Prof. Ing. Marco Cantamessa

Innovation Management

What are the key things that are happening in this world of innovation?

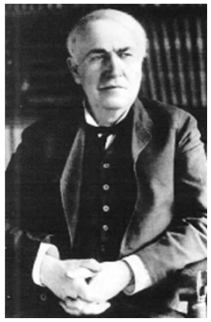
Tricky «trivial pursuit» questi

- Who would ***you*** want to be?
- Who were the ***innovators*** and how did they do it?
- What's the value of technology without the management of innovation?

•**Who invented the light bulb?**

Sir Humphry Davy
(1778-1829)

Joseph Wilson Swan
(1828-1914)

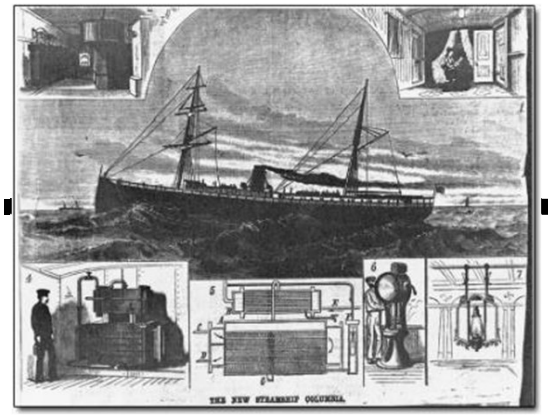


Thomas Alva Edison
(1847-1931)

Alessandro Cruto
(1847-1908)

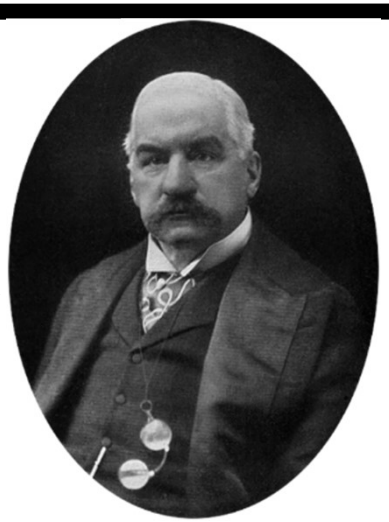
Nikola Tesla
(1856-1943)

George Westinghouse
(1846-1914)



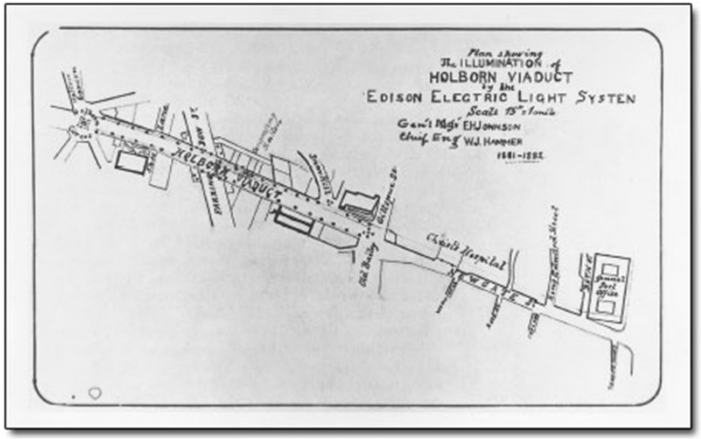
S.S. Columbia

May 1880



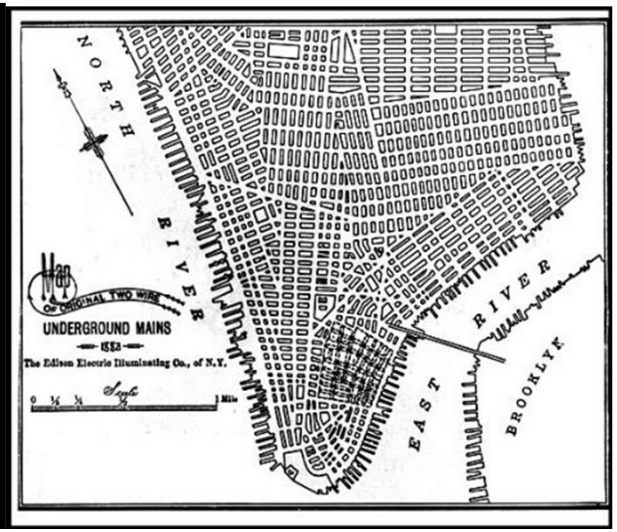
J.P. Morgan's home, New York

June 1880



Holborn Viaduct, London

January 1882



Pearl Street Station, New York

September 1882

A few definitions

The five Ws of (technological?**) innovation**	
What	• "*The economic exploitation of an invention"* (Roberts, 1998) • "*The act or process of introducing new ideas, devices, or methods*" (Merriam Webster dictionary)
Who	• Supply → People or organizations who *propose* the innovation (taking risks) • Demand → People or organizations who *adopt* the innovation (taking risks)
Why	• Craftsmanship and ingenuity making it *possible* (= technology?) • Competition making it *necessary* • Culture making it *agreeable*
When	• Cost of *change* < Cost of *staying put*

Where	• Products, processes, organizations, business models, society
	• "Promethean" places (national/regional innovation systems, entrepreneurial ecosystems) where
	  • a 'dynamic' and 'modern' culture prevails (Phelps 2013)
	  • resistance to change is weaker or manageable (Juma 2016)
	  • institutions and culture are oriented to growth and change, and not to conservation (Mokyr 2016)
	  • B2B technology adoption is not encumbered by 'socioemotional wealth' biases typical of family firms (Souder et al., 2017)

It's a cultural issue! Think about the Aeneid, or read Alfred Tennyson's Ulysses aloud

A perspective from 2000 years ago

Aeneid, VIII book

- Aeneas has fled Troy, tries to settle in Latium, but ends up in war with the locals
- Venus "asks" Vulcan to build new weapons for him
- Vulcan accepts and heads for the Aeolian islands to build the weapons
- Aeneas' shield is decorated with scenes of the future of Rome, which Aeneas does not understand. However, he enjoys the pictures and, unaware of it, he bears the fate of future generations on his shoulders

A. Van Dyck, 1632

Venus asking Vulcan for the Armour of Aeneas

(Musée du Louvre, Paris)

Modern culture, according to Phelps (2013)

To what extent does this contrast the concept of "industrial policy" and Mazzucato's "entrepreneurial state" (2013)?

Modern economies have witnessed "Rostowian take offs" thanks to "flourishing" systems of "indigenous" innovation

Societies valuing "modern" culture

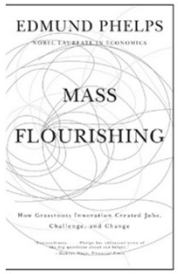
- Jeffersonian individual pursuit of happiness
- Dynamism and radical change vs. tradition
- Dealing with Knightian uncertainty
- Accepting failure *and* success
- Innovation vs. trade

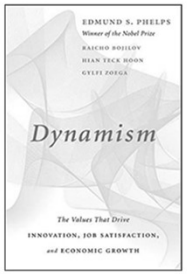
Institutions that

- Allow capitalism and competition (interpreted as a Hayekian "discovery process") to prevail over corporativism and socialism
- Facilitate business and do not have a claim to direct or co-manage it
- Place incentives for long-term value creation vs. short-term opportunistic behavior

Economic knowledge (supply and demand side)

- Technical creativity (making new things)
- Entrepreneurial and strategic insight (perceiving opportunities and understanding how to exploit them)
- Technical and managerial capability (executing and scaling technology and firms)
- Financial judgement (discerning where and when to invest)





A few definitions

- What is the role of this "perennial gale of creative distruction" in the capitalist system?
- Should it be studied by economists (= what portion is endogenous to the economy)? What about historians and technologists?
- Can you also manage innovation?
  - Use history and look for patterns (Suddaby et al., 2019)
  - Balance risk and reward

Joseph Schumpeter
1883-1950

A few definitions

When does "innovation" really happen?

Discovery — *Invention / Technology (demonstrator)* — *Invention (prototype)* — *Product* — *Innovation*

Basic research → **Applied research** → **Product development (pre- and post- competitive)** → **Diffusion**

Should you really believe in this "linear model"?

If

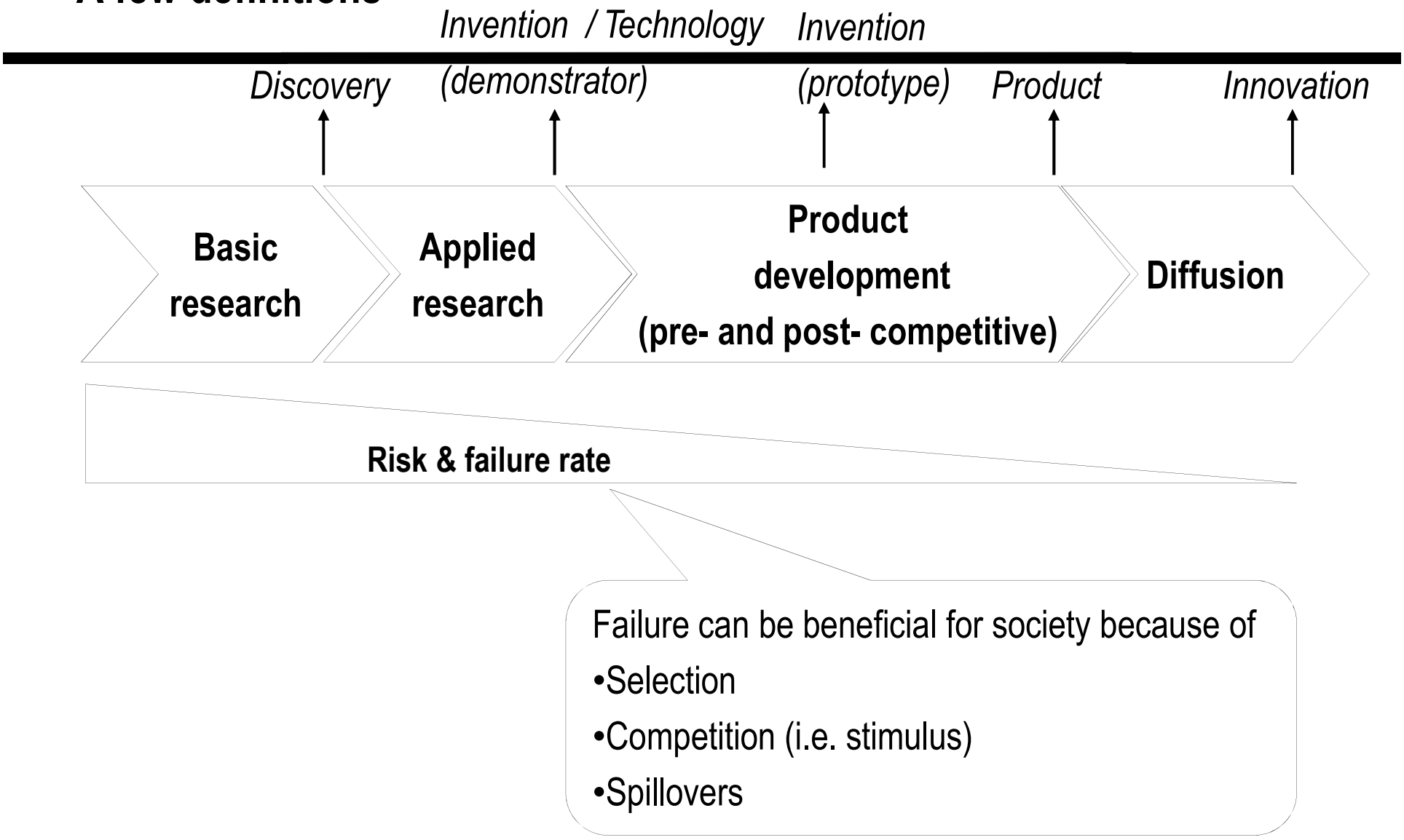
"research and invention = using $ to generate ideas and knowledge"

Then

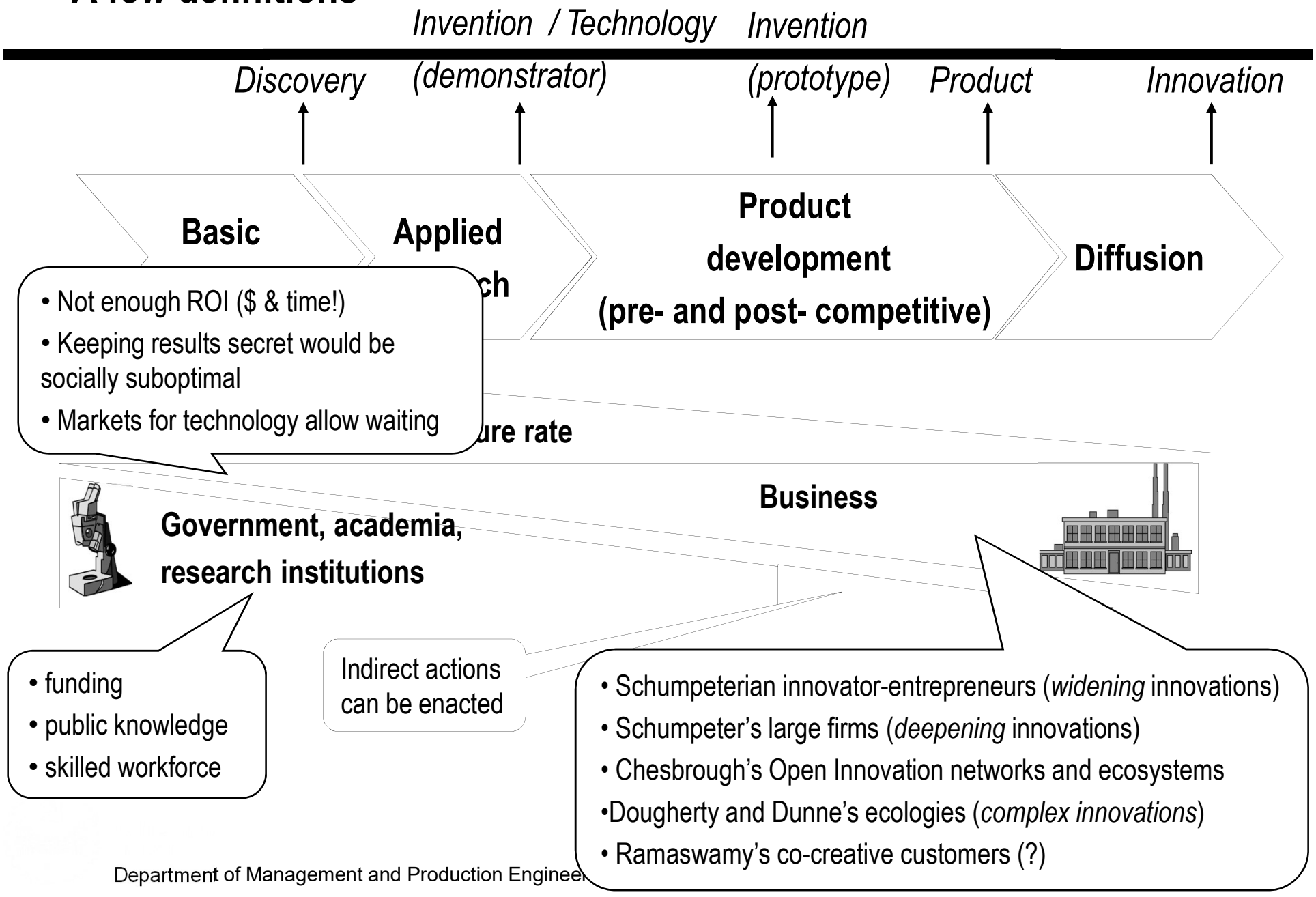
"Innovation = using .... to generate ....."

Mokyr's definition of "useful knowledge", made up of "propositional" and "prescriptive" knowledge

A few definitions



A few definitions

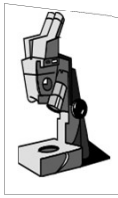


A few definitions

Invention / Technology *Invention*

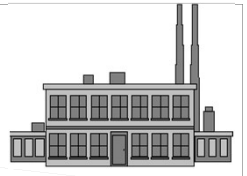
Discovery *(demonstrator)* *(prototype)* *Product* *Innovation*

Basic research | **Applied research** | **Product development (pre- and post- competitive)** | **Diffusion**



Government, academia, research institutions

Business



Basic principles observed

Fundamental Research | Industrial Research | Experimental Development

TRL 1 | TRL 2 | TRL 3 | TRL 4 | TRL 5 | TRL 6 | TRL 7 | TRL 8 | TRL 9

Technology Readiness Levels

Technology concept / application formulated

Experimental critical function / characteristic POC

Technology validated in lab

Technology validated in relevant environment

System / subsystem prototype demonstrated

System / subsystem prototype demonstrated in operational environment

System complete and qualified

System proven in operational environment

Policy	Rationale	Tools	Pros	Cons
Supply side / Direct funding	State provides resources that Market does not supply	Grants, low interest loans (e.g., Smart&Start, H2020 SME instrument)	Speed (depending on procedures) Ex-ante definition of budget	Allocational efficiency (picking winners based on proposals?) Bureaucracy (time and cost)
Supply side / Incentives	State increases ROI to Market by reducing immediate outflows or risk	Matching funds Tax breaks (e.g., for startup financing) Guarantees (e.g. for bank loans)	Speed Market involvement	Needs a market cpable of selecting Risk of opportunistic behavior Cost of policy difficult to quantify ex-ante
Supply side / Boosting outcomes	State increases ROI by boosting potential inflows, if and when results are achieved	Rebates to income tax (e.g., 10-year tax waivers on corporate income tax, tax exemptions for capital gains, "patent boxes")	Market involvement Lower risk for state (resources go those who 'risk *and reap*' if and only if, and after, benefits have accrued)	Needs a market capable of selecting Difficult to quantify ex-ante cost of policy (still a problem?)
Demand side / procurement	State stimulates innovation by creating an early market for innovation	Public Technology Procurement (e.g., US SBIR, DoD)	Award given to effective results and not to promises Creates a market and supply chain State benefits from improved technology	Requires an entrepreneurial culture and appropriate rules within civil service
Demand side / regulation, standardization	State creates and shapes the demand for innovation	Product-specific regulation (e.g., biodegradable bags, CO2 emissions for vehicles)	No immediate cost	Technical choices / targets can be non-neutral and difficult to achieve Risk of technological lock-in Requires a credible State and a capable Market

Public funding

Policy	Rationale	Tools	Pros	Cons
Demand side/incentives	State reduces the cost/boosts the benefits of *adopting* the innovation	Direct incentives to adopters when purchasing (e.g., purchase rebates for Evs, hyperamortization for capital goods) Incentives to the usage (e.g., feed-in tariffs for renewable energy producers)	Strong and immediate impulse to adoption Award given to effective results and not to promises Creates a market and supply chain Society benefits from rapid diffusion	Applicable to technology that is market-ready Risk of benefiting producers abroad Cost can be high and difficult to quantify Risk of technological lock-in Can induce volatility in demand before and after the policy is active Could be fiscally regressive, could not generate additionality and lead to unused goods
Demand side / complementary assets	State facilitates and shapes the demand for innovation	Investment in complementary assets (e.g., BEV recharging stations	High probability of having impact	No technological neutrality and risk of lock-in High cost
Non-specific	State improves general "business friendliness"	General reforms (tax, education, infrastructure, judicial system, education, etc.)	Stable and visible impact throughout the economy No ex ante directional choice w.r.t. industry or field	Time required

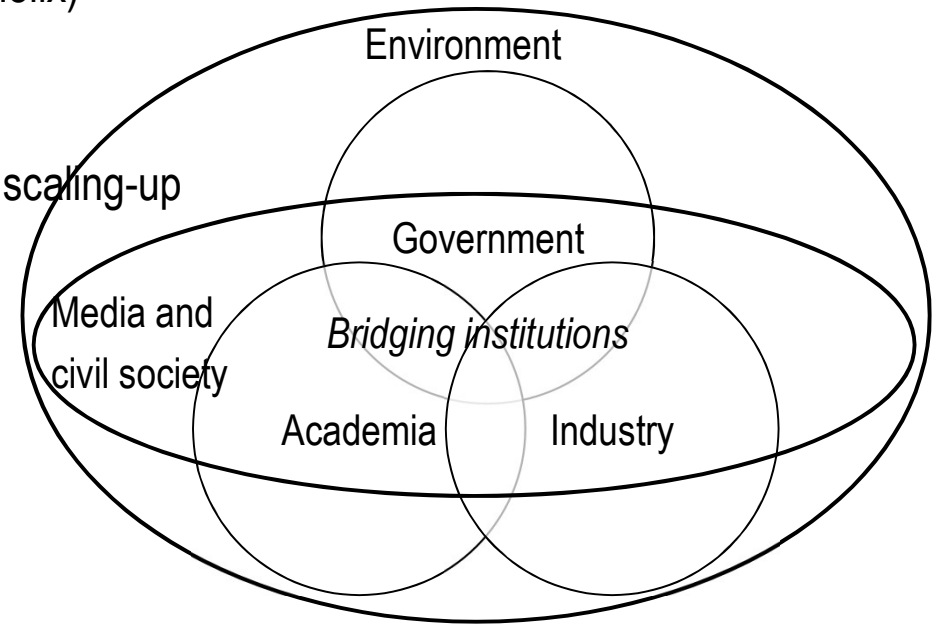
Private financing	How does it work?	Pros	Cons
Bootstrapping	Use margins from operations to finance innovation	No dilution and total independence	Time required, entity and variability of margins
Debt	Get loans from bank or issue bonds… and then pay it back (or convert to equity, if the loan is convertible)	No dilution	Not acceptable for high-risk projects
Customer financing	Early customers finance your innovation (from pilots to reward crowdfunding)	Deep engagement with market needs No dilution Risk sharing	Narrow engagement with customer needs Can you find such customer(s)?
Business angels	Wealthy people with industry experience, alone or in club deals, provide "smart money" as equity (or future equity if SAFE is used) to high-risk startups	High risk acceptance Competencies and relations	Dilution Possible intrusiveness
Venture Capital	VC funds (GPs) raise money from investors (LPs) and provide staged financing to high-risk startups, supporting their growth and looking for an exit (IPO/trade sale). A few "home runs" compensate for failures and write-offs	High risk acceptance Need an exit	Dilution Need an exit
Private Equity	Like VC, but for less risky firms, might not need an exit and entails greater PE involvement in management	Risk acceptance	Dilution Loss of control
Equity redemption	Like VC, for firms with less risk/growth potential. Fund buys a stake, and put/call options make/allow founders to redeem it later, via retained earnings/LBO, at predefined conditions (multiples of investment and/or financials)	Useful for firms that VCs would shun. VCs exit, leaving founders in the firm	Very uncommon structure Risk of failing exit
IPO	Raise money from public markets	Amount that can be raised Founders can keep control Liquidity of shares	Dilution Costly and complex process

A few definitions

- Need to go beyond the linear model of innovation, since history tells us that invention and innovation are *usually not* the direct outcome of science, but of extensive trial and error within the domain of technology (e.g., steam and IC engines, airplanes, etc.)
- Alternative models consider that
  - You have "feedforward" and "feedback"
  - The links along the model are not necessarily 1:1
- Is innovation about having scientists and entrepreneurs (Schumpeter), or a society that exhibits dynamism (Mokyr, Phelps)?

A few definitions

- Innovation tends to occur in confined geographies
- Local (i.e., national or regional) systems of innovation exhibit
  - A Marshallian district-like behavior, based on economies of agglomeration
    - specialization around a focal + complementary technology/industry,
    - labor and resource pooling among multiple and flexible firms,
    - low transaction costs due to spatial, cultural and relational proximity
    - knowledge spillovers
  - A "knowledge producing and sharing" interplay betwen heterogeneous actors (from Etzkowitz's triple helix to Carayannis' quadruple/quintuple helix)
- Autio et al. (2018) propose an "entrepreneurial ecosystems model" centered around
  - high-growth opportunity discovery, pursuit and scaling-up
  - digital and business model innovation
  - a community of (serial) entrepreneurs and complementary actors
  - a common "economic knowledge" and culture
  - continual recycling of resources



Basics of economics of innovation

Hyman (2018) argues that technology does not "shape" society and work. Pre-existing trends leverage technology and are empowered and amplified by it (e.g., gig economy vs. Manpower)

- Technological innovation is hugely relevant to society today
  - Social impact of technology
    - job displacement and "industry disruption"
    - adoption divides between social strata and countries
    - wealth/income inequality, mostly between-firm, due to enduring monopolistic power

      - network effects
      - users' switching costs
      - combined effect of big data and machine learning
  - Philosophical and ethical aspects (from Heidegger to Galimberti)
    - Technology is a strong and pervasive force acting on the environment and on humankind
      - Impact can be inherently irreversible (e.g., nuclear war) or self-sustaining (e.g., dystopian visions of AI/robotics)
      - People are *identified* by the technology they adopt, with varying levels of consciousness

    → society needs time to develop "proper" use modes (Anders' «Promethean discrepancy»)

    - Absent social norms, technology is not a neutral ("innocent") tool that humans use (or do not use) as means to a (consciously deliberated) end → it can become *the* end, obeying own criteria of effectiveness and efficiency (e.g., designer babies, critical decisions delegated to opaque deep learning algorithms, etc.)

