Technology and Innovation Management

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Measuring Innovation and Performance

(the 'micro' story)

The 10 most innovative companies in 2018

1	Alphabet/Google
2	Amazon
3	Apple
4	Microsoft
5	Samsung[1]
6	Netflix
7	IBM
8	Facebook
9	Tesla
10	Adidas

Source: BCG (adapted), Google images

The 10 most profitable companies in 2018

NAME	PROFITS ($M)
Apple	$59,531.0
JPMorgan Chase	$32,474.0
Alphabet	$30,736.0
Bank of America	$28,147.0
Wells Fargo	$22,393.0
Facebook	$22,112.0
Intel	$21,053.0
Exxon Mobil	$20,840.0
AT&T	$19,370.0
Citigroup	$18,045.0

Source: Fortune, Google images

Most innovative = Most profitable?

- Is there maybe a time lag?
- 5-year comparison:

	2014		2015		2016		2017		2018	
	Most innovative	Most profitable	Most innovative	Most profitable	Most innovative	Most profitable	Most innovative	Most profitable	Most innovative	Most profitable
1	Apple	Apple	Apple	Apple	Apple	Apple	Apple	Apple	Google	Apple
2	Google	Exxon Mobil	Google	J.P. Morgan Chase	Google	J.P. Morgan Chase	Google	Berkshire Hathaway	Amazon	J.P. Morgan Chase
3	Samsung	Wells Fargo	Tesla	Berkshire Hathaway	Tesla	Berkshire Hathaway	Microsoft	Verizon	Apple	Google
4	Microsoft	Microsoft	Microsoft	Wells Fargo	Microsoft	Wells Fargo	Amazon	AT&T	Microsoft	Bank of America
5	IBM	J.P. Morgan Chase	Samsung	Gilead Sciences	Amazon	Google	Samsung	J.P. Morgan Chase	Samsung	Wells Fargo
6	Amazon	Berkshire Hathaway	Toyota	Verizon	Netflix	Bank of America	Tesla	Comcast	Netflix	Facebook
7	Tesla	Chevron	BMW	Citigroup	Samsung	Microsoft	Facebook	Wells Fargo	IBM	Exxon Mobil
8	Toyota	Walmart	Amazon	Google	Toyota	Johnson & Johnson	IBM	Pfizer	Facebook	AT&T
9	Facebook	Johnson & Johnson	Daimler	Exxon Mobil	Facebook	Citigroup	Alibaba	Microsoft	Tesla	Citigroup
10	HP	General Electric	Bayer	Bank of America	IBM	Altria Group	Netflix	Exxon Mobil	Adidas	Microsoft

Source: BCG, Fortune

- Results:
  - Some companies are highly innovative and highly profitable
  - Most profitable companies are banks
  - Some highly innovative companies are not (yet) highly profitable

Most innovative = Most valuable? Most income?

- Are we using the wrong measure for performance?
- Comparison for market value and revenue:

	2018		
	Most innovative	**Most valuable**	**Most revenue**
1	Google	Microsoft	Walmart
2	Amazon	Apple	Exxon Mobil
3	Apple	Amazon	Apple
4	Microsoft	Google	Berkshire Hathaway
5	Samsung	Berkshire Hathaway	Amazon
6	Netflix	Facebook	UnitedHealth Group
7	IBM	Johnson & Johnson	McKesson
8	Facebook	Visa	CVS Health
9	Tesla	Exxon Mobil	AT&T
10	Adidas	JPMorgan Chase	AmericourceBergen

Source: BCG, Fortune

- Results:
  - Some companies are highly innovative and valuable, and also generate high revenues
  - Some correlation between Innovativeness and market value

The 10 most reputable companies in 2018

The World's Most Reputable Companies 2018 : .	
Rank	**Company**
1	Rolex
2	LEGO
3	Google
4	Canon
5	The Walt Disney Company
6	Sony
7	Adidas
8	Bosch
9	BMW Group
10	Microsoft

Source: American Banker/Reputation Institute 2019, Google images

Is innovation always a good thing?

- "Being perceived as innovative and first to market with new solutions and adaptive to industry changes"…
- …has **lowest impact** on Bank's reputation for both costumers and non-costumers (American Banker/Reputation Institute, 2019)

- Does (perceived) innovation come with a risk markup?

