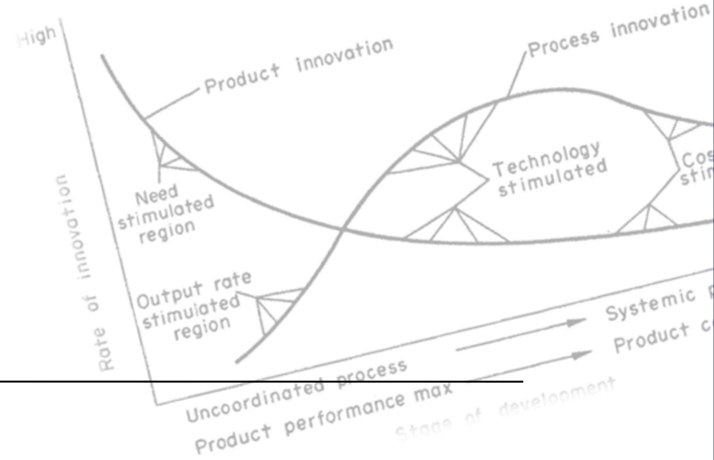
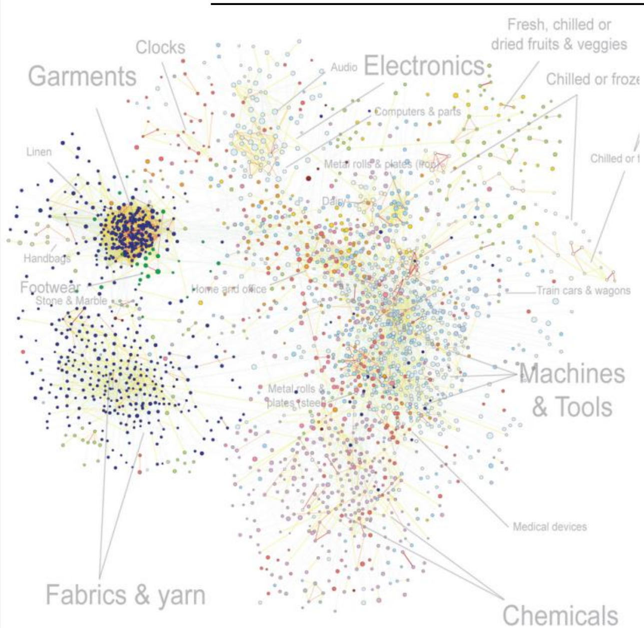


KAIST I&TM **ITM501 Innovation Management**

Sources of Innovation

Science, Technology and knowledge



2023. 9. 16.

Euiseok Kim

Sources of Innovation

Technology Push

The increasing importance of science in the innovation process, increasing complexity which necessitated a long-term view, apparently strong correlations between R&D and innovative output, and the inherent uncertainty of the innovation process.

Dosi (1982)

Technology Push model

Demand Pull

Changes in market conditions create opportunities for firms to invest in innovation to satisfy unmet needs.

(Schmookler, 1962, 1966)

Demand Pull model

Government Push or Public Push

Sustainability Issues, Space development, Defense

User innovation

- Innovation by intermediate users (e.g. user firms) or consumer users (individual end-users or user communities), rather than by suppliers (producers or manufacturers).

- Many products and services are actually developed or at least refined, by users, at the site of implementation and use.

Eric von Hippel

Linear model

Technology Push model

Basic Science → Applied Science and Engineering → Manufacturing → Marketing

Demand Pull model

Market Need → Development → Manufacturing → Sales

Demand-pull, technology-push, and government-led incentives for non-incremental technical change

Gregory F. Nemet

Research Policy 38 (2009) 700–.709

Critique of Tech-push : market conditions 무시 * radical

* 가격과 다른 변화들을 무시
* 선형모델

Critique of Demand-pull : 기술의 역량을 무시 * incremental

"Demand"라는 범주가 너무 넓다
* 불연속보다는 점진적 기술변화를 설명
* 들어나지 않는 니즈를 어떻게 설명? 등

절충적인 모델 : 두가지 동인이 동시에 작용

Public policy 관점에서의 응용

* 정부의 혁신을 위한 두 가지 방법
- 혁신생산을 위한 민간비용을 감소, Tech-push : R&D 지원, R&D 조건 세금감면
- 혁신에 대한 민간이득 증대, Demand-pull : 특허제도, 정부조달, 경쟁기술에 대한 규정

But, Highly cited patents do not correspond to policy-led demand……. (Demand side policy)

Demand-pull, technology-push, and government-led incentives for non-incremental technical change

Gregory F. Nemet

Research Policy 38 (2009) 700–.709

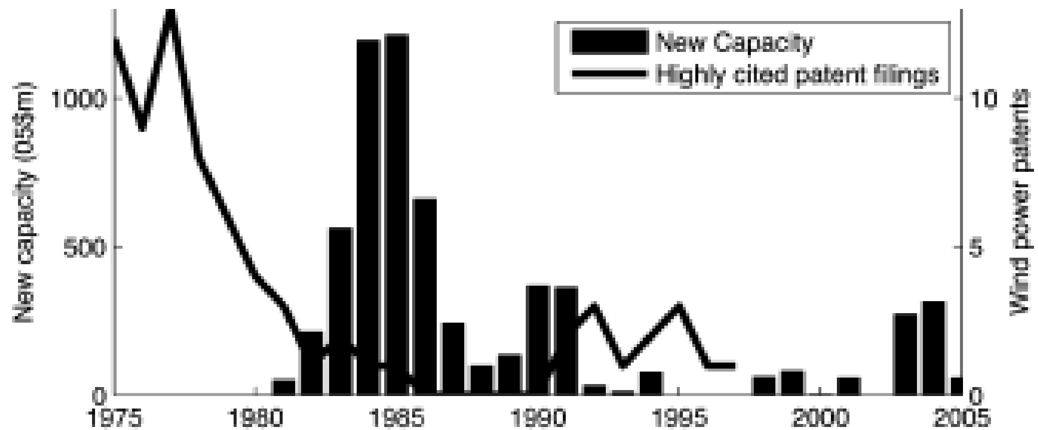
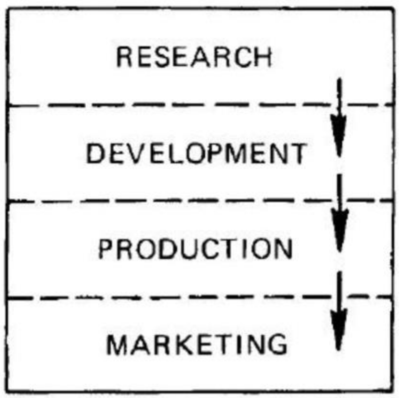


Fig. 3. Investment in new capacity and highly cited patents (≥ 5 citations received). Data: Gipe (1995); Hall et al. (2001); CEC (2006); USPTO (2006).

