調査資料 **No. 121**

日米における **21** 世紀のイノベーションシステム：変化の **10** 年間の教訓

21st Century Innovation Systems for Japan and the United States: Lessons from a Decade of Change

国際シンポジウム報告書
International Symposium Report

2006 年 **3** 月
March 2006

文部科学省　科学技術政策研究所
第 **2** 研究グループ

Second Theory-Oriented Group
National Institute of Science and Technology Policy (NISTEP)
Ministry of Education, Culture, Sports, Science and Technology

21st Century Innovation Systems for Japan and the United States:
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Ministry of Education, Culture, Sports, Science and Technology, Japan

目次
Table of Contents

はじめに

日本でも米国でもイノベーションが 21 世紀の経済成長の主たる原動力であります。日米はそれぞれの国のイノベーション能力を強化する為に様々な改革と新規政策の導入を過去 10 年あまり行ってきました。産学連携の強化、知的財産の保護の強化、スタートアップ企業によるイノベーションの強化などです。

日本にとってこの 10 年間は、「失われた 10 年間」と呼ばれる経済成長の長期的な停滞期とほぼ一致しています。しかし、科学技術政策に関しては、着実に改革が進んだ時期でもありました。特に、1995 年に科学技術基本法が制定されたことは、科学技術システムの改革の重要な契機となりました。この法律に基づいて、1996 年度から 2000 年度までの 5 年間を対象とした第 1 期科学技術基本計画と、2001 年度から 2005 年度までを対象とした第 2 期科学技術基本計画が策定・実施されました。この間、厳しい財政状況にもかかわらず政府研究開発投資が拡充されるとともに、科学技術の戦略的重点化や、競争的な研究開発環境の整備、さらには国立試験研究機関や国立大学の法人化といった構造改革が実施されてきたのです。

科学技術政策研究所（NISTEP）では、こうした 10 年間の成果をそれ以前の状況や海外と比較しレビューする大規模なプロジェクトを、昨年度までの 2 年間に渡って実施しました。このレビューを通じて、日本の研究開発水準の向上や知的資産の増大を確認することができました。

このような状況のもとで、来年度からは第 3 期基本計画が実施されることになっています。先日公開されたこの計画の原案は、第 1 期・第 2 期基本計画期間の投資により向上した日本の潜在的な科学技術力を、経済・社会の広範な分野でのイノベーションの実現を通じて、日本経済と国民生活の持続的な繁栄を確実なものにしていけるか否かはこれからの取組にかかっていると指摘しています。つまり、現在の日本においては、イノベーション振興がこれまで以上に重要な政策課題となっているのです。このことは、この計画の基本理念である、科学技術が社会・国民に支持され、成果を社会・国民に還元することを目指す、という考え方にも現れています。この基本理念は、まさにナショナル・イノベーション・システムの強化を意味します。そして、この計画案で提案されている具体的な政策目標の多くが、イノベーション振興に関するものです。

一方、米国については、伝統的に多くのイノベーションを生み出してきた国であり、それが国の活力の源になってきたのだと思います。特に 1985 年のバイ＝ドール法制定以降のイノベーション振興のための様々な試みは、日本だけでなく各国の政策策定者や専門家たちにとって、学ぶべきことの多い先行事例であります。しかし、米国においてもイノベーション振興は容易な課題ではなく、試行錯誤はこれからも続けられていくのではないかと思います。

この国際シンポジウムは、これらの分野における日米の経験と教訓を共有し、21 世紀のイノベーションの在り方について方向性を得ることを目的として開催されました。日米の各分野の代表的な研究者に加えて、政府・大学・産業界から約 250 人が参加し、パネル I からパネル VII に分かれて両国からの発表があり、活発な討議・質疑応答が行われました。本報告書が、イノベーションの長期的な能力を強化していくに当たって、両国における過去のトレンドと現状から学ぶための一助となることを希望致します。

2006 年 3 月　科学技術政策研究所
所長　小中元秀

日米における **21** 世紀のイノベーションシステム：変化の **10** 年間の教訓

21st Century Innovation Systems for Japan and the United States: Lessons from a Decade of Change

国際シンポジウム

主催
文部科学省 科学技術政策研究所
全米アカデミー 科学技術経済政策委員会

共催
一橋大学イノベーション研究センター

2006 年 **1** 月 **10** 日－**11** 日

三田共用会議所
東京，日本

第 **1** 日：**2006** 年 **1** 月 **10** 日

9:30 AM 開会の辞

司会：犬塚 隆志，科学技術政策研究所 企画課長

小中 元秀，科学技術政策研究所 所長

9:45 AM 基調講演

座長：桑原 輝隆，科学技術政策研究所 総務研究官

米国のイノベーションシステムの挑戦
Challenges in the U.S. Innovation System
ドナルド・マンズーロ Donald Manzullo，合衆国下院議員 小企業委員会委員長

日本のイノベーションシステムの発展と挑戦
Evolution and Challenges to the Innovation System in Japan
薬師寺 泰蔵，総合科学技術会議議員／慶應義塾大学客員教授

11:00 AM コーヒーブレーク

11:15 AM パネル **I**：企業 **R&D** 支援における政府の役割の展開－米国と日本のモデル
Panel I: Government's Evolving Role in Supporting Corporate R&D—U.S. and Japanese Models
モデレーター：アリス・アムスデン Alice Amsden，マサチューセッツ工科大学教授

日本における技術政策：**1990** 年以降
Technology Policies in Japan: 1990 -
後藤 晃，東京大学先端科学技術研究センター教授／経済産業研究所ファカルティフェロー
元橋 一之，東京大学先端科学技術研究センター助教授／経済産業研究所ファカルティフェロー

企業 **R&D** 支援における政府の役割の展開：先進技術プログラム（**ATP**）における理論と実践
Government's Evolving Role in Supporting Corporate R&D: Theory and Practice in the Advanced Technology Program
ステファニー・シップ Stephanie Shipp，国立標準技術研究所（NIST） 先進技術プログラム（ATP）経済評価室 ディレクター

ディスカッサント
中島 一郎，東北大学未来科学技術共同研究センター長，教授

12:45 PM ランチ

2:15 PM パネル **II**：政府-産業間 **R&D** 協力－日米の実験

Panel II: Government-Industry R&D Partnerships - U.S. and Japanese Experiments

モデレーター：ロニー・エーデルハイト Lonnie Edelheit，ゼネラル・エレクトリック（GE）元 R&D 担当上席副社長／全米工学アカデミー

日本における半導体コンソーシアム：経験と教訓

Semiconductor Consortia in Japan: Experiences and Lessons

藤村 修三，東京工業大学大学院イノベーションマネジメント研究科教授／一橋大学イノベーション研究センター客員教授

中馬 宏之，一橋大学イノベーション研究センター教授／科学技術政策研究所客員総括主任研究官

国際 **R&D** 連携の経済的影響：**SEMATECH**、国際技術ロードマップ、及びマイクロプロセッサにおけるイノベーション

Economic Impacts of International R&D Coordination: SEMATECH, the International Technology Roadmap, and Innovation in Microprocessors

ケネス・フラム Kenneth Flamm，テキサス大学オースチン校 リンドン・B・ジョンソン公共政策スクール ディーン・ラスク国際関係講座長，教授

ディスカッサント

本城 薫，独立行政法人新エネルギー・産業技術総合開発機構（NEDO）理事

3:45 PM コーヒーブレーク

4:00 PM パネル **III**:スタートアップ企業と中小企業によるイノベーション促進のための政府プログラム

Panel III: Government Programs to Encourage Innovation by Startups and SMEs

モデレーター：ブラッドレイ・ノックス Bradley Knox，合衆国下院 小企業委員会

スタートアップ企業と中小企業によるイノベーション促進のための政府プログラム：イノベーション支援の役割

Government Programs to Encourage Innovation by Start-ups & SME's: The Role of Innovation Awards

チャールズ・ウェスナー Charles Wessner，全米アカデミー 科学技術経済政策委員会

日本におけるスタートアップと起業家精神を促進するプログラム：経験と教訓

Programs to Stimulate Startups and Entrepreneurship in Japan: Experiences and Lessons

安田 武彦，東洋大学経済学部教授

ディスカッサント

飯塚 哲哉，ザインエレクトロニクス株式会社 社長

5:30 PM レセプション

第 **2** 日：**2006** 年 **1** 月 **11** 日

9:30 AM　パネル **IV**：知的財産とイノベーションシステムの相互作用
Panel IV:　Interaction between Intellectual Property and Innovation Systems
モデレーター：植村　昭三，世界知的所有権機関（WIPO）前事務局次長／東京大学先端科学技術研究センター客員教授

米国特許システムの課題と可能な改革
Issues and Possible Reforms in the U.S. Patent System
ブロンウィン・ホール Bronwyn Hall，カリフォルニア大学バークレー校教授

日本における特許システムの改革と挑戦
Reform of Patent System in Japan and Challenges
長岡　貞男，一橋大学イノベーション研究センター長，教授

ディスカッサント
マーク・マイアーズ Mark Myers，ゼロックス（元），ペンシルベニア大学ウォートン・ビジネススクール客員教授

11:00 AM　コーヒーブレーク

11:15 AM　パネル **V**：産学連携
Panel V:　Industry and University Collaboration
モデレーター：渡部　俊也，東京大学先端科学技術研究センター教授

米国における **R&D** 産学連携
Industry-University R&D Partnerships in the United States
アーウィン・フェラー　Irwin Feller，米国科学振興協会上席客員サイエンティスト／ペンシルバニア州立大学名誉教授

日本における産学連携
Industry-University Partnerships in Japan
近藤　正幸，科学技術政策研究所客員総括主任研究官／横浜国立大学大学院教授

ディスカッサント
ゲイル・カッセル　Gail Cassell，イーライリリー　科学担当副社長
ジェームズ・ターナー　James Turner，合衆国下院科学委員会民主党チーフスタッフ

12:45 PM　ランチ

2:15 PM　パネル **VI**：大学における研究への政府の支援
Panel VI: Government Support for University Research
モデレーター：永野　博，独立行政法人科学技術振興機構（JST）研究開発戦略センター，上席フェロー

DARPA と米国におけるイノベーションの連結科学モデル－現在の状況
DARPA and the US Connected Science Model for Innovation – Where Is It Now?

ウィリアム・ボンヴィリアン William Bonvillian，ジョセフ・リーバーマン合衆国上院議員オフィス　立法ディレクター，チーフスタッフ

大学における研究への政府の支援－日本における動向と課題
Government Support to University Research – Trend and Issues in Japan
下田　隆二，東京工業大学統合研究院教授

ディスカッサント
ウィリアム・スペンサー　William Spencer，全米アカデミー　科学技術経済政策委員会／SEMATECH 元会長

3:45 PM　コーヒーブレーク

4:00 PM　パネル **VII**：産学官連携：バイオテクノロジーの挑戦
Panel VII: Industry-University-Government Cooperation: The Biotechnology Challenge
モデレーター：ウィリアム・ボンヴィリアン William Bonvillian，ジョセフ・リーバーマン合衆国上院議員オフィス　立法ディレクター，チーフスタッフ

米国における医薬品開発の最新動向の展望
Perspective on Current Trends in Drug Development in the United States
ゲイル・カッセル Gail Cassell，イーライリリー　科学担当副社長

日本の公的部門はバイオメディカル研究に大きく貢献したのか？：**1991-2001** 年における政府／大学の特許の詳細分析
Is There a Significant Contribution of Public Sector in Biomedical Research in Japan?: A Detailed Analysis of Government/University Patenting, 1991-2001
岡田　羊祐，一橋大学大学院経済学研究科助教授

ディスカッサント
長井省三，日本製薬工業協会　知的財産部長，弁理士

5:30 PM　締め括りのまとめと所感
Closing Summary and Remarks
司会：近藤　正幸，科学技術政策研究所客員総括主任研究官／横浜国立大学大学院教授

ウィリアム・スペンサー　William Spencer，全米アカデミー　科学技術経済政策委員会／SEMATECH 元会長
長岡　貞男，一橋大学イノベーション研究センター長，教授

21st Century Innovation Systems for Japan and the United States: Lessons from a Decade of Change

International Symposium

Organized by

The National Institute of Science and Technology Policy (NISTEP)
Ministry of Education, Culture, Sports, Science and Technology, Japan

and

The Board of Science, Technology, and Economic Policy
U.S. National Academies

in collaboration with

Institute of Innovation Research, Hitotsubashi University, Japan

January 10-11, 2006

Mita Kaigisho
Tokyo, Japan

Day 1: January 10, 2006

9:30 AM **Welcome**
Introduction: Takashi Inutsuka, Director, Planning Division, NISTEP

Motohide Konaka, Director General, NISTEP

9:45 AM **Opening Addresses**
Chair: Terutaka Kuwahara, Deputy Director General, NISTEP

Challenges in the U.S. Innovation System
Rep. Donald Manzullo, Chairman, Committee on Small Business, United States House of Representatives

Evolution and Challenges to the Innovation Systems in Japan
Taizo Yakushiji, Member, Council for Science and Technology Policy, and Visiting Professor, Keio University

11:00 AM **Coffee Break**

11:15 AM **Panel I: Government's Evolving Role in Supporting Corporate R&D - U.S. and Japanese Models**
Moderator: Alice Amsden, Professor, Massachusetts Institute of Technology

Technology Policies in Japan: 1990 -
Akira Goto, Professor, Research Center for Advanced Science and Technology (RCAST), University of Tokyo, and Faculty Fellow, Research Institute of Economy, Trade and Industry (RIETI)
Kazuyuki Motohashi, Associate Professor, Research Center for Advanced Science and Technology (RCAST), University of Tokyo, and Faculty Fellow, Research Institute of Economy, Trade and Industry (RIETI)

Government's Evolving Role in Supporting Corporate R&D: Theory and Practice n the Advanced Technology Program
Stephanie Shipp, Director, Economic Assessment Office, Advanced Technology Program, National Institute of Standards and Technology

Discussant
Ichiro Nakajima, Director and Professor, New Industry Creation Hatchery Center, Tohoku University

12:45 PM **Lunch**

2:15 PM **Panel II: Government-Industry R&D Partnerships - U.S. and Japanese Experiments**
Moderator: Lonnie Edelheit, Retired Senior Vice President, Research & Development, General Electric (GE), and National Academy of Engineering

Semiconductor Consortia in Japan: Experiences and Lessons
Shuzo Fujimura, Professor, Tokyo Institute of Technology, and Visiting Professor, Institute of Innovation Research, Hitotsubashi University
Hiroyuki Chuma, Professor, Institute of Innovation Research, Hitotsubashi University, and Affiliated Senior Fellow, NISTEP

Economic Impacts of International R&D Coordination: SEMATECH, the International Technology Roadmap, and Innovation in Microprocessors
Kenneth Flamm, Professor and Dean Rusk Chair in International Affairs, Lyndon B. Johnson School of Public Affairs, University of Texas at Austin

Discussant
Kaoru Honjo, Executive Director, New Energy and Industrial Technology Development Organization (NEDO)

3:45 PM **Coffee Break**

4:00 PM **Panel III: Government Programs to Encourage Innovation by Startups and SME's**
Moderator: Bradley Knox, Committee on Small Business, US House of Representatives

Government Programs to Encourage Innovation by Start-ups & SME's: The Role of Innovation Awards
Charles Wessner, Board on Science, Technology and Economic Policy, National Research Council

Programs to Stimulate Startups and Entrepreneurship in Japan: Experiences and Lessons
Takehiko Yasuda, Professor, Toyo University

Discussant
Tetsuya Iizuka, President and CEO, THine Electronics

5:30 PM **Reception**

Day 2: January 11, 2006

9:30 AM **Panel IV: Interaction between Intellectual Property and Innovation Systems**
Moderator: Shozo Uemura, Former Deputy Director General, World Intellectual Property Organization (WIPO), and Visiting Professor, Research Center for Advanced Science and Technology (RCAST), University of Tokyo

Issues and Possible Reforms in the U.S. Patent System
Bronwyn Hall, Professor, University of California at Berkeley

Reform of Patent System in Japan and Challenges
Sadao Nagaoka, Director and Professor, Institute of Innovation Research, Hitotsubashi University

Discussant
Mark Myers, Xerox, ret. and Wharton Business School, University of Pennsylvania

11:00 AM **Coffee Break**

11:15 AM **Panel V: Industry and University Collaboration**
Moderator: Toshiya Watanabe, Professor, Research Center for Advanced Science and Technology (RCAST), University of Tokyo

Industry-University R&D Partnerships in the United States
Irwin Feller, Senior Visiting Scientist, American Association for the Advancement of Science, and Professor Emeritus of Economics, Pennsylvania State University

University-Industry Partnerships in Japan
Masayuki Kondo, Affiliated Senior Fellow, NISTEP, and Professor, Yokohama National University

Discussants
Gail Cassell, Vice President, Scientific Affairs, Distinguished Lilly Research Scholar for Infectious Diseases, Eli Lilly
James Turner, Chief Democratic Counsel, Committee on Science, U.S. House of Representatives

13:00 PM **Lunch**

2:15 PM **Panel VI: Government Support for University Research**
Moderator: Hiroshi Nagano, Principal Fellow, Japan Science and Technology Agency (JST)

DARPA and the US Connected Science Model for Innovation - Where Is It Now?
William Bonvillian, Legislative Director and Chief Counsel, Office of Senator Joseph Lieberman, United States Senate

Government Support to University Research - Trend and Issues in Japan
Ryuji Shimoda, Professor, Integrated Research Institute, Tokyo Institute of Technology

Discussant
William Spencer, Board on Science, Technology and Economic Policy, National Research Council, and Chairman, SEMATECH, ret.

3:45 PM **Coffee Break**

4:00 PM **Panel VII: Industry-University-Government Cooperation: The Biotechnology Challenge**
Moderator: William Bonvillian, Legislative Director and Chief Counsel, Office of Senator Joseph Lieberman, United States Senate

Perspective on Current Trends in Drug Development in the United States
Gail Cassell, Vice President, Scientific Affairs, Distinguished Lilly Research Scholar for Infectious Diseases, Eli Lilly

Is There a Significant Contribution of Public Sector in Biomedical Research in Japan?: A Detailed Analysis of Government/University Patenting, 1991-2001
Yosuke Okada, Associate Professor, Hitotsubashi University

Discussant
Shozo Nagai, Patent Attorney and Director, Intellectually Property Division, Japan Pharmaceutical Manufacturers Association (JPMA)

5:30 PM **Closing Summary and Remarks**
Chair: Masayuki Kondo, Affiliated Senior Fellow, NISTEP, and Professor, Yokohama National University

William Spencer, Board on Science, Technology and Economic Policy, National Research Council, and Chairman, SEMATECH, ret.
Sadao Nagaoka, Director and Professor, Institute of Innovation Research, Hitotsubashi University

国内組織･実行委員会

委員長	近藤正幸	科学技術政策研究所第 2 研究グループ客員総括主任研究官 横浜国立大学大学院環境情報研究院教授
	長岡貞男	一橋大学イノベーション研究センター長、教授
	後藤　晃	東京大学先端科学技術研究センター教授
	富澤宏之	科学技術政策研究所第 2 研究グループ主任研究官
	鎗目　雅	科学技術政策研究所第 2 研究グループ主任研究官
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	山下泰弘	科学技術政策研究所第 2 研究グループ客員研究官
	清水佳津子	科学技術政策研究所第 2 研究グループ事務補助員

Organizing Committee in Japan

Chair:	Masayuki Kondo	Affiliated Senior Fellow and Leader, Second Theory-Oriented Group, NISTEP, and Professor, Graduate School of Environment and Information Sciences, Yokohama National University
	Sadao Nagaoka	Professor, Institute of Innovation Research, Hitotsubashi University
	Akira Goto	Professor, Research Center for Advanced Science and Technology, University of Tokyo
	Hiroyuki Tomizawa	Senior Research Fellow, Second Theory-Oriented Group, NISTEP
	Masaru Yarime	Senior Research Fellow, Second Theory-Oriented Group, NISTEP
Secretariat:	Sen Ueno	Research Fellow, Second Theory-Oriented Group, NISTEP
	Kazuhiko Fukuda	Affiliated Fellow, Second Theory-Oriented Group, NISTEP
	Yasuhiro Yamashita	Affiliated Fellow, Second Theory-Oriented Group, NISTEP
	Kazuko Shimizu	Clerical Assistant, Second Theory-Oriented Group, NISTEP

シンポジウム結果概要

基調講演

Opening Addresses

座長：桑原 輝隆，科学技術政策研究所 総務研究官

米国のイノベーションシステムの挑戦

Challenges in the U.S. Innovation System

ドナルド・マンズーロ Donald Manzullo，合衆国下院議員 小企業委員会委員長

米国のイノベーションシステムの現状と課題について報告を行った。米国が近年直面している課題として、規制や税金によるビジネス・コストの上昇、過度の短期的利益の追求による R&D 投資の低下、科学技術を学ぶ学生数の減少、製造業の海外流出によるエンジニアの雇用の減少などを指摘し、問題解決の第一歩は、まずこうした状況を正確に認識することであり、現在議会や政府が動き出しつつあると述べた。

日本のイノベーションシステムの発展と挑戦

Evolution and Challenges to the Innovation System in Japan

薬師寺 泰蔵，総合科学技術会議議員／慶應義塾大学客員教授

日本のイノベーションシステムの現状と課題を報告した。科学技術と社会規範の観点から、優良イミテーターが外生技術を接ぎ木することによるエミュレーションを通じて各国のイノベーションシステムが歴史的に変遷していくと論じ、現在、日本のエミュレーション・パワーは弱体化しており、それをどのように補強するかが課題となっていると指摘した。イノベーションを促進するためには人を育てる必要があり、これから日本は第 3 期科学技術基本計画の下で社会制度改革を進め、安全で夢のある科学技術を目指すことが重要であると指摘した。

討論

自由主義経済体制の下で、イノベーションを盛んに生み出すための政府部門の役割に関して、米国では政府が企業部門の研究開発にあまり関与しない一方、企業側は株式市場のプレッシャーのため、短期利益追求で長期的・基礎的な研究開発が難しい状況が起きているが、特にバイオ・医薬分野について、今後政府は深く関与していく必要があるとの指摘があった。また、研究開発に日米の両政府がどのように関与しているのかについては、研究開発費の絶対値、GDP 比、政府・企業の比率、軍事部門の役割などに違いがあり、その状況を単純に比較することはできないとの指摘があった。また、研究開発費は金額ではなく、どこの分野に集中的に投資するのか、どのように効率的に投資するのかが非常に鍵であるとの指摘もあった。

新製品・プロセスは現在国境を越えて開発されるなど、技術開発の状況が変化しているが、国単位で科学技術政策を考えるというフレームワークへの影響に関しては、確かにそうした変化も起きているが、依然として国単位で技術進歩が主導されているのも事実であり、特に米国ではかなりダイナミックに政府が主導しているように、現在は科学技術が一国を牽引するような時代に変化してきており、その一例として中国の科学技術政策への言及があった。

米国が製造業におけるイノベーションで成功したのは、最も優秀な人材が世界中から集まってくることという要素が大きく、科学技術政策上、教育を含めた人材育成は最重要課題であるが、科学技術政策としての教育には資金はそれほど必要ではなく、科学技術者を志すモチベーションを高める仕組みが必要であろうとの指摘があった。

パネル I：企業 R&D 支援における政府の役割の展開－米国と日本のモデル
Panel I: Government's Evolving Role in Supporting Corporate R&D—U.S. and Japanese Models
モデレーター：アリス・アムスデン Alice Amsden，マサチューセッツ工科大学教授

日本における技術政策：1990 年以降
Technology Policies in Japan: 1990 -
後藤 晃，東京大学先端科学技術研究センター教授／経済産業研究所ファカルティフェロー
元橋 一之，東京大学先端科学技術研究センター助教授／経済産業研究所ファカルティフェロー

1990 年以降の日本経済とイノベーションシステムに関して、データに基づいて概観した。新しい科学技術政策の枠組みとして、科学技術基本計画と総合科学技術会議（CSTP）の重要性が増し、政府資金の増加と産学連携の推進が行われたが、現在基礎科学と市場経済が重視される中で、従来の産業政策をイノベーションへ向けて再定義する必要性を指摘した。

企業 R&D 支援における政府の役割の展開：先進技術プログラム（ATP）における理論と実践
Government's Evolving Role in Supporting Corporate R&D: Theory and Practice in the Advanced Technology Program
ステファニー・シップ Stephanie Shipp，国立標準技術研究所（NIST） 先進技術プログラム（ATP）経済評価室 ディレクター

米国企業への R&D 支援策として、先進技術プログラム（ATP）について報告した。1990 年以来 ATP は比較的リスクの高い初期段階の技術開発に資金援助を行っているが、ピア・レビューによってプロジェクトを選定し、定期的なマネジメントを行い、またプロジェクト終了後も追跡調査を行って技術が社会に還元されているかモニタリングするなど厳しい評価を実施することにより、イノベーションを生み出すことに貢献し、また産学官連携を促進していると報告した。

ディスカッサント
中島 一郎，東北大学未来科学技術共同研究センター長，教授

経済における新産業の登場などの構造変化に対応して、日米両国ではサイエンス型 R&D、産学連携、地域クラスター、中小企業に注目し、基本計画、ロードマップ、プロジェクト・マネジメントなどで新しい取り組みが行われていることを指摘した。

討論

従来の狭義のイノベーションを組織イノベーションなども含む広義のイノベーションシステムに捉えなおした場合、当然政策の対象範囲も広範囲に広げていかなければならず、政府の役割には、R&D 費支出を積極的に行う役割と、社会制度・規範の変化、税制度や規制緩和などを実施する役割の 2 つがあるとの指摘があった。

イノベーションシステムの大きな課題として、リーダーシップが特に重要であるが、研究費の予算配分に関するものではなく、評価制度とインセンティブ作りの領域にリーダーシップが必要であるとの意見があった。

外部性・スピルオーバーの問題があるサイエンス型プロジェクトの評価に関しては、ATP では指数化した指標を使ってプロジェクトの費用対効果分析を行い、実際にプロジェクト投資が決定した後も、研究開発、商業化、技術普及の各段階で継続的にプロジェクトの評価を行っているとの報告があった。

パネル **II**：政府-産業間 **R&D** 協力－日米の実験

Panel II: Government-Industry R&D Partnerships - U.S. and Japanese Experiments

モデレーター：ロニー・エーデルハイト Lonnie Edelheit，ゼネラル・エレクトリック（GE）元 R&D 担当上席副社長／全米工学アカデミー

日本における半導体コンソーシアム：経験と教訓

Semiconductor Consortia in Japan: Experiences and Lessons

藤村 修三，東京工業大学大学院イノベーションマネジメント研究科教授／一橋大学イノベーション研究センター客員教授
中馬 宏之，一橋大学イノベーション研究センター教授／科学技術政策研究所客員総括主任研究官

日本における半導体コンソーシアムの系譜、実施体制、そこでの重要な技術課題などについて説明した。過去 10 年間に組織された数多くの半導体コンソーシアムの経験を振り返り、デバイス・材料・装置メーカー間の協力が少ないこと、参加企業の事情が優先されてコラボレーションに難点があること、新しい技術に対する R&D マネジメントが適切でなく、急激に複雑化しつつある半導体製造に効果的に対応できていないことなどを指摘した。

国際 **R&D** 連携の経済的影響：**SEMATECH**、国際技術ロードマップ、及びマイクロプロセッサにおけるイノベーション

Economic Impacts of International R&D Coordination: SEMATECH, the International Technology Roadmap, and Innovation in Microprocessors

ケネス・フラム Kenneth Flamm，テキサス大学オースチン校 リンドン・B・ジョンソン公共政策スクール ディーン・ラスク国際関係講座長，教授

マイクロプロセッサに焦点を当て、米国の国際半導体コンソーシアム SEMATECH の経済インパクトを分析した。SEMATECH や国際半導体技術ロードマップ（ISTR）を通じた国際 R&D 連携は、米国外の強みも取り込むことで、製造コストの減少と性能の改善に貢献してきたが、現在は技術的な壁につき当たっており、その解決にはソフトウェアへの投資が重要であると指摘した。

ディスカッサント

本城 薫，独立行政法人新エネルギー・産業技術総合開発機構（NEDO）理事

NEDO は産業界、大学、公的研究機関の間の協力によって R&D プロジェクトを実施しているが、プロジェクトの選択と集中、技術戦略マップの策定、異なるプロジェクト間の連携、垂直連携体制の構築、プロジェクトリーダーの権限の強化などを通じて、その成果を効果的に実用化・産業化に結びつける努力をしているという報告があった。

討論

米国の SEMATECH は、日本の超大規模集積回路（VLSI）プロジェクトの成功に刺激を受けて発足したが、そこを通じて国際的な R&D 協力が行われてきたことが、米国の半導体産業の改善の原因の一つになっていると考えられる一方、マイクロエレクトロニクス製造科学技術（MMST）プロジェクトはほとんど影響が無かったとの指摘があった。

半導体ロードマップに関しては、集積密度を上げることが強調されているが、今後は省エネのほうが大きなファクターになることが予想され、ソフトウェアがカギになるとの指摘もあった。

パネル **III**：スタートアップ企業と中小企業によるイノベーション促進のための政府プログラム
Panel III: Government Programs to Encourage Innovation by Startups and SMEs
モデレーター：ブラッドレイ・ノックス Bradley Knox，合衆国下院 小企業委員会

スタートアップ企業と中小企業によるイノベーション促進のための政府プログラム：イノベーション支援の役割
Government Programs to Encourage Innovation by Start-ups & SME's: The Role of Innovation Awards
チャールズ・ウェスナー Charles Wessner，全米アカデミー 科学技術経済政策委員会

グローバル時代のイノベーションについて、小企業の役割と重要性、政策、課題等について報告した。米国にとって中小企業によるイノベーションは極めて重要であるが、市場でのベンチャー・キャピタルからの技術開発の初期段階への投資は限られており、企業側からのプロポーザルに基づいた、政府の小企業イノベーション研究（SBIR）プログラムや先進技術プログラム（ATP）を通じた資金援助は大きな役割を担っていると報告した。

日本におけるスタートアップと起業家精神を促進するプログラム：経験と教訓
Programs to Stimulate Startups and Entrepreneurship in Japan: Experiences and Lessons
安田 武彦，東洋大学経済学部教授

1990 年代に入ってから日本における起業家活動は停滞している状況を踏まえ、その解消のために、有限責任会社に必要な最低資本金の撤廃、起業家精神の教育、担保なしの資金援助などの政策が導入されたが、潜在的起業家の間ではそれほど認知されておらず、情報を広く知らせるためには、過去にスタートアップの経験がある人材を有効に活用する必要があると指摘した。

ディスカッサント
飯塚 哲哉，ザインエレクトロニクス株式会社 社長

自らのファブレス半導体企業のスタートアップの経験に基づいた報告を行い、米国と比較して環境が整っていない日本においても有力スタートアップ企業の成長力は大手企業よりも高くなっており、その促進には単なる補助金の供給ではなく、リスクを取った投資が最も効果的であると指摘した。

討論

中小企業への融資に関して、国民金融公庫の融資制度における貸し倒れ率のデータは持ってはいないが、貸し倒れ率が高いという議論はこれまで特にないため、ある程度機能していると思われるとの意見があった。また、保証人がいない場合でも、国民金融公庫から借りて逃げ出すような人はほとんどおらず、引き続きお金を借りるため、モラルハザード的なものは蔓延しているとはいえないとの指摘もあった。

米国におけるリスクの高い最先端の企業への投資に関して、政府による支援プログラムはうまく機能しているのか、また改善余地あるのかという点については、ATP は 3 分の 1 しか成功してないという批判があったが、これでも成功率は十分高いはずなのにあまり評価されていないという現状が紹介された。成功・機能しているというのをどのように定義するかは難しいものの、創業開始時の資金調達には情報の非対称性の問題があることを考慮すると、SBIR による小規模な支援であってもその緩和につながるため、大きな効果があると考えるという指摘があった。

パネル IV：知的財産とイノベーションシステムの相互作用

Panel IV: Interaction between Intellectual Property and Innovation Systems

モデレーター：植村　昭三，世界知的所有権機関（WIPO）前事務局次長／東京大学先端科学技術研究センター客員教授

米国特許システムの課題と可能な改革

Issues and Possible Reforms in the U.S. Patent System

ブロンウィン・ホール Bronwyn Hall，カリフォルニア大学バークレー校教授

米国の特許およびイノベーションシステムの経済学的背景について議論し、その四半世紀における変容とその改革に向けた議論のレビューを行った。特許は R&D 活動へのインセンティブを与える一方、短期的には独占を与えることによって競争上悪影響を持っているという伝統的な見方に対して、特許はイノベーションに関わるコストを上昇させる反面、知識集約型産業において新しい小企業の参入を促すという最近の考え方を紹介した上で、1980 年以降の特許システムの拡大・強化は特許出願・取得数を増加させたものの、質の低下や取引費用の増加を招いたなどの批判があり、現在議会で法律の改革が議論されている最中であると指摘した。

日本における特許システムの改革と挑戦

Reform of Patent System in Japan and Challenges

長岡　貞男，一橋大学イノベーション研究センター長，教授

近年の日本の特許システム改革の流れを俯瞰した。現在特許システムが直面する課題として、特許出願の増加や特許の複雑性の上昇、質の高い特許への要求の下での効率的な特許審査、公開された特許情報の研究開発における効率的な活用、標準設定や累積的な技術分野で顕著な特許の藪（patent thicket）の問題を挙げ、政策的対応として、日米欧での検索・審査結果の相互認証、標準化団体による特許の管理などが重要であると指摘した。

ディスカッサント

マーク・マイアーズ Mark Myers，ゼロックス（元），ペンシルベニア大学ウォートン・ビジネススクール客員教授

上記の問題に加えて、発明と特許に対するインセンティブの相違、バイオテクノロジー特許の境界、特許制度の調和化、開発途上国の問題、科学研究活動の免除、オープンソース・ソフトウェアの問題などを指摘した。

討論

途上国では、先進国の知財制度や TRIPs 協定等に対して強い敵対感を持っているということを踏まえた上で、新たな制度の立案に対して何らかの貢献は可能かという点に関して、現在の制度は先進国の知的財産の利益保護を目的として設計されており、積極的な模倣による途上国のキャッチアップを促すものではなく、先進国と途上国の間で妥協案を見つけるのは困難であり、途上国の貧困状態や所得水準を考慮すれば、先進国がプロパテント政策をもって途上国に対峙し、単一の知財制度を全世界で共有するというアイデアは必ずしも望ましいとは言えないとの意見があった。その一方で、知的財産権の侵害を伴う模倣は、イノベーションの阻害に繋がる行為であり、望ましい行為とはいえず、米国のプロパテント政策は問題視されることが多いものの、実際には途上国での侵害行為に対して必ずしも強力な経済制裁を発動しているわけではないという指摘もあった。

パネル V：産学連携
Panel V: Industry and University Collaboration
モデレーター：渡部 俊也，東京大学先端科学技術研究センター教授

米国における R&D 産学連携
Industry-University R&D Partnerships in the United States
アーウィン・フェラー Irwin Feller，米国科学振興協会上席客員サイエンティスト／ペンシルバニア州立大学名誉教授

米国の産学連携に関して、産学連携が深まるに伴って大学側の認識・行動が変わりつつあり、ロイヤルティーや一時金の代わりに株式を受け取ることや、萌芽的な技術のより下流領域への投資、経済的に大きなリターンを生む確率が低いことに対するリスク管理戦略などが行われるようになったが、一方で、独立して中立的な科学技術知識の供給源としての大学の役割の衰退、個人と機関の間の利益相反、知識の流通ひいては科学発見・技術進歩を妨げる「反共有地」の拡大など、公共的な利益が損なわれる可能性があることを指摘した。

日本における産学連携
Industry-University Partnerships in Japan
近藤 正幸，科学技術政策研究所客員総括主任研究官／横浜国立大学大学院教授

日本の産学連携に関して、世界で始めて総合大学に工学部ができるなど日本の大学は当初から応用志向が強く、代表的な研究機関であった理研は大きな産業グループを率いていたことを説明した。現在は共同研究による知識の共同生産や、ライセンスを通じた知識の移転、大学からのスタートアップが国・地域レベルでのイノベーションシステムで重要な役割を果たしつつあるが、ライセンス収入ではアメリカの大学とまだ大きな差があると指摘した。また課題として、大学のアイデンティティの維持、利益相反に関する規則の確立、研究ツール特許の取り扱いを指摘した。

ディスカッサント
ゲイル・カッセル Gail Cassell，イーライリリー 科学担当副社長

現在大学機関・研究者がバイオテクノロジーのスタートアップ企業の株式を取得するなど、産学官で人材、金銭、法律の側面で複雑な関係が形成されつつあるが、それは大学の研究者に資金を提供し、また産業に最先端の知識へのアクセスを可能にするなど利点がある一方で、科学研究における秘密主義、研究結果のバイアス、教育への悪影響、金銭的な利益相反などリスクも存在し、産学官連携のバランスを取る必要があると指摘した。

ジェームズ・ターナー James Turner，合衆国下院科学委員会民主党チーフスタッフ

大学は特許などで柔軟な対応ができない場合には優秀な研究者や学生を失う可能性があり、また大企業は研究のアイデアに関するジャスト・イン・タイムのサプライヤーを必要としているため、やがて大学や公的研究機関も企業のサプライ・チェーンに組み込まれる可能性がある一方、大学側も産業界のシックス・シグマなどベスト・プラクティスから学ぶべきことが多いと指摘した。

討論

現在、学際的研究ではチームサイエンスが主流であり、今後は大学研究の多様性、異分野相互交流が大きな研究成果に結びつくと期待されるとの指摘があった。

パネル **VI**：大学における研究への政府の支援

Panel VI: Government Support for University Research

モデレーター：永野 博，独立行政法人科学技術振興機構（JST）研究開発戦略センター，上席フェロー

DARPA と米国におけるイノベーションの連結科学モデル－現在の状況

DARPA and the US Connected Science Model for Innovation – Where Is It Now?

ウィリアム・ボンヴィリアン William Bonvillian，ジョセフ・リーバーマン合衆国上院議員オフィス 立法ディレクター，チーフスタッフ

イノベーションを生み出す要因として、R&D と人材に加えて組織が重要であり、過去の成功事例に共通しているのは､協力的で非階層的かつ民主的な環境でラディカルなイノベーションを目的に研究を行っていることであると論じ、基礎研究から開発、プロトタイピング、製造初期まで連結したモデルは国防総省国防高等研究事業局（DARPA）でも採用されてきたが、近年 DARPA がそのモデルからシフトしつつある一方で、エネルギー省や国立衛生研究所（NIH）など他の機関で同様の組織の採用が進められていると報告した。

大学における研究への政府の支援－日本における動向と課題

Government Support to University Research – Trend and Issues in Japan

下田 隆二，東京工業大学統合研究院教授

過去 10 年間の日本の大学における研究の状況と、それに対する政府の政策及び研究支援をレビューした。科学技術基本計画は政府による大学への研究資金を増加させ、その研究環境を改善することに貢献する一方、大学の法人化はかつてないほど運営上の自由を与えたと高く評価した。現在の課題として、大学研究の多様性、資金提供機関及び大学による競争的資金の管理、大学の開放性、産学連携・知的財産権の重要性を指摘した。

ディスカッサント

ウィリアム・スペンサー William Spencer，全米アカデミー 科学技術経済政策委員会／SEMATECH 元会長

1980 年代以降企業の基礎研究部門が縮小する中で、好奇心に基づく研究分野のみではなく、現実の問題を解くために原理的な研究が必要となる分野においても大学の役割が大きくなっており､最近は企業がキャンパス内に研究所を設けるなど産学連携に大きな変化が起きているが､そうした状況でも大学は基礎研究と教育を最重視し､その文化を守ることが重要であると指摘した。

討論

日本の国立大学法人化後の意思決定に関して､文部科学省の定めた中期計画の項目には拘束されるものの、その範疇の中では各大学は自由に意思決定を行うことができるとの指摘があった。

各国のイノベーションシステムにおける国立研究機関の役割に関して､米国では公的研究機関は産業と大学の中間的存在であり､エネルギーや物理などの基礎研究を行っている優秀な人材も多く、直接的な経済効果は大きくなくても、ノーベル賞級の発見をするなど、新技術の孵化、底上げに貢献しているとの報告があった。また、安全規制や標準設定に関する国研は引き続き必要だが､戦後キャッチアップのために設立された国研については、現在新たな役割を模索しており、専ら好奇心に基づく大学の研究を補完するような方向性で検討しているとの指摘があった。

パネル **VII**：産学官連携：バイオテクノロジーの挑戦
Panel VII: Industry-University-Government Cooperation: The Biotechnology Challenge
モデレーター：ウィリアム・ボンヴィリアン William Bonvillian，ジョセフ・リーバーマン合衆国上院議員オフィス 立法ディレクター，チーフスタッフ

米国における医薬品開発の最新動向の展望
Perspective on Current Trends in Drug Development in the United States
ゲイル・カッセル Gail Cassell，イーライリリー 科学担当副社長

バイオテクノロジー分野における産学連携の米国の最新動向について報告した。現在医薬品産業では、研究開発費用が増大する一方で新薬の発見・開発はますます困難になり、研究開発の生産性が低下しつつある中で、産学官連携による効果は特に感染症対策などの分野で非常に大きいと考えられるが、一方で利益相反を最小限にしながらそれぞれの役割・能力を有効に活用し、リスクを共有していくことが課題であると指摘した。

日本の公的部門はバイオメディカル研究に大きく貢献したのか？：**1991-2001** 年における政府／大学の特許の詳細分析
Is There a Significant Contribution of Public Sector in Biomedical Research in Japan?: A Detailed Analysis of Government/University Patenting, 1991-2001
岡田 羊祐，一橋大学大学院経済学研究科助教授

日本で過去 10 年間に導入された産学官連携推進策がバイオメディカル研究で重要な成果を生み出しているのかを探るため、詳細な特許分析を行った。大学と公的研究機関による特許出願は増加したものの、全般的にそうした特許の価値は企業によるものと比べて低いという結果を得たと報告する一方、これが本当に産学官連携が有効に行われた結果なのか、また研究者の流動性が低く、特許の保護が弱いという日本のイノベーションシステムにおいて、公的部門による特許出願を促進するのが本当に望ましいのか、さらに検討が必要であると指摘した。

ディスカッサント
長井省三，日本製薬工業協会 知的財産部長，弁理士

大学―企業間の共同研究件数・共同研究費、大学の特許出願数で見ると、日本でも産学連携は一応進んでいると言えるが、医薬品を保護する特許は原則物質特許一件であり、数百件の特許で製品を保護するエレクトロニクスなどとは大きく異なるため、ライフサイエンス分野における産学連携の評価は量ではなく質、具体的には臨床に入ることが出来たか否かで評価されるべきであり、また国際的な競争という観点から海外の大学やベンチャー企業との連携も重要であると述べた。

討論

特許とイノベーションの関係は複雑であり、回帰分析の結果の解釈では、大学や国研の縦割り組織、研究者の労働市場の非流動性などの日本における制度的特性を考慮すべきとの指摘があった。

日本版バイドール法などの制度改革は 1999 年以降だが、研究者の特許出願への意識が高まったのはもう少し前で、産業界出身の大学事務担当者の増加が大学特許の増加の背景にあるとの指摘があった。また、日本では産学連携法制の歴史がまだ浅く、バイドール法は助けにはなるものの、大学組織のマネジメントも同時に変わらなければ、産学連携は効果を生まないのではないかとの意見もあった。

締め括りのまとめと所感

Closing Summary and Remarks

司会：近藤 正幸，科学技術政策研究所客員総括主任研究官／横浜国立大学大学院教授

ウィリアム・スペンサー William Spencer，全米アカデミー 科学技術経済政策委員会／SEMATECH 元会長

イノベーション政策は長期の経済成長に大きな影響を与える重要な政策であり、全米アカデミーは今回のコンフェレンスのような外国との比較研究プログラムを強化し、効果的なイノベーション政策の在り方を探求していきたいと述べた。半導体やバイオ分野の技術では大きな転換期を迎えており、IT やバイオ分野の強いアジアは重要な役割を果たし、その中で日本がリーダーシップを取っていくことが必要であると指摘した。

長岡 貞男，一橋大学イノベーション研究センター長，教授

本会議のユニークな点として、本会議が日米の共同プログラムであったことと、大学、産業界、政府から多様な参加者があったことを指摘した。イノベーションを効果的に進めるための政策や制度のあり方には、さらに多くの証拠と分析が必要な未解決の問題も多く、今回のコンフェレンスが日米の専門家の更なる協力を促す契機となることを期待すると述べた。

発表スライド
Presentation Slides

基調講演

Opening Addresses

座長：桑原 輝隆，科学技術政策研究所 総務研究官

米国のイノベーションシステムの挑戦

Challenges in the U.S. Innovation System

ドナルド・マンズーロ Donald Manzullo，合衆国下院議員 小企業委員会委員長

日本のイノベーションシステムの発展と挑戦

Evolution and Challenges to the Innovation System in Japan

薬師寺 泰蔵，総合科学技術会議議員／慶應義塾大学客員教授

Challenges in the U.S. Innovation System

Rep. Donald A. Manzullo
Chairman
Committee on Small Business
U.S. House of Representatives

Challenges facing the U.S.

- Cost of Doing Business
- Decline in R&D funding
- Visa policies
- Science & Technology education
- Wall Street Pressure

Cost of Doing Business

- Regulatory compliance costs are disproportionately heavier on small firms
  - Cost of federal regulations totals $1.1 trillion;
  - Cost per employee for firms with fewer than 20 employees is $7,647.
- Soaring cost of health care
- High corporate tax rates
- Increasing energy costs

Decline in R&D Dollars

- Both federal and private sector investments in R&D have been down for years
  - Particularly in basic and physical sciences
- Most dollars have gone to incremental development
  - New research for creative solutions has been hampered by demand for risk-averse solutions with quick turnarounds
- Congress is considering a bill to increase federal R&D spending to:
  - Accelerate tech transfer
  - Create innovation test beds

Visa Policy

- Since 9/11, it's been very difficult for foreign travelers to enter the U.S.
  - U.S. companies have lost millions because foreign customers couldn't enter to view products
  - Foreign students are going to other countries for higher education
  - Other countries are taking advantage of the opportunity

Science & Technology Education

- The number of students (American and foreign-born) going into S&T continues to decline
  - U.S. companies have arguably created their own problem.
    - As offshoring of engineering work continues, students perceive less opportunity and choose other fields
    - As the number of S&T students decreases, companies perceive the need to seek engineering work offshore
    - NOTE: India now claims it can't find enough engineers (the increase in living standards means cost of labor is rising)
  - Other countries' educational quality is rising
  - Foreign-born students that do study here are finding their way back home

Wall Street Pressure

- Quarterly earnings reporting creates undue pressure on managers to focus on short-term results
- Discourages investment in real R&D
- Discourages long-term planning
- U.S. Chamber of Commerce chastised Wall Street and encourages all publicly-traded executives to stop reporting quarterly projections

Offshoring

- The biggest challenge for the U.S. is balancing low-end manufacturing and services offshore, while maintaining domestic incentives for companies (foreign and domestic) to develop next generation, or leap ahead, technologies onshore.

Conclusion

- First step to fixing a problem is recognizing there is one
- The U.S. has been in denial, but reality seems to be setting in
  - Augustine Report by The National Academies
  - Legislation recognizing need for innovation leap
  - Thomas Donohue, U.S. Chamber of Commerce

Evolution and Challenges to the Innovation Systems in Japan

<Innovation by Emulation>

The Council for Science and Technology

Taizo Yakushiji

Two Views of S/T Progress

(1) Paradigm Change (*The Kuhnian*)

-----Social Dynamism (*Discrete Process*)

(2) Logical Empiricism (*The Popperian*)

-----Refutability Dynamism (*Incremental Process*)

System or Social Norms ? *(Japan Problem)*

(Question 1) Why Japan once bashed, and now passed?

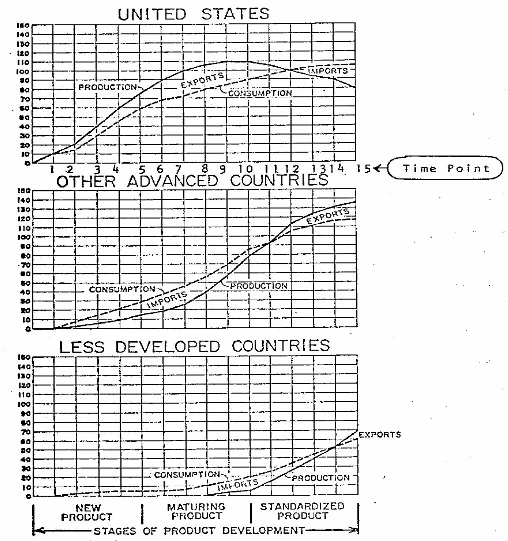
(Question 2) Will China become a “*techno-hegemon*”?

<Three Accounts>

·*Geese-flying theorem*

·*Made in Germany (1898) Syndrome*

·imitation＋ α ＝*emulation*



(Note) Reproduced from: Vernon, R., "Int'l. Investment and Int'l. Trade in the Product Cycle," Quarterly Journal of Economics, 80(2), pp.190-207.