Basics of economics of innovation

- Technological innovation is hugely relevant to society today
  - Different approaches to ethics of technology
    - The «Promethean discrepancy» (Anders) calls to go beyond both «ethics of intention» and «ethics of responsibility»
    - Anglo-saxon approach (utilitarian, based on deontological principles and specialization)
    - Continental approach (principles-based, stresses “unintended consequences” and tends to view technology as a whole)
  - Business-level aspects
    - Business ethics and Corporate Social Responsibility
    - Risks associated to non-acceptance of technology (e.g., GMOs, nanotech, AI, etc.)
    - Legal liability risks due to "unforeseeable" consequences of innovation
      - Objective liability vs. liability associated to behavior
      - Liability vs. compliance with regulatory processes
      - The definition of liability regimes requires a tradeoff between consumer protection and incentive to conduct proper investigations vs. incentive to innovate (e.g., development risk clause in the EU)
      - What about liability for AI-based products? Who is responsible?

Paradigms

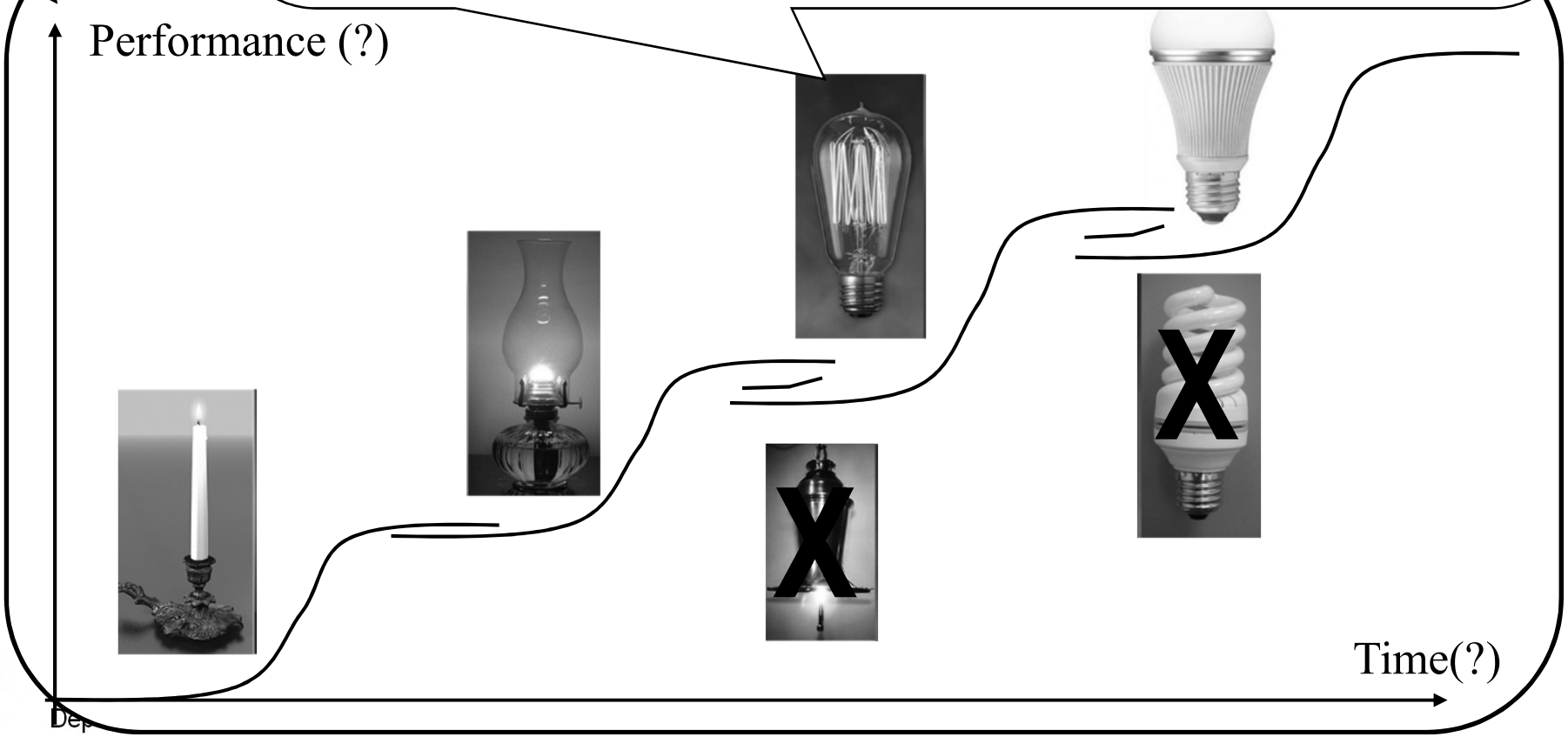
Does it look like a story characterized by continuous progress?

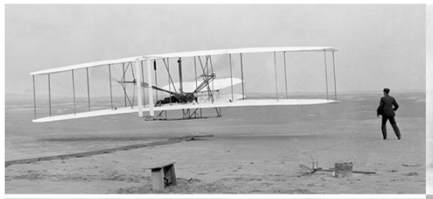
Paradigms

R&D and marketing have different roles within the process

Not really! Dosi and Freeman show that innovation follows a continuous alternation of

- Evolutionary and revolutionary change
- Performance s-curves
  - Bounded by technological limits
  - Initiated by tapping into new technical solutions (*technology push*)
  - Emerging after a period of uncertainty (*revolution*)
  - Evolving in accordance to the emergent paradigm (*demand pull*)



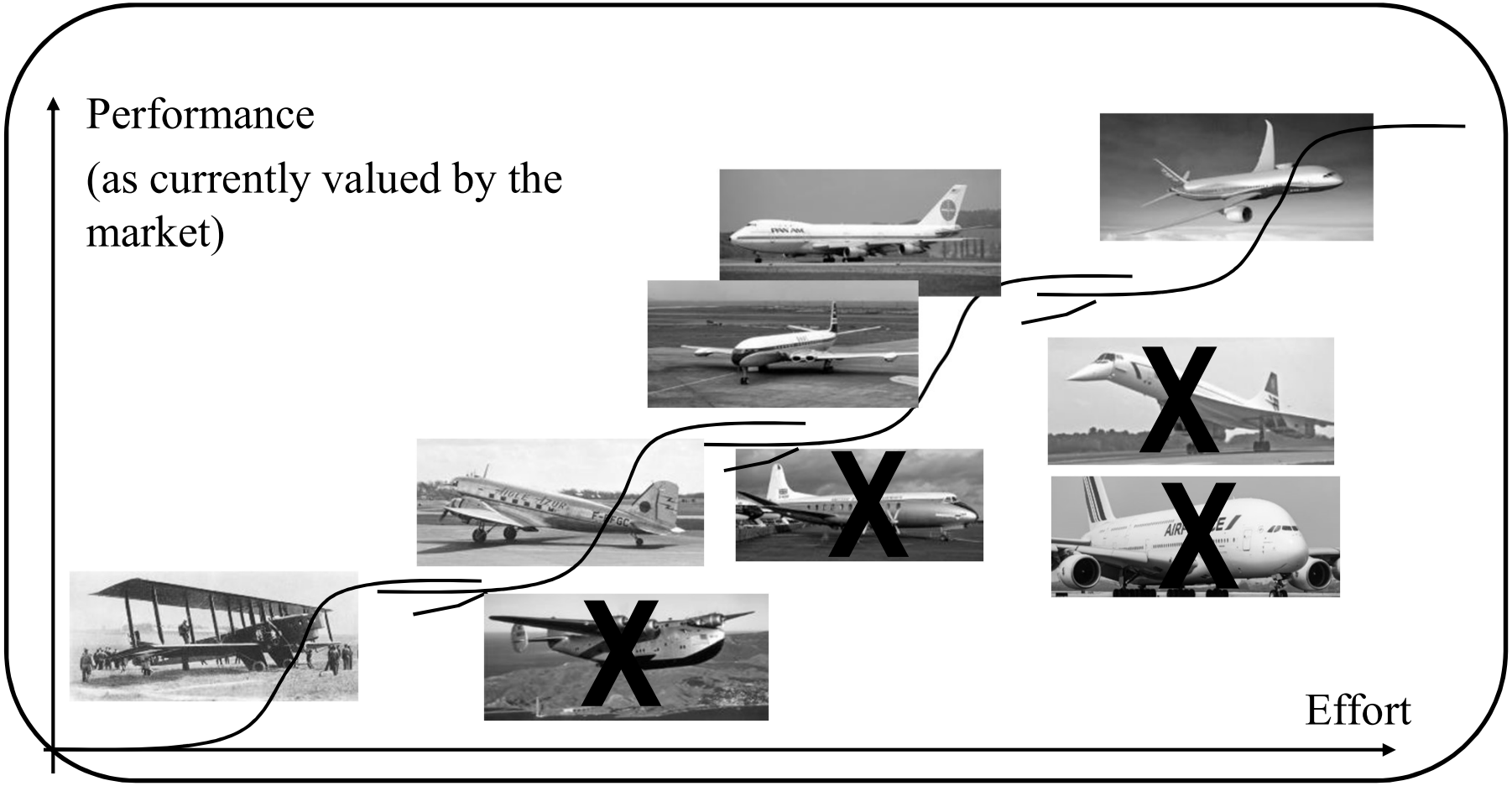







Airliner	Year	Airframe	Engines	Cruise speed (km/h)	Range (km)	Max pass.	Fuel eff. (km seat/l)
Flyer	1903	Wood + fabric	1 piston + propeller	48	-	1	-
Farman Goliath	1919	Wood + fabric	2 piston + propeller	120	400	14	13.4
Douglas DC-3	1936	Metal	2 piston + propeller	333	2400	32	8.4
Boeing 314	1938	Metal	4 piston + propeller	340	5900	74	23.5
Vickers Viscount 700	1948	Metal	4 turboprop	496	2220	48	15.3
De Havilland Comet	1949	Metal	4 turbojet	740	2400	44	3.56
Boeing 747-100, 200	1970	Metal	4 turbojet	893	12690	550	26.9
Concorde	1976	Metal	4 turbojet	2158	7222	120	6.4
Airbus 380	2007	Metal	4 turbofan	903	15460	853	31.6
Boeing 787	2011	Composites	2 turbofan	913	15400	440	36.6

Paradigms

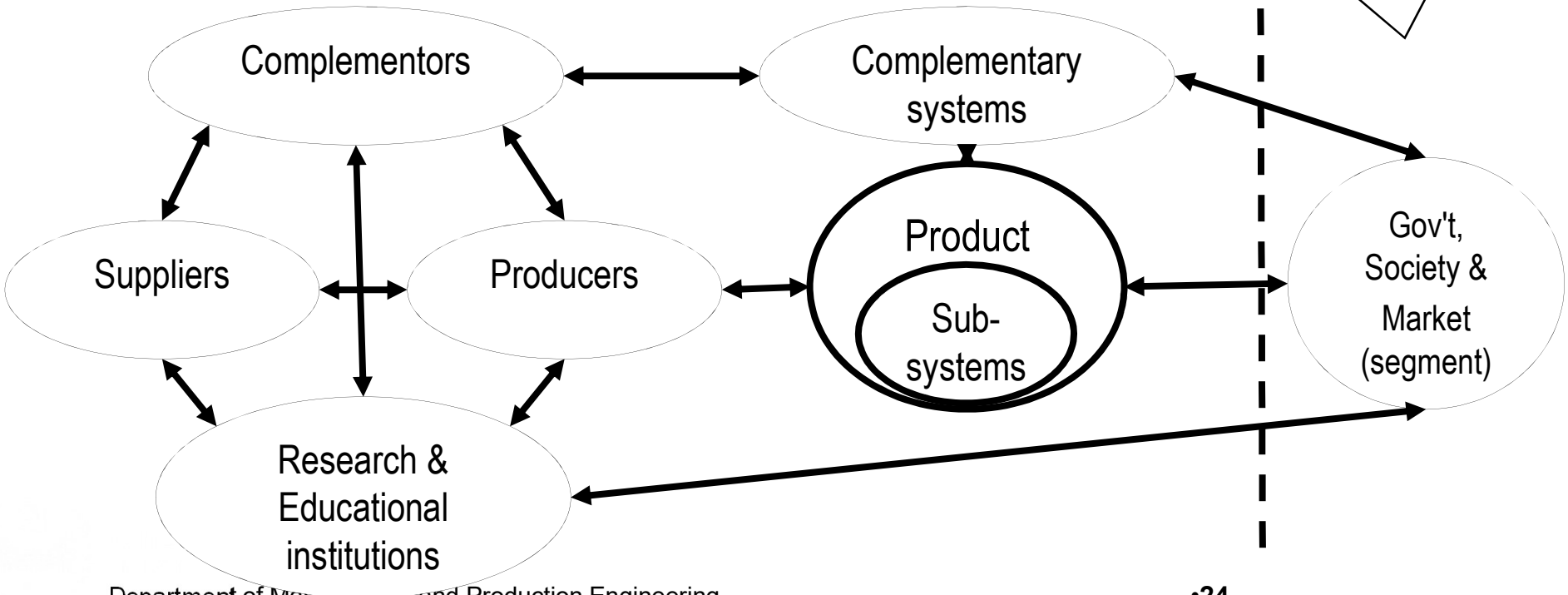


The distinction between
- suppliers (integration done by producers)
- complementors (integration done by customers)

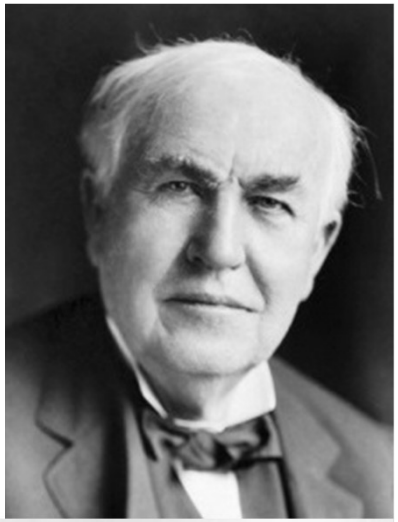
is not 'objective', but depends on producers' integration choices

Supply side
- Technological regime (knowledge, methods and tools)
- Sustainability of all actors' business models

Demand side
- Needs and objectives,
- Beliefs and meanings
- Norms and rules



Paradigms



- What were the competing paradigms they proposed?
- Which one won?
- Why?

Types of innovation

Criterion (look at...)	An "evolutionary" innovation is called	A "revolutionary" innovation is called
Product and the technical tradeoffs that define it	Incremental innovation	Radical innovation
Producer and its organization	Competence enhancing innovation	Competence destroying innovation
Product architecture	Peripheral innovation	Core innovation
Business impact	Sustaining innovation	Disruptive innovation

"Disruptive" is here intended in its broader sense

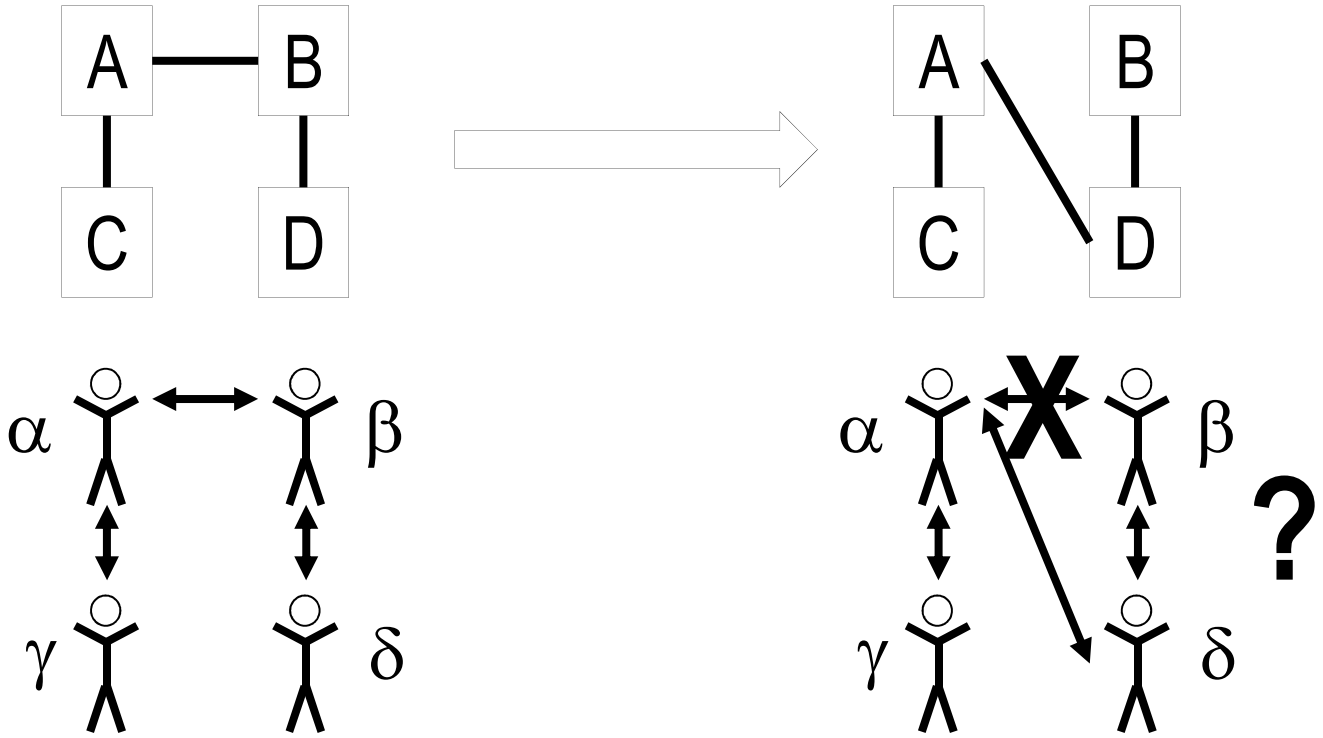
What kind of innovation is it?

It depends on who you are!

Types of innovation

Product architecture ≈ components and their mutual relationships

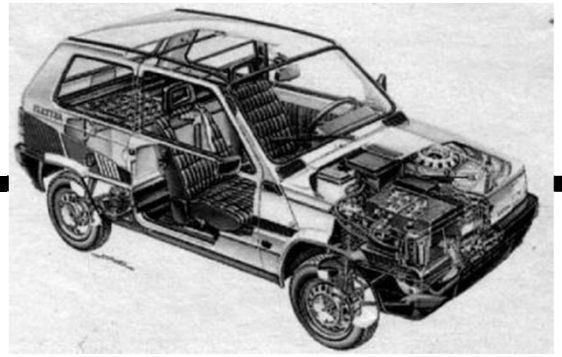
- Innovation and product architecture (Henderson and Clark)
  - Product architecture and the organization are coupled
  - What must happen if product architecture changes?

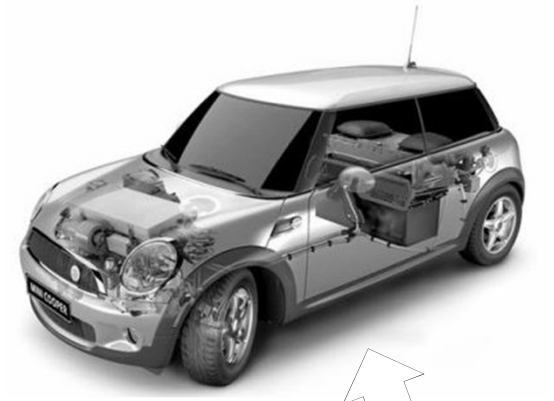


Types of innovation

- Innovation and product architecture (Henderson and Clark)
  - Product architecture and the organization are coupled
  - It is generally harder to change architecture than technology
  - Innovations often are not incremental or modular (but incumbents tend to downplay them as such)

Relationships between components / Reference technologies	Do not change	Change
Change	Modular innovation	Radical innovation
Do not change	Incremental innovation	Architectural innovation





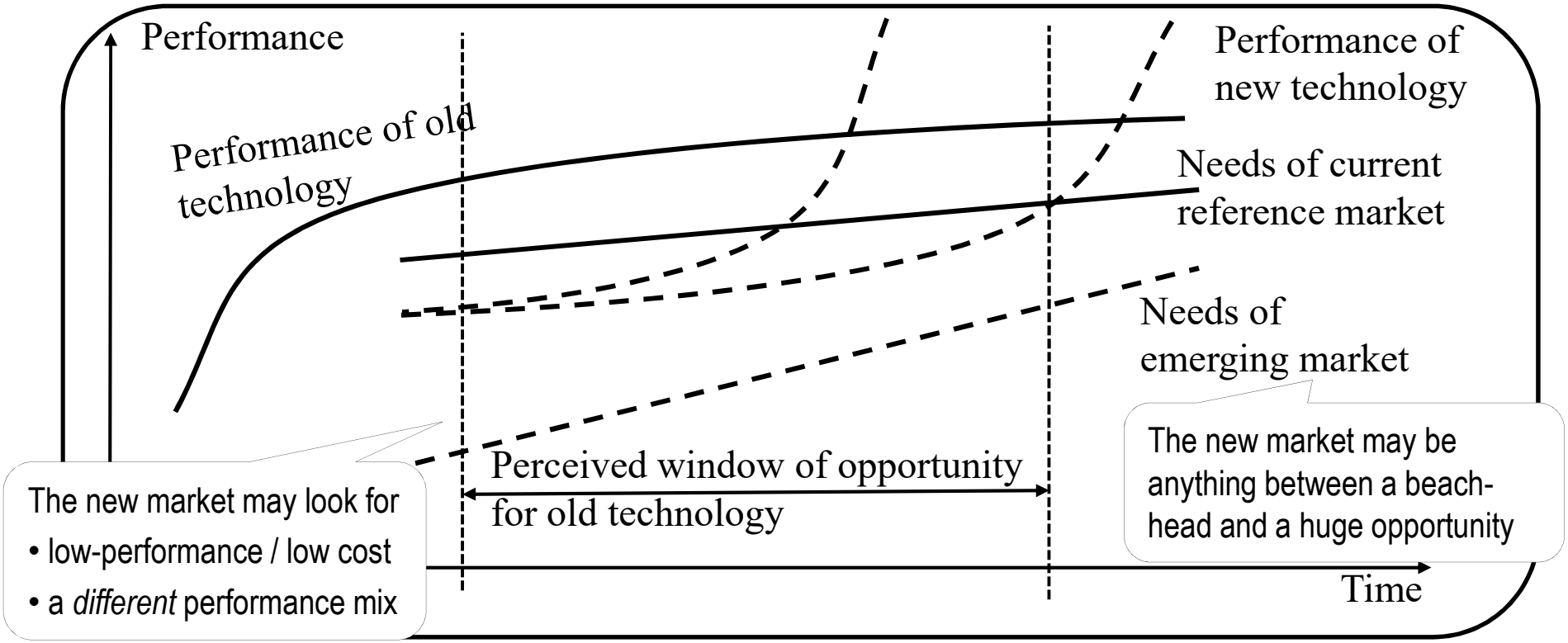
Relationships between components / Reference technologies	Do not change	Change
Change	Modular innovation	Radical innovation
Do not change	Incremental innovation	Architectural innovation

Types of innovation

- Why can innovations be *disruptive* (i.e. why do *incumbent* firms fail to tackle them)?
  1. The old technology does not keep pace with growing or new customer needs, but new technology does AND misaligned resources and organizational inertia → refrigerators
     - *competence destruction* and *competency traps* often arise in firms that have survived highly competitive industries (a weapon is valued when you've won many battles with it... Microsoft's focus on Windows and losing out in upcoming markets)
     - the effect is increased by three additional "traps"
       - Sunk cost trap ("*the old technology is more profitable because we already have assets associated to it*"... will this true beyond the short term, when assets will have to be replaced or maintained?)
       - Status quo trap ("*our old technology is more profitable because it is superior*"... for how long?)
       - Incentive trap (Employees lack high-powered incentives linked to expected firm growth and do not go "above and beyond", Bennet and Levinthal 2017)

Types of innovation

- Why can innovations be *disruptive?*
  2. New technology satisfies *unmet or changing customer needs* or *entirely new markets* … while incumbents focus on reference markets and powerful customers (Christensen) → PCs, digital cameras, Blackberry vs. touch-screen smartphones, cars.