* Why did policy(Demand side policy) not stimulate valuable patents?
- Convergence on a dominant design (급속하게 전개되는 마켓과 기술 때문)
- Lags to payoffs and policy uncertainty
- Exhaustion of the technical frontier (기술성숙에 따라 특허활동 저조)

Models of Innovation process

The Linear Model



The Chain Linked Model

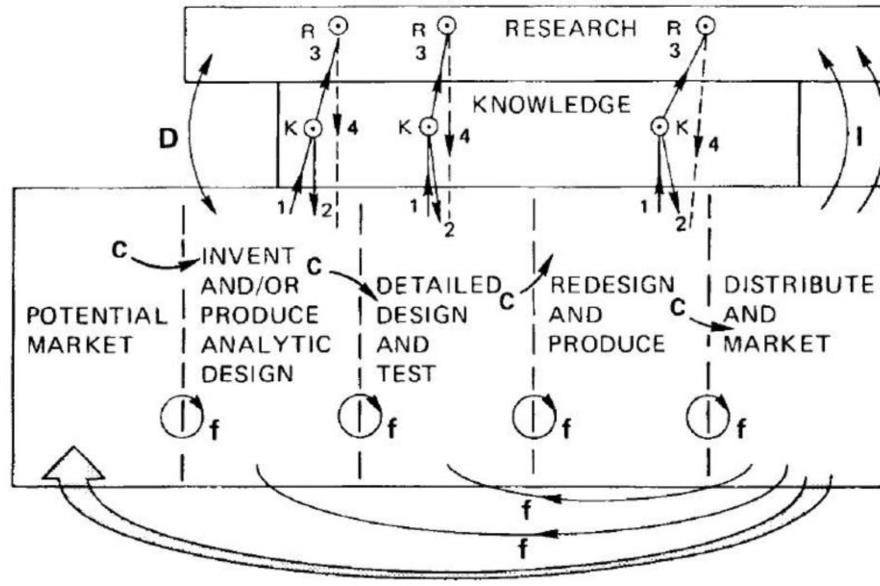
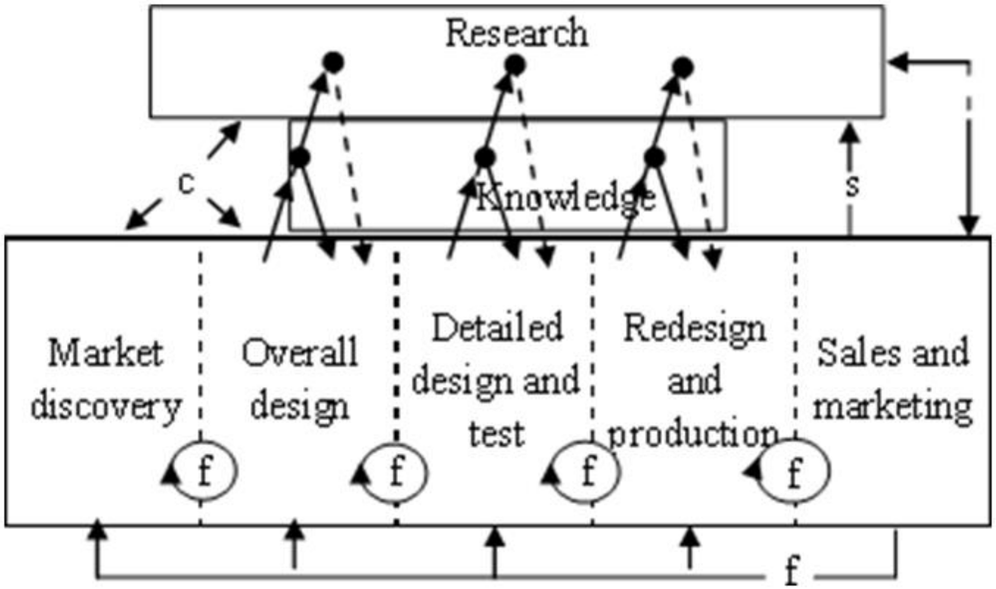


FIGURE 2 Elements of the "chain-linked model" for the relationships among research, invention, innovation, and production.

- 혁신 프로세스를 선형 모델로 이해 하는 것은 여러가지 방식으로 혁신의 현실을 왜곡함
- 혁신에는 피드백이 필수적이지만 선형모델에서는 "피드백" 경로가 없음
- 선형모델에서는 혁신의 중심을 과학이 아닌 설계라고 생각함
- 혁신은 과학에 의존할 뿐만, 과학과 기술의 상호작용은 매우 강력함

Chain-Link model

Stephen J. Kline



f : Feedback
I : New equipment stimulates science, and science generates new equipment
C : Idea germination
S : Company's support for long-term research

Technological innovation does not follow a linear flow (linear model) of "research" - "development" - "design" - "production" - "sales," but is explained by a chain-link model, as shown below, where each function is linked and interacts, and feedback is generated.

cf. Seven sources of innovation

By Peter F Drucker

- **Unexpected**
- **Incongruity**
- **Market Structure**
- **Necessity**
- **Demographics**
- **Changing perception**
- **New Knowledge**

