Science of Institutional MOT

- Elucidation of Japan’s Co-evolutionary Dynamism Accruing to Global Assets

Tokyo Institute of Technology

Dept. of Ind. Eng. & Mgmt., Graduate School of Decision Science and Technology
Graduate School of Science and Engineering
Center for Research in Advanced Financial Technology
Dept. of Computer Science, Graduate School of Information Science and Engineering

Leader : WATANABE, Chihiro, Professor, Dept. of Ind. Eng. & Mgmt.
Sub leader : ENKAWA, Takao, Professor, Dept. of Ind. Eng. & Mgmt.
Planning coordinator : MIYAKAWA, Masami, Professor, Dept. of Ind. Eng. & Mgmt.
Planning coordinator : UMEMURO, Hiroyuki, Associate Professor, Dept. of Ind. Eng. & Mgmt.
Planning coordinator : SENOO, Dai, Associate Professor, Dept. of Ind. Eng. & Mgmt.
Outline of the 21st Century COE Program

1. The 21st Century COE Program was established by MEXT in 2002 aiming at establishing research and education bases (centers of excellence: COE) across a range of academic disciplines. These COEs are expected to enhance the standard of Japanese research to the world highest level while fostering creative people of a caliber to become world leaders in their respective field. They will also help to raise the universities' international competitiveness and to enhance unique characteristics by prioritizing the funding system.

2. The selected COE centers meet the following expectations:
   (1) Potential for excellent research output.
   (2) Committed leadership and support from the top level.
   (3) Novelty of the research and education program.
   (4) A clear research vision and roadmap for sustainable development.
   (5) A strong research track record.
   (6) Organization-wide support of the COE program.

3. The 21st Century COE Program selected 113 and 133 COE Centers in 2002 and 2003, respectively, across 5 academic fields. In 2004, out of 320 proposals applied, 30 COE centers are selected in the field of innovative sciences.