Types of innovation

- Why can innovations be *disruptive?*
  - The "Christensen effect" is mainly due to
    - Criteria used for resource allocation and project selection, (market risk is overweighted w.r.t. technical risk)
    - Market research dominating over envisioning
    - The choice of suboptimal technology trajectories / business models that may leverage on existing complementary assets, often leading to «hybrid» products and services (e.g., Polaroid and Kodak)
    - Middle managers, who are in the position of championing innovative projects… but can't "change the givens" (and don't even think of escalating)

Legacy complementary assets create incentives to invest in disruptive technology, but following biased and suboptimal strategies (Wu et al., 2014)

Types of innovation

- Why can innovations be *disruptive?*
  - The "Christensen effect" is mainly due to
    - Top managers' rigid cognitive framing (which may be overcome by introducing "frame flexibility" and playing with emotions, Raffaelli et al., 2019)
    - Profitability of existing business and shareholders' expectations to go on "milking the cash cow" until the very last moment (Kodak/film vs. Netflix/streaming)
    - Moving to commercialization implies managing heterogeneous business models → conflicts within the organization / value chain (risk of being deserted and "stuck in the middle") and diseconomies of scope (Greenstein 2017)

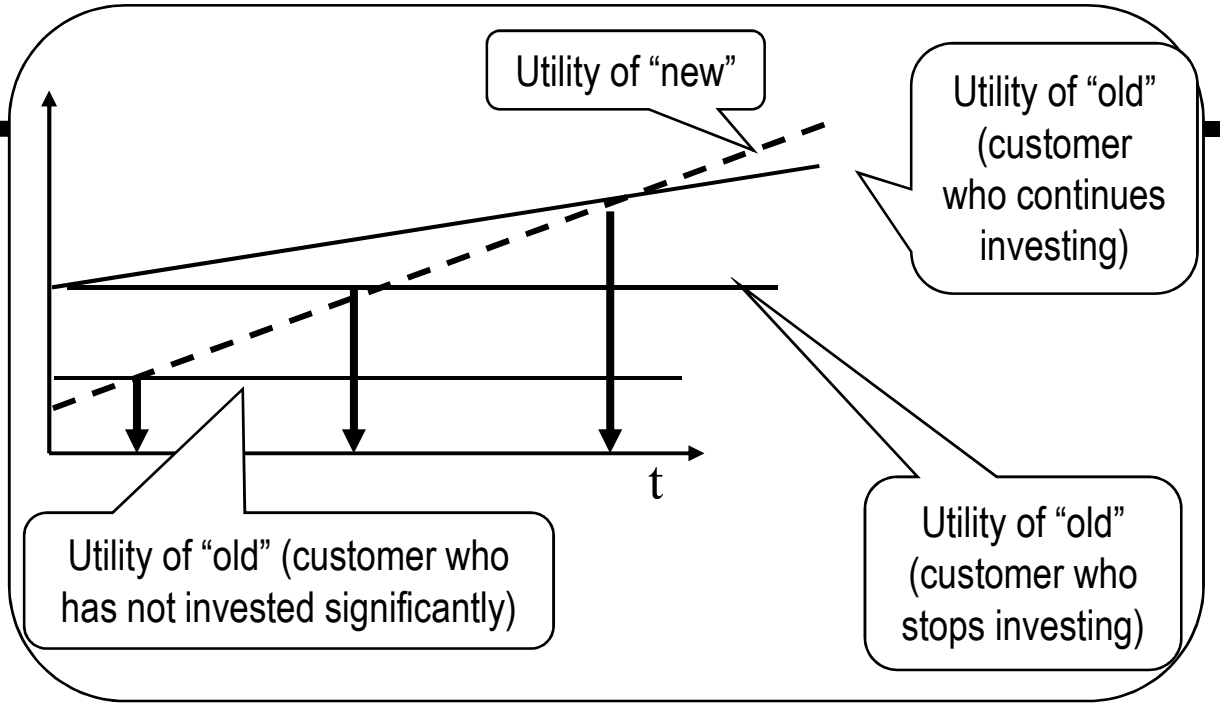
Institutional shareholding determines incentives to CEOs that positively influence innovation in general (Aghion et al., 2013), but does this hold for radical/disruptive innovation as well?
Is there a risk of "uniqueness paradox" (i.e., to be successful the CEO must have a unique strategy, but this increases his personal risks), unless shareholders are cognizant enough (Oehmichen et al., 2021)?

Types of innovation

- Why can innovations *not become* disruptive (with follower-incumbents win over innovators-new entrants)?
  1. Adoption might be delayed / rejected because of lock-in and/or switching costs
  2. "Appropriability regimes" and complementary assets matter a lot
  3. Many things can happen within a "maturing" S-curve → weak forecasting power
  4. Markets for technology allow incumbents to acquire new entrants

Types of innovation

- Adoption decisions are based on 5 factors (Rogers, 2003)
  - Relative advantage
  - Compatibility
  - Complexity
  - Trialability
  - Observability
- Technological change is 'localized' (Antonelli, 2012)
  - Each customer continuously evaluates the opportunity of switching from "old" to "new"
  - The customer will switch if/when utility of "new" is greater than utility of "old"



Utility of "old" is path-dependent and depends on (*endowment advantage*):
- Costs and revenues accruing from "old"
- Experience gained with "old"
- Complementary assets to "old"

Utility of "new" depends on:
- Costs and revenues accruing from "new"
- Switching costs to "new"
- Expected value of costs needed to switch back to "old" (cost x probability)

Types of innovation

- Risk of focusing on product innovation and neglecting market-making (Godley 2013)
  - In the case of durables and experience goods (≠ search goods), customers can be
    - Risk averse
    - Afraid of miscalculating utility deriving from adoption
    - Wary of information asymmetries w.r.t. the utility of the innovation
  - Producers must invest in «market-making»
    - Lower price (can backfire!)
    - Make customers aware of their latent needs and their proximity to product specifications
    - Generate trust on the product and on their own future actions
  - The far-reaching complexity of this process opens doors to entrepreneurial firms

- Enroll key influencers and opinion leaders
- Make credible commitments
  - warranties
  - license parts of the process to competitors (e.g., production, after-sales service, etc.)
  - sell a service (not the product), or offer a cheap and reliable service subsidized by a high purchase price (Singer sewing machines)

Types of innovation

- Appropriability and relationship with complementary assets required to develop the business / ecosystem / paradigm (Teece)

Entrants may have to

- develop an ecosystem from scratch
- work from within the existing ecosystem → «disrupters' dilemma» requiring a well-thought coopetion strategy with incumbents and complementors (Ansari et al., 2016)

The "appropriability regime" of technology can be strong or weak (w.r.t. legal protection or nature of technical knowledge)

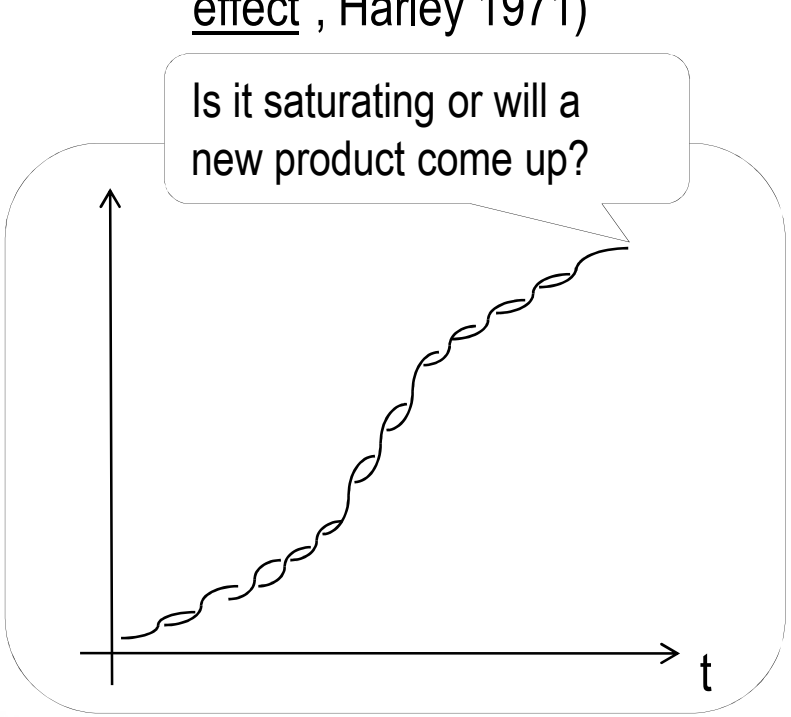
Complementary assets can be generic, specialized (technology shaped on asset, or *viceversa*) or co-specialized → ownership is critical

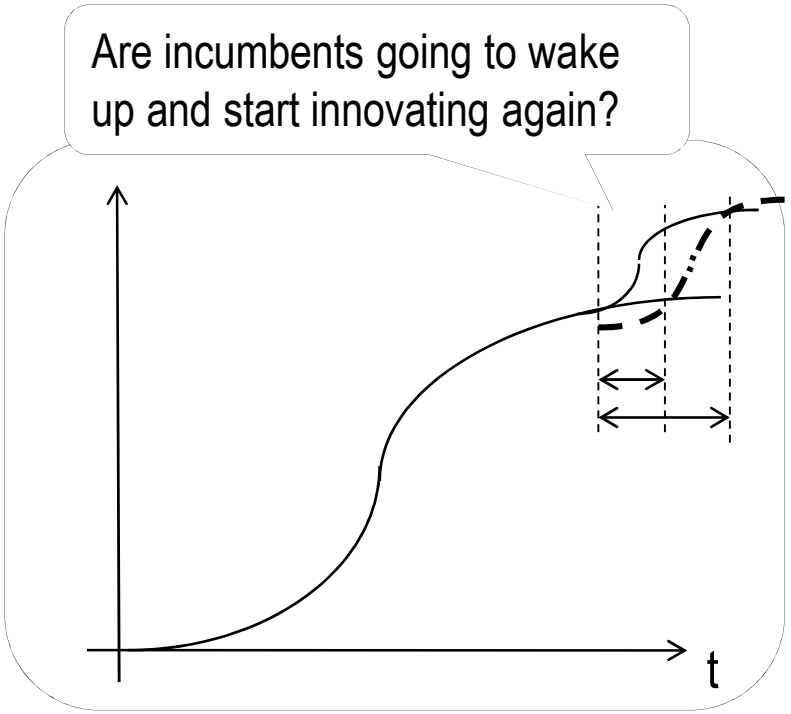
The innovator may attempt to own complementary assets (→ need for finance), buy them on the market, or leverage on the existing ecosystem (→ coopetion)

Appropriability / Owners of complementary assets are	Strong	Weak	
		Commissioning complementary assets easy for innovator	Commissioning complementary assets easy for all
Weak	Contract → Innovator should win	Contract → Innovator should win	Contract → Either innovator or imitator could win.
Strong	Contract or integrate → Innovator should win but profits will be shared with asset holders	Integrate → Innovator should win, but profits will be shared with asset holders	Contract → Innovator will probably lose to imitators and/or asset holders

Types of innovation

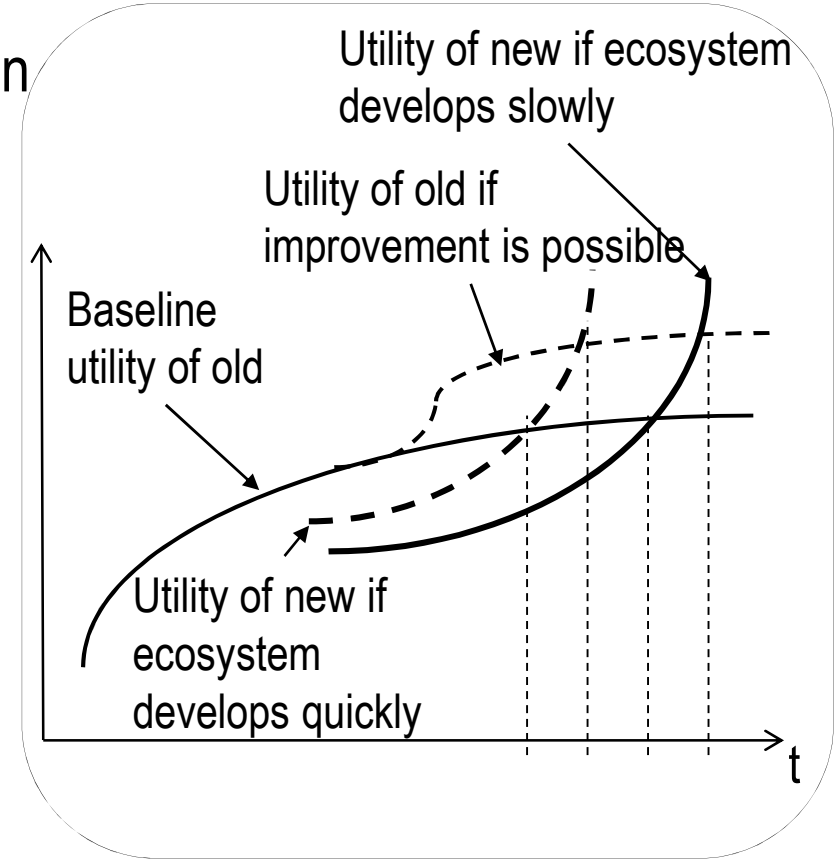
- It is often misleading to use s-curves to predict radical and disruptive change
  - s-curves exhibit *some* discontinuity because of *nested* s-curves (product generations, individual products) → difficult to understand *what* is saturating
  - s-curves are often drawn with time on the x axis (just add effort + retreat to the applications where technology can stay stronger for a while! →"sailing ship effect", Harley 1971)





Types of innovation

- Adner and Kapoor (2016) blend the impact of the sailing-ship effect and of the ecosystem (or paradigm) building challenge
- Adoption of potentially disruptive technology can be delayed by the
  - ease with which the old technology can still improve
  - difficulty with which the new technology can develop a utility-creating ecosystem



Types of innovation

- Analyzing maturity of s-curves is especially tricky at component level

- If a supposedly radical innovation really occurs at component-level
  - This causes limited disruption to the organization (switch suppliers!)
  - Component-level innovation *tends* to be incremental and enhances performance indicators valued by current markets → incumbents still have an advantage

- Radical change (maturing s-curves) <u>at architectural level</u> are more disruptive to incumbents, since architectural innovation
  - is disruptive to the organization and the value chain
  - *tends* to be radical (i.e. it alters the tradeoffs between performance indicators) → creates a potential offering for "new" markets

Did you see disruption in reflex cameras?

What about compact cameras?

Why?

Types of innovation

- When a radical innovation is upcoming what could your strategy as incumbent be?
  - Aside from «objective» rigidities, the main problem lies in top management's ability to perceive the risk of disruption and react by changing business models
  - 2 possible strategies are exploitation and exploration (Osiyevskyy and Dewald, 2015)

Exploitative strengthening of current business model **Explorative adoption of disruptive business model**	**No**	**Yes**
Yes	Pure exploration (jump ship quickly)	Integration (complex migration or create a spinoff)
No	Defiant resistance (no change)	Pure exploitation (incremental innovation)

  - Empirical research tells us that the choice depends on
    - The perception of the innovation, as an opportunity (→ leads to exploration) or as a threat (→ leads to doing nothing)
    - Managers' prior experience in dealing with risk (→ leads to doing something)
    - Industry experience (→ leads to doing nothing)

Types of innovation

- When a radical innovation is upcoming what could your strategy as incumbent be?
  - There always will be tension between the need for renewal and the cannibalization of the current business
  - In principle, exploitation and exploration are complements but – at organizational level – they induce negative externalities on one another
  - Literature proposes two major approaches (Boumgarden et al., 2012)

Ambidexterity

- Exploitation and exploration activities occur simultaneously within the company
- Exploitation and exploration are located in different organizational units, with different KPIs and management approaches
- Top management must mediate / balance / integrate appropriately between then two
- Ambidexterous behavior must be induced throughout the firm (down to each BU, team and individual)
- Ambidexterity should allow a smoother transition (but beware of reactions when "the new puppy starts eating into the old dog's bowl")

Vacillation

- The organizational focus alternates between phases of exploration and exploitation
- Organizational changes determine the shift (e.g., centralize / decentralize), but be aware that, while formal organizational change can be discontinuous, informal routines will adapt with inertia
- Vacillation lessens the risk of being «stuck in the middle»
- Vacillation is more effective when it is not too abrupt, especially if resources are limited (Kang and Kim, 2000)

Types of innovation

- So, when a radical innovation is upcoming what could your strategy as incumbent be?
  - Pre-emptively lock customers in your technology
  - Try “killing” the new technology or buy time
    - improve the old technology
    - start a price war
  - Segment the market by “needs” and closely monitor (or serve) them all (“incumbent’s advantage”)
  - Be wary of “sunk cost” and “status quo” traps
  - Migrate to the new technology
    - Listen to “people on the edges”
    - Fund R&D top-down and/or go for acquisitions
    - Bring new champions on your top management team on time and allow some tension
    - Look for the “right” market and business model
    - Involve entrants in your ecosystem and work on the new paradigm in order to minimize disruption
  - Retreat to a niche or relocate to a different market where you can use your assets

Acquiring a «complementary» large incumbent with vested interests is dangerous (Sony/CBS, AT&T/AOL)... inertia is simply amplified

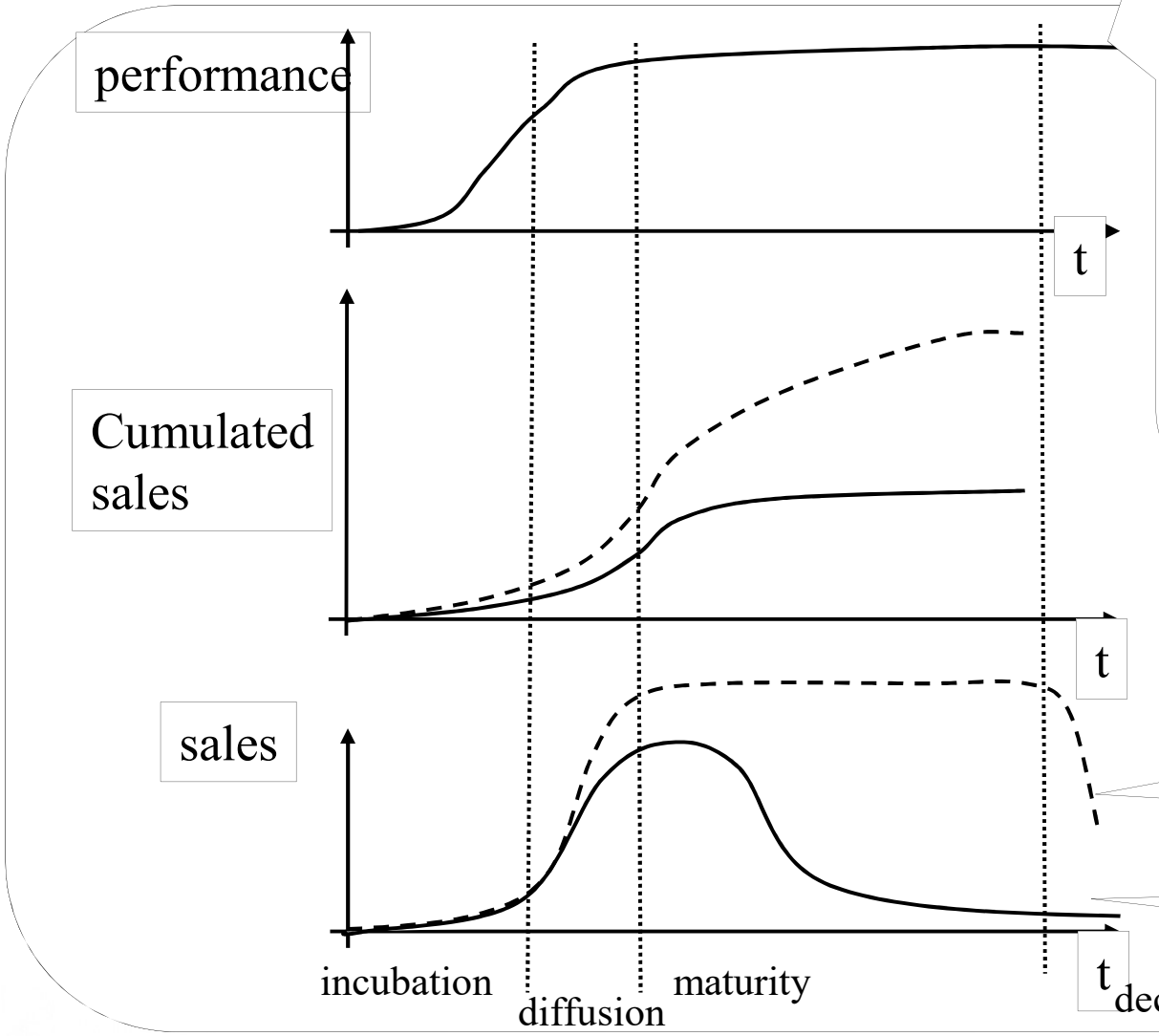
Types of innovation

Speed of diffusion and technical progress, cash burn rates are key elements to consider

- ... and what if you are a new entrant?
  - Find the right beach-head market that is
    - right for your immature technology
    - likely to be overlooked by incumbents
  - Stay away from markets that are overserved and locked-in the old technology
  - Make the right vertical integration choices
  - Strengthen your IPRs
  - Be wary of your lack of complementary assets and develop the right strategy, eventually coopeting with incumbents (e.g., B2C fintech firms moving to B2B2C)
  - Watch out for improvements in the existing technology
  - Consider selling your business to an incumbent

Dynamics of innovation

- S-Curves and diffusion



The product life-cycle model works for most products that have to do with new technology.

The **co-constructivist perspective** says that "*products stay alive as long as there is a social network of actors that see value and meaning in producing and purchasing them*" (think about food, fashion, design, etc.)

Performance and ***meaning***, can be weighted differently by markets as time goes by

subsequent purchases (additional and replacement sales)

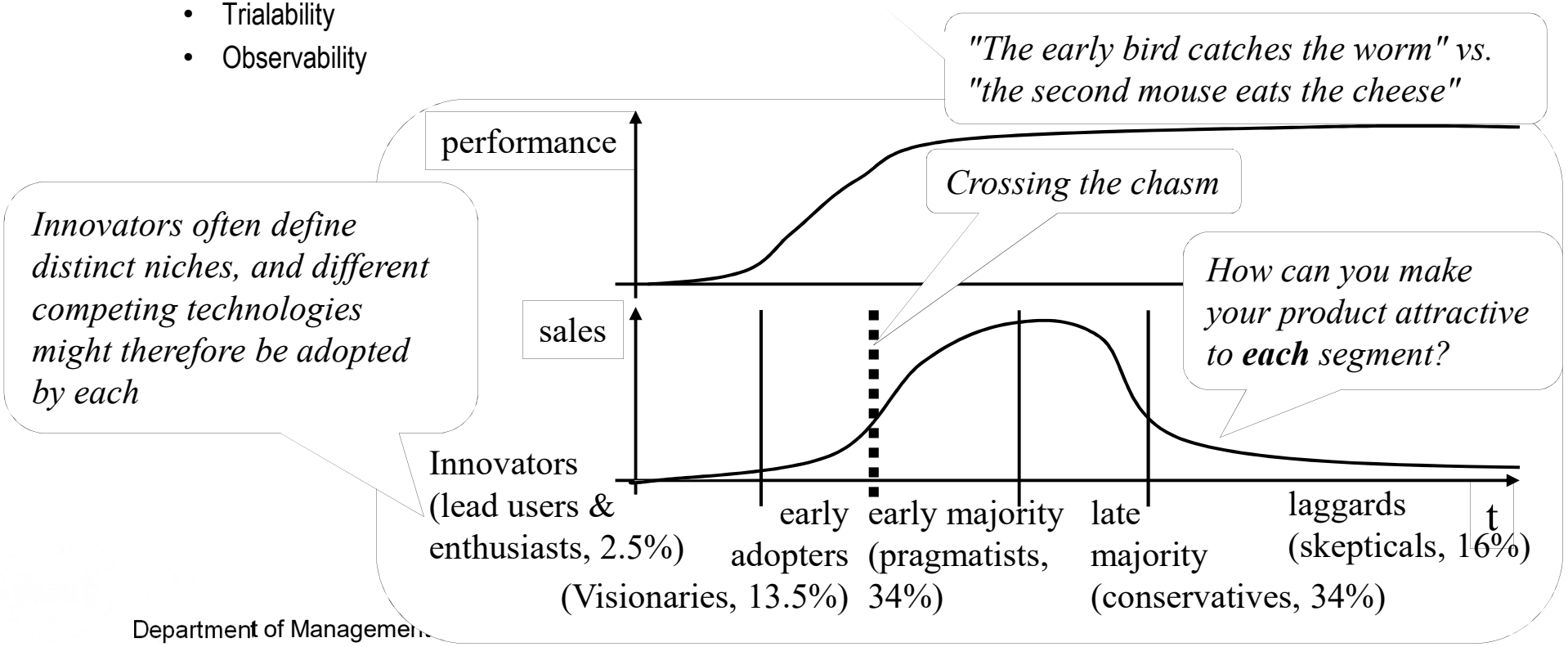
1° purchase (adoption sales)

Dynamics of innovation

- S-Curves and diffusion can be studied under a number of perspectives
  - Mathematically (Bass model and its variants)
  - Diffusion of Innovation (Rogers, Moore and others)… the technology is assumed to be value creating, and will be gradually accepted by a sequence of market segments
  - Technology Acceptance Models (Davis) / Unified Theory of Acceptance and Use of Technology (Venkatesh) …
  - Social Network Threshold theory (Valente)…

Dynamics of innovation

- Rogers (1962) DoI theory
  - 5 segments, profiled w.r.t. their attitude towards innovation
  - Key features are
    - Relative advantage
    - Compatibility
    - Complexity
    - Trialability
    - Observability
- Moore (1991) shows that moving to the early majority requires new competencies and assets
- Is it better to be leaders or followers?
  - It depends on capability to lock-in the early market, rate of learning and observability of lessons learned (iPods)
  - If diffusion is fast, crossing the chasm is much easier for incumbents that for de alio entrants and startups



Dynamics of innovation

- How can you make your radically innovative product attractive to ...

Innovators?

- Understand who these beach-head innovators are and their specific needs
- Find a way to contact them
- Make sure that initial technical shortcomings can be overcome by users and field service
- Engage in dialogue with them

Early Adopters?

