ETH zürich

Discovering Management: Technology and Innovation Management

Prof. Dr. Stefano Brusoni

The TIM group at MTEC, ca. last September

Technology and Innovation Management

Understand how stability and change interact within organizations

Learn how firms manage the shift from phases of stability to phases of change

Discuss and make sense of the interplay between technological and organizational change

Sources of pictures: google images

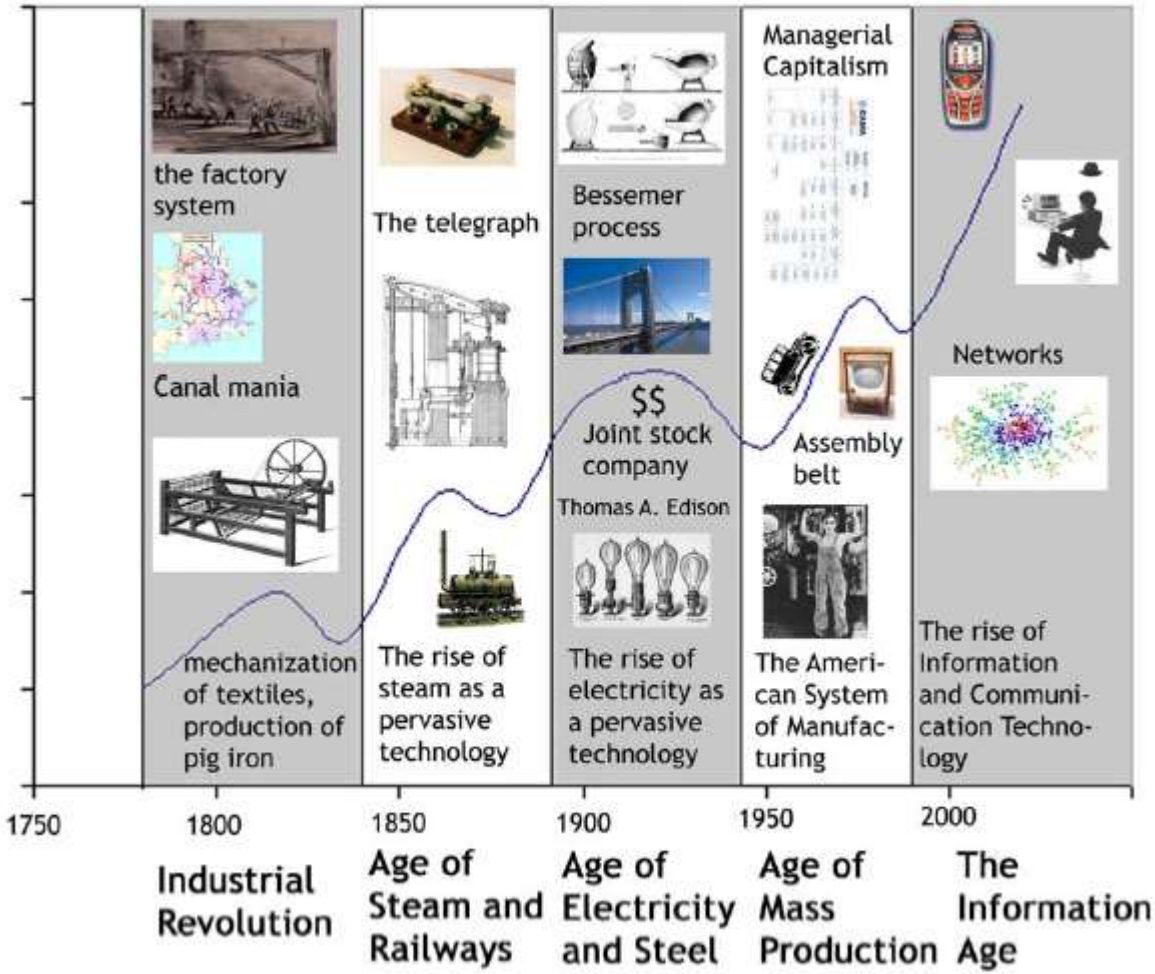
Learning Objectives

- Understand the evolutionary dynamics of technologies
  - (the long term): trajectories, industry life cycle
- The sources of innovation and change
  - (the medium term): technology push vs. demand pull
- Analyse and reflect on the interplay of stability and change in decision making
  - (the here and now): exploitation, exploration, ambidexterity

Readings

- O'Reilly, Charles A., III, and Michael L. Tushman (2004) 'The Ambidextrous Organization' *Harvard Business Review,* 82, 4, pp. 74-81
  - Very easy
- Hargadon, A., & Sutton, R. I. (1999). Building an innovation factory. *Harvard business review*, *78*(3), 157-66.
  - Very easy
- Laureiro-Martínez, D., Brusoni, S., Canessa, N., & Zollo, M. (2015). Understanding the exploration–exploitation dilemma: An fMRI study of attention control and decision-making performance. *Strategic Management Journal*, *36*(3), 319-338.
  - Less easy, focus on pp. 319-324 until Methods begin; and pp 332 till end.

Technology and long term growth



Source: Verspagen (2004) adapted from Freeman and Soete (1997)

Technological and organizational trajectories

Technological trajectories	Organizational trajectories
The quest for time saving innovation in the cotton industry *Flexibility through mechanization*	**Factory work (1° and 2° waves) to control time and pace** *Wedgwood's pottery (& early steps of marketing practices)*
The quest for flexible energy *Steam power (larger, more efficient)*	
The quest for large scale production (chemicals, steel) *Scale economies, high pressure reactions, flow production, catalysis*	**Cost accounting (3° wave)** *Andrew Carnegie and US Steel* **Time & Motion studies (3° to 4° waves)** *FW Taylor and Scientific Management*
The quest for cheap mobility *Internal combustion engine (small, reliable, efficient)*	**Moving assembly line (4° wave)** *Henry Ford and mass production/consumption*
The quest for cheap computational power *Semiconductors (smaller, faster)* *Software, now AI …*	**Networks (5° wave)** *Big Tech and internet enabled organizational forms (platforms?)*