<table>
<thead>
<tr>
<th>2002</th>
<th>Life sciences</th>
<th>Chemistry, material sciences</th>
<th>Information sciences, electrical and electronic engineering</th>
<th>Humanities</th>
<th>Interdisciplinary, combined fields, new disciplines</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied</td>
<td>112</td>
<td>82</td>
<td>78</td>
<td>79</td>
<td>113</td>
<td>464</td>
</tr>
<tr>
<td>Selected</td>
<td>28</td>
<td>21</td>
<td>20</td>
<td>20</td>
<td>24</td>
<td>113</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>2003</th>
<th>Medical sciences</th>
<th>Mathematics, physics, earth sciences</th>
<th>Mechanical, civil, architectural and other fields of engineering</th>
<th>Social sciences</th>
<th>Interdisciplinary, combined fields, new disciplines</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied</td>
<td>138</td>
<td>86</td>
<td>106</td>
<td>105</td>
<td>176</td>
<td>611</td>
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<tr>
<td>Selected</td>
<td>35</td>
<td>24</td>
<td>23</td>
<td>26</td>
<td>25</td>
<td>133</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>2004</th>
<th>Innovative science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied</td>
<td>320</td>
</tr>
</tbody>
</table>
| Selected     | 30*                 * estimated
### Member of the Project Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliations</th>
<th>Interest &amp; Degree</th>
<th>Role of this project</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATANABE, Chihiro</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Technology Innovation, Ph. D.</td>
<td>Project leader, General coordination</td>
</tr>
<tr>
<td>ENKAWA, Takao</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Production Management, D. Eng.</td>
<td>System analysis on the driving force of innovation (Co-evolutionary analysis)</td>
</tr>
<tr>
<td>MIYAKAWA, Masami</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Applied Statistics, D. Eng.</td>
<td>Project subleader, General coordination</td>
</tr>
<tr>
<td>UMEMURO, Hiroyuki</td>
<td>Associate Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Ergonomics, D. Eng.</td>
<td>Japan’s system of innovation emergence</td>
</tr>
<tr>
<td>SENOO, Dai</td>
<td>Associate Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Management Theory, D. Com.</td>
<td>Member of planning and operation</td>
</tr>
<tr>
<td>MIZUNO, Shinji</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Optimization Theory, D. Sci.</td>
<td>System analysis on the driving force of innovation (Optimal theory)</td>
</tr>
<tr>
<td>MIYAZAKI, Kumiko</td>
<td>Professor, Graduate School of Science and Engineering, and Engineering for Strategic Planning</td>
<td>MOT, Ph. D.</td>
<td>System analysis on the driving force of innovation (International comparative analysis)</td>
</tr>
<tr>
<td>YAJIMA, Yasutoshi</td>
<td>Associate Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Mathematical Programming, D. Eng.</td>
<td>System analysis on the driving force of innovation (Operational analysis for resources of management)</td>
</tr>
<tr>
<td>MURAKI, Masaaki</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Environmental Management, D. Eng.</td>
<td>Japan’s system of innovation emergence (Environmental management)</td>
</tr>
<tr>
<td>ITOH, Kenji</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Ergonomics, D. Eng.</td>
<td>Japan’s system of innovation emergence (Technology risk)</td>
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<tr>
<td>TANAKA, Yoshitoshi</td>
<td>Associate Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Intellectual Property, M. Eng.</td>
<td>Inventory management of intangible assets (Organizational impeding factor)</td>
</tr>
<tr>
<td>SAEKI, Tomoko</td>
<td>Associate Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Intellectual Property, M. Pharm.</td>
<td>Inventory management of intangible assets (State of intangible assets utilization)</td>
</tr>
<tr>
<td>TSAO, De-bi</td>
<td>Associate Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Process Management, D. Eng</td>
<td>Inventory management of intangible assets (Inventory management analysis)</td>
</tr>
<tr>
<td>NAGATA, Kyoko</td>
<td>Lecturers, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Accounting Theory, D. Com</td>
<td>Inventory management of intangible assets (Evaluation of intangible assets)</td>
</tr>
<tr>
<td>IIJIMA, Junichi</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Information Systems, D. Eng.</td>
<td>Technology start-up in Japan’s institutional system (Analysis of information services)</td>
</tr>
<tr>
<td>MORI, Kinji</td>
<td>Professor, Dept. of Computer Science, Graduate School of Information Science and Engineering</td>
<td>Computer Science, D. Eng</td>
<td>Technology start-up in Japan’s institutional system (Technology management framework)</td>
</tr>
<tr>
<td>HIGA, Kunihiko</td>
<td>Professor, Center for Research in Advanced Financial Technology</td>
<td>Management Information Systems, Ph. D</td>
<td>Technology start-up in Japan’s institutional system (Start-up process)</td>
</tr>
<tr>
<td>KIMOTO, Tadaaki</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>History of Technology, Ph.D.</td>
<td>Historical suggestion on the institution co-evolving with innovation (History of technology)</td>
</tr>
<tr>
<td>YAMAZAKI, Masakatsu</td>
<td>Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>History of Science, D. Sci.</td>
<td>Historical suggestion on the institution co-evolving with innovation (History of science)</td>
</tr>
<tr>
<td>HACHIYA, Toyohiko</td>
<td>Associate Professor, Dept. of Ind. Eng. &amp; Mgmt., Graduate School of Decision Science and Technology</td>
<td>Corporate Finance, Ph. D</td>
<td>Historical suggestion on the institution co-evolving with innovation (Business management analysis)</td>
</tr>
</tbody>
</table>
1. Significance of the Project in the Context of Tokyo Tech’s Vision

To be able to:

• Explore new innovative fields based on Tokyo Tech’s comparative advantages.
• Challenge world top level research by establishing the COE Center.
• Dramatically advance innovative science through trans-departmental organization.

Organizational development over the last 58 years maintaining the world top level research and education in Industrial Engineering and Management

1. To establish new innovative science, “Science of Institutional MOT,” enabling any country with different institutions to effectively utilize its MOT leading to accruing global assets.

2. To establish a globally recognized top research center as a joint collaborative base with a graduate school of MOT (expecting far reaching dramatic impacts on advanced education and research at the graduate school)
2. Research and Education Activities

– Necessary Conditions as a Top Level Research and Education Center

(1) Institutions – Core Element of the Project

Douglass North’s (1993 Nobel Laureate in Economics) Postulate

The humanly devised constraints that structure human interaction. They are made up of formal constraints (e.g. rules, lows, constitutions), informal constraints (e.g. norms of behavior, conventions, self-imposed codes of conduct), and their enforcement characteristics. Together they define the incentive structure of societies and specifically economies (North, 1994).

