Marginal Productivity of Technology

TFP: Total Factor Productivity



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

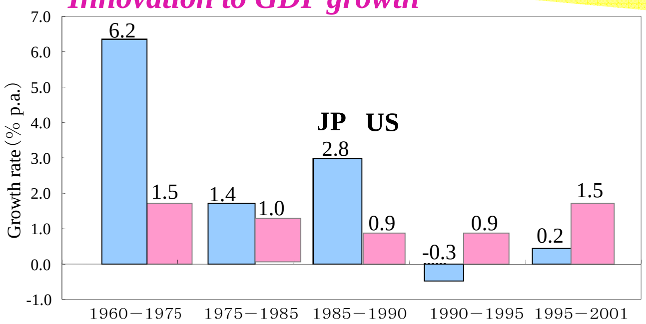


Marginal Productivity of Manufacturing Technology
(1975-1999) - Index: 1990 =1.

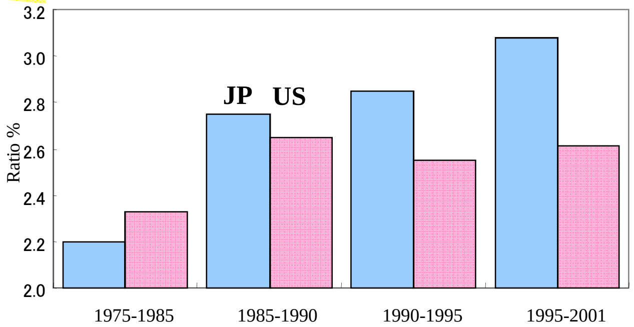
(ii) Consequent Decrease in Innovation

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

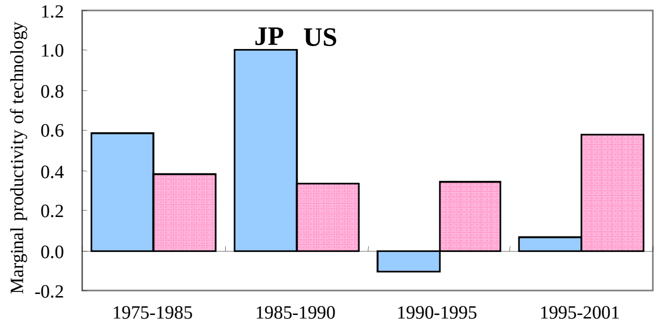
Innovation to GDP growth



TFP Growth Rate *(1960-2001).*



R&D Intensity *(1975-2001).*



Marginal Productivity of Technology *(1960-2001).*

1.5.4 Functionality Development for Sustainable Growth

(1) Integration of Production Function and Diffusion Function - *Innofusion*

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	L : Labor
K : Capital	T : Technology
R : R & D investment	**FD: Functionality development**
N : Carrying capicity	*a: Diffusion velocity*
b : Diffusion at the initial stage	

(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)

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

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

(2) FD for Sustainable Growth

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

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

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

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

Marginal productivity of technology

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

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

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

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

System conflict   System match

Contrast of Growth Option.

1.5.5 Implications for Success and Failure

1. Japan constructed function in transforming crises into a springboard for new innovation.

Crisis	New innovation
1960s Labor shortage 1970s Energy crises 1980s Intl. trade conflict 1990s Systems conflict in IT	Labor saving, automation tech. Robotics Energy saving, oil-alternative tech. High-technology High-functional MP driven innovation
2000s Once-in-a century crisis	Supra-functionality incorporating new social, cultural and aspirational value beyond economic value
Group of consumers with disability	More demanding to supra-functionality

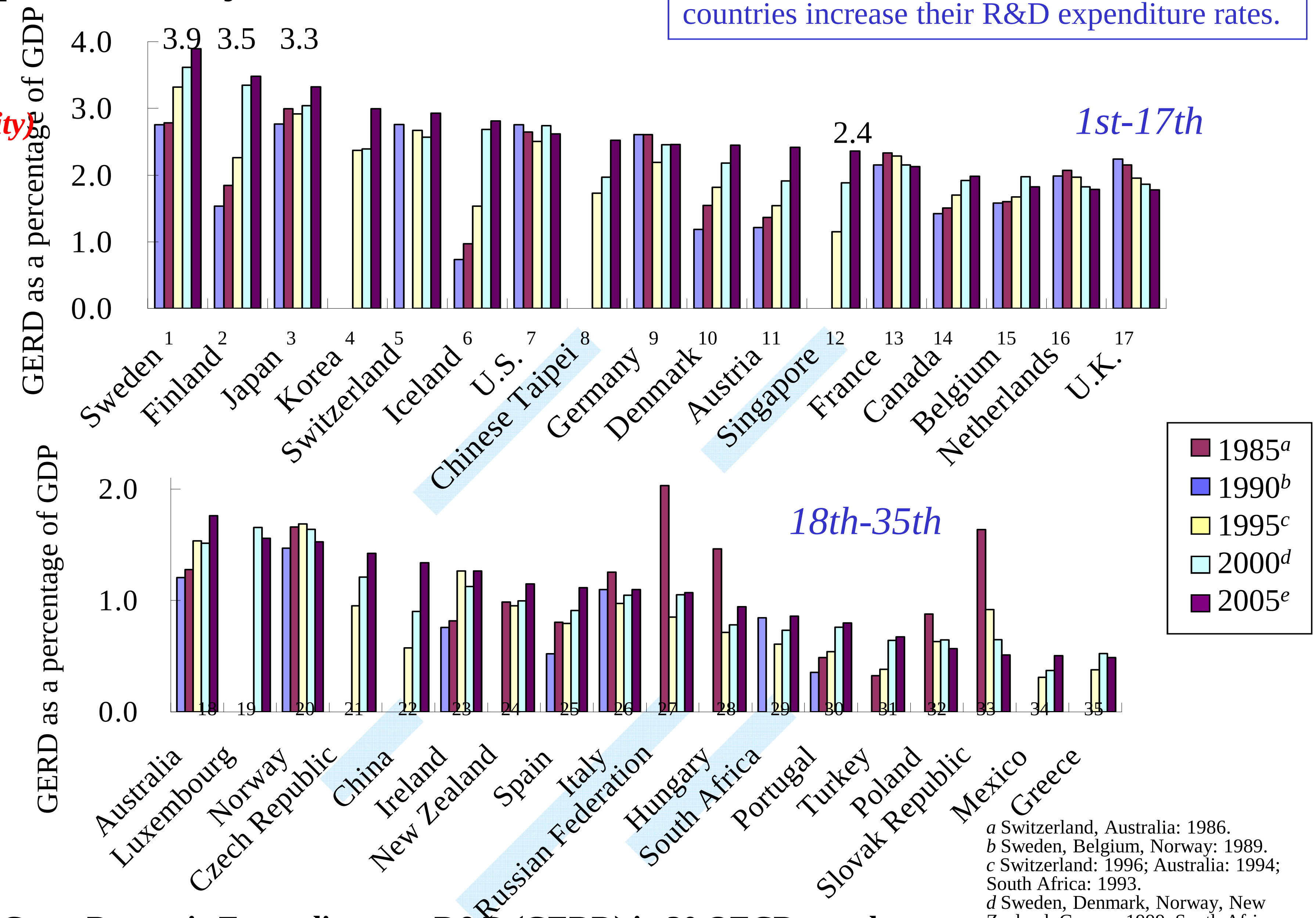
2. Sources of this notable function can be attributed to a technology substitution for constrained factors based on high level of marginal productivity of technology (MPT).
3. Such high level of MPT can be enabled by high level of labor productivity in the 1960s which led to growth oriented trajectory in an industrial society.
4. High level of MPT in an information society can be enabled by shifting to functionality development trajectory.
5. However, due to organizational inertia in an industrial society, Japan clung to growth oriented trajectory.

1.6 Sources of Success
- Sophisticated Combination of Industry Efforts and Government Stimulation

1.6.1 Japan's Catalysis Mechanism

The top 3 and some emerging or middle/small countries increase their R&D expenditure rates.