→ **Balancing stability and change**

Measuring Innovation and Performance

(the 'micro' story)

Last time

Long waves of economic development and growth

- Evidence of a positive, long term relationship between developments in S&T and growth, at the macro level → good news for engineers and scientists

'Boom and bust' dynamics

- Crisis happen due to the existence of 'frictions' between changes in S&T (that can be very fast) and changes in organizations and institutions (that tend to lag behind) → role of TIM (CTOs) in practice

Trends in S&T (R&D expenditure)

- Recent empirical trends point toward a decrease of the 'S' component in investments in 'S&T'. Is this a problem? → open innovation, platforms, ecosystems

Learning objectives

Key concepts

- Indicators and measures of innovation

Innovation and performance

- Some evidence, at various levels of analysis

Abilities

- Critically evaluate the use of the term ‘innovation’

Required Readings for today

- Cefis, E., & Ciccarelli†, M. (2005). Profit differentials and innovation. *Economics of Innovation and New Technology*, *14*(1-2), 43-61.

- Smith, K. (2006) Measuring Innovation. In Fagerberg, J. Mowery, D.C. and Nelson R. R. (eds.) The Oxford Handbook of Innovation (p. 14-177). Oxford University press.

Suggested Readings for today

- Cefis, E., & Marsili, O. (2006). Survivor: The role of innovation in firms' survival. *Research Policy*, *35*(5), 626-641.
- Silvestro, R. (2016). Do You Know What Really Drives Your Business's Performance?. MIT Sloan Management Review, 57(4), 28.

First, definitional clarity

Invention vs. Innovation

Definition (Schmookler, 1966)

When an enterprise produces a good or service or uses a method or input that is new to it, it makes technical change. The first enterprise to make technical change is an innovator. Its action is innovation

Definition (OECD, 1995)

Scientific and technological innovation may be considered as the transformation of an idea into a new or improved product introduced on the market, into a new or improved operational process used in industry and commerce, or into a new approach to a social service

First! Otherwise imitation.

First on the market! Otherwise 'invention'

Key difference between these two definitions?

Different types of innovation

Novelty Difference		
Radical	⟷	Incremental

Input/Output		
Product	⟷	Process

Scope		
Architecture	⟷	Component

Adapted from HKUST Business School

The innovation process

Characteristics

- All of the activities which bring about technological change, and the dynamic interaction among them.
- Innovations involve a series of scientific, technological, organisational, financial and commercial activities.
- One of the most important elements of the innovation process is the so-called ‘R&D process’

R&D: What is it? Who performs it?

Research and Development

Definition: R&D

- **Research and experimental development (R&D)** comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man [***sic***], culture and society, and the use of this stock of knowledge to devise new applications

Categories of indicators

Macro vs. micro

e.g. R&D expenditures vs. S&T personnel

Input vs. output

e.g. patents vs. publications vs. product launches

Relative vs. absolute

e.g. ‘new to the firm’ vs. ‘share of revenues’

‘Subjective’ vs. ‘objective’ (careful here)

e.g. innovation surveys vs. financials

Science, Technology, and Innovation indicators

R&D Data (following the *Frascati Manual*)

- ✓ Can distinguish between sector of performance, source of funding, objectives, fields of research
- ✓ Long record of standardized data collection over many countries
- • Measures *input* to innovation only
- • A country's R&D intensity is more complex than a number (e.g. different industries)

Patents (applications, grant, citations)

- ✓ Record advances in technical knowledge, in significant detail, in public records (for centuries)
- ✓ Requires a commercial promise (innovation?)
- ▪ Firms patent for many reasons (and protect knowledge in many other ways than patents)

Other public records of innovation

- ▪ Bibliometric data (scientific publications and citations)
  - ▪ Vast amount of data on basic (and applied) research that captures scientific development
- ▪ Trademark statistics to complement patents
  - ▪ Growth in advanced countries is increasingly in areas that patents don't capture

Specific and specialized datasets:

- ▪ Technometric indicators: performance characteristics of products
- ▪ Synthetic scoreboard indicators (mainly in consulting)
- ▪ Databases on specific topics as research tools

Patents, in more detail

(12) **United States Patent**
Olson

(10) **Patent No.: US 6,368,227 B1**
(45) **Date of Patent: Apr. 9, 2002**

(54) **METHOD OF SWINGING ON A SWING**

(76) Inventor: **Steven Olson**, 337 Otis Ave., St. Paul, MN (US) 55104

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/715,198**

(22) Filed: **Nov. 17, 2000**

(51) **Int. Cl.**[7] **A63G 9/00**
(52) **U.S. Cl.** **472/118**
(58) **Field of Search** 472/118, 119, 472/120, 121, 122, 123, 125