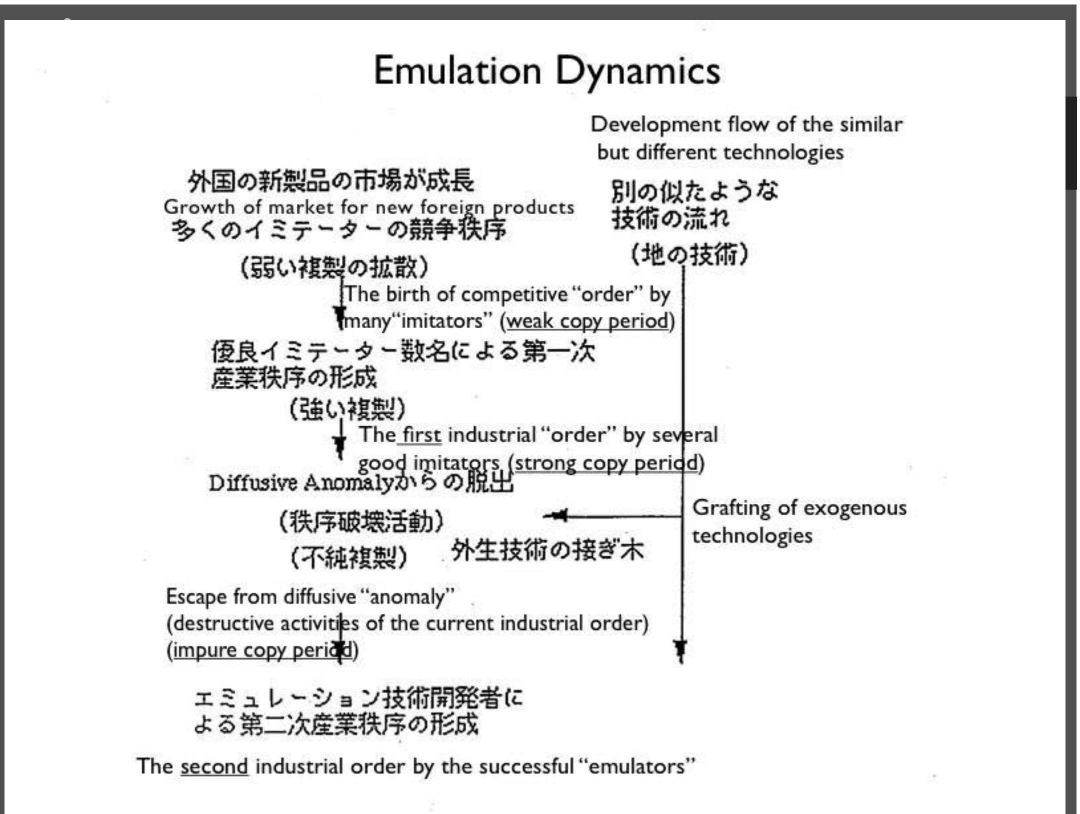
FIGURE VI- 20

R. Vernon's Model on Stages of Product Development

Social Norms and S/T (*US Case*)

(Question) Why the US became No.1 in S/T in a short time?

- S/T as the national integration and identity
- French S/T (*West Point, Du Point de Nemours, etc.*) and *emulation*
- *Pluralism* and American *liberalism*
- A county of S/T immigrants
- A country for experiment (*A. Schlesinger, Jr.*)



Stage	American Wheels
1) Antecedents	I-Steam engine; coal-gas engine; Otto's I internal combustion engine; Daimler's engine; I Benz's cars; French Panhard-Levassor
2) Imitation and the First Competitive Emulation	I-Entries from bicycle business; from wagon I and carriage business I-Emulation of European attempts I
3) The First Industrial Order	I-The Selden patent suits; ALAM vs. I AMCMA I-Ford retained independence (heterogeneity)
4) Technological Carrier and Transplanting	I-European engineers at Ford and Winton I-Ford's reverse engineering of the European cars I-Inter-industry carriers of technology
5) Developmental Constraint, Articulation, Exogeneity	I-Poor road condition I-Intra-company conflicts over a cheap car vs. I a costlier car I-Continuous flow and belt-conveyor system I from the exogenous industries
6) Pre-eminence and Novelty	I-Model-T Ford (the vast reduction of mfg. cost) I-The rapid diffusion into farmers, due to the I rural free delivery system, and the enlight- I ment of farmers by the Granger Movement
7) Key Actors	I-Henry Ford, Billy Durant, Walter Chrysler, I etc.; George Selden
8) The 2nd Competitive Emulation and Industrial Order	I-Clones of Model T Ford I-The establishment of GM I-Ford-GM industrial heterogeneity I
9) Sustenance Skills	I-No patent monopoly (by Ford) I-Coexistence with competitors
10) Spill-over/ Boomerang	I-Hitler's emulation of "Fordization" (Volks- I wagen) I-Japan GM, Japan Ford, Nissan, Toyota
11) Crisis control or Exiting	I-Japanese exports in the U.S. market I-The Voluntary Export Restraint I-GM-Toyota joint-venture; GM's "Saturn" Project

Social Norms and S/T (*USSR Case*)

(Question) Why Soviet Union collapsed?

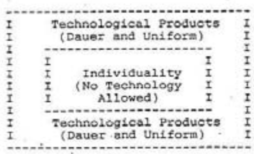
- ·German influences (*German Village in the 17th Century*)
- ·German military industry in the USSR during *the Weimar Republic*
- ·The COMECON's division of labor in S/T (USSR for military S/T, periphery states (Czechs and Poles) for civilian S/T)

Social Norms and S/T (*German Case*)

(Question) Why German S/T is strong although its social norm is conservative?

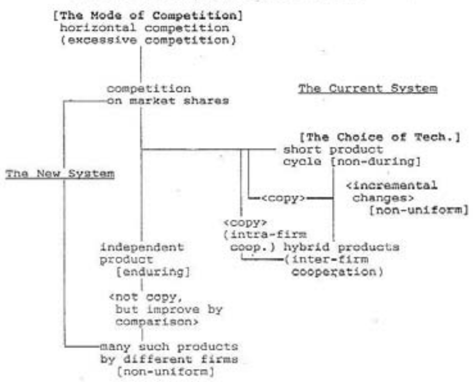
- *"Schaffe, Schaffe, Haeusle, Baue"*
- "The Double Tracks" approach (*DIN, Benz, V2, etc.*)
- *"soziale Marktwirtschaft"*
- *"Technikfeindseligkeit"*
- *"sozialer Stand"* as a social division of labor

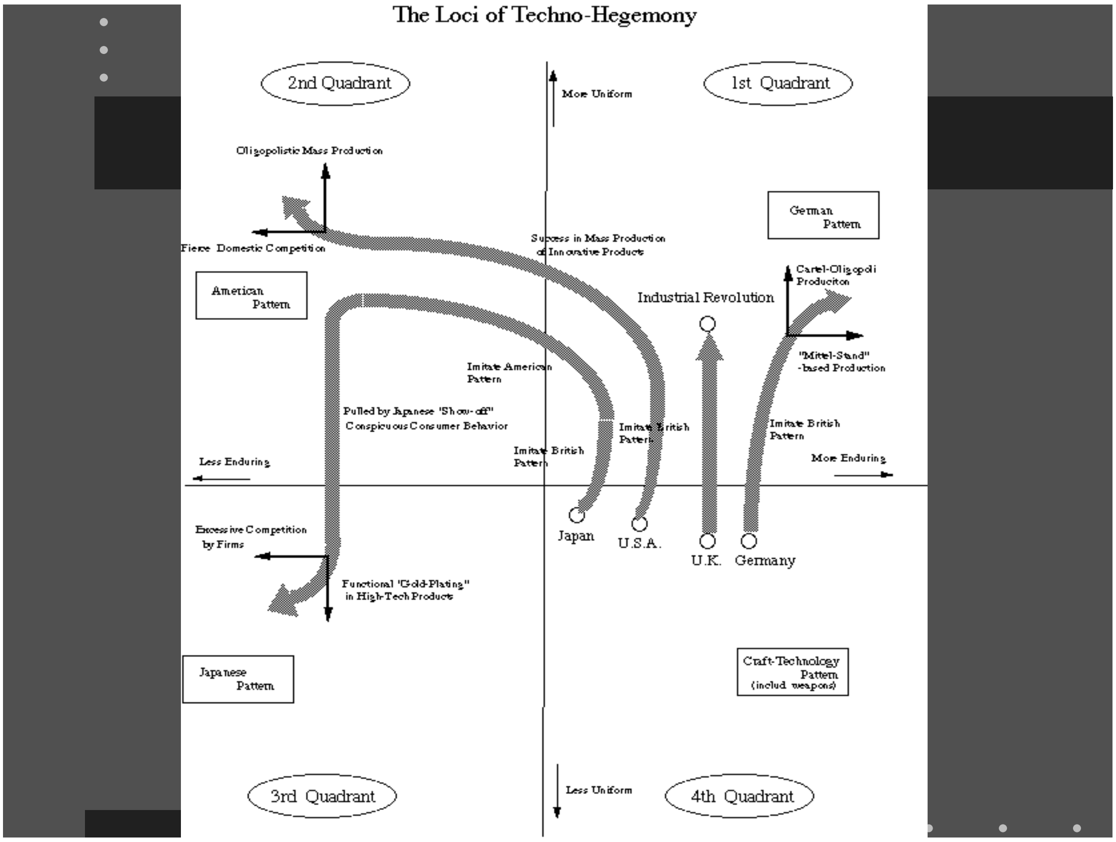
Traditional Pattern of Germans' Techno-"Lebensform"



	"dauerhaftigkeit"	uniformity
Japanese Model	non-enduring	non-uniform
American Model	non-enduring	uniform
German Model	enduring	uniform

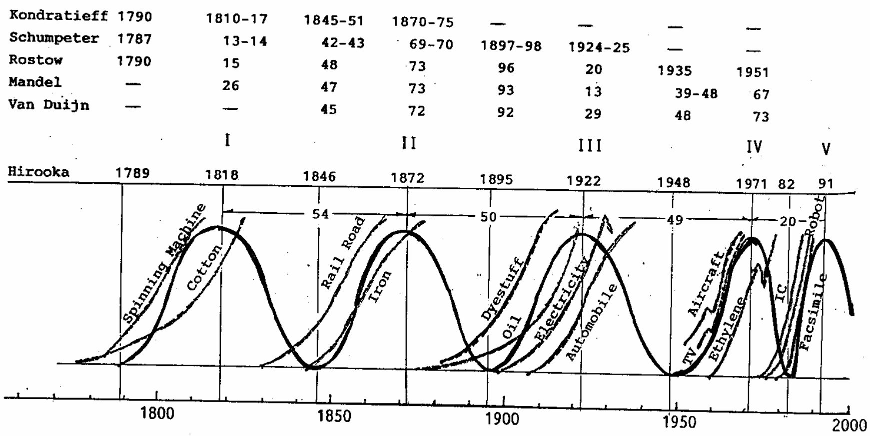
(The Current and New Japanese Models)





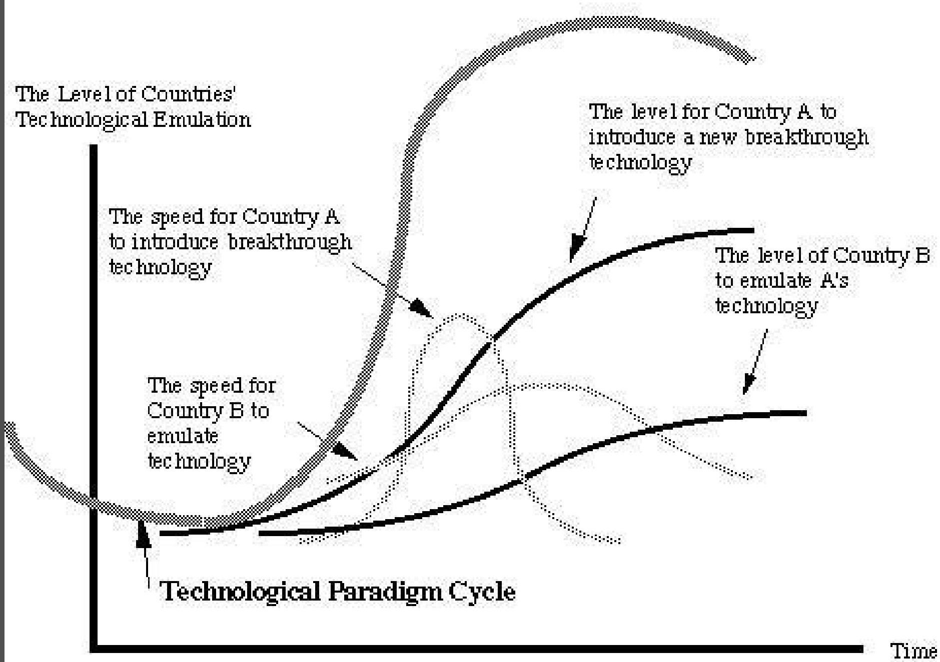
The Rise and Decline of the Great Powers, Why?

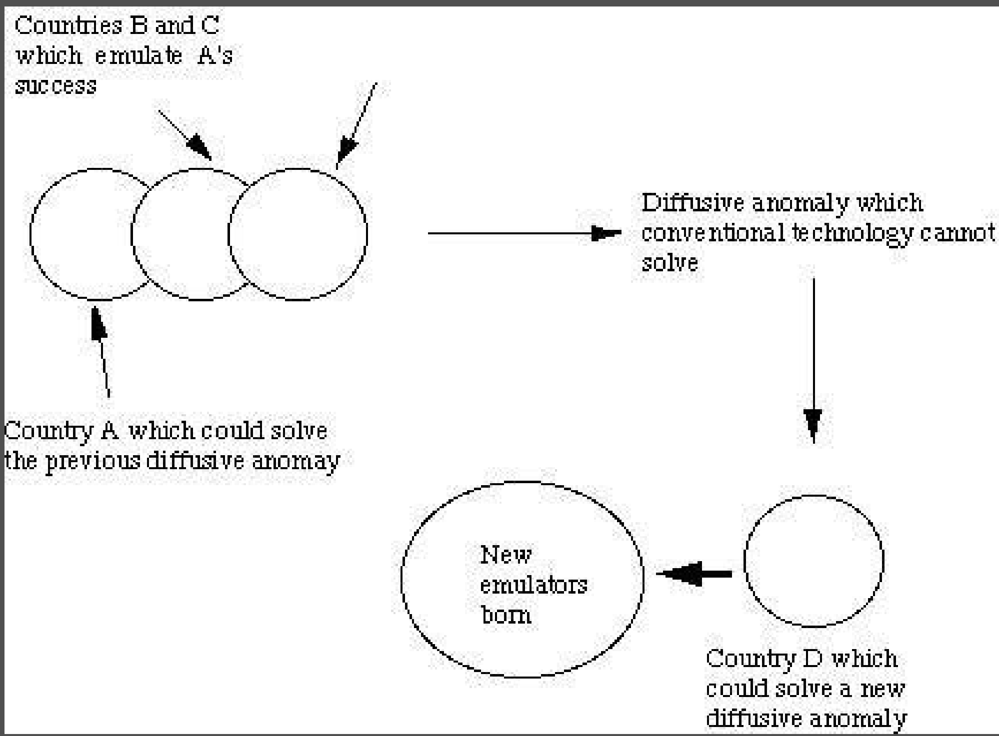
- Decline forever?
- A 60-year cycle
- A 100-year cycle
- Who determines the hegemonic cycle?
- The mysterious coincidence of the early 17th century (UK, Russia, Japan)



Identification of Kondratieff Business Cycle
and Correlation to Product Life Cycle

——— : Kondratieff Business Cycle
----- : Product Life Cycle





Conclusion (*New Japan*)

(Question) Where Japan goes?

- Industrial "*hollowing*"
- Japan strikes back, but how?
- The *Third S/T Plan* for social institutional reforms
- Graduation from *"modernization" mindset*
- S/T for safety, dreams and a new social norm (*back to the future, an new emulous power*)

パネル **I**：企業 **R&D** 支援における政府の役割の展開－米国と日本のモデル

Panel I: Government's Evolving Role in Supporting Corporate R&D—U.S. and Japanese Models

モデレーター：アリス・アムスデン Alice Amsden，マサチューセッツ工科大学教授

日本における技術政策：**1990** 年以降

Technology Policies in Japan: 1990 -

後藤　晃，東京大学先端科学技術研究センター教授／経済産業研究所ファカルティフェロー

元橋　一之，東京大学先端科学技術研究センター助教授／経済産業研究所ファカルティフェロー

企業 **R&D** 支援における政府の役割の展開：先進技術プログラム（**ATP**）における理論と実践

Government's Evolving Role in Supporting Corporate R&D: Theory and Practice in the Advanced Technology Program

ステファニー・シップ Stephanie Shipp，国立標準技術研究所（NIST）　先進技術プログラム（ATP）経済評価室 ディレクター

ディスカッサント

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Technology policies in Japan;1990~

Akira Goto and Kazuyuki Motohashi

Univ. of Tokyo
and
Research Institute for Economy, Trade and Industry

1

OUTLINE

1. Overview of the Japanese Economy in the 1990s ～;Was technology responsible for the long recession?
2. Review of technology policies
   - 2-1 New Framework of technology policy---”Basic Law on Science and Technology”, creation of CSTP
   - 2-2 Government R&D programs（subsidies, commissioned research, cooperative research)
   - 2-3 R&D tax credit
   - 2-4 Technology policy towards SMEs (Japanese version of SBIR)
   - 2-5 Promotion of University-industry links
   - 2-6 Government labs
3. Conclusion
   - market friendly approach
   - closer cooperation with university
   - basic research

2

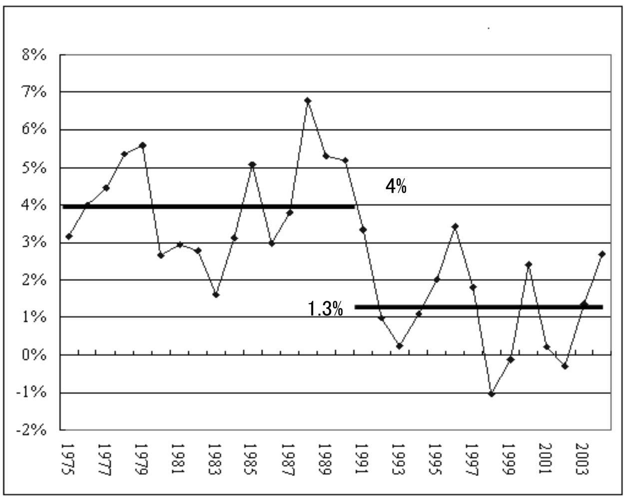
1. Overview of the Japanese Economy in the 1990s ～

Boom in the 1980s
and
long recession in the 1990s and early 2000s

3

Fig 1 GDP growth ratio

source; K.Motohashi, Empirical Analysis of IT Innovation: Has IT Changed Long-term Japanese Economic Performance?, Toyokeizai,2005



4

Cause of long recession

- Macro-financial view
  Collapse of asset bubble in the 1980s
  dysfunction of financial sector
  Excess capacity built in the 1980s
- Alternative view---Productivity slowdown
  Productivity slowdown in the 1990s
  Hayashi-Prescott, Jorgensen-Motohashi, Fukao,,,,

5

Cause of productivity slow down

- Government policy and banks to keep “zombies” alive?
  less productive firms stayed while
  more productive firms exited

- Deterioration of Innovation capability?

6

Deterioration of innovation capability?

- "R&D became less efficient because Japan moved from catch-up to front runner stage"?

  exhaustion of easily "borrowable" technology
- "Mismatch" of Japan's innovation system ?

  to newly emerging key industries in the 1990s,such as IT and BT, and/or

  to innovation in how to innovate, such as more reliance in science

7

However, R&D spending/GDP ratio remained among the highest in the world, and

output (patents, papers, technology exports) improved steadily

8

Fig.2 R&D Expenditure in Japan

source: Report on the Survey of Research and Development, each year, Statistics Bureau

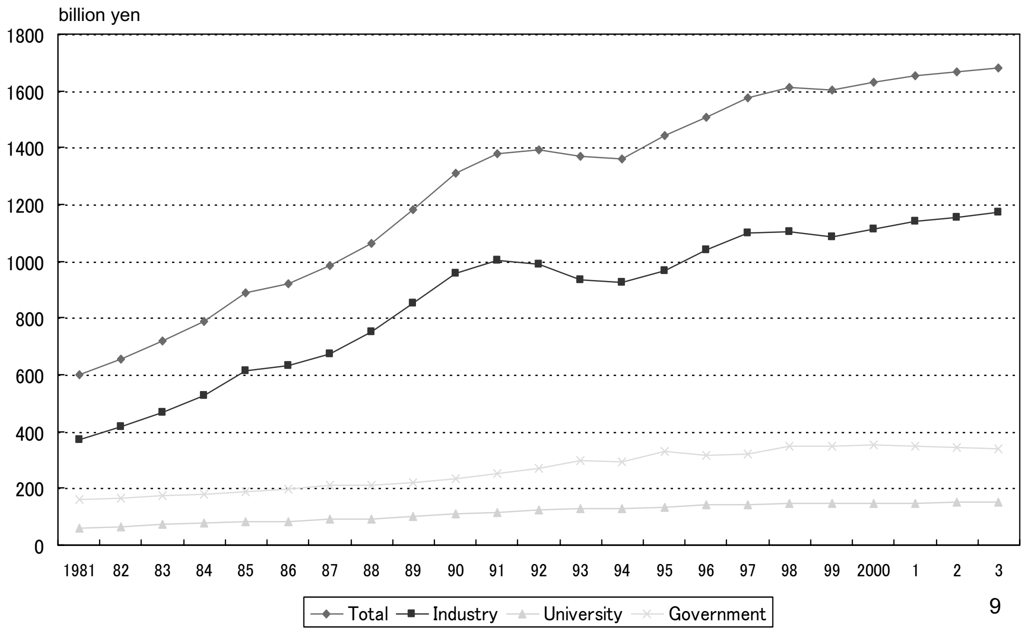


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Fig. 3 Japan's share in the U.S. Patents

source: NISTEP Science and technology indicators

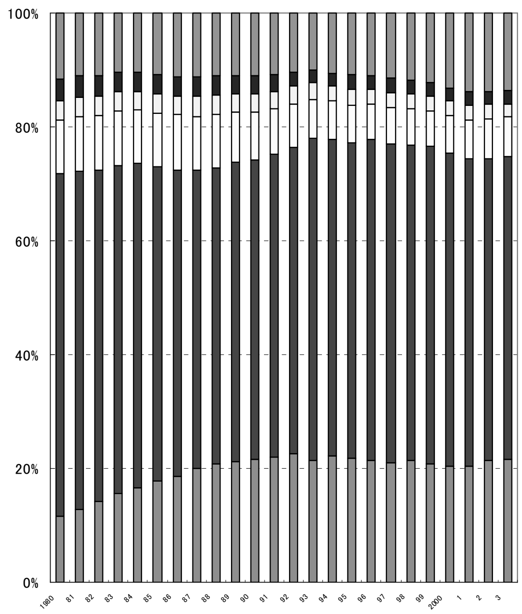

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Fig. 4 Japan's technology balance of payments

source; NISTEP, Science and Technology Indicators

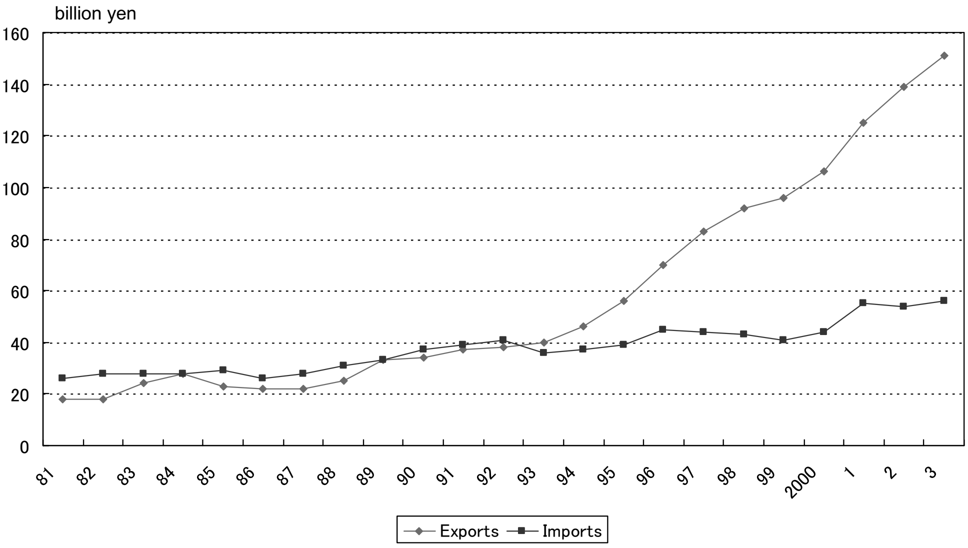

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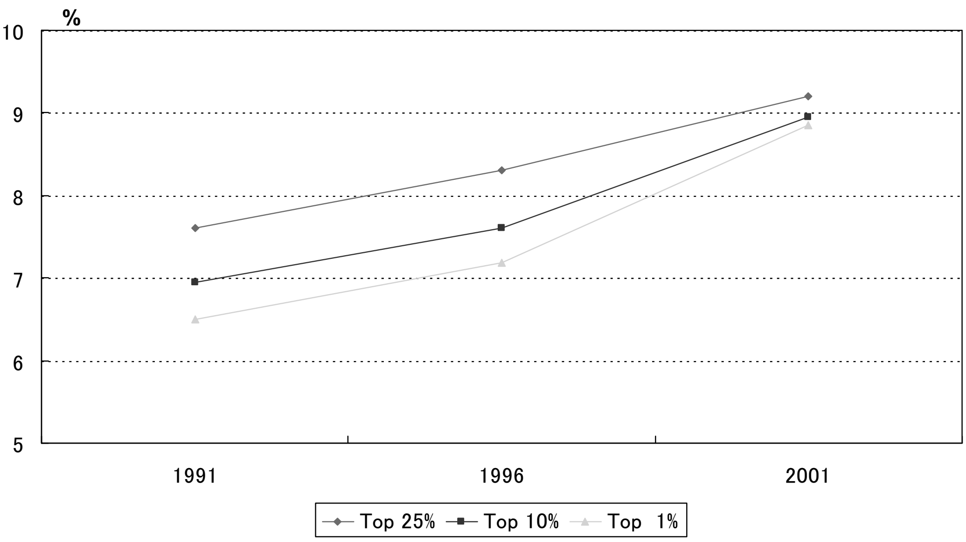
Fig. 5 Japan's share among most highly cited papers

source; NISTEP documents



12

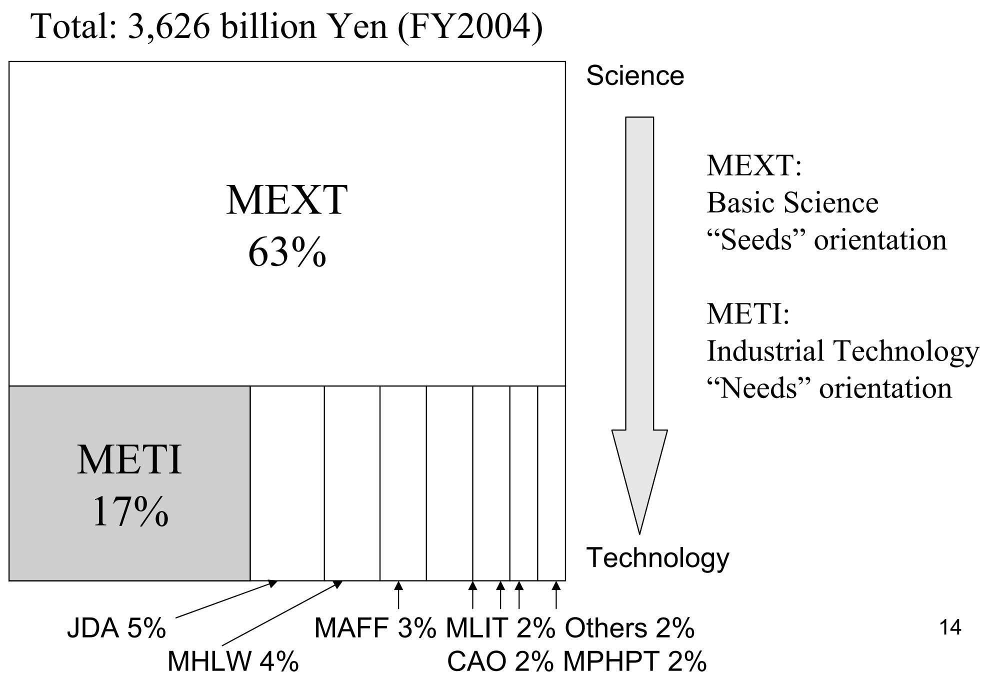
2.Review of Technology Policies in Japan in 1990s

2-1 New Framework of S&T Policy

- Enactment of “Basic Law on Science and Technology” in 1995, and subsequent planning of the Science and Technology Basic Plans
- Merger of Science and Technology Agency with Ministry of Education in 2001
- Strengthening of Council for Science and Technology Policy in 2001

13

Structure of S&T Budget and Organization



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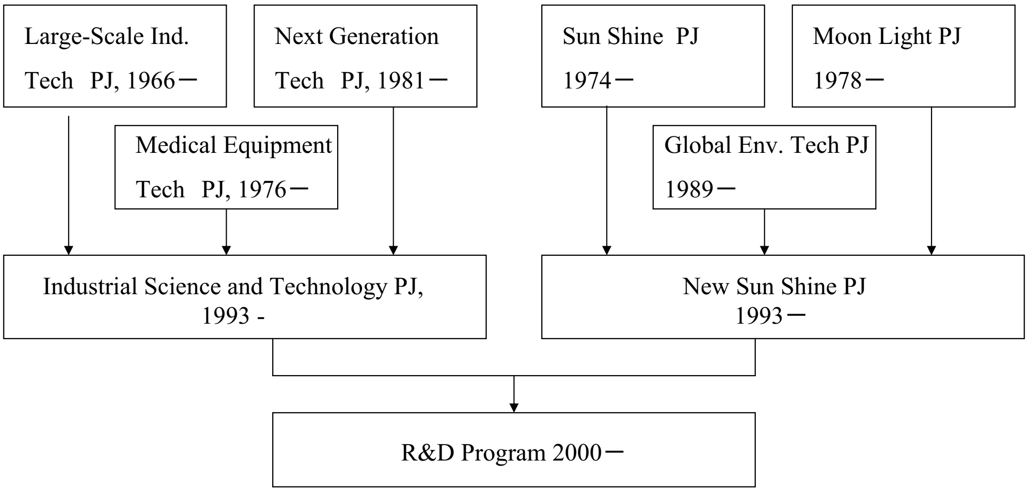
2-2 Government R&D programs:Development of METI's R&D Project



15

METI's R&D Program

A policy package for technological breakthrough and innovation targeting at specific policy goal

- Focusing on important technological fields (2^{nd} basic S&T plan)
- Based on technology roadmap and industrial needs
- Policy orientations by METI's industrial policy sections

Example of R&D Program in FY2005 (budget: 230.8 billion yen)

- **Life Science**: Health Assurance Program, Program for the creation of recycling based industrial system using biological functions
- **Nanotechnology and Materials**: Nanotechnology program, Program to create an innovative components industry
- **Information & Telecommunications**: Program for fundamental technologies of advanced information and telecommunication equipment and devices, Information infrastructure software development promotion program
- **Environment & Energy**: New global warming prevention technology program, The 3R (Recycle-Reuse-Reduce) Program

16

2-3 R&D Tax Credit

- Firms, not government, decide the project →market friendly policy
- Change in design of R&D tax credit system

  existing system lost effectiveness because

  tax credit was linked to increased amount of R&D spending

  ⇒ many firms' R&D spending were not increasing and, many firms were losing money

17

New R&D tax credit system

- 10~12% of R&D spending, not exceeding 20%of corporate tax payment of the company, can be deducted from corporate income tax (2% temporary measure for three years 2003~5)
- Amount to 600 billion yen of corporate income tax reduction

18

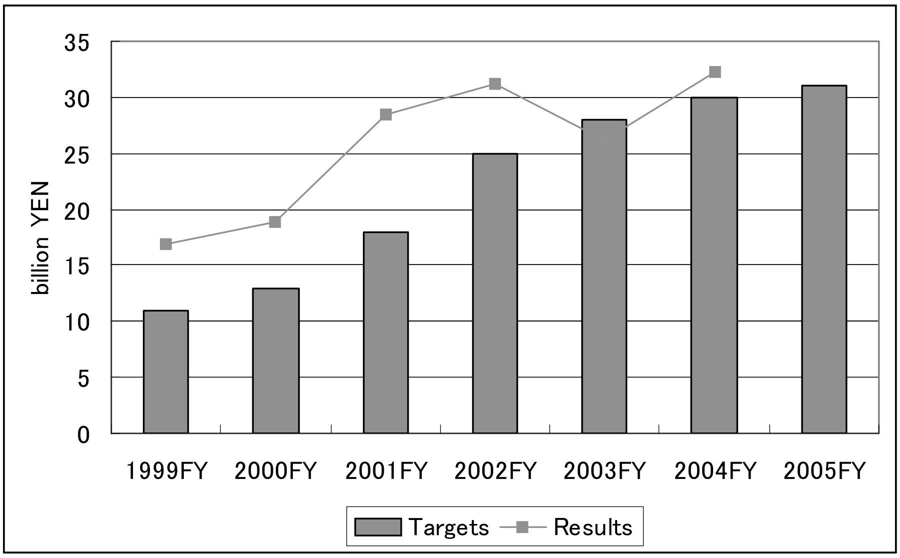
2-4Te4chnology Policy towards SMEs:Japanese version of SBIR
(Small Business Innovation Research)

- Started in 1999
- Setting the target amount of R&D subsidy to SMEs
- Inter-ministerial joint approach: 7 ministries in 2005 (ex. MEXT, METI etc.)
- Other financial incentives
  - – Low interest loan to SME's innovation activities
  - – Wider coverage of SME's loan guarantee program

19

Implementation of SBIR

source; METI documents



20

- Series of laws introduced to promote closer university – industry collaboration, following perceived U.S. model

  1998 TLO Act

  1999 Japanese version of Bayh-Dole Act

- Culminated in National University Corporation Act of 2004

  →National Universities became independent administrative body, faculties are not civil servants anymore

  →Flexibility, and necessity to work with industry

21

2-6 Government Labs

- Restructuring of the government labs under METI and other ministries

  → merger of labs within ministries

  → most of them became independent administrative body with non public servant status

22

3. Discussion

- Further emphasis on R&D in the 1990s
  long run consideration and
  short run response
- Emphasis on basic research (S&T Basic plan)—increased government spending for public institution, but at the same time, closer ties with industry encouraged

23

- More market friendly approach
- R&D for "competitiveness", short term results –industry put more emphasis on R&D with short term results, less on basic long term R&D during recession
- With recent recovery, importance of long term research is emphasized, searching the best way to do long term R&D

24

Government's Evolving Role in Supporting Corporate R&D: Theory and Practice in the Advanced Technology Program

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"21st Century Innovation Systems for Japan and the United States : Lessons from a Decade of Change" Symposium
January 10-11, 2006

1

Outline

- ATP's mission and background
- Economic rationale for ATP
- Fifteen years of Innovation
- ATP Practices
  - ATP is part of NIST
  - Project competition & selection
  - Project management
  - Project and portfolio evaluation

National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce

2

ATP is Praised by National Academy of Sciences

"The Committee finds that the **Advanced Technology Program** is an effective federal partnership program. The selection criteria applied by the program enable it to meet broad national needs and help ensure that the benefits of successful awards extend across firms and industries. Its cost-shared, industry-driven approach to funding promising new technological opportunities has shown considerable success in advancing technologies that can contribute to important societal goals."

The Advanced Technology Program, Assessing Outcomes, C.W. Wessner, editor, National Academy of Sciences, 2001, page 87.

ATP's Mission and Rationale

ADVANCED TECHNOLOGY PROGRAM

ATP mission

To accelerate the development of innovative technologies for broad national benefit through partnerships with the private sector.

ADVANCED TECHNOLOGY PROGRAM

Key features of the ATP

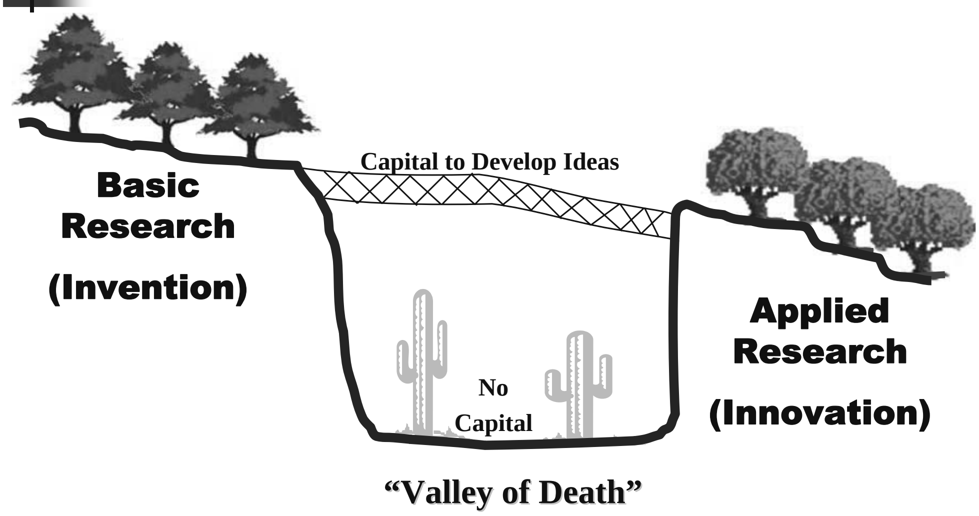
- Emphasis on innovation for broad national economic benefit
- Industry leadership in planning, implementing, and sharing costs of projects
- Project selection based on technical and economic merit
- Demonstrated need for ATP funding
- Requirement that projects have well-defined goals/sunset provisions
- Project selection rigorously competitive, based on peer review
- Program evaluation from the outset

Economic rationale for ATP

Systematic Under-Investment in R&D, due to:

- High technological risk
- Long time horizons
- Knowledge and market spillovers (appropriability)
- Coordination failures
- Information asymmetries

ATP provides a bridge from invention to innovation



Congressman Vernon J. Ehlers

Fifteen years of ATP-funded innovation

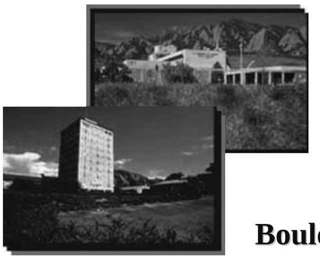
- Since 1990, almost 7,000 research proposals submitted to ATP in 44 competitions.
- 768 projects awarded to over 1,500 participants and an equal number of subcontractors.
- 218 joint ventures (28%) and 550 single company projects (72%).
- $4.3 billion of high risk research funded, with industry contributing half the costs.
  - ATP$ to joint ventures (56%); to single co projects (44%);
  - average ATP$ to joint ventures is $5.9M; to single companies is $1.8M.
- Small businesses lead 2 out of 3 projects.
- Over 165 universities and 30 national laboratories participate.

ATP Practices

ATP is part of NIST.

The NIST mission is to…

Gaithersburg, MD



Boulder, CO

Develop and promote measurement, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life.

Companies Apply for ATP Funding…

As a single applicant company

- For-profit company
- 3-year time limit
- $2M award cap
- Company pays indirect costs
- Large companies cost share at least 60% of total project cost

As a joint venture

- At least 2 for-profit companies
- 5-year time limit
- No limit on award amount (other than availability of funds)
- Industry share >50% total cost

Project competition and selection: Technical and economic criteria

Scientific and Technological Merit (***50%***)

- Technical innovation
- High technical risk with evidence of feasibility
- Detailed technical plan

Potential for Broad-Based Economic Benefits (***50%***)

- National economic benefits
- Need for ATP funding
- Pathway to economic benefits

National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce

Project Selection Process

PROPOSALS

SCREENING

CLASSIFICATION

Gate 1: FULL TECHNICAL PLAN + PRELIMINARY ECON/BUS PLAN

SCIENTIFIC & TECHNOLOGICAL MERIT
- Technical Innovation
- High Technical Risk with Evidence of Feasibility
- Detailed R&D Plan

ECONOMIC/BUSINESS MERIT
- National Economic Benefits
- Need for ATP Funding
- Pathway to Economic Benefits

Gate 2: FULL ECONOMIC/BUSINESS PROPOSAL + BUDGET NARRATIVE

Gate 3: SEMIFINALISTS IDENTIFIED
- *Oral review*

Gate 4: AWARD → Cooperative Agreement

DEBRIEFING

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Project management

Projects evaluated regularly

- Continuation/termination.
- Annual visits (or more often for larger projects).

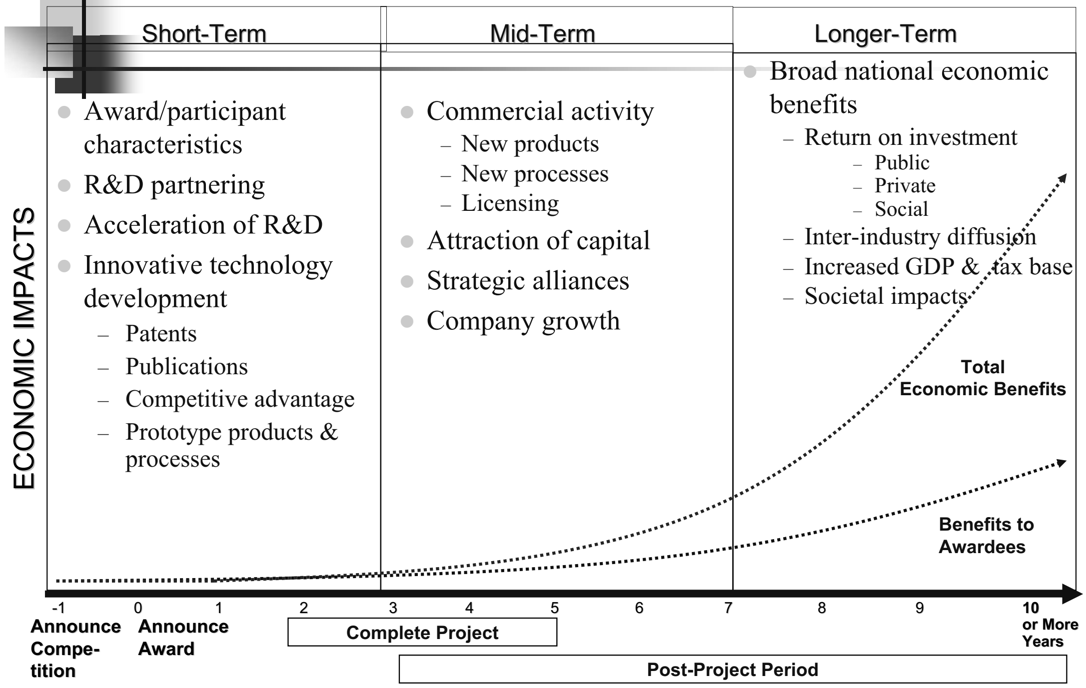
Data

- Quarterly and annual technical reports.
- Annual reporting through Business Reporting System (baseline, anniversary, closeout, and post-project).
- Annual performance plans and reports.

Project management: ATP Business Reporting System

- Business plans:
  - Identification of applications.
  - Strategies for commercialization, protection of IP, and dissemination of nonproprietary information.
  - Significant business developments.
  - Update of business plans and progress on products, processes and licensing activity.
- Collaboration experiences.
- Attraction of new funding.
- New patents.
- Technology diffusion.
- Company financial data.
- Next 5 years-technical and business goals.
- Effects outside of organization.

Project Evaluation Timeline: What We Measure When



Project evaluation activities tied to timing of expected results

Short and Mid-Term

- Ex ante peer review for project selection
- Survey tools to monitor project progress
- Performance measures
- Expert reviews
- Portfolio-wide analysis

Longer Term

- Post-project surveys and data analyses
- In-depth and cluster case studies—return on investment
- Econometric analysis
- Macroeconomic analysis

ATP's Evaluation Program: "An exceptional assessment effort."

"The ATP assessment program has produced one of the most rigorous and intensive efforts of any U.S. technology program…the quality, quantity, and analytical range of [their] studies are impressive."

The Advanced Technology Program, Assessing Outcomes, C.W. Wessner, editor, National Academy of Sciences, 2001, page 91

ATP's evaluation best practices [1]

- Management and institutional commitment to performance evaluation.
- Integration of evaluation into program management while preserving independence.
  - design, implementation, assessment, learning, and feedback from performance metrics (and results).
- Dedicated and appropriate mix of expert staff.
- Coordination with technical office staff.
- Involvement of outside experts.

ATP's evaluation best practices [2]

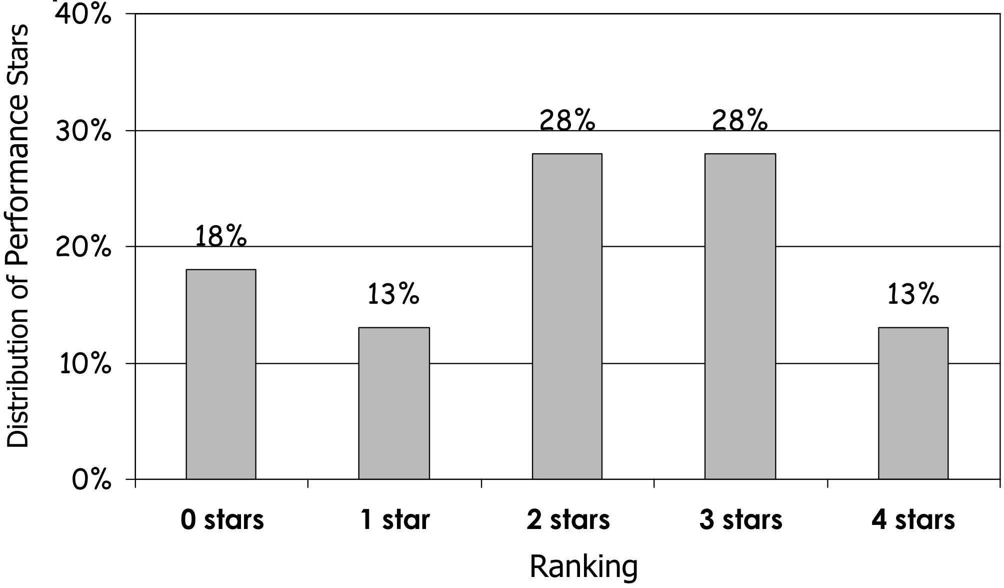
- Matching assessment methods to questions posed.
- Systematic data collection and regular reporting systems.
- Gradual evolution toward more rigorous tests of causal relationships.
- Pursuit of development and testing of new tools.
- Examination of successful and unsuccessful projects.
- Strategic communication of results.

Portfolio-wide analysis

- Performance measures
- Status reports of completed ATP projects
  - Descriptive mini-case studies.
- Portfolio analysis of project performance.
  - Each project receives a rating between 0 and 4 stars on how well it met ATP's mission objectives
    - overall project performance = knowledge creation and dissemination + commercialization progress and diffusion + future outlook.
  - Aggregation of stars provides portfolio of ATP success.

Portfolio Performance Results

First 150 ATP Completed Projects



Portfolio of ATP performance measures of outputs (2004)

Performance Measure	**Actual** FY 2004
Cumulative number of projects with new **technologies under commercialization**	**297**
Cumulative number of **publications**	**1462**
Cumulative number of **patents filed**	**1254**
Percent of projects reporting an increase in longer-term and/or **higher-risk R&D**	**96**
Percent of projects involving R&D **collaboration**	**86**
Percent of project participants reporting **acceleration of R&D cycle time**	**88**

Source: ATP Business Reporting System and status reports of completed projects.

ATP accelerates technology development

- **9 out of 10 project participants indicate that ATP funding accelerated their R&D cycle.** Of those organizations indicating they were *ahead* in the R&D cycle
  - 13% indicate they are ahead by a year
  - 53% indicate that they are ahead by one to three years
  - 7% indicate that they are more than three years ahead

Based on Business Reporting System (BRS) survey data from 673 organizations in 347 ATP projects funded from 1993-1998 – for projects with one or more years of ATP funding.

ATP accelerates Introduction of new products

- **ATP participants report that the acceleration of R&D will reduce the time it will take to bring products to market or to implement new production processes.**
  - Reduction in time-to-market by two years or more is anticipated for about 3 out of 5 planned commercial applications.

Based on Business Reporting System (BRS) survey data from 673 organizations in 347 ATP projects funded from 1993-1998 – for projects with one or more years of ATP funding.

Survey of ATP Applicants 1998, 2000, 2002

Key Findings:

- ATP awards attract additional funding ("**Halo Effect**")
- ATP fosters new R&D directions and partnerships
- ATP fosters collaboration between companies and universities

Survey of Applicants- What happened to nonfunded projects?

When ATP decides to not fund a project, what happens to these projects?

- 39% of these projects are not pursued.
- 44% are pursued on a smaller scale.
  - 4 out of 5 report that project is less than 40 percent of proposed ATP project.

Source: Survey of Applicants, 2002

Behavioral additionality: Joint venture survey-Key findings

- Governance and contractual provisions are more important than goodwill in fostering trust and increase perceived value of project
- ATP involvement is important to ensure stability and to help foster cooperation
- Joint venture size

Behavioral Additionality: 2 Years After ATP Project Ends- Did ATP Companies Continue in any R&D?

- Yes: 83% continued R&D
  - 55% due to positive ATP experience
  - 39% no ATP impact
  - 6% negative impact or DK
- NO:
  - 17% did not continue any R&D
  - Only 2 out of 78 said it was due to negative ATP experience

Source: ATP Post-Project Survey (2 years after ATP project ends)

Behavioral Additionality: 2 Years After ATP Project Ends

ATP companies continued work on ATP Technology:
- New collaborations with new partners: 27%
- Continued collaborations with ATP JV partners: 19%
- Continued collaborations with ATP subcontractors: 31%

ATP companies work on non-ATP Technology:
- Working with ATP JV partners: 46%
- Working with ATP subcontractors: 14%

Source: ATP Post-Project Survey (2 years after ATP project ends)

Hot-spot cluster analysis of high impact patents: purpose

- **Motivating Question: What is the regional impact of ATP?**
- **Hot-Spot Analysis** is a powerful tool that maps out current areas of innovative activity off the beaten path. This tool:
  - Examines clusters of patents that are highly cited by recently issued patents.
  - Identifies a subset of clusters that are developing early stage technologies most relevant to ATP.
  - Analyzes the regional, organizational, and collaborative characteristics of these clusters.