ZA1 Zeijen Axel, 25-Sep-19

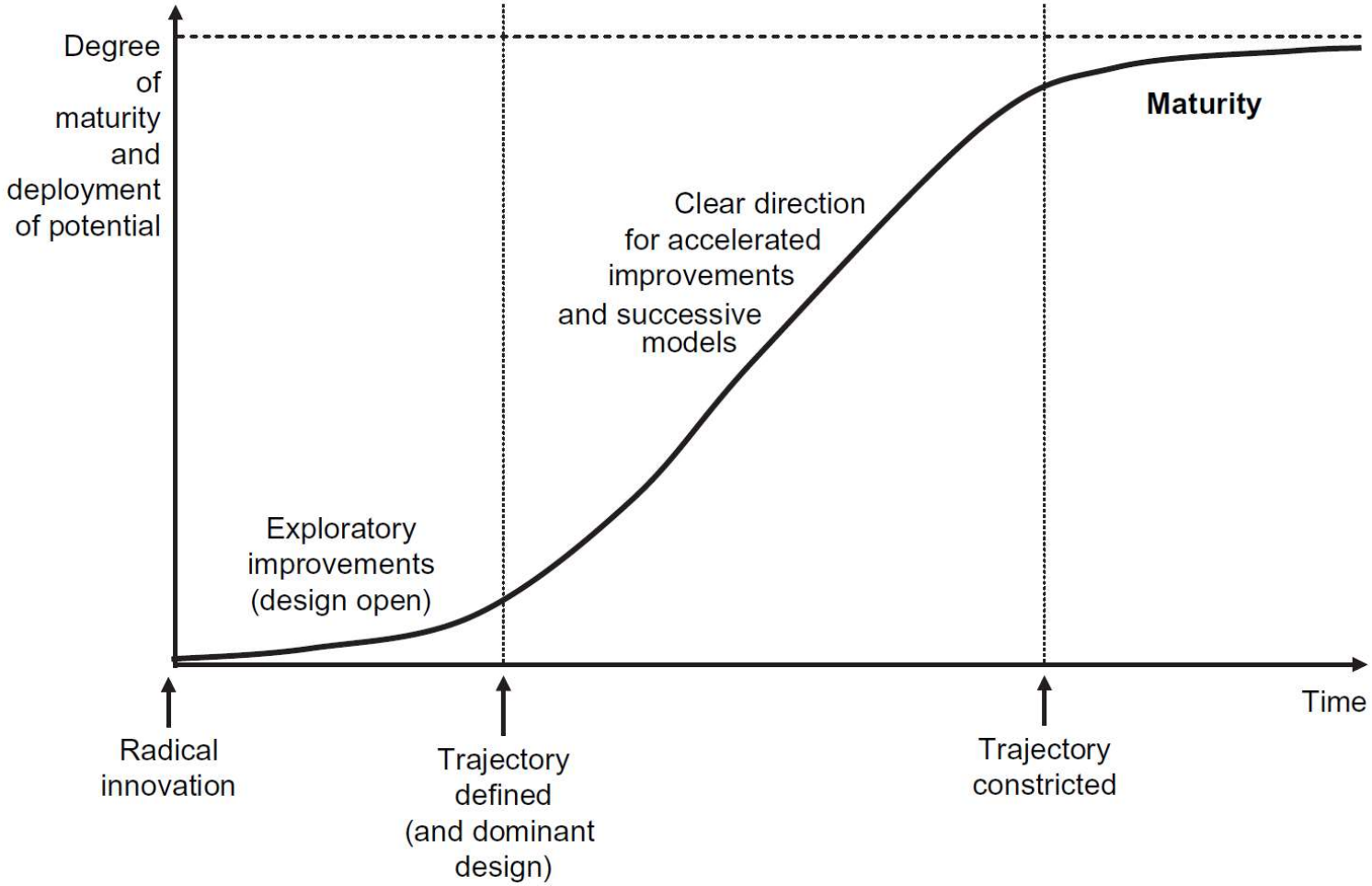
Invention vs.Innovation

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

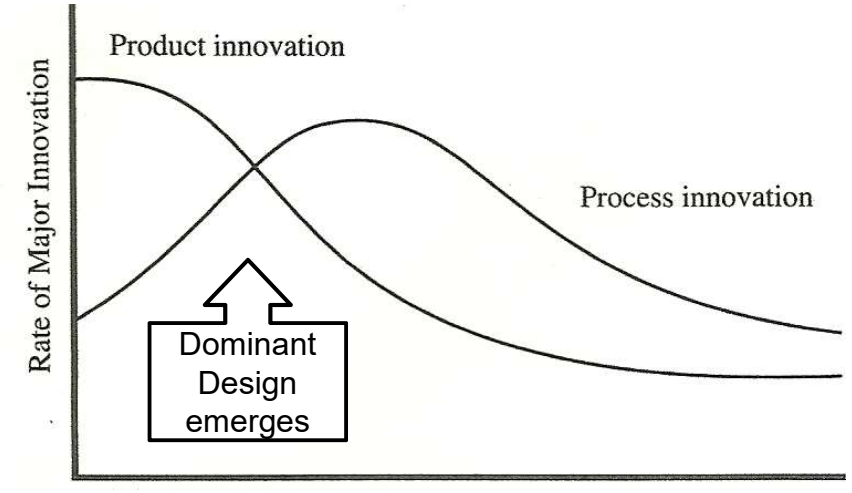
First on the market! Otherwise 'invention'

The trajectory of individual technologies

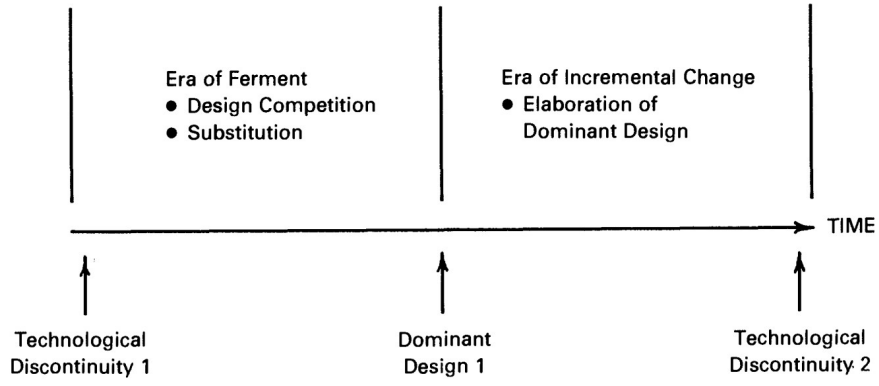


Source: Perez, 2010

Innovation and Industry development



Adapted from Utterback, 1994



Anderson & Tushman, 1990

Era of Ferment

- Trial and error in product design (competition)
- Inefficient processes (expensive, unreliable)
- Number of competitors grows

Dominant Design emerges

- Architecture-level dominant design
- Major Process improvements (production – efficient/effective)
- Number of competitors declines

Era of Incremental change

- Incremental improvements (component-level)
- Scale-driven, highly efficient (the war on cost)
- Sizable competitor structure

Different types of innovation

Novelty Difference		
Radical	⟷	Incremental

Input/Output		
Product	⟷	Process

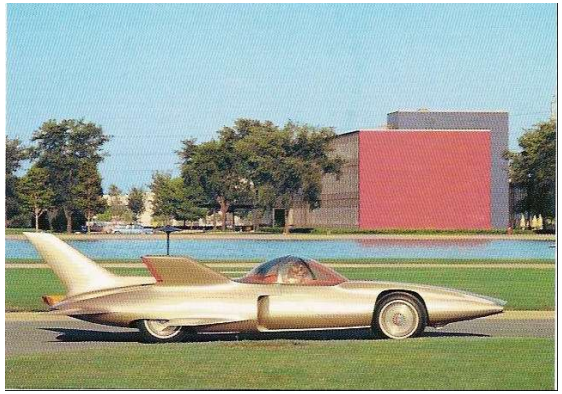
Scope		
Architecture	⟷	Component

Adapted from HKUST Business School

The sources of innovation and change

(Technology push vs. market pull)