(56) **References Cited**

U.S. PATENT DOCUMENTS

242,601 A * 6/1881 Clement 472/118
5,413,298 A * 5/1995 Perreault 248/228

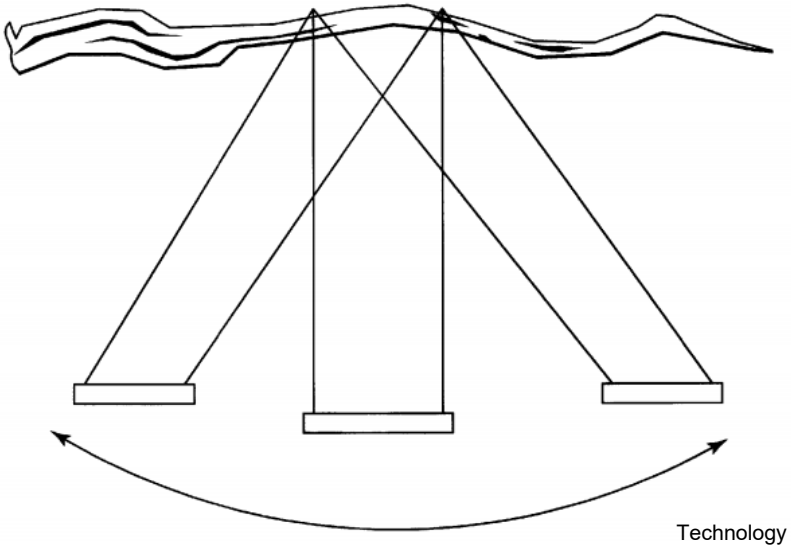
* cited by examiner

Primary Examiner—Kien T. Nguyen
(74) *Attorney, Agent, or Firm*—Peter Lowell Olson

(57) **ABSTRACT**

A method of swing on a swing is disclosed, in which a user positioned on a standard swing suspended by two chains from a substantially horizontal tree branch induces side to side motion by pulling alternately on one chain and then the other.

4 Claims, 3 Drawing Sheets



Patents, in more detail

Information contained in a patent

- Declaration of prior art (patents and scientific papers)
- Explanation of the technical principle
- Novelty claims (hierarchically)
- Suggested application in commercial use
- Classification (indication of technology field)
- Information on the inventor (persons + organization)

Uses (and abuses) of patent statistics

Research uses

Generally, to study patterns of technological activity and their effects on economic and competitive performance.

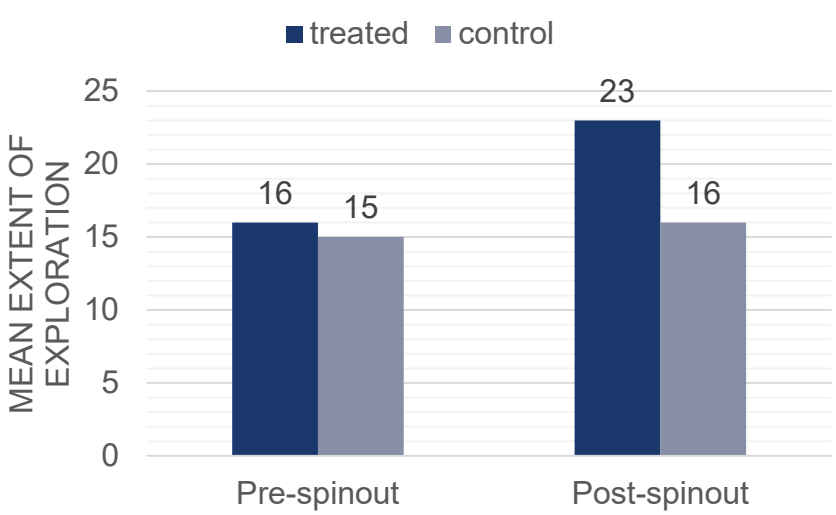
Specifically, for example:

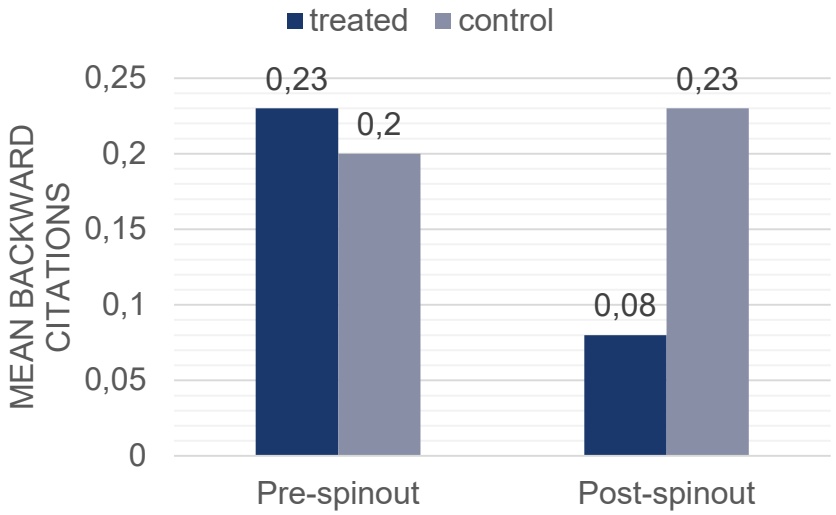
- Classifications: knowledge bases of firms/sectors, analysis/comparisons of technological fields
- Citations: which inputs were used for innovation; positioning/importance of patent in larger system
- Novelty claims: provide measure of importance of individual inventions
- Authorship: who are inventors, and what drives their output

Caveats

- Is a patent an invention, innovation, both, or neither?
- Industries differ: how to compare patents in pharma, construction, and software?
- Countries differ, in the cost and benefit of patenting inventions
- Understand why firms apply for patents in the first place, and why they write them the way they do

Research using patents: "Inventor rejuvenation through spinouts" (more in session 7)





* 1st year in spin-outs (i.e., t_0) dropped

Source: Cirillo, Brusoni & Valentini (2013)

- Study on how spinout constructions change the inventive behavior of personnel
- Combining data on inventors, assignees, citations, and classification

Innovation surveys

Approaches to surveys

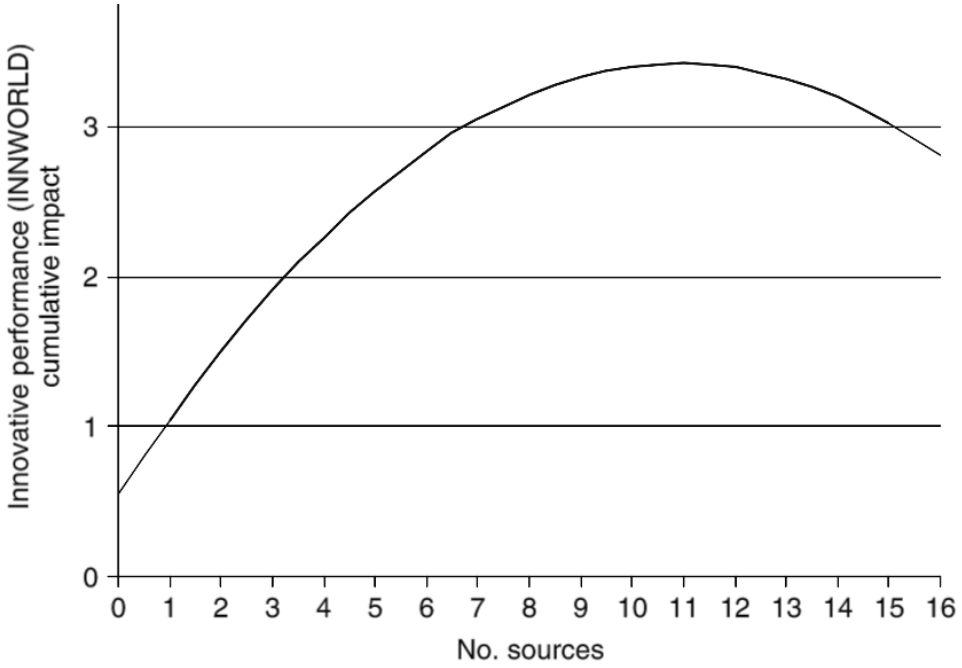
- The “object” approach: create a complete overview of *output* (e.g. innovations) in a given area
- The “subject” approach: understand what a complete set of *firms* are doing in terms of innovative activity

The Community Innovation Survey (CIS)