Hot-spot cluster project: Implications and next steps

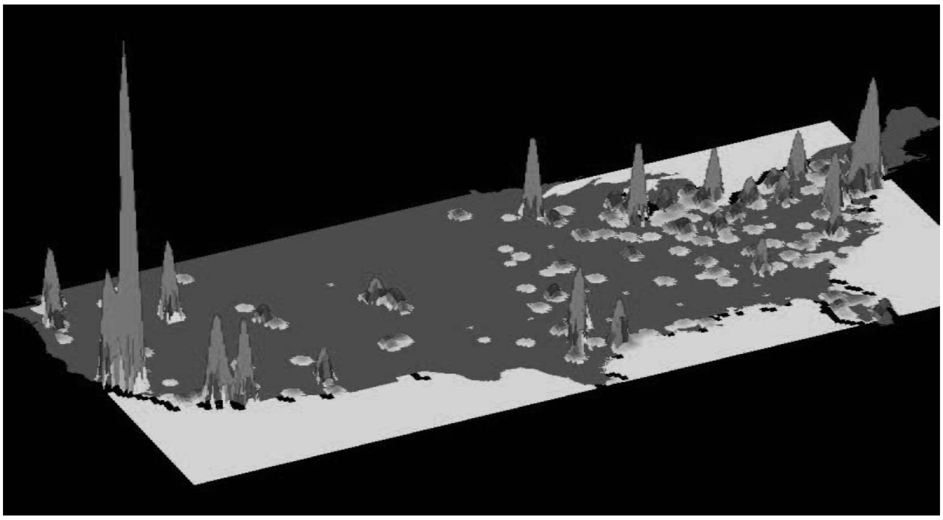
Findings:

- Association between ATP-related patents and Next Generation Clusters.
- Suggests that ATP is funding technology that is closely linked to high-impact technology.
- ATP dollars are likely to have a broad impact beyond individual award recipients.

Visualizing innovative activity

"Understanding Regional Innovative Capacity" Project

Visualization of the 2002 Hot-Spot Patents



ATP is meeting its mission

ATP Studies Provide Evidence that ATP is *Meeting Its Mission* through

- Acceleration of R&D
- Increased collaborations
- Strong small business participation
- Refinement of manufacturing processes
- Commercialization of products and processes by US companies
- Large spillovers, leading to broadly distributed economic benefits

In summary … ATP

- ***Focuses*** on the civilian sector
- ***Funds*** enabling technologies with high spillover potential
- ***Focuses*** on overcoming difficult research challenges that cannot find private funding
- ***Encourages*** company-university-laboratory collaboration - capitalize on R&D investments
- ***Requires*** commercialization plans and implementation to ensure societal outcomes
- ***Measures*** against mission in our evaluation work

Understanding ...

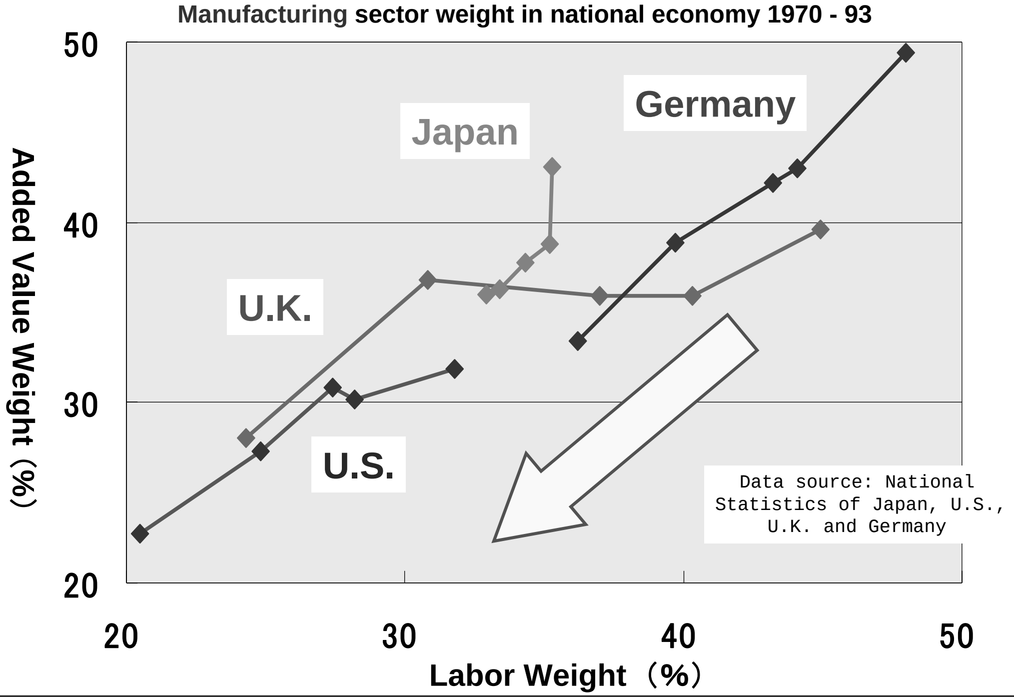
1. ***New Context***
2. ***New Effect / Aspect***
3. ***New Management***

Structural Change in National Economy **:**

new industry : promising new tech. opportunity #3
broad national economic benefit #6
newly emerging key industries #7
. . .

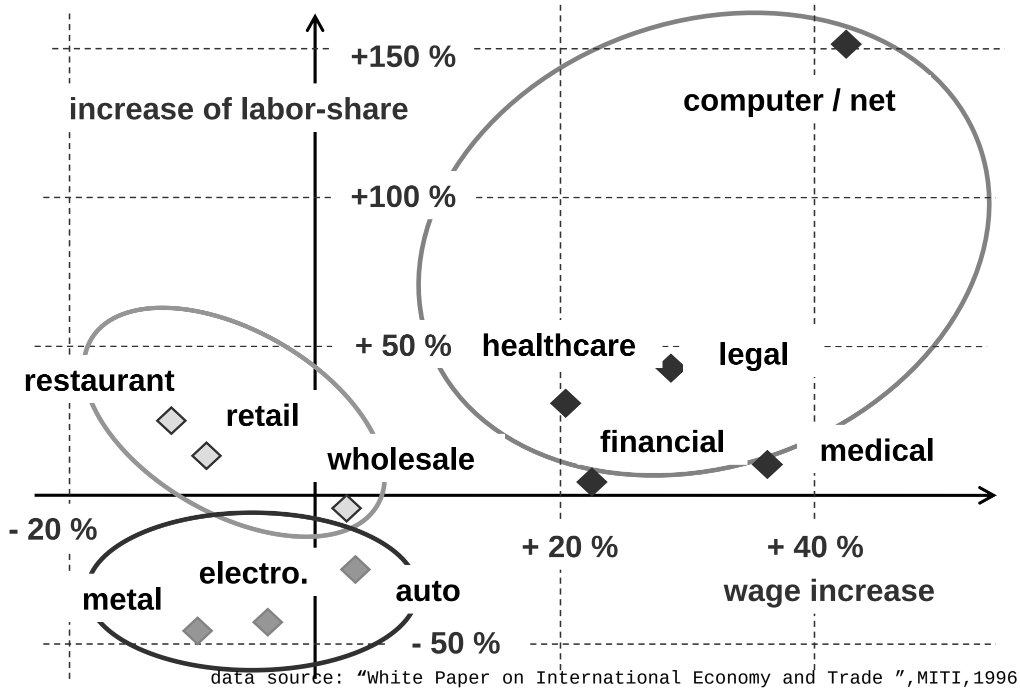
new method: industry leadership / sunset … #6
national plan #16
tech. roadmapping #20
tax policy change #23-24
. . .

Industrial Evolution : same direction, different speed 3



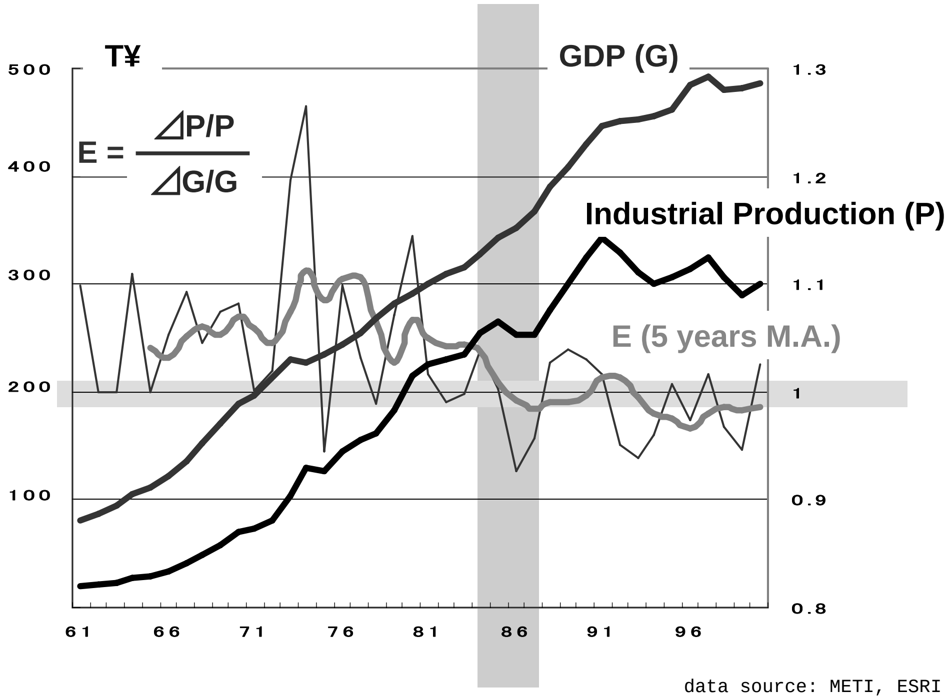
Tokyo, Jan.10, 2006 nakajima ichiro

US Industrial Evolution in 1980 - 94 4



Tokyo, Jan.10, 2006 nakajima ichiro

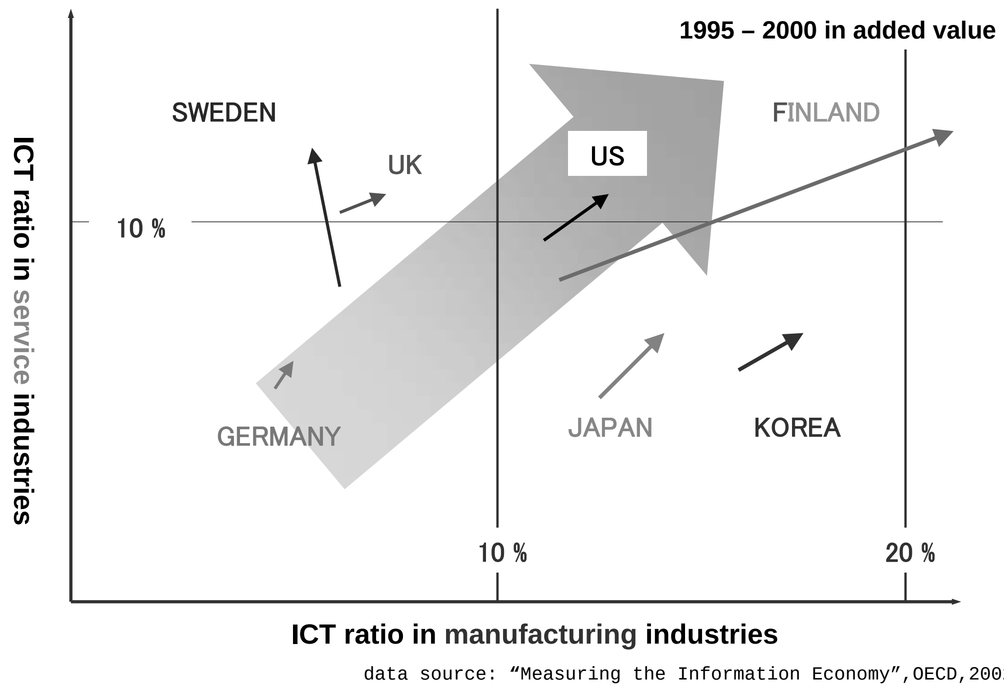
Industrial Change in mid-1980s（Japan） 5



data source: METI, ESRI

Tokyo, Jan.10, 2006 *nakajima ichiro*

ICT ratio : balanced US, Japan’s speed 6



data source: “Measuring the Information Economy”,OECD,2002

Tokyo, Jan.10, 2006 *nakajima ichiro*

Government's Evolving Role in Supporting Corporate R&D <2> 7

New Aspects of Industrial R&D **:**

Science based R&D, U - I Collaboration :

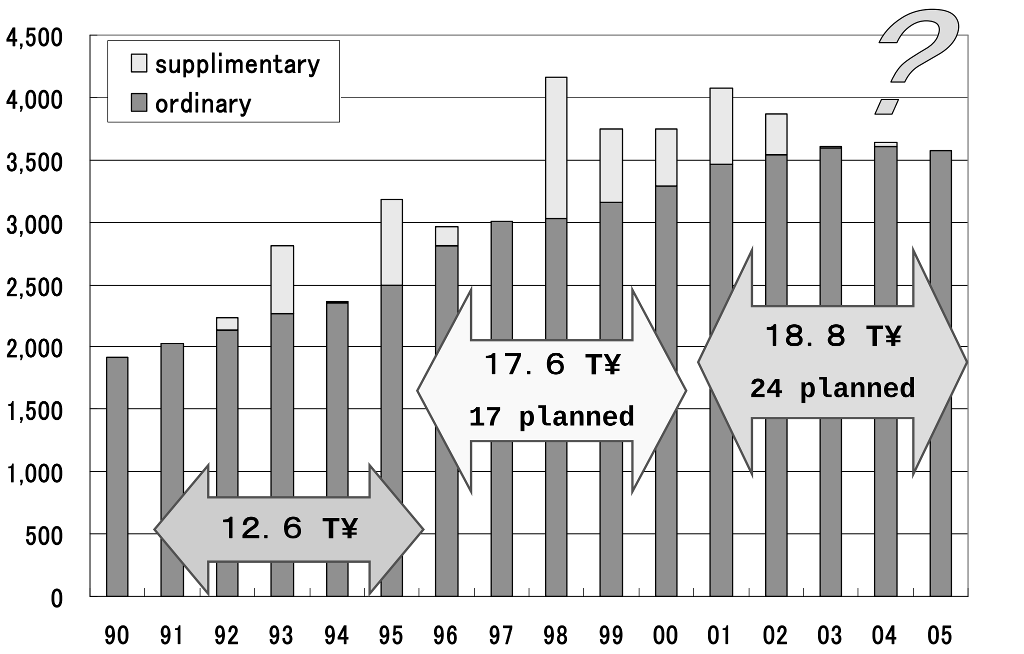
- **ATP fosters collab. U-I #9, #27**
- **increased importance of science #7**
- **recent reforms in Univ. #25-29**
- **also in National Labs #30**

Region（Cluster）, SMEs :

- **hot spot analysis #32-34**
- **SMEs / SBIR #21-22**

Tokyo, Jan.10, 2006 *nakajima ichiro*

Increasing R&D Budget in Japan 8

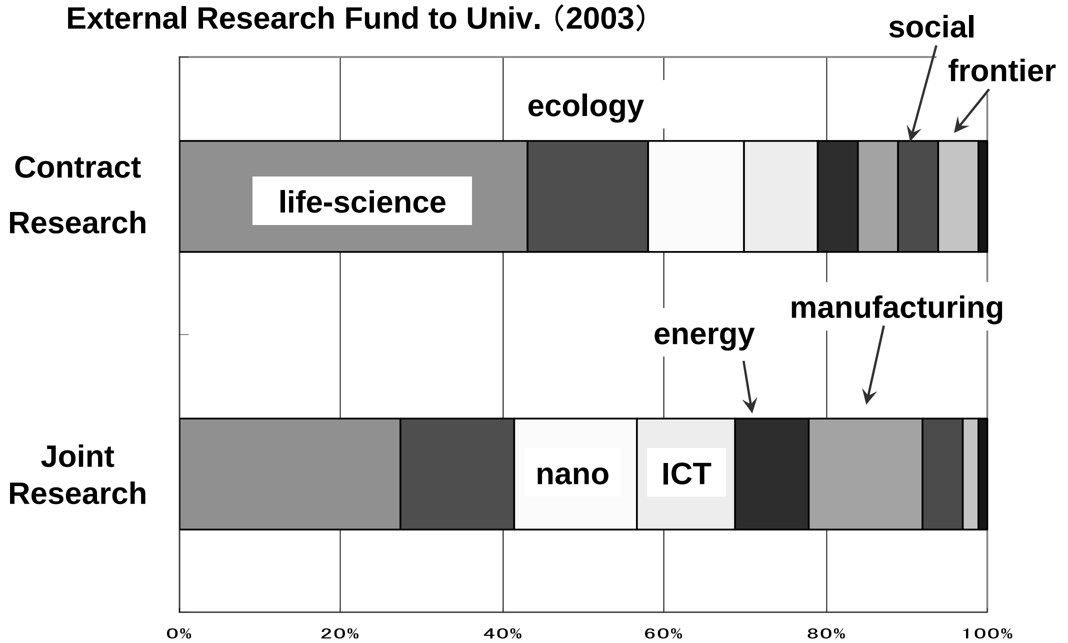


Data source: MEXT

Tokyo, Jan.10, 2006 *nakajima ichiro*

U - I Collaboration : to Newly Emerging Sector

External Research Fund to Univ.（2003）



data source: MEXT, 2004

Government's Evolving Role in Supporting Corporate R&D <3>

New Management **:**

project selection #13-14

project management #15-16

project evaluation #17-21

portfolio-wide analysis #22-24

national plan #16

national tech. roadmapping #20

National Technology Roadmapping（2005）

< ICT >

semiconductor, storage & non-volatile memory, computer, network, usability, software

< Life Science >

pharmaceutical, medical equipment, regenerative medicine

< Environment, Energy >

CO2, fluorocarbon, chemical products control, recycle / reuse / reduce, energy

< Manufacturing >

robotics, aeronautics, space, nano-technology

source: http://www.nedo.go.jp/denshi/roadmap/

パネル **II**：政府-産業間 **R&D** 協力－日米の実験

Panel II: Government-Industry R&D Partnerships - U.S. and Japanese Experiments

モデレーター : ロニー･エーデルハイト Lonnie Edelheit, ゼネラル･エレクトリック（GE）元 R&D 担当上席副社長／全米工学アカデミー

日本における半導体コンソーシアム：経験と教訓

Semiconductor Consortia in Japan: Experiences and Lessons

藤村 修三，東京工業大学大学院イノベーションマネジメント研究科教授／一橋大学イノベーション研究センター客員教授

中馬 宏之，一橋大学イノベーション研究センター教授／科学技術政策研究所客員総括主任研究官

国際 **R&D** 連携の経済的影響：**SEMATECH**、国際技術ロードマップ、及びマイクロプロセッサにおけるイノベーション

Economic Impacts of International R&D Coordination: SEMATECH, the International Technology Roadmap, and Innovation in Microprocessors

ケネス・フラム Kenneth Flamm，テキサス大学オースチン校 リンドン・B・ジョンソン公共政策スクール ディーン・ラスク国際関係講座長，教授

ディスカッサント

本城 薫，独立行政法人新エネルギー・産業技術総合開発機構（NEDO）理事

Semiconductor Consortia in Japan: Experiences and Lessons

Shuzo FUJIMURA
Tokyo Institute of Technology

Hiroyuki CHUMA
Hitotsubashi University

Contents

Consortia for Device Technologies

MIRAI (2002/8)

; Millenium Research for Advanced Information Technology

Selete (2001/4～2006/3)

; Semiconductor Leading Edge Technologies, Inc.

ASPLA (2002/7)

; Advanced SoC Platform Corporation

STARC (1995/12)

; Semiconductor Technology Academic Research Center

Consortia for Equipment

HALCA (2001/8～2004/3)

; Highly Agile Line Concept Advancement

EUVA (2002/6～2006/3)

; Extreme Ultraviolet Lithography System Development Association

ASET (1996/2)

; Association of Super-Advanced Electronics Technologies

LEEPL (2000/6)

; Low Energy E-beam Proximity Projection Lithography

Consortia for Materials

SiP (2002/8)
; System in Package Consortium

CASMAT (2003/3)

; Consortium for Advanced Semiconductor Materials and Related Technologies

Others

VDEC ; VLSI Design Education Center

DIIN; New Intelligence for IC Differentiation

What happened in semiconductor industry(?256K)

	Business Matter	Technological Matter
16K	▪ Japanese Companies' entry into the semiconductor industry ▪ R&D Consortium for VLSI	▪ Plasma equipment had come into wide use. ▪ Automatic controlled equipment became popular
64K	▪ 3 Japanese makers entered into top 4 DRAM supplier	▪ New process technologies (RIE, Sputtering, Ion implantation, etc) appeared
256K	▪ Japanese DRAM occupied 80% of word 256k DRAM market ▪ Intel quitted DRAM business	▪ Stepper and Plasma CVD appeared ▪ Single-wafer equipment

What happened in semiconductor industry (1M?)

1M

- **Korean Companies' entry into DRAM business**
- **Cluster tools appeared**
- **Chip companies gave up developing in-house equipment.**
- **Stacked capacitor and Trench capacitor appeared**

4M

- **Samsung became no. 1 DRAM supplier.**
- **I-line stepper**
- **Oligopolizing of equipment suppliers**

16M

- **NEC was only 1 Japanese company in top 4 DRAM suppliers.**
- **KrF stepper**
- **Popularizing of CMP**

64M

- **Rapid growth of Taiwanese companies in DRAM market.**
- **AMAT advocated "Total solution"**
- **Cu wiring and Low-k insulator were introduced into the LSI processing.**

Research Schedule

ASET Projects		R&D Targets	Money (~FY2007)	H7 95	H8 96	H9 97	H10 98	H11 99	H12 00	H13 01	H14 02	H15 03	H16 04	H17 05	H18 06	H19 07
Super Advanced Technology																
Semicon.	EB DW	High speed EB direct writing	32													
	EB Mask Writer	High accuracy EB mask writer	22													
	EB Lithography	Advanced EB technology	12													
	PXL	Proximity X ray Lithography	62													
	EUV	Extreme Ultraviolet Lithography	75													
	ArF Lithography	ArF lithography	17													
	Plasma	Plasma physics and diagnostics	25													
	Cleaning	Surface cleaning and simulation	8													
Mag Storage	Magnetic Storage	40Gbit/in2 class hard disk technology	57													
LCD	Reflective LCD	Reflective LCD material and devices	82													
EUV Absolute Wave Front		EUV absolute wave front measurement system	6													
EUV Process Technology		EUV mask and resisit process technology	11										4			
Equipment	Process equipment	Plasma equipment, Eximer laser	29													
	Simulation	FTP, Probe card	4													
	F2 Lithography	F2 light source, coating, purging	20													
PFC Substitution Process		Reduction of PFC in etching process, PFC free new wiring technology	62													
Electronic System Integration		3D packaging, Optical/electrical combined printed circuit boards	47													
Optical Packaging Standardization		Following Electronic System Integration Standardization of optical interconnection between boards and active interposers	1										1			
MIRAI Project		High-k gate stack, Low-k interconnect module, New transistor, etc	151										35			
HALCA Project		Energy saving, miniline concept fab for SoCs	82													
High Efficiency Semiconductor Manufacturing Tool		Following HALCA Stencil mask, 300mm FTP, CMP	–													
F.S. for Mask D2I		Feasibility Study of the Optimization Technology of Mask Design, Drawing, and Inspection for 45nm hp System LSI	–													

ASET: Semiconductor Process Technology *(First Stage)*

ASET has various lithography technology development programs started in 1996. They are Electron Beam Direct Writing Technology, Electron Beam Mask Writing Technology, ArF Eximer Laser Lithography Technology and Proximity X-Ray Lithography Technology. Former 3 programs have been completed and some of the research results are used for commercial production.

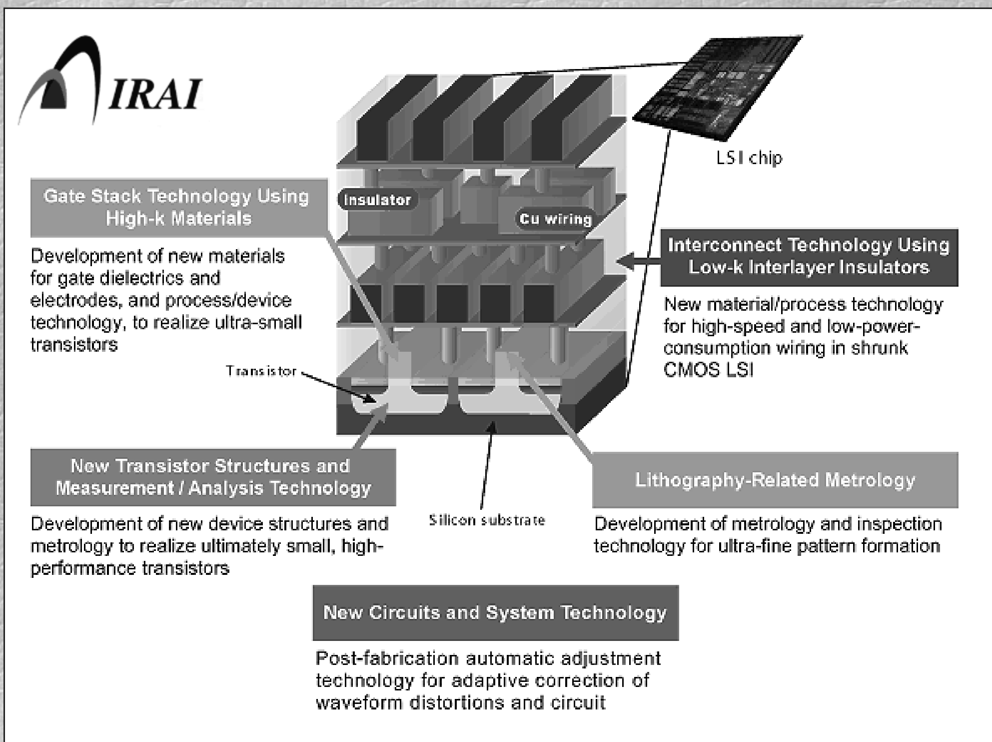
ASET is also conducting Plasma Science and Diagnostics Technology and Surface Cleaning Technology necessary for very small pattering and fabrication of next generations of semiconductors

ASET: Semiconductor Process Equipment Technology *(Second Stage)*

In 1999, ASET made R&D programs for basic technology of next generation semiconductor equipment. They were Advanced Plasma Processing Equipment, Eximer Laser Source, High Speed Processing and Energy Conservation Technology (Self Cleaning Wafer Cassette, High Speed Thermal Processing Technology).

In 2000, R&D of F2 Laser Lithography and Simulation Technology (High Speed High Density Probe Card, High Speed Thermal Processing Technology) programs are continued.

The seven-year MIRAI project (consisting of a three-year first phase and four-year second phase) comprises R&D in new insulating materials, which will be indispensable for semiconductors of the future, and development of the processing technologies necessary for their practical realization. As a result of these activities, the project will develop and demonstrate the feasibility of semiconductor technologies to markedly improve such basic performance features as the power consumption and data processing speed of LSIs in the 45 nm and future technological generations.



Selete

Advanced Lithography

- Optical Lithography and Photomask / Electron Beam Lithography→ 45nm and 65nm nord

Advanced Process (Front End Process)

- High-k Material Selection and Film Formation Methods
- Ultra Fine Gate Patterning Technology
- High-k Wet etching technology
- Flash Lamp Anneal Technology
- SiN-CVD technology
- SiN-Cat-CVD Technology
- Base CMOS Module for 65 nm node
- High-k transistor module
- Metal gated MOSFET Technology

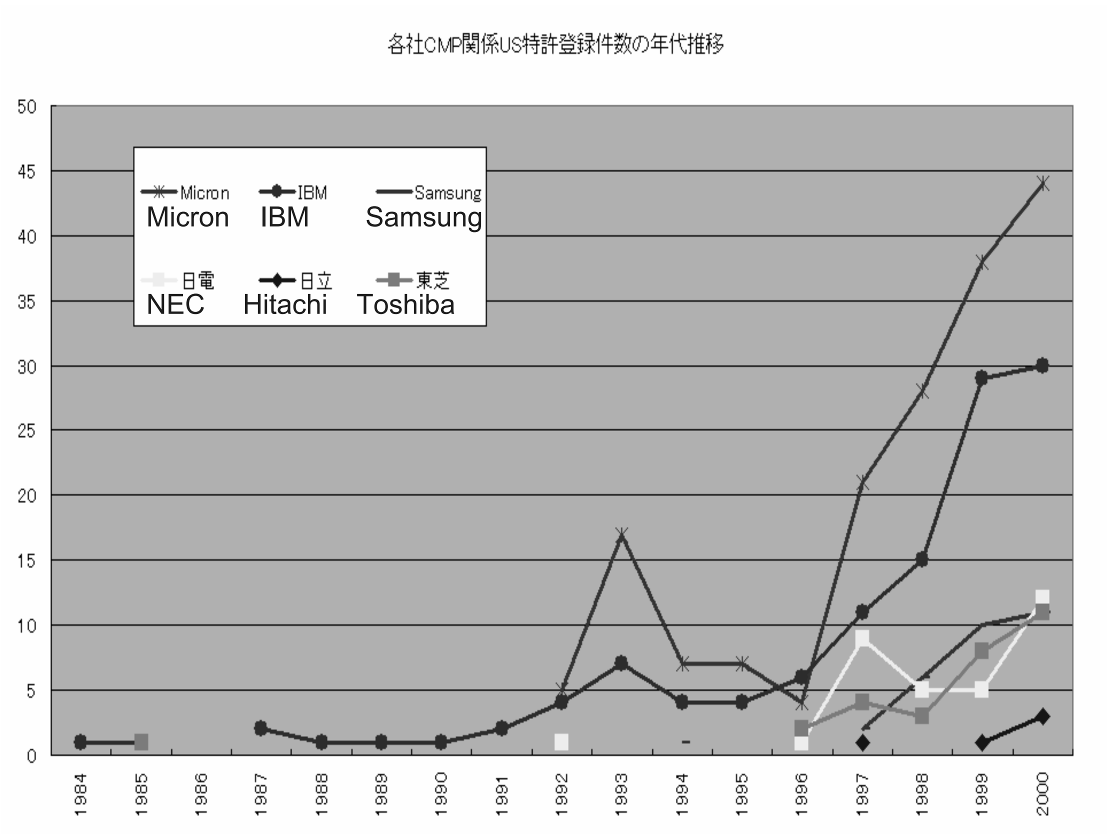
Selete

Advanced Process (Back End Process)

- Development and evaluation of high-strength porous low-k film
- Development of low-damage process
- Copper embedding technology using ALD barrier
- Evaluation of 200nm pitch, two-level copper interconnect TEG and module fabrication

Number of accepted papers relating to CMP in IEDM

	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
Hitachi											★		★		★
Toshiba							★	★		★	★				
NEC					★	★	★	★	★★		★	★			
Mitsubishi															
Fujitsu							★★★				★				★
IBM	★	★		★									★		★
Intel															
Micron					★										
Mostek															
Motorola					★	★	★		★		★				
TI										★					
Infineon +Siemens															
Samsung						★★		★★		★		★	★		★
Hynix +Hyundai + LG															



Meaning of CMP and High-k, Low-k

CMP; Eliminating the influence of the difference in under layers and improving independence of following wiring process.

→ Cancellation of process complexity

High-k, Low-k; New material. The material physical properties, the deposition method, and the device structure that are the key factors that decide the process performance depend mutually.

→ Concentrating the knowledge of the device maker, the device manufacturer, and the material manufacturer have to be needed.

CASMAT

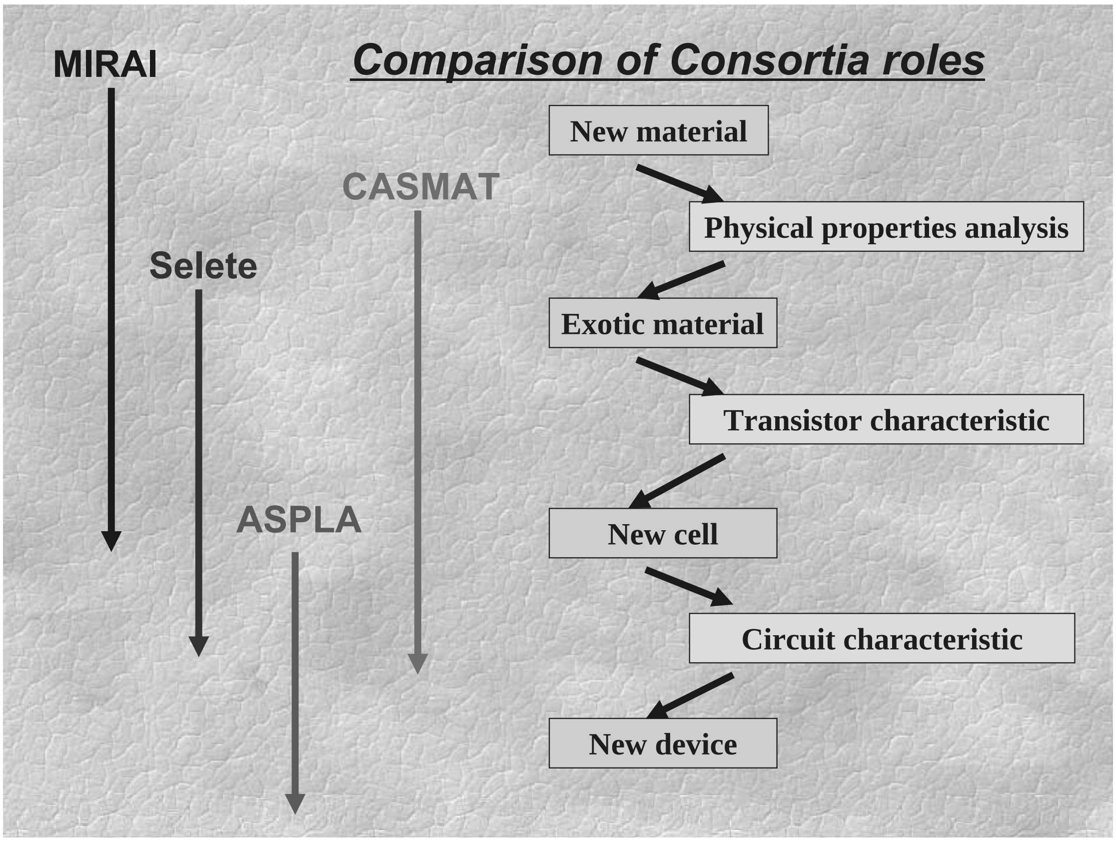
Japanese semiconductor materials manufacturers are playing a major role in the world market and will try to continue to offer high quality and advanced semiconductor materials, but are now facing the difficulties to overcome the methodology limit of the individual material research to improve the performance of the comprehensive set materials under the changing circumstances of rapid progress of nano-meter devices and complex processes.

Against this backdrop, **it becomes more and more important to have close cooperation between different manufacturers of semiconductor devices, semiconductor materials and semiconductor equipments in order to promote the concurrent development of processes and materials**, thus achieving the high efficient development of the world's leading new semiconductors and their necessary materials.

Recognizing this importance, Consortium for Advanced Semiconductor Materials and Related Technologies (CASMAT) was formed and founded by a group of major Japanese manufacturers of semiconductor materials in March, 2003

Comparison among MIRAI, Selete, and CASMAT

MIRAI	*Selete*	*CASMAT*
65-45nm	65nm ～	65nm
Next generation (65nm), and the exotic material for generation (45nm) and the developments of the process module and the device technology, etc.	**1)157 nm lithography, mask, and EPL (electron beam projection exposure lithography)、2) Transistor that adopted an exotic High-k material for gate、3) Multilevel interconnection using an exotic Low-k material and Cu**	**1) Development of element technology, evaluation technology, and supporting tools for back end process of 65 nm semiconductor devices. 2) Design of TEG(=Test Element Group) for the evaluation of the materials.**
・Development of materials, material and measurement and analysis technology for the high-k gate. **・Development of materials, material and measurement and analysis technology for the Low-k insulator.** **・Others**	**Leading edge lithography technology** **-Optical lithography mask** **-EB lithography** **・Leading edge processing technology（FEP)** **-High-k Element process** **-Front end process** **-Process module** **・Leading edge processing technology（BEP)** **-Back end process**	**・Material related to the insulation film between low permittivity layers** **・Material related to copper interconnect CMP** **・Buffer court and material related to re-wiring** **・Material related to wafer processing for assembly**



Comparison among MIRAI, Selete, and CASMAT

MIRAI	*Selete*	*CASMAT*
Part of AIST (Nationa Institute)	*Company*	*Research Association*
¥3.8 billion in Fiscal 2001, ¥4.56 billion and ¥1.78 billion for extra budget in 2002, ¥4.55 billion in 2003, ¥4.55 billion in 2004, and ¥4.55 billion in 2005. By Advanced Semiconductor Research Center (ASRC) and the Association of Super-Advanced Electronics Technologies (ASET)	Capital: ¥5.5 billion R&D Budget for ASKA project: ¥70 billion / 5years	
ASM Japan; EBARA; Fujitsu; Hitachi Construction Machinery,; Hitachi High-Technologies; Hitachi Kokusai; Intel; Matsushita Electric; Mitsui Chemicals; NEC; Nikon; Oki Electric; Renesas Technology; ROHM; Sanyo; Seiko Epson; Sharp; Sony; Sumitomo Chemical; Sumitomo Heavy Industries; Tokyo Electron; Toshiba, and ULVAC24 companies	Stockholders; Fujitsu; Matsushita Electric; NEC Electronics; Oki Electric; Renesas Technology ; Sanyo ; Seiko Epson ; Sharp ; Sony ; Toshiba Contractors; Samsung	JSR Sumitomo Chemical Sumitomo Bakelite Sekisui Chemical Tokyo Ohka Kogyo Toray Industries Nissan Chemical Nitto Denko Hitachi Chemical Fuji Photo Film Co., Ltd.

Selete engineer A (High-k); Our processes are not leading edge. The development of a top major company is more advanced than we. Therefore the process developed here would not be used in the major semiconductor manufacturer. However, their development doesn't necessarily succeed without fail . If their development fails, the processes of us become the substitutions. On the other hand, the companies in secondary position will use our processes as it is.

Selete engineer B (High-k); The content of our research and the content of the research of MIRAI consequentially become the same almost. Because the device structure depends on the material, and an appropriate material is selected according to the device structure.

☆ **Why was the development start to CMP delayed?**

→ Japanese semiconductor device manufacturers have the possibility of not noticing the importance of the reduction of the interference between the processes to ease the complexity.

☆ **Why were not the device makers, the equipment manufacturers, and the material suppliers able to cooperate for the development of High-k and the Low-k process?**

→ Japanese semiconductor device manufacturers did not have adequate management skills for R&D with completely new materials to which physical properties have not been clarified enough. They were not able to get rid of the traditional R&D management progressed gradually based on the improvement of the past.

The increase in the number of processes strongly demanded the improvement of experimental efficiency.

→ STARC ?

The increase in the product development cost strongly demanded the improvement of experimental efficiency.

→ ASPLA ?

The increase in the wafer fabrication cost strongly demanded the improvement of productivity.

→ New joint fab?

Typical examples to cope with rapidly increasing complexity:

- Increasing *ex ante* indeterminacy should be alleviated by *ex post* agility -

- Software (including embedded system):
  Structured programming & Waterfall-style development method
  → Object-oriented programming & UML-based and agile development method (Aspect-oriented method considers even the nonlinearity among objects *per se*)
- Data base:
  Era of Relational Database → Era of XML Database
- CPU architecture:
  Architecture that aims to secure *ex ante* "high reproducibility" → Architecture that presupposes *ex ante* indeterminacy induced by rapidly increasing complexity (Single-core →Multi-core)
- Semiconductor device:
  Design and manufacturing that presupposes the validity of scaling rule
  → Design and manufacturing that presupposes *ex ante* indeterminacy caused by variations in gate length and interconnect geometry
- Production system:
  Push-type production system → Pull-type production system (with SCM)

Complexity-Reducing Public Projects in the US: MMST (88−93)

- Microelectronics Manufacturing Science & Technology (MMST) project newly created open object-oriented MES (Manufacturing Execution System)

→Revolutionary execution-based factory management software to easily understand the composition of the whole and part ".

→Hierarchical visualization at a glance among semiconductor processing technologies

→Texas Instruments as a key player in MMST intended to incorporate Toyota Production System (TPS) in this MES.

→The advent of such a MES with "high visibility" increased the importance of TPS-like organizational management that could enhance employees' intrinsic motivation.

→The fruits were instantly enjoyed by the US chipmakers through SEMATEC and immediately by the Korean, Taiwanese, and European. (The real dissemination among Japanese ones was the late 90's.)

Summary

- Against chipmakers' original intention, the governance of most Japanese consortia seems to have cut out even their existing business.

  → The business that cannot be done in the chip manufacturer cannot be done.

  → Non-participation of material and tool makers

- To develop state-of-the-art process technologies, several process consortia were consecutively built to follow conventional ways of R&D collaboration.

  → They could not catch up with the rapidly increasing complexity in process technologies.

- Since the most of Japanese consortia were built as an allopathy, they could not effectively cope with technologically quite novel complexity.

  → This might not be limited to Japanese semiconductor consortia.

Economic Impacts of International R&D Coordination:
SEMATECH, the International Technology Roadmap, and Innovation in Microprocessors

Kenneth Flamm
University of Texas at Austin
January 2006

1990s Were An Important and Dynamic Period for the Semiconductor Industry

- New US R&D Strategy in Semiconductors
- Acceleration in rate of innovation in semiconductors
- Increasing global dispersion of technology & production
- This presentation analyzes how these events were linked
  - Focus on microprocessors
- Trace links between details of tech change and economic impacts of innovation

Why Look at Microprocessors?

- Has come to dominate US (geographic) industry
  - In 2004, 46+% of US IC shipments
    - Compare to 29% in 1995, 37+% in 2002
    - Compare with DRAMs:
      - Approx 14% in 1995, 7% 2001, 11% 2004
- In 90s, highest rate of tech innovation
- Largest value type of semi input to computers
  - Big impact on tech improvement in computers
  - Productivity in downstream IT-using industries
  - Return to this theme at end of talk
- Rich data set

New US R&D Strategy

- SEMATECH formed in late 1980s
  - Spencer strategic plan, 1992+
  - Focus on manufacturing, accelerate introduction of new tech nodes
    - From 3 years to 2 years
  - Apparent success, inspires imitation elsewhere
- National Semiconductor Technology Roadmap
  - Started as MicroTech 2000, on behalf of NACS
    - 1992 workshop and report
  - SEMATECH provided technical leadership for effort
  - First National Technology Roadmap in 1994
  - Update in 1997, codified 2-year tech nodes

Roadmap Evolved Into International Effort in Late 1990s

- Now called ISTR
- Recognized that leading edge players in semis were multinational, scattered around globe
- Common belief that closer coordination among specialized suppliers, users, has worked to accelerate innovation in industry
- Has worked to keep 2 year nodes coming
  - Not all think is a good thing
  - To date, have been unable to slow it down!
- Unique and interesting structure of great economic interest
  - Unaware of any other high tech industry with similar degree of R&D coordination
  - Coordination– lawyers' ears perk up!
  - But US law passed in 1980s that granted limited antitrust immunity for registered consortia like SEMATECH

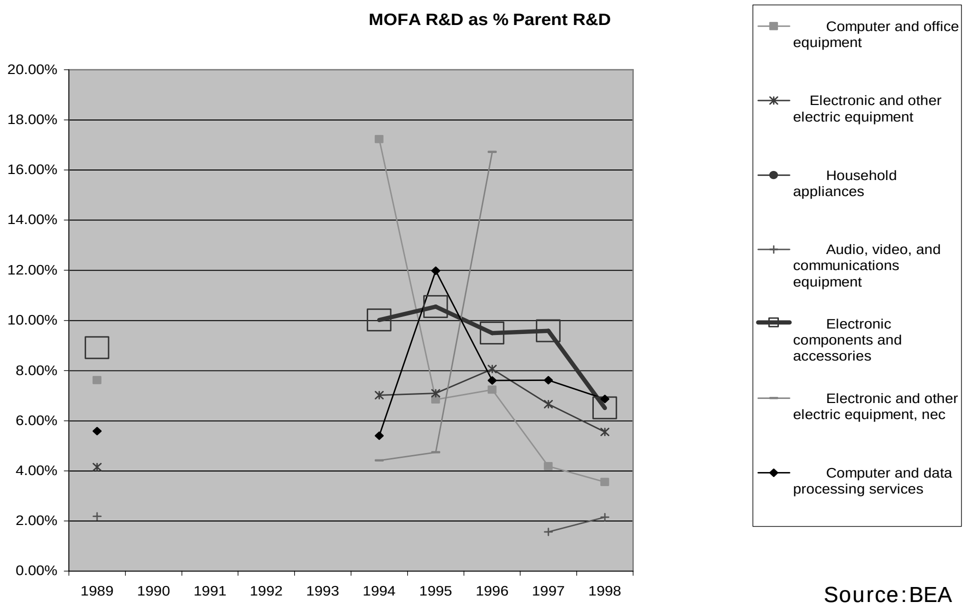
International SEMATECH

- SEMATECH also went international in late 1990s
  - Recognized that tech capability, best technology now dispersed globally
  - Another Bill Spencer initiative
    - Encouraged by USG (including KF@DoD)
  - Prior recovery, stabilization of health of US semi industrial base
    - Critical to decision by all parties
- Began with international partnership to work on 300mm wafer tech (I300I)
- Continued with non-US companies as full members of IST
  - No continuing USG subsidy after 1997
- Today, share of world semi output accounted for by members exceeds share when formed in late 1980s

~~International~~ SEMATECH

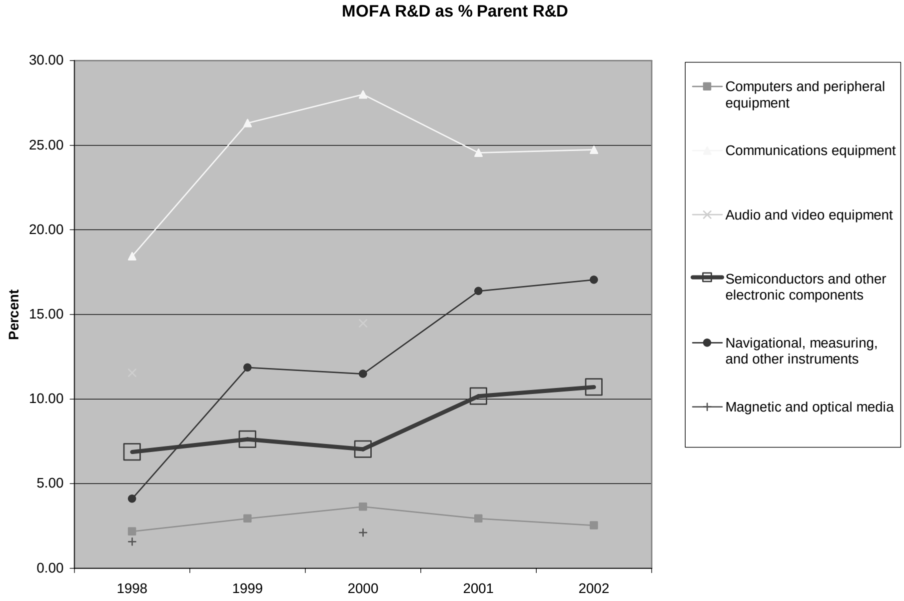
- SEMATECH dropped the I-word in 2004
- What does this mean?
  - ?... a "branding" issue
  - Still has many international members
    - (including Samsung, most recently)
- Also, spun off subset of R&D activities into ISMI
  - Walled off from access to "highest tech" (e.g., litho) R&D in main SEMATECH organization
  - All 9 "full" SEMATECH members also get membership in ISMI
    - AMD, Freescale, Hewlett-Packard, IBM, Infineon, Intel, Philips, Samsung, Texas Instruments
  - 3 ISMI-only members are do not get access to full SEMATECH information set
    - TSMC, Panasonic/Matsushita Electric, Spansion
    - First Japanese membership in SEMATECH consortia

But…Even as SEMATECH internationalized, US semi industry did less of R&D globally

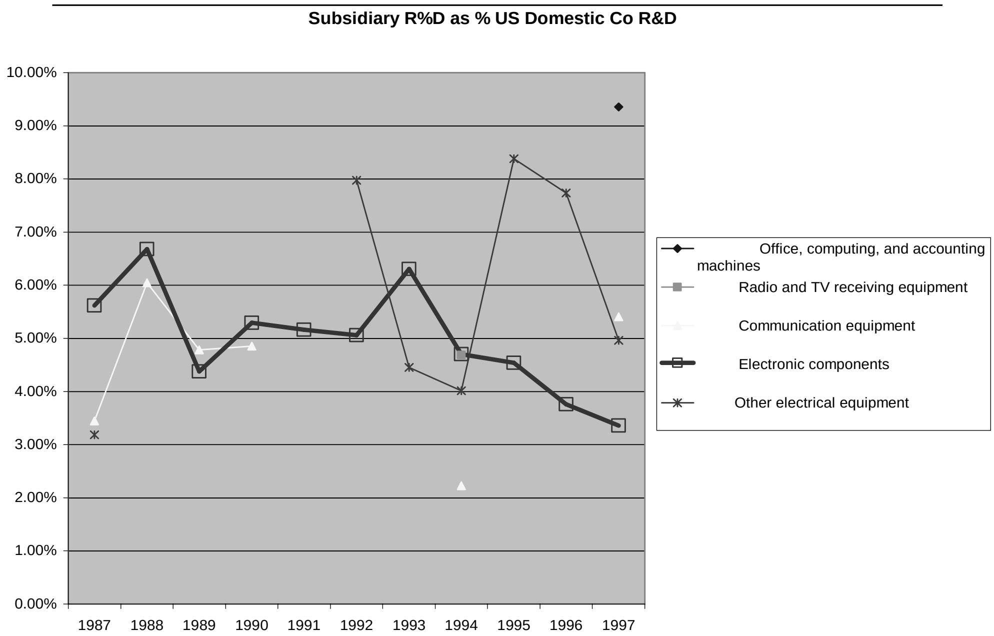


Source:BEA

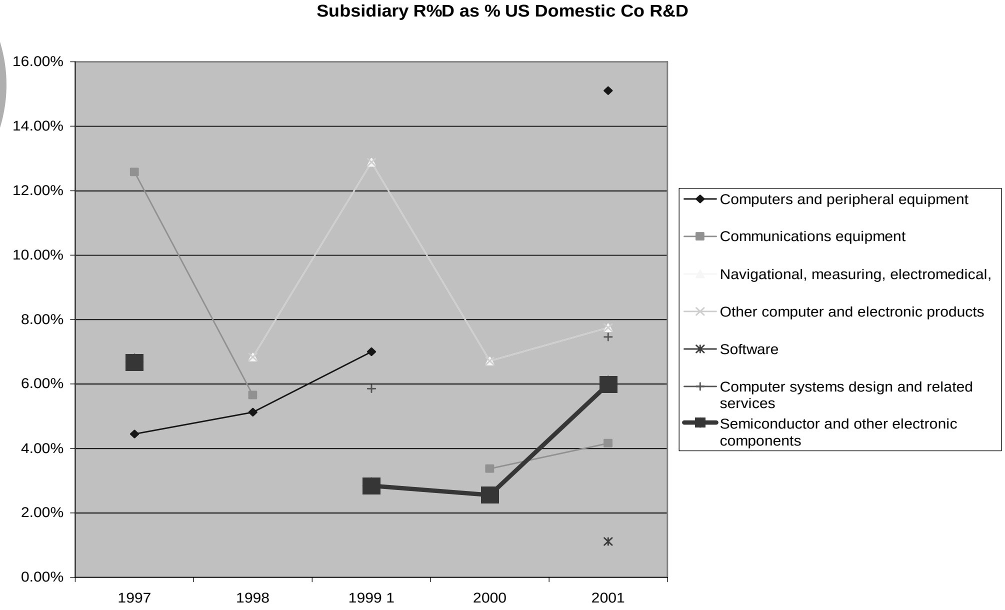
Very Recent Trend Toward Increased Offshore R&D in US Semi Industry



NSF Data Verify 1990s Trend



And Subsequent Turnaround



What to Make of This?