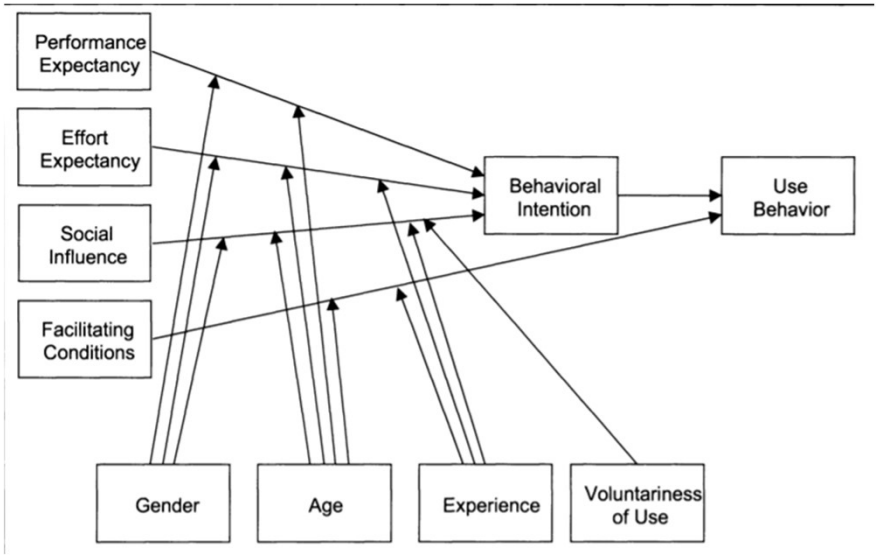
- Start creating a solid “adoption network” (distributors, complementors, etc.)
- Start working on ancillary features such as ease of use, design, etc.
- Define a satisfactory (if not perfect) price-benefit ratio
- Ensure that the product is reliable and “cool”, so that early adopters can start a positive imitation effect
- Lower purchasing risk (“get your money back”, razor-blade business models, etc.)

the Early Majority?

- Work hard on ease of use, design, etc.
- Consolidate the “adoption network” (ensure that complementary products & services are made available)
- Sell as a bundle with other goods with which the user is familiar
- Make technical features “just good enough” but not more
- Look carefully at pricing (not too high to discourage, not too low to kill margins)
- Lower risk in purchasing

Dynamics of innovation

- Technology Acceptance Models (Davis 1989, Venkatesh 2000 and others)
  - Developed in the field of Information Systems research
  - Users must first *intend* to use the new product, then start using it
  - Key constructs of TAM/TAM 2 are
    - Perceived usefulness (create a gain / relieve of a gain)
    - Perceived use of use
    - Subjective norm (ie, the perception that people who are important to you think you should act)
  - UTAUT (Unified Theory of Acceptance and Use of Technology) expands TAM/TAM2 with constructs from DoI

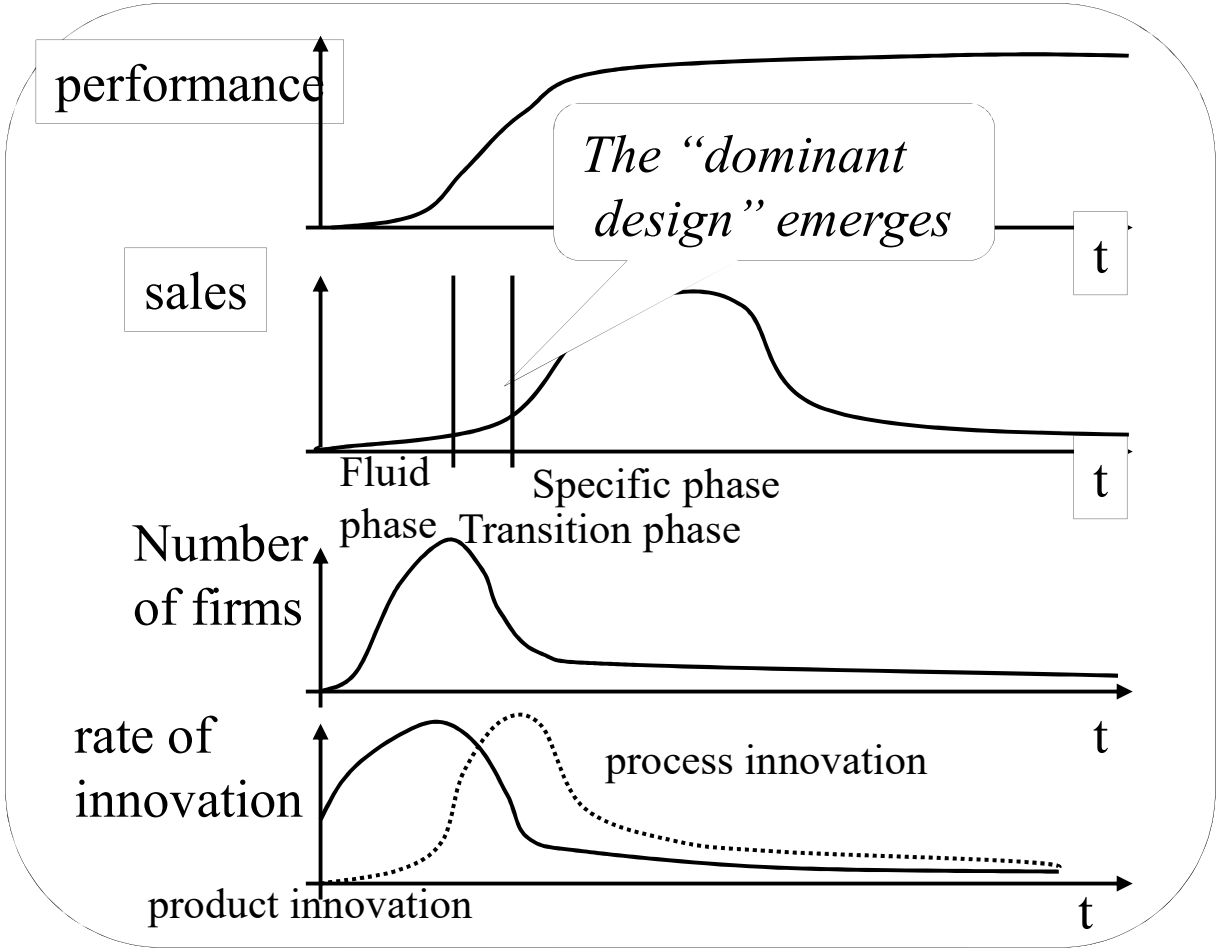


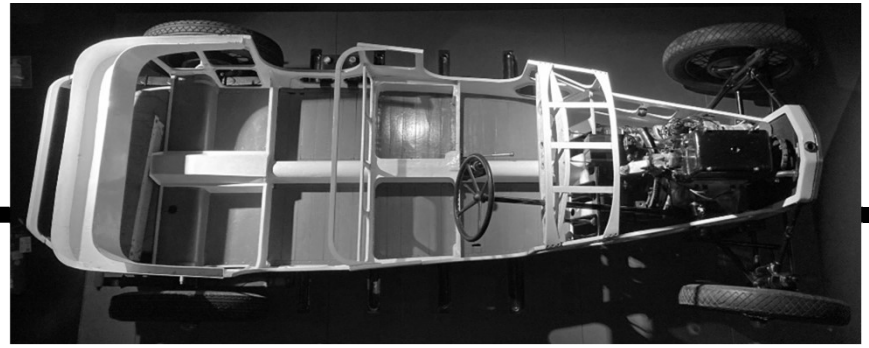
Dynamics of innovation

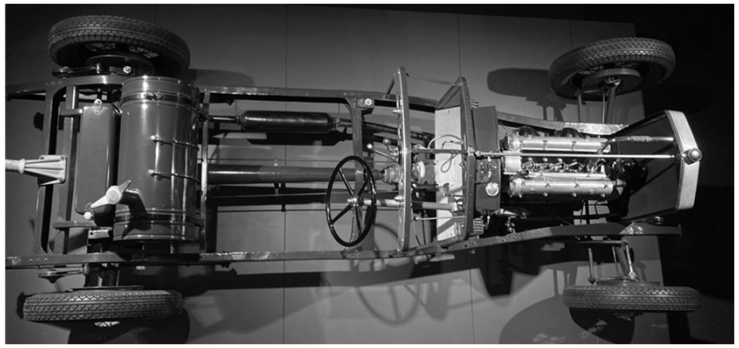
- Social Network Threshold theory
  - Each individual adopts after the "pressure to adopt" has passed a given threshold
  - Each individual is characterized by a specific threshold (this recalls Rogers' segments)
  - The "pressure to adopt" depends on
    - individuals' exposure to their social network,
    - the adoption behavior of those who are connected with him
    - external influences (e.g., advertising)
  - Therefore, each individual can be categorized differently, if you look at the overall social system vs. his specific social network.

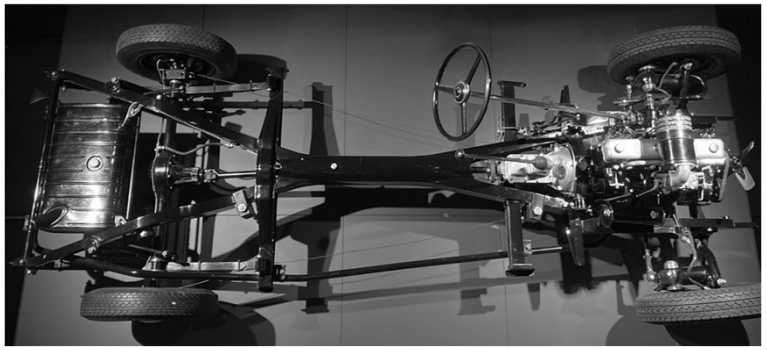
Dynamics of innovation

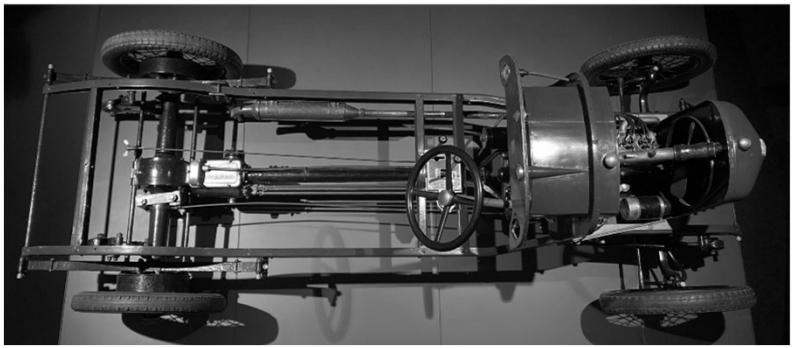
- Abernathy-Utterback (assembled products)

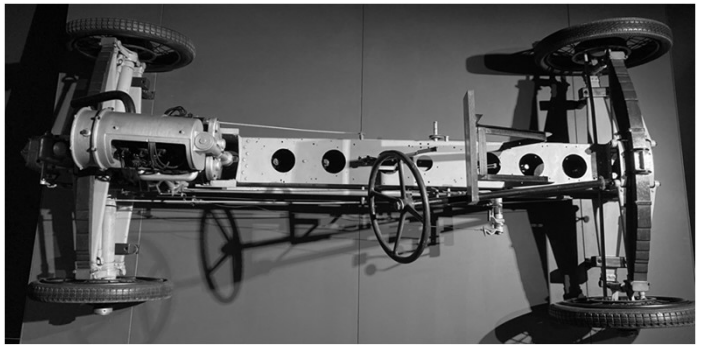












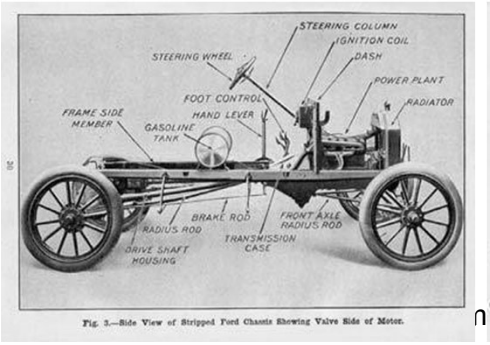
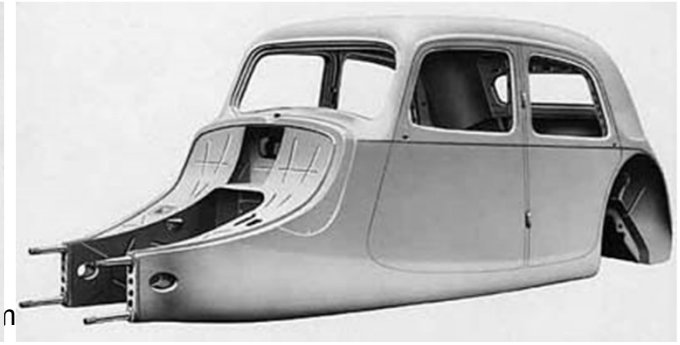


Fig. 3.—Side View of Stripped Ford Chassis Showing Valve Side of Motor.



	Fluid	Transitional	Specific
Main strategic challenges	Entering • with the "right" technology / product concept, making best use of technological assets and vision of the future (Benner and Tsipras 2012) • at the «right time» in the «window of opportunity» (Christensen et al. 1998) Trying to make *your* design / technology dominant Keeping some options open with other competing technologies	Switching to the «right» technology at the right time, if feasible Readjusting specific and wrong choices associated to the right technology (which is hard – Eggers 2014) Managing initial growth and surviving the shakeout	Surviving further shakeouts Surviving commoditization (looking for further innovations) Anticipating the next S-curve
Competitive emphasis	Functional performance on the «right» product features	Product variation	Cost and quality
Favored firms (diversifying entrants vs. startups)	Probably no difference between diversifying entrants and startups who make the «right» choice. Among the others, diversifying entrants may switch technology with greater ease.	Diversifying entrants (because of scale and complementary assets)	Startups might find it easier to keep abreast with technology and have no fear of cannibalizing existing products Diversifying entrants may find the «transition to incumbency» easier because of prior experience (Chen et al. 2012)

Dynamics of innovation

	Fluid	Transitional	Specific
Innovation stimulated by opportunities in	Market and technology	Internal technical capability	Pressure to reduce cost and improve quality
Predominant type of innovation	Radical on product	Radical on process (to scale volume up)	Incremental on product and process
Production processes	Flexible	Becoming rigid	Rigid
Equipment	General purpose, requires skilled labor	Islands of automation	Special-purpose and highly automated
Materials and components	Generally available or internally developed (critical decision!)	Specialized, from suppliers or through vertical integration	Specialized, sometimes through vertical integration
Plant	Small-scale	Growing	Large-scale
Organizational control	Informal and entrepreneurial	Project- and task-based	Bureaucratic

Dynamics

Case of gasoline-powered vs. steam-powered and electric cars (Geels 2005)

- prevailing initial niches and seamsless progression to new ones (taxis, luxury urban transport, sports, tourism, followed by doctors, salesmen and farmers, but **not** freight transportation)
- gasoline as "surplus" of oil cracking already having an initial distribution network
- Ransom Olds attending 1895 car race
- horse troughs shut down because of livestock diseases
- technical improvements (e.g., clutch and gearbox) and spillovers from competing dominant designs (e.g., electric starter)

- Dominant designs emerge because of selection criteria that are endogenous to the technical and economic environment
  - Superior technology (as perceived by the initial customer niches) and opportunity to improve products and processes
  - Seamless diffusion across market niches, with little reaction by actors affected by disruption
  - Reputation of the firm(s) following the design, especially if the leader allows some technological spillover to competitors
  - Existence of complementary assets
  - Public policy (regulation, taxation, infrastructure)

Spillovers reduce competitors' incentives to develop

- a different technology → lower risks and shorter time
- own competencies → weaker competitors

(Pacheco de Almeida and Zemsky 2012), e.g. Intel and AMD, Tesla

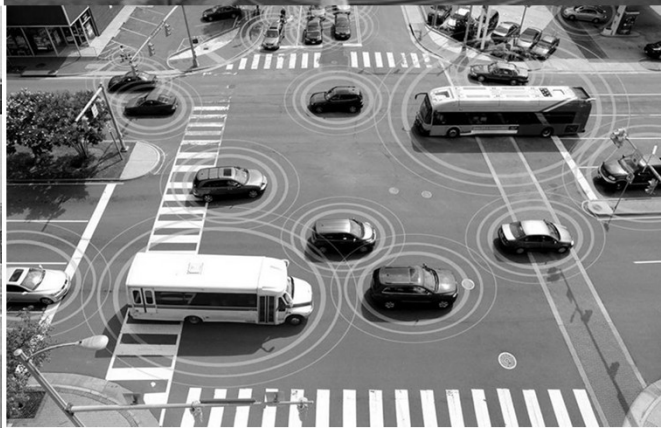
Dynamics of innovation

- Dominant designs remain stable (*lock-in*) because of
  - Economies of scale in production
  - Organizational learning within firms & value chains
  - Network externalities
  - Investment in complementary assets
- Unsuccessful designs tend to disappear… or serve niches

Dynamics of innovation

- The model by Abernathy and Utterback applies to non-assembled goods (process industry) and services (Barras) too but
  - In such industries it is difficult to observe innovation (organizationally embedded)
  - Dominant designs emerge in the process (not in the product)
  - Rates of innovation for product and process are inverted
  - The process/infrastructure determines lock-in

Clearinghouses in legacy ATM infrastructure
RF-ID vs. GPS/V2I tolling systems in German autobahns
Cable vs. FTTC/xDSL vs. FTTH in telecommunications
WiFi V2V vs. 5G C-V2X infrastructure for connected cars



Dynamics of innovation

- Does the Abernathy-Utterback model still hold today?
  - Modularity might make dominant designs less important (Cebon et al., 2002)
    - Specialization resides within modules (not architectures)
    - Economies of scale are found at the level of modules (not products)
    - The role of organizational learning is reduced by functional independence
  - The Abernathy-Utterback model does not deal with product-services
  - The model doesn't say much about vertical integration choices, which are critical
  - The fluid phase is very complex

    Even before commercialization, there is a long and complex "investment-incubation" process

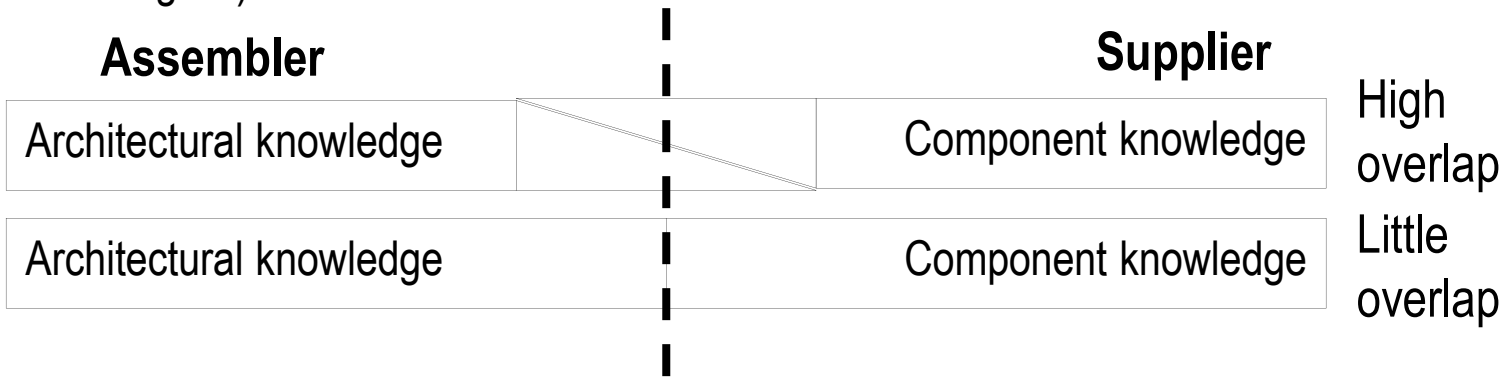
    The dominant design emerges as a process, with an «innovation shock» (launch of a highly successful product, Argyres et al., 2015, or emergence of a «dominant category», Suarez et al., 2015) → simultaneous attraction of entrants and initial shakeout → emergence of the related dominant design
  - There can be «false starts»
    - Subsequent process (process) innovation may or not effectively allow the long-term establishment of a dominant design emerging in the product (process)
    - Uncertainty is such that later adopters «follow leaders» blindly, allowing initial diffusion of soon-to-be-abandoned innovations (Greve and Seidel, 2015)
  - Innovation is not only "product" and "process"

Dynamics of innovation

- Given that assembled products and services exhibit opposite behavior, what happens for bundles of product-services (e.g., navigation devices and mapping services)?
- What happens if these bundles are *also* based on modular architectures (in the product *vs.* in the infrastructure)?
  - You have to look at standards (where do they make sense?, e.g. DRM in music)
  - You have to look for components where economies of scale might arise (e.g. SIRF chips and maps for navigators)
  - The "typical" dynamics (dominant design, innovation rates, etc.) arises in the part (product vs. infrastructure) where you have less modularity

Dynamics of innovation

- Vertical integration choices are strategically important
  - The degree of vertical integration will be lower if (Christensen et al., 2002)
    - Initial architectural problems have been solved, and the architecture / dominant design allows the development of a value chain
    - the market values component-level (i.e. localized) product performance instead of performance that is determined by system integration
  - Architectural and component knowledge is partitioned among assemblers and suppliers with some overlap. Overlap will decrease (Lee and Veloso 2008).
    - as the paradigm progresses along the s-curve (at first *both actors* mus focus on architectural innovation)
    - if modular architectures arise
    - as long as the trajectory does not encounter significant uncertainties (market or technological)



Dynamics of innovation

- The rise of a dominant design requires interplay between product and process innovation
  - Abernathy and Utterback's model assumes that, once the dominant design has been established in the product, process innovation will take care of ensuring manufacturability and economies of scale (for continuous products and services, product innovation will allow a fuller economic exploitation of the infrastructure)
  - However, a candidate dominant design could fail prematurely if this does not happen, i.e., if the product dominant design is not easy to manufacture (for continuous products and services, if it is not easy to generate new products)
  - The transition phase can therefore take a long time and exhibit a sequence of «false» dominant designs, and the final will be the one for which the second stream of innovation (process or product) becomes feasible

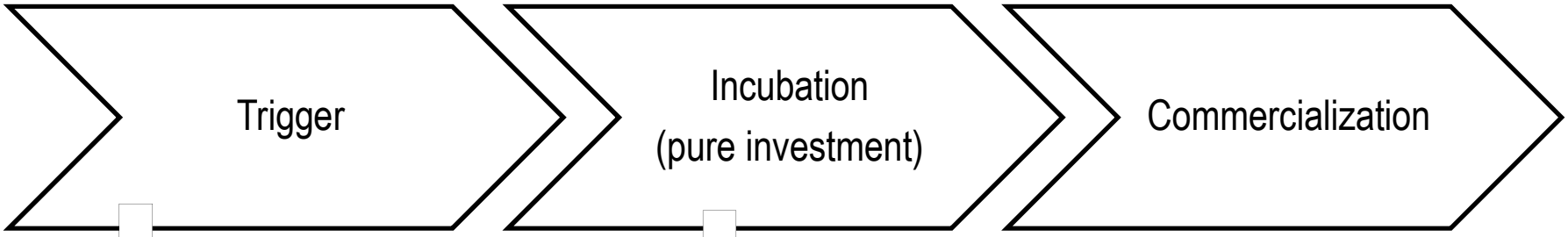
«Ease» is not necessarily in absolute terms... could be in «local» terms (w.r.t. industry, geography,e tc.)

e.g., integrated photonics chips, many contemporary battery designs

e.g., proprietary network protocols before TCP/IP

Dynamics of innovation

- Industry dynamics in the incubation period is critical, and 'entry' must consider both the incubation and the commercialization phases (Moeen and Agarwal, 2017, Agarwal et al, 2017, Moeen 2017)



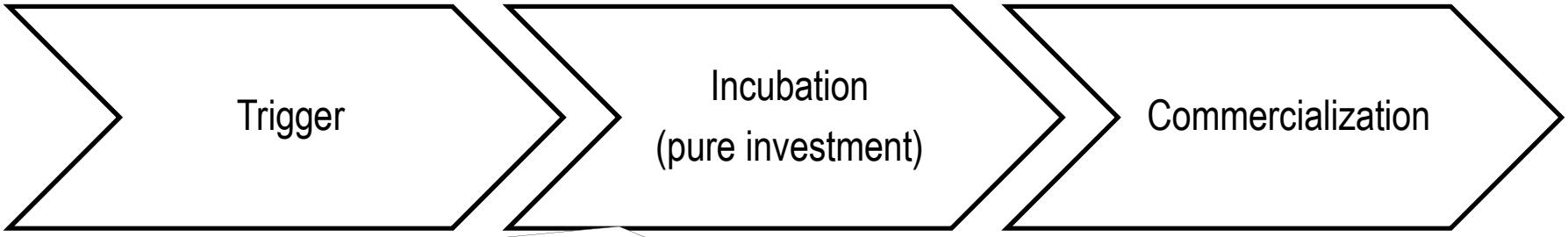
Trigger event	Key actors	Technological actions	Market actions
Scientific discovery (e.g., GMOs)	Academia and research Firms	Developing core and complementary technologies in absolute terms and for the 'right' applications	Finding the 'right' applications Building identity and acceptance
Unmet user needs (e.g., dishwashers)	User inventors, entrepreneurs, communities	Moving from prototype to product	Finetuning user requirements
Mission-oriented 'grand challenges' (e.g., antibiotics)	Government agencies, nonprofits, academia and research, firms	Moving from prototype to product Developing core and complementary technologies	Moving from 'generic' to 'commercial' need Finding new applications

Incubation implies

- A trigger event
- Heterogeneous actors
- Knowledge sharing
- Iterative activities aimed at reducing technology and market uncertainty (technology as 'enabler' or 'affordance', Gibson 77)

Dynamics of innovation

- Industry dynamics in the incubation period is critical, and 'entry' must consider both the incubation and the commercialization phases (Moeen and Agarwal, 2017, Agarwal et al, 2017, Moeen 2017)



Three types of firms enter and exit

- Incumbents from closest industry,
- De alio (diversifying) entrants,
- De novo (startup) entrants

Different knowledge bases are brought to the industry

- Obsolescing
- Emerging
- Complementary

Firms operate a flurry of activity (competition, alliances, acquisitions) leading to

- Knowledge and technology transfer
- A first shakeout
- A variety of modes for capturing value (i.e., getting to commercialization, being acquired, licensing)

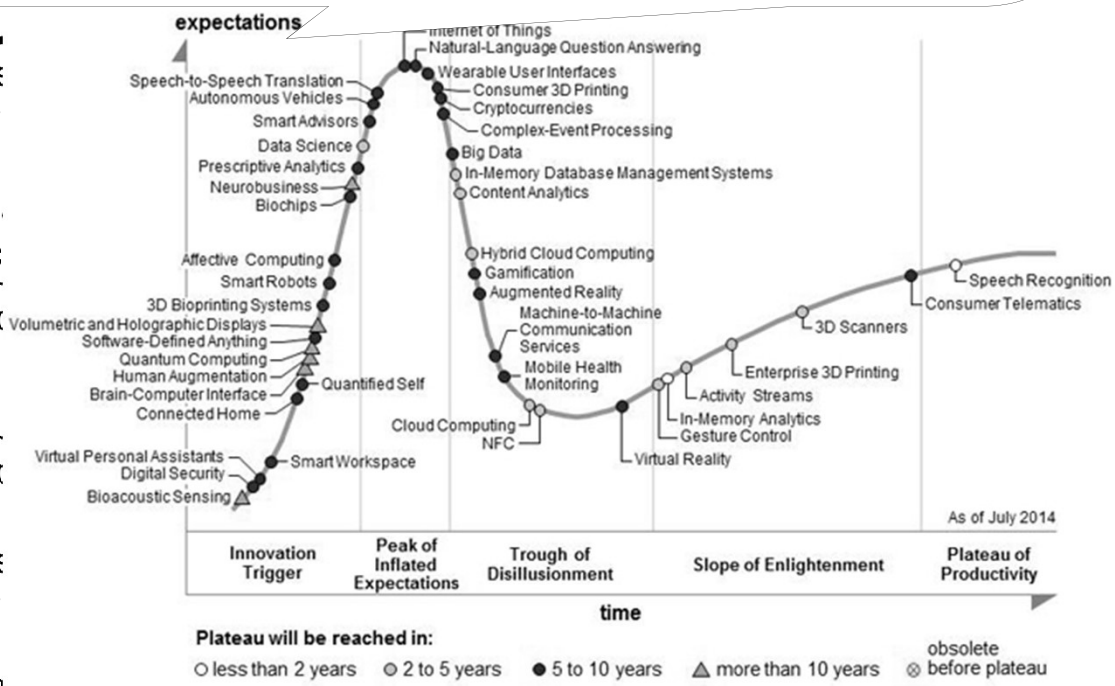
- Practitioners often use Gartner's "hype cycle", representing emerging technologies' evolution (at different speeds) over 5 phases.
- When is the dominant design *really* determined?