- ✓ Asks European firms about innovation input, output, sources for innovation, collaboration, factors affecting innovation
- ✓ Highly standardized (Oslo Manual), but informed by research
- ✓ Forms the basis of official databases (Eurostat), national policy, and innovation research

- Emerging fields pose challenges to the validity of the survey (services, IT, platforms?)
- Does not capture non-technological aspects of innovation

CIS in innovation research: “Open for innovation” (2006)



Source: Laursen & Salter (2006)

Figure 1. Predicted relationship between innovative performance and the breadth of search through external sources of innovation

- First large-scale empirical evidence for the “Open Innovation” model
- Based on the CIS 2001, UK data

The link between innovation and performance

Some Evidence: Innovators vs. Persistent Innovators

Many firms innovate, few innovate persistently.

Advantages of persistent Innovators

- **Profitability**
- **Survival**
- Export (for high tech sectors, mainly)
- Growth (more complex measurement issues)

Conducting research on innovation and performance

Where to get the data:
Sample selection:
- 267 UK Manufacturing firms
  - Random samples of 400 innovating firms and non-innovating firms
  - Filtered for which had complete data
- In the form of a balanced 5-year panel (for economic variables), 14-year panel (patent data)

Data sources:
- Firm-level: DataStream / ICC (economic variables), EPO data (patents)
- Industry-level: Business Monitor

Operationalizing 'innovation' and 'performance'
Independent variables ("innovation") and controls:
- Number of patents as proxy for innovative activities
  - 0 patents: non-innovator
  - 1 patent: innovator
  - No 2 years without new patent: persistent inn.
- Sector information (with associated concentration degree and average scale)
- Cost considerations of firm (capital intensity, average labor costs)
- Firm-level controls (market share and size as employee count)

Dependent variables ("performance")
- Operating profit margin as a proxy for performance
  - Operating profits – after depreciation and before taxes – divided by total sales

Some Evidence: Innovation and Profitability

Bayesian Estimates of the AR(1) for Profit Margins

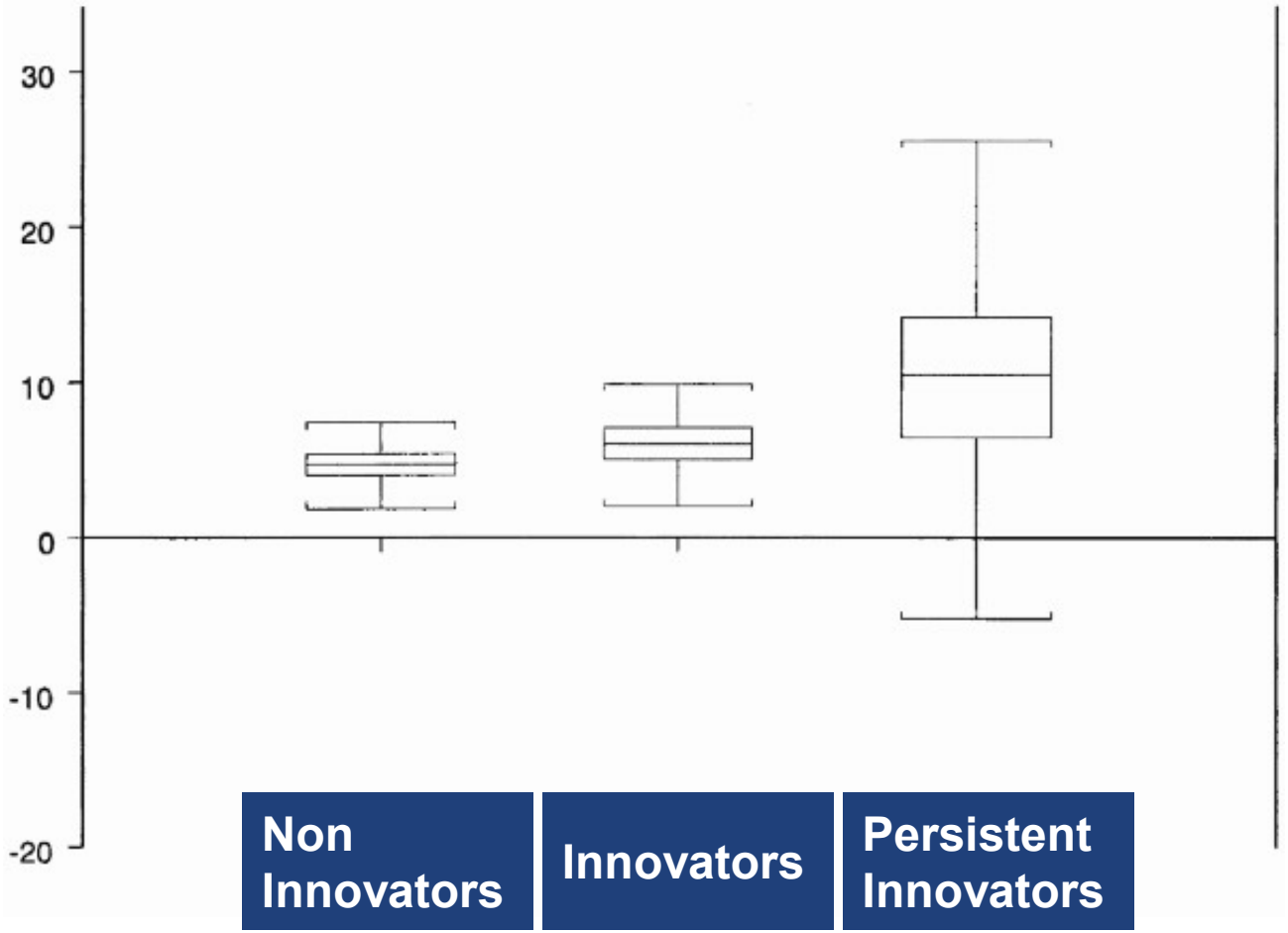
	All		Non-innovators		Innovators		Persistent innovators	
	ρ	ss	ρ	ss	ρ	ss	ρ	ss
1st quart	0.38	4.33	0.27	3.99	0.69	5.01	0.73	6.42
Median	0.7	5.59	0.33	4.71	0.72	6.03	0.83	10.49
3d quart	0.79	7.31	0.38	5.4	0.76	7.09	0.94	14.19