- Speculation
- US Semi Firms Best at What They Were Doing
  - US the place to be for R&D in these areas?
- R&D Cooperation Thru Roadmap in 1990s a Way to Coordinate with Suppliers in Areas Where Best of Breed Not in US
- Increasing Offshore Competence led to Some Increase in Offshore in R&D by US Firms After Millenium

Back to Possible Impacts of Coordination….

Acceleration in rate of innovation in semiconductors!

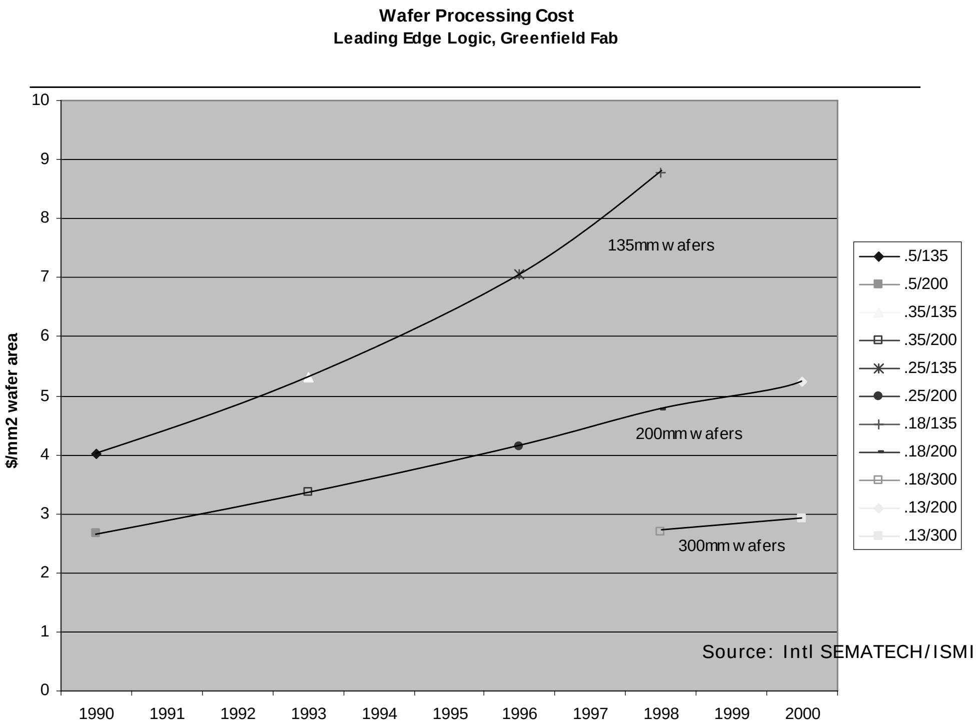
Two Sources of Improvements in Price-Performance

- Declines in manufacturing cost lead to lower price for given quality / functionality
- Improved capabilities / performance / quality of functions provided by IC
- Both happen, are not independent
  - Design innovation may be needed to use lower cost components productively
  - Improved manufacturing techniques may bring quality improvement
    - Example: smaller features, faster gates
  - But will analyze separately

Declines in Manufacturing Cost

- Linked to intro of new tech nodes
  - Process innovation ➔ smaller feature sizes
  - New tech node organized around 50% reduction in silicon area
    - (30% reduction in feature size)
    - On 2D plane, twice as many devices (transistors, logic gates, DRAM cells) in given area
    - All other things equal, would expect 2x as many devices in given area
      - i.e., ***device density*** would double with new node
    - To rough order of approximation, IC manufacturing cost per area of silicon has remained roughly constant
      - (more accurately, risen slowly)

Microprocessor Wafer Processing Costs



Simplest model

$$\text{Mfg Cost/device} = \frac{\dfrac{\underline{\$\ \text{processing cost}}}{\text{area silicon}}}{\text{devices/Area silicon}} \quad \frac{c}{t}$$

- t is what is improved w/innovation in semi lithography
- feature size reduced 30%, device area 50% w/new node
  - so t doubles when this happens
- if we assume
  - no quality change (i.e., simply producing same chip in smaller area)
  - c remains constant
  - new t = "technology node" (an approximation) every 3 years
- Then…

Result:

- Manufacturing cost drops by half every new technology node
  - every 3 years
- Works out to cost declining by
  - -21 % CADR

Compare to Historical Reality at the Leading Edge

Decline Rates in Price-Performance

		Percent/Year
Microprocessors, Hedonic Index	**1975-85**	**-37.5**
	1985-94	**-26.7**
DRAM Memory, Fisher Matched Model	**1975-85**	**-40.4**
	1985-94	**-19.9**
DRAMs, Fisher Matched Model, Quarterly Data		
	91:2-95:4	**-11.9**
	95:4-98:4	**-64.0**
Intel Microprocessors, Fisher Matched Model, Quarterly Data		
	93:1-95:4	**-47.0**
	95:4-99:4	**-61.6**

Prices generally exceeded prediction about costs!
Slowed down over time, then speeded up in mid-90s

Why?

- Improvement in device density exceeded 2-dimensional impact of smaller feature size
- Ingenuity, innovation in feature design made this possible:
  - For example, building structures/transistors vertically, in 3-D
  - Using additional layers, in 3-D, to interconnect devices, instead of using up 2-D real estate to wire things together
- What happened:
  - In memory chips (DRAMs), density historically increased by about 2.9x (> 2X) with each new technology node

Result:

- New tech node every 3 years
- + historical additional ingenuity (2.9x density increase at new tech node instead of 2x)
- ➔ density increases at 43% per year
- ➔ cost decline of -30% per year
- = approximate long run average rate of decline for both DRAM and microprocessor prices in 1975-95 period

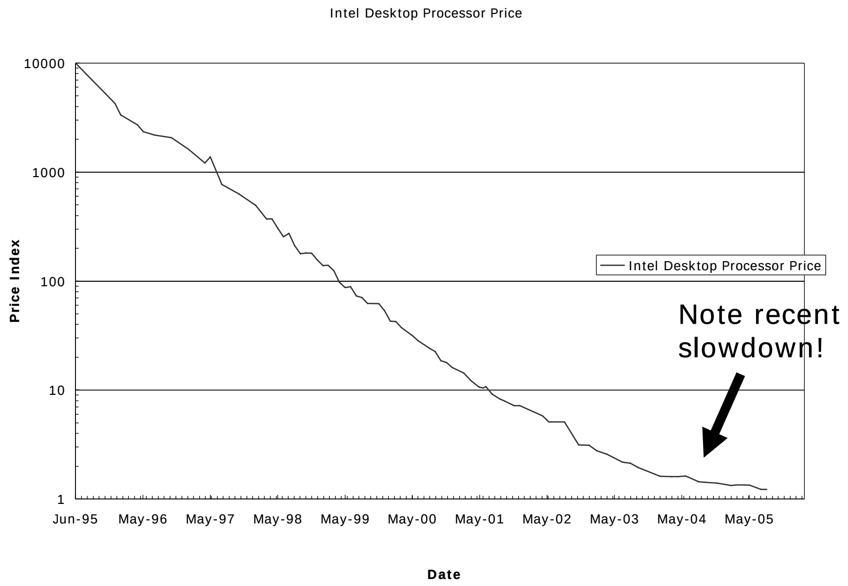
Impact of 2 Year Technology Cycle (R&D Coordination) on Cost

- Now tech node every 2 years
- Maintain historical additional ingenuity (2.9x density increase at new tech node instead of 2x)
- ➔ density now increases at 70% per year
- ➔ cost decline of -41% per year
- Big increase in rate of decline in price, but still less than what measured in late 1990s (60%+ annual decline in prices in late 1960s)
- So let’s look at other candidate explanations (beyond manufacturing cost decline) for the rest of the story

First, Analysis of Impact of Different Attributes of Improvement in Microprocessors on Price

- Constructed "hedonic" price indexes for Intel desktop microprocessors
  - Used detailed Intel price sheet data
  - Estimated over one year time periods
  - Price-characteristics relationship allowed to vary over time
  - Linked using common month in both periods
- Used regression analysis to links prices of microprocessors to measured characteristics
- Would expect other methods (price indexes) of constructing quality-adjusted prices to somewhat underestimate true decline in price
- Covered period 6/95-9/05
- Very detailed microprocessor characteristics
  - Processor clock speeds, bus speeds, L1, L2, L3 cache sizes, chip archtecture (Pentium, Celeron, P2, P3, P4), Instruction set features, voltage levels

Hedonic Price Index for Intel Desktop Processors



Example of Hedonic Regression Output

Dependent Variable: lp

Number of Observations Read 484
Number of Observations Used 484

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	25	306.69959	12.26798	510.94	<.0001
Error	458	10.99687	0.02401		
Corrected Total	483	317.69647			

Root MSE	0.15495	R-Square	0.9654
Dependent Mean	5.21507	Adj R-Sq	0.9635
Coeff Var	2.97127		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	-16.77791	1.50892	-11.12	<.0001
lproc		1	3.25134	0.09312	34.91	<.0001
p4	p4	1	0.18154	0.04648	3.91	0.0001
l1c16cel		1	-0.38673	0.12118	-3.19	0.0015
l1c16p		1	-0.20458	0.13991	-1.46	0.1444
L2C2000		1	0.11858	0.06139	1.93	0.0540
L3C2000		1	1.33076	0.05024	26.49	<.0001
B800		1	-0.01174	0.04525	-0.26	0.7955
B1066		1	0.44815	0.07751	5.78	<.0001
hvolt	hvolt	1	-0.90918	1.09809	-0.83	0.4081
lvolt	lvolt	1	-1.89787	0.64063	-2.96	0.0032
HT	HT	1	0.18346	0.04849	3.78	0.0002
LGA775	LGA775	1	0.01850	0.02095	0.88	0.3777
dualcore	dualcore	1	1.06352	0.08021	13.26	<.0001
EIST	EIST	1	0.08066	0.05672	1.42	0.1556
EM64T	EM64T	1	0.03341	0.03791	0.88	0.3785
D200406		1	0.00968	0.03208	0.30	0.7630
D200408		1	-0.11177	0.03764	-2.97	0.0031
D200410		1	-0.12228	0.03199	-3.82	0.0002
D200412		1	-0.13788	0.03674	-3.75	0.0002
D200502		1	-0.18498	0.03749	-4.93	<.0001
D200503		1	-0.17653	0.03665	-4.82	<.0001
D200505		1	-0.17474	0.03634	-4.81	<.0001
D200506		1	-0.18078	0.03792	-4.77	<.0001
D200508		1	-0.27205	0.04038	-6.74	<.0001
D200509		1	-0.26966	0.04004	-6.74	<.0001

Results Consistent with Other Non-Hedonic Studies

Aizcorbe, Corrado, Doms
Matched Model
Fisher Ideal Price Index

Q2/93-Q2/94	-28.27%
Q2/94-Q2/95	-57.39%
Q2/95-Q2/96	-66.22%
Q2/96-Q2/97	-48.54%
Q2/97-Q2/98	-71.82%
Q2/98-Q2/99	-68.06%

Flamm
Hedonic
Annualized Rates

May96-May97	-55.52%
May97-May98	-69.27%
May98-May99	-73.77%
May99-Apr00	-65.02%
Apr00-May01	-74.56%
May01-May02	-45.46%
May02-Apr03	-58.80%
Apr03-May04	-40.07%
May04-May05	-16.03%

Hedonic Analysis Suggests Large Big Role for Processor Speed in Price

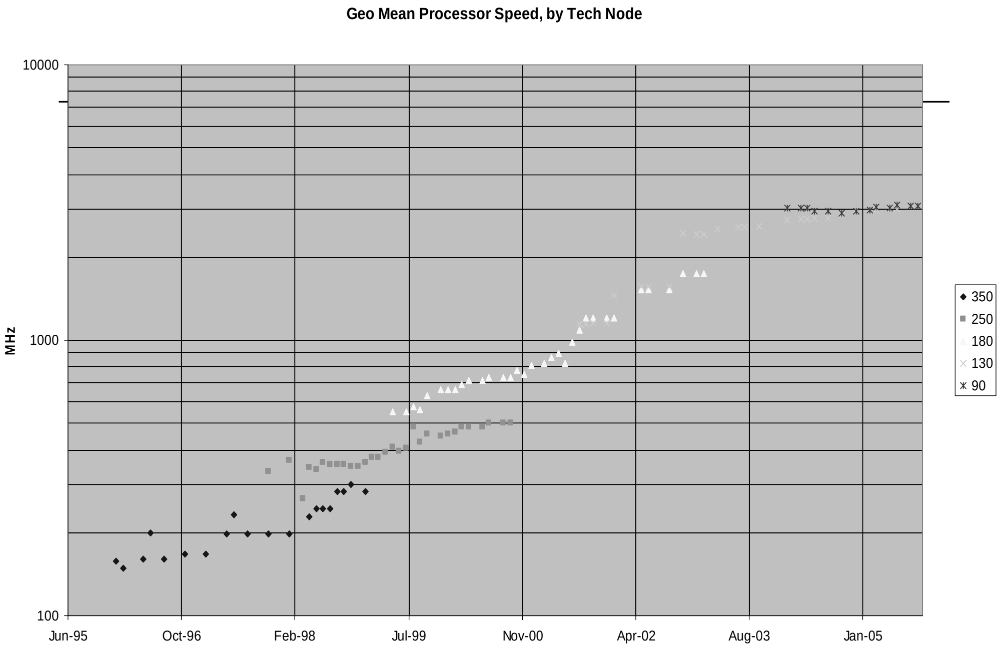
- Elasticity in range of 2 to 3 in regressions for all years from 1996 on
- 10% increase in processor speed associated with 20-30% increase in price, at any moment in time

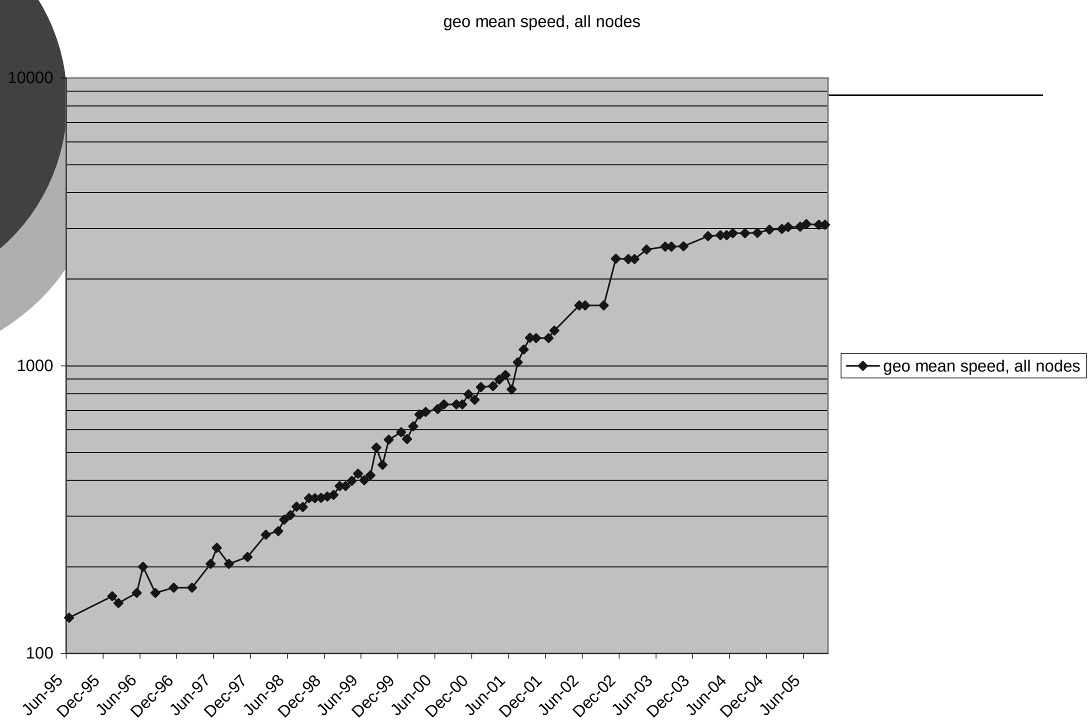
Acceleration in technology nodes also led to acceleration in processor speed improvement!

- New technology node historically led to discontinuous increase in processor speed
- Byproduct of smaller feature sizes is shorter distances between features, potentially faster chips
  - Design innovation needed to make use of greater switching speeds
- Another benefit of roadmap-led acceleration in nodes beyond merely reducing manufacturing cost

Crisis in Microprocessors?

- Hit "brick wall" related to power and heat dissipation in 2004-2005
- Processor speed no longer increasing significantly
- Processor speed now increasing very slowly if at all
- Processor speed slowdown in 2003-04, halt in 2004-05 coincide with big declines in rate of price performance improvement
- Feature proliferation going on in new microprocessors, hedonics suggest relative small enhancement to value of new processors
- Slowdown in new node intro at Intel may also explain slowdown in price decline rate





New Tech Node Introduction at Intel (Using Intro of 1st Commercial Product)

Year	Month	Tech Node (nm)	Years since last Node Introduction
1974	4	6000	
1976	3	3000	
1982	2	1500	5.92
1989	4	1000	7.17
1991	6	800	2.17
1994	3	600	2.75
1995	3	350	1.00
1997	9	250	2.50
1999	6	180	1.75
2001	1	130	1.58
2004	2	90	3.08

Big Trouble?

- Rapid improvement in price performance for processors and memory➔ rapid improvement in PC price-performance
- Rapid improvement in PC price-performance➔ widespread use of IT, productivity improvements in entire economy
- Likely to significantly reduce incentive to purchase new computers
- Slowdown in purchases of PCs, application of IT, likely to have significant ripple effects throughout global economy

Microprocessor Industry Response

- Dual and multi-core processors
  - Unlike faster processors (with higher clock rates), do nothing to improve performance of applications written as single threads
    - As opposed to running multiple instances of a single app on a server
  - Rewriting existing applications to "parallelize" and divide work into parallel threads difficult and expensive—lesson from supercomputer industry
  - But it is possible to do it with appropriate investment—another lesson from recent history of supercomputer industry
  - Suggests that increased investments in high end computing ultimately likely to be generating new wave of "spillover" benefits to IT users—and broader economy
- New feature proliferation
  - Verdict out on how worthwhile

Feature proliferation

Processor Number Feature Table

Type	Intel® Brand or Processor Family	Processor Name	Architecture	Cache (MB/KB)	Clock Speed (GHz/MHz)	Front Side Bus (MHz)	Dual-core	Intel® Virtualization Technology	Hyper-Threading Technology	Enhanced Intel SpeedStep® Technology	EM64T	Execute Disable
	Intel® Pentium® Processor Extreme Edition	Intel® Pentium® Processor Extreme Edition 840	90nm, LGA775	2 x 1 MB L2 Cache	3.20 GHz	800 MHz	Yes	No	Yes	No	Yes	Yes
	Intel® Pentium® D processor	Intel® Pentium® D processor 840	90nm, LGA775	2 x 1 MB L2 Cache	3.20 GHz	800 MHz	Yes	No	No	Yes	Yes	Yes
	Intel® Pentium® D processor	Intel® Pentium® D processor 830	90nm, LGA775	2 x 1 MB L2 Cache	3 GHz	800 MHz	Yes	No	No	Yes	Yes	Yes
	Intel® Pentium® D processor	Intel® Pentium® D processor 820	90nm, LGA775	2 x 1 MB L2 Cache	2.80 GHz	800 MHz	Yes	No	No	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 672 supporting Hyper-Threading Technology	90nm, LGA775	2 MB L2 Cache	3.80 GHz	800 MHz	No	Yes	Yes	Yes	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 670 supporting Hyper-Threading Technology	90nm, LGA775	2 MB L2 Cache	3.80 GHz	800 MHz	No	No	Yes	Yes	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 662 supporting Hyper-Threading Technology	90nm, LGA775	2 MB L2 Cache	3.60 GHz	800 MHz	No	Yes	Yes	Yes	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 660 supporting Hyper-Threading Technology	90nm, LGA775	2 MB L2 Cache	3.60 GHz	800 MHz	No	No	Yes	Yes	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 650 supporting Hyper-Threading Technology	90nm, LGA775	2 MB L2 Cache	3.40 GHz	800 MHz	No	No	Yes	Yes	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 640 supporting Hyper-Threading Technology	90nm, LGA775	2 MB L2 Cache	3.20 GHz	800 MHz	No	No	Yes	Yes	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 630 supporting Hyper-Threading Technology	90nm, LGA775	2 MB L2 Cache	3 GHz	800 MHz	No	No	Yes	Yes	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 571 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.80 GHz	800 MHz	No	No	Yes	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 570J supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.80 GHz	800 MHz	No	No	Yes	No	No	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 561 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.60 GHz	800 MHz	No	No	Yes	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 560J supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.60 GHz	800 MHz	No	No	Yes	No	No	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 560 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.60 GHz	800 MHz	No	No	Yes	No	No	No
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 551 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.40 GHz	800 MHz	No	No	Yes	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 550J supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.40 GHz	800 MHz	No	No	Yes	No	No	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 550 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.40 GHz	800 MHz	No	No	Yes	No	No	No
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 541 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.20 GHz	800 MHz	No	No	Yes	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 540J supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.20 GHz	800 MHz	No	No	Yes	No	No	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 540 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3.20 GHz	800 MHz	No	No	Yes	No	No	No
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 531 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3 GHz	800 MHz	No	No	Yes	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 530J supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3 GHz	800 MHz	No	No	Yes	No	No	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 530 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	3 GHz	800 MHz	No	No	Yes	No	No	No
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 521 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	2.80 GHz	800 MHz	No	No	Yes	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 520J supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	2.80 GHz	800 MHz	No	No	Yes	No	No	Yes
Desktop	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 520 supporting Hyper-Threading Technology	90nm, LGA775	1 MB L2 Cache	2.80 GHz	800 MHz	No	No	Yes	No	No	No
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 519K	90nm, LGA775	1 MB L2 Cache	3.06 GHz	533 MHz	No	No	No	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 519J	90nm, LGA775	1 MB L2 Cache	3.06 GHz	533 MHz	No	No	No	No	No	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 516	90nm, LGA775	1 MB L2 Cache	2.93 GHz	533 MHz	No	No	No	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 515J	90nm, LGA775	1 MB L2 Cache	2.93 GHz	533 MHz	No	No	No	No	No	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 515	90nm, LGA775	1 MB L2 Cache	2.93 GHz	533 MHz	No	No	No	No	No	No
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 511	90nm, LGA775	1 MB L2 Cache	2.80GHz	533 MHz	No	No	No	No	Yes	Yes
	Intel® Pentium® 4 processor	Intel® Pentium® 4 processor 505J	90nm, LGA775	1 MB L2 Cache	2.66 GHz	533 MHz	No	No	No	No	No	Yes

Conclusions

- R&D coordination effort started with SEMATECH and continuing through ISTR appears to have created significant benefits over last decade
- Technology node acceleration has big impact on manufacturing costs, quite apart from any other benefits
- Examination of microprocessors suggest additional important benefits
- Microprocessor analysis also suggests new technical barriers seem to have at least temporarily slowed down creation of additional benefits
  - Significantly slowing declines in quality-adjusted microprocessor prices
- Investment in advancing software technology may be needed to capitalize on continuing advance in semiconductor manufacturing
- Implication- in long run, supercomputer software R&D investment is likely to be as or more economically important than new supercomputer hardware– where $ are now going

21st Century Innovation Systems for Japan and the United States
Lessons from a Decade of Change

Government-Industry R&D Partnerships
Japanese Experiences
"Introduction of NEDO"

January 2006

Kaoru HONJO
Executive Director
New Energy and Industrial Technology
Development Organization
(NEDO)

1

Contents

- **１. Outline of NEDO**
- **2. Examples of R&D Activities**

-Nanotechnology and materials Processes Technology

-Fuel Cell and Hydrogen Technology

2

Outline of NEDO

3

History of NEDO

１９８０：**Established (New Energy Development Organization)**

１９８８：**Added industrial technology R&D**
(New Energy and Industrial Technology Development Organization)

１９９０：**Added global environment R&D**

１９９３：**Added promotion of new energy and energy conservation**

２０００：**Added support for private companies to strengthen international competitiveness**

２００３：**Re-organized as an "Incorporated Administrative Agency"**

4

NEDO's Mission

- To strategically prioritize and promote R&D projects on industrial, new energy, energy conservation and environmental technology by means of government ,industry and academic cooperation.
- To contribute to solve energy and environmental problems.
- To yield successful results through flexible operation management and stringent evaluation systems.
- To disseminate information about NEDO's activities and achievements to the public.

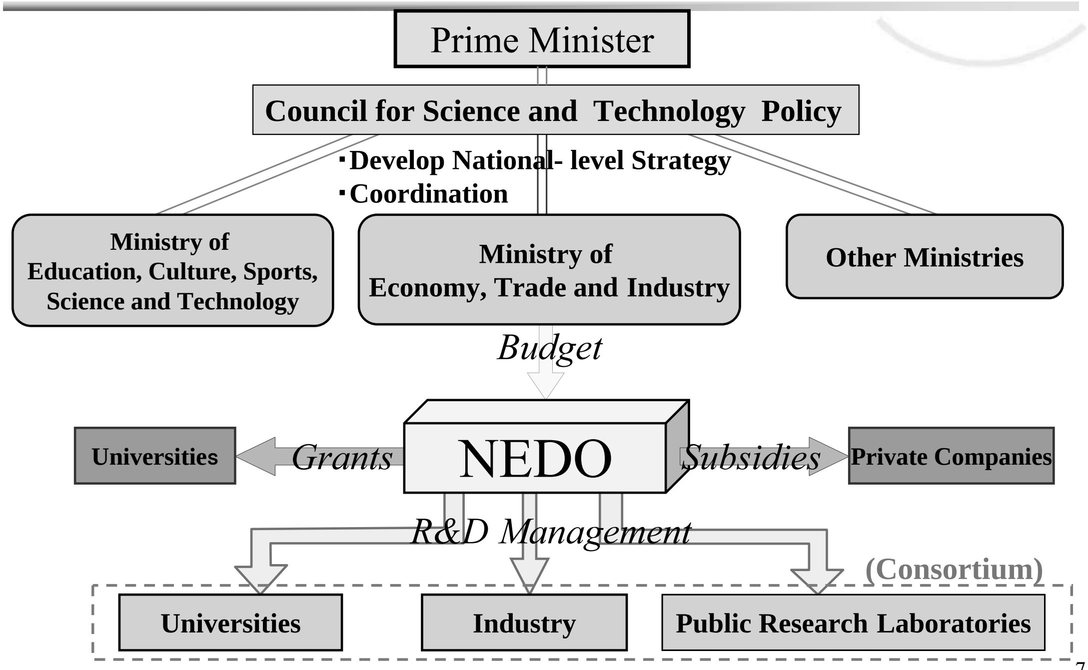
5

NEDO's Main Activities

- R&D of industrial technology, new energy, energy conservation, environmental technology
  - ･Industrial Technology--- IT, Nano, Bio, Mechanical system
  - ･Energy Technology---New energy, Energy conservation, Fuel cell
  - ･Environmental Technology
- Penetration support of new energy and energy conservation

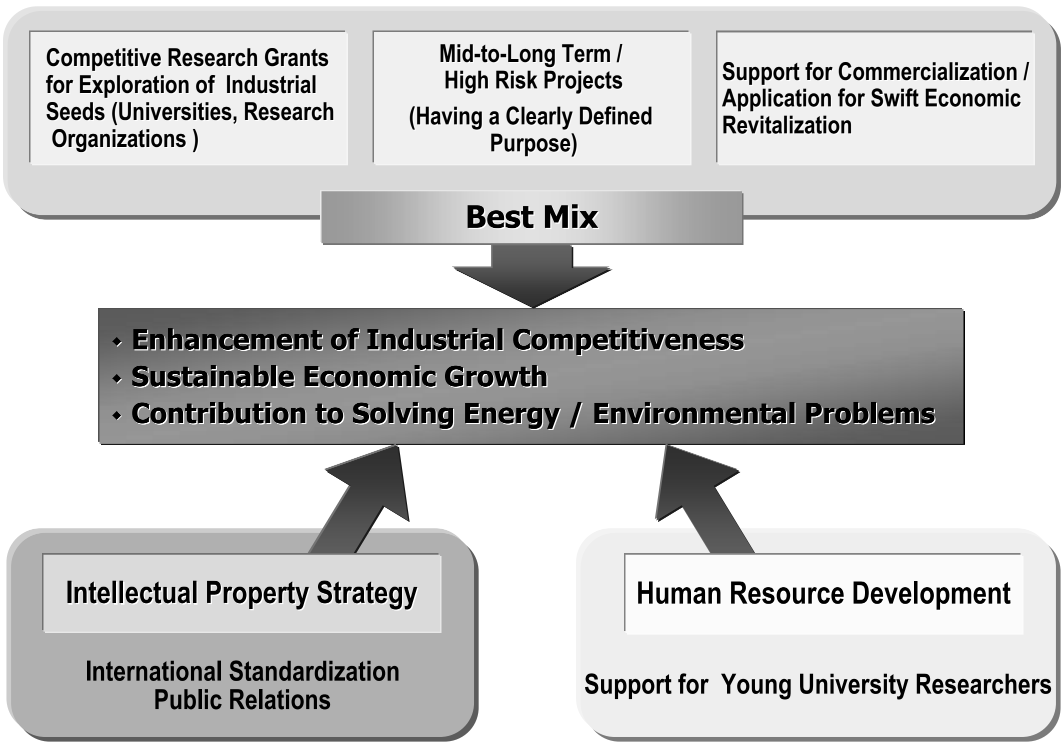
6

Japan's R&D Promotion Scheme



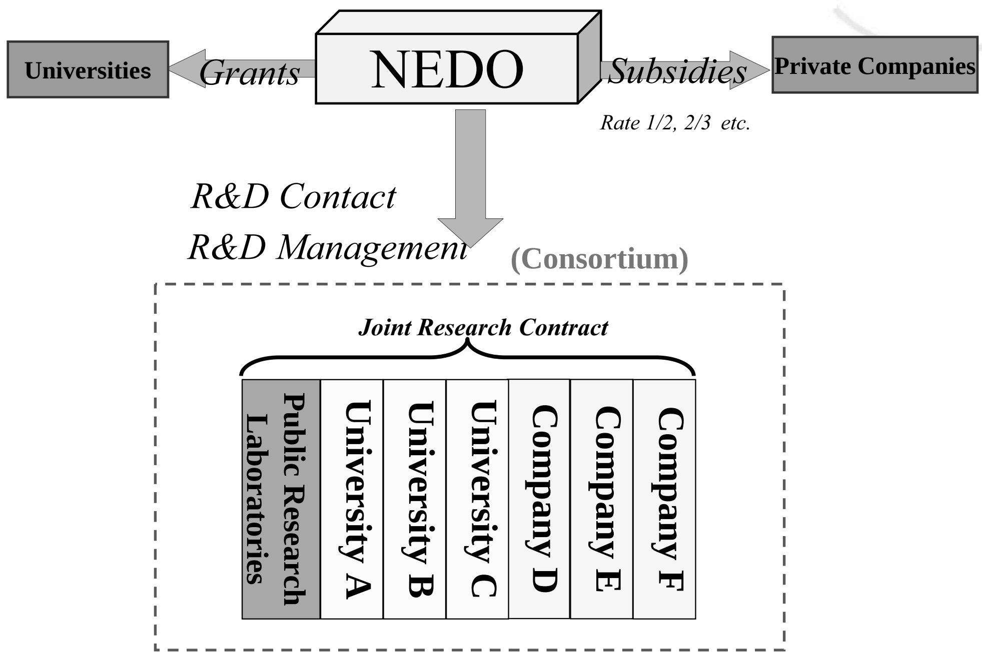
7

Basic Principles of NEDO's R&D Scheme



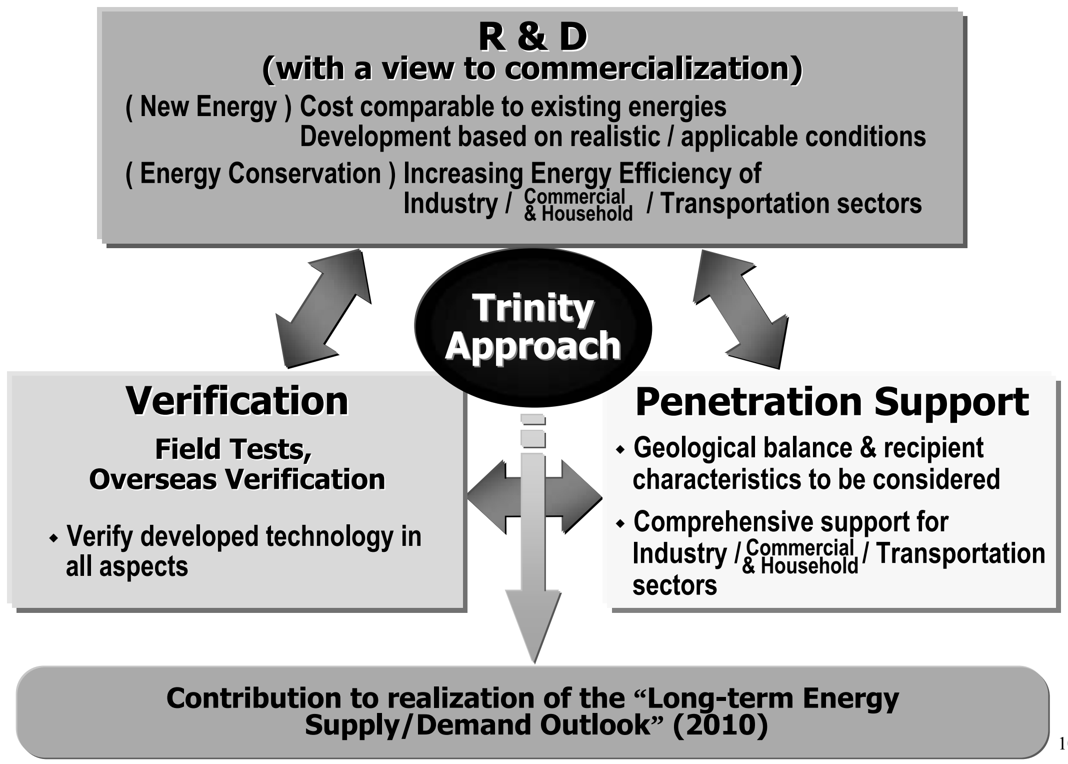
7

Project Style & Formation



9

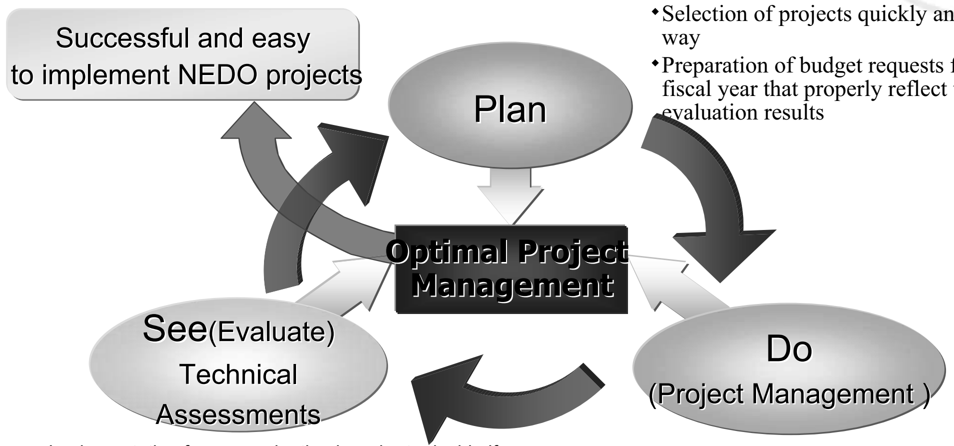
NEDO's Energy Related Activities



10

NEDO ’s “Plan-Do-See” Approach to Optimal Project Management

- Development of fundamental project plans based on industrial technology policy
- Selection of projects quickly and in a fair way
- Preparation of budget requests for the next fiscal year that properly reflect the latest evaluation results



- Implementation former evaluation in order to decide if a project should be start or not
- Implementation of midterm evaluations for all projects after 3 years and post-project evaluations after project completion
- Implementation of follow-up surveys in order to improve evaluation methods and project management tools

- Organization of project implementation groups
- Effective management through appropriate assignment of roles to NEDO and project managers
- Promotion of smooth and continuous R&D through multi-year contracts

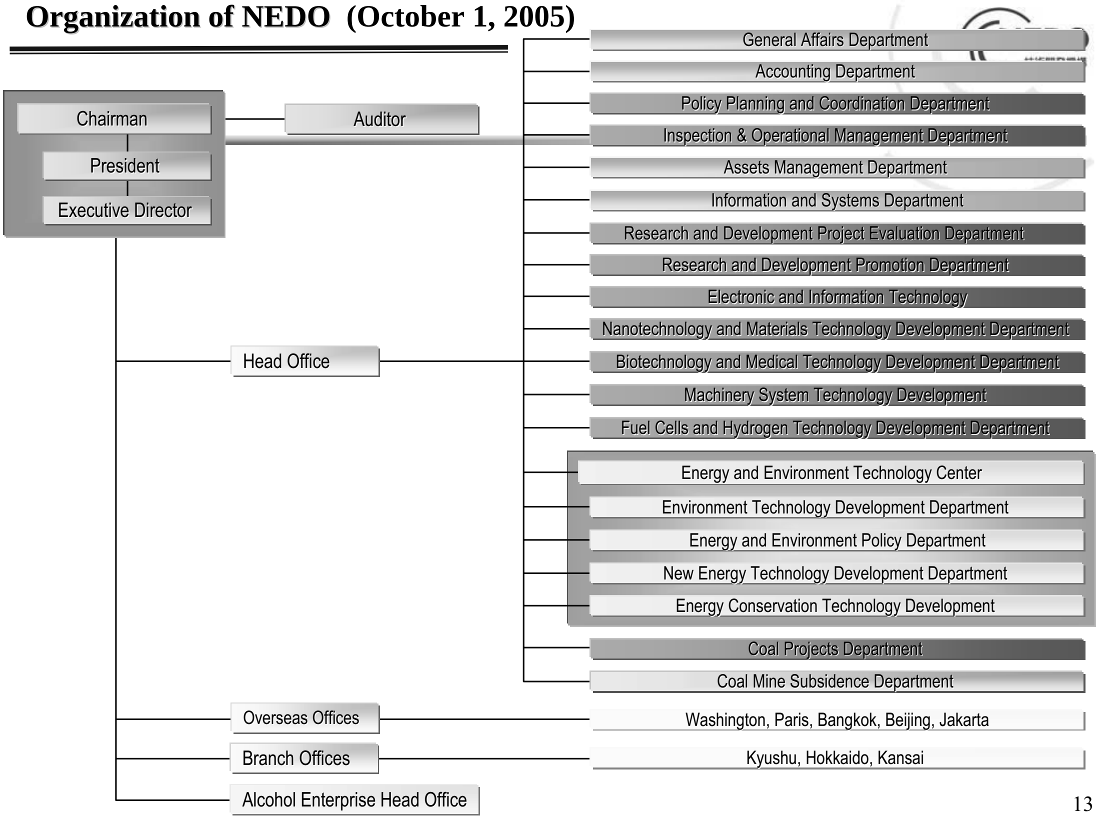
11

Budget of NEDO

		(Billion yen)
	FY2004	FY2005
R&D	162.9	148.8
Introduction of new energy and energy conservation	59.4	63.9
International affairs	14.8	12.0
Coal related activities	5.0	5.0
Alcohol production & sales	56.0	56.3
Others	3.4	2.2
Total	301.5	288.2

12

Organization of NEDO (October 1, 2005)



13

METI's 1 9 R&D Programs

①	**Healthy and Comfortable Society Creation**
②	**Bioscience-Driven Recycling-Based Industrial System Creation**
③	**Basic Equipment and Devices for Advanced Information Communications R&D**
④	**Basic Software Development Promotion Program for Information Communications**
⑤	**New Manufacturing Technology Development**
⑥	**21st Century Robot Challenge**
⑦	**Basic Technology Program for a More Sophisticated Space Industry**
⑧	**New Technology Program for Prevention of Global Warming**
⑨	**3R ('Reduce', 'Reuse', 'Recycle')**
⑩	**Comprehensive Assessment and Management Program for Chemical Substances**
⑪	**Next-Generation Low-Emission Vehicle Technology Development**
⑫	**Basic Technology Program for Commercial Aircraft**
⑬	**Energy Consevation Technology Development**
⑭	**New Energy Technology Development**
⑮	**Fuel Technology Development**
⑯	**Electroric Power Technology Development**
⑰	**Nuclear Power Technology Development**
⑱	**Nanotechnology Development**
⑲	**Innovative Material and Materials Industry Creation**

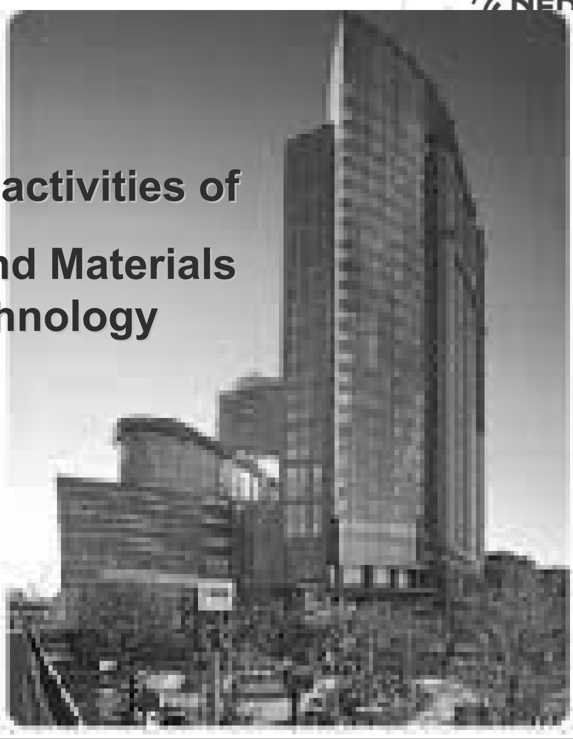
14

NEDO's FY2005 R&D Budget

Technology Development & Research Development Projects	Amount
1. Biotechnology and Medical Technology Development Projects	16.6
2. Electronic and Information Technology Development Projects	18.2
3. Mechanical System Technology Development Projects	17.4
4. Environment Technology Development Projects	7.7
5. Nanotechnology and Materials Technology Development Projects	16.3
6. Fuel Cell and Hydrogen Technology Development Projects	20.8
7. New Energy Technology Development Projects	14.4
8. Energy Conservation Technology Development Projects	7.5
9. CO2 Fixation and Development for Effective Commercial Uses	0.7
10. R&D Promotion Projects	27.4
11. Research Evaluation and Surveys	1.7
TOTAL	148.8

15

Introduction of the activities of Nanotechnology and Materials Processes Technology



NEDO 技術開発機構

16

Council for Science and Technology Policy

Cabinet Office, Japanese Government

March 30, 2001

(1) Life Sciences

(2) Information and Telecommunications

(3) Environmental Sciences

(4) Nanotechnology and Materials

17

Budget related to S&T

(Billion Yen)

	FY2001	FY2002	FY2003
Life sciences	390.7 19.5%	393.4 19.4%	406.8 20.1%
Information & telecommunication	166.3 8.3%	175.8 8.7%	175.3 8.7%
Environmental sciences	84.7 4.2%	100.6 5.0%	108.8 5.4%
Nanotechnology and materials	80.4 4.0%	85.6 4.2%	90.4 4.5%
Total amount of above 4 priotisized areas + Energy + Manufacturing Technology + Infrastructure + Frontier	2003.1 100%	2027.5 100%	2019.8 100%
Total Budget for Science and Technology	3468.5	3591.6	3591.6

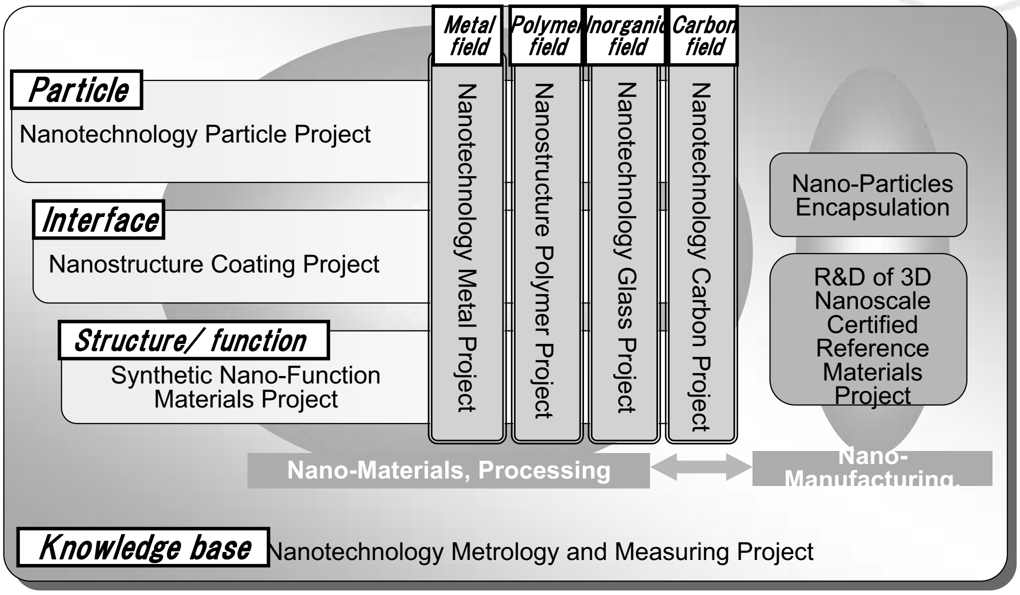
Not Including University Budget except below two (total)

Based on S&T Basic Plan, Council for Science and Technology Policy (2003.5.27)

18

Structure of the Nanotechnology Program

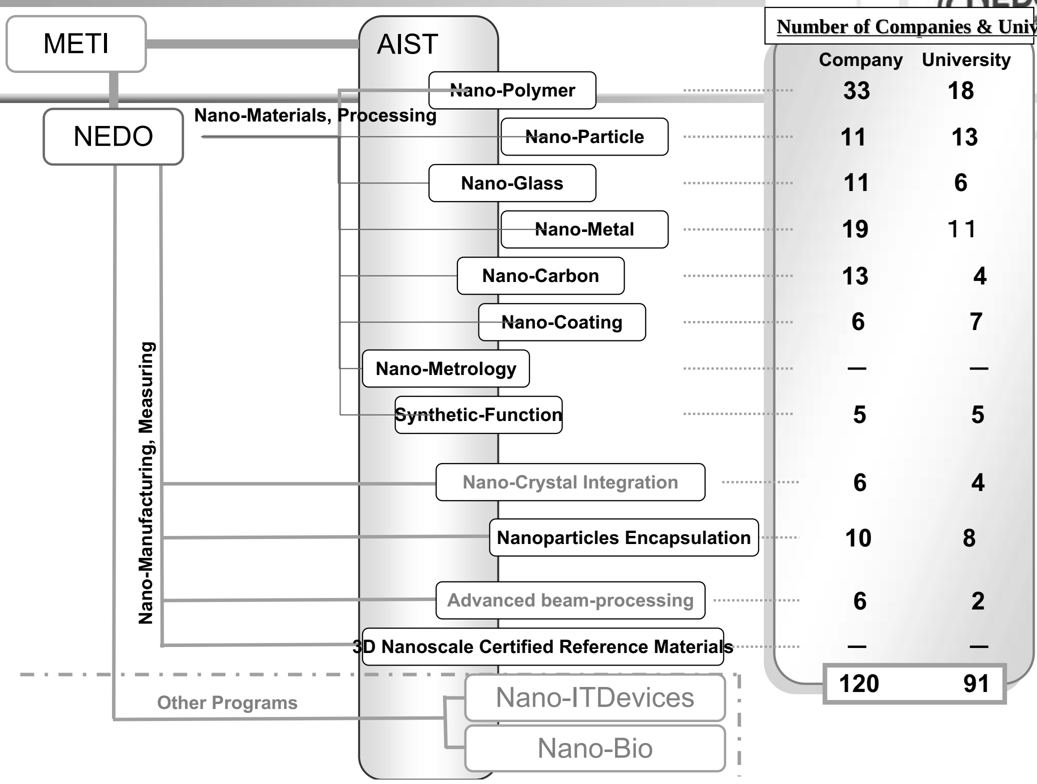
FY2006:about $67million
(FY2005:about $65million)



19

Nanotechnology Program Research Structure

(March,2005)



20

Schedule of Nanomaterials and Processing Sub-Program

Project	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
Nanostructure Polymer Project		10.8	9.6	7.8	7.5	5.5		
Nanotechnology Glass Project	2.5	5.0	5.2	3.6	3.4	3.4		
Nanotechnology Metal Project		2.5	5.6	4.0	3.3	2.6		
Nanocarbon Technology Project			8.5	10.4	9.4	9.0		
Nanotechnology Particle Project		7.5	7.6	5.3	5.1	4.6		
Nanostructure Coating Project		4.2	4.3	3.0	3.0	2.7		
Synthetic Nano-Function Materials Project		2.1	3.0	2.1	2.1	2.0		
Nanotechnology Material Metrology Project		1.9	1.9	1.4	1.4	1.8		

Budget in million $ ($1=¥120)

20

R&D activities of Fuel Cell and Hydrogen Technologies in Japan

Current Topics

Fuel Cell Vehicles (FCV)

- December 2001: Prime Minister Koizumi took a test ride in a FCV.
- October 2002: Fuel cell commercialization and diffusion scenario was decided by concerned ministries.
- December 2002: FCV supplied for Government use.