GM's Technical Center

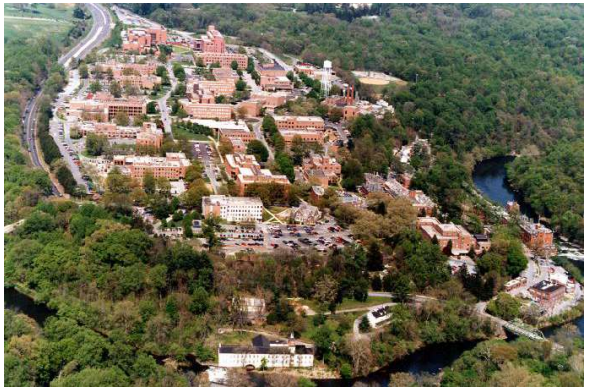


Bells Lab

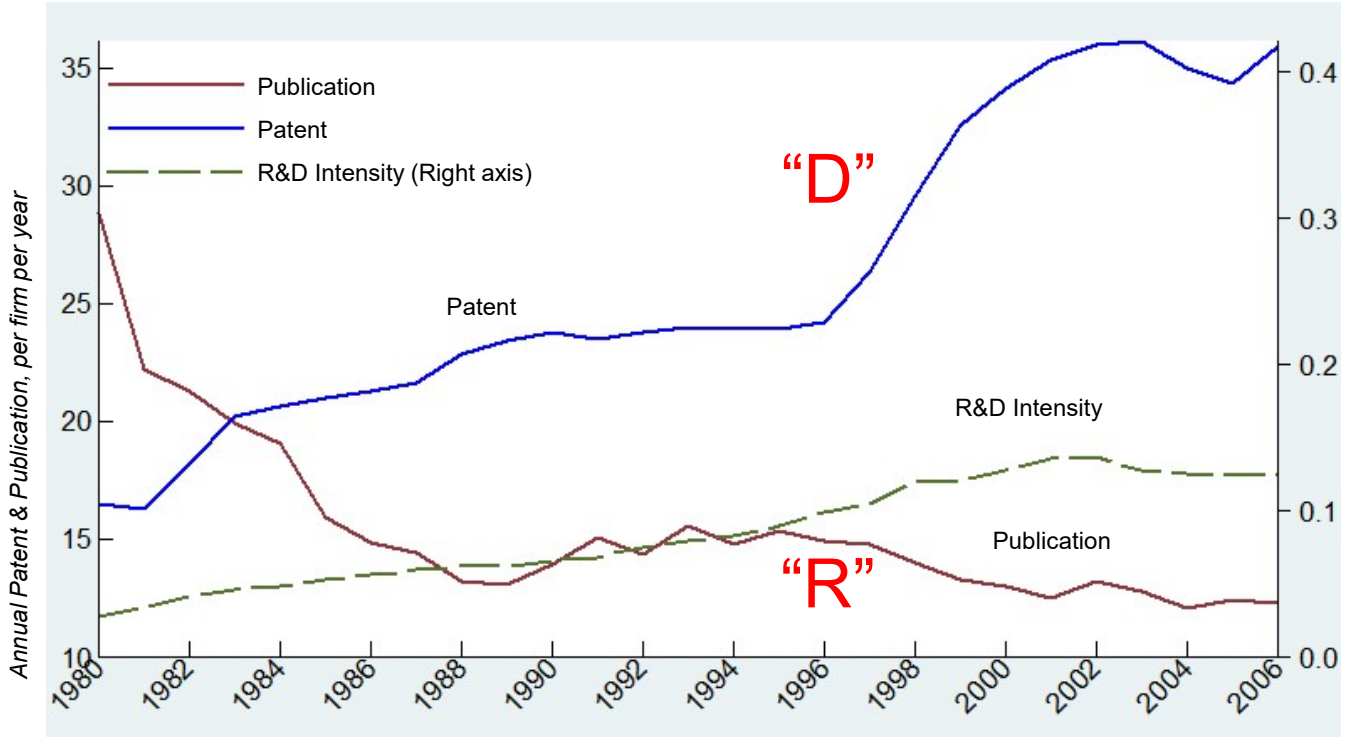
IBM's Watson Lab (1961)

Hughes Research Lab

DuPont Corporation's Experimental Station



Publishing, patenting, and research: Publicly listed U.S. firms, 1980-2006



Corporate R&D
Less "R" More "D"

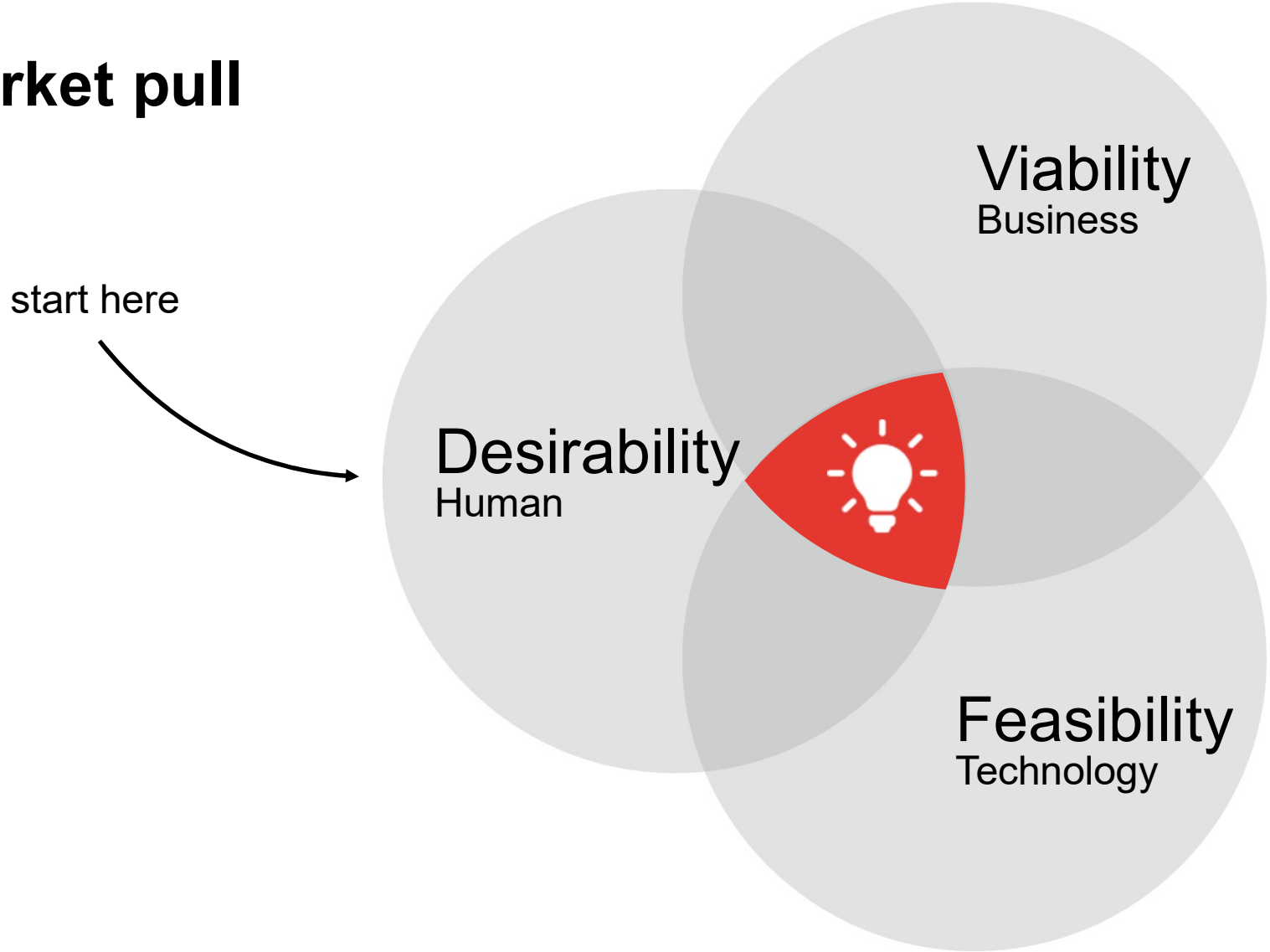
Note: Taken From: "Killing the golden goose? The decline of science in corporate R&D", Arora, A., Belenzon, S. and Patacconi, A., 2015. Figure 1 presents per firm per year publications and patents over time for U.S. publicly traded R&D performing firms with at least one patent stock. R&D intensity is defined as R&D expenditures over sales

Is this a problem?