Postulate from Industrial Engineering and Management

“Soil” emerging innovation consisting of:
National strategy and socio-economic system,
entrepreneurial organization and culture, and
historical perspectives.

(2) MOT (Management of Technology)

1) Management of a cycle of technological innovation from its emergence to utilization.
2) Activation of the innovation cycle depends largely on the co-evolution with the institutions (change in innovation and also change in institutions)
Sow the seeds of technology + MOT (nutrition)

MOT in institutions

Non-adaptive

Adaptive

Seeds of technology will grow up, the soil could be improved and the growth could be accelerated (Virtuous cycle of co-evolutionary development)

\[
\begin{align*}
\frac{dx}{dt} &= x \cdot (a - bx - cy) \\
\frac{dy}{dt} &= y \cdot (d - ex - fy)
\end{align*}
\]

\(x\): Innovation  \\
\(y\): Institutions  \\
x, y are functions of MOT

Engineering approach: Elucidate the mechanism from scientific principle → Conceptualize and visualize the mechanism inside the black box → Operationalize to be useable to anyone

Institutions (soil) are also improved and evolved

Elucidation of co-evolutionary dynamism

→ Conceptualize and operationalize

Driving force of innovation

Growth
(4) Historical Evidence of Co-evolutionary Dynamism

1) Japanese management system up to the end of the 1980s actively introduced advanced technologies and systems from the US and Europe, and co-evolved these systems with its own institutions. The US and Europe were inspired by Japan’s advancement, leading to a propagating cycle. Japan learnt their inspired achievements and led to a propagating cycle.

Trajectory of Co-evolutionary Development of Japan’s System of MOT

2) TQM, for example, was developed by Tokyo Tech and Tokyo University by means of an engineering approach with the broad involvement of Japanese industries. This can be seen as a way of co-evolving with US originated quality control (QC) in Japan’s institutions, and accruing to global assets.

3) MOT, originated in the US in the 1980s, was aimed at regaining its competitiveness against Japanese firms, which led to the recovering of the US position in the 1990s.
(5) World Top Level Research and Education Center

1) The center aims at:

Elucidating, conceptualizing and operationalizing the co-evolutionary dynamism between innovation cycle and institutions, leading to accruing to global assets.
2) This ambitious challenge can only be possible by utilizing interdisciplinary collaboration throughout the Tokyo Tech group. This interdisciplinary group is the Center of Excellence in the field of science and engineering.

3) Department of Industrial Engineering and Management, which plays a leading role in this challenge, has experienced the following organizational development through research and education based on engineering and systems approach, covering the integrated process of development, production, logistics, distribution, consumption and disposal:

• Starting from operational level research centered by development and production based on science and engineering (1946-)

• Policy and strategy level initiated by the Techno-economic System course (1992-)

• Historical perspective stimulated (induced) by the Science and Technology History course (1996-)

• Engineering IPR course (2002-)
(6) Identity

1) This COE Center is unique throughout the world, since it initiates and conducts an ambitious challenge of **elucidating**, **conceptualizing** and **operationalizing** the co-evolutionary dynamism between innovation cycle and institutions, leading to **accruing** to global assets based on an engineering approach with three dimensions such as Operational Level Research, Policy and Strategy and Historical Perspectives.

2) Comparative world top level renowned research institutes include:

   a) **IIASA** (International Institute for Applied Systems Analysis in Vienna),

   b) **SPRU** (Science and Technology Policy Research Unit at the University of Sussex in Brighton),

   c) **CASRIP** (Center for Advanced Study and Research on Intellectual Property at the University of Washington in Seattle)

3) While these institutes share certain complementarities with this proposed center, they can not be compared in terms of the science and engineering approach and a management oriented practicality.
(7) Comparative World Top Level Renowned Institutes

(7) - 1 IIASA *International Institute for Applied Systems Analysis* (Vienna)

(i) Non-governmental international organization established in 1972. 18 member countries including Japan, the US, Germany, Russia and China.

(ii) *World COE in applied systems analysis.*

(iii) Challenge to elucidate global issues including *innovation*, energy and environment, and national security.