  Prior to commercialization, based on sequential experimentations of "variants" of technology, which then are "frozen" (Roy et al, 2019)?

  vs.

  After initial commercialization, during the "slope of enlightment", and as an emergent recombination of technological alternatives (→ "technical performance") and application "verticals" (→ "economic value")?
- We see Rosenberg's (1994) "economic experiments", and Gans et al.'s (2016) "paradox of entrepreneurship" (i.e., to make the best choice you must learn. To learn, you must experiment. By experimenting in a given direction, you foreclose other options)

		actions
Scientific discovery (e.g., GMOs)	Academia and research Firms	Developing core complementary technologies in absolute terms the 'right' applic
Unmet user needs (e.g., dishwashers)	User inventors, entrepreneurs, communities	Moving from pr to product
Mission-oriented 'grand challenges' (e.g., antibiotics)	Government agencies, nonprofits, academia and research, firms	Moving from pr to product Developing core complementary technologies



Dynamics of innovation

- It is possible to link innovation content at (upstream) component level and (downstream) complementary good level (Adner and Kapoor, 2010)... look at Project Better Place
  - Challenges have to be managed both upstream and downstream... and this is tough
    - With multiple challenges, probabilities are multiplied, and lead times may not be in parallel!
  - Impact on "first-mover advantage"
    - greater if challenges are at component level (creates room for improvement)
    - lower if challenges are at complementor level (slower demand reduces progress on the learning curve and buys time for imitators)
  - Impact on vertical integration choices
    - At the beginning of the s-curve vertical integration should be focused on solving technological uncertainty AND behavioral ambiguity in the market
    - Later on, it should mostly be focused on behavioral ambiguity

Also depends on degree of modularity

Also depends on whether complementary goods are proprietary or not

External *complement* challenges External *component* challenges	Easy	Tough
Easy	Only internal innovation challenges	Internal challenges + constraint on demand
Tough	Internal challenges + constraint on production	Internal challenges + constraints on demand and production

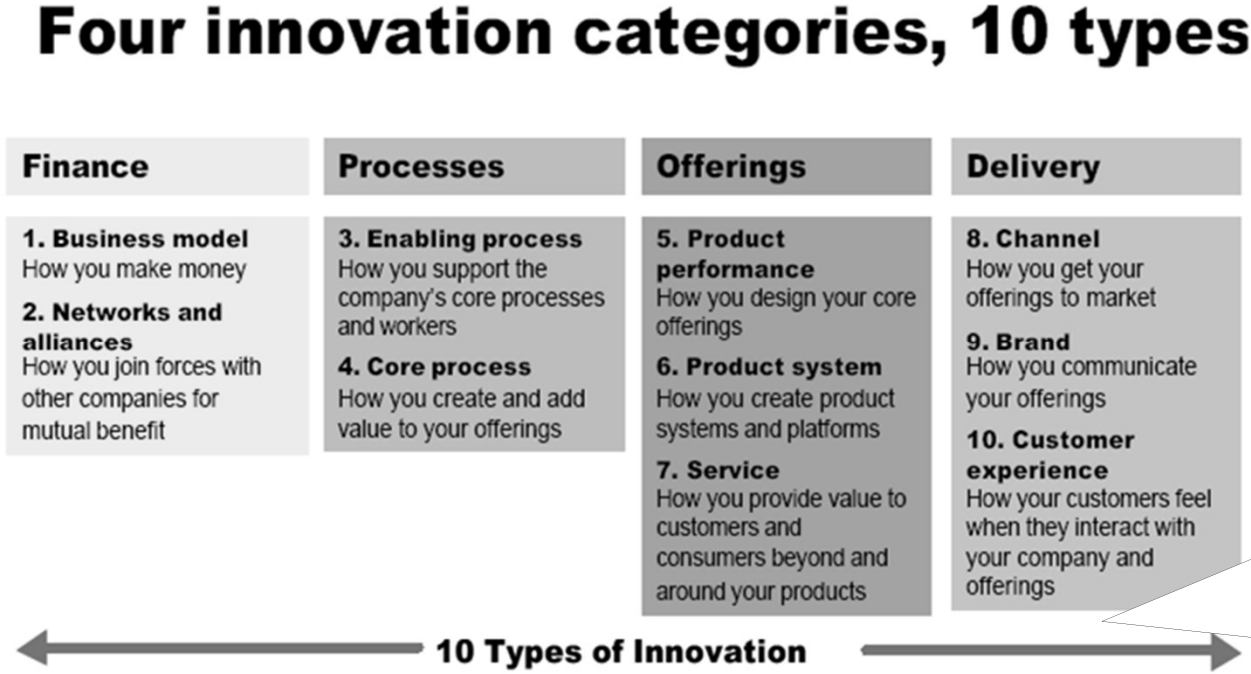
Traditional and reverse innovation

- Traditionally, innovations diffused in developed countries and then «trickled down» to emerging countries
- In «reverse innovation» (Govindarajan and Ramamurti, 2011), innovation diffuses in developing countries and «trickles up» to developed countries
- 5 main reasons

Features of the emerging country innovation	Determinants of diffusion in the developed country
Low cost	Appeals to poor people in rich countries
Low cost	Expands demand in rich countries
Particular features (e.g. ruggedness, portability)	Creates new market segments in rich countries
«Good enough» product, with room for improvement	Mainstream customers adopt improved versions of the product
Incorporation of radically innovative technology (leapfrogging) thanks to large demand, absence of legacy technology, low regulatory barriers	The emerging country leads the dominant design-formation process, and the innovation quickly enjoys economies of scale

Dynamics of innovation

- Doblin and Keeley – innovation categories, types and landscapes
- As with Abernathy and Utterback, innovation follows “waves”… product, process, followed by the rest
  - if you miss them out, you risk disruption even within the same s-curve (Netflix vs. Blockbuster)
  - need to keep constant watch on the business model, change management team, recruit talent, with a long-term (5-7 years) view (Nunes and Breene 2011)



Corporate competencies will become obsolete before it shows on P&L statement

You can have incremental or radical innovations in each of these categories!

The more categories are affected, the more radical is the overall innovation

Can be observed in case of

- Broad change in product (→ revenue model) and process (→ cost structure) (e.g., low-cost airlines)
- «complex innovations» emerging in an «ecology of firms» (Dougherty and Dunne, 2011)

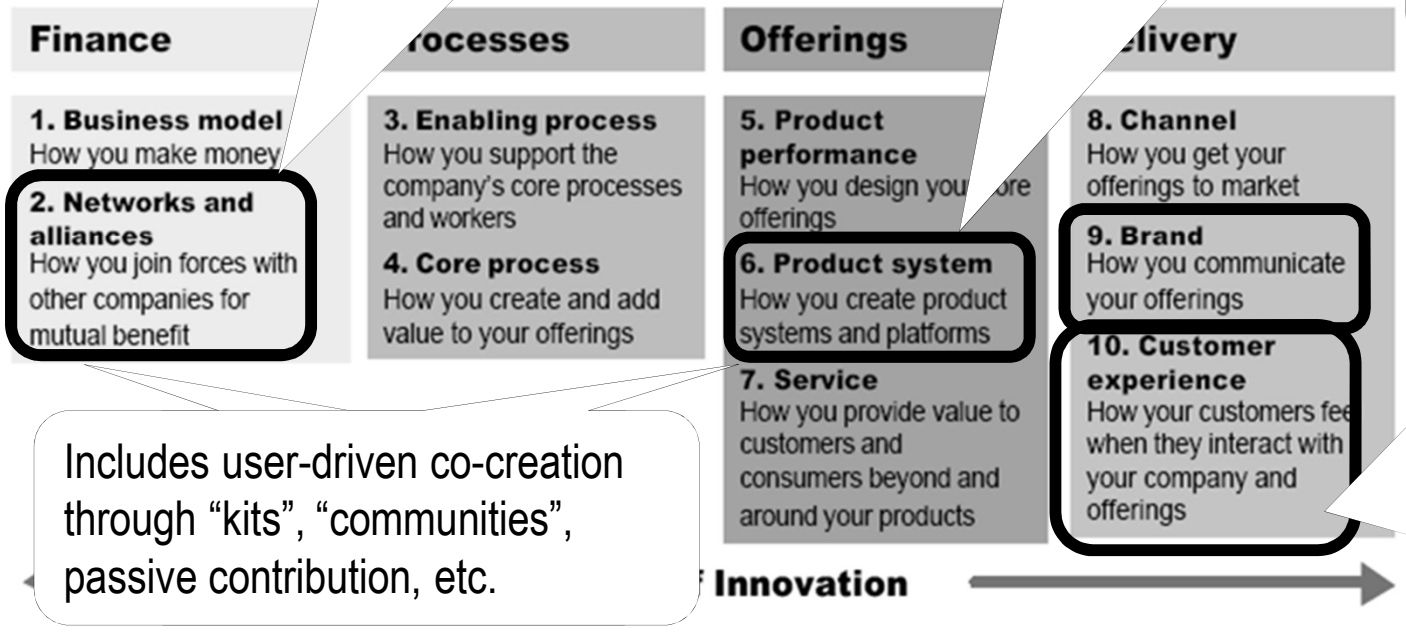
Strategic integration choices and strong tradeoffs when dealing with platforms (Boudreau 2010):

- "Completely open" vs. "open but with controls" vs. "closed" systems
- "adoption vs. appropriability" tradeoff
- "investment vs. appropriability" tradeoff (for all actors!)
- "diversity vs. control" tradeoff

Brands as easy-to-recognize "tradeoff solutions" in complex products

The innovation content has to be coherent to the brand

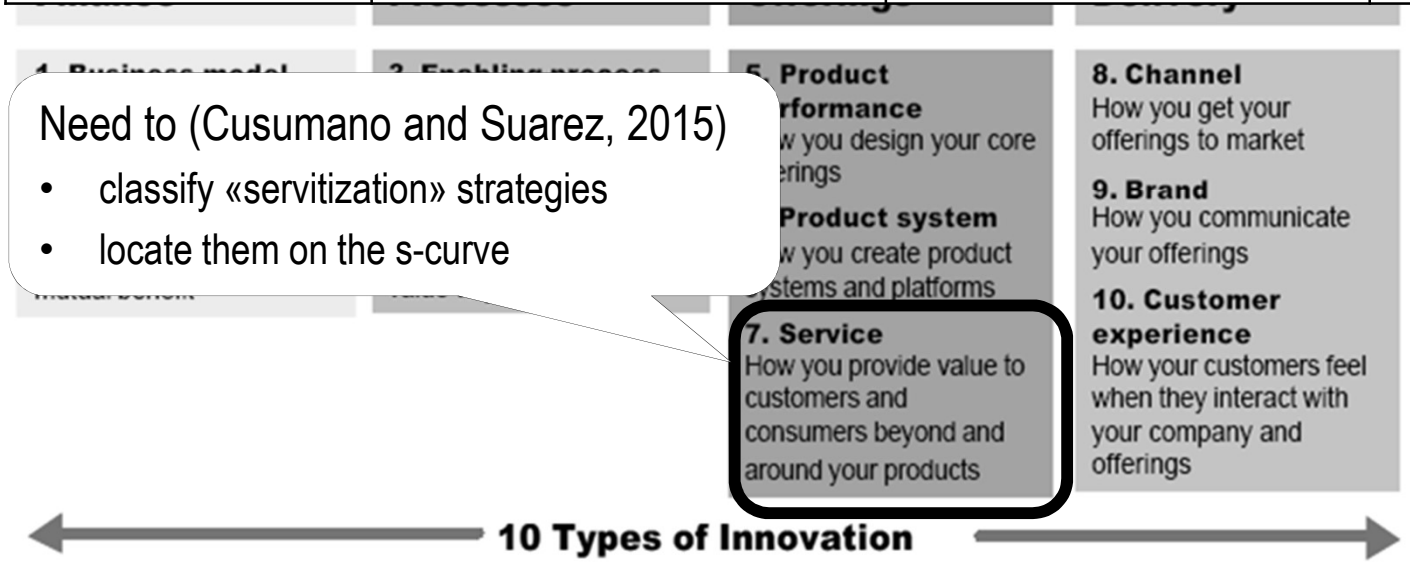
When dealing with radically innovative products should firms use new brands or extend old ones? (Klink and Athaide 2010)



Includes user-driven co-creation through "kits", "communities", passive contribution, etc.

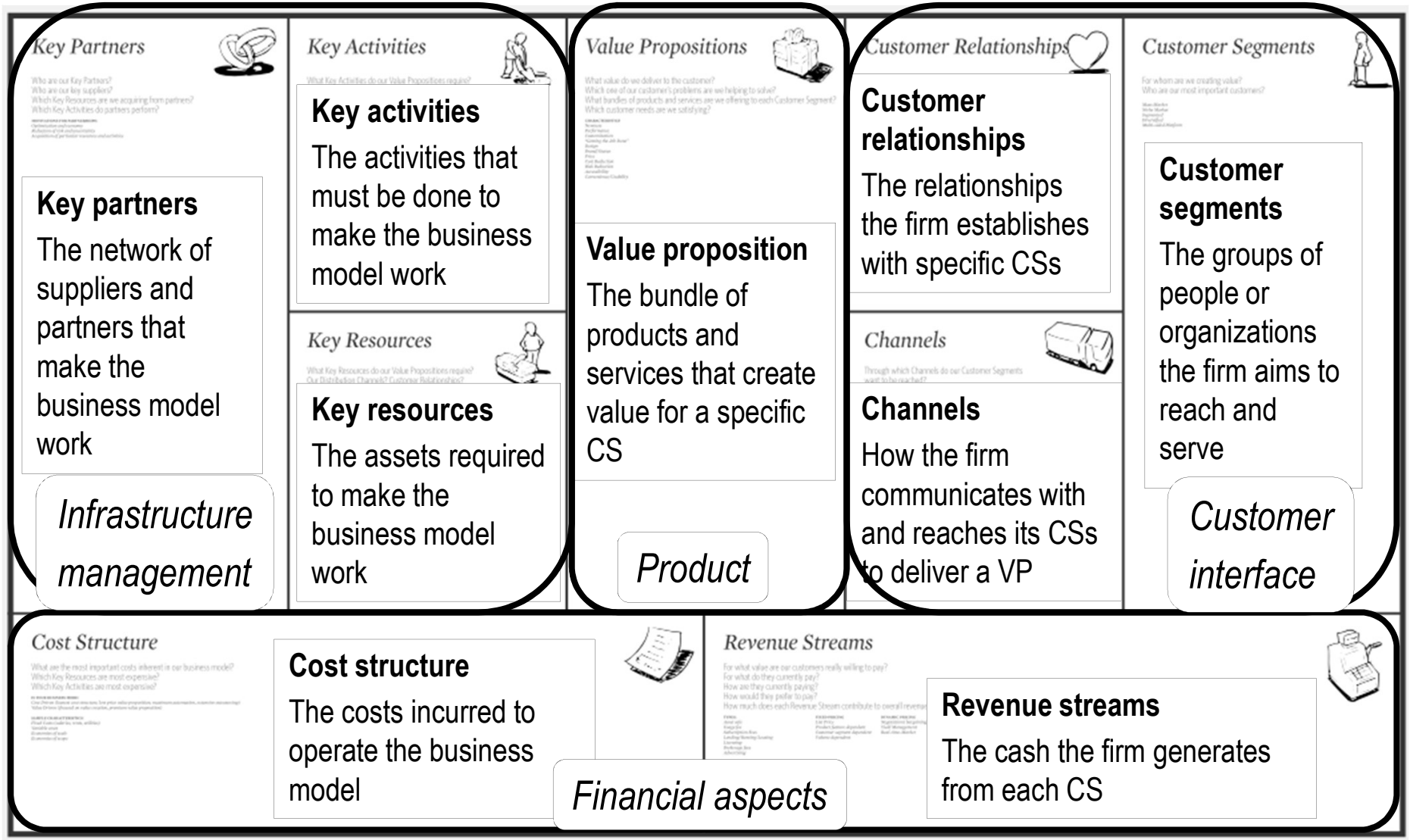
ıcludes "design-driven" innovations, which affect the *aesthetics* of the product and the *meanings* attached to it (e.g. B&O as furniture, Swatch as fashion item, etc.)

Type	The service complements product purchase		The service substitutes product purchase
	Smoothing	**Adapting**	**Substituting**
Definition	The service does not significantly alter product functionality (e.g., insurance, technical support, EV charging stations)	The service significantly expands or alters product functionality (e.g., customization of «solutions», consulting)	X as a service (e.g., SaaS, «pay by the hour», etc.)
Role in fluid phase	Provide services needed to solve «chicken and egg problems»	Educate the market to introduce the innovation	Reduce risks of ownership
Role in transitional phase	Capture value from the «profit pool»	-	-
Role in specific phase	Capture value	Capture value, educate the market to new sophisticated functions	Capture value, stimulate replacements



Dynamics of innovation

- Osterwalder's business model representation (www.businessmodelalchemist.com)



Dominant designs and standards

- Standard:

"*set of specifications that provide value to the product because of its conformity to the standard*"

- Standards can be dominant designs or not

	Dominant design	Non dominant design
Standard	GSM, BlueRay	Layout of pedals in cars
Non standard	Unibody automobile architecture	--

Dominant designs and standards

Lee et al. (2016) show that the effect is significant if the underlying social network exhibits relatively low degrees of separation

- Standards can provide value through
  - Network externalities (e.g., fax, e-mail, data exchange formats)
  - Complementarity with other goods (e.g. HW & SW, VCRs & content)
  - Specific learning (e.g., human interfaces)
  - Economies of scale (e.g., screws, threads)
  - Modularity (es. BUS architectures on PCs)

Dominant designs and standards

Standards can arise

- De facto (standards war → monopoly)
- By agreement
- De iure

Standards war dilemma

- Agreeing («let's make sure there is one big cake and then we can compete for a slice»)

vs.

fighting («let's try to get 100% of the cake, with the risk of getting nothing... and a possibly a smaller cake)"

- The decision is influenced by the number of competitors
- Technical tradeoffs that have different appeal to the parties might make agreement impossible

Standards wars can be socially undesirable

- Proprietary standards lead to entrenched monopolies
- Adoption and industry growth are delayed
- Risk of being locked in a low-quality standard which just happened to come out sooner
- Local firms may lose the standards war to foreign ones (de iure standards are non-tariff trade barriers)

Regulator's dilemmas

- Whether to intervene, and on what grounds
- Finding the right balance in the timing for freezing the standard (e.g., de facto V2V vs. arising C-V2X for connected cars)

Fighting a standards war requires specific strategies

Dominant designs and standards

- Products that are (or may be) associated to standards have peculiar competitive factors
  - Achieving critical mass as fast as possible
    - Accelerating entry
    - Spending lots of money on advertising
    - Penetration pricing (Microsoft, freemium services)
    - Boosting imitative / reciprocal diffusion effects (smartphone app stores)
    - Licencing to competitors (Intel, Open Source)
    - Gaining support from players that are closer to customers (Sony and Blockbuster)
  - Arising expectations (Microsoft with handheld PCs and smartphones)
  - Declaring irreversible commitments (Sony with Blue Ray)
  - Supporting the availability of complementary goods (Microsoft with applications)
  - Exploiting the *lock-in* phenomenon
  - Supporting “competitive migrations” (Microsoft Excel)

Prof. Ing. Marco Cantamessa

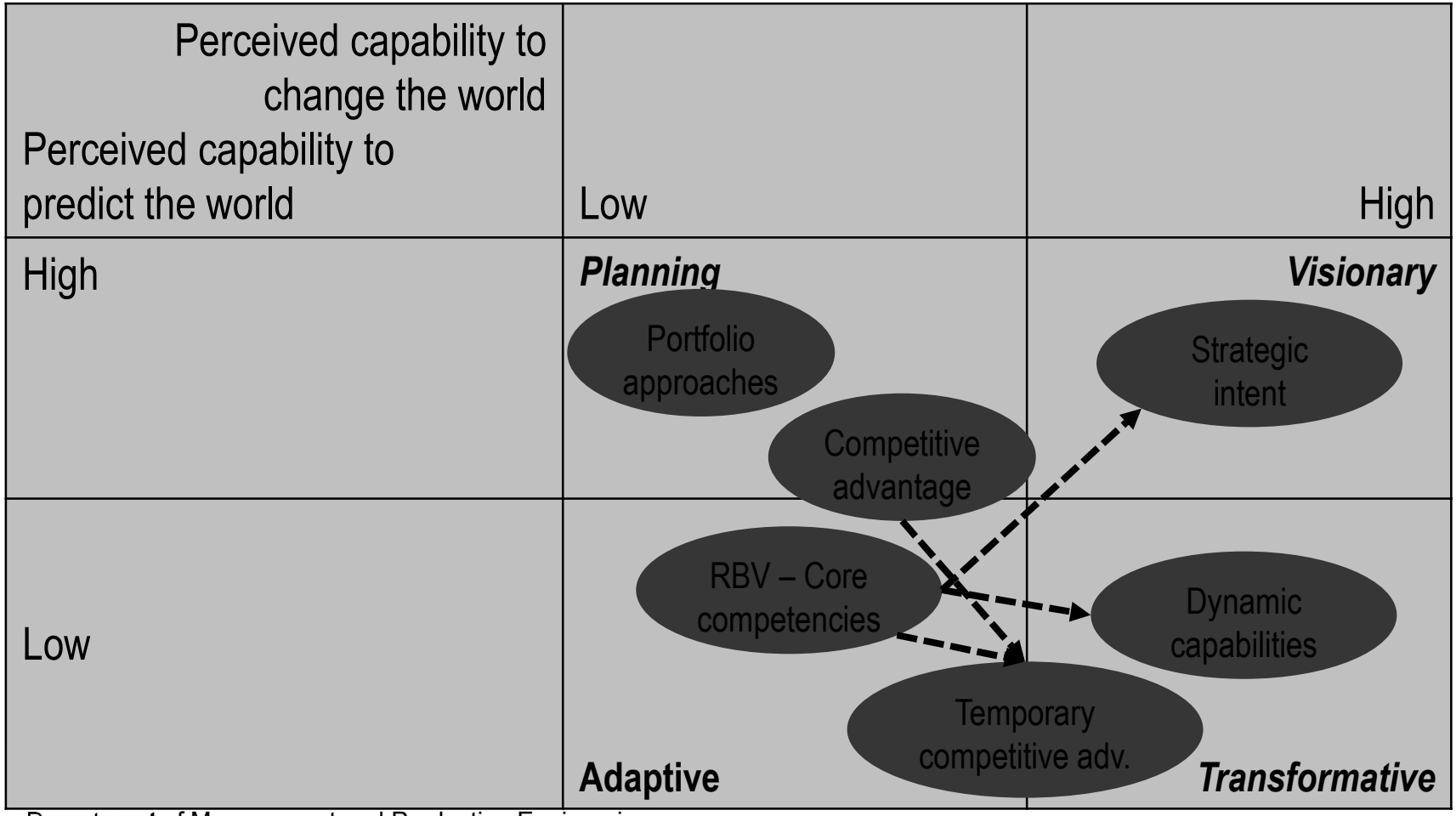
Innovation Management
Formulating an innovation strategy
Part 1 – Innovation strategy as the management of competencies

Outline of the presentation

- Innovation and product portfolio management
- Innovation and the theory of “competitive advantage”
- Innovation and “core competencies”
- Sustainability of competitive advantage
- Auditing and benchmarking competencies
- Managing the development of competencies

Innovation and corporate strategy

- Objective: to create a link between differente “schools” of corporate strategy and innovation management → how can you develop an “innovation strategy”?
- Schools of corporate strategy have different approaches with respect to uncertainty



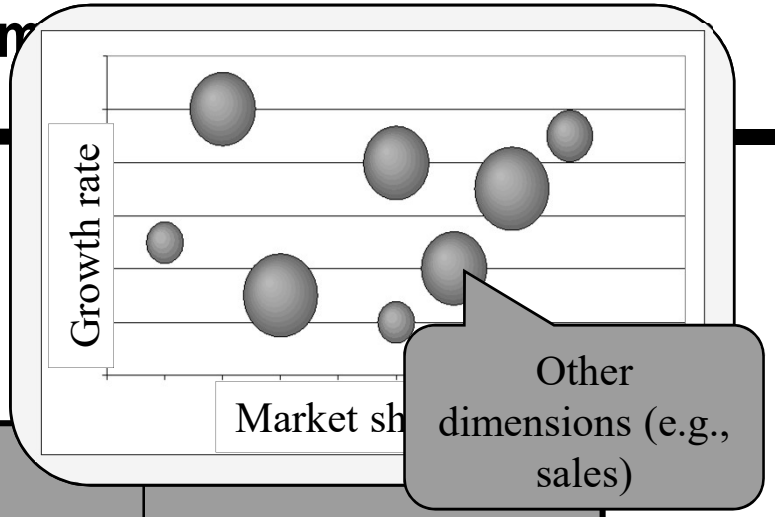
Innovation and product portfolio management

- The firm is represented as
  - A portfolio of heterogeneous products, directed to a variety of markets
  - An “internal capital market” (cash from mature product lines finances the development of embryonic products)
- Strategic competence consists in
  - Managing the product portfolio by entering and exiting markets

… but what’s the purpose of this kind of a firm (think of GE)?