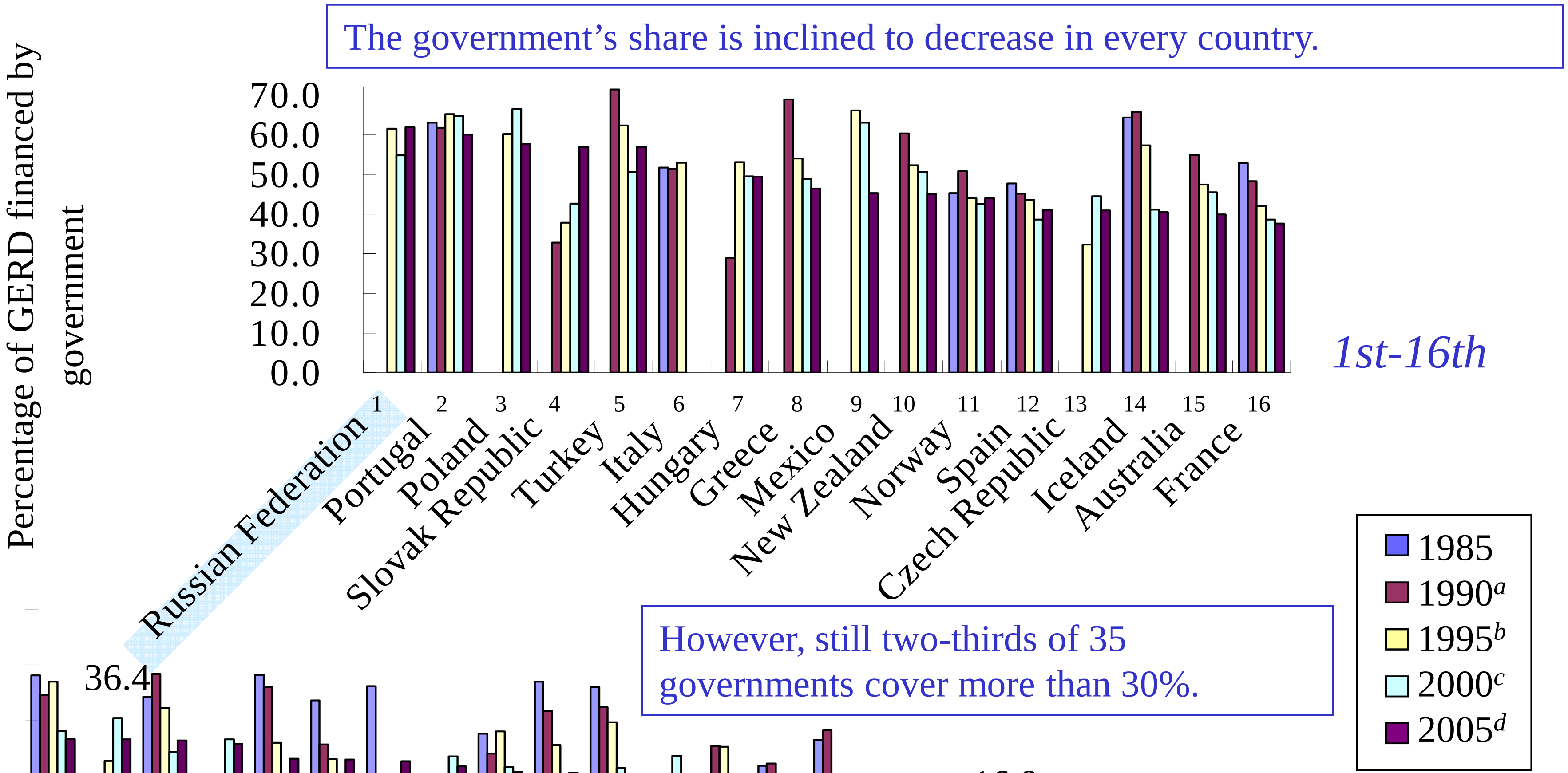
(1) *R / V*
(R&D intensity)

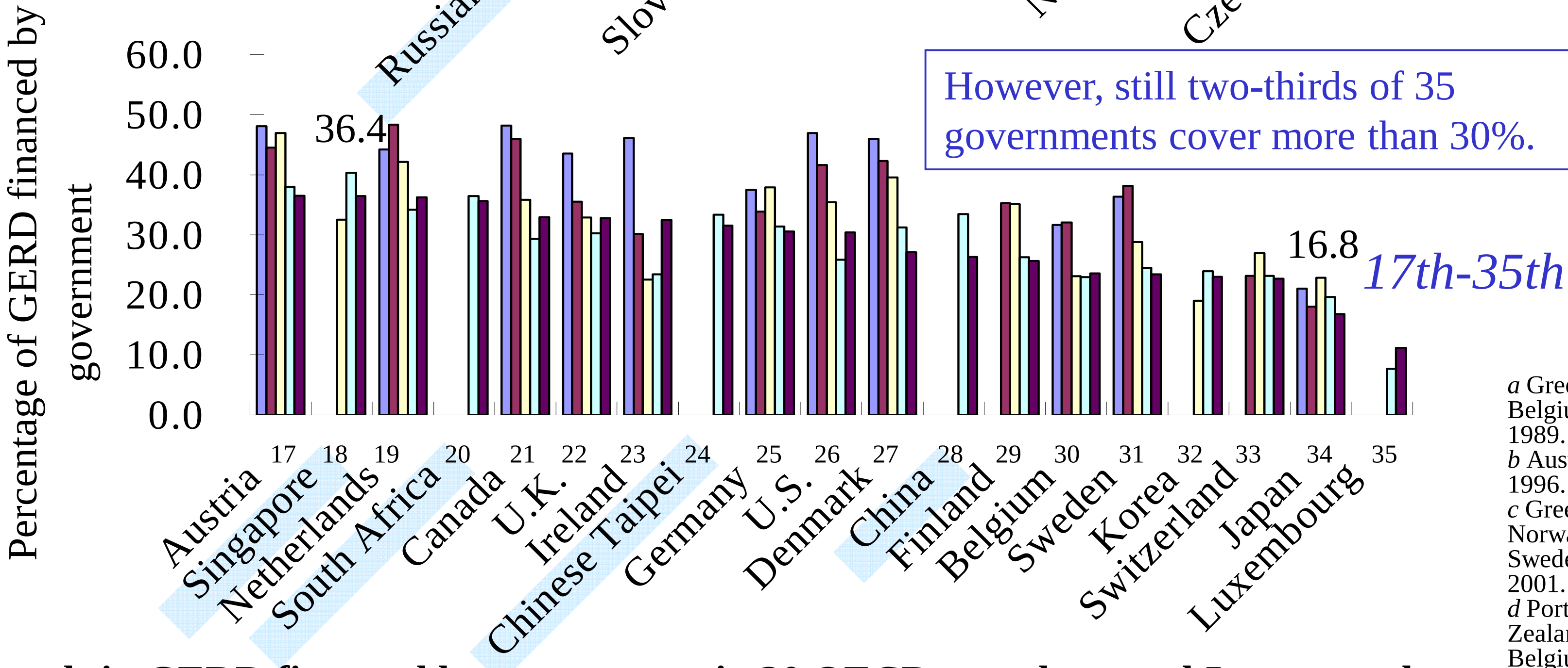


a Switzerland, Australia: 1986.
b Sweden, Belgium, Norway: 1989.
c Switzerland: 1996; Australia: 1994; South Africa: 1993.
d Sweden, Denmark, Norway, New Zealand, Greece: 1999; South Africa: 2001.
e Switzerland, Netherlands, Australia, Italy, South Africa, Turkey: 2004; New Zealand: 2003

Trends in Gross Domestic Expenditure on R&D (GERD) in 30 OECD members and 5 non-members *(1985-2005).*

(2) R_g / R
(Government support ratio)





Trends in GERD financed by government in 30 OECD members and 5 non-members *(1985-2005).*

a Greece, Norway, Finland, Belgium, Sweden, Switzerland: 1989.
b Australia: 1994; Switzerland: 1996.
c Greece, New Zealand, Norway, Iceland, Denmark, Sweden: 1999; South Africa: 2001.
d Portugal, Greece, New Zealand, Netherlands, Denmark, Belgium, Sweden, Luxembourg: 2003; Turkey, Spain, Australia, France, South Africa, Germany, Switzerland: 2004.