(i) Complementarity

Elucidation and modeling of the dynamism of the emergence of innovation by complementing applied systems analysis approach with engineering and business oriented practical approach.

(ii) Expectation

Maximize the benefits of the complementarity by dramatically advancing and developing the ongoing cooperation.
SPRU: Science and Technology Policy Research Unit (Brighton, UK)

(i) Complementarity

Conceptualize and operationalize the dynamism of the emergence of innovation by complementing policy oriented research with engineering and business oriented research.

(ii) Expectation

Maximize the benefits of the complementarity by developing comprehensive avenues of cooperation.

(i) The international academic center established in 1966, conducting policy oriented research and education by accepting worldwide researchers.

(ii) World COE in policy oriented research focusing on national systems of innovation.

(iii) Challenge to analyze the impacts of innovation and the inducing role of science and technology policy for its emergence.
(7) – 3 CASRIP : Center for Advanced Study and Research on Intellectual Property  
(Seattle, Washington, USA)

(i) Independent research and policy development institute established in 1987 and accredited by WIPO.

(ii) World COE in the analysis of intellectual property system.

(iii) Challenge to analyze the environment generating novel ideas in design, operation and administration of intellectual property systems in high technology.

(i) Complementarity

Identification of the effective role of the intellectual property regimes as an integral component of the institutions by complementing IP oriented analysis with the three dimensional comprehensive analysis.

(ii) Expectation

Maximize the benefits of complementarity by exploring exchange programs.
(8) Education at the Ph. D. Course

1) Educational Achievement

(i) Remarkable number of students (from all continents **20% Master and 40% in Ph. D. course**)

(ii) **Graduated 120 Ph. D. students since the establishment of the Ph. D. course in 1964.**

   a) Active acceptance of Ph. D. candidates from the business circle since 1992. (Graduated **40 students**)

   b) Graduated 30 Ph. D. students in the field of MOT.

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**Number of Ph. D. students** – current and graduated

<table>
<thead>
<tr>
<th></th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph. D. capacity</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Enrollment</td>
<td>11 (4)</td>
<td>14 (3)</td>
<td>15 (6)</td>
</tr>
<tr>
<td>From external univ.</td>
<td>8 (2)</td>
<td>11 (2)</td>
<td>9 (3)</td>
</tr>
<tr>
<td>Current number</td>
<td>13 (6)</td>
<td>30 (11)</td>
<td>51 (19)</td>
</tr>
<tr>
<td>Graduated number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course</td>
<td>4 (1)</td>
<td>7 (1)</td>
<td>8 (3)</td>
</tr>
<tr>
<td>Non-course</td>
<td>2 (0)</td>
<td>0 (0)</td>
<td>1 (0)</td>
</tr>
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</table>

Figures in parenthesis indicate students from abroad.
Examples of Ph. D. Dissertation Titles in the Last 3 years


(viii) An Analysis of Technology Structure Inducing Canon’s Technological Diversification Strategy (2002).


(9) Research

1) Research Achievements

(i) Publication in outstanding journals

(ii) Awards
US OR Society Lanchester Prize, US IAMOT Research award, IBM Japan Scientific award, Japan Society for Quality Control award, Reliability Engineering Association of Japan Takagi award, Japan Industrial Management Association award, Science and Technology Minister award, Minister of Transport award, Logistics Merit award, etc.

(iii) Lecture and presentation at international conferences (Keynote, invited and chair): Frequent.

(iv) International collaboration
IIASA (Austria), SPRU (UK), LISO National Research Institute (Denmark), Delft Institute of Technology (Netherlands), Australian Academy of Technological Science and Engineering, etc.

2) Research Grants

<table>
<thead>
<tr>
<th></th>
<th>JSPS Grant</th>
<th>Ministerial Grants</th>
<th>Foundation Grants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>9</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2002</td>
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<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2003</td>
<td>8</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

3) Mobility

Outstanding number of faculty members with experience in firms, government and other universities including three patent attorneys.