Introduction Target

2010: 50,000 vehicles

2020: 5 million vehicles

2030: 12.5 million vehicles

Support by Government

R&D, Demonstration test,
Examination of related regulations

23

Fuel Cell Commercialization and Diffusion strategy

1: To 2005 (Basic work and technology demonstration stage)

- Drawing up FC R&D Strategy and its Implementation
- Soft-infrastructure/Codes & Standards (Millennium project)
- Demonstration

2: 2005 to 2010 (Introduction stage)

- Acceleration of the Introduction and Gradual Establishment of Fuel Supply System
- Leadership of Public Sector as well as FC Industry in Promotion of FCV and Buses

3: After 2010 (Diffusion stage)

- Establishment of Fuel Supply System and Self-sustained Growth of the Market
- Private Sector Promotion of the Introduction

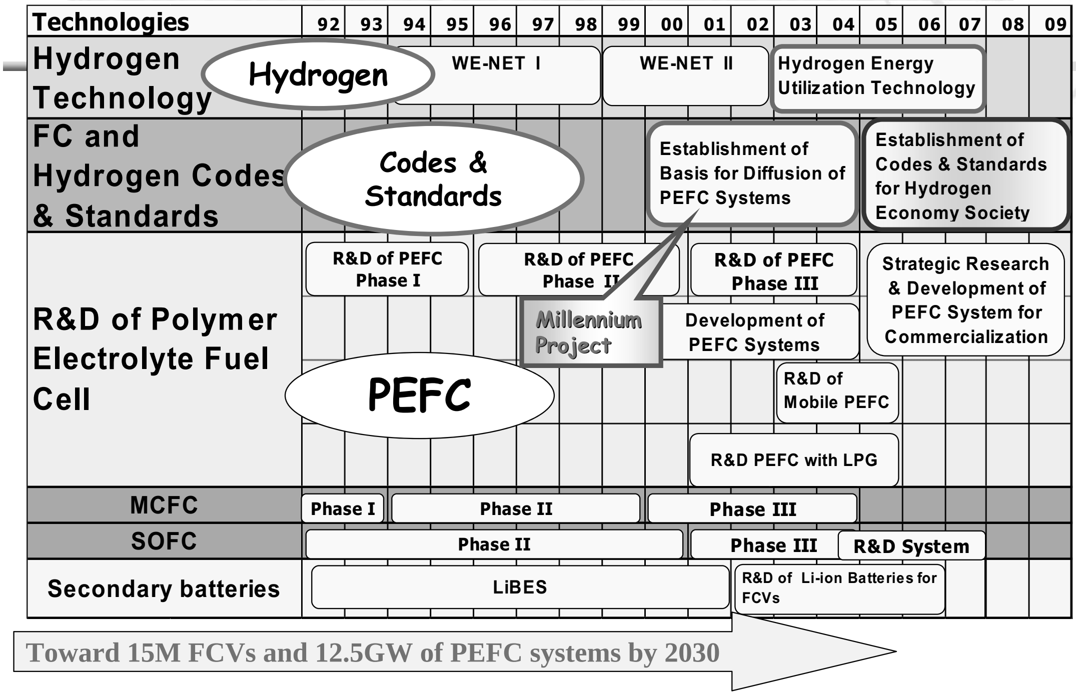
New Target

Forecast of Fuel Cell Introduction

	2010	2020	2030
FCV	50,000 vehicles	5,000,000	15,000,000
Stationary FC	2.2 million kW	10 million	12.5 million

24

NEDO R&D of FC/Hydrogen Projects



25

R&D Target for FCV and Stationary FC System

- Commercialization period: 2005-
- diffusion period: 2010-

	FCV	Stationary FC
Power generation efficiency of stack	65%(LHV) @25% of rated output	55%(HHV) @ rated output
Cost of stack	YEN 4,000/kW	YEN 80,000/kW
Efficiency of system	60%(LHV) Pure H2	40%(HHV,net)
Economy	YEN 5,000/kW	YEN 300,000/unit

26

パネル III：スタートアップ企業と中小企業によるイノベーション促進のための政府プログラム

Panel III: Government Programs to Encourage Innovation by Startups and SMEs

モデレーター：ブラッドレイ・ノックス Bradley Knox，合衆国下院 小企業委員会

スタートアップ企業と中小企業によるイノベーション促進のための政府プログラム:イノベーション支援の役割

Government Programs to Encourage Innovation by Start-ups & SME's: The Role of Innovation Awards

チャールズ・ウェスナー Charles Wessner，全米アカデミー 科学技術経済政策委員会

日本におけるスタートアップと起業家精神を促進するプログラム：経験と教訓

Programs to Stimulate Startups and Entrepreneurship in Japan: Experiences and Lessons

安田 武彦，東洋大学経済学部教授

ディスカッサント

飯塚 哲哉，ザインエレクトロニクス株式会社 社長

Government Programs to Encourage Innovation by Start-ups & SME's

The Role of Innovation Awards

21st Century Innovation Systems for
Japan and the United States:
Lessons from a Decade of Change"

Tokyo, Japan
January 10, 2006

Charles Wessner, Ph.D.
Board on Science, Technology and Economic Policy
National Research Council

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Advisers to the Nation on Science, Engineering, and Medicine

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Presentation Topics

- The Global Innovation Challenge
  - U.S. and Japanese Challenges in Innovation
  - The Importance of Innovation
- The Importance of Openness
- The Role of Small Businesses in Innovation
- Policy Myths and Market Realities about Small Business Innovation
  - Myth of Perfect Markets
  - The VC Myth & the Valley of Death
- The Role of Innovation Awards
  - Fostering Small Business Innovation
  - The SBIR and ATP Models
- Conclusion
  - Learning from Each Other

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The Global Innovation Challenge

Japan and the U.S. face Common Realities

Our ability to ability to invent, design and manufacture goods and services are vital to our future prosperity

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What are the Sources of these Structural Changes in the Global Economy?

- The Internet and the Death of Distance are integrating the Indian, Chinese & other economies into the Global Market
  - Aided by Business Outsourcing and Global Sourcing—e.g. Wal-Mart
- Rapidly Growing Markets and the Competition for Share combined with…
- Major Programs Designed to Attract, Nurture, & Support High-tech Industry within the National Economy

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China—Strengths

- Structural Advantages
  - Very high savings and investment rate
  - Low wage advantage
  - Efficient export trade logistics
  - Becoming world's manufacturing base
- Government with strong sense of national purpose
  - Strong investments in education and training
  - Strategy to move rapidly up value chain from labor intensive to more technology intensive exports
  - Effective requirements for training and tech transfer
  - Critical mass in R&D is beginning to be deployed to generate autonomous sources of innovation & growth

Modified from C. Dahlman

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India – Strengths

- Structural Advantages
  - Large critical mass of educated, skilled, and English speaking knowledge workers—260,000 engineers p.a.
  - Strong science and engineering capabilities centered in chemical, software, and IT sectors
  - Has network of successful Indians in U.S. and Europe providing links to markets, technology, and finance
  - Relatively deep financial markets; rule of law
- Policy Liberalization now Unleashing Growth
  - Growth jumped from traditional rate of 2-3% growth in past decades to 6-8% last decade
  - Emerging as world's service center for software development, back office services
  - Now a cutting-edge innovation center for global companies including major R&D centers for core products for GE and Intel (BusinessWeek 6 Dec 2005)

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Innovation is Key to Maintaining Competitive Position in Global Economy

- Innovation is essential to compete in the global economy
  - Raise productivity and growth levels
  - Position ourselves to compete effectively against low-wage, newly-emerging economies
- To advance our knowledge-driven economies, we need to
  - Strengthen our science and technology base
  - Become the knowledge hubs of the world
  - Create incentives for R&D and knowledge transfer by improving links between Universities, Industry, and Government

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U.S. Enjoys Advantages in Innovation…

- A large and integrated domestic market
- An economic and institutional infrastructure that quickly re-deploys resources to their most efficient use
  - Strong and diverse higher educational infrastructure
  - Deep and flexible capital and labor markets
  - Strong S&T institutions
  - Flexible managerial and organizational structures
  - Entrepreneurial Culture
  - Ability to grow new Large Firms

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…but U.S. Also Faces Major Challenges

- Improvement needed in Education System
  - K-12 Challenges in Science and Math
  - Fewer students pursuing Science Careers
  - Post 9/11 Reductions in Foreign Students
- Uneven & Insufficient R&D Funding
  - Physical Sciences and Engineering Funding is down or flat
  - Too Much Focus on Military R&D
- Insufficient Support for Commercialization
  - Few programs—Effective, but limited scope
  - Too few Consortia—Limited Funding & Evaluation
  - Ideological Blockages limit the Commercialization of R&D

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Growing Chorus of Concern on U.S. Innovation Policy

- PCAST Report 2005
  - Academy Contribution of Innovation Ecosystem Concept
- National Innovation Initiative
  - Led by IBM and leading Universities
  - Ignored by the White House but not by the Congress
- Congress Tasked the National Academies with an Assessment of U.S. Innovation and Competitiveness

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10

"Rising Above the Gathering Storm"

A New National Academies Report*

- Scientific & Technical Building Blocks of U.S. Economic Leadership are Eroding
  - Weakening commitments to S&T puts future U.S. prosperity in jeopardy
  - Risk of an abrupt loss of U.S. leadership in S&T
- Report calls for more support to Education, more focus on Energy Research, & more support for Innovation
  - Need new policies that address emergent realities
  - Popular policy Myths often obscure need for pragmatism

*October, 2005

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11

Japan Shares U.S. Concerns but Remains one of the World's Top Technology Powerhouses

- A world leader in patents
  - Five of top ten global companies for patents are Japanese
  - Most patents in IT, telecomm, electronics
- Leader in Integrated Manufacturing
  - Machine tools, automobiles, high-end electronics
- Still, there is concern that Japan's "innovative genius is more suited to constant improvements in integrated manufacturing than to blue-sky inventions."
  - Financial Times, Oct 12, 2005
- Others Point out that Incremental Approaches have Proven Effective in the Past and are Likely to Work Again, e.g., in Solar Energy
  - Economist, Dec 17, 2005

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Japan is Focused on Strengthening its Innovative Potential

Japanese policymakers recognize that:

- Innovation in Japan is traditionally concentrated in large firms (prompting incremental improvements); less breakthrough innovation, e.g., Google
- Institutional links between Universities and Industry are not well developed
- Keiretsu structure may make it difficult for new firms to break into markets

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New Positive Incentives to Improve Innovation in Japan

- 1995 Basic Law encourages University-Industry partnerships
- More public investment in universities and new graduate programs designed to avoid hierarchical limitations of traditional universities
- Government is seeking to create conditions for new, entrepreneurial firms
- Japanese and foreign venture capitalists are showing more interest in new firms
- Some Analysts Emphasize the Importance of greater openness to new global economy for Universities, Cooperative Research, and Foreign Investment

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OECD's Tanaka: Openness has Positive Consequences for Innovation

- Successful innovation closely linked to openness
  - Cross-border Openness of S&T environment, foreign students, companies (FDI), and new products
  - Openness among public research, academia & business
- Open & Attractive Environment
  - Attraction of foreign R&D funding and students
  - Mobility of intellectual property
  - Mobility of highly skilled human capital both domestically and internationally

Source: Nobua Tanaka, Director, DSTI/OECD, 11-04-05

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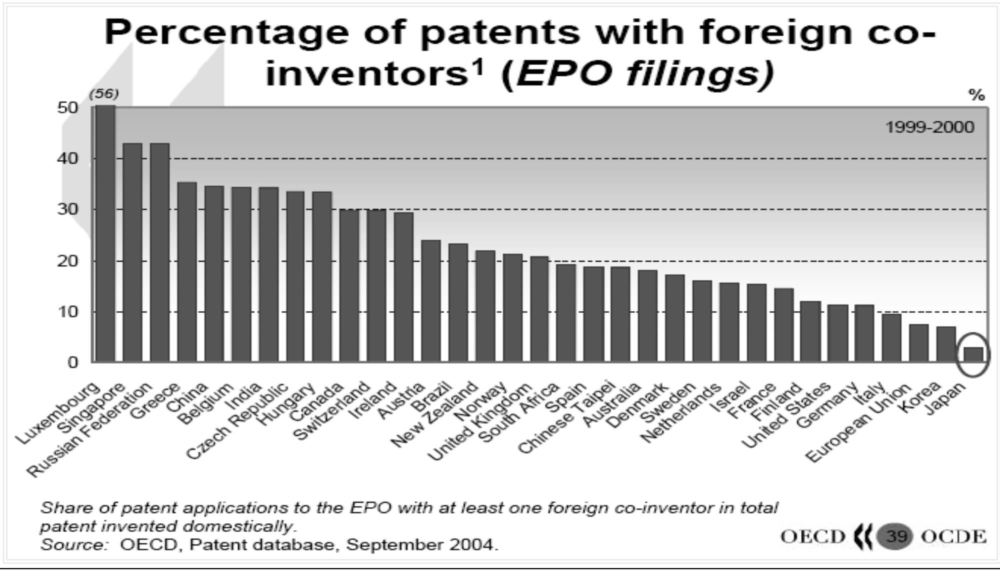
OECD: Japan's Industry-centered R&D System is Relatively Closed



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More International Universities Promotes Openness and Innovation

- U.S. benefited from postwar Internationalization of University Research
  - Access to best minds in the world—many of whom stayed and in the U.S. and contributed
  - Returning students often a source of research collaboration, business relationships, and political support
  - Exposure helped U.S. students to function in an integrated world
  - National Academy of Sciences studies (1982, 1987) found open research laboratories in U.S. national interest
- Today, Japan is sponsoring more university-based research; encouraging more cooperation with small business

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The Importance of Small Business for Innovation

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Small Businesses are a Key Driver of the U.S. Knowledge-Based Economy

- Major Employment Generator
  - Generated 60% to 80% of Net New Jobs in the 1990s
  - Created 2.5 million of the 3.4 million total jobs created in 1999-2000
  - Locus of all net new jobs 2000-2001
- Employs 39% of High-Tech Workers—Scientists, Engineers, Computer Workers
- Produces 14 times more Patents per Employee than Large Patenting Firms
  - Patents are of High Quality
  - Twice as Likely to be Cited
- Source: SBA Office of Advocacy 2005

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The Importance of Equity-Financed Small Firms

- Equity-Financed Small Firms are a Leading Source of Innovation in the United States
- Equity-Financed Small Firms are One of the Most Effective Mechanisms for Capitalizing on New Ideas and Bringing Them to the Market
  - Audretsch and Acs
- Key Goal: Encourage New Equity based Hi-tech Firms that bring Innovation, Jobs, and Growth
  - U.S. Strengths: Firm Creation & Growth—Microsoft, Intel, AMD, FedEx, Qualcom, Adobe have changed the U.S. Economy
  - Case of Sweden: No new large firms since 1970
  - Postwar Japan: New Firms and Rapid Growth

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U.S. Norms and Policies Create Positive Incentives for Entrepreneurs

- Positive Social Norms
  - High Social Value on Commercial Success
  - Forgiving Social Norms allow more than one try
- Entrepreneur-friendly Policies
  - Markets Open to Competition from new Entrants
  - Gentle Bankruptcy Laws permit rapid recovery
  - Taxes give Prospect of Substantial Rewards
- Strong Intellectual Property Regime:
  - Personal Incentive for Invention
  - Encourages Research & Diffusion

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U.S. Myths about the Innovation Process are an Obstacle to Small Firm Development

U.S. Policy Myths about Perfect Capital Markets

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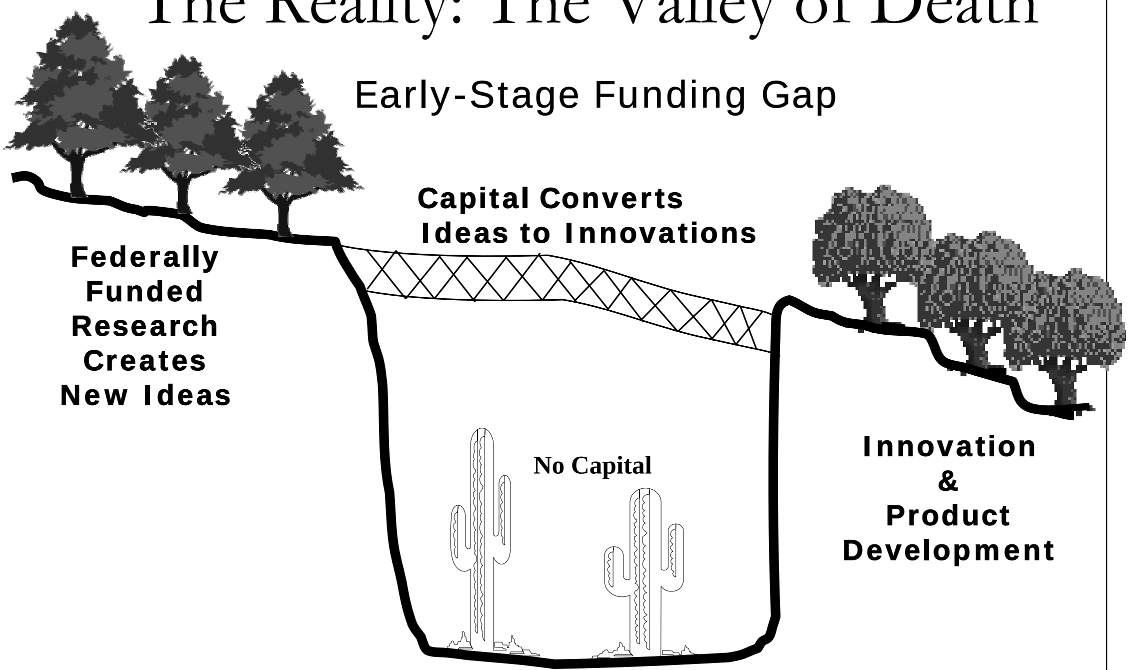
The Myth of Perfect Markets

- Strong U.S. Policy Myth: “If it is a good idea, the market will fund it.”
- Reality:
  - Potential Investors have less than perfect knowledge, especially about innovative new ideas
  - “Asymmetric Information” leads to suboptimal investments
    - This means that it is hard for small firms to obtain funding for new ideas
  - Development of new technologies within an economy is not automatic
    - Technology trajectories are not pre-ordained
- Firms with Promising Ideas Face Major Challenges

The Reality: The Valley of Death

Early-Stage Funding Gap



The Myth of U.S.Venture Capital Markets

- Myth: “U.S. VC Markets are broad & deep, thus there is no role for government awards”
- Reality: Venture Capitalists have
  – Limited information on new firms
  – Prone to herding tendencies
  – Focus on later stages of technology development
  – Most VC investors seek early exit
- Large U.S. Venture Capital Market is Not Focused on Early-Stage Firms
  – See the current Funding break out

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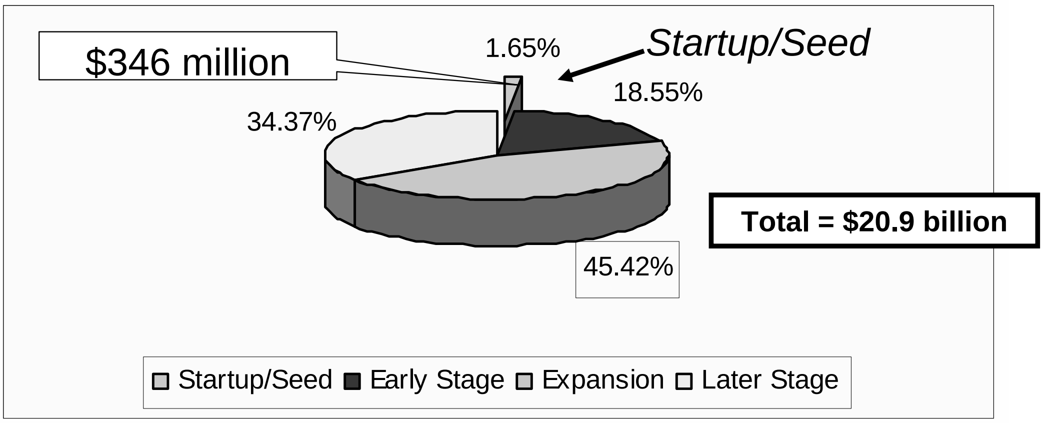
Large U.S. Venture Capital Market is Not Focused on Early-Stage Firms

Breakdown of U.S. Venture Capital by Stage of Development-2004



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The Valley of Death: A Venture Capitalist's View

- A Series of Gaps
  - Gaps in Information between Entrepreneur and potential Investor about
    - Technology: What is it? Will it work?
    - Potential of Technology: What can it do?
    - Business Opportunity
      - What size is the market?
      - What is the competition?
    - What level of risk do investors want to accept?
      - Changes over time and by sector
  - ➢ Result=Gaps in Financial Resources necessary to develop technology from prototype to market

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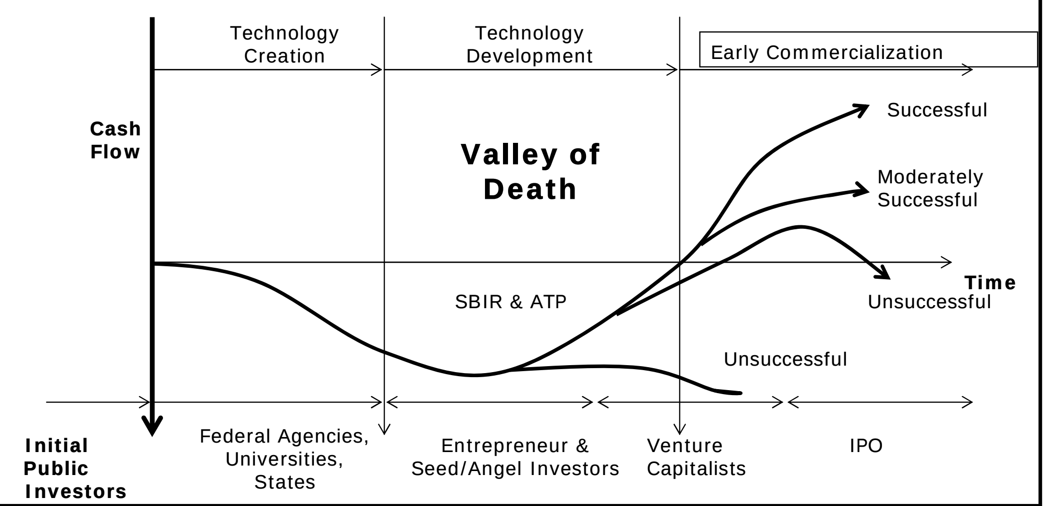
The Public-Private Funding Transition & the Valley of Death

Adapted from: L.M. Murphy & P. L. Edwards, **Bridging the Valley of Death—Transitioning from Public to Private Sector Financing**, Golden CO: National Renewable Energy Laboratory, May 2003



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How does the U.S. fill the Funding Gap?

- The Early Stage Finance challenge is complex:
  - There is no single solution!
  - Money to large companies is not the solution
  - A multi-phase approach is required
- The U.S. system includes a mixture of institutions and mechanisms:
  - University Research and DARPA Funding
  - Proof of Principle & Prototype with SBIR
  - Joint Ventures with ATP
  - Industry-led Consortia for Standards & Joint Research
  - Broad R&D Tax Credits
  - All complemented by an Entrepreneurial-friendly Policy Environment

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The Government Role in Crossing the Valley

The Role of Innovation Awards: The Case of SBIR

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Funding Sources for Early-Stage Technology Development in the U.S.

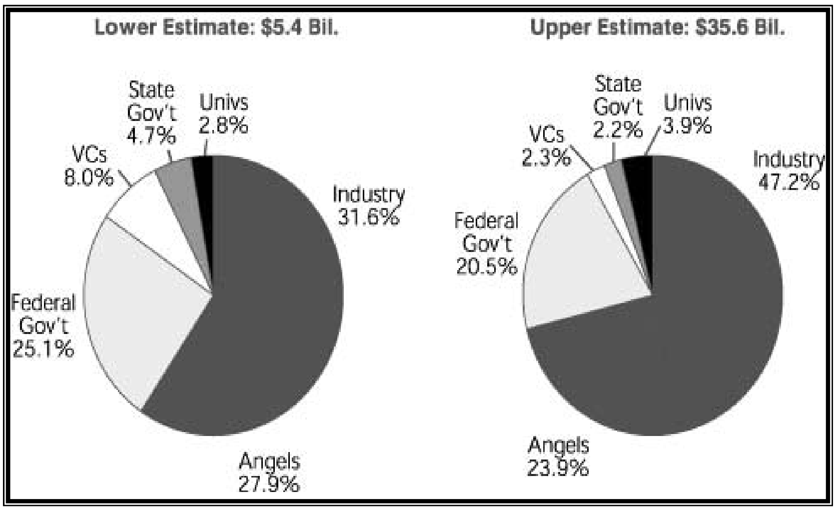
Multiple Actors

*

Multiple Sources of Finance Focused on Different Stages

*

Government Role is Significant



Branscomb & Auerswald, *Between Invention and Innovation An Analysis of Funding for Early-Stage Technology Development*, NIST, 2002

Figures based on 1998 data

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The SBIR Program

- Created in 1982, Renewed in 1992 & 2001
- Participation by all federal agencies with an annual extramural R&D budget of greater than $100 million is mandatory
  - Agencies must set aside 2.5% of their extramural R&D budgets for small business awards
- Currently a $2 billion per year program
  - Largest U.S. Partnership Program
- The National Academy is Reviewing SBIR Program Operation and Performance

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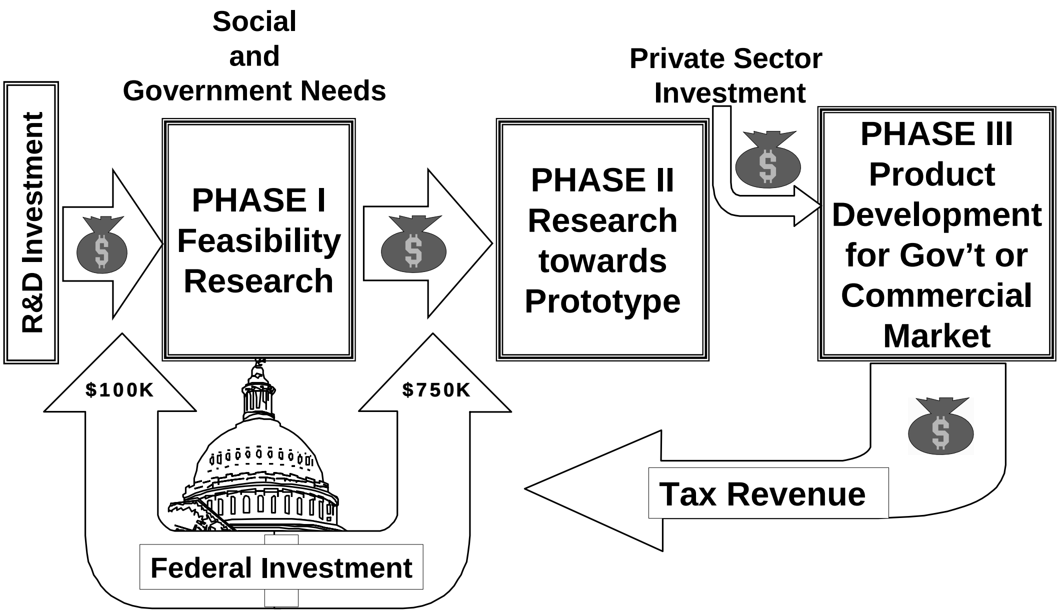
32

The SBIR Model



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SBIR Concept Advantages

- Program is Focused on Government and Societal needs in health, security, environment, & energy
- Proposals are Industry-Initiated
- 2-Phase Filter to Screen Bad Ideas
- No new money, hence politically viable
- Program ownership rests with many agencies, not a single "tech agency"
- Changes incentives within Organizations for those who wish to change, e.g., Universities, Laboratories, and Small Firms

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How Easy is SBIR for Firms to Use?

- SBIR uses a Self-Select Mechanism
  - A Bottom-up approach
  - Agencies post broad Solicitations; Companies define terms of Proposals
  - Most Agencies permit Multiple Proposals from Companies
  - Low Paperwork
    - 15-page description for Phase I award
    - Relatively easy to fill out

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35

Why do Entrepreneurs like SBIR?

- Additional Research Funds: $850+
- No dilution of ownership
- No repayment required
- Grant recipients retain rights to IP developed using SBIR funds
- No royalties owed to government
- Awards attract private capital
  - Certification Effect

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Why do Governments like SBIR?

- SBIR helps Agencies solve their Problems
  - NIH:
    - Biotechnology Research Tools
    - Medical Devices
    - Computer Software & Audio-Visual Health Materials
  - DOD:
    - Vaccines
    - Low-cost, High-performance Drones
  - NASA:
    - Aeronautics and Aircraft Systems
    - Robots to assist in surgery
- Private Sector Ingenuity helps address Public needs

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37

SBIR links the University with Industry

- SBIR Innovation Awards Directly Cause Researchers to create New Firms
  - Faculty does not have to give up University post
  - Cooperation creates High-Tech Jobs
- Universities help diversify and grow the job base
  - Increasingly universities are the largest regional employer for <u>all</u> types of employment
- Cooperation validates Research Funding
  - Returns to Society in Health, Wealth, & Taxes
  - SBIR is a proven mechanism in an uncertain game

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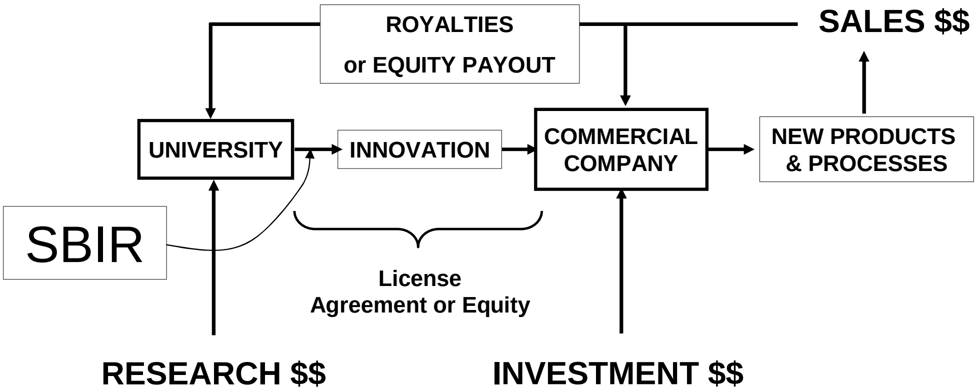
38

SBIR Primes the Pump of University Technology Transfer



- Licensing to existing companies – brings royalty $
- New company formation – brings royalties and/or equity
- Other, less direct, contributions to regional economic activity

Drawn from C. Gabriel, Carnegie Mellon University

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The Government Role in Crossing the Valley

The Role of Innovation Awards: The Case of ATP

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ATP is the "Next Rung" on the Innovation Ladder

- Larger award is in effect an 'SBIR-Phase III'
  - ATP focuses on the next stage—Competition and Commercialization
  - Helps bring early-stage, high-risk, enabling and innovative civilian technologies to market

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41

The ATP Approach: Industry Leadership

- Industry-initiated proposals: Bottom-up approach
- Industry Managed Projects
- Highly Competitive: Only 12.5% receive awards
  - Rigorous independent selection process
    - Evaluation of the project's technical merit
    - Commercial worthiness and broad-based benefits
- Industry cost-share required
  - All ATP awards are cost shared with industry

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ATP Encourages Synergies between Small and Large Companies

- Programs like ATP enable business partnerships between Small and Large Firms
- Why Small Firms like ATP
  - Provides significant capital and a powerful certification effect
  - Provides access to Large Firm technologies, skills, management and marketing reach
  - Allows shift from a supplier role to full partnership in an ongoing relationship
- Why Large Firms like ATP*
  - Helps Large Firm keep up with faster pace of innovation
  - Provides access to niche expertise and unique talents of small companies
- ATP Encourages Partnering Between Large and Small Firms, Inventors and Labs

* Kathleen Kingscott, IBM

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The U.S. Approach to Innovation Partnerships

- Highly Competitive—Not a Right
- Awards are limited in time
- Awards are limited in amount
- Partnering encouraged: Small companies, large companies, and (increasingly) universities participate in the programs
  - Dissemination of enabling technologies is key to public benefits for ATP
  - Mission support for SBIR

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U.S. Myths Remain Powerful

- U.S. Has Been Slow to Renovate its Innovation System
  - Limited Appreciation of Scope and Scale of Foreign Programs
  - Limited Recognition of Need to Facilitate Transition of Technology to Products
- U.S. Ideology on Perfect Markets limits Innovation Policy
  - SBIR under siege by Office of Management and Budget
  - ATP Budget for New Awards frozen at zero for 2nd year
- Recent Experiments such as HSARPA have Shown Limited Impact
- Congressional Action is Probable

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45

Conclusion

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Japan and the U.S. Face Common Challenges

- National Innovation Systems are Different in Scale and Flexibility
  - Flexibility is a differentiator
  - It is less how much is spent but *how well*
- All Systems Have Common Challenges
  - Need to justify R&D expenditures by creating new jobs & new wealth
  - Need to reform institutions (or invent new ones)
  - Need to try new mechanisms that shift innovation incentives in a positive way
- Learning from each other is a Pathway to Progress--That is why we are here

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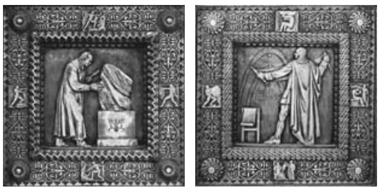
47

Thank You



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48

Programs to Stimulate Startups and Entrepreneurship in Japan: experiences and lessons

January 10, 2006

Takehiko Yasuda,

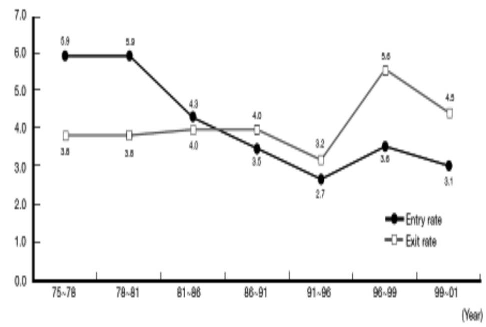
Toyo University

1

Since 1990s, entrepreneurship activity in Japan has been stagnant, and it is suspected that this phenomenon leads to weakening of economic activity.
In such a situation, various policy measures are taken for promotion of startups.

Trends in entry and exit rates based on number of enterprises (non-primary industry, annual averages)

Entry rate declines from 1980s



Source: MPHPT, *Establishment and Enterprise Census of Japan.*
Notes: 1. Survey conducted as the *Establishment Census* up to 1991 and the *Establishment Directory Maintenance Survey* in 1994.
2. See Appended Note 2-2-1 regarding the method of calculation of the entry and exit rates.

(Main responses of policy since 2000)

① Removal of minimum capital requirement for limited liability companies

② Educational activity on entrepreneurship (national startup and venture forum)

③ New startup loan program (Loan for startups by National Life Finance Corporation, which requires no collateral, guarantors or personal guarantees)

2

① Removal of minimum capital requirement for limited liability company: Limitedly executed from February 2004 (in view that minimum capital requirement is constraint for startups)

Actual performance：

From February 1, 2004 to January 21, 2006
Number of confirmed applications: 24,639 (1,172)
Number of notification completions: 20,211 (927)

[Reference]
According to the aggregation of "Monthly Report on Statistics (Ministry of Justice)", newly registered limited liability companies January-October 2004 tended to increase compared with 2003.

3

② Educational activity on entrepreneurship（National startup and venture forum）

- ***Japan Venture Award***
  In order to show the next generation role model in startups and venture, *Japan Venture Award* is conducted to honor entrepreneurs and their sponsors who succeeded in the continual challenge for new business.

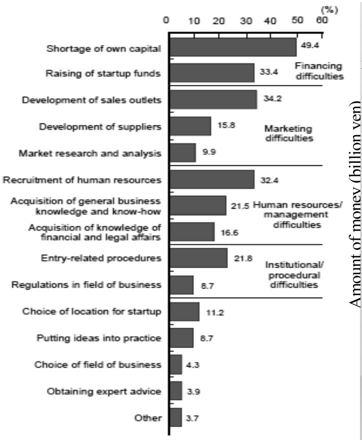
- **"Startup and venture evening forum"**
  In order to realize startups, small symposiums which focus on special themes are held for giving advice to problems participants face.

4

③ New startup loan program

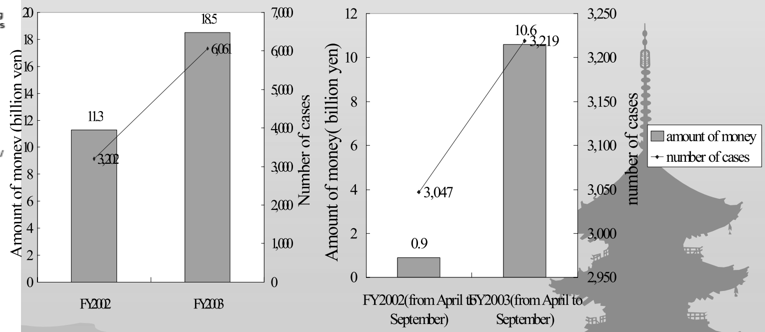
Startup firms suffer from liquidity constraint（Evans-Jovanovic 1989, et.al.）. For this reason, National Life Finance Corporation lends up to 7.5 million yen for startups without requirement for collateral, guarantors or personal guarantees by screening contents of business.

Difficulties encountered at startup



Source: SME Agency, *Survey of the Environment for Startups* (December 2001).
Note: Total exceeds 100 due to multiple responses.

Actual performance of new startup loan program



5

④ The other policies - *Startup classes*（Education for startups）

- Startup classes held by strong partnership between Japan Chamber of Commerce and Industry and local chamber of commerce and industry etc. help to complete concrete business strategy and competitiveness to potential entrepreneur.
- Actual performance

	No. of places	No. of participants
FY2000	133	5,776
FY2001	184	6,535
FY2002	221	6,963
FY2003	287	11,500
FY2004	275	9,026

◎**Target of startup promotion policy →** Under startup-doubling plan, it is targeted that for the period from 2001-2006, annual average number of startups of firm is doubled from 180,000 to 360,000.

6

1. Setting up the questions and framework for analysis

・Which degree of entrepreneurs recognize startup promotion policies?
・Which type of entrepreneurs recognize startup promotion policies?

These questions have close relationship to effective advertisement of startup promotion policy.

↓

ex. For startups that bother to assure selling outlet, information of policies for sales promotion（venture fair etc.）is useful.

Could startups who bother with pass of sales acquire information on policies for sales promotion?

→ This question is close to advertisement of startup promotion policy

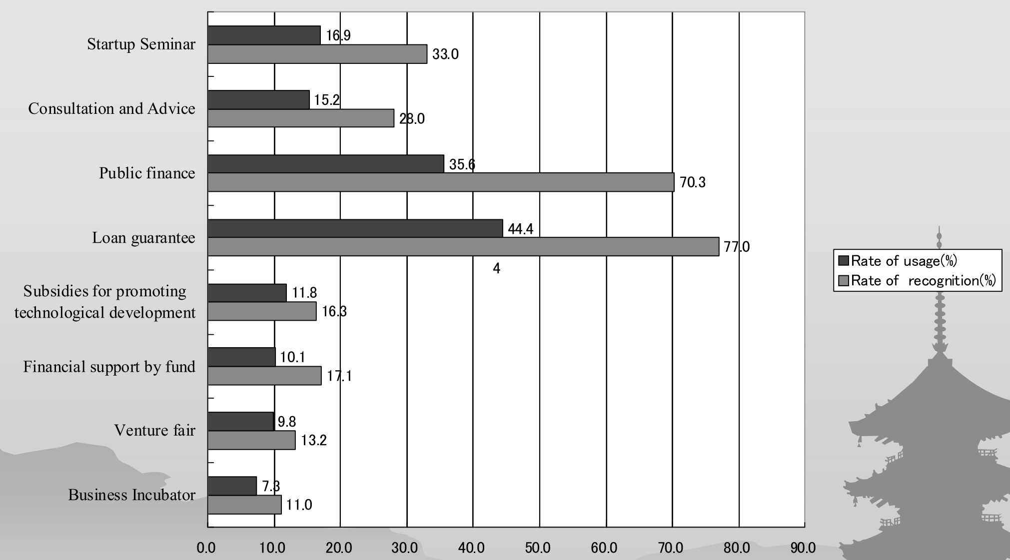
→ Lessons on advertisement of startup promotion policy could be attained through analyzing startups’ degree of recognition on startup promotion policy.

7

2. Recognition of startup policy for entrepreneur

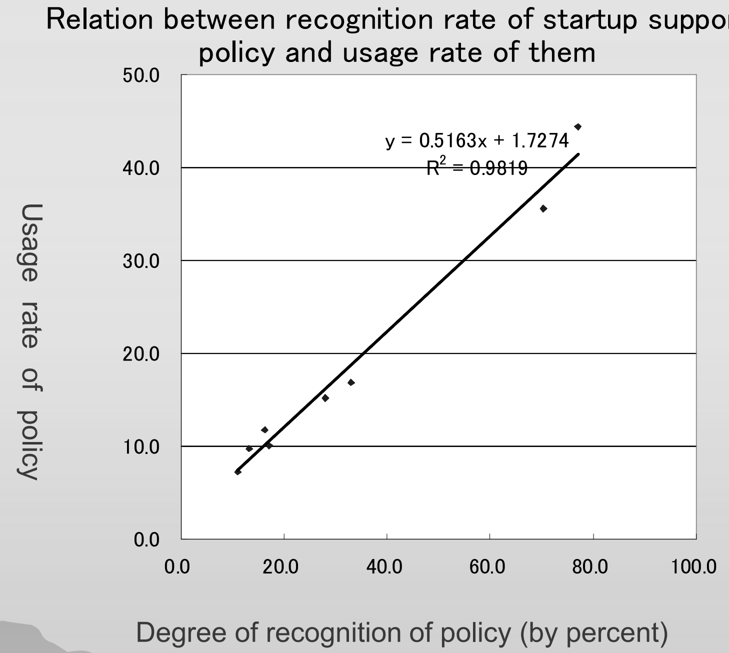
Answer to question to entrepreneurs at time of startup, whether each startup related policy carried out by national government, local municipality and agencies.

The rate of recognition and usage of startup related policy by new startups



Japan Small Business Research Institute

8



High positive relation between degree of recognition and degree of use of policy measures → recognition is necessary for use.

9

3.Which entrepreneurs acquire information (recognize) on startup promotion policy?

（1）Model

In model, the degree of recognition at time of startup on policies useful for startup（knowing at time of startup=1, not knowing at time of startup=0）is regressed by entrepreneur components and firm components (Probit Model).

Explained variable

Degree of recognition of policies described below.

①Startup seminar - *Startup classes* etc.

②Consultation and advice - Inquiry counter for business counsel and advice）

③Public finance - New startup loan program etc.

④Loan guarantee by loan guarantee association

⑤Subsidies for promoting technological development（SBIR etc.）

⑥Financial support by fund organized by local government etc. (Small Business Investment & Consultation Co. Ltd. etc.)

10

⑦Venture Fair - Exhibition for business venturing（Organization for Small & Medium Enterprises and Regional Innovation etc.）
⑧Business Incubator - Business workplace for business venturing;（Organization for Small & Medium Enterprises and Regional Innovation ）

Explanatory variable

a）Components of entrepreneur

- Age of entrepreneur at startup
- Gender dummy（female=1, otherwise=0 ）
- High education dummy（university graduate or higher=1, otherwise=0）
- Related work experience dummy（has related work experience =1, otherwise=0)

11

- Business management experience dummy（Has business management experience=1, otherwise=0）
- Startup type dummies（spin-off-type, Franchise-type, Independence-type, family business development-type and others. Benchmark is “others”）
- Dummies for personal income level just before startup（Benchmark is 5.0 million-10.0 million or less)
  ①2.5 million yen or less, ②2.5-5.0million yen or less, ③10.0-15.0 million yen or less, ④15.0 million yen or more

b）Component of firm

- No. of workers at time of startup
- Startup form dummy（Limited liability=1,Unlimited liability=0
- Sector dummy（manufacture, transportation, communication, retail, wholesale, restaurant, service. Benchmark is service.）

12

4. Used Dataset: “Survey of the Environment for Startups”

(1) Responsible organization :

Japan Small Business Research Institute

(2) Period of survey: Oct.-Dec. 2002

(3) Objects of survey

10,000 firms which started from 1995-1999, that is extracted randomly from database of TOKYO SHOKO RESEARCH, LTD. (TSR)(Firms age 3-8 years old)

(4) Mail survey (Response rate 11.4%)

(5) Main questionnaire item

Archival record of entrepreneur, basic data of startup firm, usage of policy etc.