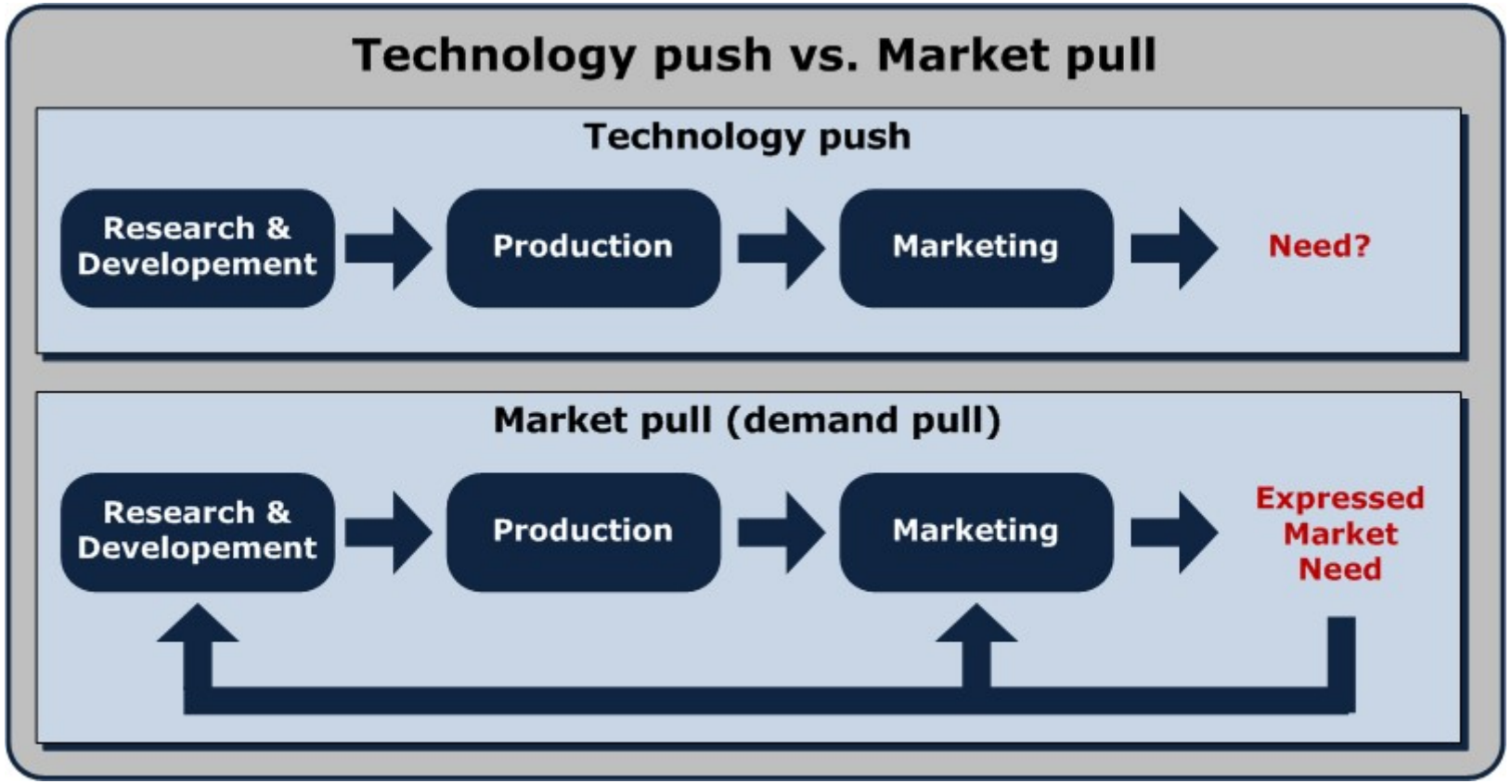
- Nope, if we assume that corporations (in the US) are becoming "D" specialists because of the reliance on alternatives sources of innovation

- Part of the answer is in the analysis of the 'health' of upstream research institutions (universities, government labs) → foresight studies, university/industry interfaces
- Part of the answer is in the analysis of how firms leverage external sources of innovation → ecosystems/platform studies
- Part of the answer is in the ability of firms to access 'customers/users' insight → market pull

Market pull


start here
Viability
Business
Desirability
Human
Feasibility
Technology

Hence, two basic innovation ‘models’



Source: https://de.wikipedia.org/wiki/Datei:Technology-Push_Market-Pull.png

Organizing for innovation and change

(exploitation vs. exploration)

Google and IBM in Zurich

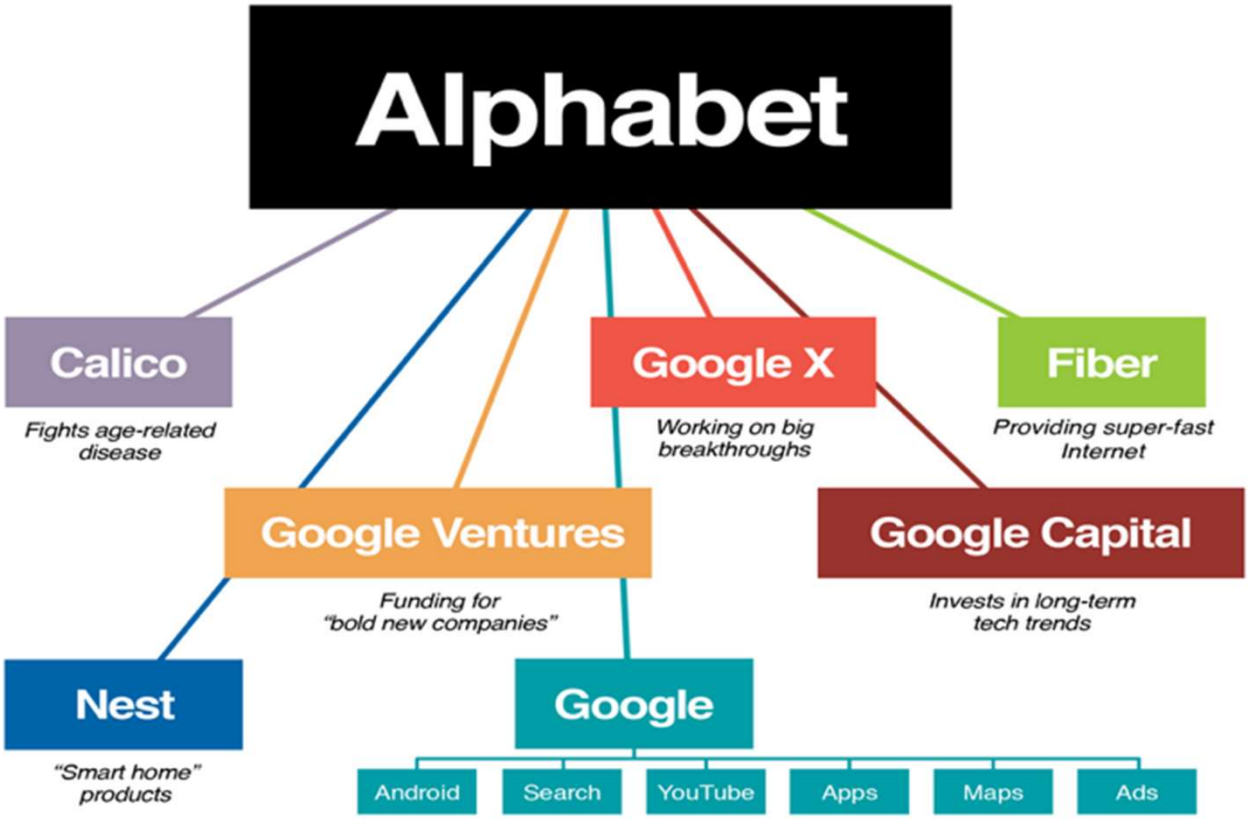
Google

- 100’000 employees
- 3’000 employees in ZH
- Established 2004
- Largest research and development site outside USA
- Plans for 5’000 employees until 2021

IBM

- 350’000 employees
- 350 employees in ZH
- Established 1956
- 4 Nobel prize winners are associated with the lab
- Many scientific achievements (e.g. Token Ring)