<table>
<thead>
<tr>
<th></th>
<th>Professors</th>
<th>Assoc. Prof.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current number</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>with external experiences</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>B/A ≥ 100</td>
<td>36 % (1)</td>
<td>40 % (2)</td>
</tr>
</tbody>
</table>

(1) Less than 2 years Experiences 86 %
(2) Similarly, 80 %
## 3. COE Center Establishment Plan

### (1) Innovativeness

<table>
<thead>
<tr>
<th></th>
<th>Traditional Leading Centers</th>
<th>Proposed Center</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(i) Target</strong></td>
<td>Interpretation and improvements of Japan’s system of MOT</td>
<td>Elucidation of the co-evolutionary dynamism between innovation and institutions taking primarily the illustrative case of Japan.</td>
</tr>
<tr>
<td><strong>(ii) Approach</strong></td>
<td>Social science approach: Observe and systematize the phenomenon.</td>
<td>Three dimensional engineering approach: Conceptualize and Operationalize. **(Policy and strategy level, Operational level, Historical perspective)**</td>
</tr>
<tr>
<td><strong>(iii) Vision</strong></td>
<td>International competitiveness of Japan and/or certain nations.</td>
<td>Creation of and accruing to global assets beneficial to mutual development of all nations in the world.</td>
</tr>
</tbody>
</table>

### (2) Historical Relevance

(i) Re-activation of Japan’s economy is indispensable to the revitalization of the world economy. A virtuous cycle between them is essential. Its triggering can be expected by reactivation of MOT.

(ii) This proposed center not only provides an invaluable blueprint, academic base and leaders for research and education towards the reactivation of Japan’s economy but also significant intellectual contribution towards the revitalization of the world economy.

(iii) Japan’s exceptional initiative towards the exploration of new horizons to international academic and economic contributions.
(3) Research Approach: Fundamental Research

— Innovative research approach by 5 research themes along 3 dimensions

Theme 1: Systems analysis on the interacting mechanism between market and technology as a critical driving force of innovation

[Watanabe, Miyazaki, Miyakawa, Mizuno, Yajima]

Theme 2: Identification of Japan’s system of innovation cycle

[Kimoto, Yamazaki, Hachiya]

Theme 3: Historical suggestion on the institution co-evolving with innovation

[Kimoto, Yamazaki, Hachiya]
(4) Education and Training Program in the Ph. D. Course

(4) - 1  3 Layered Structure Education and Training Program

[A] Fundamental Research

(i) Policy and strategy level
(ii) Operational level
(iii) Historical perspectives

[B] International Collaboration

(i) Invitation of overseas outstanding scholars
(ii) Education and training of outstanding international students
(iii) Sending excellent students/researchers to overseas COE

[C] Tie-ups with graduate school of MOT

1) MOT Leaders: Leading role at graduate school of MOT in and out of Japan
   - Business expertise + Academic expertise on MOT

   Potential demand of MOT leaders, 10000 p.a., while the present supply capacity is 500 p.a. and US 16000 p.a.

2) International Business Leaders: Worldwide dissemination of Japan’s system of innovation.
   (i) Deepening the understanding of Japan’s business model
   (ii) International contribution by unveiling Japan’s intangible assets

3) Young Research Leaders: Academic research on the Science of Institutional MOT
   – Leader of the next generation research on the Science of Institutional MOT established by this center
(4) - 2 Program for Education and Training

A. Invitation and acceptance
   - Invitation of overseas outstanding scholars
   - Invitation of business leaders with outstanding MOT expertise

B. Research and education
   - Global Excellence Development On-Business Research Experimental Program
   - Cooperation with selected enterprises implementing outstanding MOT
   - Gaining advice on forefront research from world top level scholars

C. Graduation of experts
   - Young research leaders
   - MOT leaders
   - Participation in GSM and joint research projects

Graduate School of MOT (GSM)
(5) Expected Outcomes after 5 years


### Research output

- Co-evolutionary Dynamism between Innovation Cycle and Institutions
- Elucidation
- Conceptualize and Operationalize
- Accruing to global assets

### Education output

- Graduation of more than 30 world competitive
- (i) MOT leaders
- (ii) International business leaders
- (iii) Young research leaders on science of institutional MOT

### Far reaching impacts

- Dramatically advanced education and research at the Graduate School of MOT

### Organizational output

- Establish the science of institutional MOT enabling any country with different institutions to effectively utilize its MOT leading to accruing global assets

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Establish the COE Center as a joint collaborative base with Graduate School of MOT leading to developing the Science of Institutional MOT