Key Figures in 30 OECD members and 5 non-members *(2005)* [a] (1)

	Gross Domestic Product (Billion current PPP$)	GDP per capita (Thousand current PPP$)	GERD as a % of GDP	% of GERD financed by government	BERD as a % of GDP	**% of BERD financed by government**	Total researchers (Thousand)	Number of triadic patent families (priority year)	Technology balance of payments: Receipts (Billion current$)	Payments (Billion current$)
Australia	701.0	34.2	1.8	39.8	0.9	4.3	81.7	414.5		
Austria	283.2	34.4	2.4	36.5	1.6	6.4	28.2	300.9		
Belgium	345.6	33.0	1.8	23.5	1.2	5.8	32.0	332.9	6.6	5.4
Canada	1099.1	34.1	2.0	32.9	1.1	2.2	125.3	819.6	1.7	0.9
Czech Republic	210.9	20.6	1.4	40.9	0.9	14.7	24.2	15.2	0.3	0.8
Denmark	184.7	34.1	2.4	27.1	1.7	2.4	28.2	219.5		
Finland	162.2	30.9	3.5	25.7	2.5	3.8	39.6	263.8	2.7	2.2
France	1897.8	30.3	2.1	37.6	1.3	**9.3**	200.1	2463.3	5.2	3.2
Germany	2538.0	30.8	2.5	30.5	1.7	**5.9**	271.1	6266.0	31.6	28.3
Greece	328.4	29.6	0.5	46.4	0.1	4.4	17.0	13.3		
Hungary	176.4	17.5	0.9	49.4	0.4	3.9	15.9	36.6		
Iceland	10.7	36.2	2.8	40.5	1.4	2.8	2.2	5.3		

[a] Statistics in 2004, 2003, or 2002 are used for those countries that 2005 statistics are unavailable.

Key Figures in 30 OECD members and 5 non-members *(2005)* [a] (2)

	Gross Domestic Product (Billion current PPP$)	GDP per capita (Thousand current PPP$)	GERD as a % of GDP	% of GERD financed by government	BERD as a % of GDP	% of BERD financed by government	Total researchers (Thousand)	Number of triadic patent families (priority year)	Technology balance of payments: Receipts (Billion current$)	Payments (Billion current$)
Ireland	161.2	38.9	1.3	32.4	0.8	4.1	11.5	58.8		
Italy	1651.1	28.2	1.1	36.5	0.5	13.8	72.0	716.0	4.3	4.6
Japan	3932.0	**30.8**	**3.3**	**16.8**	2.5	**1.2**	704.9	15238.6	18.4	6.4
Korea	1067.2	22.1	3.0	23.0	2.3	4.6	179.8	3157.9	0.8	3.2
Luxembourg	32.1	70.2	1.6	11.2	1.3	2.5	2.1	23.6	2.8	0.9
Mexico	1119.1	10.8	0.5	45.3	0.2	5.7	48.4	20.5	0.0	0.6
Netherlands	573.0	35.1	1.8	36.2	1.0	3.4	37.3	1184.4	2.7	2.2
New Zealand	106.4	26.0	1.1	45.1	0.5	10.0	15.6	64.4	5.2	3.2
Norway	222.7	48.2	1.5	44.0	0.8	8.9	21.7	111.4	2.3	2.2
Poland	531.0	13.9	0.6	57.7	0.2	13.7	62.2	10.8	0.2	1.0
Portugal	211.6	20.1	0.8	60.1	0.3	5.3	21.0	8.5	0.6	0.9
Slovak Republic	86.1	16.0	0.5	57.0	0.3	26.7	10.9	2.8		

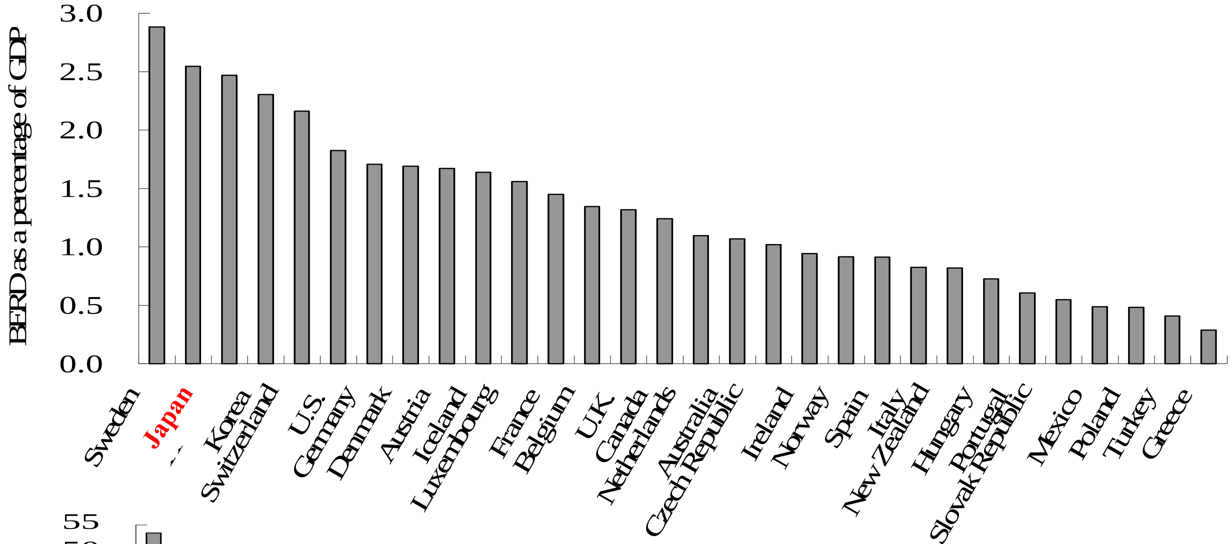
[a] Statistics in 2004, 2003, or 2002 are used for those countries that 2005 statistics are unavailable.

Key Figures in 30 OECD members and 5 non-members *(2005)* [a] (3)

	Gross Domestic Product (Billion current PPP$)	GDP per capita (Thousand current PPP$)	GERD as a % of GDP	% of GERD financed by government	BERD as a % of GDP	% of BERD financed by government	Total researchers (Thousand)	Number of triadic patent families (priority year)	Technology balance of payments: Receipts (Billion current$)	Technology balance of payments: Payments (Billion current$)
Spain	1189.1	27.4	1.1	41.0	0.6	12.5	109.8	200.9		
Sweden	290.0	32.1	3.9	23.5	2.9	5.9	54.2	652.5		
Switzerland	267.4	35.6	2.9	22.7	2.2	1.5	25.4	800.7	7.5	8.1
Turkey	555.7	7.7	0.7	57.0	0.2	4.2	33.9	27.3		
U.K.	1978.8	32.9	1.8	32.8	1.1	**8.6**	0.0	1587.8	29.2	14.4
U.S.	12397.9	41.8	2.6	30.4	1.8	**9.7**	1394.7	16368.3	57.4	24.5
China	8608.6	6.6	1.3	26.3	0.9	4.6	1118.7	433.3		
Russian Federation	1559.9	10.9	1.1	61.9	0.7	53.6	88.9	48.7	0.4	1.0
Singapore	130.2	**30.0**	**2.4**	**36.4**	1.6	**6.2**	464.6	95.3		
South Africa	562.4	12.0	0.9	35.6	0.5	7.7	23.8	33.0		
Chinese Taipei	641.2	28.2	2.5	31.5	1.7	2.2	17.9	134.9	0.3	1.6

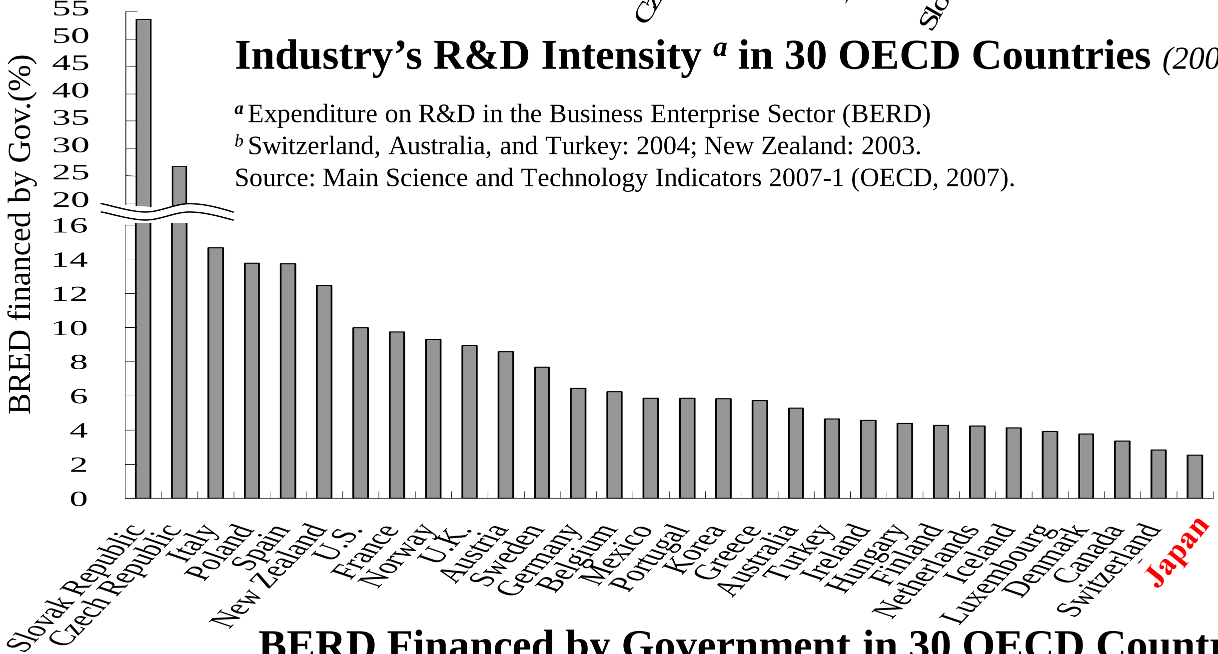
[a] Statistics in 2004, 2003, or 2002 are used for those countries that 2005 statistics are unavailable.