Alphabet, Google and Google X



Source: Google home page

Google in Zurich

Google in Zurich

*"Googlers in Zurich do important work across our technology groups, and our launches have included **Maps for EMEA, Search refresh, key Gmail features** like the priority inbox and account abuse protection, and content ID and **monetization products for YouTube**. Other key projects we have in Zurich include **Shopping, Ads, Calendar and Spam & Abuse**"*

Source: Google Inc. home page

(Google) X

*"X is a diverse group of inventors and entrepreneurs who **build and launch technologies** that aim to improve the lives of millions, even billions, of people. Our goal: 10x impact on the world's most intractable problems, **not just 10% improvement**. Our projects have the **riskiness** and aspiration of research, and we approach them with the **focus, speed, and ambition of a startup**"*

Source: https://x.company

Google in Zurich

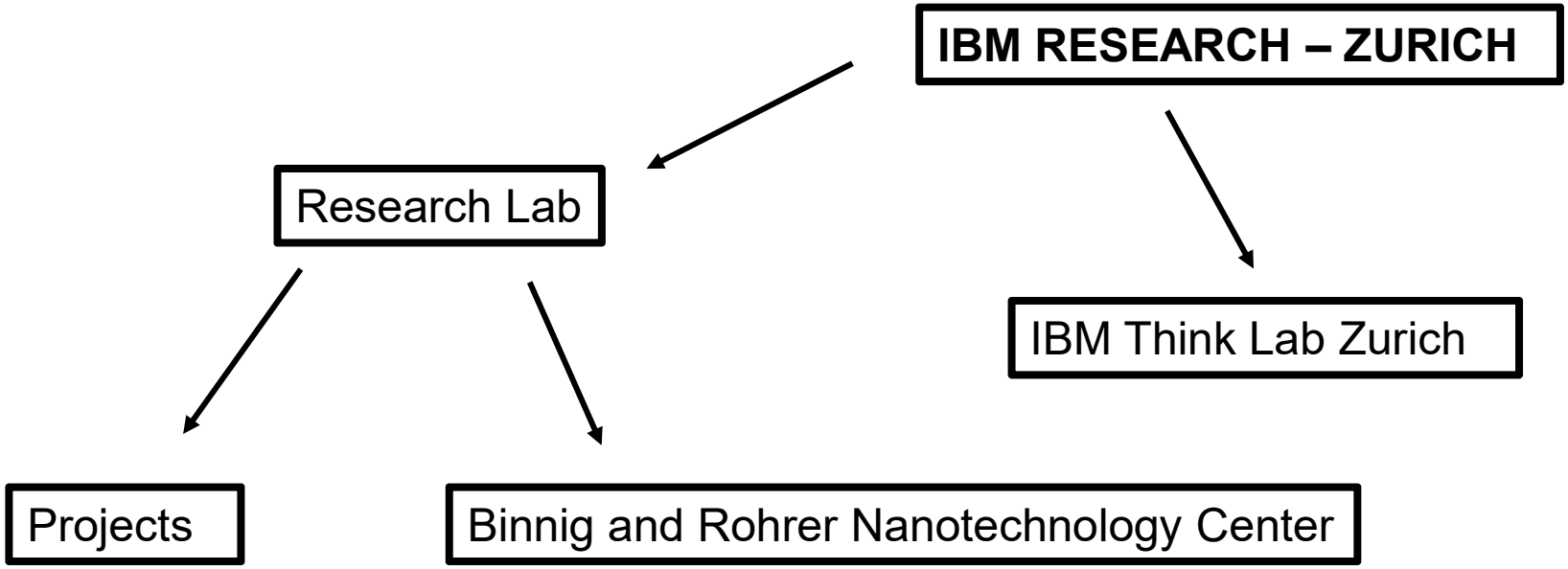
- Google in Zurich
- Focus on applied research for **improving** existing Google products and services

- (Google) X
- Focus on **creating** breakthroughs and commercializing new technology