(6) No. of observations with information on explanatory variable is 894

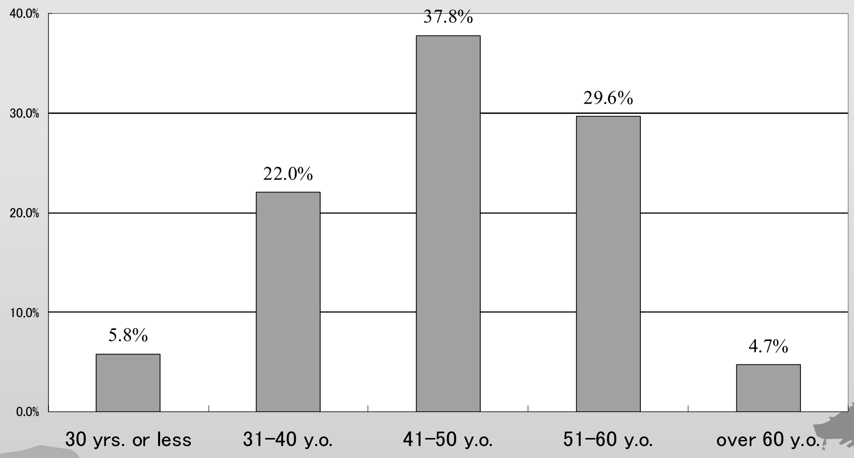
13

5. Basic statistics

①Entrepreneur components

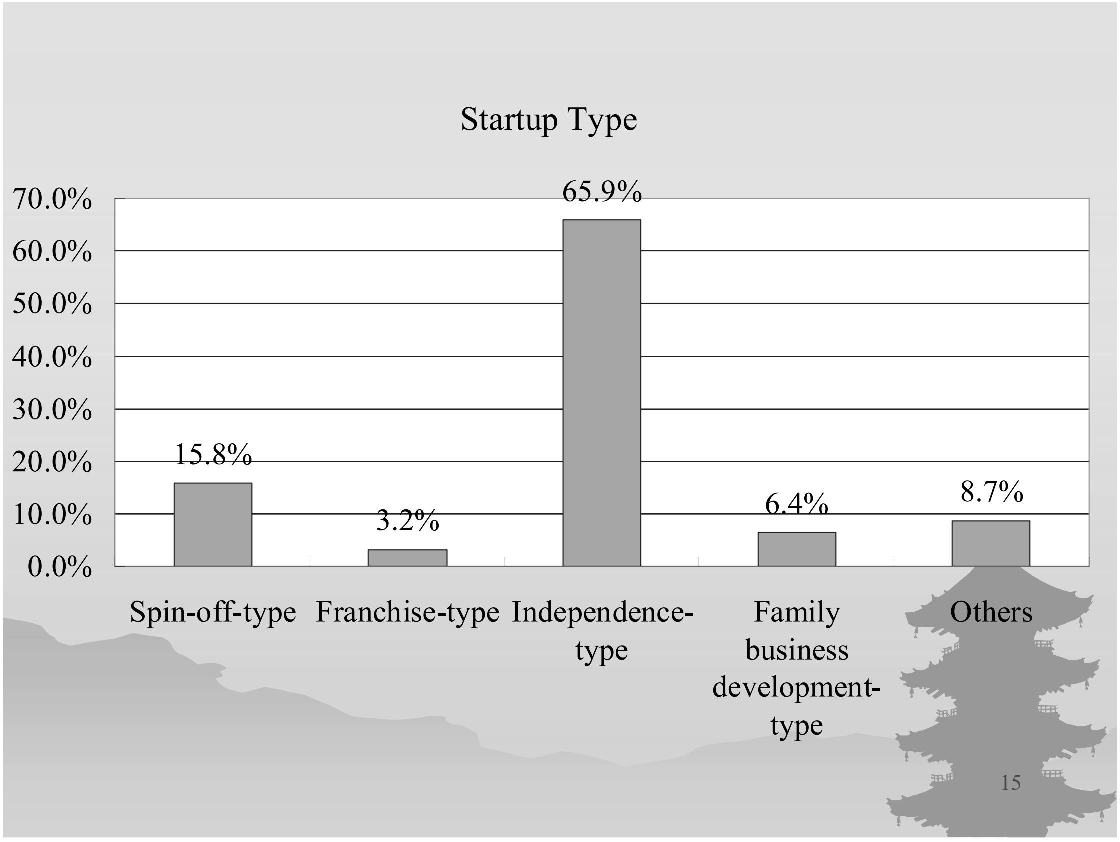
Age of entrepreneur at the time of statup

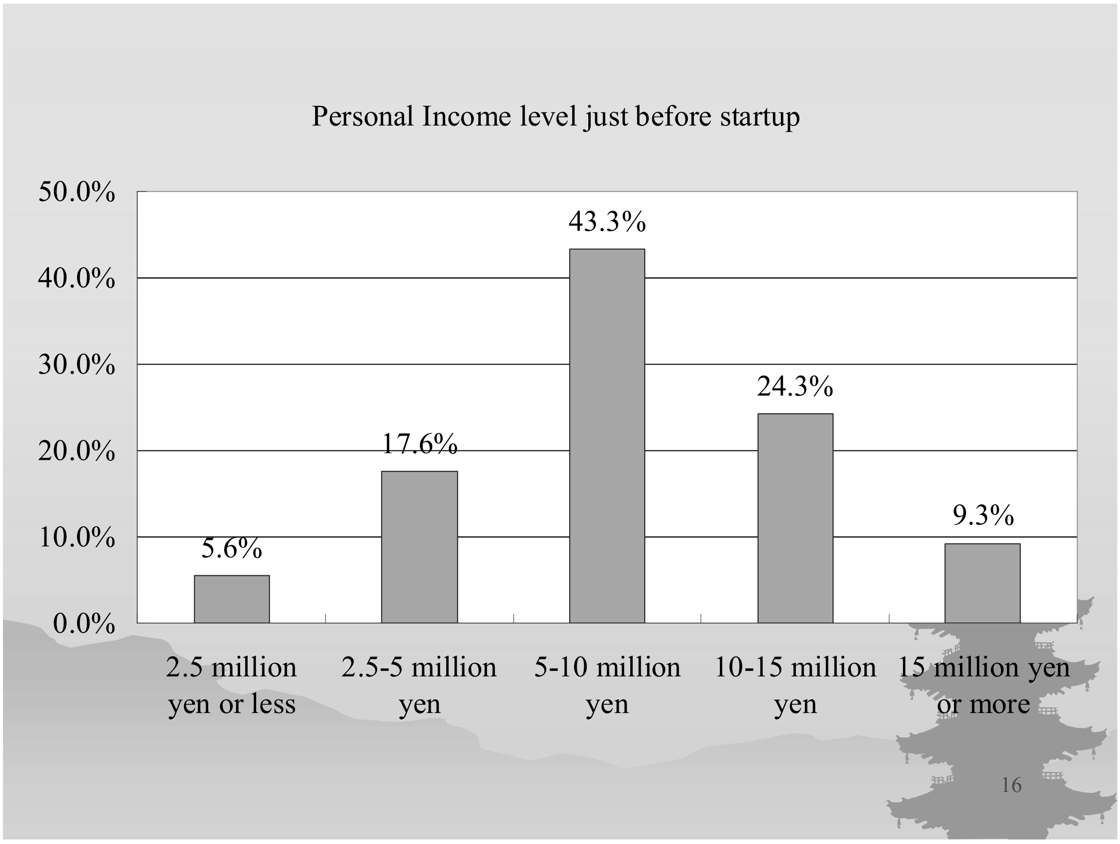
Average age 45.8 Median 46.4
standard deviation 9.49



Female	High education	Related work experience	Business management experience
2.9%	57.4%	79.6%	32.2%

14

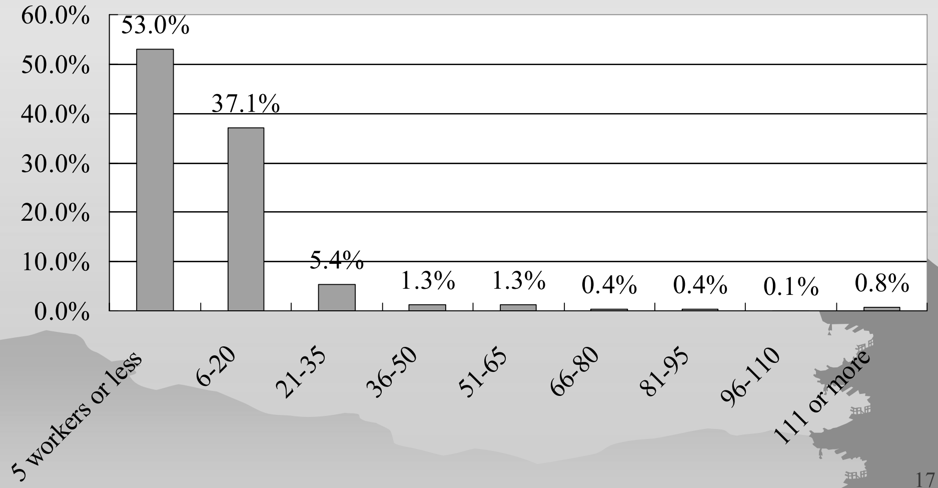

Startup Type
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
15.8%
3.2%
65.9%
6.4%
8.7%
Spin-off-type
Franchise-type
Independence-type
Family business development-type
Others
15


Personal Income level just before startup
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
5.6%
17.6%
43.3%
24.3%
9.3%
2.5 million yen or less
2.5-5 million yen
5-10 million yen
10-15 million yen
15 million yen or more
16

② firm components

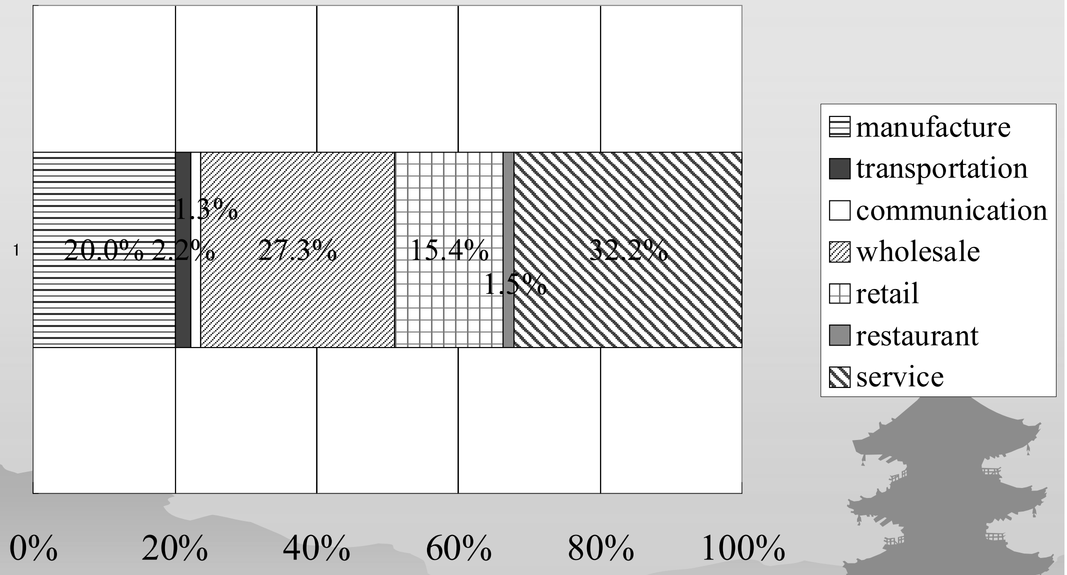
(a) legal form at startup・・・・limited liability (85.9%)、
Unlimited liability (14.1%)

(b) **Number of workers at the time of startup** **Average 11.3 Median 5 Standard deviation**



17

Sector of startup firm



18

6. Results of expected sign of coefficient and reason (entrepreneur components)

Explanatory variable	Expected sign of coefficient	Reason
Entrepreneur's age at startup	+ for financial support policies ? for the other policies	Aged entrepreneurs face less liquidity constraint.
Female dummy	?	
High education dummy	+ for financial support policies ? for the other policies	Educated entrepreneurs face less liquidity constraint.
Related work experience dummy	?	
Business management dummy	+ for overall policies	Entrepreneurs with business management experience tend to have startup experience.
Startup type dummies	+ for overall policies in independence-type	Independence-type have less resources.
Dummies for just before personal income	+ for financial support policies in low income class	Entrepreneurs with low income face greater liquidity constraint.

19

7. Results of expected sign of coefficient and reason (firm components)

Explanatory variable	Expected sign of coefficient	Reason
Limited liability dummy	?	
Employment size at startup	?	
Sector dummy	?	

Disturbing factor for interpretation of results of estimation

→ Public relation policy (If public relation policy is perfect, coefficient of every variable is not efficient.)

20

8. Estimation results (Basic components of entrepreneur and recognition of startup promotion policy)

	Startup seminar	Consultation and advice	Public finance	Loan guarantee	Subsidies for promoting technological development	Financial support by fund	Venture fair	Business incubator
Entrepreneur age at startup			−−	−−−				−−
Female dummy								
High education dummy								
Related work experience dummy			+	+				
Business management dummy		+	+++	+++	++	++		+++

21

9. Estimation results (Startup type, income level just before startup)

	Startup seminar	Consultation and advice	Public finance	Loan guarantee	Subsidies for promoting technological development	Financial support by fund	Venture fair	Business incubator
spin-off type				−−−		−−−		−
Franchising-type								
Independence-type						−−		−−
Family business development-type			−−−	−				
pre-income class 1								++
pre-income class 2								+
pre-income class 4								++
pre-income class 5								++

22

10. Estimation results (firm component)

	Startup seminar	Consultation and advice	Public finance	Loan guarantee	Subsidies for promoting technological development	Financial support by fund	Venture fair	Business incubator
Limited liability								
Employment at startup				+++				
Manufacturing			++	++	+++	+		
Transportation	+							
Communication			−−	−−				
Wholesale	−−	−−	++	++				
Retail			+++	+++				
Restaurant								

23

11. Observed facts from estimation

(1) Entrepreneurs with business management experience tend to have more information on startup support policy at time of startup

→ Many inferred to be "serial entrepreneurs" with startup experience.

(2) Entrepreneurs with related work experience have more information on financial support policy to startups.

→Acquire information on financial support policy through work. However they do not know overall policy for promoting startup because many of them have no experience with startups.

(3) Aged entrepreneurs do not know financial support policy.

→ Face liquidity constraint to smaller extent than young entrepreneurs.

(4) In "Family business development-type" and "Spin-off type", entrepreneurs tend to know financial support policy.

→ Face less liquidity constraint.

(5) Little deference of degree of recognition by income class just before startup.

24

12. Further consideration on the observation

Why do serial entrepreneurs have better information on startup support policy?

＜Implementing and advocating agency of startup support policy＞

① Government-affiliated agency（Organization for Small & Medium Enterprises and Regional Innovation, JAPAN, Small Business Investment & Consultation Co. Ltd. etc.）

② Chamber of Commerce and Industry, Society of Commerce and Industry

③ Government-affiliated financial institution (National Life Finance Corporation, The Central Cooperative Bank for Commerce and Industry, Japan Finance Corporation for Small and Medium Enterprises etc.）

→ These organizations are familiar for existing SMEs, but for startups, they are not familiar.

25

・ Distinction of “Small business policy” and “entrepreneur support policy (startup support policy)（Lundstorm-Stevenson 2001)

→ Distinction of policy advocacy to existing firm and that to newly born firm is crucial.

13. Lessons：

○It is necessary to establish a different route of public relations for startups from the one for existing small businesses. (Public financial institutions, post office, gas station etc.）

○ It is necessary to take advantage of those with startup experience so new entrepreneurs can know about startup-supporting policy. (Role of angels and mentors most of whom have startup experience)

26

21st Century Innov. Sys. For Japan & U.S., Jan. 10-11, 2006 **THine**

Key Role of Startups in the Drastic Paradigm Change

-Lack of Startups promises Industry Decay-

Tetsuya Iizuka

THine Electronics, Inc.

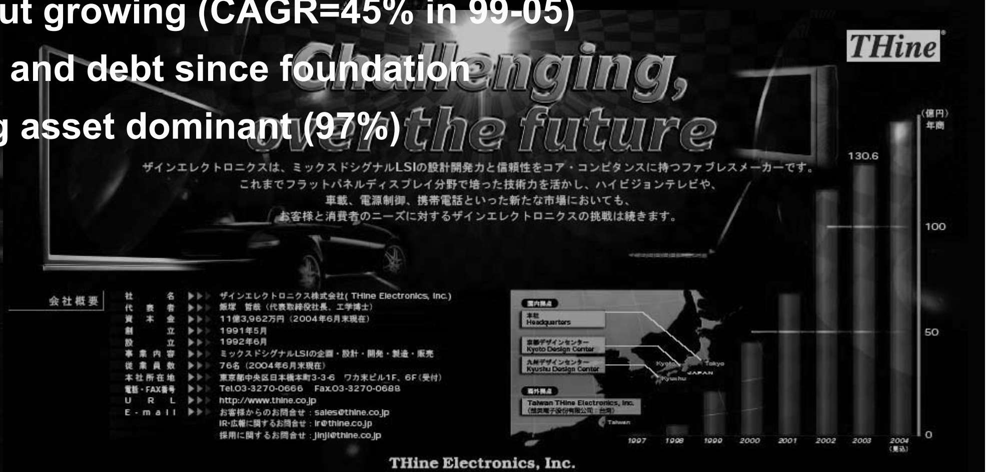
JASVA

Japan Semiconductor Ventures Association

1

THine ?

- Founded in ’91, IPO in ’01
- Fabless Semiconductor Venture with 200M$ Sales (’05)
- Supplying FPD peripherals, RF, power ICs
- Small but growing (CAGR=45% in 99-05)
- No loss and debt since foundation
- Floating asset dominant (97%)



THine

159

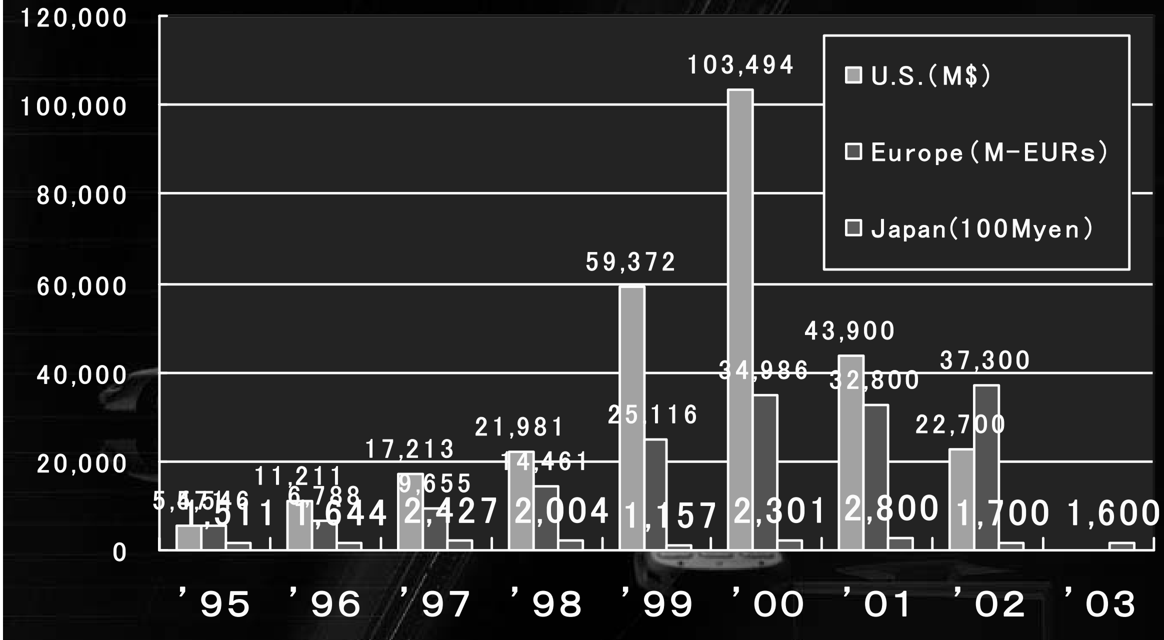
Japanese Notorious Environment for Entrepreneurs

- Total Entrepreneurial Activity (TEA) Index: 38th out of 40 countries @ 2003, @2000-2003 average
- Firm Entrepreneurial Activity (FEA) Index: 30th @2002-2003
- Employment creation by startup:
  40th out of 40 countries
- Startup by young generation: 40th
- Startup by women: 39th
- Total valuation: E-rank (worst)

Global Entrepreneurship Monitor 2003, Babson-LBS-Kauffman (2004)

THine 3

Annual Disbursements from VC



THine 4

Key Role of Startups

- Hard to see next business winner in age of drastic paradigm change
- Requires various Try&Error tool at low cost (Time, Money, Human resources)
- VB provides the best cost performance social T&E scheme for new paradigm
- Not just mere money worship

THine 5

Great Success hindered the Change

- Financial system collapse and huge debt destroyed B/S.
- Traditional small profit rate businesses required long time to improve B/S
- Even core business lacked the cash flow
- Traditionally low fluidity of talented people

- Slow change in industry structure
- Slow in technology, monetary shift to enforce core business sectors

THine 6

社団法人日本半導体ベンチャー協会

JASVA

Japan Semiconductor Venture Association

- Foundation on Oct. 27, 2000
- Support startups in semiconductor and FPD
- Through seminars, conferences
  - Action Seminar
  - IP Design Committee, FPD Committee, RF technology committee
  - IR Conference
- Collaboration VB & established firms
- Increase Ex. Of Success ⇒Shortcut to create strong impact (7 IPO companies, 7 University startups)
- 230 members (incl. 6 Large Electronics Firms, VCs, Accounting firms, Local public bodies)

THine 7

社団法人日本半導体ベンチャー協会

JASVA

Japan Semiconductor Venture Association

- 7 member VBs made IPO
- 7 member VBs founded by university researchers
- Tokyo JASVA founded in 2000
- Kyushu JASVA in 2002
- Kansai JASVA in 2003

THine 8

"E-Nova Fund"

(Electronics, New Star Nurture Fund)

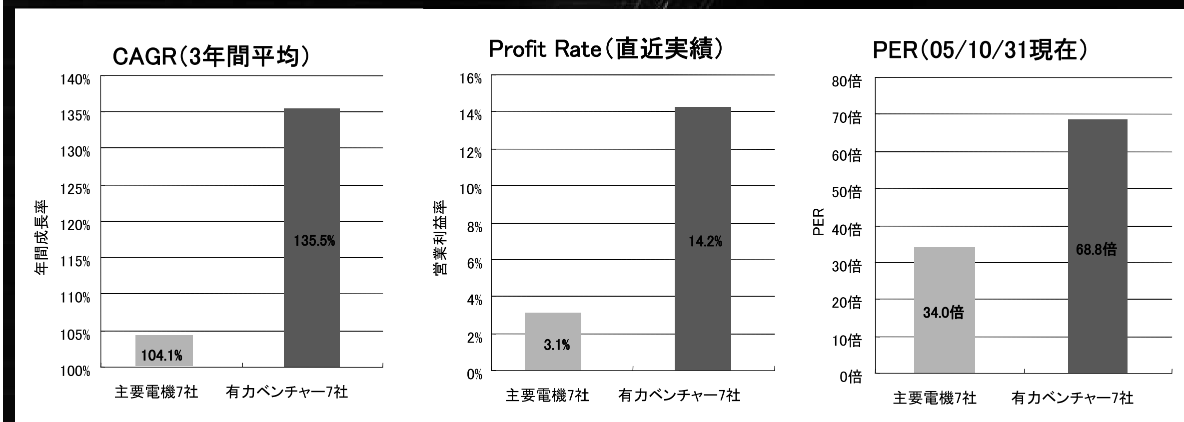
- Focus on electronics, semiconductor startups
- Spin-out/off from large companies
- Reasonable options for mother company, rather than ownership or tight control
- Utilize ample size of resources/capitals from outside the mother company
- Partnership with Asian funds and foundries
- Cooperation with JASVA

THine

9

Japanese Electronics Startups' Performance

悪名高き日本でもベンチャーの成長力は高い



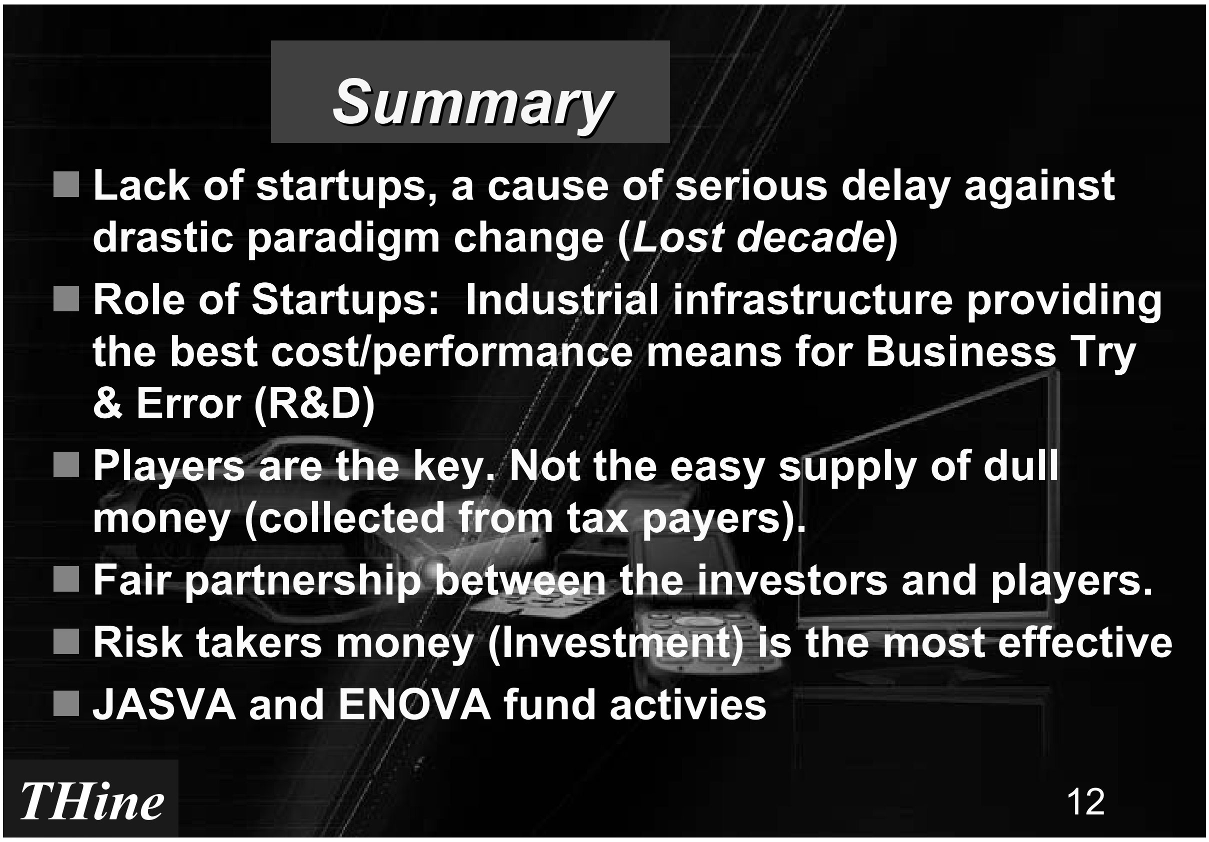
主要電機7社 ：So, T, H, P. Sa, M、Sh

有力エレクトロニクスベンチャー ：ザインエレクトロニクス・アクセル・IRIユビテック・チップワンストップ・MCJ・ワコム・ブイテクノロジー

THine

10


Angel activities
Utilize knowledge obtained through his own experiences of starting business and success.
Invest some amount of personal money
Connect to large Capital, customers, human networks
Help creating new business, industry, and employment
Social contribution to strengthen the country against the Change of Paradigm
THine
11


Summary
Lack of startups, a cause of serious delay against drastic paradigm change (Lost decade)
Role of Startups: Industrial infrastructure providing the best cost/performance means for Business Try & Error (R&D)
Players are the key. Not the easy supply of dull money (collected from tax payers).
Fair partnership between the investors and players.
Risk takers money (Investment) is the most effective
JASVA and ENOVA fund activies
THine
12

パネル **IV**：知的財産とイノベーションシステムの相互作用

Panel IV: Interaction between Intellectual Property and Innovation Systems

モデレーター：植村 昭三，世界知的所有権機関（WIPO）前事務局次長／東京大学先端科学技術研究センター客員教授

米国特許システムの課題と可能な改革

Issues and Possible Reforms in the U.S. Patent System

ブロンウィン・ホール Bronwyn Hall，カリフォルニア大学バークレー校教授

日本における特許システムの改革と挑戦

Reform of Patent System in Japan and Challenges

長岡 貞男，一橋大学イノベーション研究センター長，教授

ディスカッサント

マーク・マイアーズ Mark Myers，ゼロックス（元），ペンシルベニア大学ウォートン・ビジネススクール客員教授

Issues and Possible Reforms in the U.S. Patent System

Bronwyn H. Hall
Professor in the Graduate School
University of California at Berkeley

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Overview

- Economics of patents and innovations
- Changes to US patent system in the past quarter century
- Proposed US patent reform legislation and its current prospects

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Patents, innovation, and competition

- Traditional view
  - Patents provide incentive for innovation
  - Patents grant short term monopolies, bad for competition
- "New" view
  - Patents increase cost of innovation
  - Patents encourage entry in knowledge-intensive sectors

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The Patent System Viewed by a Two-Handed Economist

Effects on	Benefits	Costs
Innovation	creates an incentive for R&D; promotes the diffusion of ideas	impedes the combination of new ideas & inventions; raises transaction costs
Competition	facilitates entry of new small firms with limited assets; allows trading of inventive knowledge, markets for technology	creates short-term monopolies, which may become long-term in network industries

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Which effect dominates?

- Economic Theory: mixed
  - an incentive for innovation, but
  - can slow advance in cumulative technologies
  - litigation fears discourage investment
- Across U.S. Industries: great variation
  - Clearest benefits: pharma, chemicals, medical devices
  - Ambiguous: semiconductors, other IT
- Across countries and time:
  - Not much evidence that strengthening IP protection induces more domestic R&D and innovation

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Conclusions from research

- Introducing or strengthening patent system results in an increase in patenting and the strategic uses of patents.
- Not clear that it increases innovation, although it may change its direction.
- Most responsive sectors are pharmaceuticals, biotechnology and specialty chemicals.
- Existence and strength of patent system affects organization of industry by facilitating trade in knowledge assets.

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Evolution of the U.S. Patent System since 1980

- Patenting extended to
  - new technology (biotechnology)
  - technologies previously not subject to patent protection (business methods, software)
  - upstream scientific research tools, materials, and discoveries
- Emergence of new players (universities and public research institutions)

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Evolution of the patent system, cont.

- Position of patent holders strengthened vis-à-vis alleged infringers
  - Court of Appeals for the Federal Circuit ⟹ higher validity rates from 1982
  - Process Patent Amendments, 1988 (blocks imports)
  - Major damage awards (e.g. *Polaroid v. Kodak*, 1986/1991)
  - TRIPS Agreement, 1994
  - No research exemption (*Madey v. Duke*, 2002)
- Antitrust constraints on patent use relaxed

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Contributing to…

- Doubling of patent applications and grants (to 100 per working hour), 1992-2002
- Higher renewal rates
- More frequent assertion of patents
- Doubling of U.S. District Court patent suits, 1988-2001

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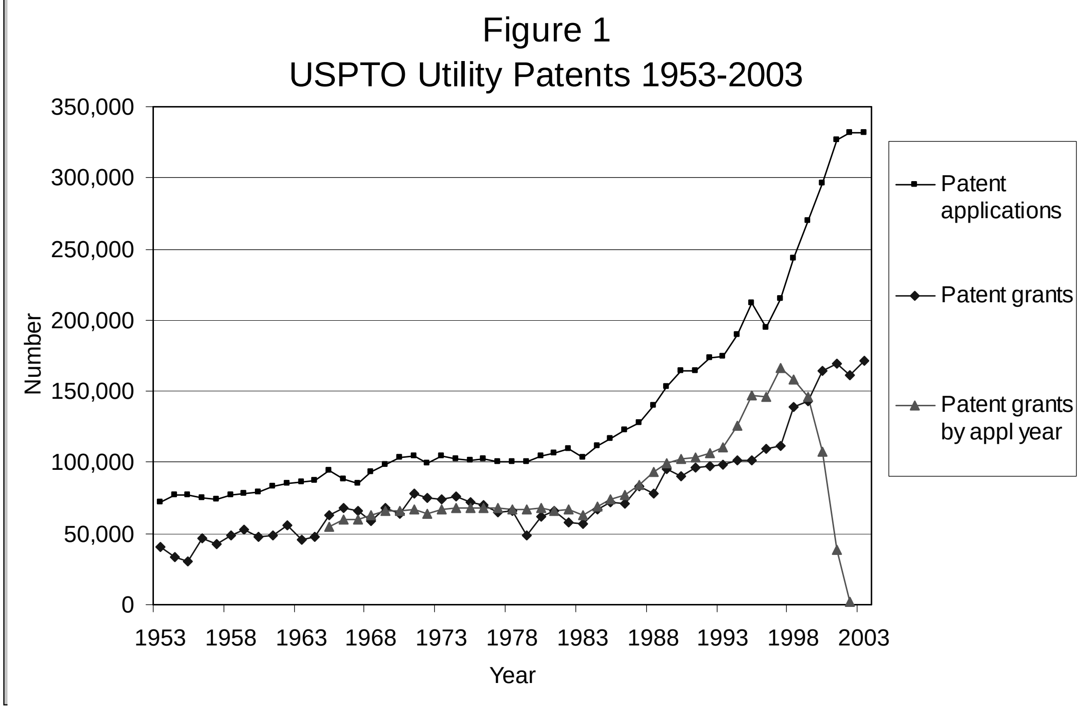

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Concerns and criticisms

- Volume of patent applications threatens to degrade quality or lengthen backlog or both
- Decline in quality from other sources (prior art)
- Rising costs for acquiring and defending patents and securing licenses
- Increase in defensive patenting
- Difficulty negotiating patent thickets/risk of hold-ups, especially in cumulative technologies
- Some impediments to research

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Estimated Median Litigation Costs for Each Party in Litigation ($ Thousands)

	2001	2003	Percent Change, 2001 to 2003
Less than $1 million at risk			
End of Discovery	$250	$290	16.0
Inclusive of discovery, motions, pre-trial, trial, post-trial, and appeal	$499	$500	0.2
$1-$25 million at risk			
End of Discovery	$797	$1,001	25.6
Inclusive of discovery, motions, pre-trial, trial, post-trial, and appeal	$1,499	$2,000	33.4
More than $25 million at risk			
End of Discovery	$1,508	$2,500	65.8
Inclusive of discovery, motions, pre-trial, trial, post-trial, and appeal	$2,992	$3,995	33.5

Source: AIPLA

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Current prospects for reform

- High interest in U.S. Congress
  - Response to NAS and FTC reports
  - Lamar Smith (House) Orrin Hatch (Senate)
  - Hearings - April, June, July, September last year
  - HR 2795 introduced in June, substitute in Sept.
- Interested groups
  - AIPLA, IPO, ABA IPL Section, BIO, BSA
  - Coalition – 37 large cos. plus these groups propose a reform package

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H. R. 2795 as proposed (amended)

- Changes the current "first to invent" standard to "first inventor to file“; one year grace period (§ 3)
- Eliminates the subjective "best mode" requirement from § 112 of the Patent Act, delineating objective criteria that an inventor must set forth in an application (§ 4)
- Imposes a duty of candor and good faith on parties to contested cases before the patent office, eliminating inequitable conduct as a defense of patent unenforceability, unless at least one claim in the patent has already been found invalid. (§ 5).

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H. R. 2795 as proposed (amended)

- Reduces the scope of willful infringement by raising the standard of proof required, and limits the amount of damages a patentholder can collect from an infringer (§ 6). Substitute bills change wording, limit to cases where notice has been given.
- Limits patentees' ability to get injunctions (§ 7). Removed.
- Authorizes the director of the patent office to regulate continuation applications (§ 8). Removed, but Dudas has taken the initiative with Fed Register proposal

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H. R. 2795 as proposed (amended)

- Establishes a new post-grant opposition system in the patent office with 9 month window (§ 9). Subsequent 6 month window removed.
- Allows members of the public to introduce new information to the patent office up to six months after the date of publication of the patent application to challenge the patent and to provide a final quality check (§ 10)

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Will there be a bill?

- Eventually, yes – a lot of support for some provisions
- Possibly not this year – problems with
  - apportionment of damages
  - injunctions when patent is not being "worked"
- In the meantime, USPTO goes ahead with reforms to stem the tide

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Reform of patent system in Japan and challenges

Sadao Nagaoka*
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January 2006

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1. Introduction

- Intellectual property rights (IPRs) protection in Japan has been significantly strengthened since early 1990s.
- Initially the impetus for such changes came from abroad:
  the US-Japan agreement in 1994
  the TRIPs agreement in 1995
- the reform has been undertaken as a one of the corner stones of the domestic reform in Japan in the 2000s

- The experiences for the past decade or so has highlighted new challenges

- Three major challenges facing patent system in Japan and in the US on which this paper focuses

-efficient patent examination

-efficient utilization of information disclosed in patent documents for industrial research

-the patent thicket problem

2. **Reform of patent system in Japan in recent years**

- Important reforms in the 1970s and 1980s

  -introduction of product patent in 1976

  -full liberalization of multiple-claims for a patent in 1987

- The effect of the latter reform has unfolded gradually and significantly in the 1990s

- The stronger deterrence against infringement through strengthening

  -the private damage system,

  -criminal sanctions and

  -the power for a patentee to collect evidence of infringement
- The expansion of the patentable subject matter in the filed of computer program.

  In 2000 computer program of itself became fully patentable as a product patent

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- the affirmation of the “doctrine of equivalents” by the Supreme Court in 1998

- the switch from pre-grant opposition system to the post-grant opposition system in 1994,

  integrated with the invalidation trial in 2004

- No recourse to a compulsory licensing in order to resolve the blocking relationship, unless it is for the purpose of correcting an anticompetitive conduct or for the public or non-commercial use

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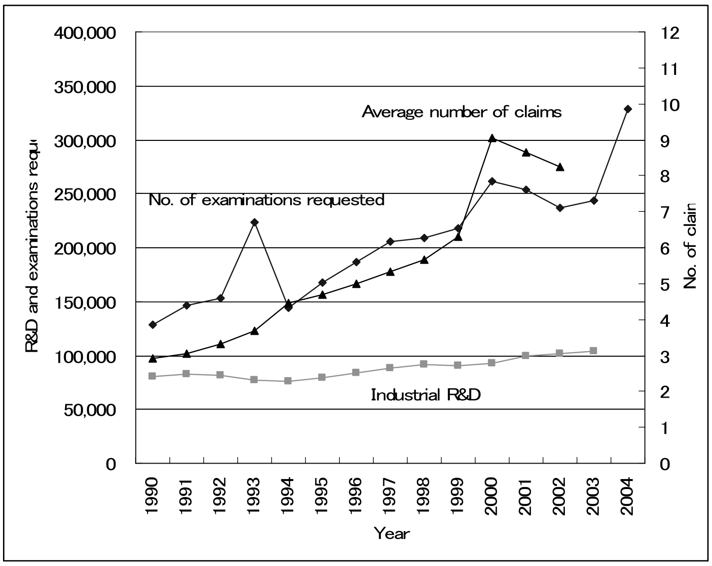
3 Efficient patent examinations

- In Japan, industrial R&D increased in real terms by 30% from 1990 to 2003, while the number of patent examinations requested and the number of claims per patent application almost tripled from 1990 to 2004.

  see Figure 1
- They reflect both stronger patent protection including the introduction of multiple claims and emergence of new technological opportunities.
- The sharp increase of the number of patent examinations requested in 2004 was due to the patent law amendment in 1999, which forced a firm to decide whether it will seek a patent examination or not within 3 years

Figure 1. Increasing patent examinations requests and increasing number of claims per patent



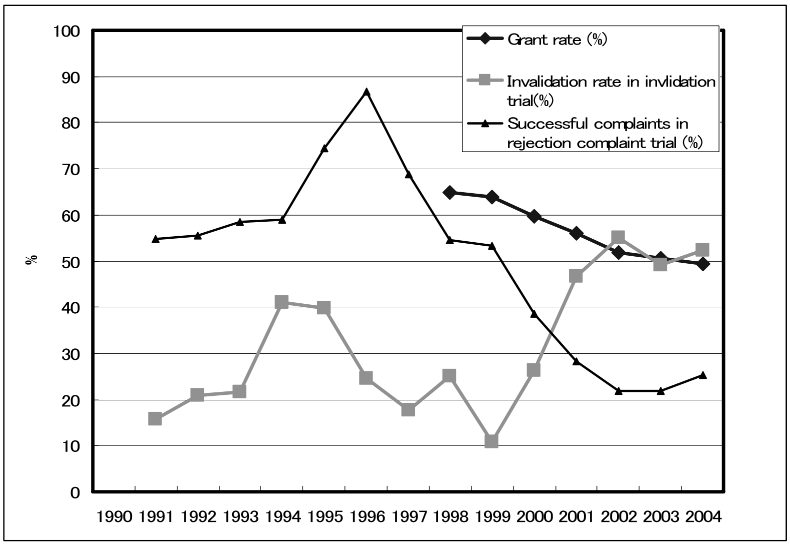
Data source. The numbers of examinations requested are from the annual reports of JPO. The average numbers of claims per patent applications are from the IIP patent database. Industrial R&D are from the Science and Technology White Paper (real industrial R&D expenditure in 1995 price, million$ (1$=118yen).

- The increasing complexity of a patent and increasing requests for patent examinations are putting strong pressure on the scarce examination capacities of the JPO.
- The waiting period for examination increased from 19months at the end of 1998 to 26 months at the end of 2004.
- Fast truck examinations are available for those who will implement patents in the near future.

Patent quality

- Application of stricter inventive step standard in recent years
- The grant rate of a patent declined to around 50%, compared to more than 60% one decade ago. (See Figure 2)
- Only 8% grant rate for business method related software
- The increase of invalidation rate in invalidation trial and the decrease of successful complaints in rejection complaint trial.

Figure 2. Application of stricter inventive step standard



Grant rate=the ratio of the granted patent applications relative to the sum of granted and rejected patents, including abandoned patents. Made from the annual reports of the JPO.

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Searching for the system of efficient examinations

- Lemely (2001) for the hybrid system similar to that of the Japanese system vs.

  Jaffe and Lerner (2004) for the presumption of validity assisted by stronger re-examination system
- The experience of the utility model of Japan since 1994 suggests that the hybrid system postponing the examination of an invention at the enforcement stage may not work

  (see Figure 3)

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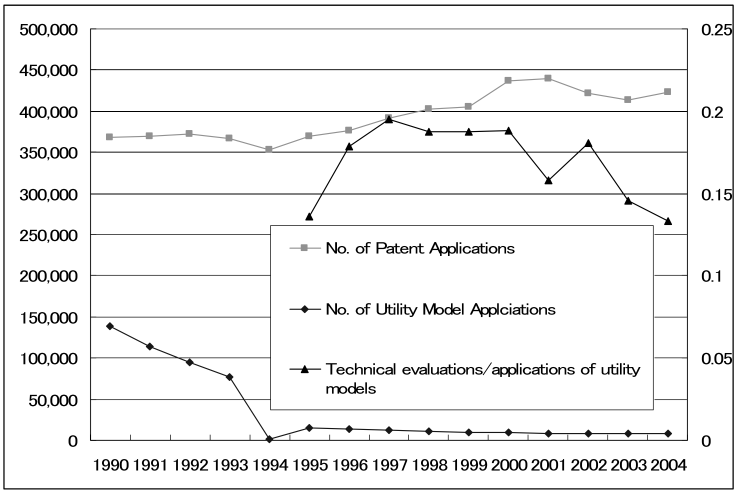
Figure 3. Applications for patents and utility models, and the intensity of the use of technical evaluations

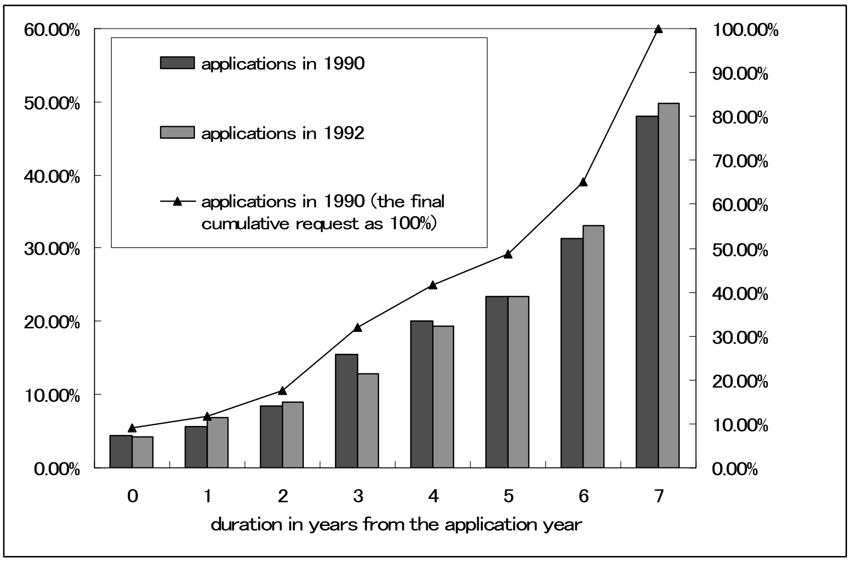


the intensity of the use of technical evaluations=No. of technical evaluations by The JPO / the No. of applications of utility models in each year
Made from the annual reports of the JPO

- On the other hand, inventors do not want immediate examinations, since lots of uncertainties exist with respect to the commercial applicability of an invention and a long time is necessary for its resolution
  (see Figure 4)
  → Forfeiting the option to postpone the requests of examinations as in the USA would probably not make sense

- The participation of a third party in post-grant opposition system tends to improve patent examination quality significantly.

Figure 4. The timing of the examination requests from the year of patent application



Source: Prepared from the annual reports of the JPO

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In addition,

- International collaboration among US, Japanese and European Patent Offices for mutual recognition of search results and examination results would significantly leveraging the examination resources globally .

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4. Efficient utilization of disclosed information

- All patent applications are laid open in 18 months in the Japanese patent system. In addition, the first to file is the priority rule.
- Japanese firms regard patent as the most important source of information on rivals' R&D (Cohen, Goto, Nagata, Nelson and Walsh (2002))
- The patent examiners in Japan often cite only non-granted patents as the basis of rejection on novelty and/or inventive step grounds. → the availability of such information would significantly help firms to avoid duplicative R&D efforts

  (see Table 1)

Table 1 Unexamined or non-granted prior patent applications used for rejecting patent applications

IPC sections		No. of cited patents	Unexamined	Nongranted
A	HUMAN NECESSITIES	27,981	26.1%	49.3%
B	PERFORMING OPERATIONS; TRANSPORTING	87,715	28.2%	51.9%
C	CHEMISTRY; METALLURGY	62,307	27.3%	45.4%
D	TEXTILES; PAPER	11,704	27.6%	48.1%
E	FIXED CONSTRUCTIONS	10,684	23.5%	45.9%
F	MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; BLASTING	32,845	29.9%	52.8%
G	PHYSICS	143,020	32.1%	60.7%
H	ELECTRICITY	115,305	33.2%	61.4%
	Total	491,561	30.3%	55.6%
	For ultimately granted patents total	582,737	27.8%	49.3%

Source: nagaoka(2005)

- A rejection based on novelty and/or inventive step ground are often based on relatively old patent documents .

  (see Table 2)
- This is the case in spite of the fact that a firm with higher R&D speed is more successful not only in getting a patent but also in obtaining a patent with broader scope.

  (see Figure 5)
- The patent database of the patent office is an important knowledge infrastructure for invention and innovation. There may be room for improving the functioning of the database.

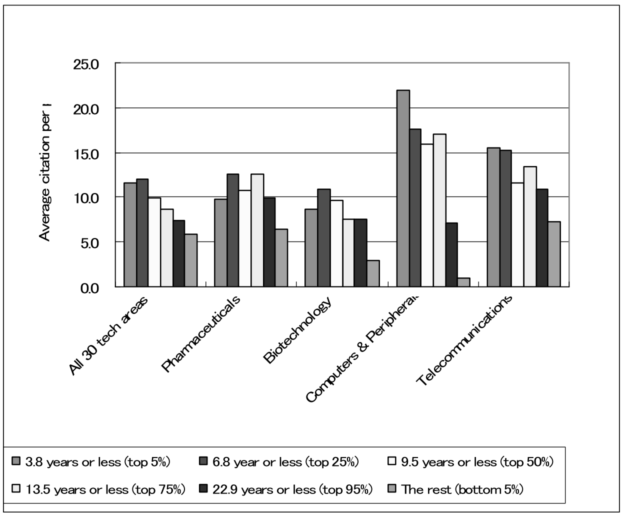
Table 2 Age of prior patent applications cited for ultimate rejections of patent applications based on novelty/inventive step(1985-1993)

		Age of cited patent applications as ultimate rejections			
IPC section		median	75%	90%	median for initial rejection for granted patent applications
A	HUMAN NECESSITIES	5.3	7	12	5.1
B	PERFORMING OPERATIONS; TRANSPORTING	5.4	7	12	5.1
C	CHEMISTRY; METALLURGY	5.0	6	11	5.0
D	TEXTILES; PAPER	5.7	8	13	5.6
E	FIXED CONSTRUCTIONS	6.2	9	13	5.9
F	MECHANICAL ENGINEERING; LIGHTING; HEATING; WEAPONS; BLASTING	5.5	7	12	5.2
G	PHYSICS	4.1	5	8	4.1
H	ELECTRICITY	4.5	6	9	4.4
	Total	4.8	6	10	4.8

Note Age is measured by the most recent prior art cited by an examiner for

Source: nagaoka (2005)

Figure 5. Citation lag and forward citation frequency
(based on the US patent grants between 1988 to 1992)



Source: made from the Chi database

5. **Ameliorating the patent thicket problem**

- The proliferation of patents and the other intellectual property rights can deter rather promote innovation.
- Patent thicket problem: high transaction costs, holdup risk, inefficiency of the chains of vertical monopolies and the difficulty of coalition formation
- Erosion of the profit of a pioneer firm

The problem looks to be most acute in IT related standard areas

- Standards can have many essential patents
- It is often possible for a firm to apply for new patents by using continuations and divisions especially in the USA even after the standard specification is set.
- The disclosure policy is weak and no precise definitions of what RAND (reasonable and non-discriminatory licensing) means for each firm are provided by standard bodies.
- Non-granted patent applications may not be published in the USA

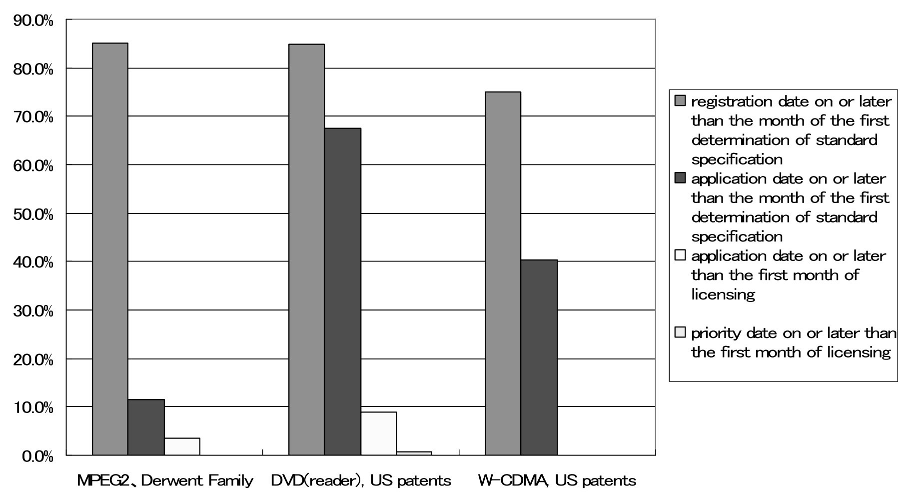
Table 3 Recent Standard-specifying Patent Pools

Standard	Pool Admin., Year	Members of the pool licensors	Essential patents	Non-members	Licensees
MPEG 2 (standard specifiation in December 1994)	MPEG LA, 1997	Originally (July 1997) 7 firms, 1 university; 22 firms, 1 univ. as of April 2004	Originally 125 patents (34 families); currently(July 2004) 644 patents (127 families)	Lucent , IBM	800 (November 2004)
DVD (standard specifiation in December 1995)	6C,Toshiba, 1998	Toshiba, Matsushita, Mitsubishi Electric, Time Warner, Hitachi, Victor Company of Japan, IBM	180 US patents for player, and 166 US patents for recorders	Thomson	245 firms for hardware (decoders and encoders) 157 firms for discs
	3C, Philips, 1998	Philips, Sony, Pioneer	131 US patents for DVD players, 106 US patents for recorders		179 firms for hardware (decoders and encoders) 216 firms for discs
3G	3G Patent Platform, 2003	7 firms for W-CDMA	in the process of certification (All the essential patents of the member firms)	Many, including Qualcomm, Motorola, Ericsson, and Nokia	

Source: based on http://www.3gpatents.com; http://www.mpegla.com; DOJ Review Letter from Joel Klein to Carey R. Ramos, June 10, 1999; DOJ Review Letter from Joel Klein to Gerrard R. Beeney, December 16, 1998.