(3) Japan’s Catalysis Mechanism



Industry’s R&D Intensity [a] in 30 OECD Countries *(2005)*[b].

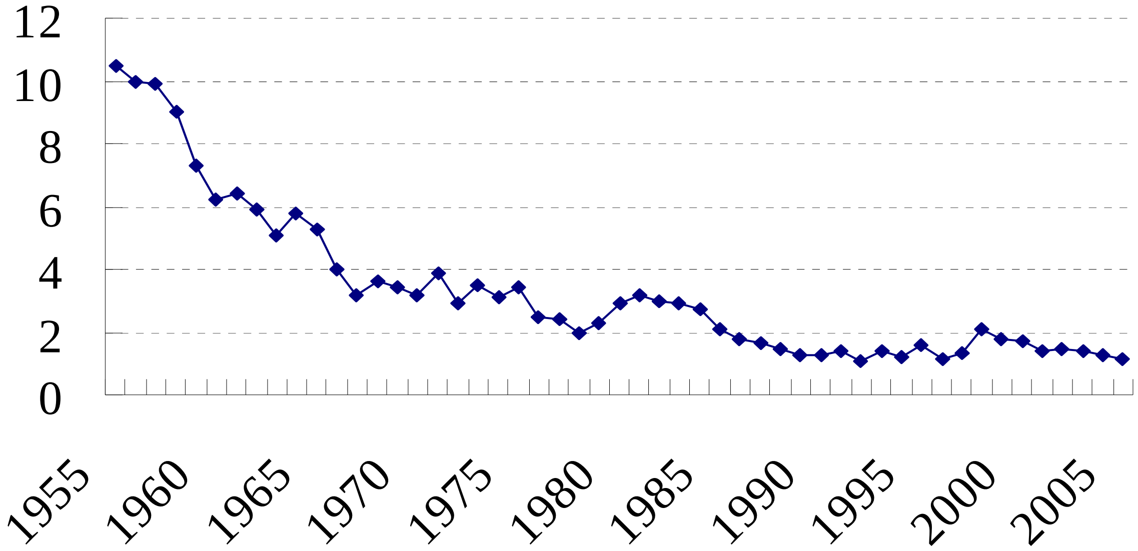
[a] Expenditure on R&D in the Business Enterprise Sector (BERD)
[b] Switzerland, Australia, and Turkey: 2004; New Zealand: 2003.
Source: Main Science and Technology Indicators 2007-1 (OECD, 2007).



BERD Financed by Government in 30 OECD Countries *(2005)*[a].

[a] Italy, Spain, France, Austria, Germany, Belgium, Australia, Turkey, and Switzerland: 2004; New Zealand,
[b] Sweden, Portugal, Greece, Netherlands, Luxembourg, and Denmark: 2003.
Source: Main Science and Technology Indicators 2007-1 (OECD, 2007).

1.6.2 Government Support for R&D Investment by Industry



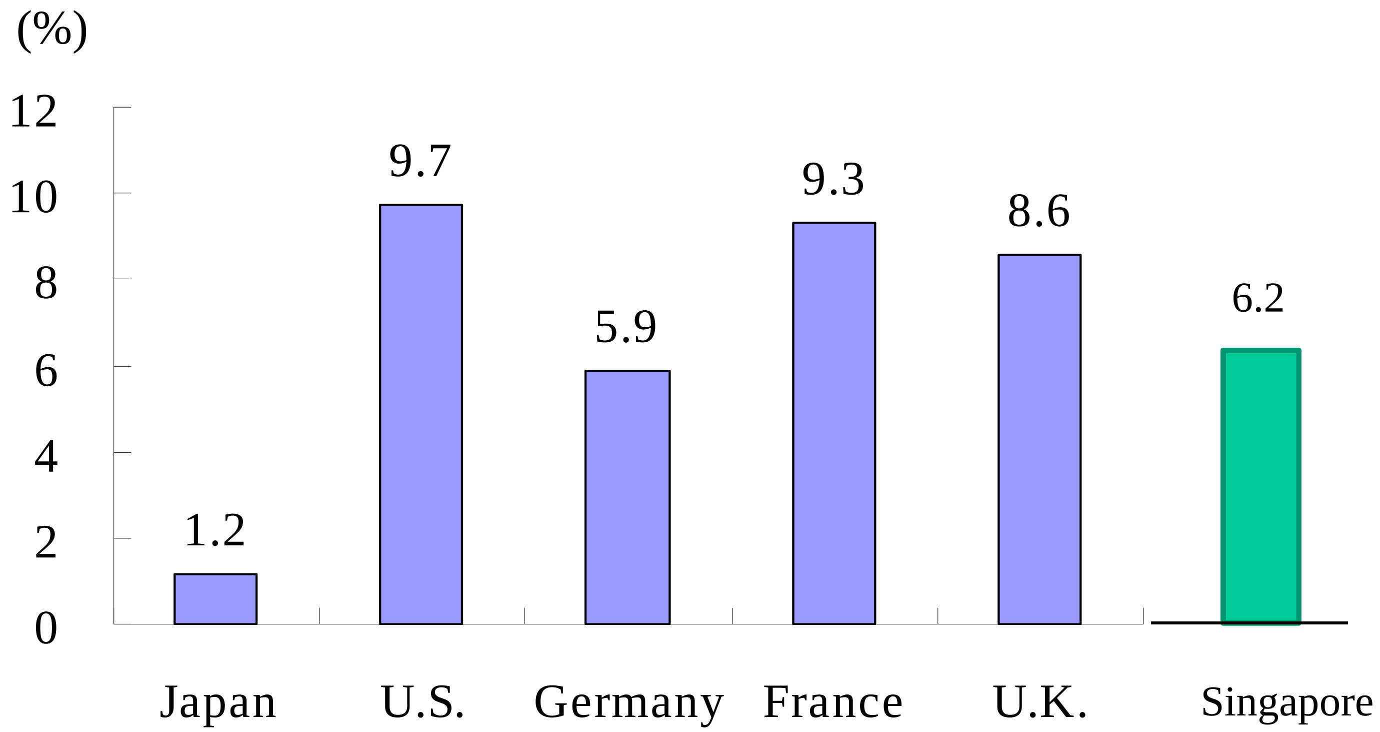
Trends in Japan's governmental Support for R&D Investment by Industry *(1955-2005)* - *%.*

Ratio of government R&D funds in industry's R&D expenditure.
Sources: Wakasugi (1986), AIST of MITI, White Paper on Japanese Science and Technology (Science and Technology Agency: Annual issues), and OECD.

Comparison of Governmental Support for Industry R&D Investment in Advanced Countries *(2005)* - %

Japan	USA	Germany	France	UK	S'pore
1.2	9.7	5.9	9.3	8.6	6.2

[a] Ratio of government R&D funds in industry's R&D expenditures.
[b] Germany and France are in 2004.



Comparison of Government R&D Fund in Industry in Advanced Countries ***(2005)***.