Literature

Mode 1 & Mode 2

	제 1 양식(Mode 1)	제 2 양식(Mode 2)
지식생산의 배경	해결해야 할 문제는 순수 연구와 연관해서 아카데믹한 배경에서 발견되고 추구됨. 연구는 실제적인데 별로 관심이 없는 학자 공동체(academic community)에 의해 수행됨.	연구는 산업, 정부, 혹은 사회 전체에 유용한 것을 지향하고, 특정한 이슈나 문제를 중심으로 이루어짐. 지식생산은 다양한 이해당사자와의 협상 속에서 이루어지고, 이들의 이해를 반영함.
학제적 기반	지식은 특정한 학적 학제에 준해서, 그 지식과 사회적 기준에 준해서 발달함. 이론과 응용의 구분이 비교적 분명.	지식은 초학제적(transdisciplinary). 지식은 다양한 이해당사자의 숙련, 인식, 사회적 표준을 통합해서 발달함. 이론과 응용 사이에 동적인 흐름이 존재.
지식생산을 담당하는 사회적 조직	지식은 대학에 기반. 다양한 제도적 조직 사이에 협동은 상당히 제한적. 연구팀은 학제(discipline)에 근거해 있음.	지식은 대학, 연구기관, 정부기관, 비영리기관, 산업, 컨설팅 회사 등의 네트워크 속에서 만들어짐. 연구팀은 다양한 기술과 숙련을 모을 수 있어야 하고 끊임없이 진화해야 함.
책무성(accountability)	연구자는 동료에게 책임을 지고 동료에 의해 평가받음. 과학자는 전문지식을 무지한 대중에게 전파하는 사람으로 간주됨.	사회적 책무(social accountability)가 지식생산을 지배함. 연구 과정 자체가 다양한 이해당사자의 이해를 반영.
지식의 질(quality)에 대한 통제	연구의 질을 평가하는 중요한 기준은 이 연구가 그 전문 분야에 기여하는가 그렇지 않은가임.	연구의 질은 다양한 기준에 의해 평가. 지적 우수성 말고도 비용효율(cost- effectiveness)이나 경제적, 사회적 함의가 중요.

M. Gibbons et al (1994), The New Production of Knowledge

Source: Gibbons et al. 1994. 홍성욱, 이두갑, 신동민, & 이은경. (2002). 선진국 대학연구체계의 발전과 현황에 대한 연구. *정책연구*, 1-249.

Literature - From Mode 1 to Mode 2

Gibbons et al. (1994), *The New Production of Knowledge*

- Mode 1 – discipline-based, largely in academic institutions, primarily concerned with furthering knowledge, subject to internal scrutiny
- Mode 2 – transdisciplinary, in variety of institutions, pursuing knowledge 'in the context of application', subject to ext accountability
- Shift over time from Mode 1 to Mode 2?
- But disputed by historians of science and technology

'Pasteur's Quadrant' – Stokes (1997)

- Research that is aimed **both** at increasing knowledge **and** at generating useful results – cf.
  - Bohr's Quadrant – aimed solely at increasing knowledge
  - Edison's Quadrant – aimed solely at generating useful results

'Triple Helix' (Etzkowitz & Leydesdorff, 1997)

- Growing 3-sided interaction of universities, industry and government
- 'The second academic revolution' – adoption of '3rd Mission'
  ➔ emergence of 'the entrepreneurial university'

Source: Ben R. Martin, The Evolution of Science, Technology and Innovation Policy Research

Science-push model – Bush (1945)

- Provided rationale for govt funding
- Favoured by scientists

Demand-pull model – changed market demand 'calls forth' innovation

Mkt demand ➔ App res ➔ Tech devlpt ➔ Innovation

- Often attributed to Schmookler (1966)
- Model picked up by e.g. Myers and Marquis (1969)
  - Study of >550 innovations in 5 industries
  - "Recognition of demand is a more frequent factor in innovation than recognition of technical potential"

2 models have very different policy implications, so various empirical studies to investigate

Source: Ben R. Martin, The Evolution of Science, Technology and Innovation Policy Research

Literature - From Science push to demand pull

- Project Hindsight (1967) – DoD funded
  - Study of 20 military innovations
  - Critical research events primarily ‘technology’ rather than ‘science'
  - 95% of critical research events directed towards a DoD need
    ➔ demand pull more important
  - BUT arbitrary cut-off point of 20 years
- TRACES (1968) – NSF funded
  - Study of 5 civilian innovations
  - Much longer time-period
  - 70% of critical research events ‘non-mission-oriented’
    ➔ science push more important
- Battelle (1973) – NSF funded
  - Study of ~10 civilian innovations
  - ‘Recognition of technical opportunity’ important in 89% of decisive events, cf. 69% for ‘recognition of need’

Source: Ben R. Martin, The Evolution of Science, Technology and Innovation Policy Research

Literature - From Science push to demand pull

- Comroe & Dripps (1976) – NIH funded
  - Key research underpinning advances in cardiovascular medicine
  - 62% of the research 'basic' – pays off "twice as handsomely"
- Langrish et al., *Wealth from Knowledge* (1972*)*
  - Study of 84 innovations
  - Innovation ""must involve synthesis of some kind of need with some kind of technical possibility"
  - Rejected simple linear models – "the sources of innovation are multiple"
- Mowery & Rosenberg (1979) review
  - Innovation an "iterative process, in which *both* demand and supply forces are responded to"
  - i.e. both demand and supply side influences crucial to understanding the innovation process

Source: Ben R. Martin, The Evolution of Science, Technology and Innovation Policy Research

Science, Technology and Knowledge

Science & Technology

✓ 과학(Science)
검증 가능한 방법으로 얻어진 지식의 체계
Science is the discovery and explanation of nature

✓ 기술(Technology)
과학이론을 실제로 적용하여 자연의 사물을 인간 생활에 유용하도록 가공하는 수단
(사물을 잘 다룰 수 있는 방법이나 능력)
Technology is the manipulation of nature for human purpose

과학과 기술의 구분

구 분	과학(Science)	기술(Technology)
대 상	자연	인공물
목 적	자연현상의 이해	산업 또는 경제적 응용을 전제
동 기	지적 호기심	실질적인 유용성
과 정	가설 연역적, 검증	가설 응용, 실현
핵 심	순수한 지식의 산출에 관여	응용적인 투입과 산출에 관여
목 표	진리의 규명과 발견	생산적인 결과 창출
형 태	이론적인 면	사실적인 면
법 칙	보편적, 미래 예측적	처방적, 구체적
권 리	공공재[4] (전유될 수 없음)	사유재[5] (전유될 수 있음)
특 성	시장에서 거래될 수 없음	시장에서 거래될 수 있음
가 치	지식의 보급	특허제도를 통한 지적소유권의 보장
보 상	경제적 보상과 무관	경제적 이윤에 대한 기대