From Nagaoka(2005)

Figure 6 Proportion of the essential patents applied or registered on or later than the month of standard determination or the initiation of licensing



Note. There are no essential patents with the priority date on or later than the first month of licensing.
The collective licensing of the W-CDMA was not yet initiated as of the date of developing this table.

Source: Nagaoka(2005)

Conclusions (Patent system for innovation)

- Stricter inventive step standard
- Facilitation of the third-party to provide information
- Providing the menus for self-selection by inventors
- International collaboration of examinations
- Facilitation of the utilization of disclosed information for R&D and patenting decision
- Tighter rule on continuations and divisions
- Strengthening the patent policy of standard bodies, including the clarification of RAND conditions
- Exemption for research on subject matter

Interaction between Intellectual Property and Innovation Systems

Mark B. Myers

mbmyers@kennett.net

The U.S. Intellectual Property System

- Held in High Respect Within and Outside the U.S.
- IP Rights Being Aggressively Extended, Asserted & Enforced
- Coincides With a Period of Economic High Productivity
- How Well Does It Support Invention?

Concerns and Criticisms

- Concern for patent quality
- Difficulty negotiating patent thickets especially in cumulative technologies
- Increase in defensive patenting
- Rising transaction costs
- Incursions on public domain of ideas
- Impediments to research

1.11.2006 M.B. Myers

Contrasting Different Forms of IP

	Copyrights	**Patents**	**Trade secrets** -
Can you go there? -	YES – except for software's hidden "source code"	YES – upon publication	NO
Can you stay there?	NO – except for "fair use" of short quotes	NO – not without licensing	NO
Can you do it yourself?	YES – express the ideas differently	NO – the basic ideas are protected	YES – come up with the ideas on your own

1.11.2006 M.B. Myers Ref S. Winter, Wharton, U Penn

Economics of the Patent System

Effects on:	Benefits	Costs
Innovation	◻ Creates an incentive for research and new product/process development. ◻ Encourages the disclosure of inventions.	◻ Impedes the combination of new ideas and inventions. ◻ Raises transaction costs for follow-on inventions. ◻ Provides an opportunity for rent seeking.
Competition	◻ Encourages the entry of new (small) firms with a limited asset base or in early stages of financing.	◻ Creates short-term monopolies that may become long-term network industries. ◻ May be used to maintain a cartel.

1.11.2006 M.B. Myers Ref. B. Hall UC Berkeley

Incentives and Rewards for Invention

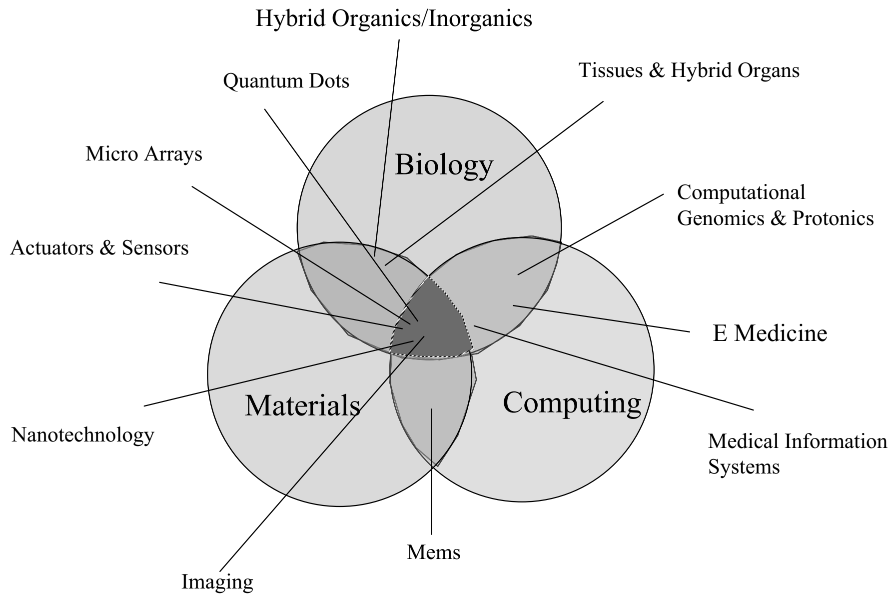
- **The Inventor:**
  - **Solving Important Technology in Use Problems**
  - **Professional Reputation, Recognition and Advancement**
  - **Altruism**
  - **Financial Gain**
  - **Intellectual "Currency Within Organization**
- **Patents Are a Secondary Incentive for Invention**
  - **Increased Innovation → Increases in Patents**
  - **Importance Highly Sector Dependent**
  - **Only 10% are Important and 1% Are Seminal**

1.11.2006 M.B. Myers

Incentives and Rewards for Patents

- *However for the Inventor/entrepreneur Patents Support*:
  - **Opportunity to Start Companies**
  - **Early Stage Funding**
- *A Form of Insurance*
  - **10% of US Patent Applications Challenged**
  - **2 % of Patents Litigated**
  - **Threat can be extremely high for small firm**
- *A New Form of Currency for Exchange*
  - **Patents can provide access to needed technology**
- *A Qualified Option for Future Investment*

Hot Spots of Confluence



Continuing Issues

1. U.S. Patent Reform Act 2005
2. Biotechnology Patent Boundaries
3. Harmonization
4. Developing Nations
5. Science Exemption
6. Proprietary v.s Open Source Software
7. Free Use of IP?

1.11.2006 M.B. Myers

パネル **V**：産学連携

Panel V: Industry and University Collaboration

モデレーター：渡部 俊也，東京大学先端科学技術研究センター教授

米国における **R&D** 産学連携

Industry-University R&D Partnerships in the United States

アーウィン・フェラー Irwin Feller，米国科学振興協会上席客員サイエンティスト／ペンシルバニア州立大学名誉教授

日本における産学連携

Industry-University Partnerships in Japan

近藤 正幸，科学技術政策研究所客員総括主任研究官／横浜国立大学大学院教授

ディスカッサント

ゲイル・カッセル Gail Cassell，イーライリリー 科学担当副社長

ジェームズ・ターナー James Turner，合衆国下院科学委員会民主党チーフスタッフ

Industry-University R&D Partnerships in the United States

Irwin Feller, Senior Visiting Scientist,
American Association for the Advancement of Science

"21st Century Innovation Systems for Japan and the United States: Lesson from a Decade of Change"

Tokyo, Japan

January 11, 2006

Outline

- Framework: Levels of Relationships
- Learning as an Evolutionary Process
- Typology of Issues
- Recent Changes: Firms & Universities
- Principles for Collaborative R&D Partnerships
- Excluded Third Party Considerations

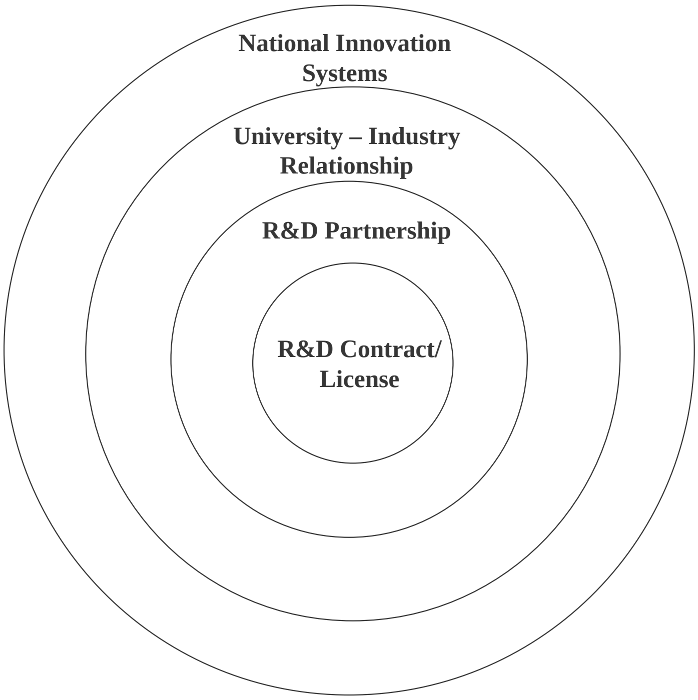
Learning

- Parties have realized benefits and adjusted expectations to experiences
- New issues have surfaced
- Parties seeking to formulate revised principles to guide future collaborative relationships
- Principles are not practices

Framework

- R&D Exchanges
- R&D Partnerships
- Industry-University Relationships

Levels of Relationship



United States National Innovation System Characteristics

- Industry primary performer of r&d
- Universities primary performer of basic research
- Federal government primary source of funds for basic research (and thus of academic r&d)

Magnitude of Financial Ties: I (FY2002)

- Universities perform 13% ($36B) of total U.S. r&d and 54% of basic research
- Industry share of academic r&d: 7%
- Academic r&d is 1.3% of industry r&d of industry's estimated self-funded r&d ($177 B)
- Federal share of academic r&d: 59%

Magnitude of Financial Ties: II

- Industry philanthropy to universities and college-- $1.5B (cash and in-kind) (2003)
- University licensing revenue-$1.1B (2004)

Expectations and Accomplishments
(Findings from Engineering Research Centers)

- What do Firms Expect/Receive from Partnerships?
  - “Knowledge Generation and Transfer”
  - Access to new ideas
  - Opportunity to keep abreast of university-based research in a field
  - Access to specific faculty
  - Access to students as prospective hires
  - Leverage Federal investments in basic research

- What do Universities Expect/Receive from Partnerships?
  - Funds to support faculty research/facilities
  - Funds to support graduate students
  - Internship/placement opportunities for students
  - Access to proprietary data/specialized equipment
  - Participation in state government economic development programs

UC-Berkeley/Google, Microsoft, Sun Collaboration, 2005

- 3 Firms each to provide $500,000 annually for 5 years to support new laboratory in computer design
- Support 6 faculty and 30 graduate students
- Pre-competitive generic research
- Nonproprietary, freely licensed licensed research
- Decline in DARPA support for academic computer science

Typology of Issues

Size of Firm	Industry Funded R&D	Federal/Other Funded R&D
Large	• Ownership of Intellectual Property • Royalty-free licenses • Exclusive licenses	• Upfront payments • Royalty rates • Sublicenses • Patent filing costs
Small	• Ownership of Intellectual Property	• Equity • Royalty rates • Spin-offs

Supporting Actions: Universities

- One-stop shopping: integration of Sponsored Research and Technology Transfer Offices
- Acceptance of publication delays (and deletion of proprietary material)
- Master agreements (with templates on disposition of intellectual property rights and provisions for mediation and arbitration)
- Risk management approach to intellectual property

Surge in University Patent/Licensing Activities

Increases in:

- Number and size of technology transfer offices;
- Number of invention disclosures;
- Patent applications;
- Patents;
- Licenses;
- Start-up firms

Contention about Licenses

Shared recognition that most university inventions/patents are "embryonic technologies" leads to different positions on apportionment of costs and benefits of next steps

Industry Perspectives

- Universities making excessive claims for IP ownership on industry sponsored research agreements
- Excessive claims for upfront payments, inconsistent with technical and economic uncertainties of academic inventions
- Alternative suppliers of basic research are available elsewhere

University Perspective

Upfront fees/milestone payments are needed "incentives" to lead firms to make necessary additional investments to get the university technology to market.

Changes in Universities Perspectives and Practices

- Increased acceptance of equity in lieu of royalties and fees
- Investments in "downstream" development of "embryonic technologies"
- Risk management strategies, consistent with low probabilities of industry funded r&d yielding economically significant inventions/patents

University-Industry Partnership, "Guiding Principles for University-Industry Endeavors" (IRI-NCRUA)

#1 A successful university-industry collaboration should support the mission of each partner. Any effort in conflict with the mission of either party will ultimately fail

#2 Institutional practices and national resources should focus on fostering appropriate long term relationships between universities and industry

#3 Universities and industry should focus on the benefit to each party that will result from collaborations by streamlining negotiations to ensure timely conduct of the research and the development of the research findings

Excluded Third Party Benefits

- Public interest science—diminished role of universities as independent, neutral sources of scientific and technical expertise
- Conflicts of individual and institutional interests
- Development of an “anti-commons” that impedes the flow of knowledge, and thus the rate of scientific discovery and technological innovation

University-Industry Partnerships in Japan

Presented at
Symposium on "21st Century Innovation System for Japan and the United States"
Tokyo, January 10-11, 2006

Prof. Masayuki KONDO
Yokohama National University/
National Institute of Science and Technology Policy (NISTEP)

M.Kondo 1

Outline of Presentation

- University-Industry Partnerships in a National Innovation System
- University-Industry Partnerships
  - Historical Development in Japan
    - The First Engineering Department of a University in the World
      -- Department of Engineering, Tokyo University --
    - A Research Institute that Lead a Large Industrial Group
      -- RIKEN (Institute of Physical and Chemical Research) --
  - Recent Movements in Japan
    - Joint Research
    - Technology Licensing
    - Academic Spin-offs -- From "Collaboration" to "Cross-over" --
- Concluding Remarks

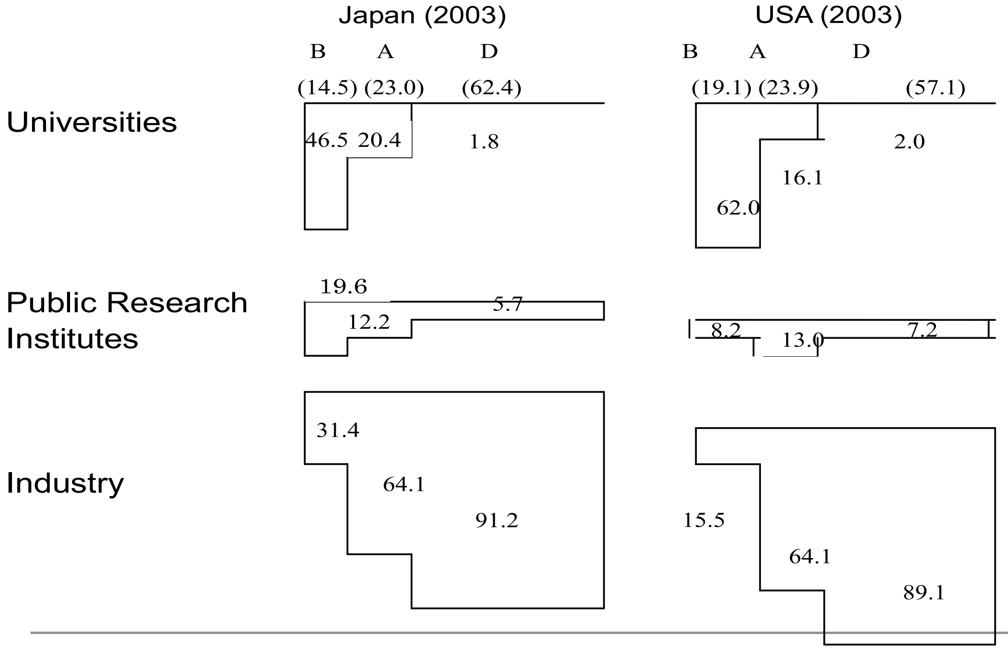
M.Kondo 2

University-Industry Partnerships in a National Innovation System

M.Kondo 3

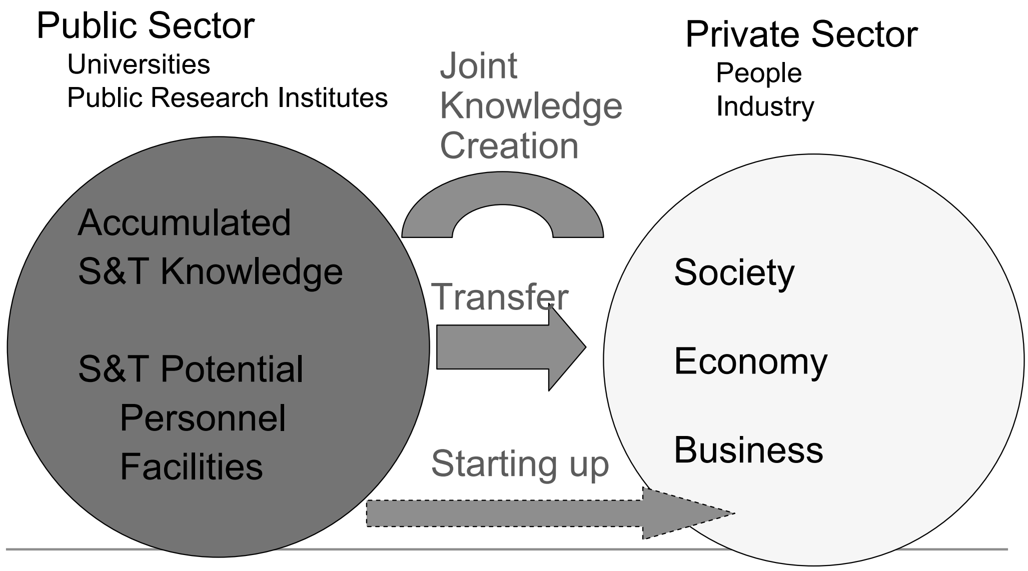
Role Charts

(unit: %)

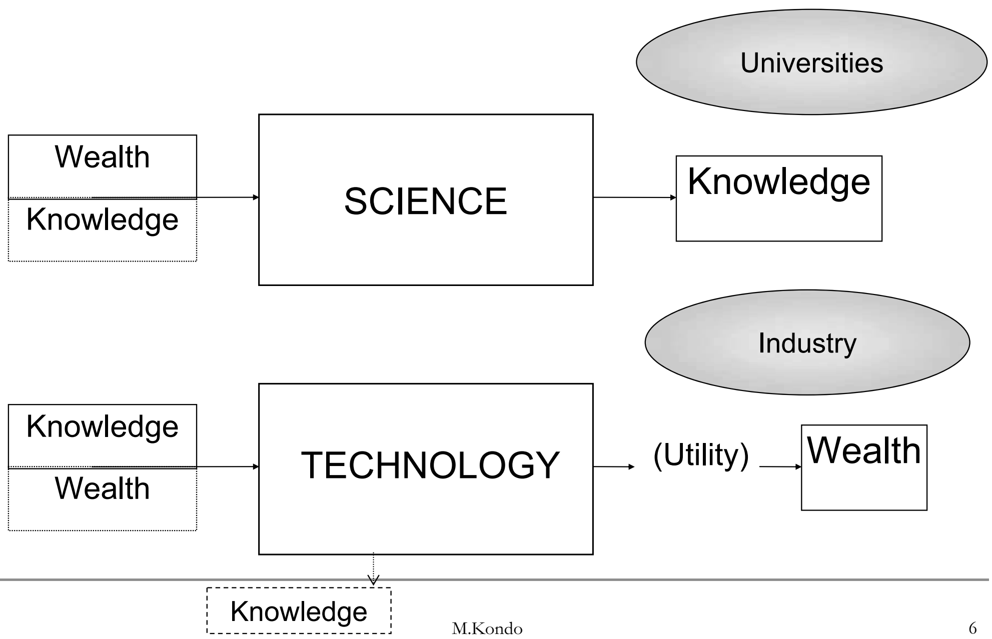


M.Kondo 4

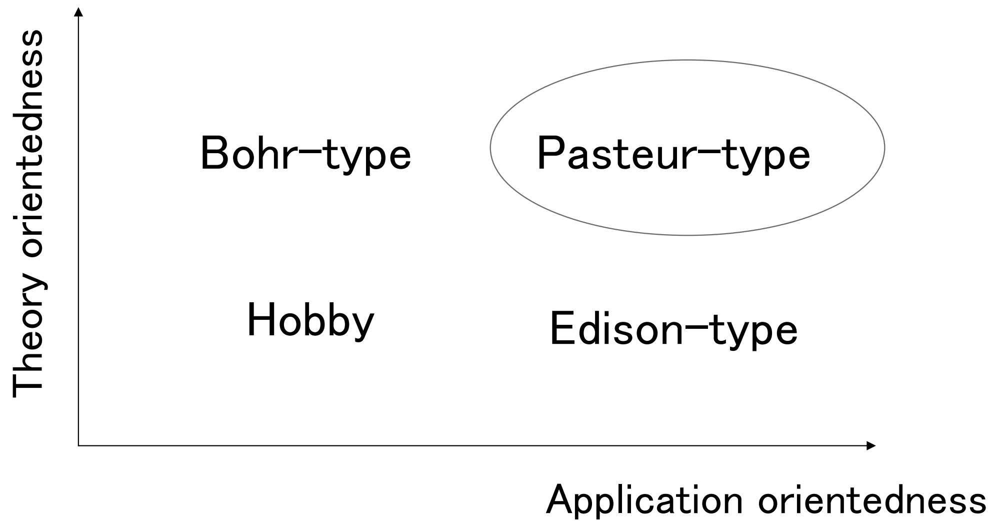
Question:
How can we utilize S&T for society, economy and business in a national innovation system?



Science vs. Technology



Science-Based Technology



Note. The author modified the diagram of Stokes (1997).

M.Kondo 7

University-Industry Partnerships
Historical Development in Japan

M.Kondo 8

The First Engineering Department of a University in the World

- Imperial College of Engineering was established under Ministry of Engineering in 1873.
- This became College of Engineering of Imperial University (Current Tokyo University) in 1886.

Education at Imperial College of Engineering

- Dr. Henry Dyer from Scotland was the President from 1873-1882.
- Combination of Theories and Practices
  - School 2 years
  - College 2 years
  - Practice 2 years
- Graduates worked in the industry.
- Japanese universities were application-oriented in the beginning.

A Research Institute that Lead a Large Industrial Group - RIKEN (Institute of Physical and Chemical Research) -

- Academic Achievement
  - 2 Nobel Prize Laureates:
  - Dr. Yukawa and Dr. Tomonaga
  - (Dr. Fukui was also related.)
  - 1,686 papers in Japanese and 1,072 papers in foreign languages from 1922 to 1941

- Industrial Achievement
  - RIKEN registered 0.7 percent of all patents (848 patents) registered in Japan during the period from 1918 to 1944.
  - The RIKEN Industrial Group consisted of 63 companies at its peak. One of them is the root of Ricoh.

M.Kondo 11

Establishment of RIKEN

- Dr. Jokichi TAKAMINE, a scientist and millionaire living in the United States, pointed out the need for a National Science Research Institute in 1913.

- Prime Minister Shigenobu OKUMA convened the Council to Promote Establishment of RIKEN in 1916.

- It was established as a nonprofit foundation in 1917 and was abolished in 1948.

- Some principal researchers were joint appointment of university professors.

M.Kondo 12

Revenue of RIKEN

Revenue of RIKEN

year	1927		1939		1940	
	thousand yen	%	thousand yen	%	thousand yen	%
R&D	13	2.0	264	7.1	137	3.8
patent royalty	0	0.0	1793	48.4	2182	60.4
production work	206	31.2	53	1.4	44	1.2
stock operation	37	5.6	740	20.0	6	0.2
rent	6	0.9	1	0.0	1	0.0
interests and dividends	143	21.7	793	21.4	876	24.3
subsidies	250	37.9	0	0.0	0	0.0
miscellaneous	4	0.6	61	1.6	367	10.2
total	660	100.0	3705	100.0	3611	100.0

Source: The author tabulated using the data from Saito, Ken, Research on a new concern RIKEN Industrial Group (in Japanese), Jichosha, January 1987.

Unique Management Concepts of RIKEN Industrial Group

- Science Capital Industry (Scientific knowledge is the key.),
- Intellectual Management (eg. mechanical engineering for chemical plants),
- Combinatory Management (the use of byproducts for other processes in the same premise) and
- Rural Industrialization with Single-Function Machines

University-Industry Partnerships
Recent Movements in Japan

M.Kondo 15

Forms of University-Industry Partnership

- Joint Knowledge Creation
  - Joint research
  - Contract research
  - (Donation)
  - Comprehensive collaboration agreement
- Knowledge Transfer
  - Journal papers and books
  - Conference presentations
  - Via students
    - Graduating students
    - Internship in companies
    - Students sent by companies
  - Consultancy
  - Licensing
- Knowledge-based Starting Up
  - Academic spin-offs

Notes. 1. This classification is based on M. Kondo, Policy Innovation in Science and Technology in Japan –from S&T Policy to Innovation Policy– (in Japanese), *J of Science Policy and Research Management*, Vol.19, No.3/4, pp.132-140, 2004.
2. Facility and equipment usage is another form of partnership.

M.Kondo 16

Policies to Promote University-Industry Partnerships in Japan

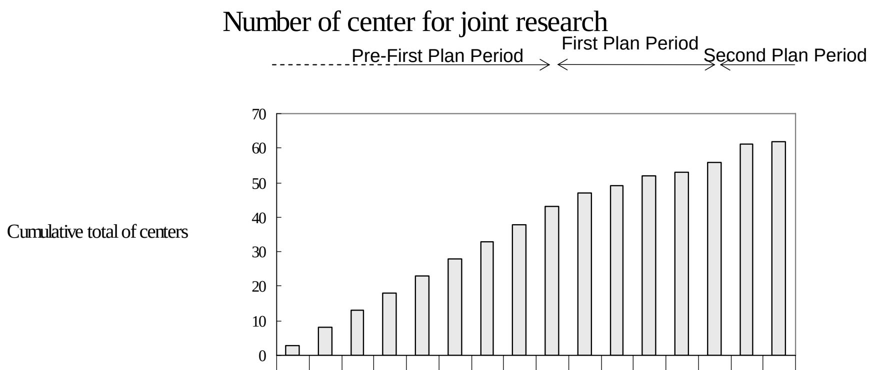
Joint Knowledge Creation
- Joint Research Centers
- Research Grants for University-Industry Collaborative Research

Knowledge Transfer
- Technology Licensing Organizations (TLOs)
- University IPR Management Centers

Knowledge-based Starting Up
- Venturing Business Laboratories (VBLs)
- Incubation Centers
- Relaxation of the regulation on side jobs

Overall
- Changing National Universities into National University Agencies

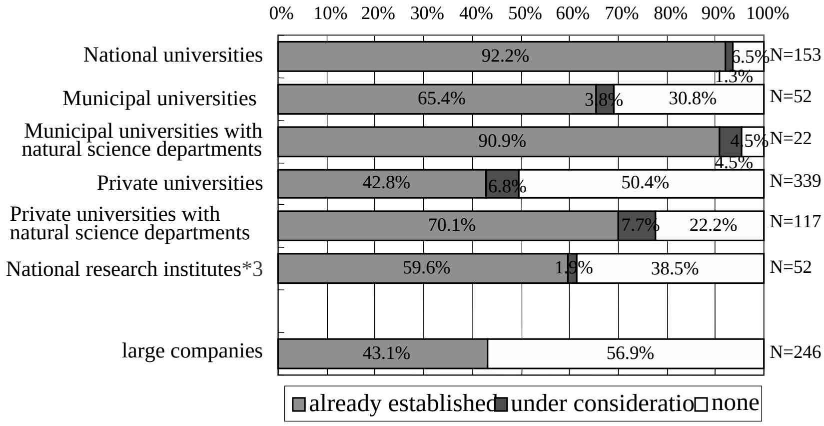
Joint Research Centers at National University



	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
□ Cumulative total of centers	3	8	13	18	23	28	33	38	43	47	49	52	53	56	61	62
(Number established annually)	3	5	5	5	5	5	5	5	5	4	2	3	1	3	5	1

Source: MEXT Website

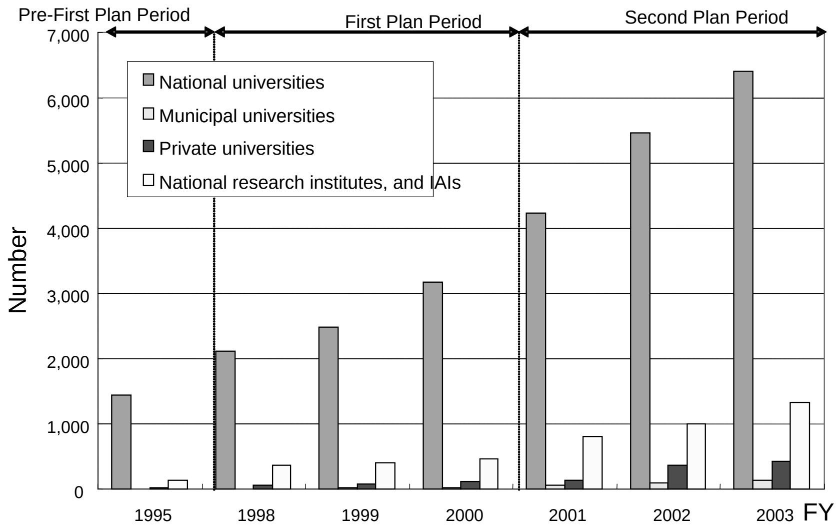
Offices for University-Industry Cooperation



Data: Based on the responses to "Questionnaire Survey on Achievements of S&T Basic Plan (survey on policies related to industry-academia-government cooperation and regional innovation)," (distributed in June 2004)

Source: NISTEP

University – Industry Joint Research



Data: The data for national universities is calculated, using the source from MEXT HP and its "University-Industry Research Cooperation: A Status Report, 1983-2001," March 2003. Others are based on the result from the questionnaires made by NISTEP and Mitsubishi Research Institute, Inc. (distributed in 2004).

Source: NISTEP

Trends of Joint Research at Yokohama National University - Deepening and Diversification -

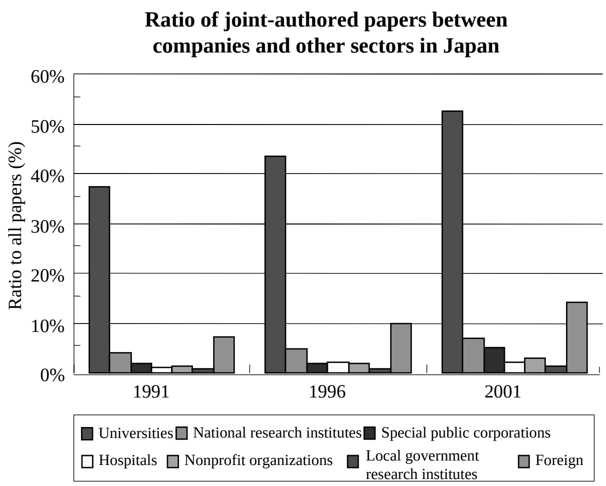
- Deepening
  - Number of joint research projects per company increased.
  - Joint research projects with large budget increased.
  - Joint research in the same prefecture increased in terms of number and total budget.

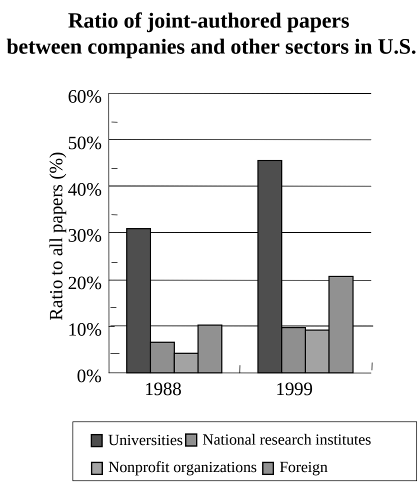
- Diversification
  - The budget difference between the largest and the smallest became wider.
  - Joint research projects with new companies including MNCs increased.
  - The ratio of university researchers conducting joint research with companies over all university researchers increased.

Source: K. Sakamoto and M. Kondo, The Analysis of University-Industry Research Collaborations by Time Series and Corporate Characteristics (in Japanese), Development Engineering, Vol.10, 11-26, 2004.

M.Kondo 21

Coauthorship between Company Researchers and University Researchers



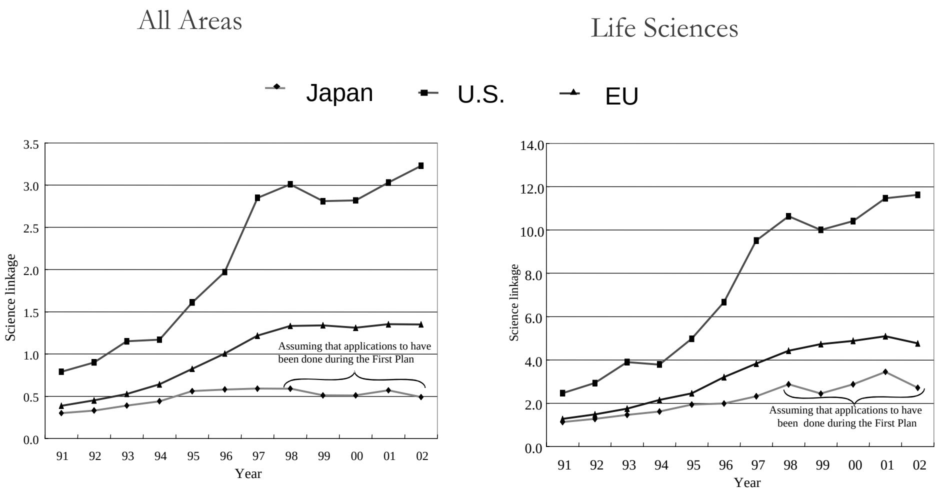


Source: (Japan)Prepared by NISTEP using the CD-ROM version of SCI
(U.S.)NSF, "Science & Engineering Indicators: 2002"

Source: NISREP REPORT No.74 (2004)

M.Kondo 22

Science Linkage in U.S. Patents



*: "Science linkage" is the number of cited scientific papers in the U.S. patent examination reports per registered patent. It indicates a frequency of the use of scientific knowledge among patents.

Data: CHI Research Inc. "International Technology Indicators 1980-2002"

Source: NISTEP

M.Kondo 23

University Licensing (Japan-US Comparison)

	Japan	US	Ratios
R&D	3.3 trillion yen (in 2002)	5.4 trillion yen (in 2002)	1.6
Patent Application	1,680 (in 2003)	6,509 (in 2002)	3.9
Licensing Contracts	531 (in 2003)	3,739 (in 2002)	7.0
License Income	0.55 billion yen (in 2003)	145 billion yen (in 2002)	264
cf. Academic Spin-Offs	179 (in 2003)	364 (in 2002)	2.0

Source: NISTEP

M.Kondo 24

Academic Spin-Offs

Stage-by-Stage Penetration

An Enterprise to Overseas Market

Exports → Licensing → FDI

A Professor (or a Researcher) to Market/Society

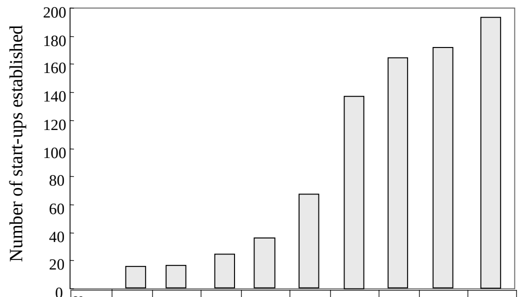
Consulting
Students
Joint Research → Licensing → Start-up

Source: M. Kondo, Policy Innovation in Science and Technology in Japan –from S&T Policy to Innovation Policy-- (in Japanese), *J of Science Policy and Research Management*, Vol.19, No.3/4, pp.132-140, 2004.

Academic Spin-Offs in Japan

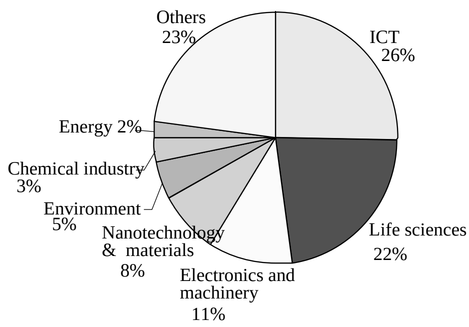
Academic Spin-Offs

*Accumulated total is 916 as of August of 2004.



	Up to 1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Number of start-ups annually established	38	14	15	22	33	62	127	152	159	179

Academic Spin-Offs by Areas

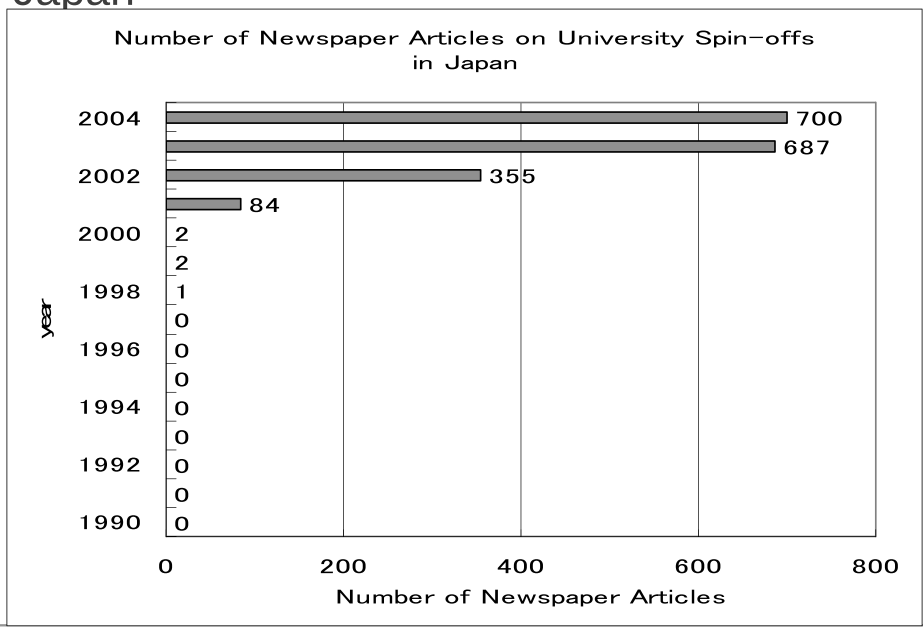


*: Breakdown of 916 companies as of August 2004.

Data: Calculated by NISTEP based on “University-Spin-Off Survey FY2004” by Tsukuba University and Yokohama National University.

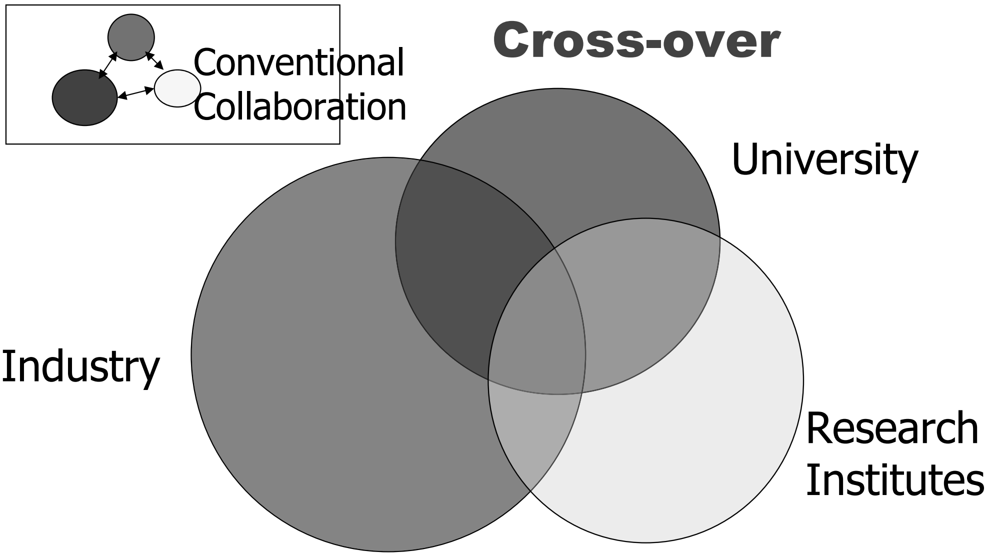
Source: NISTEP

Newspaper Articles on “University Spin-offs” in Japan



Note. The number of articles in four newspapers published by NIKKEI.

Cross-over among Industry, Universities and Public Research Institutes



Source: M. Kondo, University spin-offs in Japan, Asia Pacific Tech Monitor, March-April 2004, pp.37-43, Asian and Pacific Centre for Transfer of Technology, ESCAP, UN.

M.Kondo 29

Profiles of Academic Spin-off Founders

Table: Profiles of Founders

Founders	Ratios (%)
Faculty	69.7
of which professors	44.2
Students	22.9
of which doctor course students	11.2
of which master course students	7.5
of which undergraduate students	3.0
Researchers/technicians	7.5
Total	100.0

Source: FY2004 Survey.

M.Kondo 30

Future Business of Academic Spin-offs

Future Business

Intended Future Business	Ratios (%)
Licensing out	25.7
Product sales using OEM	22.4
Product manufacturing and sales	16.1
Contract research and design	14.6
Sales of developed patents	11.5
Others	9.6

Source: Year 2004 Survey.

M.Kondo 31

Concluding Remarks

M.Kondo 32

Some Reservations

- A university needs to keep its identity.
- Rules to avoid conflicts of interests need to be established.
- Practices to handle research tool patents in academic research need to be established.

M.Kondo 33

The Roles of University-Industry Partnerships in Japan

At the national level

- Narrowing the gap between high S&T potential and low industrial performance to strengthen industrial competitiveness
- Creating internationally competitive universities

At the regional level

- Creating regional innovation systems
  - University-industry collaborative R&D and university spin-offs are promoted in regional innovation policies.
    - Knowledge Cluster Initiative
    - Industrial Cluster Program

M.Kondo 34

21st Century Innovation Systems for the US and Japan

Jim Turner

Chief Democratic Counsel

House Committee on Science

Overview

- Professors Feller and Kondo gave very broad and rich talks
- Good pairing
- Between them they covered the history and breadth of university/industry relations
- Would love to hear their views on the other's talk and to see future Feller/Kondo collaboration

Issues from Kondo Presentation

- Many parallels between US and Japanese institutions mentioned by Prof. Kondo
  - University of Tokyo School of Engineering/Land Grant Universities in the US
  - Riken(Rikoh)/Radio Corporation of America (RCA)
  - National University Agencies/Charter Universities in US
  - Joint Research Centers at Universities/ Industry presence at major US universities
  - The diversity of industries served at Yokohama National University and Penn State University

University Licensing: Japan-US Comparison

- Japan's experience mirrors the US experience over Bayh-Dole's first 20 years
- In U.S., growth in R&D preceded large expansion in University patent applications came
- Licensing income increase came after growth in licensing contracts
- Large spin-offs from academia took longest to develop and were preceded by deepening of university-industry mutual understanding

Bayh-Dole Results

- Change took time.
- Increase in patents granted to universities (1982—375; 1990—1184; 1998—3151; 2003—3450: New patents filed—7203).
- University royalties from licensing (1991--$130 million; 1999--$675 million; 2003—$1.033 billion).
- Startup companies formed with university patents (1994—175; 1999—275; 2002—370; 2003—348).

Issues from Feller Presentation

- Agree that 25 years is proper period of review since in 1980 both Bayh-Dole and Stevenson Wydler Innovation Act passed
- Agree with content of Feller speech
- Relationships and framework of university-industry cooperation are still evolving
- Large number of second-tier universities now trying to participate
- International firms' participation increasing

Industry Perspective

- Feller talk was written from university point of view
- If done from industry point of view, National Cooperative Research Act as much a change agent as Bayh-Dole
  - This anti-trust reform preceded joint research in industry, formation of high technology small businesses, and subsequent decline of large corporate labs

Industry-University Conflict

- Conflict currently a problem but probably short-term because market forces are at work. Great competition among universities for relations with top companies.
- Universities who are rigid in patent matters can lose not only relations with companies but also labs, professors or students to competitors.
- Model ground rules for collaborations will evolve quickly and become norms for efficient markets.
- National Academies involved in related software development.

Small vs. Large Companies

- It is important to realize that successful university dealings with small companies very different from dealings with multinationals
- Many university innovations too small for established companies
- Nurturing an entrepreneur is closely related to traditional university role as nurturer of students
- Universities becoming major force in local economic development and politics

Large Companies

- Internet and IT advances are dramatically shortening product cycle times and revolutionizing the way businesses deal with those outside the company
- Universities currently not structured to move beyond the 1.7 percent of industrial research they now perform.
- Working with large firms will increasingly require major shifts in university culture
- Large firms will need just-in-time suppliers of research ideas, who understand modern business practices.
- Eventually, universities will be involved in virtual companies and company supply chain networks
- Government agencies dealing with industry face analogous challenges

Preservation of University Culture

- Quality of research universities is highly dependent on federal funding. Increased university funding by industry will come, but will take time.
- Concerns of Professors Feller and Kondo about potential adverse effects on university culture are very real.
- Universities have a lot to gain from best industry practices such as Six Sigma.
- In my opinion, the good from closer university-industry cooperation will greatly outweigh the bad.

パネル **VI**：大学における研究への政府の支援

Panel VI: Government Support for University Research

モデレーター : 永野 博, 独立行政法人科学技術振興機構（JST）研究開発戦略センター, 上席フェロー

DARPA と米国におけるイノベーションの連結科学モデル－現在の状況

DARPA and the US Connected Science Model for Innovation – Where Is It Now?

ウィリアム・ボンヴィリアン William Bonvillian，ジョセフ・リーバーマン合衆国上院議員オフィス 立法ディレクター，チーフスタッフ

大学における研究への政府の支援－日本における動向と課題

Government Support to University Research – Trend and Issues in Japan

下田 隆二，東京工業大学統合研究院教授

ディスカッサント

ウィリアム・スペンサー William Spencer，全米アカデミー 科学技術経済政策委員会／SEMATECH 元会長

William B. Bonvillian
Conference on 21st Century Innovation Systems for Japan and the U.S. - Tokyo
January 10-11, 2006
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DARPA AND THE US CONNECTED SCIENCE MODEL FOR INNOVATION - WHERE IS IT NOW?

I. INTRODUCTION – FUNDAMENTALS OF TECHNOLOGY DEVELOPMENT

- *Carlotta Perez (Schumpeterian economist) – industrial and therefore societal transformation roughly every half century starting with the emerging industrial revolution in Britain in 1770, and based on long innovation waves; military power transformed as well, and world military leadership parallels industrial leadership
- *US led last three innovation waves (IT is the most recent); will this continue? If it doesn't, then over time the US loses economic leadership
- *Deep interaction in US between war and technology – war has greatly influenced technology evolution, but the converse is also true.
- DARPA good example of that interaction

Introduction, Con't

- Concerning DARPA, can't talk about US defense technology separate and apart from the technology that is driving the US economy – they are both part of the same technology paradigms.
- *If technology innovation is a driving force in US economic progress (and also for US military capability), we need to understand what are the causal factors behind innovation.
- *One of the factors is critical institutions. Arguably, there are critical technology and science institutions that can introduce not simply inventions or applications, but significant elements of entire innovations.
- *We will focus on aspects of the U.S. innovation system supported by DARPA – Eisenhower creation; primary inheritor of WW2 connected science model; disproportionate postwar technology role
- *Further, we will attempt to understand where DARPA came from, and ask, how strong does it remain, as a way of focusing on the continuing strength of the US innovation system. Will also note DARPA clones.

SUMMARY OF MAJOR POINTS

- AS WE REVIEW THIS QUESTION OF THE INTERACTION BETWEEN US ECONOMIC LEADERSHIP AND TECHNOLOGY LEADERSHIP, AN INITIAL QUESTION IS:
- GROWTH ECONOMISTS SOLOW AND ROMER HAVE POSITED TWO DIRECT INNOVATION FACTORS – R&D/TALENT
- INDIRECT INNOVATION FACTORS
- IS THERE A 3RD DIRECT INNOVATION FACTOR? S&T ORGANIZATION?
- INNOVATION SYSTEMS OPERATE AT THE INSTITUTION LEVEL, AND AT THE PERSONAL LEVEL
- AT THE PERSONAL LEVEL WE WILL EXPLORE THE NATURE OF THE INNOVATION CULTURES AT:
- EDISON AT MENLO PARK
- VANNEVAR BUSH AND ALFRED LOOMIS – THE RAD LAB AT MIT
- BARDEEN, BRATAIN, SHOCKLEY AT BELL LABS
- THEN WE WILL TURN TO AN ARGUABLY UNIQUE INSTITUTION:
- DAPRA, THAT OPERATES AT BOTH THE PERSONAL AND INSTITUTIONAL LEVELS
- AT DARPA WE WILL REVIEW THE STORY OF
- JCR LICKLIDER AND THE DARPA CULTURE – PERSONAL COMPUTING, THE INTERNET; GREAT GROUPS AND GREAT INSTITUTIONAL CONNECTEDNESS
- WE WILL CLOSE WITH A LOOK AT, WHERE IS DARPA NOW?
- AND WE WILL NOTE THE DARPA CLONES THAT ARE EMERGING AT OTHER US R&D AGENCIES

Solow and Romer

II. ROLE OF TECHNOLOGY INNOVATION AND TALENT IN GROWTH

- What do we know about the nature of innovation in economic transformation? what are the causal factors in economic growth?