- Financial markets are imperfect
- You can have synergies among businesses that seem non-related (management skills, brand, reputation etc.)
- In a dynamic environment you can have inter-temporal economies of scope which benefit from a large footprint w.r.t. technologies and markets

- BCG Matrix



Cash flow generation (market share / market share of first competitor) Cash flow absorption (growth rate)	**High**	**Low**
High	"Star" ★	"Question mark" ?
Low	"Cash cow"	"Dog"

Optimal cash flow

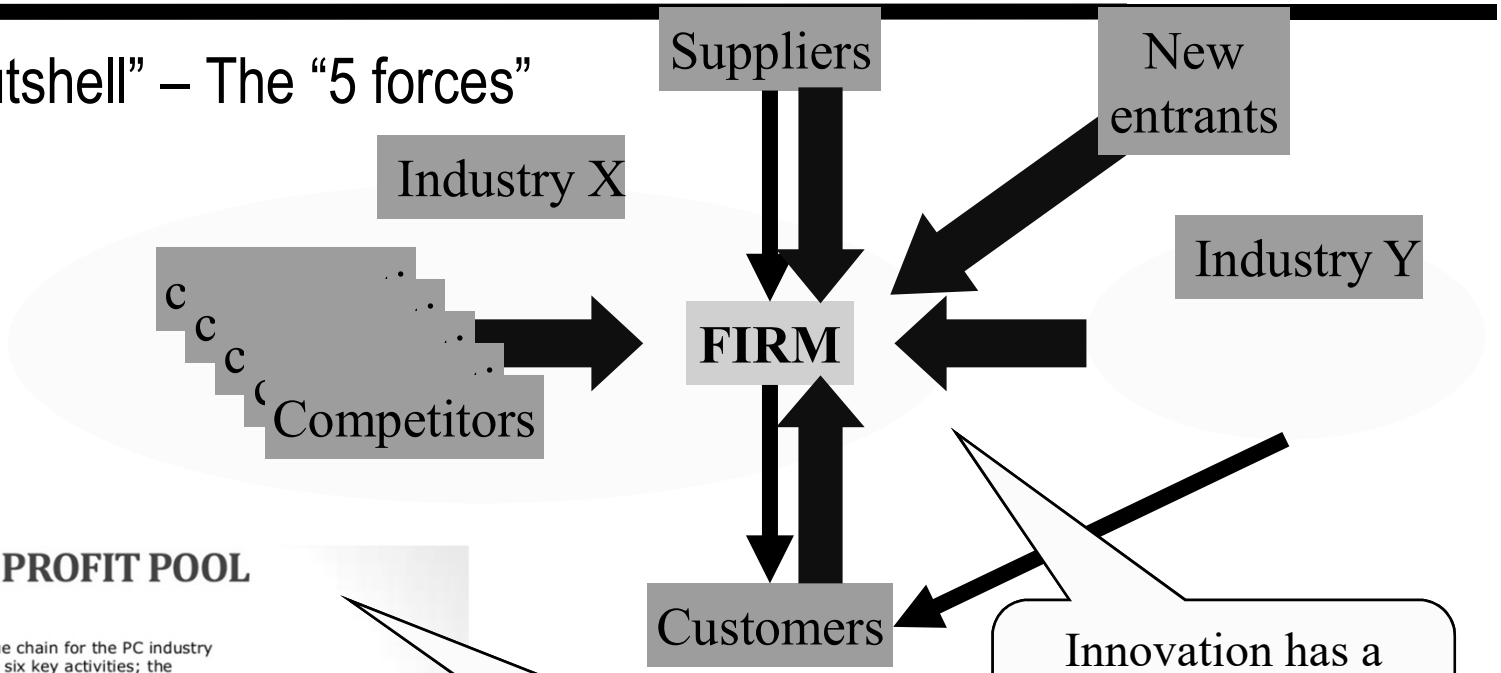
Innovation and "competitive advantage"

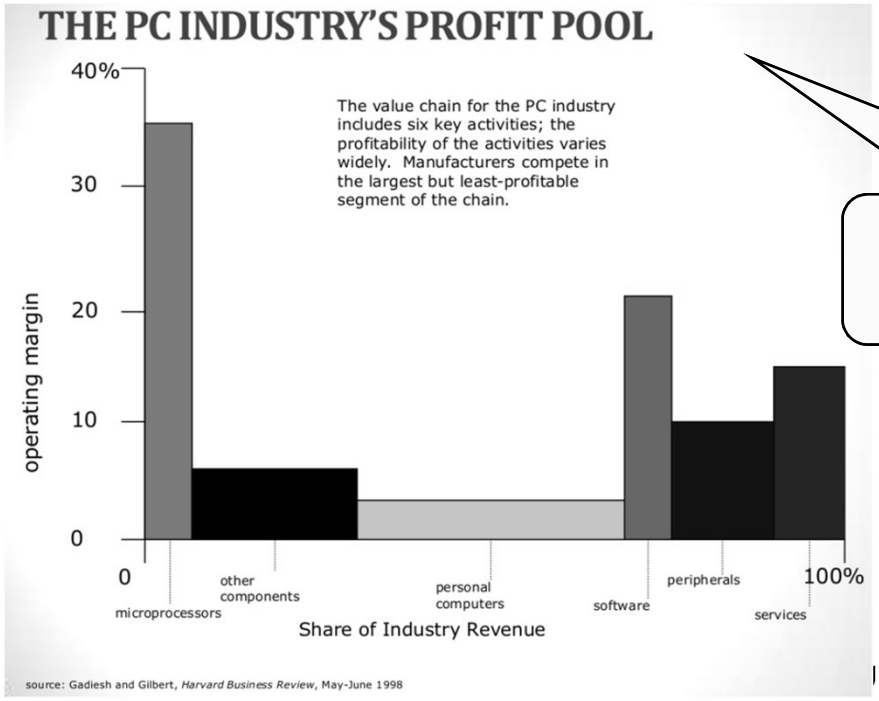
- The firm is represented as
  - Part of a value chain
  - Part of a competitive context

    ("structure → behavior → performance", or *structuralist* paradigm of Industrial Economics)
- Strategic competence consists in
  - Spotting a potentially favorable industry and entering
  - Structuring the firm's operations in order to create value
  - Maneuvering in the environment in order to retain the value created within the firm

Innovation and "competitive advantage"

- "Porter in a nutshell" – The "5 forces"





These forces help explain the industry profit pool

Innovation has a strong influence on the 5 forces

Innovation and "competitive advantage"

- "Porter in a nutshell" – Competitive advantage comes from "generic strategies" (cost vs. differentiation, industrywide vs. focused)

	Cost leadership (industrywide)	Cost leadership (differentiation)	Differentiation (overall)	Differentiation (focused)
Product	Reduce direct cost Exploit economies of scale in R&D	Design product "just enough" for needs of segment	Enhance differentiating features (at lowest cost possible)	Design product to exactly meet needs of segment
Process	Exploit economies of scale in production Exploit learning economies	Develop low-cost process "fine tuned" to segment needs	Exploit economies of scope and flexibility	Develop "fine tuned" process to meet performance required by segment

Innovation and “competitive advantage”

- “Porter in a nutshell” – Firms can be represented as a value chain… and technological innovation is relevant to each of its phases

Inbound logistics	Operations	Outbound logistics	Marketing & sales	Service
Transportation Material handling Storage ICT	Product technology Materials Machine tool Material handling Packaging Maintenance Testing ICT	Transportation Material handling Storage ICT	Media ICT	Diagnostics ICT

Sustainability of competitive advantage

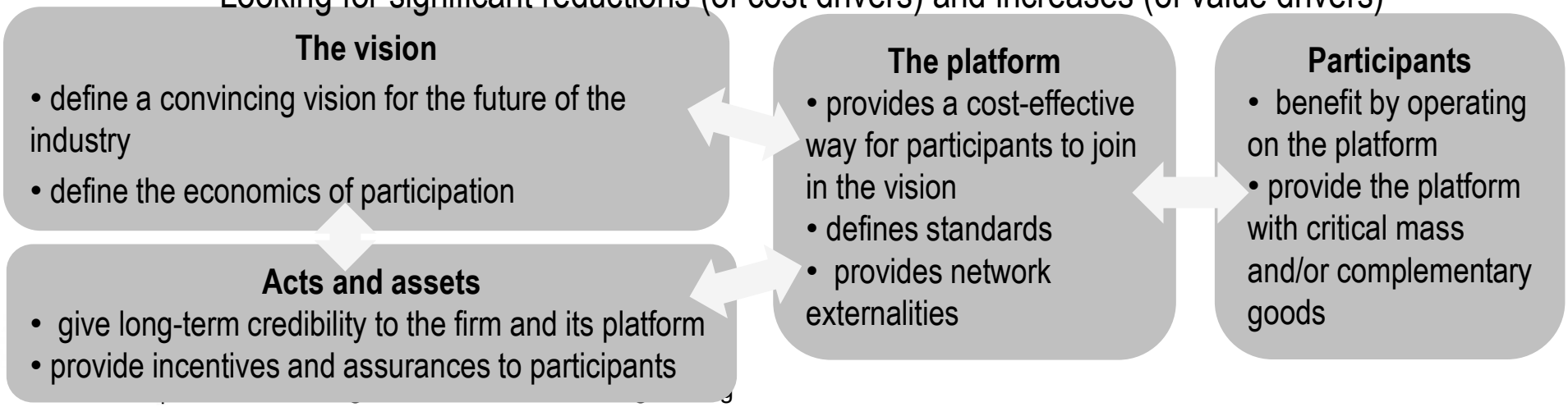
- Is technology-based competitive advantage sustainable?
- Answer - It depends on
  - exclusivity (how many other firms in the industry have comparable resources and competencies?)
  - imitability (can routines / organizational competencies be observed and replicated by competitors? Is there any specificity in the set of resources and their complementary relationships? What about IP?)
  - appropriability (who “owns” the competencies and who extracts rents from them?)
  - transferability (can organizational competencies be observed and replicated by the firm in order to grow the business?)
  - maturity (can competencies be grown further? What is the “depreciation rate” of competencies?
  - capability to exploit their value (strategy w.r.t. business model and vertical integration, execution capability)

A popular concept in assessing strategic value of assets (including technology) is VRIO analysis (Value, Rarity, Imitability, Organizational foundations)

Innovation and "shaping strategies"

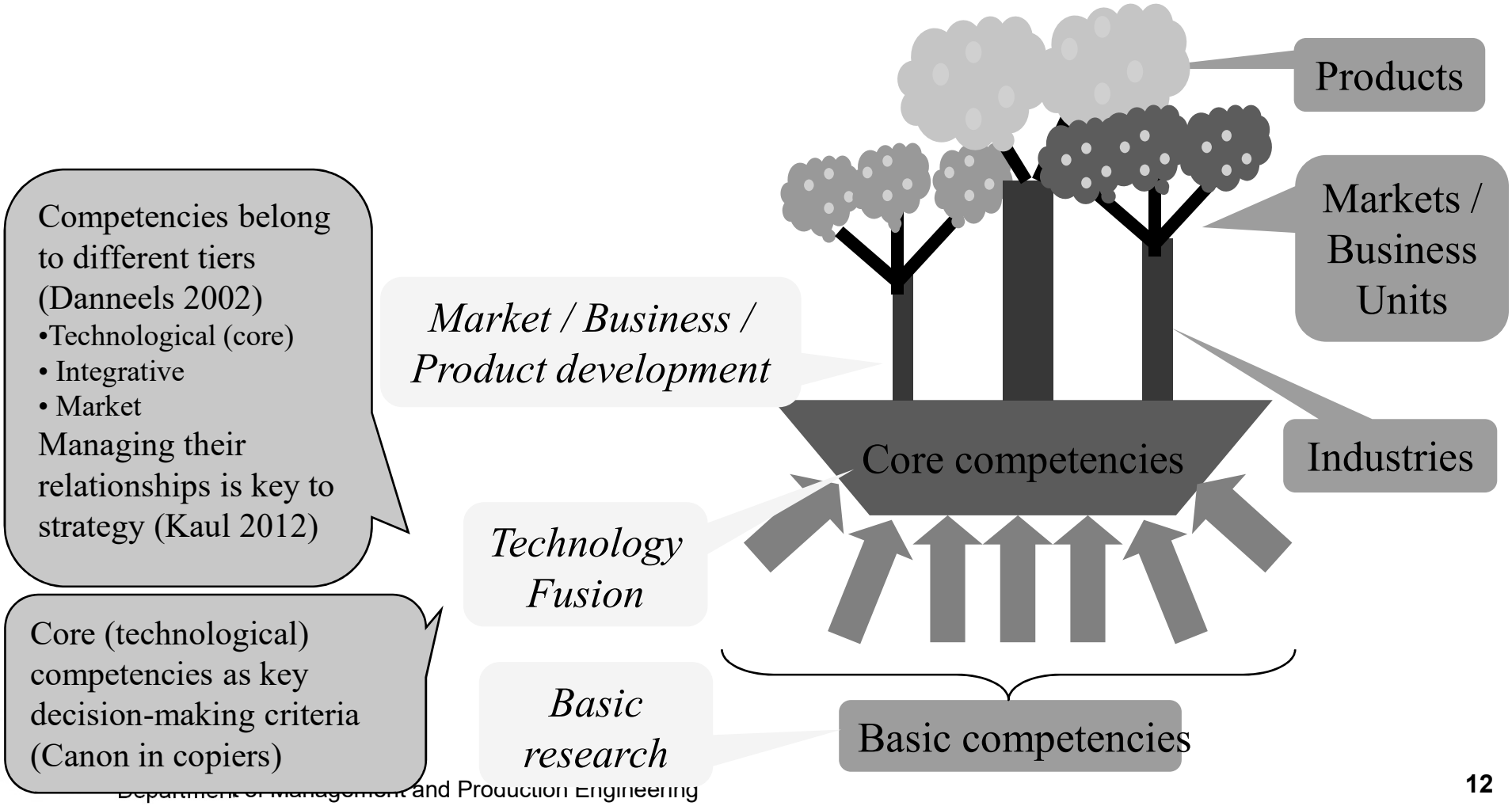
"The best way to predict the future is to invent it." (Alan Kay)

- Shaping strategies are typical of disruptive innovators (Hagel et al. 2008)
  - The firm does not analyze the "as-is" scenario but defines one, based on a vision ("blue-ocean" *reconstructionist* paradigm of Industrial Economics), and then "designs the business" (e.g. Roger Martin)
  - Rewards pertaining to the vision are perceived to be ***very*** high w.r.t. risks
  - The strategy is usually based on
    - Value Innovation, i.e. aligning propositions related to value, profit and people (→ business model innovation)
    - Pursuing both low cost and differentiation
    - Providing incentives for drawing stakeholders on a "platform"
    - Looking for significant reductions (of cost drivers) and increases (of value drivers)



Innovation and "core competencies"

- Prahalad and Hamel (the core competence of the corporation)… NEC vs. GTE, Canon, Honda, 3M, Corning



Innovation and "core competencies"

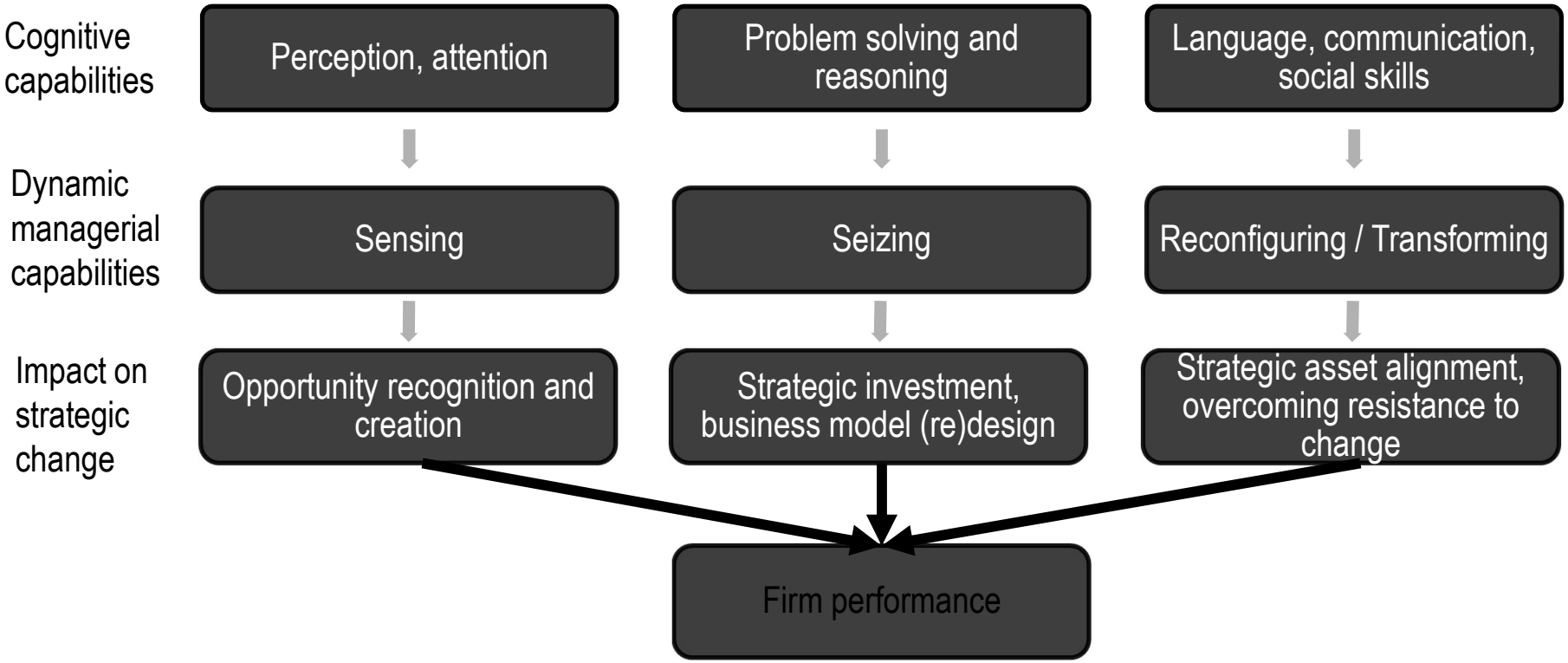
- The *resource based* theory looks inside the firm
  - The focus is on differences between firms, which is the source of competitive advantage (*why are firms different*?)
- The firm is represented as a set of
  - complementary resources (role of *stickiness* of resources and of luck)
  - competencies (routines that involve resources), a few of which are acknowledged to be "core"
- Strategic competence consists in
  - Ensuring the growth of the firms' resources and competencies
  - Using them in order to develop products and markets
- *Capability* = "*competence that has been strategically understood*"
- "Dynamic capabilities" = capability to purposefully and dynamically integrate, develop and re-configure internal and external resources and competencies

Some routines are aimed at effectiveness / efficiency, other ones at ensuring adaptability

Sensing	**Seizing**	**Managing threats / transforming**
Sensing and framing opportunities	Structuring the business model and the organization	Continuous realignment of tangible and intangible assets

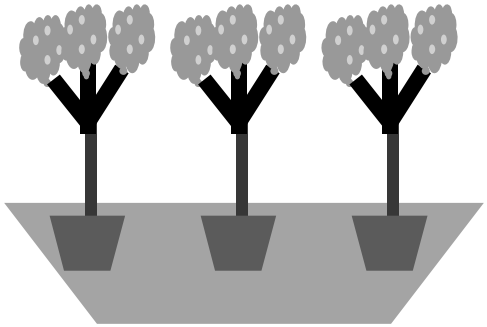
Innovation and «core competencies»

- There is an obvious connection between strategic change and top management
- A connection can be drawn between dynamic capabilities at firm level, managerial level, and managers' cognitive capabilities (Helfat and Peteraf 2015)



Innovation and “core competencies”

- “Core competencies” as strategy-guiding principles can also be defined more broadly (e.g., “capability to serve a market”, or a specific process)

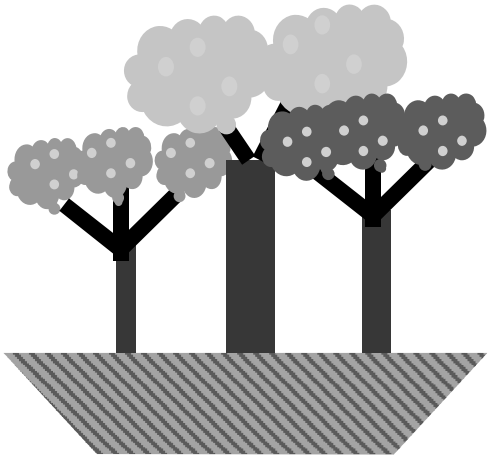


Product portfolio-managed

•Many technologies, many markets

•Synergies in cash, some infrastructure and “management culture”

• e.g. GE, United Technologies Corp.