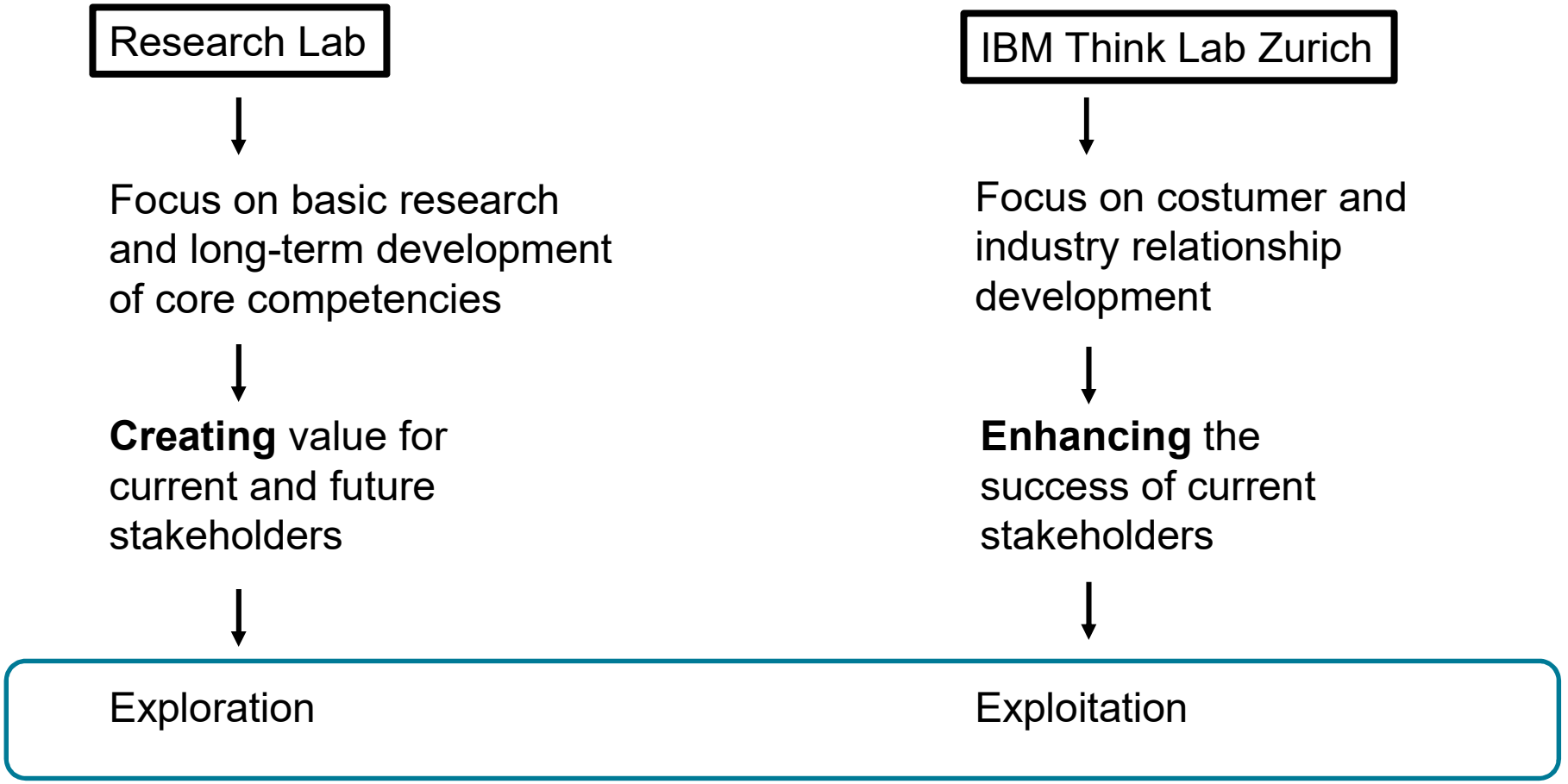
- ***Exploitation***

- ***Exploration***

IBM in Zurich – organizational structure



IBM in Zurich



Exploitation and exploration

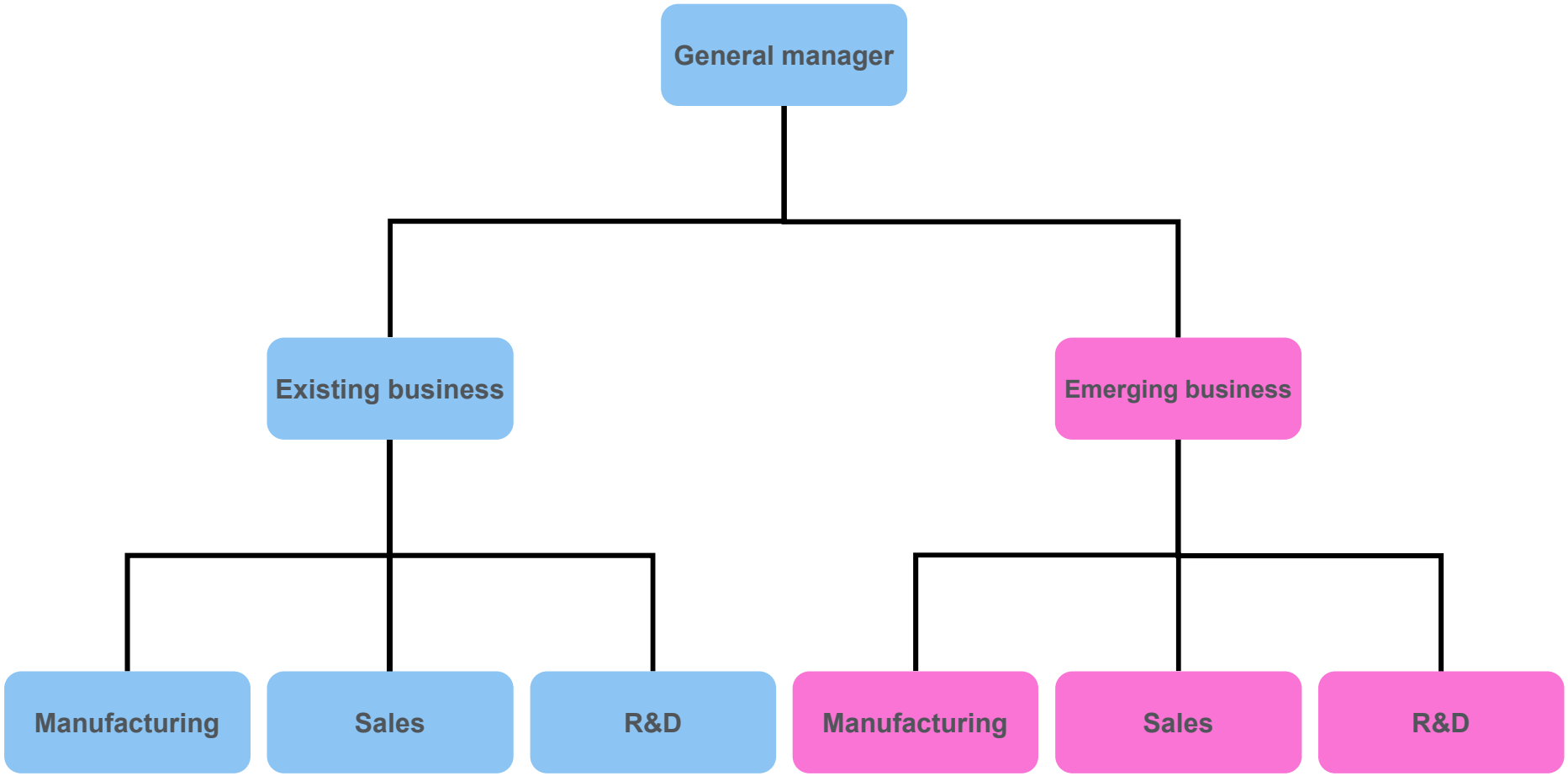
- Exploitation
  - Refinement, production, efficiency, implementation …
- Exploration
  - Variation, risk taking, experimentation, play, flexibility …
- Returns from exploration are uncertain, more remote in time, and organizationally distant from the locus of action and adaptation
  - **E.g. the R&D lab!!**
- Returns from exploitation are reliably linked to the time and place in which they take place.
  - **E.g. the manufacturing unit.**

Ambidexterity

"The ability to simultaneously pursue both incremental and discontinuous innovation and change results from hosting multiple contradictory structures, processes, and cultures within the same firm"
–Tushman & O'Reilly, 1996: 24

Sources of pictures: google images

Structural ambidexterity



O'Reilly & Tushman, 2004. pp.74-81

Google in Zurich

"You have a good foundation in computer science which allows you to consistently **come up with new ideas**, as well as to strive for a deep understanding of **our products and services** in order to continually **improve** upon them"

Source: Google Inc.
Job description for software engineering intern,
July 2019

"Whether the answer is a bespoke solution to solve a unique problem, or a **new tool that can scale across Google**, everything we do aims to ensure our customers benefit from the **full potential** of **Google products**"

Source: Google Inc.
Job description for product technology manager,
July 2019

→ Individual responsibilty for radical product innovation ("exploration") and adjustment ("exploitation") → contextual ambidexterity

Structural vs. Contextual ambidexterity

	Structural Amb.	Contextual Amb.
How is ambidexterity achieved?	Explorative- and exploitative activities are done in separate units or teams	Individual employees divide their time between explorative and exploitative activities
Where are decisions made about the split between exploration and exploitation?	At the top of the organization	On the front line — by salespeople, plant supervisors, office workers
Role of top management	To define the structure, to make trade-offs between exploration and exploitation	To develop the organizational context in which individuals act
Nature of roles	Relatively clearly defined	Relatively flexible
Skills of employees	More specialists	More generalists

Short exercise and video

IDEO and contextual ambidexterity (https://www.youtube.com/watch?v=uhOg95BsyG8)

A process view of exploration, exploitation: The IDEO case, in video (on moodle)

"*Design thinking is a **human-centered approach** to innovation that draws from the designer's toolkit to **integrate** the needs of people, the possibilities of technology, and the requirements for business success.*"

Tim Brown, president and CEO

Thomke, 2003. Ideo Product Development. Teaching notes. HBS.

IDEO Case, exercise (with answers)

Please write down cues about IDEO's innovation system. Please identify as many elements in the video as you can and classify them under "exploration" or "exploitation":

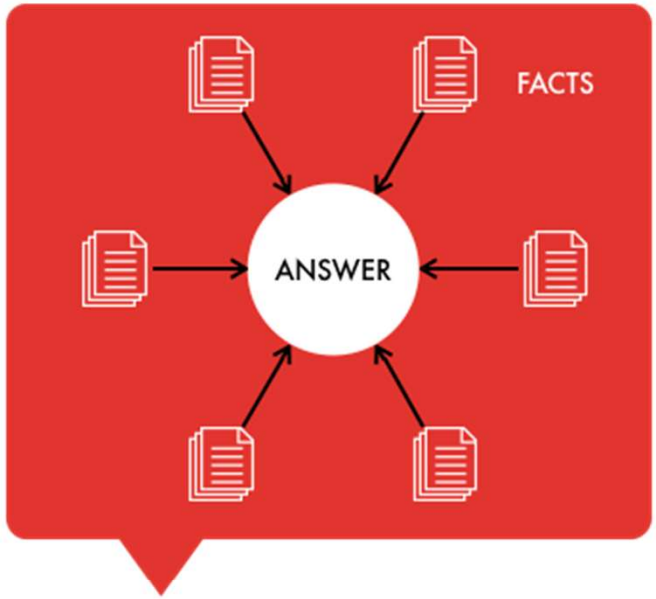
Exploration	Exploitation	Ambidexterity

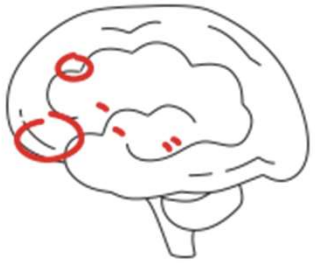
How do we study humans involved in innovation decisions?