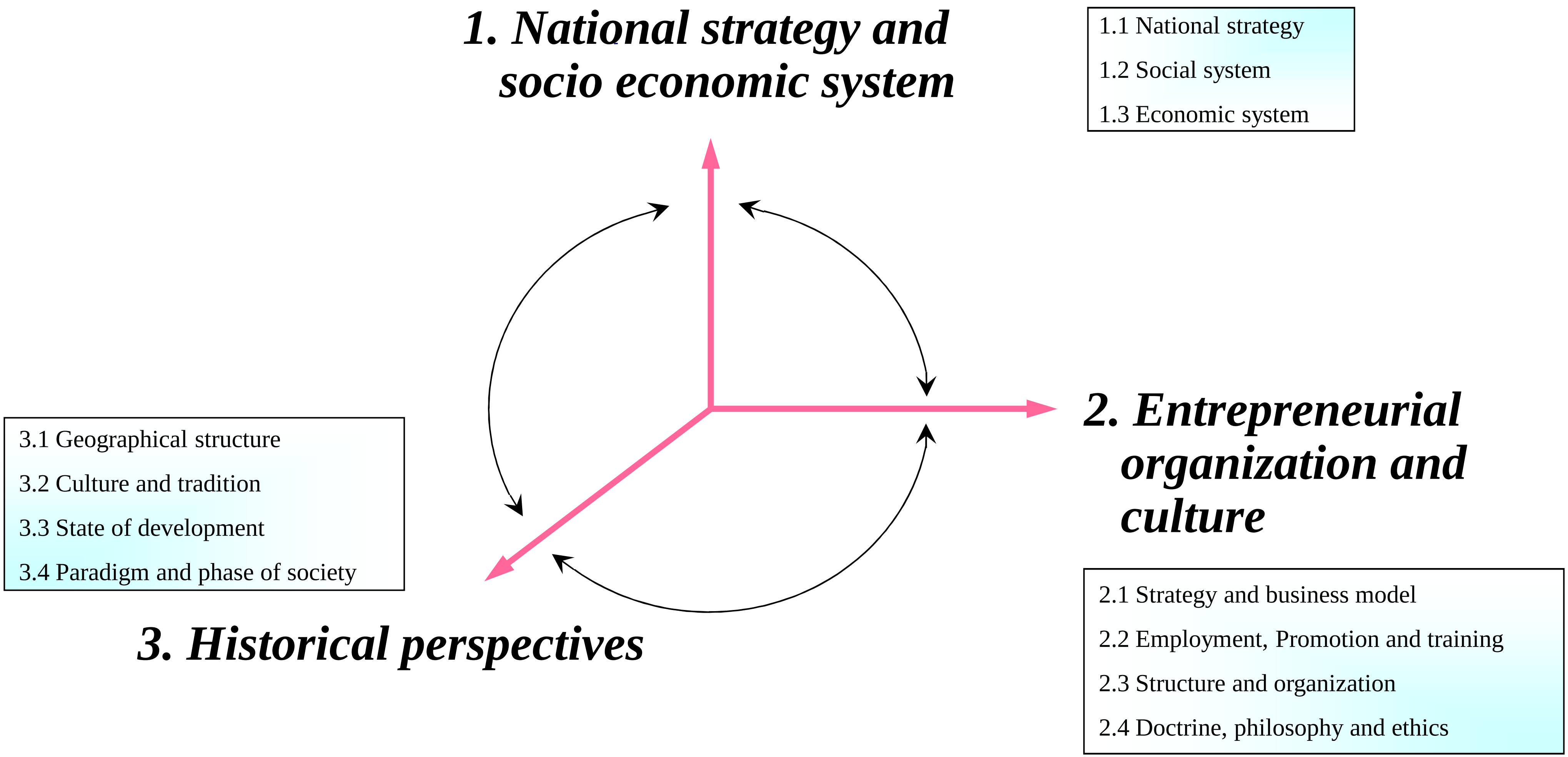
[a] Ratio of government R&D funds in industry's R&D expendifurns.
[b] Germany and France are in 2004.

Source: 1955-1985: MITI; 1985-2005: OECD, 2007.

1.6.3 System Stimulating Governance

(1) Three Dimensional Structure of Institutional Systems

Institutional systems are similar to soil in that they cultivate emerging innovation realized by means of 3 dimensional system.



Three Dimensional Structure of Institutional Systems.

(2) *Three Dimensional Structure of Institutional Systems*

Institutional systems are similar to soil in that they cultivate emerging innovation realized by means of 3 dimensional system.

1. National strategy and socio - economic system

1.1 National strategy

- 1.1.1 Democracy
- 1.1.2 Constitution, Law, Regulation, Standard, Manner
- 1.1.3 Separation of the three powers of *Administration, Legislation*, and *Judicature*

1.2 Social system

- 1. 2.1 Education system
- 1.2.2 Employment system
- 1.2.3 Infrastructure investment

1.3 Economic system

- 1.3.1 GDP and GDP per capita
- 1.3.2 Trade- based nation, Export and Import
- 1.3.3 Tech- based nation, ICT and Government ICT

2. Entrepreneurial organization and culture

2.1 Strategy and Business model

- 2.1.1 Vision and Business strategy
- 2.1.2 Business model and Market policy
- 2.1.3 R&D and ICT

2.2 Employment, Promotion and Training

- 2.2.1 Appointment
- 2.2.2 Promotion
- 2.2.3 Training

2.3 Structure

- 2.3.1 Entrepreneurial organization
- 2.3.2Affiliated firms
- 2.3.3 Foreign capital

2.4 Doctrine, Philosophy and Ethics

- 2.4.1 Business doctrine and Culture
- 2.4.2 Philosophy and Ethics
- 2.4.3 Corporate governance

3. Historical perspectives

3.1 Geographical structure

- 3.1.1 Geopolitical environment
- 3.1.2 Population
- 3.1.3 Homogeneous/Heterogeneous, Gini index

3.2 Culture and Tradition

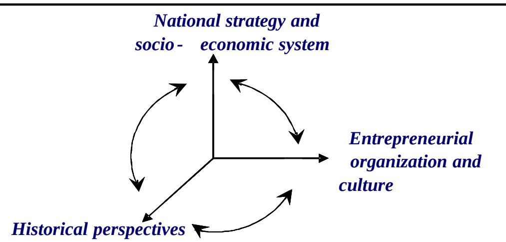
- 3.2.1 Culture, Custom and Common idea
- 3.2.2 National spirit, Moral ethic, Manners and Customs
- 3.2.3 Religion

3.3 State of development

- 3.3.1 Rapid economic growth
- 3.3.2 Mature economy
- 3.3.3 Diminishing population and Aging trend

3.4 Paradigm and phase of industrial society

- 3.4.1 Indust . society, Inform. society, Post- inform. society
- 3.4.2 Heavy and chemical industrial structure
- 3.4.3 Knowledge- intensified industrial structure