유경만, 양혜영 (2008). 기초원천연구의 개념 정립 및 추진방안에 대한 정책제언, KISTEP

Science & Technology

	과 학	기 술	산 업
지식생성 동기	- 호기심에 의한 발견	- 신제품·공정의 개발	- 기업의 수익추구
지식생성 주체	- 과학자 - 대학, 공공 연구소	- 기술자 - 기업 연구소	- 기업가, 산업분석자 - 기업
지식생성 목적	- 소속 커뮤니티에서 명성 확보 - 자신의 존재를 인식	- 소유가능한 기술이나 프로세스를 구성하고 디자인 - 제도를 통해 지식을 보호	- 회계보고 등 제도적 강제 - 기업전략 수립 - 산업시장 분석
지식표현 특성	- 문서화 경향	- 문서화 거부 경향	- 제한적 문서화
지식생성 형태	- 학술논문	- 특허 - 영업비밀(노하우)	- 생산실적, 재무자료 등 - 기타 다양한 형태
지식활용 특성	- 공공성	- 사유성 - 암묵성	- 사유성 - 부분적 공공성
지식축적 형태	- 체계적/누적적(과학문헌 DB)	- 체계적/누적적(특허 DB) - 비체계적(암묵지)	- 비체계적 - 비누적적

박현우, 손종구, & 유선희. (2010). 과학-기술-산업 간 지식흐름 연계구조 분석체계 개발.

R&D

연구개발단계별 특성 비교

구 분	기초연구	응용연구	실험개발
개 념	일반적 원리 및 이론 규명	특정목적에의 활용가능	사회적으로 유용한 재화 생산
투 입	Scientific knowledge, Scientific problems	Scientific knowledge, Technology, Practical problems	Scientific knowledge, Technology, Practical problems, Raw inventions
산 출	일반적 지식 (Formula)	특정목적을 위한 지식(Sketches)	Blue prints, Manuals, Proto-types
성과물	새로운 과학적 지식 (논문 중심)	응용성 검증 (특허 중심)	새로운 재료·제품 및 장치의 생산 (신제품, 신공정)
투자주체	정부(중심)	정부+기업	기업(중심) *
연구기간	장 기	중 기	단 기
성공요인	창의성 (새로운 아이디어, 모험심)	발견된 원리들의 효과적인 조합	현실에의 활용가능성

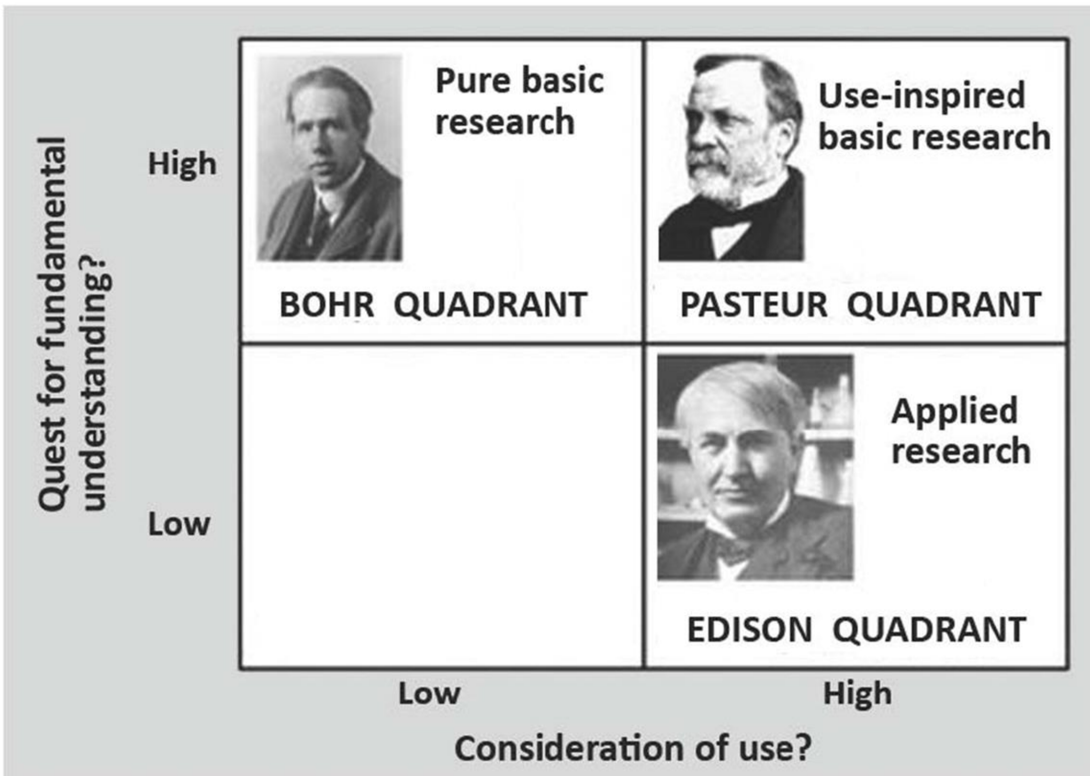
* 개발연구 중 중소기업, 국방, 리스크가 큰 우주 등은 정부 지원이 필요

유경만, 양혜영 (2008). 기초원천연구의 개념 정립 및 추진방안에 대한 정책제언, KISTEP

✓ Frascati Manual : 연구개발 통계 및 조사분석을 위한 표준지침으로 국제적으로 인정되는 연구개발의 정의와 분류체계 등을 제공하는 지침서(guide-line)로서 연구개발 분야의 바이블