(Divergent and convergent thinking
Exploration and exploitation)

CONVERGENT THINKING

Using logic

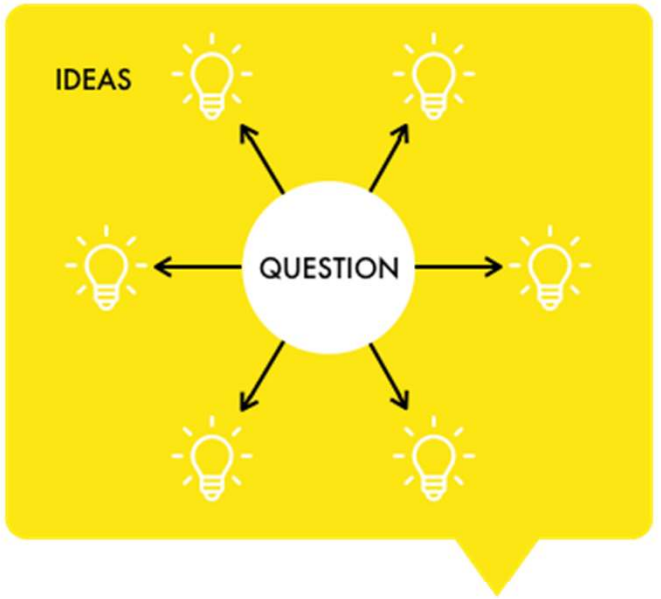




EXPLOITATION
involves stronger activations of the reward-related brain regions.

DIVERGENT THINKING

Using imagination

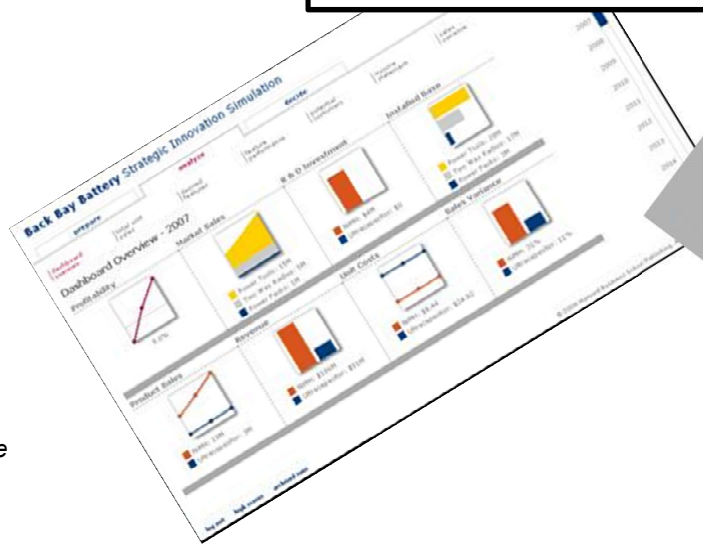


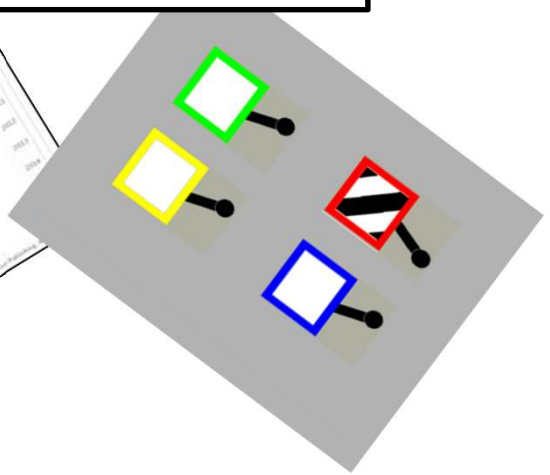
EXPLORATION
involves stronger activations of the attentional control regions.

(convergent and divergent production , by J. P. Guilford)

53 expert decision makers: matched sample of 28 specialists and 25 generalists
Four-armed gambling task (Daw et al. 2006)

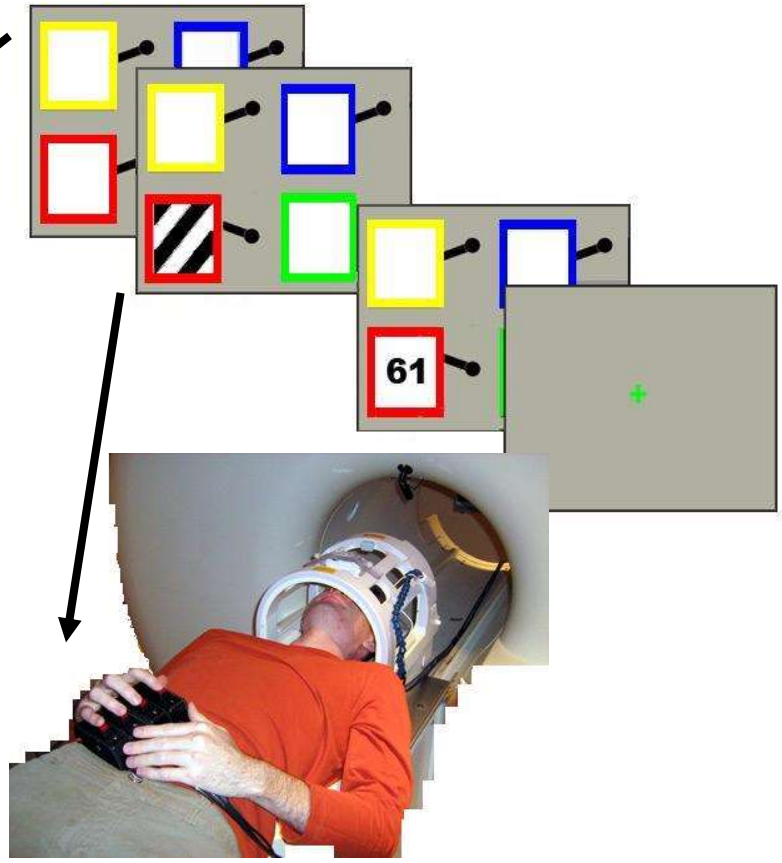
Exploration-exploitation Performance





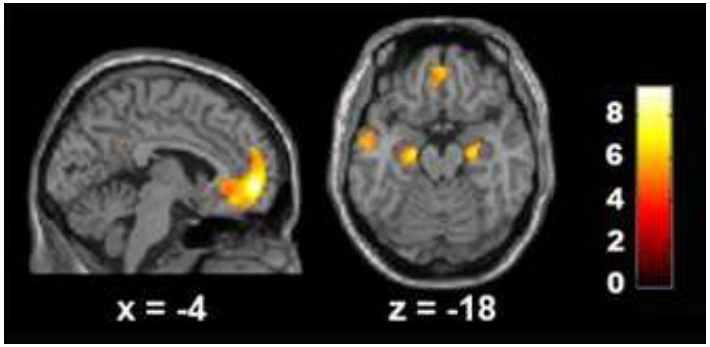
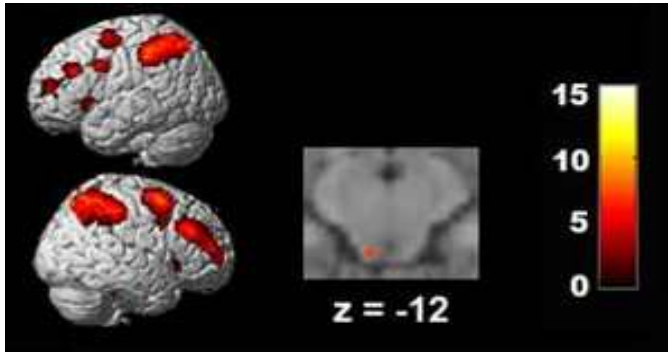
Sources: www.istockphoto.com, www.dfp-design.de