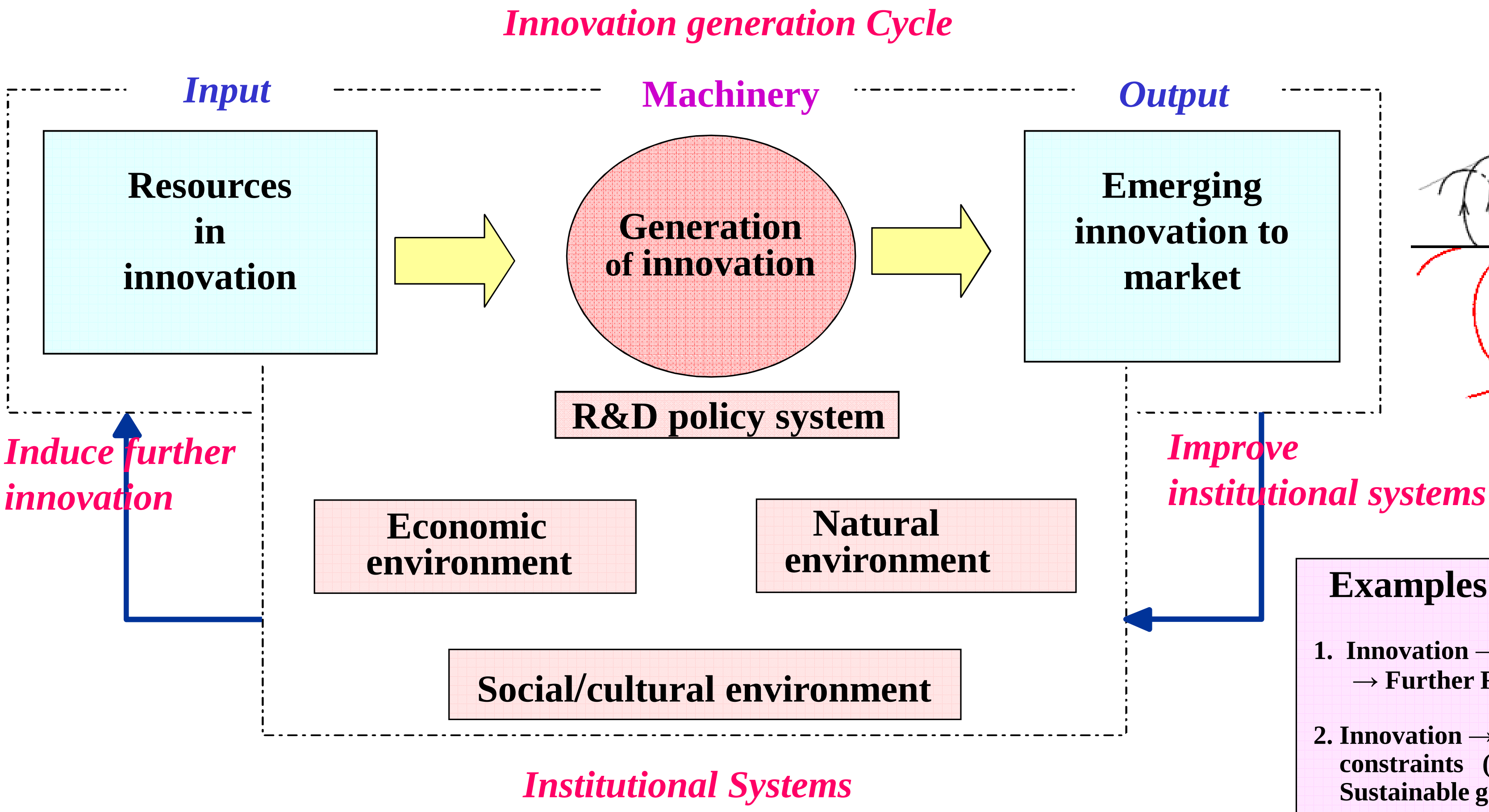
3 Dimensions of Institutions

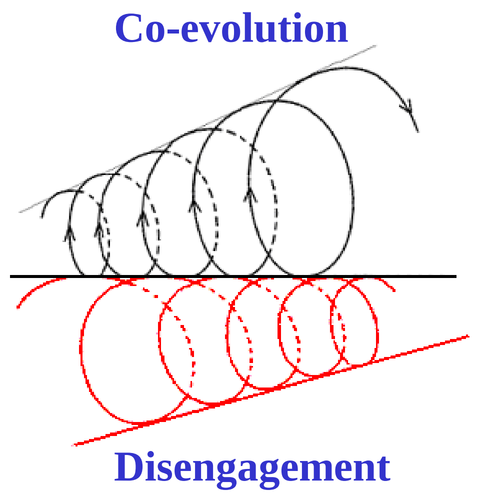
Source: Watanabe and Zhao et al. *(2006).*

Three Dimensional Structure of Institutional Systems.

(3) Institutional Systems for Innovation

1. Emerged innovation improves institutional systems which in turn induces further innovation (**co-evolution**).
2. This inducement may stagnate if institutional systems cannot adapt to evolving innovation (**disengagement**).





Scheme of Institutional Systems for Innovation.

Examples of co-evolution

1. **Innovation → Economic growth → Further R&D**
2. **Innovation → Breakthrough growth constraints (e.g. energy) → Sustainable growth**
3. **Innovation → Advancement of IT → Death of distance**

1.6.4 Foundation of Japan's Economic Development after WW Ⅱ

External factor

1. Free trade system
2. Stable exchange rate
3. Cheap and stable energy supply

Grave Situation → Stiff repulsive power
(External shocks and crises)

Internal factor

1. **High level of education**
   - Social mobility
   - Fair income distribution
   - High quality used demand
   - Competitive nature of the society
2. **Diligence/commitment of workers/managers**
   - Zero defect, QC, TQC, CWQC
   - Active improve imported tech.
3. **Highly organized systems and customs**
   - (1) Seniority system
   - (2) Life time employment
   - (3) Enterprise unions
   - Gaining consensus and trust
   - Smooth assimilation
4. **Enlightened management strategy**
   - Long-term consideration
   - Active and flexible approach
   - Dependency on Government policy

→

Severe competition

User demand for high quality

Active inter- industry stimulation

Mutual stimulation between dynamic change in industrial structure and R&D

Political stability *(1955-1993)*
Successive trends in catch-up and growth *(1945-1990)*

Foundation of Japan's Economic Development after World War Ⅱ.

1.6.5 Socio-cultural Systems Enabled Japan's Technology Assimilation

1. Socio-cultural foundation cultivated through the Edo period *(1603-1867)*

[a] Homogeneity of the nation, [b] High educational level, [c] Regional technology exchange, [d] Active information flow by "Sankin Kotai"

Cultural elasticity, Adopt and internalize ability, Pragmatism

2. Flood of western civilization and culture triggered by

[a] Unexpected call by the US vessel in 1853 → [b] Meiji Restoration in 1868

3. Japan's basic policy against the flood

Introduce and adopt a new civilization while being based its selection on

[a] Examination of traditional values, customs and institutions previously thought to have absolute value,

[b] Objective appreciation of the excellence of western civilization and culture from efficiency/higher quality of life view

4. Meiji Government's *(1868-1912)* **policy**

(1) Nat. targets/principle: [a] Japanese spirit and western learning, [b] Increase ind. prod. [c] Wealth and military

(2) Policies:

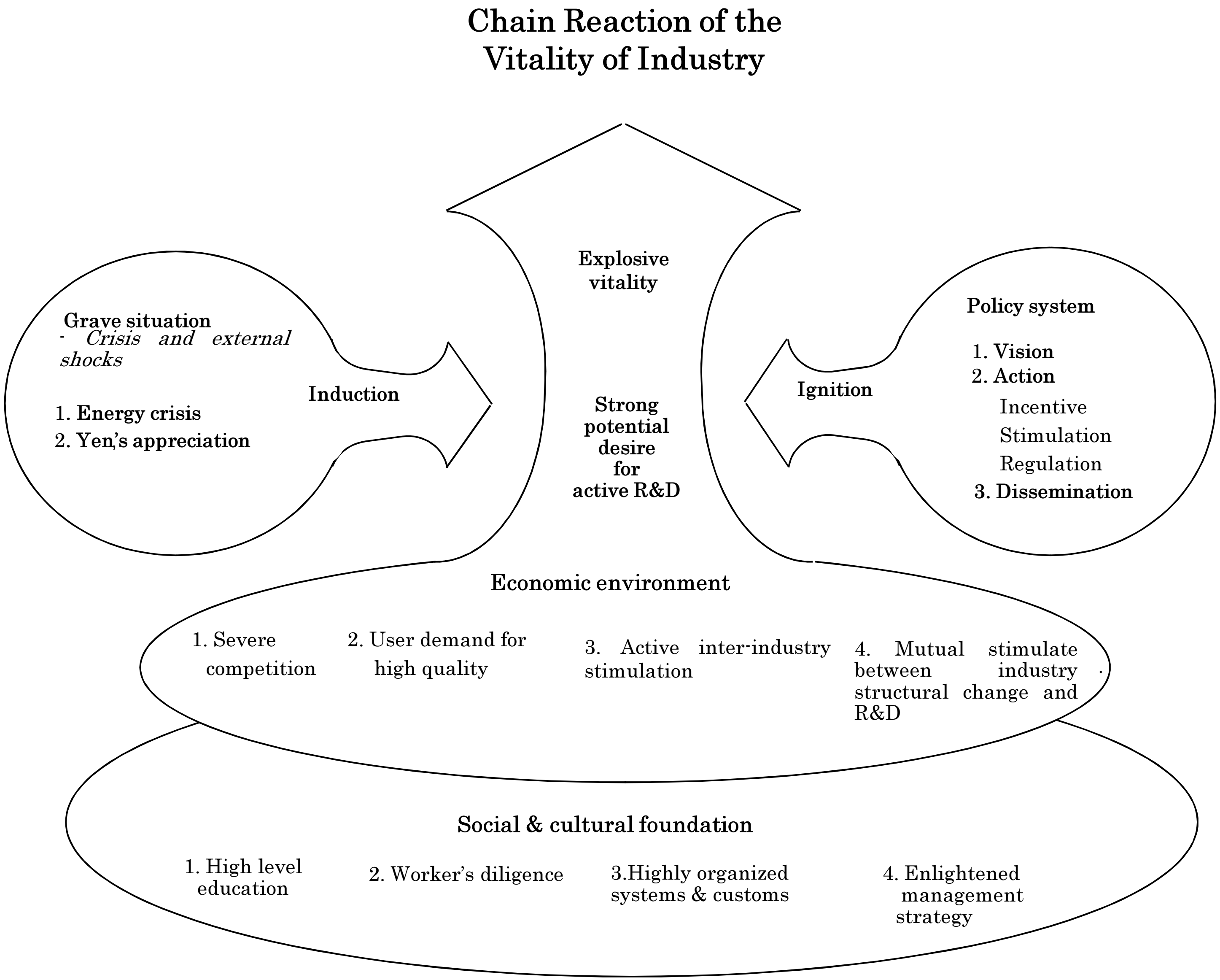
(i) Cultivating Japanese spirit: [a] Educational system, [b] Moral ethic

(ii) Western learning: [a] Literature, [b] Advisers, [c] Model factories, [d] Advanced machinery, [e] Sending youth

Introd., adopt., assimilat. and develop. of western tech. selectively into Japanese social and cultural system without spoiling indig. culture

Socio-cultural Systems Enabled Japan's Smooth and Effective Technology Assimilation.