Note: ρ, the estimate of the autoregressive parameter; ss, the estimate of the study state. The first quartile, the median, and the third quartile are reported for each distribution. Posterior distribution of the relevant parameters.

Cefis and Ciccarelli (2005)

Some Evidence: Innovation and Profitability

Posterior distribution of steady states



Cefis and Ciccarelli (2005)

Some Evidence: Innovation and Survival

Survival probabilities of innovators and non-innovators by size class and transition period

	Innovators				Non-Innovators			
	Number of Months				Number of Months			
Size Class	24	30	36	42	24	30	36	42
Small	0.95	0.94	0.93	0.92	0.93	0.91	0.9	0.89
Medium	0.96	0.95	0.95	0.94	0.94	0.93	0.92	0.91
Large	0.95	0.93	0.92	0.91	0.93	0.92	0.9	0.88

Cefis and Marsili (2006)

Some Evidence: Innovation and Survival

Survival probabilities of innovators and non-innovators by size class and transition period

	Innovators				Non-Innovators			
	Number of Months				Number of Months			
Age Class	24	30	36	42	24	30	36	42
Young	0.92	0.9	0.88	0.87	0.88	0.85	0.83	0.81
Grown-up	0.96	0.95	0.93	0.92	0.92	0.9	0.89	0.88
Old	0.96	0.95	0.94	0.93	0.94	0.92	0.91	0.9

Cefis and Marsili (2006)