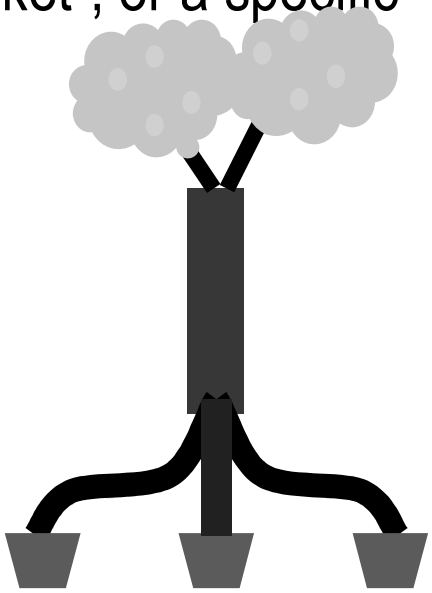


(Technological) core competence-led

• Core technologies, many markets

• Synergies in technologies

• e.g. Corning, Canon,



(Market) core competence-led

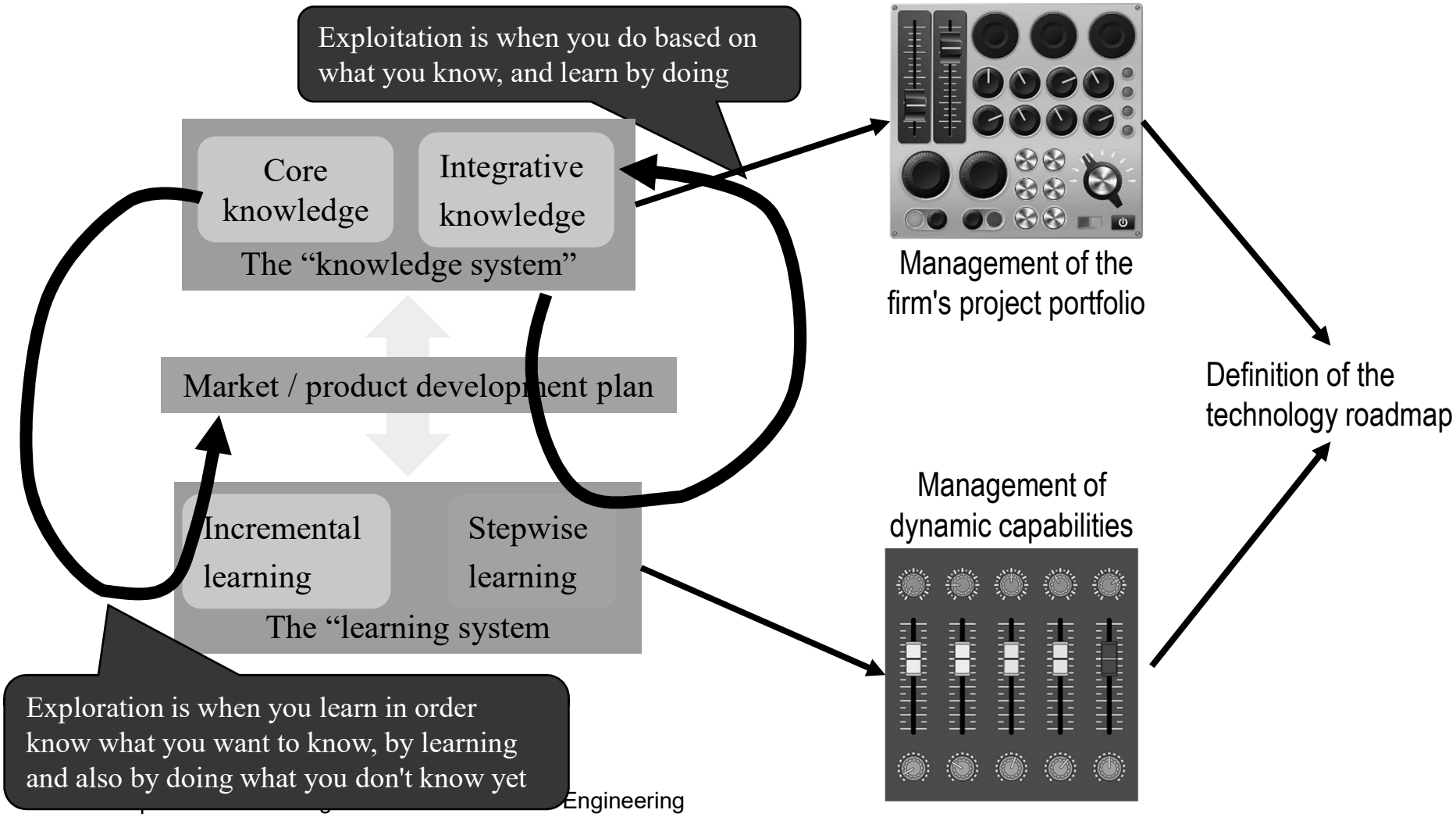
• Many technologies, core markets

• Synergies in markets

• e.g. IBM

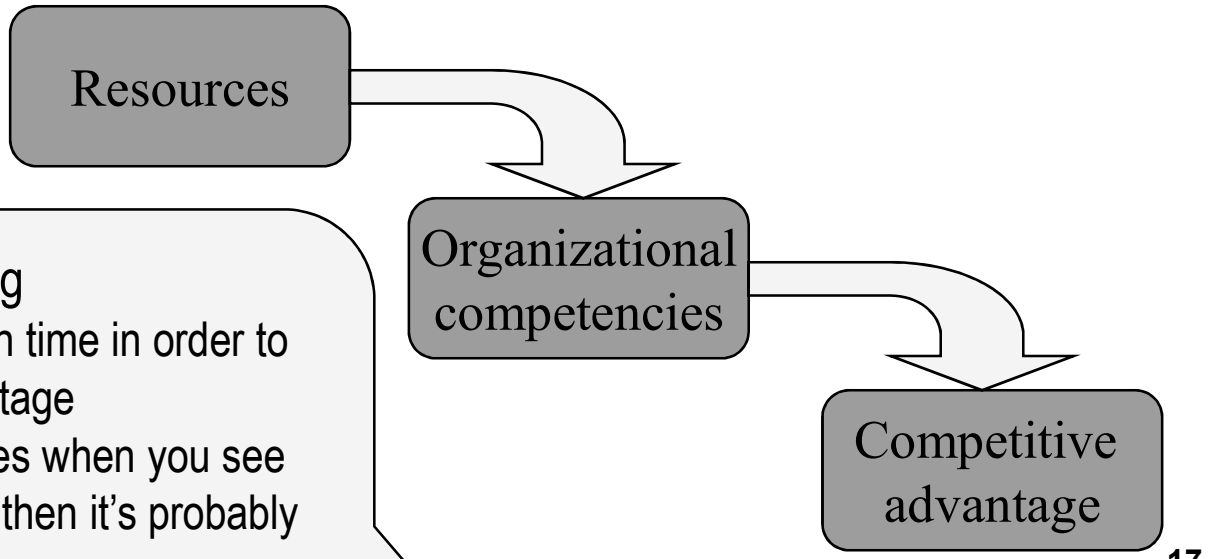
Innovation and core competencies

- Dynamic capabilities following the model by Helfat and Raubitsheck (2000) – the firm is an entity where "knowing", "learning" and "doing" coevolve, more or less strategically



Auditing and benchmarking competencies

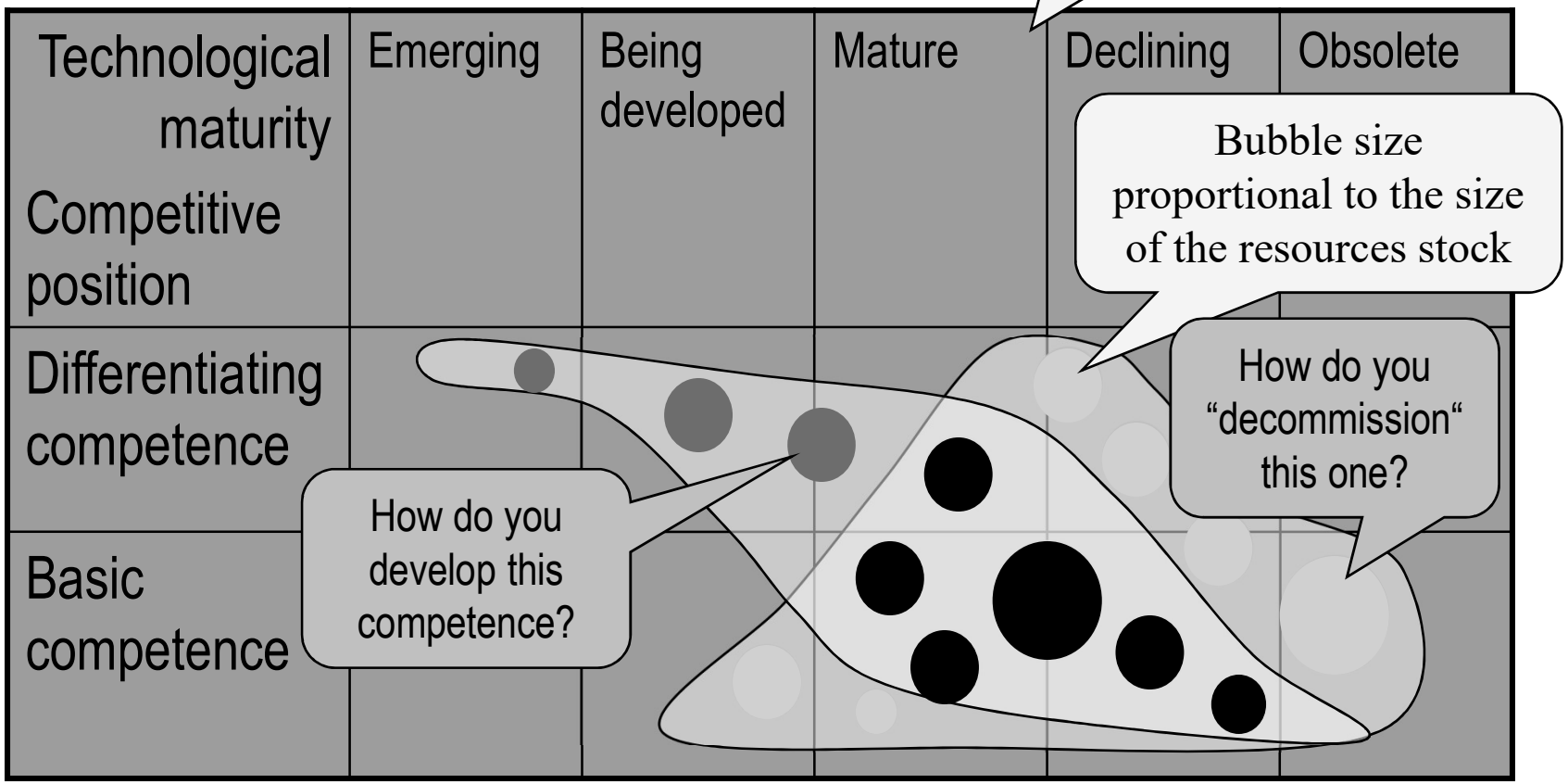
- Based on the previous, it is possible to audit, benchmark and plan the growth of
  - Resources (Valuable, Rare, Inimitable, Organizationally well-founded)
  - Competencies



The process is generally quite long
→You have to plan your resources on time in order to have an impact on competitive advantage
→ if you start changing your resources when you see problems in competitive advantage... then it's probably too late!
→ get "new resources" on the top team too, looking at future needs, not only current capabilities and merit

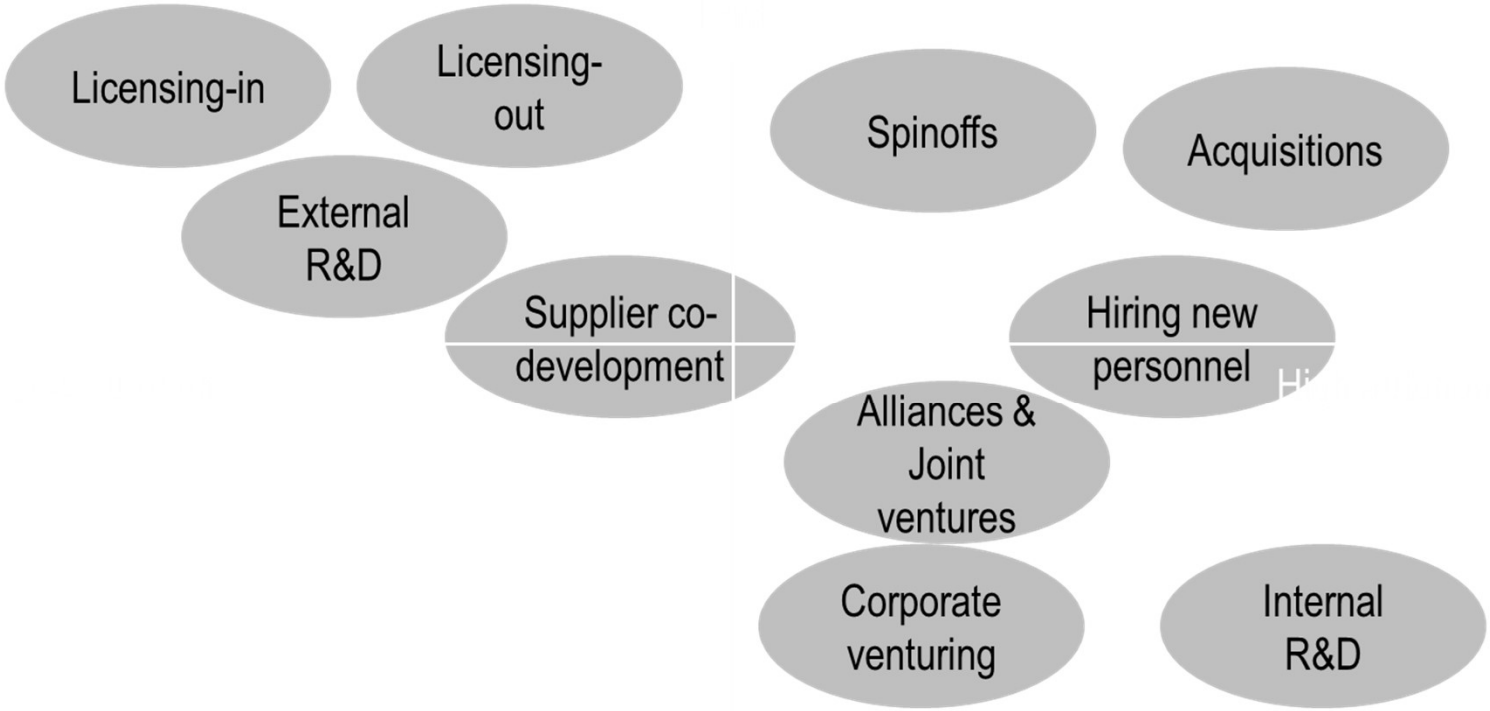
Auditing and benchmarking competencies

- Maturity vs. competitive position map



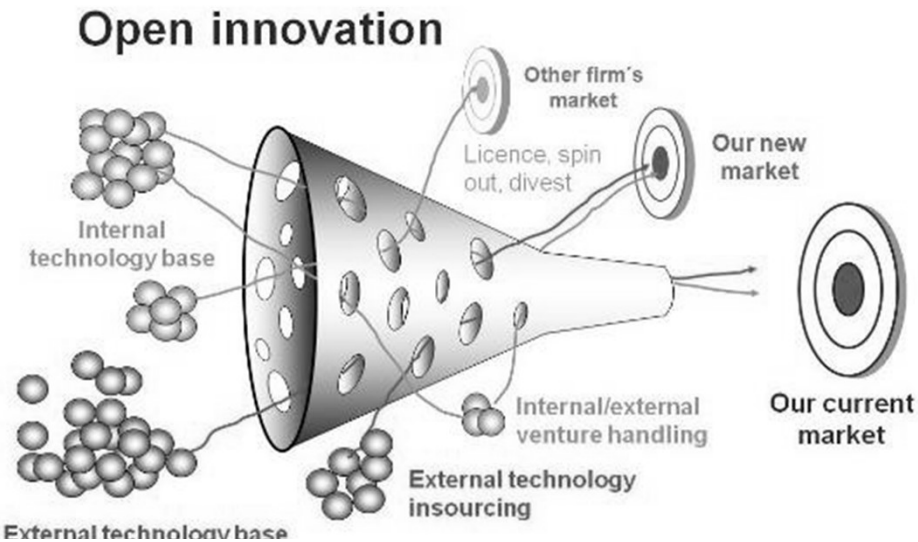
Managing the development of competencies

- Underlying theory has been covered when talking about organizational learning
- There is a variety of means (the main tradeoffs are "speed vs. appropriability" and internal vs. external level of understanding)
- Watch out for appropriateness of choice vs. execution capability



Managing the development of competencies

- Currently, “open innovation” is an umbrella term that covers many of these approaches
  - Strategically capturing ideas and competencies from outside the firm
  - “Letting go” of non-core ideas, competencies and projects to others
  - Recombining all of the above to generate new business models



Managing the development of competencies

- Internal R&D (used to be the mainstream approach)
  - Ambiguity of causal linkage with performance
    - Traditional model: "*if you invest in R&D you gain directly and because you increase your absorptive capacity in order to learn from competitors*"
    - Alternative model (Knott 2008): "*Smarter firms (organizational IQ?) gain more from R&D and righfully make more investment. 'Dumber' companies don't gain much and do not (and should not!) invest in it*"
    - Cynical interpretation: "*successful companies have money to throw at R&D, and occasionally get something out of it*"
    - Emerging interpretation (Greve 2003): «*amount and type (exploration vs. exploitation) of R&D effort is determined by the mismatch between actual (or forecasted) and desired performance, moderated by national culture, type of ownership, etc.*»
  - Tends to be rewarding for firms with low financial leverage and high cash flow
    - Intangible assets produced are difficult to use as collateral
    - R&D requires stable cash flows (difficult if firm is highly leveraged, especially with fluctuating demand)
  - In SMEs R&D frequency matters more than intensity (R&D budget/sales), and is usually higher if internal knowledge assets are stronger than in the firm's external network (Cuervo and Un, 2010)
  - Requires strong commitment by CEOs (and seems to suffer if CEOs are external and lack firm-specific technical knowledge Cummings and Knott 2018)

Managing the development of competencies

- Internal R&D
  - Takes time
  - Constrained by path dependency → can require an initial stimulus (event and resources)
  - Allows greater degree of appropriability
  - Allows attraction of talent… but requires incentives and resource retention strategies… though not to the point of dissipating profits (ar R&D people overpaid? How can you measure performance? How strong are non-compete contracts?)
  - Must be adequately placed in the organization
    - Within Business Units (decentralized)
    - In specific organizational units (centralized)
    - Spinoffs or intrapreneurship schemes (corporate venturing)

(Sauermann and Cohen 2010) R&D employees look for intellectual challenges, independence and salary. Results are correlated to *quality*, not *quantity* of effort

(Ganco 2013) Depending on complexity of knowledge, resources may leave the firm
- for another firm vs. start their own
- do it alone vs. with a group

(Wang et al., 2009) Firms tend to develop firm-specific know-how (higher sustainability of competitive advantage + lower market value of human resources) but employees are unwilling to spend effort in this direction

(Yanadori and Cui 2013) Strong individual compensation leading to pay dispersion can backfire (in case of firms with low growth prospects / financial slack)

(Conti 2014) Non-compete contracts allow firms to promote riskier R&D projects

(Kehoe and Tzabbar 2015) «Star researchers» cast both positive and negative influences on colleagues

(Gambeta et al., 2019), strong firm-employee ties push towards exploitation and away from exploration

Managing the development of competencies

- Research activities can be
  - Centralized
  - Decentralized

•Use of Intranets

•Market mechanisms… R&D funding coming from SBUs + "results showcases" (HP)

•Having both centralized and decentralized R&D (GE)

•Matrix organization … program managers (with SBU experience) control funds and technology leaders (scientists) manage people & projects (GE)

Form	Pros	Cons
Centralized	Financing is decided by top management Long-term perspective Closeness to the scientific community Well-defined career management Economies of scale, no duplication of effort	"Ivory tower"syndrome (Xerox PARC, www.parc.com)… needs mechanisms to coordinate with BUs (e.g. HP Labs) A single geographical location can limit the potential resources
Decentralized	Closeness to market and development activities R&D can be internazionalized to acces knowledge residing abroad (asset-seeking FDI)	Financing may be less stable Short-term perspective Separation from the scientific community Undefined careers Duplication of effort

Managing the development of competencies

- Acquisition
  - Delivers results quickly, especially for firms that are innovation-oriented but underperform (Zhao 2009) and ensures a high degree of appropriability
  - Creates value when acquiring
    - Knowledge assets, either similar (→ incremental innovation) or complementary (→ discontinuous innovation) (Makri et al. 2010)
    - For technology-intensive firms, IP portfolios granting monopolistic rights or freedom to operate (Grimpe and Hussinger, 2014)
  - High transactions costs → scouting, due diligence (especially for IPR), negotiation, integration
  - Integration is especially related to
    - organizational routines (role of product architecture)
    - resource retention
    - dealing with organizational inertia (on both sides) and path dependency with respect to prior exploitation / exploration orientations

Cisco

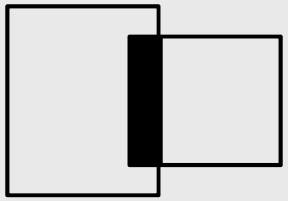
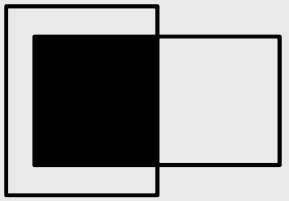
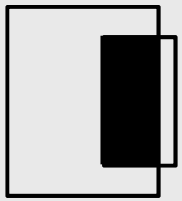
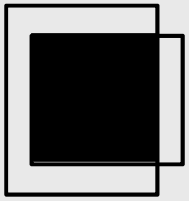
- Strategy based on product line breadth and standardization → modularity and decentralization
- Fast acquisition process based on
  - Screening of candidate companies
  - Due diligence
  - Negotiation
- Integration process based on
  - Employee retention (HR processes, benefits, CEOs as VPs)
  - Standardized operations (NPD, MRP, Quality, Suppliers)
  - Speed (product immediately on price list, everything else done within 90 days)

Intel

- Budget for technology-related acquisitions is 2x R&D
- Manages a Corporate VC fund

Managing the development of competencies

- Acquisitions are subject to an 'integration paradox'
  - integrating knowledge disrupts the acquired firm and reduces its autonomy → its innovation capabilities
  - successful integration depends on the degree of overlap between target and acquirer's knowledge. This influences the acquirer's absorptive capacity, diversity of knowledge, and potential for conflict (Sears and Hoetker, 2014)
  - There is no 'ideal' combination. Empirical evidence shows diversity might matter more than absorptive capacity

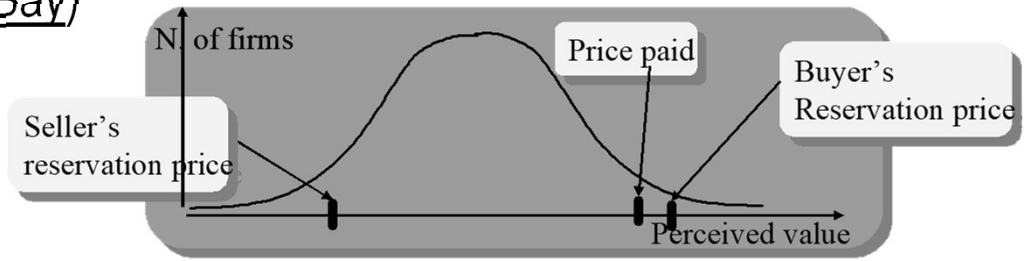
Acquirer overlap Target overlap	Low (target knows little of what acquirer knows)	High (target knows much of what acquirer knows)
Low (acquirer knows little of what target knows)	• Low absorptive capacity • High diversity • Low conflict 	• Low absorptive capacity • High diversity • High conflict 
High (acquirer knows much of what target knows)	• High absorptive capacity • Low diversity • Low conflict 	• High absorptive capacity • Low diversity • High conflict 

Managing the development of competencies

- Acquisitions are subject to the 'winner's curse'
  - Acquirers evaluate targets assuming

    Value post integration > Acquisition price + Integration cost

  - Overpayment can arise if the acquisition price is subject to a *de facto* auction (e.g. Skype's 3.1 B$ acquisition by eBay)



  - For unique targets, overpayment allows to keep the target out of competitors' hands
  - Value post integration is associated to (Ransbotham and Mitra 2010)
    - Intrinsic value of operations (acquirer-independent, grows with age of target in case of startups)
    - Unexplored growth options (acquirer-specific, and decreases with age of target)
  - Overpayment risks seem to be lower when acquiring a divested asset and not a standalone firm (Laamanen et al., 2014)

The evolution of Skype and its acqu

Price paid + integration cost < NPV(cost synergies + additional profits)

2002
Skype founded and raises 20 M$

2004
- Skype reaches 7M$ sales
- Plans for 2005 and 2006 are 60M$ and 200 M$ revenue
- Long-term margins at 25%

Could be valued up to 200M$ as an independent business

2005
Skype acquired by eBay for 2.6 B$ (+ earn-out)

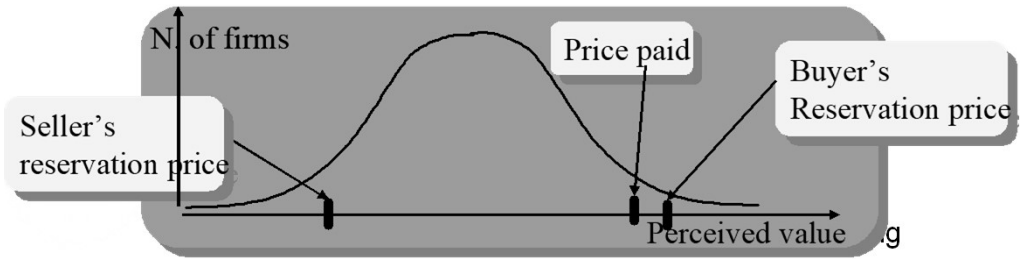
2007
eBay writes off investment by 1.4 B$

2008
Skype reaches 550 M$ revenues (+44%) at 23% margin

2009
Skype & eBay sued by Jotllid (Skype founders' "IP vault") for copyright infringement on Skype's core code

2009
IPO derailed and eBay privately sells 65% stake at implied valuation of 2.75 B$

2011
Microsoft buys Skype for 8.5 B$ (32 x EBITDA, 68$/active user, 1k$/paying user)



Managing the development of competencies

- Corporate venturing
  - The company behaves as a venture capital investor and takes up stakes in startup firms (spinoffs or not) → "hybrid" between internal R&D, acquisitions, and joint ventures
  - It is complement (not a substitute) to internal R&D, but who comes first?
  - Corporate venturing can have a number of purposes
    - Innovation venturing (financing firms that develop technology that is/might become core)
    - Ecosystem venturing (financing firms that develop complementary technology/products)
    - Harvest venturing (makes excess internal resources look for revenue in the market)
    - Private equity venturing (purely financial diversification)
  - Frequently found if (Dushnitsky and Lenox 2005)
    - IP protection is weak
    - significant technological change and uncertainty
    - complementary assets (e.g. distribution) are important
    - the venturing firm has high absorptive capacity w.r.t. the target and high cash flow

    … but under these conditions the target might not accept, in fear of imitation or rent extraction (CVC paradox, Dushnitsky and Shaver 2009) → complementary role of VCs and CVCs

Managing the development of competencies

- Hiring experts
  - "hybrid" between internal R&D and acquisition
  - allows a significant but progressive learning process (for older organizations, this occurs if new hires are experienced - Jain, 2016)
  - high transaction costs (personnel selection and integration)
  - the integration problem is different than with acquisition
    - individuals are generally easier to adapt,
    - you get many integration problems (one for each person)
    - individuals may easily be "gobbled up" by the organization
  - you must wait for results until integration is ended
  - lesser risk of incurring in the "winner's curse" (the job market is usually liquid), save for emerging technologies
  - individual competencies can be "institutionally specific" (→ a candidate who did well in his former position might underperform with you… e.g. academic researchers, Toole and Czarnitzki 2009)

Managing the development of competencies

- Strategic alliances (non-equity agreements)
  - Can create value when participating firms
    - have complementary competencies
    - are competitors (can lead to economies of scale, standard-setting, etc.)… but some degree of complementarity is always present (firms are different!)
    - jointly pursue asset exploitation (not exploration) (Hoang and Rothaermel 2010)
  - Firms are bound by contractual (not institutional) links
    - Tradeoff between transaction costs associated to contracting and ability to solve ambiguity → 'relational governance' mechanisms when sharing knowledge-based assets (Hoetker and Mellewigt 2009), or board-like "steering committees" (Devarakonda and Reuer, 2018)
    - Risks of free-riding at corporate and individual level → need to provide adequate incentives and clarify organizational status
    - Risks associated to IP leakage, which requires well-written contracts
      - more likely if focal company has a lot of IP to lose, and partners have significant absorptive capacity (Giarratana and Mariani, 2014)
      - a key decision variable is the degree of partner interaction (Contractor, 2011)

Managing the development of competencies

- Joint-ventures (equity agreements)
  - Can create value thanks to size and/or complementarity
  - With respect to alliances,
    - Firms are bound by institutional links
    - Lower degree of ambiguity, since incentives are better aligned (though “small” JVs risk not being able to provide sufficiently powerful incentives to avoid opportunistic behavior)
    - higher costs (at setup and for managing the structure)
    - the JV is separated from parent organizations (may be an advantage or a risk)

Managing the development of competencies

- Co-development (financing component suppliers' R&D activities)
  - Provides an incentive to perform R&D on customer-specific projects by reducing the risk of post-contractual hold-up
  - Results may be hard to monitor, and a principal-agent problem arises
  - Contingency-based contracts may be useful (e.g., gain-sharing)
  - New competencies do not belong to the firm
    - the supplier gains higher bargaining power and reputation
    - competencies may be spilled over to competitors' projects
    - risks can be reduced by leveraging specificity or using intellectual property clauses in contracts

"XYZ told me that if I want to be a supplier of his, I must invest 100,000 € for an R&D project whose results I can't use otherwise. I bet that after the project is ended XYZ will change the terms and force me to cut down on price. Better avoid this!"