Sources: internet images

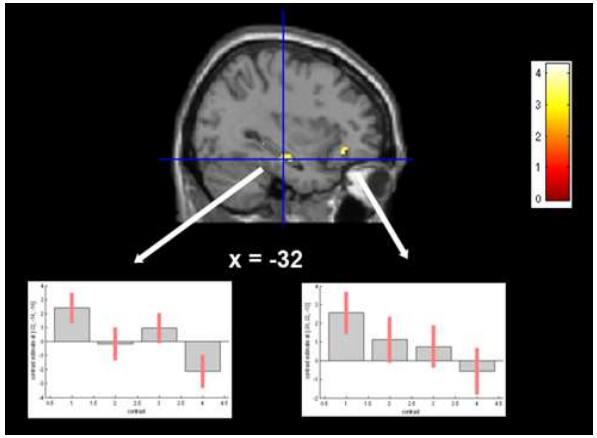
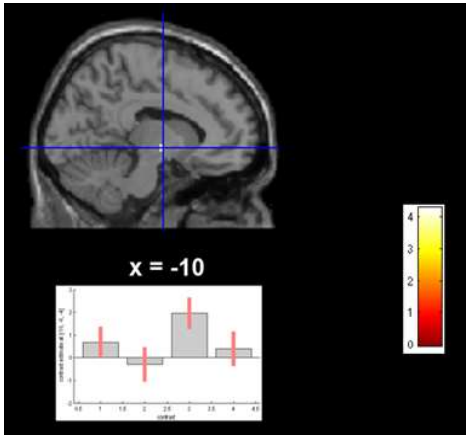
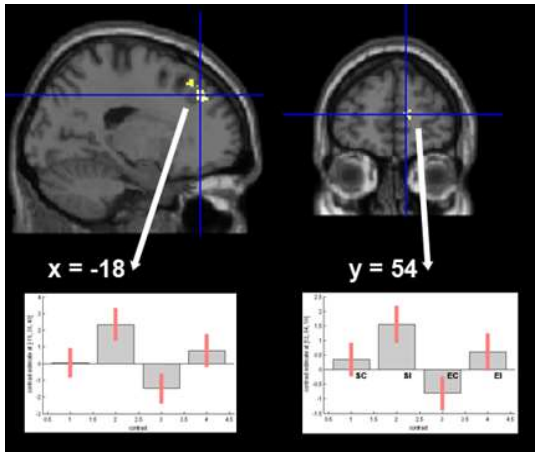
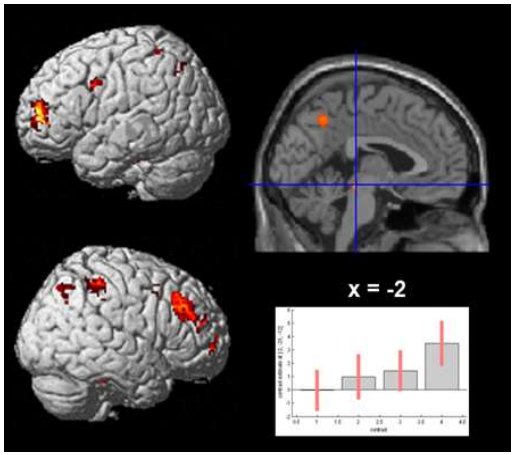


Source: own pictures

Sources: internet images

Convergent (exploitation)	Divergent (exploration)
	
Learning, reward perception, memory, persistence Dopaminergic regions Ventro medial pre frontal cortex Hippocampus (subiculum)	**Attention control regions, planning, idea generation** Bilateral fronto-parietal regions Fronto polar cortex Anterior cingulate cortex Locus coeruleus Thalamus Anterior insula

Source: Laureiro, Brusoni et al, SMJ 2015

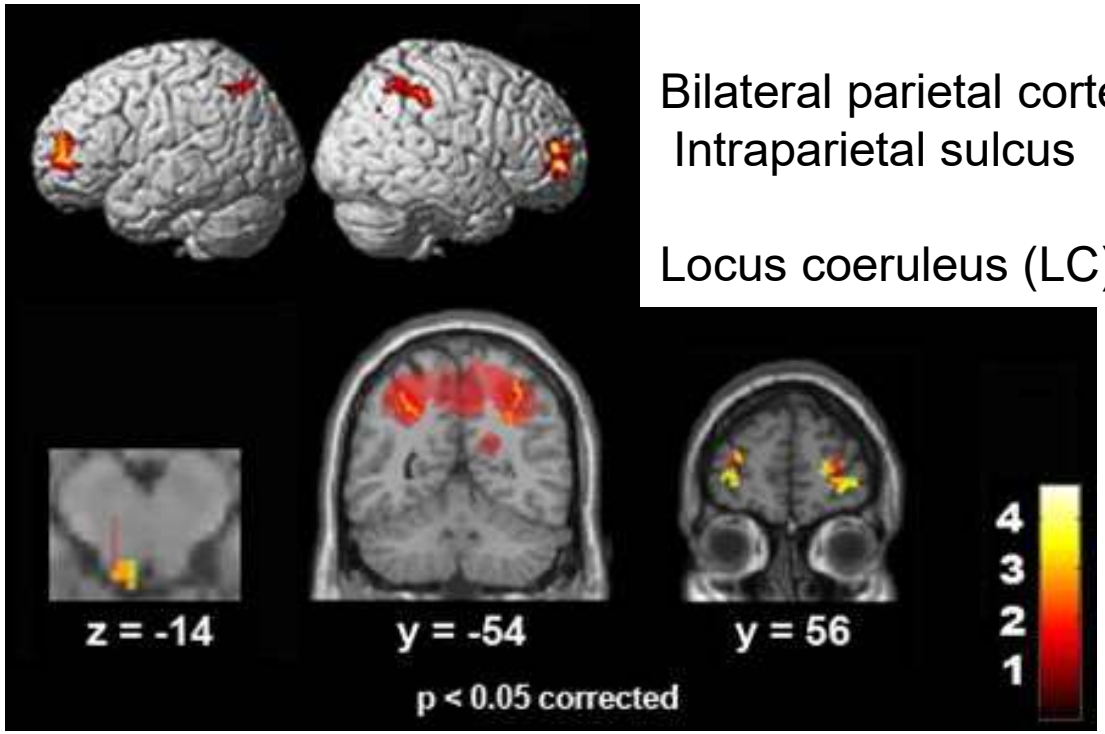
	Convergent	Divergent
Managers		
Entrepreneurs		

Source: Laureiro, Brusoni et al, SMJ 2015

Bilateral FrontoPolar Cortex

Bilateral parietal cortex
Intraparietal sulcus

Locus coeruleus (LC)



– ▶ Exploration-exploitation Performance

Source: Laureiro, Brusoni et al, FHN, 2013

Short video that summarize this discussion, cognitive flexibility and attention control: https://ethz.zoom.us/my/dlaureiro

Learning Objectives

- Understand the evolutionary dynamics of technologies
  - (the long term): trajectories, industry life cycle
- The sources of innovation and change
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- Analyse and reflect on the interplay of stability and change in decision making
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