1.6.6 Inducing Mechanism



Scheme of the Mechanism for Inducing Industry's Vigorous R&D Activities in Japan.

1.6.7 Basic Scheme of Industrial Policy

Basic Principle

- Activate Free Competition in the Marketplace
- Stimulate the Competitive Nature of Industry
- Induce the Vitality of Industry

Approach

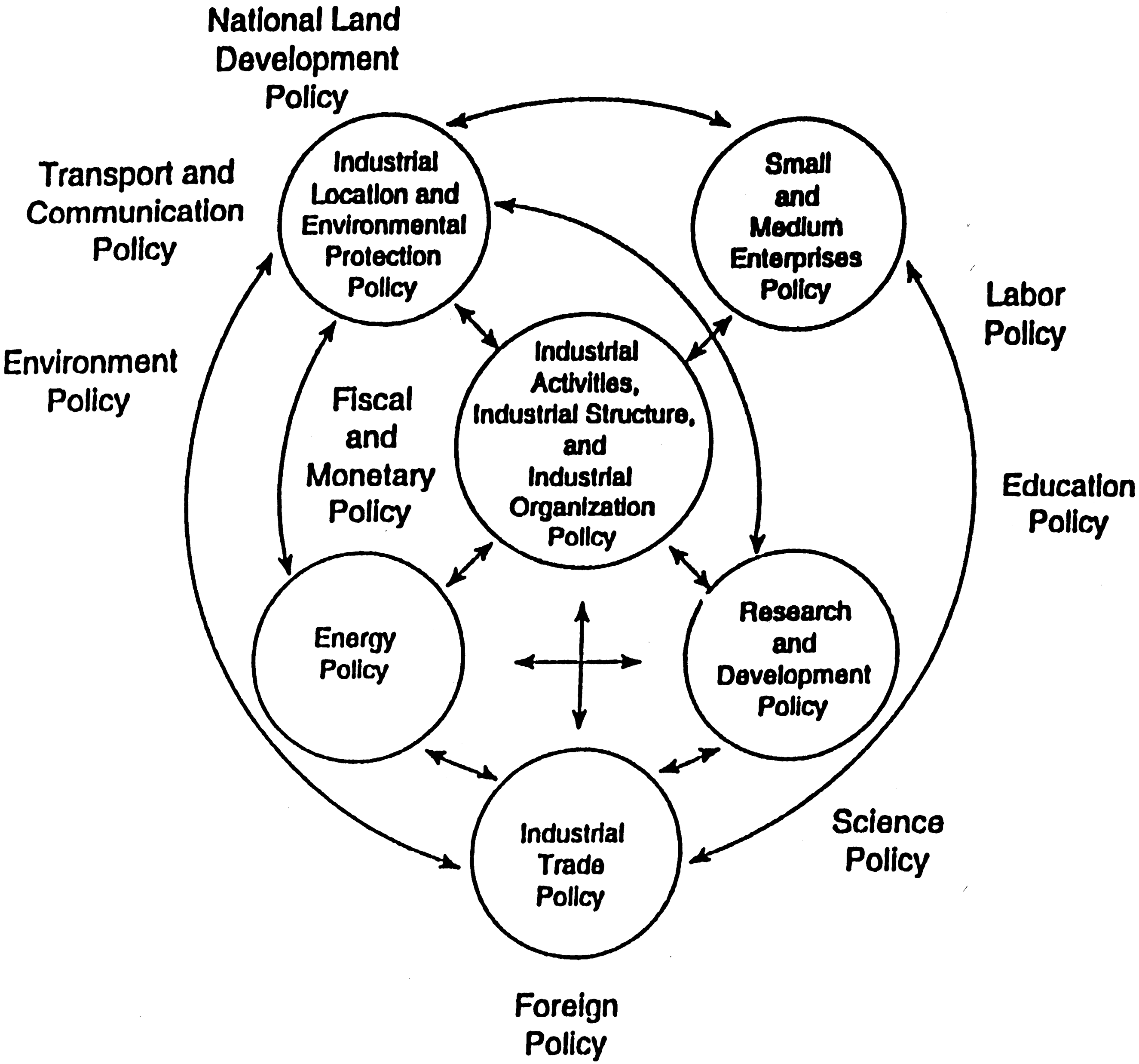
- Leading-edge Technology Foresight
- Maintain Close Cooperation with Related Industrial Policies
- Depend on an Active and Flexible Approach
- Best Utilize Innovative Human Resources in National Research Laboratories. and Universities.
- Organize Tie-ups between Industries, Universities and Government

Policy Formation/Implementation

• Vision	Penetration, Identification, Providing Direction, Instilling Confidence, Developing General Consensus
• Action	Incentive: National Research Laboratory, R&D Program, Investment, Conditional Loans, Financing, Tax Exemption Stimulation: R&D Consortium, Publication, Open Tender Regulation: IPR, Monopoly, Accounting
• Dissemination	Diffusion, Transfer, Demonstration, Public Procurement

Basic Scheme of MITI’s Industrial Technology Policy.

1.6.8 Policy Web



Relationship of Major Industrial Policies.

Trends in Japan's Industrial Structure Policy and Chronology of MITI Initiated R&D Programs

1960s Heavy and chemical industrial structure

1963 MITI's Vision for the 1960s

1966-	The Large Scale R&D Project	Leading technology

1970s Knowledge-intensive industrial structure

1971 MITI's Vision for the 1970s

1974-	The Sunshine Project (R&D on New Energy Technology)	Oil-substituting energy Technology
1976-79	The VLSI Project (Very large scale integrated circuit)	Innovative computer Technology
1976-	The R&D Program on Medical & Welfare Equipment Technology	Medical and welfare Technology
1978-	The Moonlight Project (R&D on Energy Conservation Technology)	Technology for improving energy productivity

1980s Creative knowledge-intensive industrial structure

1980 MITI's Vision for the 1980s

1981-	The R&D Program on Basic Technologies for Future Industries	Basic and fundamental Technology
1982-91	Fifth Generation Computer Project	Innovative computer Technology
1985-	Key Technology Center Project (Industrial R&D on Fundamental Technology)	Fundamental technology initiated by industry

1990s Creation of Human-values in the global age

1990 MITI's Vision for the 1990s

1990-	The R&D Program for Global Environment Industrial Technology	Global environmental technology

National R&D Programs

1966- The National R&D Program (Large-Scale Project)

1974- R&D on New Energy Technology (The Sunshine Project)

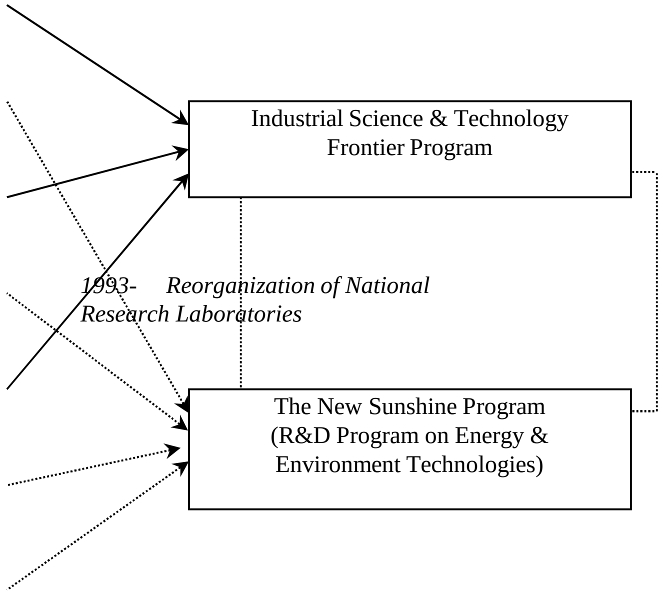
1976- R&D on Medical & Welfare Equipment Technology

1978- R&D on Energy Conservation Technology (The Moonlight Project)

1981- The R&D Program on Basic Technologies for the Future Industries

1989- The Designated Research Frame in the Global Environment Field

1990- The R&D Program for Global Environment Industrial Technology



Stimulation of R&D Initiated by the Private Sector

1951- Financing for Industry's New Technology — Japan Development Bank

1967- Tax Incentives for Technological Development

1980- Conditional Loans for Energy R&D (oil substitution)

1981- Conditional Loans for Energy R&D (new power generation)

1985- R&D on Fundamental Technology (investment/financing) — The Japan Key Technology Center

1988- International Joint Research Grant Program

1993- Conditional Loans for Energy R&D (rational energy use)

Chronology of MITI Initiated National R&D Programs.