R&D 구분의 새로운 시각 – Pasteur's Quadrant

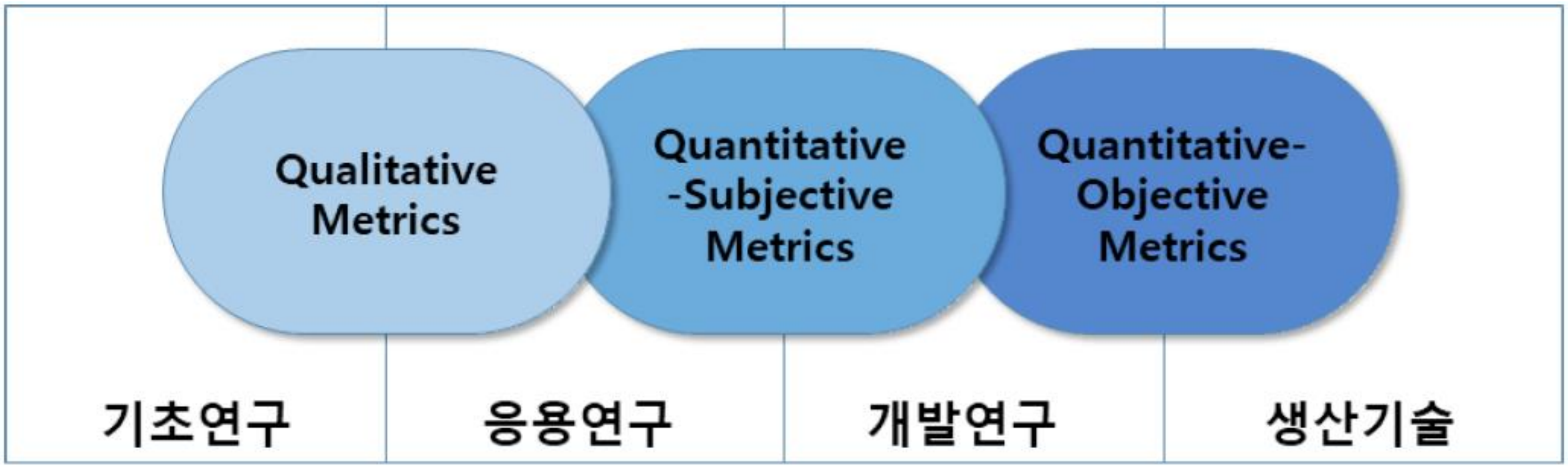
✓ 새로운 질문 : 기초연구는 순수한 이해를 목적으로, 응용연구는 실용적 목적으로 한다지만, 응용목표를 가진 기초연구도 존재 (ex. 파스퇴르의 연구들)



Pasteur's Quadrant
=> <u>이용을 위한 기초연구</u>

Stokes, D. E. (1997). Pasteur's Quadrant: Basic Science and Technological Innovation.