Professor of Economics Robert Solow, MIT --

Solow's Basic Growth Theory:

- NOBEL PRIZE IN 1987; FIRST OF THE GROWTH ECONOMISTS
- ATTACKS CLASSICAL ECONOMICS GROWTH MODEL AS STATIC MODEL - BASED ON CAPITAL AND LABOR SUPPLY
- FOUND MORE THAN HALF OF U.S. ECONOMIC GROWTH WAS CREATED THROUGH TECHNOLOGICAL AND RELATED INNOVATION
- DYNAMIC MODEL – WE CAN CREATE GROWTH AND THEREFORE SOCIETAL WELLBEING BY FOSTERING INNOVATION
- DIRECT (OR EXPLICIT) INNOVATION FACTOR #1: R&D

Professor of Economics Paul M. Romer, Stamford Univ.

Romer's Basic Growth Theory

- If economic growth occurs primarily through technological and related innovation,
- Then: the key factor behind that innovation is "HUMAN CAPITAL ENGAGED IN RESEARCH"
- Has a "Prospector Theory" of Innovation

SO: TWO KEY DIRECT OR EXPLICIT GROWTH FACTORS:

- R&D THAT YIELDS TECH INNOVATION (Solow)
- TALENT ENGAGED IN R&D (Romer)
- THESE TWO ECONOMIC GROWTH FACTORS CREATE AN INNOVATION SYSTEM ---

INDIRECT INNOVATION FACTORS

- Note: also part of Innovation Systems are Indirect/Implicit Innovation Factors:
- **INDIRECT FACTORS SET BY GOV'T:**
- Fiscal/tax/monetary policy
- Trade policy
- Technology standards
- Technology transfer policies
- Gov't procurement (for mission agencies)
- Intellectual Property protection system
- Legal/Liability system
- Regulatory system (environment, health, safety, market solvency and market transparency, financial institutions, etc.)
- Accounting standards (via SEC through FASB)
- Export controls, ETC.
- **INDIRECT FACTORS SET BY PRIVATE SECTOR:**
- Investment Capital –
- angel,
- venture,
- IPO;s,
- equity, lending
- Markets
- Management & Management Organization, re: innovative and competitive quality of firms
- Talent Compensation/Reward, ETC.

III. QUESTION: IS THERE A THIRD DIRECT/EXPLICIT INNOVATION FACTOR?

- ANSWER: ARGUABLY, YES -
- THE ORGANIZATION SCIENCE AND TECHNOLOGY –
- THE WAY THE R&D AND THE R&D TALENT COME TOGETHER IN AN INNOVATION SYSTEM
- ARGUABLY, INNOVATION ORGANIZATION OPERATES AT AT LEAST TWO LEVELS – THE INSTITUTIONAL LEVEL AND THE PERSONAL, FACE TO FACE LEVEL – WE WILL EXPLORE THESE IN SUCCESSION.

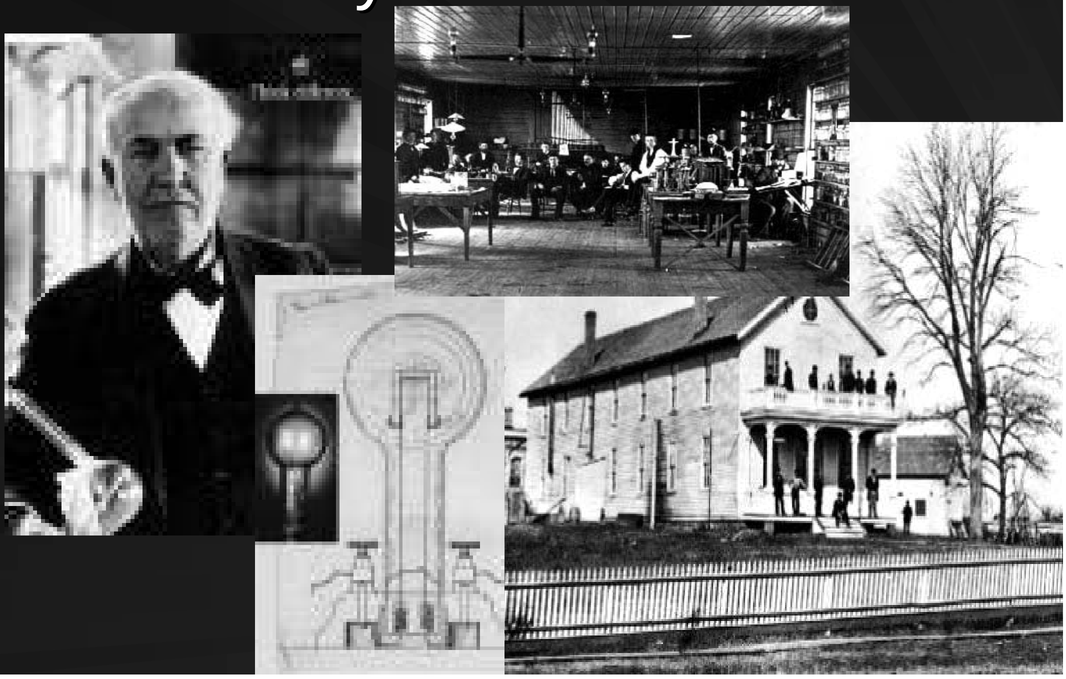
Innovation Systems at the Institutional Level

- WW2 – Vannevar Bush heads OSRD and NRDC – science/tech is integrated
- Post-WW2 – Bush's "Endless Frontier" – gov't role is to fund basic research – pipeline model – segregation of research stages
- R&D are separated
- Plethora of agencies when NSF set up late
- Result – Legacy of disconnected science
- Note: No other nation organizes science this way

Innovation Systems at the Personal Level – Great Groups

- People innovate not institutions.
- It's not only the process of creating connected science at the institutional level – what about at the personal level, the face to face level?
- Warren Bennis, "Organizing Genius" (1997) – writes about the rule sets for "great groups"
- Let's review the organizing elements of three US "great groups"
  - Edison at Menlo Park
  - Vannevar Bush and Alfred Loomis at the Rad Lab at MIT
  - The transistor team at Bell Labs

Edison and the "Invention Factory" at Menlo Park



1) Edison at Menlo Park

- Edison assembles dozen plus artisans and a few trained scientists at 100 foot wood frame building on his New Jersey farm – calls it his "Invention Factory"
- They work 24/7 – have <u>pies at midnight, sing songs, recite poems</u>
- Invent the light bulb, but then have to invent whole electrical infrastructure – generators, public utility model, fire safety, wiring
- <u>Use Challenge Model</u> – trying to solve specific challenge, goal, apply both practical and basic science to get there – Edison creates connected model tying invention to innovation – all stages
- Edison stands up <u>non-hierarchical</u>, <u>relatively flat, 2-level, collaborative</u> operation
- Mix of <u>experimentalists and theorists, artisans and trained scientists/engineers</u>
- Edison Effect – Edison has to derive electron theory to explain results – leads to atomic physics advances
- <u>Lesson</u> – science is not a linear pipeline going from basic to applied – it goes both ways: basic to applied and applied to basic – and have to have team that can collaborate in both ways

Bush and Loomis and the Rad Lab at MIT

Alfred Lee Loomis 1887-1975

MIT's Rad Lab

2) Vannevar Bush and Alfred Loomis and the Rad Lab At MIT– 1940-1945

- see discussion in: Jennet Conant, Tuxedo Park (2004), Pascal Zachary, The Endless Frontier (1997)
- Bush and Loomis mobilize science for FDR on the eve of WW2
- Bush – Engineering Dean at MIT, then heads Carnegie Institution in Wash., DC – becomes FDR's science operative
- Loomis – loves science but becomes lawyer, leading Wall St financier for electric utilities in 20's, sells out in '28, sets up private lab at Tuxedo Park estate in 30's for who's who of pre-war physics
- Loomis' field of study – microwave physics
- Bush centralizes science under "ONE TENT" – makes all the key organizational decisions -heads NACA then NDRC then OSRD
- Bush brings in Loomis, Sec. of War Stimson's 1st cousin, to organize defense science
- Loomis stands up the Rad Lab at MIT – in weeks, after British hand over microwave radar to him at the Shoreham Hotel in DC

2) Con't – V. Bush and A.Loomis

- Loomis and his friend Ernest Lawrence of Berkeley call in the whole talent base of US physics into the Rad Lab
- Loomis personally funds it while gov't approvals are delayed
- Rad Lab – flat, non-hierarchical – project managers and teams, intense work around the clock, high spirits, purposely kept out of the military
- Develop microwave radar, proximity fuse – 11 Nobel prizewinners come out of Rad Lab, lays the foundations for modern US electronics
- Use Challenge Model – challenge based on fundamental breakthrough, connected to development, prototyping, and initial product market
- Both have the connection and authority to immediately go directly to the President and Sec. of War

Transistor Team at Bell Labs

Bell Labs

2) Transistor Team at Bell Labs

- Bell Labs' Murray Hill facility is consciously modeled pre-war on Edison's Menlo Park, and postwar by AT&T's VP Mervin Kelly on the great military labs of WW2 – the Rad Lab and Los Alamos
- When Bardeen arrives at Murray Hill in '45 his first act is to sell his patent rights to AT&T for $1 – "I really feel this is only fair. People can cooperate without worrying who is going to get the patent rights and this promotes a much freer exchange of ideas." - Bardeen
- Mervin Kelly and Shockley want a solid state physics team of 50 scientists and technicians – emphasis on fundamental research but with an eye to practical applications

3) Con't - Transistor Team

- Bardeen and Brattain developed profoundly close collaboration – scientific skills and intuition of each matched each other – one outgoing, one reflective – families are social friends - deep mutual respect
- Backed up by AT&T's rich industrial technical support system, with latest equipment and tech staff support
- "magic month" – mid-Nov. to Dec. 16, 1947 – they develop first transistor
- Shockley, their supervisor who provided initial project definition, working in secret at his home adds key features [Semiconductor sandwich vs. elec. contact point], and tries to preempt patent
- Shockley's secrecy wrecks the trio's collaboration

3) Con’t - Transistor Team

- Before Shockley breaks up the collaboration:
- True Genius, p. 127 - “The solid-state group divided up tasks: Brattain studied surface properties such as contact potential; Pearson looked at bulk properties such as the mobility of holes and electrons; and Gibney contributed his knowledge of the physical chemistry of surfaces. Bardeen and Shockley followed the work of all members, offering suggestions and conceptualizing the work. ‘It was probably one of the greatest research teams ever pulled together on a problem,’ said Brattain.”
→→→

3) Con’t - Transistor Team

- “’I cannot overemphasize the rapport of this group. We would meet together to discuss important steps almost on the spur of the moment of an afternoon. We would discuss things freely. I think many of us had ideas in these discussion groups, one person’s remarks suggesting an idea to another. We went to the heart of many things during the existence of this group, and always when we got to the place where something needed to be done, experimental or theoretical, there was never any question as to who was the appropriate man in the group to do it’” Brattain in Daitch and Huddelston, True Genius, pp. 127-128

SUMMARY FROM GREAT GROUPS:

- Teams are highly collaborative
- Flat, non-hierarchical and democratic
- Networked to the best thinking (for ex., Shockley and Bardeen travel for 2 mos in the summer of '47 talking to the best European scientists in solid state area)
- Uses Challenge Model – fundamental science but breakthrough application in mind across basic, applied, prototype, development stages – you have "to ship"

IV. DARPA AS A UNIQUE MODEL – COMBINING INSTITUTIONAL CONNECTEDNESS AND GREAT GROUPS

- We have discussed the concept of innovation organization as a third direct innovation factor, and noted that it operates at both the institutional level and the personal level. Unlike the four personal level models we have discussed above, DARPA has operated at both the institutional and personal levels.
- Eisenhower's initial 1957 creation ended up as a unique entity. It got around the post WW2 dismantlement of the connected science model, and end of the "Great Group" culture at the Rad Lab.
- DARPA becomes a bridge organization connecting these two organizational elements, unlike any other R&D entity stood up in government.

JCR Licklider - “Man-Machine Interface” / “Human-Computer Symbiosis”: "The hope is that in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought.” -1960

JCR Licklider and the DARPA Model

- (see discussion in: Mitchell Waldrop, Dream Machine (2001)
- In 1960 Licklider writes about the “Man-Machine Interface” / “Human-Computer Symbiosis”: "The hope is that in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought.”
- By 1960 – Licklider has envisioned both personal computing (as opposed to the then-dominant main-frame computing), the internet, the www, and nearly all the features we are still realizing
- Then Licklider goes to (D)ARPA – brought in to solve Kennedy’s and MacNamara’s command and control problem
- Rare case of the visionary being placed in the position of vision-enabler
- He funds, selects, organizes and stands up the support network of talent – researchers at Univ’s and co’s – that builds personal computing and the internet
- DARPA under Jack Ruina, Charles Herzfeld, and George Heilmeier back Licklider in creating the first and greatest success of the DARPA model
- Licklider creates a series of Great Groups – these in turn have the key features of Rad Lab, Los Alamos – Doug Englebart’s Demo, Robert Taylor at Xerox Parc

Elements in the DARPA Model

- At the Institutional level – DARPA is able to do connected science – model requires:
- Revolutionary technology development - fundamental science connected through the development and prototyping stages
-
- Other ways DARPA assures connectedness:
- -Cook-Deegan quote about DARPA role in the Pentagon bureaucracy – developed ability to make connections across the DOD stovepipes
- -Uses funding to leverage contributions from other DOD service tech development organizations, and promote service adaptation and production
- -Uses other DOD entities as its agents – promotes cooperation across the stovepipes – helps assure prototypes will move into production stage where DOD will create first market
-
- Other DARPA Characteristics – affect it's ability to operate at the Institutional and Great Group levels

The DARPA Model -

- **Small and flexible –**100/150 professionals – "100 geniuses connected by a travel agent";
- **Flat organization -** no hierarchy, 2 levels;
- **Substantial autonomy and freedom** from bureaucratic impediments – operates outside civil service hiring and gov't contracting rules;
- **Technical staff drawn from world-class** scientists and engineers with representation from industry, universities, government laboratories and Federally Funded Research and Development Centers (FFRDC's);
- **Technical staff hired or assigned for 3-5 years** and rotated to assure fresh thinking and perspectives;

- **Project based –CHALLENGE MODEL -**
- all efforts typically 3-5 years long with strong focus on end-goals. Major technological challenges may be addressed over much longer times but only as a series of focused steps.
- The end of each project is the end. It may be that another project is started in the same technical area, perhaps with the same program manager and, to the outside world, this may be seen as a simple extension. For DARPA, though, it is a conscious weighing of the current opportunity and a completely fresh decision. The fact of prior investment is irrelevant;

The DARPA Model, Con't

- **Necessary supporting personnel (technical, contracting, administrative) are "hired" on a temporary basis** to provide complete flexibility to get into and out of an area without the problems of sustaining the staff. This is by agreement with Defense or other governmental organizations (military R&D groups, National Aeronautics and Space Administration, National Science Foundation, etc.) and from System Engineering and Technical Assistance (SETA) contractors – builds collaboration and leverages help across DOD stovepipes;

- **Program Managers (the heart of DARPA) are selected to be technically outstanding and entrepreneurial.** "The best DARPA Program Managers have always been freewheeling zealots in pursuit of their goals";

- **Management** is focused on basic stewardship of taxpayer funds but imposes little else in terms of rules. Management's job is to **enable the Program Managers – empowerment model;**

- **A complete acceptance of failure** if the payoff of success was high enough – high risk model for breakthrough opportunity

The DARPA Model, Con't

- Oriented to **Revolutionary Technology breakthroughs** – Radical not Incremental Innovation – emphasis on High Risk Investment
- Fundamental through prototype – hands off production to services OR commercial sector

- Usually works on solutions to Joint Service problems – works across DOD's stovepipes – and leverages them

- Typical project:
- $10-40m over 4 years
- Single DARPA Project Manager controls
- Other Defense R&D agency or outside contractor manages administrative side–buy in
- Typically combines private co's and Univ's, all aimed at common goal

V. DARPA TODAY – HOW HEALTHY IS THE MODEL?

- Arguably economic innovation sectors are best described as ecosystems and Marco Iansati and Roy Levien have argued (in The Keystone Advantage, Harvard Bus. Sch. Press 2005)) that within these systems are keystone firms that take on the task of sustaining the while ecosystem by connecting participants and promoting the progress of the whole system.

- Iansati has also argued that these innovation systems start to decline or shift elsewhere where the keystone firms cease being thought leaders and instead shift to what he calls “landlord” status. There, the landlord shifts to simply extracting value from the existing system rather than continuously attempting to renew and build the system. Does this analogy apply to DARPA?

- DARPA appears increasingly focused on a problem DARPA ran into the end of the Cold War and its higher levels of procurement – the breakdown of technology transition into services. However, rather than attempting build a new basis for revolutionary technology investment, DARPA has been retreating from radical innovation to incremental innovation, shifting investment into late stage development

Is DARPA Changing its Model?

- DARPA has also been growing its black programs, which has meant cutting back on Univ. ties and focusing on a much narrower group of innovators, largely in certain secure defense industries – this means greatly reduced mindshare in the technology community engaged on the problems DARPA must solve.
- So: Cutting back on breakthrough model, its historic mission

- Cutting way back on IT funding – down to around $140m – not pursuing breakthrough IT advance despite past leadership in this area. Budget analysts report that shorter term incremental work space launch and satellite “repair” are taking the growing part off the DARPA budget.

- “Up or out” review process – placing R&D on short term course with frequent policy reversals/turns that limits the ability to mount creative longer-term investment programs so important to past development.

- Heart of DARPA creativity in the past was in highly talented and empowered project managers. However, the role of project managers is now sharply curtailed by a centralized management approach

Is DARPA Changing its Model?

- DARPA has always been able to pick the brightest technologists in the nation, which has been crucial to its advances. However, critics are now saying that DARPA is now having <u>trouble filling its positions</u>.

- DARPA in the past has <u>operated in both the civilian and defense economies</u>, understanding they are the same economies. It has spun technology off to the civilian sector where it has further evolved enabling DOD to buy it back at radically lower costs and taking advantage of civilian advances, as in computing, or for defense only needs like Stealth, spun it off to the defense sector.

- Increasingly, <u>DARPA appears less interested in civilian economy</u>, despite DOD's increasing cost crisis and the need to take advantage of advances in that sector. Despite DARPA's historic role in successfully straddling both sectors, one DARPA leader has referred to advances in the civilian sector as "NSF's job" despite DARPA's need to play in both worlds.

- Danger that DARPA is <u>retreating into Iansati's and Levien's "landlordism</u>" – <u>not renewing but living off past advances</u>

Other Aspects of US Defense Technology Leadership – Also in Trouble?

- CSIS Report – disinvestment in fundamental science – leadership comes out of this area
- DSB Report – disinvestment in areas of critical advance in IT
- Defense Personnel problems – affects talent base
- Civilian Sector reports – Council on Competitiveness, National Innovation Initiative; NAS, Gathering Storm
- These issues not being dealt with at DOD

VI. DARPA CLONES EMERGE AT OTHER AGENCIES

- Homeland Security Dept. – HSARPA- in law for homeland security R&D
- Energy Dept. – Congress proposing DARPA model for DOE entity
- Cures Act from Congress – proposes HARPA at NIH – health advanced research connected to applied development
- Biothreats Act from Congress – proposes BARPA – for connected biothreat R&D

VII. CLOSING SUMMARY:

- Growth Economics posits two direct/explicit innovation factors:
- 1) R&D (Solow) and
- 2) S&T Talent (Romer)
- Is there a 3rd Direct/Explicit Innovation Factor?
- Arguably yes – the Organization of S&T – how you put together your R&D and Talent into a system
- Operates at Institutional and Personal Levels
- Looked at famous examples S&T organizational success for common threads
- Menlo Park, Vannevar Bush's and Alfred Loomis' Rad Lab at MIT, Transistor team at Bell Labs
- DARPA as a reprise of the connected challenge models at Rad Lab – operating at the institutional and personal level

Closing Summary, Con't

- These institutions are deeply collaborative, flat, feature close-knit talent, democratic, flexible, are oriented to breakthrough radical innovation
- They use a Challenge Model for R&D - move from fundamental back and forth with applied, connected to development, prototyping, and access to initial production
- Follow an innovation path not simply an invention path
- Like all human institutions, these organizational models are transitory
- DARPA as a unique model – operating at the institutional and personal level
- DARPA model has been the longest lasting – unique in the federal gov't – seemed to be the most capable of ongoing renewal
- But that DARPA model now may be being shifted – part of an issue over continued U.S. defense technology superiority
- Meanwhile, DARPA clones proposed in other agencies

パネル **VII**：産学官連携：バイオテクノロジーの挑戦

Panel VII: Industry-University-Government Cooperation: The Biotechnology Challenge

モデレーター：ウィリアム・ボンヴィリアン William Bonvillian，ジョセフ・リーバーマン合衆国上院議員オフィス 立法ディレクター，チーフスタッフ

米国における医薬品開発の最新動向の展望

Perspective on Current Trends in Drug Development in the United States

ゲイル・カッセル Gail Cassell，イーライリリー 科学担当副社長

日本の公的部門はバイオメディカル研究に大きく貢献したのか？：**1991-2001** 年における政府／大学の特許の詳細分析

Is There a Significant Contribution of Public Sector in Biomedical Research in Japan?: A Detailed Analysis of Government/University Patenting, 1991-2001

岡田 羊祐，一橋大学大学院経済学研究科助教授

ディスカッサント

長井省三，日本製薬工業協会 知的財産部長，弁理士

Is There a Significant Contribution of Public Sector in Biomedical Research in Japan? A Detailed Analysis of Government/ University Patenting, 1991-2001

Yosuke Okada (Hitotsubashi University)
Kenta Nakamura (Hitotsubashi University)
Akira Tohei (CPRC, Japan Fair Trade Commission)

11 January 2006

Symposium on “21st Century Innovation Systems for Japan and the United States”
@Mita Kaigisho

1. Introduction and Motivation

- Does the pro-patent policy for public sector research in Japan encourage industry-university-government collaboration in patenting?
- If so, did the collaboration among them really produce important patents in biotechnology research?
- For example, is the value of corporate patents positively associated with the presence of co-assignees, especially when the co-assignees are government research institutes and/or universities?

1. Introduction and Motivation (cont.)

- After the enactment of the *Basic Law on Science and Technology* in 1995, a series of legislations were implemented encouraging collaborative research among industry, government and university. (Table 1) .
- Major policy initiatives, such as *TLO Act* and the so-called Japanese *Bayh-Dole Act*, have been introduced in Japan since 1998.
- Traditionally, the Japanese government put the top priority to energy-related research (including nuclear fusion). But *the Basic Plan for Science and Technology* redirected the allocation of government research expenditures slightly, putting much more weight on life science ever than before.

Table 1 Major Policy Initiatives relating to Industry-Government-University Collaboration in Japan, 1995-2002

Year	Initiatives
1995	The Basic Law on Science and Technology
1996-2000	The First Basic Plan for Science and Technology
1998	The Law on the Promotion of Technology Licensing by Universities, etc.
1998	The Law on the Promotion of Research Exchange
1999	The Law on the Special Measures for Revitalizing Industrial Activities
1999	The Law on the Promotion of New Business Incubation
2000	The Law on the Enhancement of Industrial technologies
2001	The Council for Science and Technology Policy (CSTP)
2001-2005	The Second Basic Plan for Science and Technology
2002	Biotechnology Strategic Scheme
2002	The Basic Law on Intellectual Property

Table 2 Public Expenditures on Science and Technology in Japan

(billion yen, fiscal year)

	2001	2002	2003	2004
Life Science	390.7	393.4	427.0	436.2
Information Technologies	166.3	175.8	169.6	175.8
Environment	84.7	100.6	109.9	117.5
Nano-technologies /Materials	80.4	85.6	91.2	94.0
Energy	685.6	705.0	671.4	682.6
(Nuclear Energy)	(370.9)	(338.3)	(340.6)	(302.9)
Manufacturing Technologies	23.2	16.4	19.8	20.3
Infrastructure	266.0	255.4	256.1	263.6
Frontier (Space/Marine)	306.2	295.3	302.9	281.4
Subtotal (Top 4 Priorities)	722.1	755.4	797.7	823.5
	(36.0%)	(37.3%)	(39.0%)	(39.4%)
Total	2003.1	2027.3	2047.9	2091.4

Data Source: The Council for Science and Technology Policy (CSTP)

Note: The above figures do not include the cross-disciplinary research and university research expenditures (around 1.5 trillion yen every year).

2. Data

We explore these policy questions by using patent statistics.

Patent data:

- *Derwent Innovation Index* (DII) and *Derwent World Patent Index* (DWPI), Thomson ISI
- *IIP Database*, Institute of Intellectual Property
  This DB is based on the JPO's patent data (*Seiri-Hyojyunka Data*)
- *Intellectual Property Digital Library* (IPDL), JPO

Company information:

- *JDB Database* (Japan Development Bank).
- *Japan Bioindustry Association* (JBA) etc.

2. Data (cont.)

Retrieval of Patent Data from DII and DWPI

- Date of search: 1 March 2004
- Priority country: Japan
- Priority date: from 1 January 1991 to the date of search
- Technological field: biotechnology patents defined by the JPO search equations for life science (JPO, 2003)

19 technology fields are defined by the search equations.
(5 basic technologies, 7 post-genome technologies, 7 other technologies)

Table 2 Technology Classification

	#	Classification
Basic Technolgies	1	Genetic engineering
	2	Gene analysis
	3	Embryological engineering
	4	Protein engineering
	5	Glycoengineering
Post-genome Technologies	6	Gene function analysis
	7	Protein conformation analysis
	8	Protein function analysis
	9	Glycoprotein gene
	10	Genomic drug discovery
	11	Genetherapy and diagnosis
	12	Nano-biotechnology
Other Technologies	13	Bioinformatics
	14	Cell
	15	Microorganism and enzyme
	16	Genetically modified plant
	17	Genetically modified animal
	18	Biopharmaceutical
	19	Biochemical product

Figure 1 Number of patent filings (basic technologies)

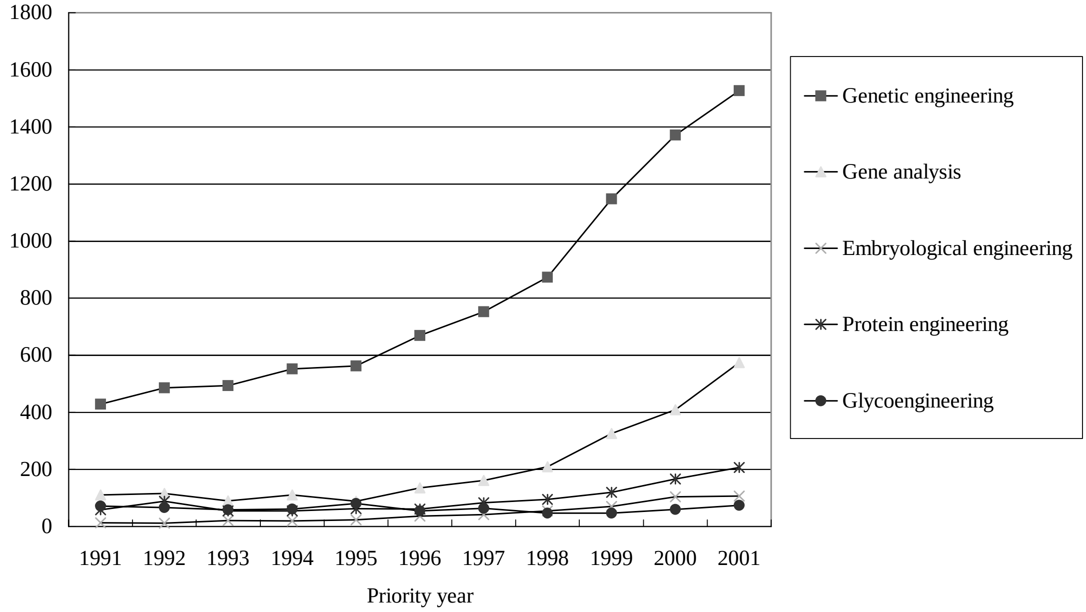


Figure 2 Number of patent filings (post-genome technologies)

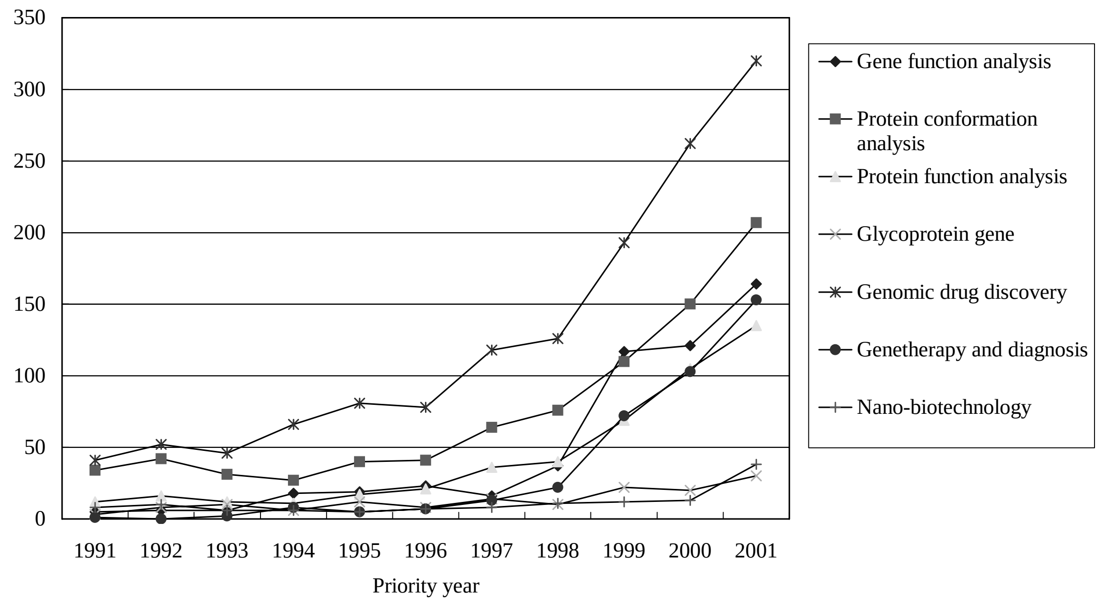


Figure 3 Number of patent filings (other technologies)

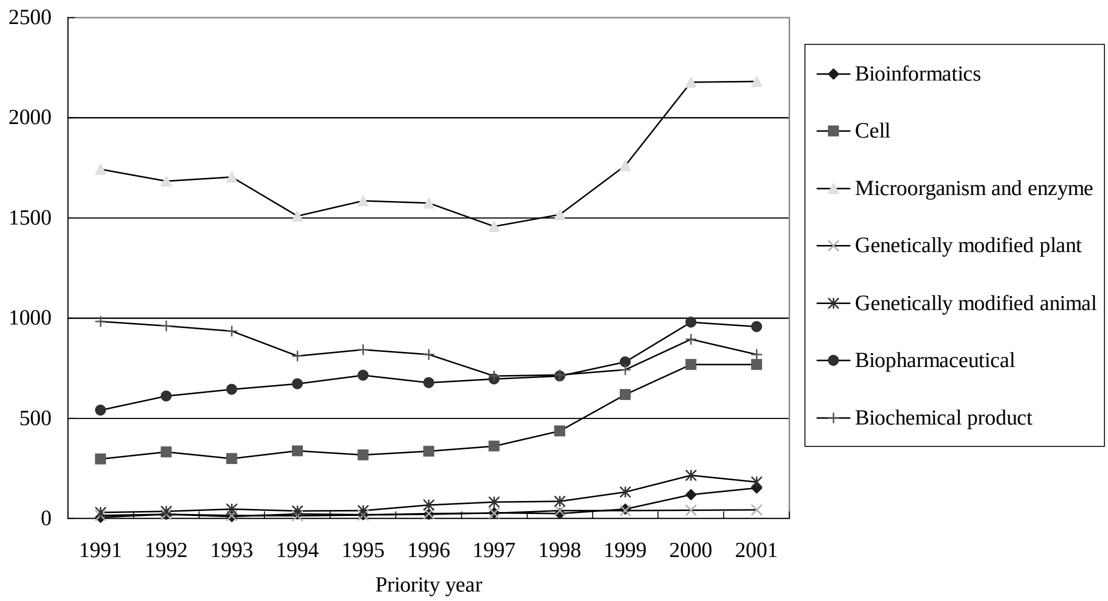
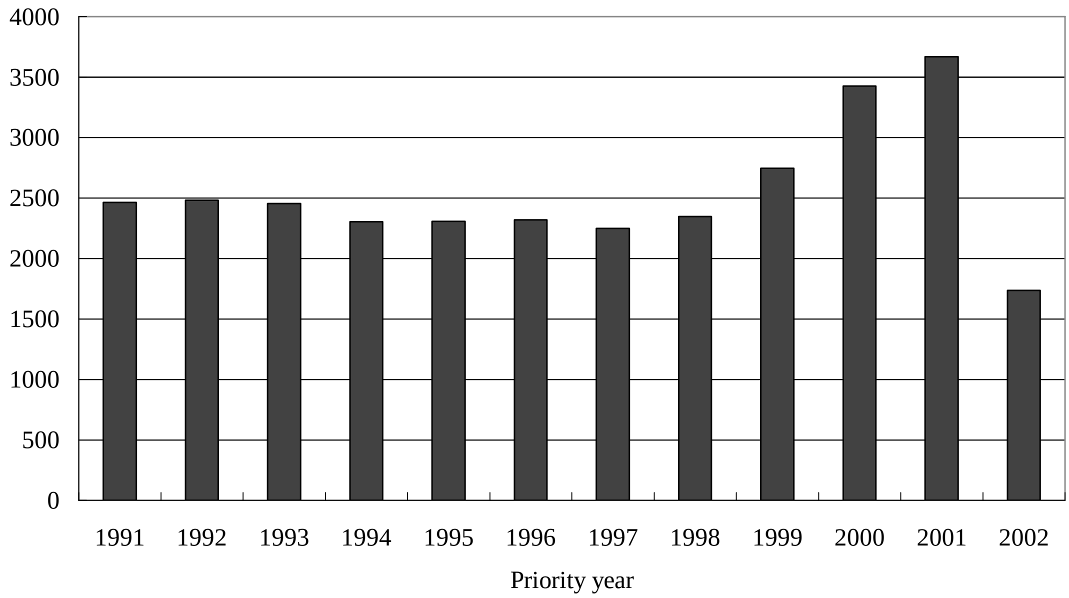


Figure 4 Biotechnology patent in Japan (total)



3. Assignee Name Matching

- First, we matched the first assignee with the other co-assignees in case there were multiple assignees for each patent.
- Second, we retrieved the Japanese assignee names (written in Japanese) from the IIP Database and matched them with the DII/DWPI patent data by using several patent numbers with distinct kind codes. The remaining missing assignee names were supplemented by using IPDL (Intellectual Property Digital Library, JPO).
- By using the name-matching procedure, we identified 5352 distinct assignees of 30,502 biotechnology patents for the years 1991-2001.
- To avoid arbitrary aggregation or disaggregation of assignee names, we adopted original assignee names at the date of patent filing.

3. Assignee Name Matching (cont.)

Classification of assignees

Single assignee

corp : single assignee is a corporation.
gov : single assignee is a government research institute.
univ : single assignee is a university.

Multiple assignees

corp_corp : no less than two assignees are corporations, and there are no assignees belonging to universities and government institutes.
corp_gov : at least two assignees are both a corporation and a government research institutes, and there are no assignees belonging to universities.
corp_univ : at least two assignees are both a corporation and a university, and there are no assignees belonging to government research institutes.

3. Assignee Name Matching (cont.)

- Many individual assignees (as well as individual inventors) had their own institutional affiliations, but their true affiliations are not shown fully in the patent documents.
- Thus we searched the original affiliation of all individual assignees by using the search engines of *Yahoo!* and *Google*.
- We identified the classification of biotechnology patents by assignee types exclusively as follows:
  corp (21,664 patents), *gov* (1611), *univ* (995),
  corp_corp (1420), *corp_gov* (873), *corp_univ* (1106),
  individuals (727), private foundations (1350),
  and others (756, including unidentified individuals).

Figure 5 Corporate patent (single assignee)

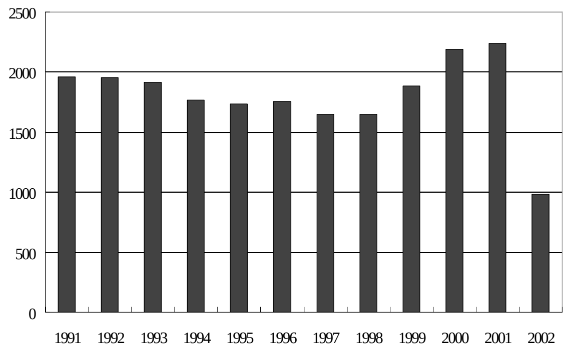


Figure 6 Government patent (single assignee)

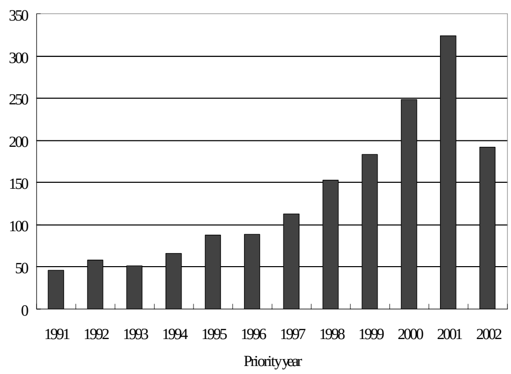


Figure 7 University patent (single assignee)

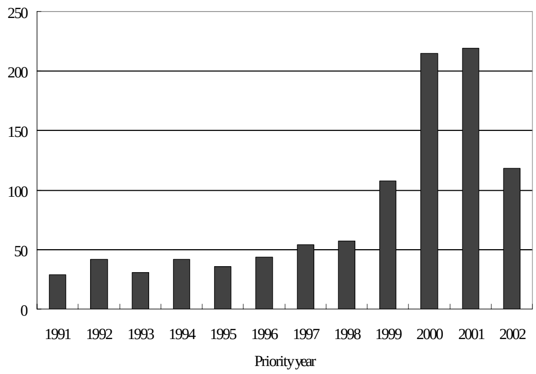


Figure 8 Number of patent filing (*corp_corp*)

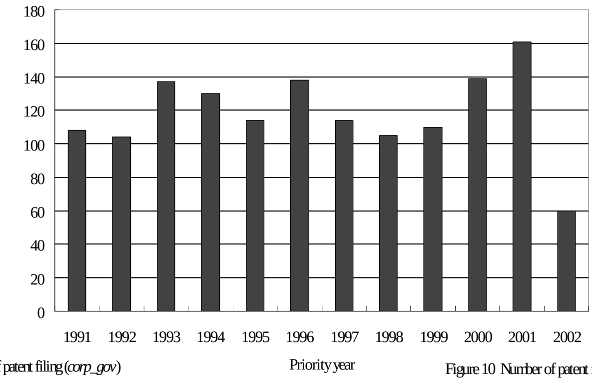


Figure 9 Number of patent filing (*corp_gov*)

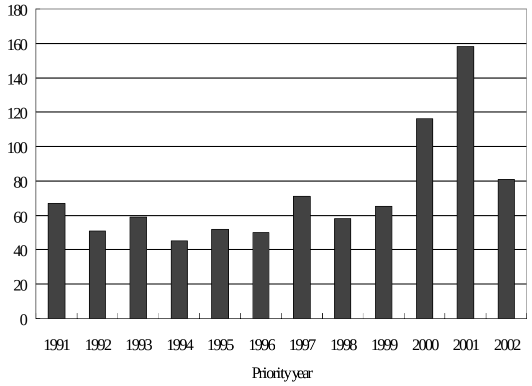


Figure 10 Number of patent filing (*corp_univ*)

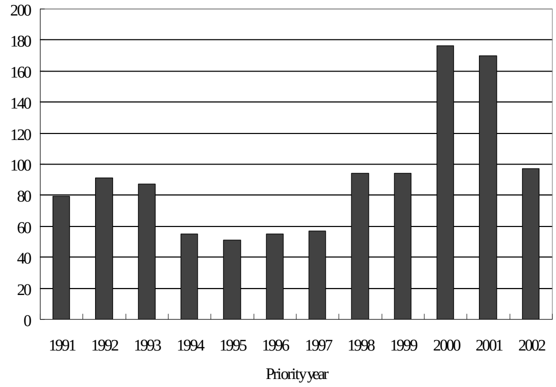


Figure 12 Biotechnology patent by assignee type (%)

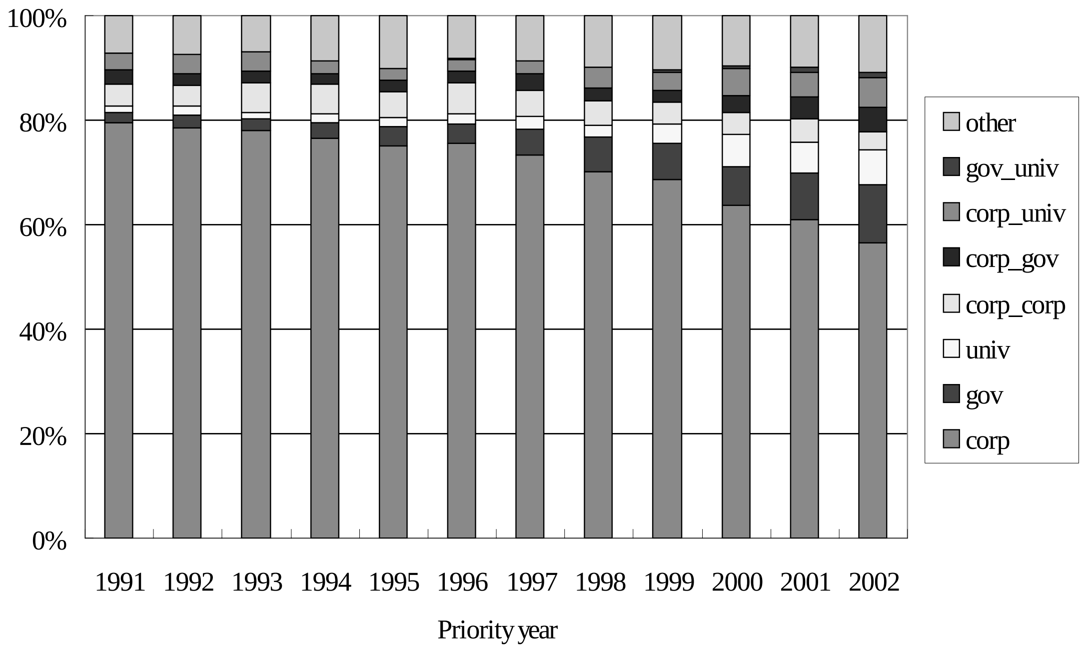


Table 3 The top 5 government research institutes in biotechnologies

#	Organization	Patent application	%	The top 3 (%)	The top 5 (%)
1	Japan Science and Technology Agency (JST)	676	25.1		
2	National Institute of Advanced Industrial Science and Technology (AIST)	528	19.6	56.7	
3	The Institute of Physical and Chemical Research (RIKEN)	322	12.0		70.4
4	National Agriculture and Bio-oriented Research Organization (NARO)	191	7.1		
5	The National Institute of Agrobiological Sciences (NIAS)	177	6.6		
	Total	2692			

Note: These data are based on biotechnology patents whose priority years are from 1991 to 2001 and the priority country is Japan. The top 5 research institutes are defined by the order of the total number of patent application since 1991 through 2001 in biotechnologies.

4. Corporate Patent by Industry (listed companies only)

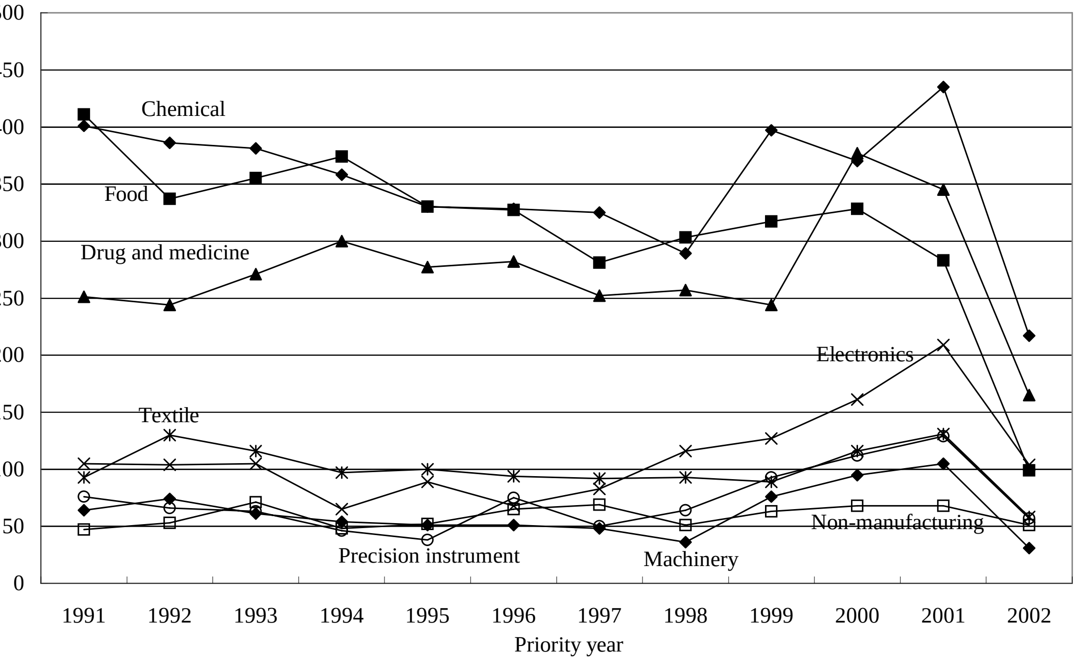
- Corporate patents filed by listed companies are not dominated by bio-pharmaceutical firms, and those patents are filed broadly by many industries. This would be starkly contrasted with the situation in the US.
- Listed companies have higher propensity to patent, but those patents do not necessarily have higher patent values (as shown later).

Table 4 Industry classification (listed companies)

#	Industry classification
1	Food
2	Textile
3	Paper and pulp
4	Publishing and printing
5	Chemical
6	Drug and medicine
7	Petroleum refinery
8	Rubber products
9	Ceramics, stone & clay
10	Steel
11	Nonferrous metal
12	Fabricated metal
13	Machinery
14	Electronics
15	Transportation equipment
16	Precision instrument
17	Miscellaneous
18	Non-manufacturing

Note: Industry classfication code is based on the JDB Database (Japan Development Bank).

Figure 13 Bio-patent by industry (top 8 industrial sectors; listed companies only)



5. Patent values and assignee types

- We used citation counts by subsequent patents (*forward* citation) as the patent value measure.
- Following Jaffe and Lerner (2001) and Hall, Jaffe and Trajtenberg (2002), we adjusted heterogeneity concerning propensity to cite on technology field in each year.
- Put differently, we constructed weighted citation count (*normalized* forward-citation intensity) which is defined by the difference between the actual number of citations received per patent and the *reference* citation intensity for each technological field in every year.

Table 6 Summary statistics by assignee type

	Observation	dif_dciting	pat_size	science_ratio	tech_scope	fam_size	claim	bwd_cites
corp	20683	0.05 (4.28)	15.95 (18.00)	0.08 (0.19)	2.03 (1.44)	2.32 (2.85)	7.39 (8.31)	2.62 (8.30)
gov	1419	-0.22 (1.85)	48.72 (59.89)	0.08 (0.21)	2.50 (1.66)	2.05 (1.63)	8.35 (9.06)	1.06 (3.38)
univ	877	-0.12 (2.09)	4.52 (4.71)	0.11 (0.23)	2.42 (1.60)	2.17 (2.14)	8.60 (9.65)	1.34 (3.49)
corp_corp	1360	0.10 (3.37)	9.60 (11.87)	0.06 (0.17)	1.73 (1.11)	2.14 (2.39)	6.84 (7.28)	2.59 (7.10)
corp_gov	792	-0.24 (1.75)	18.36 (27.65)	0.07 (0.18)	2.17 (1.56)	1.85 (1.80)	7.53 (7.58)	1.37 (3.99)
corp_univ	1009	-0.24 (2.92)	7.03 (10.56)	0.09 (0.20)	2.27 (1.61)	2.04 (2.08)	8.30 (8.02)	1.58 (4.57)

Note: All statistics are based on biotechnology patents whose priority years are from 1991 to 2001 and the priority country is Japan. Standard deviations are in parentheses.

5. Panel regressions (tentative)

- We employed several panel regressions using normalized citation counts as dependent variables.

- Main findings are as follows:

1. *corp* and *corp_corp* (i.e., joint application by corporations) produced highly valued patents on average.

2. University patents are not highly valued on average.

3. Technologically-focused patents have higher values.

4. Science linkage is positively associated with patent values.

5. Although government patents are not very important on average, the top 5 government research institutes have produced more important patents than before especially since 1998.

6. Concluding Remarks (tentative)

- There are significant differences in patent values among assignee types.

- Each assignee would have distinct incentive to patent. Propensity to patent by government research institutes and universities were rather weak, but began to increase since 1998.

- The pro-patent policy in Japan is likely to encourage public sector (especially government research institutes) to file valuable patent at least since 1998, although the value of government (as well as university) patents are virtually lower than that of corporate patents.

Further remaining (open) questions

- Is it really desirable to encourage government and university to file patent, reflecting the salient features of Japanese innovation system, such as low mobility of researchers, weak patent protection, and backwardness in bio-medical research?

- Could the increase in co-applications of patent be regarded as the result of effective research collaborations among industry-university-government?