Category	Innovation	Innovativeness	Readiness
Individual	Experience, Experience with risk technologies (1), Tenure (1), Knowlegde generality (1), Extent of exploration (1)	No of ideas(9), Invention disclosures (10), Patent filings (9), Pilots created, Impact of work on current products/operations (8)	Experience with Technology(8), Risk taking(7), Interaction(8), Competetition acquisition(7)
Team	Employee satisfaction (2), Creativity, Number and quality of patents (2), Cost versus budget, IP management	Technology adaptiveness(8), Continuous Learning(8), No.of suggestions(8), Reward system(8), Patents per employee(9)	Failure tolerance(7), Goal stability(8), Collective orientation(7), Support of new ideas(11)
Project	Cost versus budget, Number and quality of patents (2), R&D spending (5), R&D effectiveness (3), Productivity (2)	Patent applications (9), Invention disclosures(10), Patent citations(9)	Technology analysis ability(16), Agile decision making(11), Talent integration(12), Tacit knowledge(15)
Product	Performance of creation (3), Product performance (3), Product risks (3), Product quality (3) , Innovation level (3)	Time to market(18), Product quality(6), Reliability(7), Innovation level(7), Sustaining competition(18)	Legality(7), Degree of uncertainity(18), Side effects(18), Environmental impact(7)
Process	R&D spending (5), Patents (1), Extent of exploration (1), Citations (1), Spin-out (1), Productivity (2), External collaboration	Effect on costs(17), Operational work flow(11), Performance monitoring(17), Productivity(11)	Risk planning(7), Project delay(7), Resource availability(14), Knowledge accumulation system(11)
Firm	Innovation culture and strategy (3), Knowledge absorption (3), R&D effectiveness (3), Top management commitment (3)	Maintaining leadership(11), No of new products(12), Need for new resources(11), Influence on strategy(12), Skills, Discontinuity product/service can generate (6)	R&D activity index(16), Technology analysis ability(16), Capicty to build the product(16), Marketing ability(16), Innovation management ability(16)
Industry	Sales of competitors, Margins and costs, Growth, Pipeline value (2), Extending patent lifetimes	Protection possibility[7], Competetive advantage[7], Product quality[7], Synergy potential[7]	Degree of uncertainity(12), Ease of production(12), Development efficiency(12), Competetiveness progress(14)
Ecosystem	New products/service (5), Talent creation, Live events, Project innovation, Technology transfer	Competition on market(14), Distribution channels (14), Entry strategy(13)	Readiness of partners(14), Dependance(7), Entry strategy(14), Spending on reputation and branding(7), Environmental support(7)
Service firm	Customer demand (3), Customer satisfaction (3), Market situation (3), Marketing effort (3), Marketing risks (3)	Ratio of new customers(14), Break even time(7), Retention rate(13), Customer complaints(7), Response time to requests(14), Perceived value(14),	Customer awareness(14), Product education(14), Integration/adaption costs(14), Trend/Duration of demand(14), Compatability(7)
Social Media	Number of hits/visits/views (4), Number of followers or friends (4), Repeat visits (4), Product/service ratings (4), Buzz indicators (4)	Community building(15), Product Information(15), Brand promotion (15) Reactional support (15), User education (15)	Support(initial) 15, Brand defense(15), Conference activities (15), User integration (15)

Source: TIMGROUP MTEC ETH Zürich

Learning objectives, concepts

TIM
(The analysis of evolving sociotechnical systems)

Invention vs. innovation (vs. imitation)
(ideas vs. marketable products/services)

The innovation process
(science, technology but also finance, organization, marketing, etc)

Research and Development
(And its measurement)

Innovation and performance
(Easy, unless you want to measure this relationship)

Some evidence
(Persistent innovation affects performance)

Innovation Studies – the 'big' picture: Wrapping up

Long waves and techno-economic paradigms

- Macro-level trends and the role of breakthroughs

The role of science in (corporate) R&D

- Firms have different reasons for investing in science, but overall, there is a decline of "R" in R&D

Indicators for inventive and innovative activity

- Many indicators, many uses, many limitations

Measuring the link between innovation and performance

- The micro-level link is there, and more than just in 'better products': changes in behavior!

➢ Importance of definitions of "innovation"
➢ Importance of understanding the role between macro trends and micro activities
➢ Up next: a closer look at the role of decision processes around stability and change in firms and individuals

Example exam question: open

One of the fundamental research questions in Cefis & Ciccarelli (2005) is whether differences between innovators and non-innovators are transitory or permanent.

Why is this an important question, and what is the answer according to the paper?

(worth 2 points out of 50 in HS2017)

Answer:
Important because: it determines whether the increased performance is due to the competitive advantage of the innovations themselves, or because the firms themselves perform better due to higher competencies (1,5 point)

The answer according to the paper: permanent (0,5 point)

Source: (from the paper's introduction)
Answering [this] question is crucial. If, indeed, data show a certain relation between innovation and profitability, it is important to test whether differences in profitability are due to the production of specific innovations that alter temporarily the competitive position of the innovating firms, or whether they are due to the fact that innovating firms have higher competencies that allow them to face the challenges of the market better than the non-innovating firms. (p.44)

Example exam question: multiple choice

Which of the following statements about the community innovation survey (CIS) is **NOT** correct?

a) the CIS takes the "object approach" to surveying innovation
b) the CIS is standardized on an international level
c) the CIS forms the basis of official databases
d) the CIS captures only technical innovations

(from HS2018)

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(from HS2018)