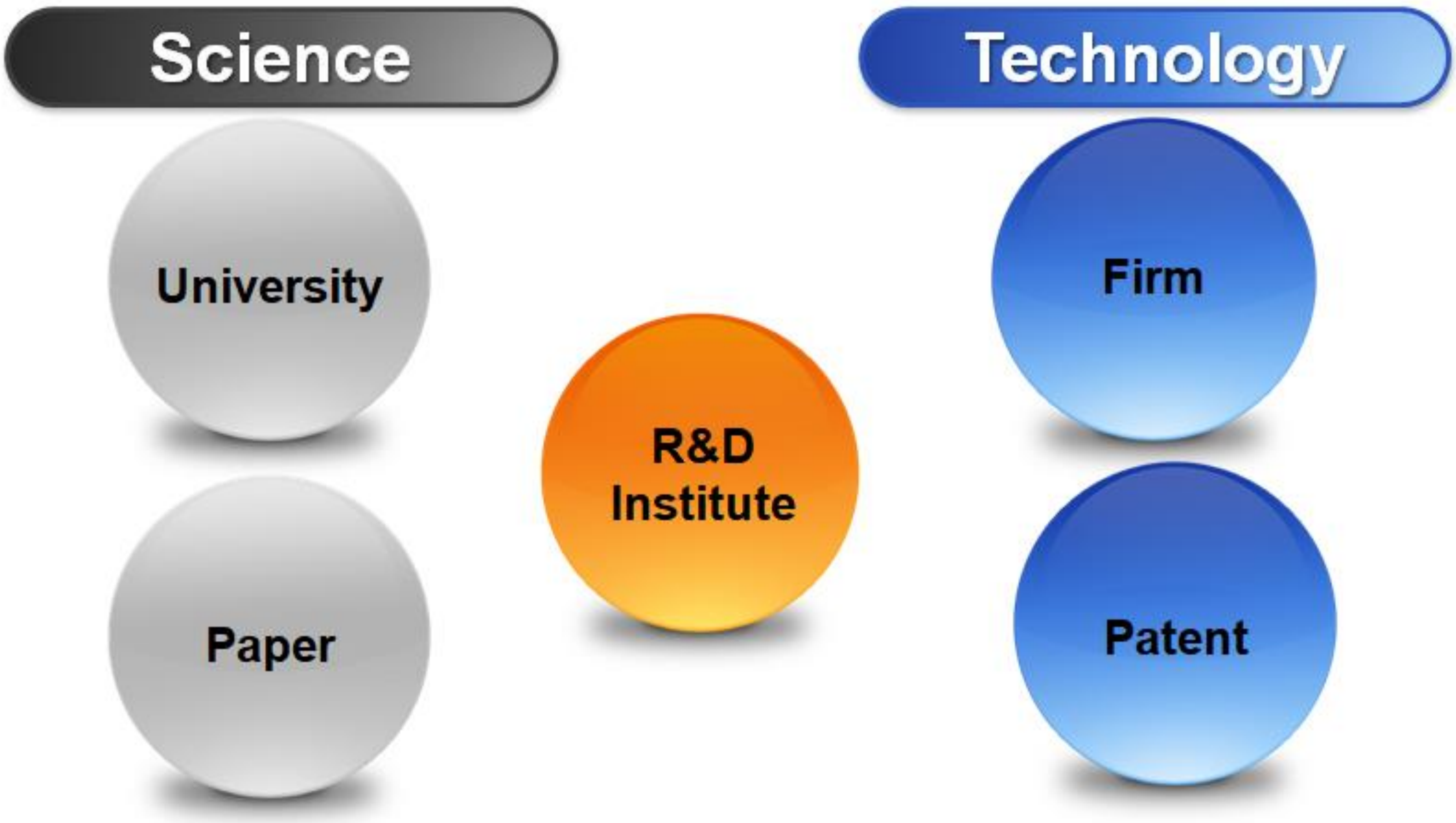
R&D Productivity



장진규, 「공공연구개발투자의 생산성 분석 방법론개발」, STEPI, 2003

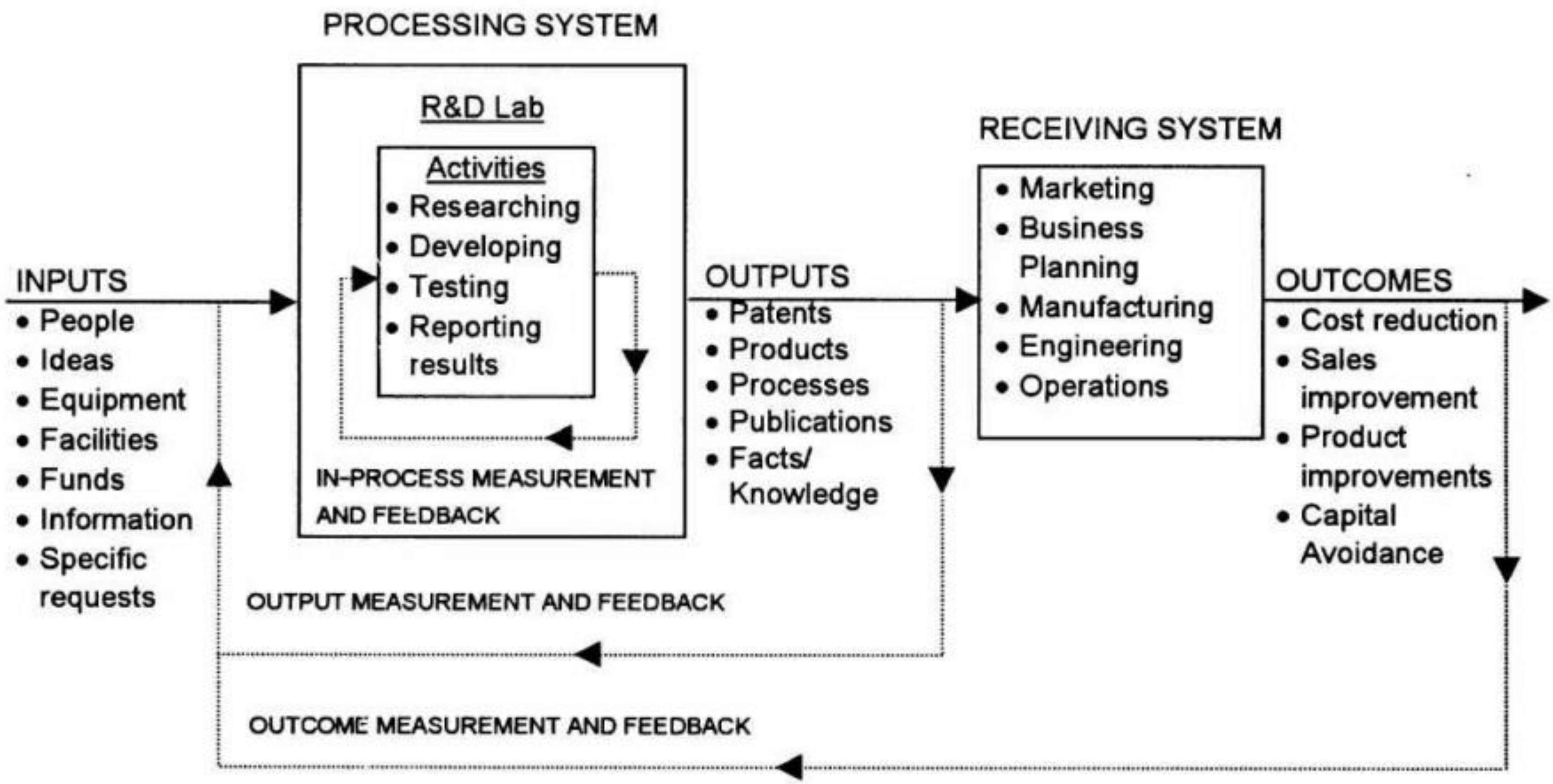
Measurement Science and Technology

In social science…(innovation study)



R&D Productivity

✓ R&D measurement framework



Brown and svenson(1988); Cozarin, 2008

Academic papers

Technological Forecasting & Social Change 76 (2009) 723–736

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Coevolutionary cycles of convergence: An extrapolation from the ICT industry

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ABSTRACT

Convergence between technologies can be regarded as an increasingly emerging trend, and has received particular attention in the coming-together of previously distinct products and solutions within the information and communication technologies (ICT) industry. In previous research, the overall impact of the convergence phenomenon remains ambiguous. Whereas some scholars suggest convergence to be associated with disintegration, entry and growth, others relate the phenomenon to opposite effects, such as consolidation and shakeouts. This inconsistency in managerial conceptions on convergence formulates a need for an integrated understanding. Within a multi-case study approach, the convergence within ICT has been observed through

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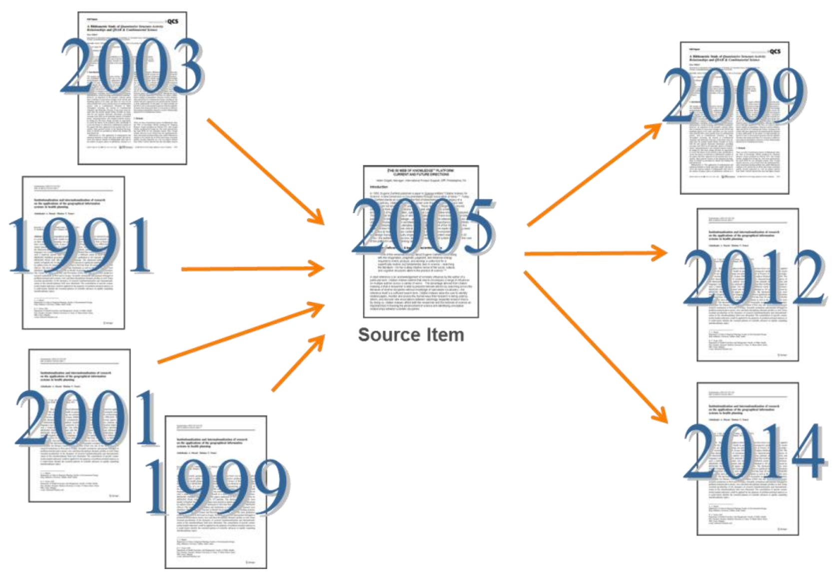

어떠한 문제를 풀 수 있나?

과학자들의 공동연구 형태

분야별 핵심 과학자, 대학(기관), 연구성과

과학 진보의 속도 및 확산 패턴

특정 과학분야에서의 우리나라(기관) 취약 부문

특정 연구성과의 수명

기관별, 분야별 융합의 정도

Patent -USPTO

US008879882B2

(12) **United States Patent**
Conner et al.