Chronology of Major Science and Technology Policies in Japan *(1995-2006)*

1995 Science and Technology Basic Law

1996 1st Basic Plan for Science & Technology *(1996-2000)*

1997 Guideline for Technology Evaluation

1998 TLO Act
Program for the Science & Technology Development for Industries that Creates New Industries
consists of **(i) R&D Projects on New Industrial Science& Technology Frontiers,**
(ii) R&D Projects on Application of Industrial Technologies,
(iii) R&D Projects in Cooperation with Academic Institutions, and
(iv) R&D Cooperative Project with Industry *(from 2000)*

1999 Industrial Competitiveness Council

2000 National Industrial Technology Strategy → ***Flexibility, Adoptability and Cooperativity of Ind. Gov. and Univ.***
Industrial Technology Strengthening Act

2001 Structural reform of the central government
MITI →METI, STA and Min. Education →MEXT
MITI's 14 research institutes →AIST (Independent Administrative Institution)
Comprehensive Science & Technology Council
2nd Basic Plan for Science & Technology *(2001-2005)*

2002 21st Century COE Program

2003

2004 National University Corporation

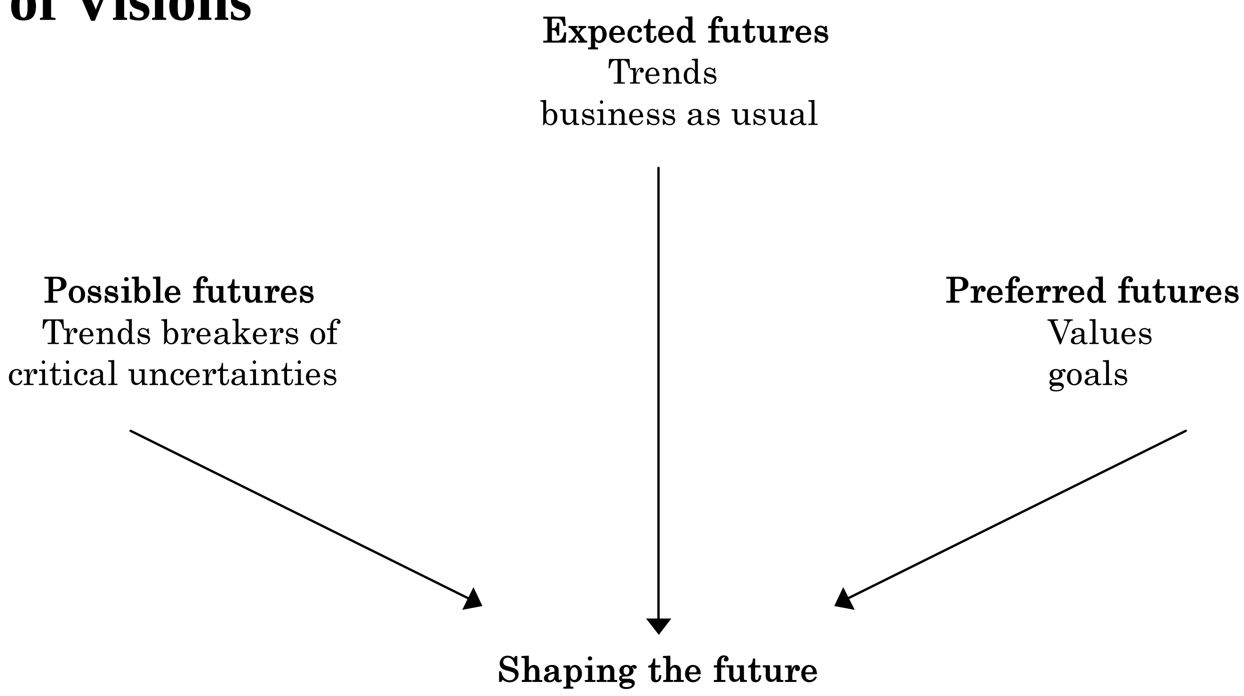
2005 Japan's National Innovation Ecosystem *(Ind. Structure Council of METI)*

2006 3rd Basic Plan for Science & Technology *(2006-2010)*
Innovation 25

2011 4th Basic Plan for Science & Technology *(2011-2015)*

1.6.9 Visions and Governance

(1) The Role of Visions



Visions

Provide a vehicle
for synchronizing
possible, expected and preferred futures
by
perceiving the future directions,
identifying long-term goals,
creating consensus,
instilling confidence, and
establishing the respective sharing of responsibilities
by broad sectors concerned.

(2) The Significance of Visions

(i) Horizontal perspective

"Visions" are formulated in view of a total comprehensive system (general industrial policy) **consideration, not a simple sub-system** (industrial technology policy) **consideration.**

(ii) Vertical perspective

"Vision" issues relevant to engineering have been further considered by a special advisory committee with expertise on engineering while maintaining a consistency and close interaction with general industrial policy.

(iii) Joint product

"Visions" are joint products resulting through joint work and open discussion between government and representatives from a broad spectrum, including:
industrial circles, academia, financial institutions, small business, consumers, labor, local public entities, and the media.

(iv) Prompt policy reaction

Prompt policy reaction in such a way as establishing national R&D Programs has been implemented by the government in response to Recommendations raised in "Visions."

(v) Fair return to contributors

Contributors to the "Visions," particularly industry and academia, have been given the opportunity to participate in R&D consortia and to conduct the R&D which they proposed as essential to their future.

(3) Characteristics of Visions

(i) Concrete blueprint

Neither philosophical nor a general picture
but concrete blueprint.

(ii) Close interaction with total system

Not a subsystem consideration
but maintains consistency and close interaction with general policy.

(iii) Soft technology for shaping the future

Neither a plan with a means of execution nor simple prediction
but a soft technology of public administration for shaping the future.

(iv) Synchronization of three futures

The future to be shaped is
not limited to only expected futures, possible futures or preferred futures
but a synchronization of these three futures.

(v) Shaping and realizing the future

Outcomes are promptly responded to through policy implementation
in which contributors to the formulation are broadly involved.

Promote a joint effort regarding
Actions for shaping the future and
the realization of the "Vision."

(4) Important Aspects of the Foresight Process

(i) Communication
bringing together disparate groups of people and providing a structure within which they can communicate;

(ii) Concentration on the linger-term
forcing individuals to concentrate seriously and systematically on the longer-term

(iii) Coordination
enabling different groups to coordinate their future R&D activities;

(iv) Consensus
creating a measure of consensus on future directions and research priorities;

(v) Commitment
generating a sense of commitment to attained results among those who will be responsible for translating them into research advances, technological developments and innovations for the benefits of society;

(vi) Comprehensive analysis and consideration
not a subsystem consideration but maintaining a consistency and close interaction with the total system;

(vii) Concrete perspective
not only a general macro analysis and shaping but also micro in-depth analysis and concrete shaping in a vertical manner; and

(viii) Consortia directing
new major long-term R&D efforts are generally proceeded by establishing R&D consortia in which contributors to a "Vision" participate and realize their proposals raised during the process of "Vision" formulation.

(ix) Credibility

(5) Implications for Science and Governance

(i) Two Trajectories

In the 1990s: Vicious cycle of science & technology
inducing socio-economic development

Proceeding decades: Virtuous cycle of science & technology
↓ inducing socio-economic development

(ii) The Sources of the Success

Sophisticated governance of science & technology
towards constructing a virtuous cycle

(iii) New Paradigm

Low, zero or minus economic growth
Globalization,
Diversification of nations interest
Increasing complexity of science & technology

(iv) New Sophisticated System

－Restructuring of a virtuous cycle between Visions indigenous function and associated policy instruments including national R&D program and consortia

－A stronger interdisciplinary challenge based on inter-ministerial joint approach and Prime Minister’s initiative

－Remidation and improvement of assimilation capacity

－Building stronger linkage between university and industry

－IT diffusion and capturing the momentum of the digital revolution