(10) **Patent No.: US 8,879,882 B2**
(45) **Date of Patent: Nov. 4, 2014**

(54) **VARIABLY CONFIGURABLE AND MODULAR LOCAL CONVERGENCE POINT**

(75) Inventors: **Mark Edward Conner**, Granite Falls, NC (US); **William Julius McPhil Giraud**, Azle, TX (US); **Lee Wayne Nored**, Watauga, TX (US); **Gary Bruce Schnick**, Granite Falls, NC (US)

(73) Assignee: **Corning Cable Systems LLC**, Hickory, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 272 days.

(21) Appl. No.: **13/094,572**

(22) Filed: **Apr. 26, 2011**

(65) **Prior Publication Data**

US 2011/0211799 A1 Sep. 1, 2011

Related U.S. Application Data

(63) Continuation of application No. PCT/US2009/062266, filed on Oct. 27, 2009.

(60) Provisional application No. 61/108,788, filed on Oct. 27, 2008.

(51) **Int. Cl.**
G02B 6/00 (2006.01)
G02B 6/44 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 6/4471*** (2013.01); *G02B 6/4452* (2013.01); *G02B 6/4454* (2013.01)
USPC **385/135**; 385/134

(58) **Field of Classification Search**
None
See application file for complete search history.

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Primary Examiner — Uyen Chau N Le
Assistant Examiner — Chad Smith

(57) **ABSTRACT**

A variably configurable fiber optic terminal as a local convergence point in a fiber optic network is disclosed. The fiber optic terminal has an enclosure having a base and a cover which define an interior space. A feeder cable having at least one optical fiber and a distribution cable having at least one optical fiber are received into the interior space through a feeder cable port and a distribution cable port, respectively. A movable chassis positions in the interior space and is movable between a first position, a second position and third position. The movable chassis has a splitter holder area, a cassette area and a parking area. A cassette movably positions in the cassette area. A splitter module holder having a splitter module movably positioned therein movably positions in the splitter holder area. The optical fiber of the feeder cable and the optical fiber of the distribution cable are optically connected through the cassette, which also may be through the splitter module. In such case, the optical fiber of the feeder cable optically connects to an input optical fiber to the slitter module, where the optical signal is split into a plurality of output optical fibers. One of the plurality of output optical fibers connects to the optical fiber of the distribution cable for distribution towards a subscriber premises. The interior space is variably configurable by changeably positioning the cassette and splitter modules in the movable chassis.

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어떠한 문제를 풀 수 있나?

- 기업간 기술 협력관계
- 분야별의 핵심 기업, 핵심 기술
- 기술 진보의 속도 및 확산 패턴
- 특정 기술분야에서의 우리나라(기관) 취약 부문
- 특정 기술의 수명
- 국가별, 기관별, 분야별 융합의 정도

과학-기술 연계성 분석

◆ 특허의 NPL (Non-Patent Literature) : 특허에 있는 참고문헌 중 비 특허문헌

분야별 과학지식 연계강도

		N	평균	표준편차	표준오차	평균에 대한 95% 신뢰구간		최소값	최대값
						하한값	상한값		
1990 년대	전기전자	1,232	1.6431	.0932	.0027	1.6409	1.6513	1.33	1.71
	도구 및 장치	216	1.9815	.1448	.0099	1.9621	2.0009	1.43	2.07
	화학, 의약품, 바이오	463	3.5508	.7909	.0368	3.4785	3.6230	2.32	4.72
	공정기술	149	2.1678	.1925	.0158	2.1366	2.1989	1.25	2.28
	기계공학, 기계류	37	1.9730	1.0870	.1787	1.6106	2.3354	1.00	4.33
	소비재	6	1.0000	.0000	.0000	1.0000	1.0000	1.00	1.00
	합계	2,103	2.1408	.8693	.0190	2.1036	2.1779	1.00	4.72
2000 년대	전기전자	2,921	2.1410	.3068	.0057	2.1299	2.1522	1.76	2.62
	도구 및 장치	934	4.0268	.7281	.0238	3.9800	4.0735	2.63	4.43
	화학, 의약품, 바이오	1,059	5.7129	1.1468	.0352	5.6438	5.7821	2.54	6.35
	공정기술	376	3.9229	.9236	.0476	3.8292	4.0165	2.57	5.43
	기계공학, 기계류	90	2.5444	2.0973	.2211	2.1052	2.9837	1.00	11.25
	소비재	13	2.2308	.0693	.0192	2.1889	2.2727	2.00	2.25
	합계	5,393	3.3002	1.5921	.0217	3.2577	3.3427	1.00	11.25
전체 기간	전기전자	4,153	1.9942	.2327	.0036	1.9871	2.0013	1.67	2.36
	도구 및 장치	1,150	3.6426	.6529	.0193	3.6048	3.6804	2.44	4.02
	화학, 의약품, 바이오	1,522	5.0552	1.0529	.0270	5.0023	5.1081	2.63	5.81
	공정기술	525	3.4248	.7764	.0339	3.3582	3.4913	2.09	4.75
	기계공학, 기계류	127	2.3780	1.7480	.1551	2.0710	2.6849	1.29	11.25
	소비재	19	1.8421	.0382	.0088	1.8237	1.8605	1.83	2.00
	합계	7,496	2.9749	1.3847	.0160	2.9436	3.0063	1.29	11.25

강도 : 국 가, 기술분야, 기업 등에 대한 특허 1건당 인용된 평균 과학논문 수 (전체 특허에 인용된 과학논문의 수/전 체 등록특 허의 수)

박현우, 손종구, & 유연우. (2011). 우리나라 기술혁신에서의 과학-기술 지식연계 특성분석. *기술혁신학회지*, *14*(1), 1-21.

과학-기술 연계성 분석

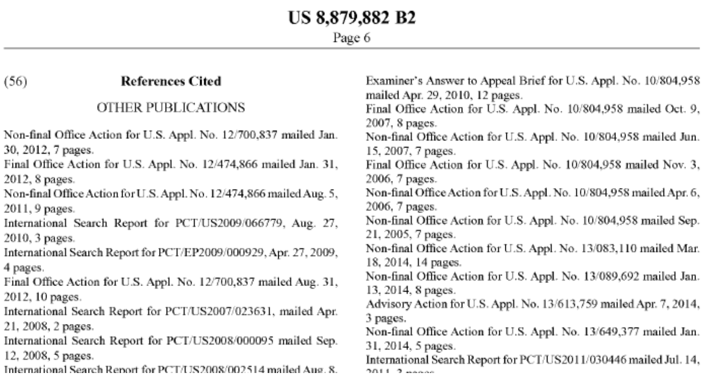
논문-특허간 시차

		N	평균	표준편차	표준오차	평균에 대한 95% 신뢰구간		최소값	최대값
						하한값	상한값		
1990 년대	전기전자	2,027	6.00	5.644	.125	5.75	6.24	-4	47
	도구 및 장치	428	7.28	7.013	.339	6.62	7.95	-2	56
	화학, 의약품, 바이오	1,644	9.67	9.246	.228	9.22	10.11	-2	72
	공정기술	323	7.84	7.959	.443	6.97	8.71	-1	54
	기계공학, 기계류	73	7.18	6.203	.726	5.73	8.63	0	34
	소비재	6	13.33	8.892	3.630	4.00	22.66	2	24
	합계	4,501	7.62	7.631	.114	7.40	7.84	-4	72
2000 년대	전기전자	6,243	5.58	5.357	.068	5.44	5.71	-3	73
	도구 및 장치	3,759	6.72	5.707	.093	6.54	6.90	-3	69
	화학, 의약품, 바이오	6,079	8.51	9.536	.122	8.27	8.75	-4	111
	공정기술	1,438	6.45	6.988	.184	6.09	6.81	-3	58
	기계공학, 기계류	229	6.64	6.543	.432	5.79	7.49	-3	31
	소비재	29	3.24	3.334	.619	1.97	4.51	-1	12
	합계	17,777	6.90	7.356	.055	6.79	7.01	-4	111
전체 기간	전기전자	8,270	5.68	5.431	.060	5.56	5.80	-4	73
	도구 및 장치	4,187	6.78	5.855	.090	6.60	6.95	-3	69
	화학, 의약품, 바이오	7,723	8.75	9.486	.108	8.54	8.97	-4	111
	공정기술	1,761	6.71	7.193	.171	6.37	7.04	-3	58
	기계공학, 기계류	302	6.77	6.456	.372	6.04	7.50	-3	34
	소비재	35	4.97	5.973	1.010	2.92	7.02	-1	24
	합계	22,278	7.05	7.418	.050	6.95	7.14	-4	111

박현우, 손종구, & 유연우. (2011). 우리나라 기술혁신에서의 과학-기술 지식연계 특성분석. *기술혁신학회지*, *14*(1), 1-21.

과학-기술 연계성 분석

◆ 특허의 NPL (Non-Patent Literature) : 특허에 있는 참고문헌 중 비 특허문헌



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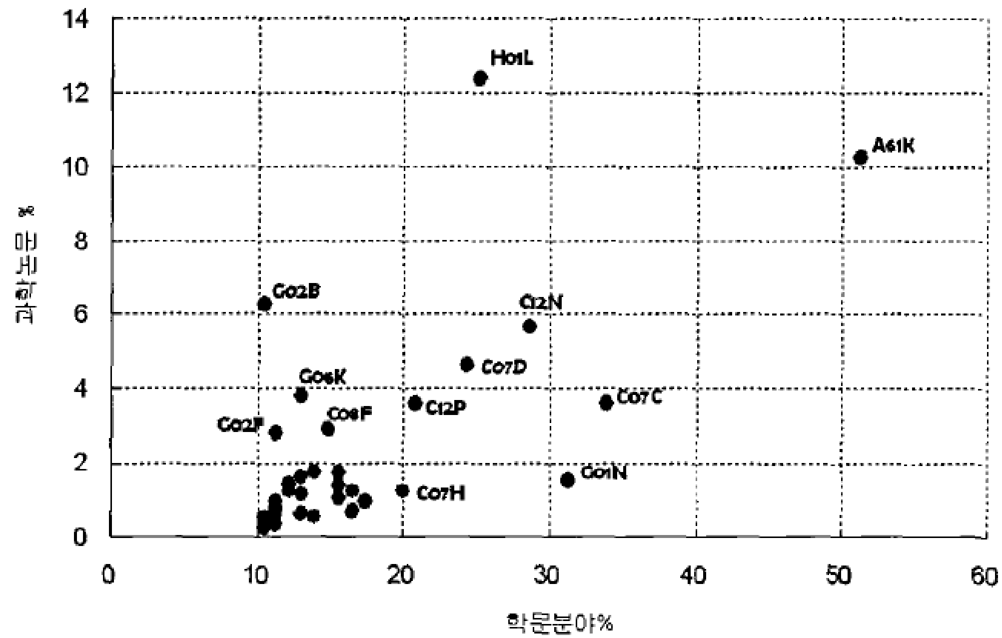
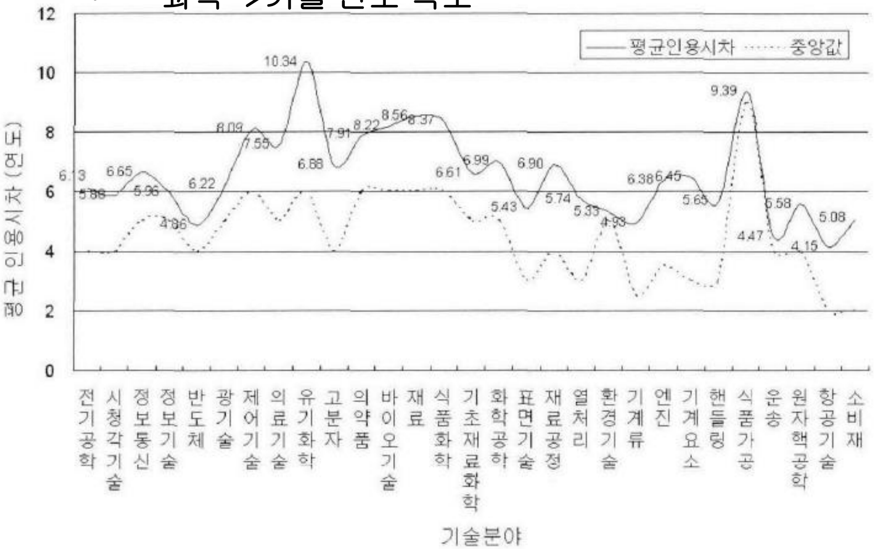
• 특허 기술분야별 과학 흡수 패턴



• 과학->기술 진보 속도



Source : 노경란,한상완(2006)

Next class……

1. **Types, Architecture and Taxonomy 관련 논문**
   (아키텍쳐 혁신, 모듈러혁신, Pavitt 분류, 혁신의 분류)

   1편 요약

Thank you

Comments & Questions