"XYZ has granted me 100,000 € for the R&D project. They aren't able to monitor what I'll do with the sum. I'll spend half of it, or maybe use it to change the scope of the project so that I can use results elsewhere"

Sometimes this can lead a supplier to take the risk of doing customer-specific R&D without financing

Sharing IP with suppliers (but retaining exclusive industry-specific rights) can become a powerful incentive (Carson and John 2013)

Managing the development of competencies

- Co-development can entail different arrangements (Bhaskaran and Krishnan 2009)
  - Revenue sharing → the supplier makes the R&D investment and shares the revenue
  - Investment sharing → the customer pays the supplier to do the R&D work
  - Innovation sharing → the customer pays the supplier but also shares R&D work

Require alignment of incentives and knowledge sharing → better to share money and/or effort

Sharing effort helps overcome technical difficulties

Funding suppliers supports them in the face of timing uncertainty

Innovation type \ Major source of uncertainty	Uncertainty in translating R&D to a product	Both types of uncertainty	Uncertainty in timing
New to the world	Innovation sharing	Innovation sharing or investment sharing	Investment sharing
Incremental	Revenue sharing	Revenue sharing or investment sharing	Investment sharing

Incremental projects, with quality mainly dependent on supplier

Managing the development of competencies

- Outsourcing R&D to third-party organizations and scouting for solutions
  - Main candidates are
    - Competitors' R&D units
    - Consultants
    - Smaller firms close to solutions
    - Not-for-profit research centers
    - Universities
  - Transaction costs can be high and require a specific organization
    - Academic Technology Transfer Offices
    - "Markets for ideas" and "crowdsourcing" (e.g. Innocentive, Ninesigma, etc.), working as "innovation contests" (→ tradeoff btw. competition and underinvestment due to uncertainty in outcome)
    - Scouting units (Monteiro and Birkinshaw 2017) working on technology push and demand pull, and operating "translation", "matchmaking" and "transformatoin" processes

With many participants (Boudreau et al. 2011) individuals' incentives are low, but there is a greater likelihood to find a "great" (i.e. extreme) idea. If problem uncertainty is

- low, solutions will be similar → contests work well if participants don't have to invest much and can apply prior knowledge or results (else, the number of participants should be reduced)
- high, solutions will tend to spread → many participants will not reduce individuals' incentives as much, and the "extreme value" effect is greater

Managing the development of competencies

- Outsourcing R&D to third-party organizations and scouting for solutions
  - Appropriability of competencies is a key point
    - A large firm will engage in Open Innovation in order to appropriate competencies to some degree
    - A «for profit» firm will partner with a large firm because of its value creation capability, but will be wary of value appropriation → risk of adverse selection (Diestre and Rajagopalan 2012)
    - Non-profit innovators may not feel this problem, but tacit competencies may be difficult to transfer
    - Contractual design must deal with incentives and IPRs
    - Managing and moving people around can help (e.g. hiring researchers, secondment of own personnel, etc.)

Managing the development of competencies

- Outsourcing R&D to third-party organizations / scouting for results
  - You can envisage four collaboration modes (Pisano and Verganti 2008)
  - Designing incentives is key
  - These models sometimes can sometimes become services to third party firms

Governance **Participation**	**Hierarchical** Greater control on innovation... provided you have the right strategy	**Flat** Sharing the responsibility on innovation ... hopefully retaining profits
Open Reach into unknown domains... but you have to screen solutions	**"Innovation Mall"** Anyone can participate but the company decides the winners (e.g. Innocentive)	**"Innovation community"** Anyone can propose solutions and the community decides on the winners (e.g. Open Source communities)
Closed Solutions from the best experts... but you have to know them	**"Elite Circle"** The company invites participants and determines the winners (e.g. Alessi)	**"Consortium"** A private group looks for solutions and chooses the best ones (e.g. IBM partnerships for semiconductors)

- Acquisition of licences
  - Apparently it looks like giving up the development of competencies
  - It often is a first step to develop them later on (e.g., emerging countries)
  - Many patents are “up for grabs”
    - non-core inventions made by large companies,
    - university patents,
    - inventions by small companies that don’t have the clout to compete in the product market
  - Grant-back clauses (the licensee must transfer rights on improvements back to the licensor) can be highly limiting

Managing the development of competencies

- Becoming a supplier (Alcacer and Oxley 2015)
  - Similar to acquiring a license
  - Can be highly beneficial, especially if
    - partnering with a technological leader
    - engaging in product development and not only manufacturing
  - Competencies are usually related to the technology (very rarely to the market)

Managing the development of competencies

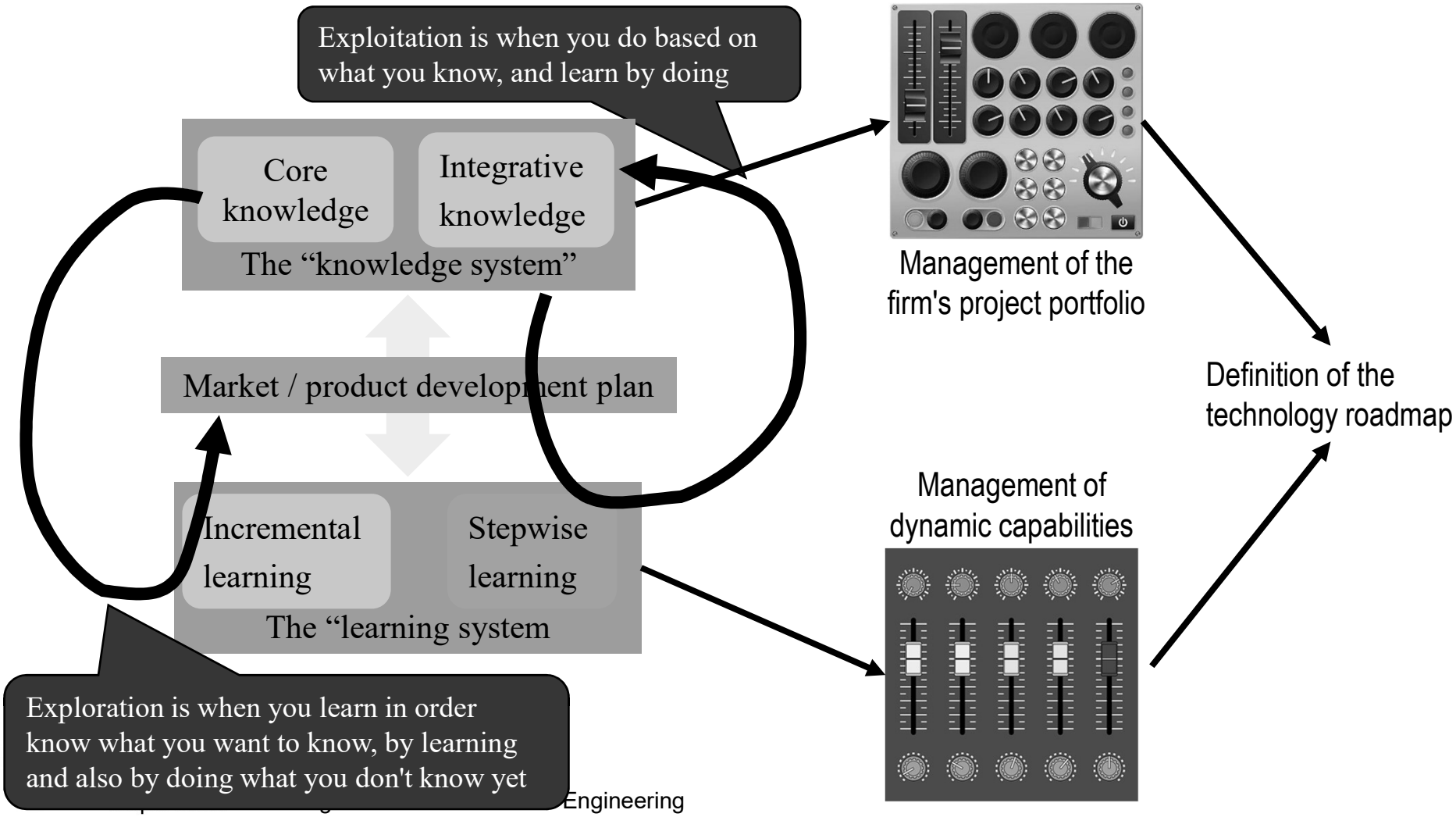
- Total outsourcing (design and production)
  - It is equivalent to “giving up” the idea of developing competencies
  - “Off the shelf” components
    - often are less than “leading edge”
    - do not differentiate the firm against competitors
  - Outsourcing requires caution
    - You risk losing the capability to specify, buy and verify
    - Suppliers may have little incentive to pursue innovation further

Prof. Marco Cantamessa

Innovation Management
Formulating an innovation strategy
Part 2 – Innovation strategy as project portfolio management

Innovation and core competencies

- Dynamic capabilities following the model by Helfat and Raubitsheck (2000) – the firm is an entity where "knowing", "learning" and "doing" coevolve, more or less strategically



Outline

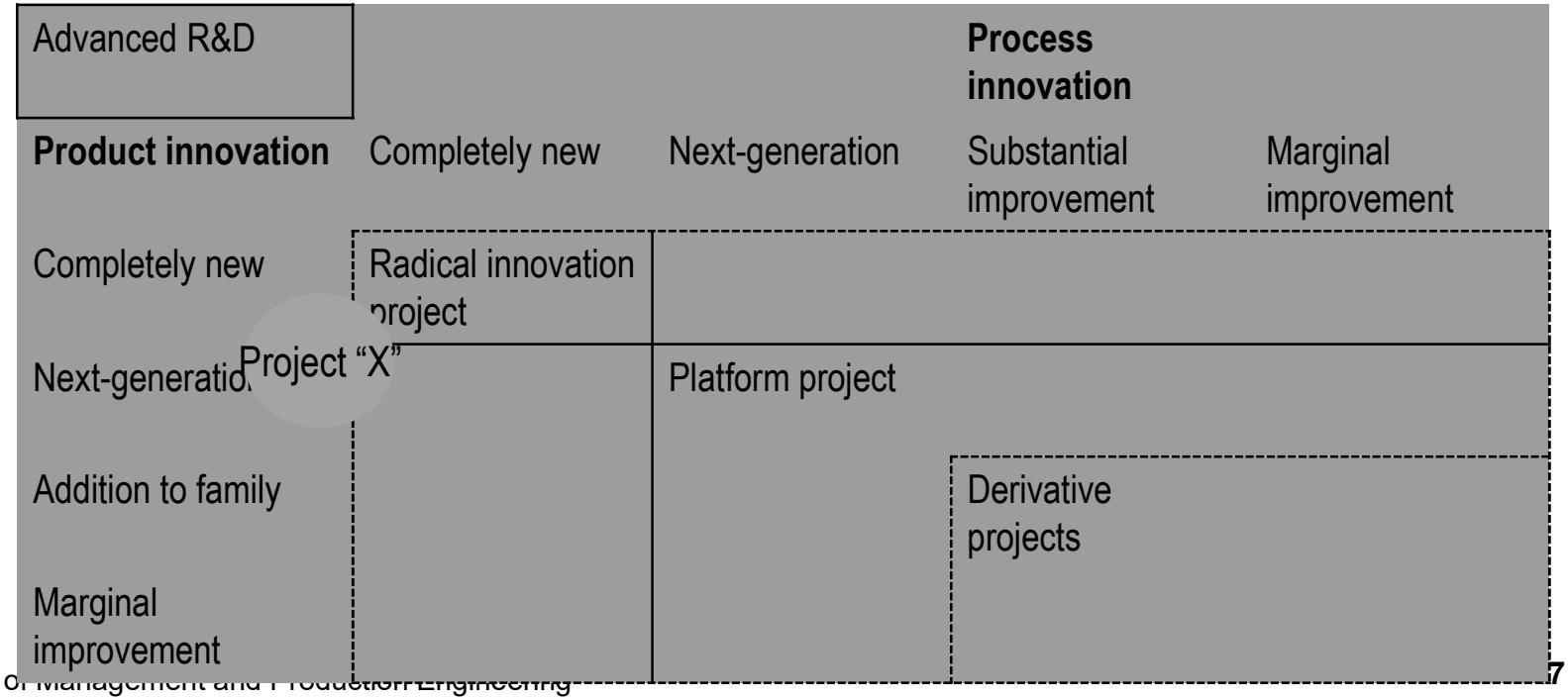
- A foreword on the importance of project portfolio management
- Taxonomies for projects (static)
- The innovation funnel (dynamic)
- Tools and methods for project portfolio management

A foreword

- The role of top management in project portfolio management (PPM)
- The strategic need to formalize PPM
  - PPM as a tool for defining / implementing innovation strategy
  - “Project glut” and over-used resources
    - No project is assigned enough resources
    - Projects fight to get hold of resources (on “political” basis)
    - Project lead time increases without bounds
  - Failed projects never die
  - Projects get overloaded with objectives
  - Decision making is subjected to cognitive biases and political influence

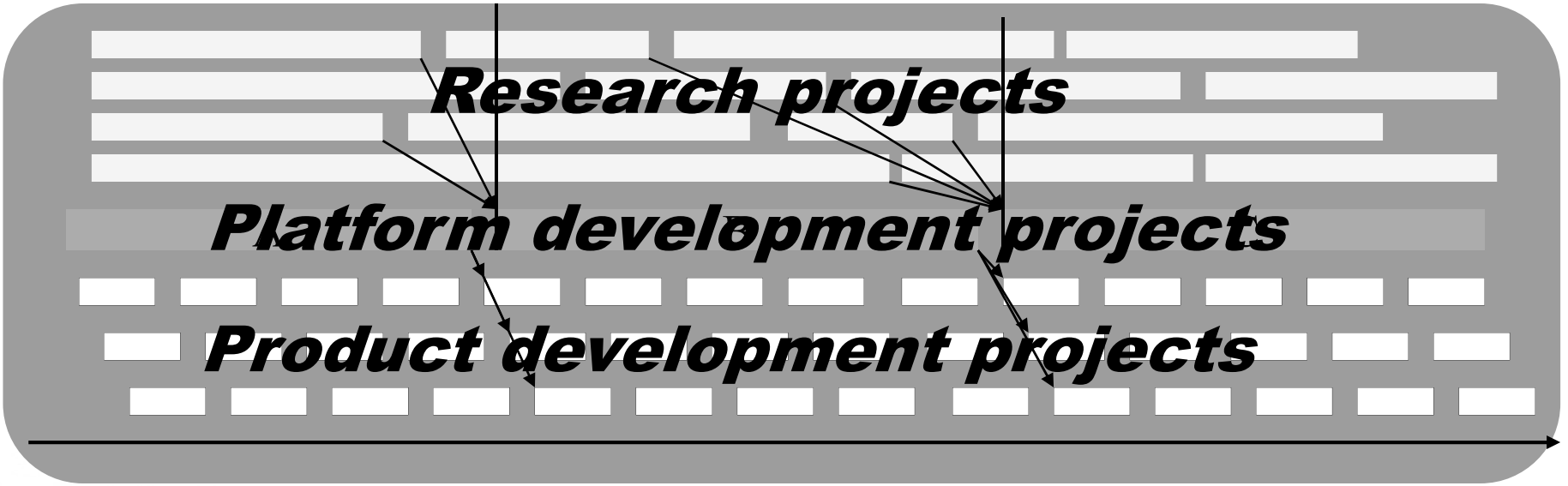
Taxonomies for projects

- Wheelwright and Clark – map and categorize your projects
  - Projects at different levels are fundamentally different (scope, decision-making process, deciding authority, etc.)
  - Projects must be compared like-for-like



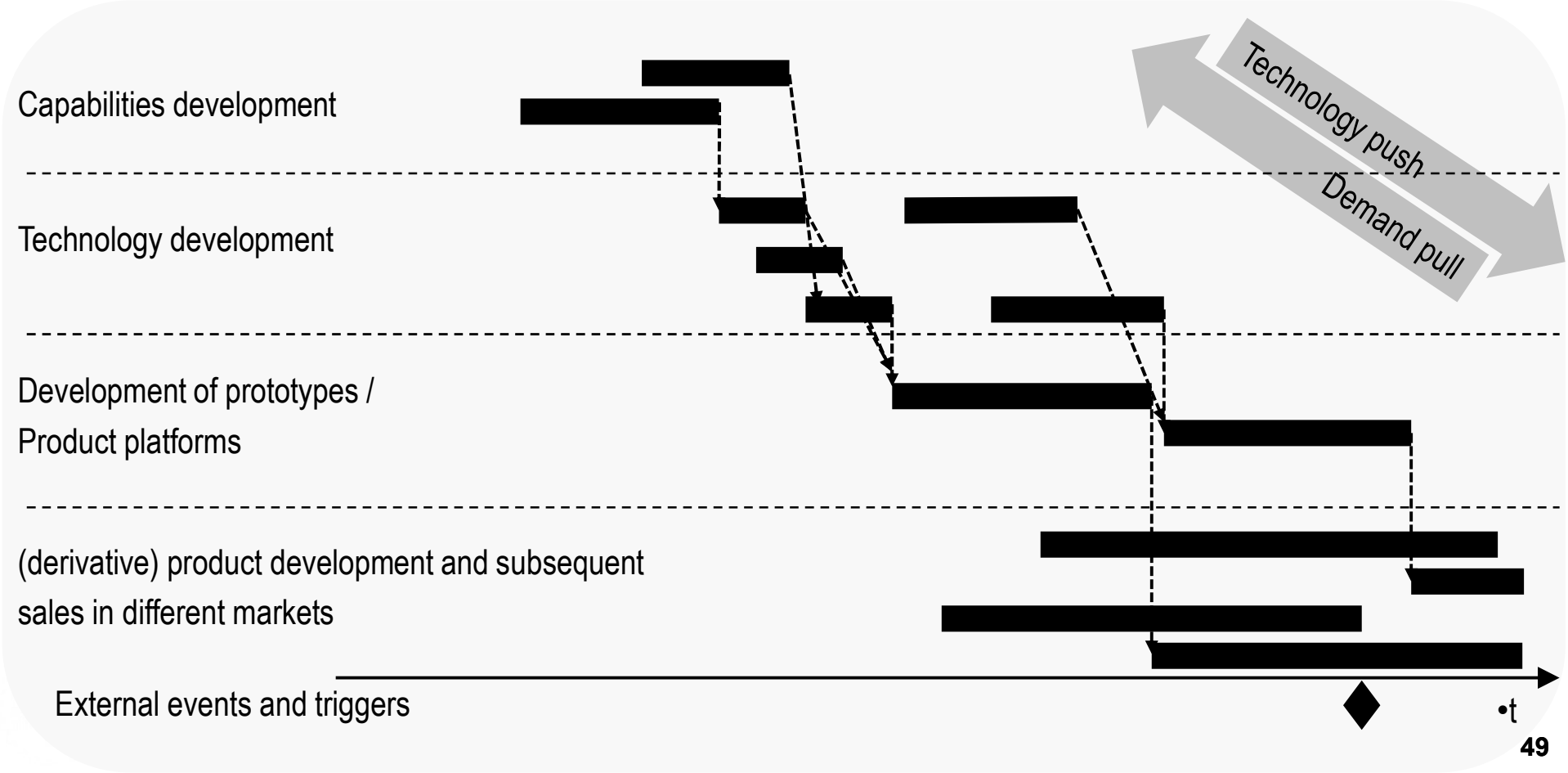
Taxonomies for projects

- Platform projects can decouple projects having different
  - innovative content
  - features and objectives



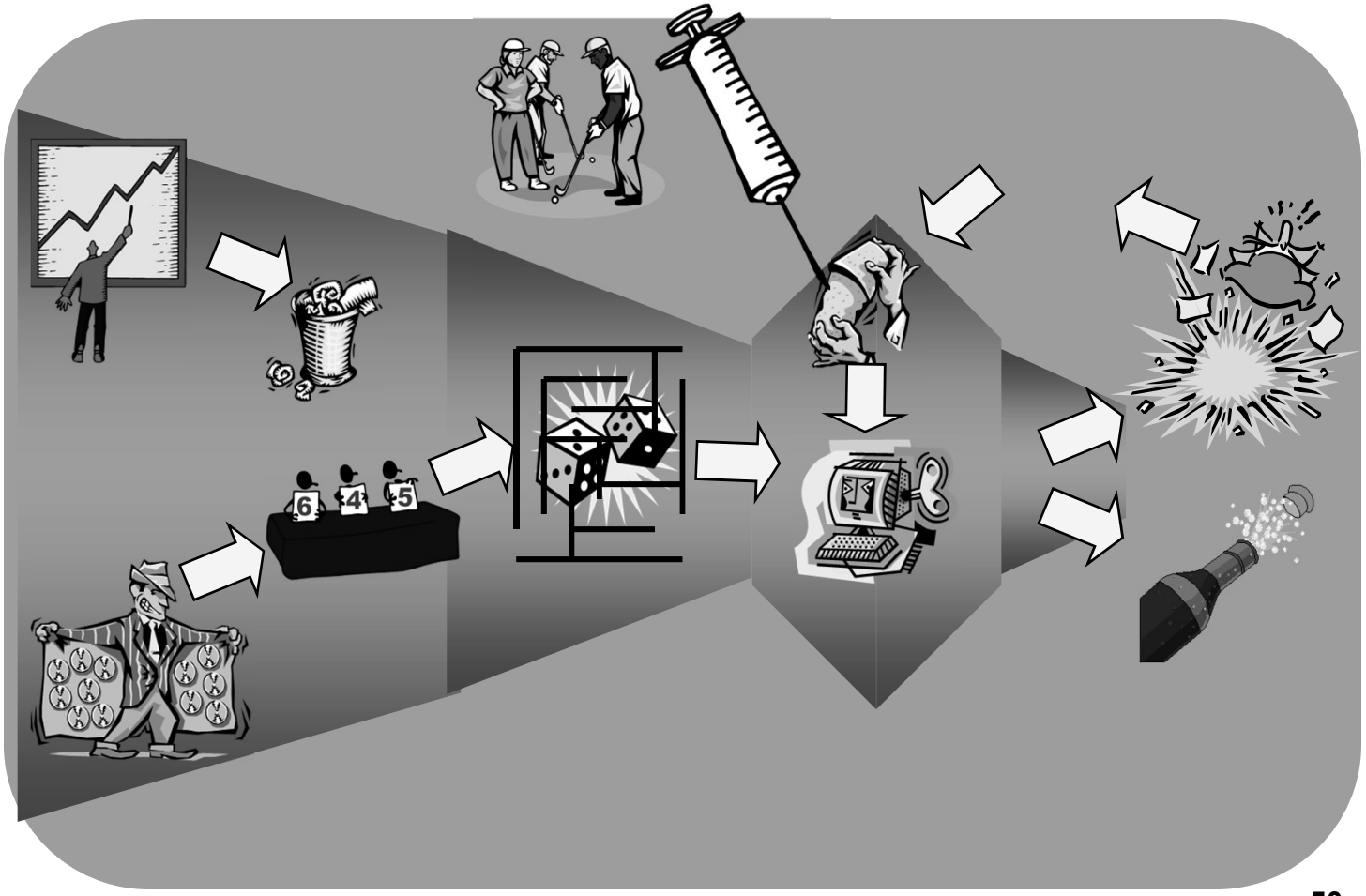
Taxonomies for projects

- Technology roadmapping can help create a coherent picture of the portfolio you are talking about



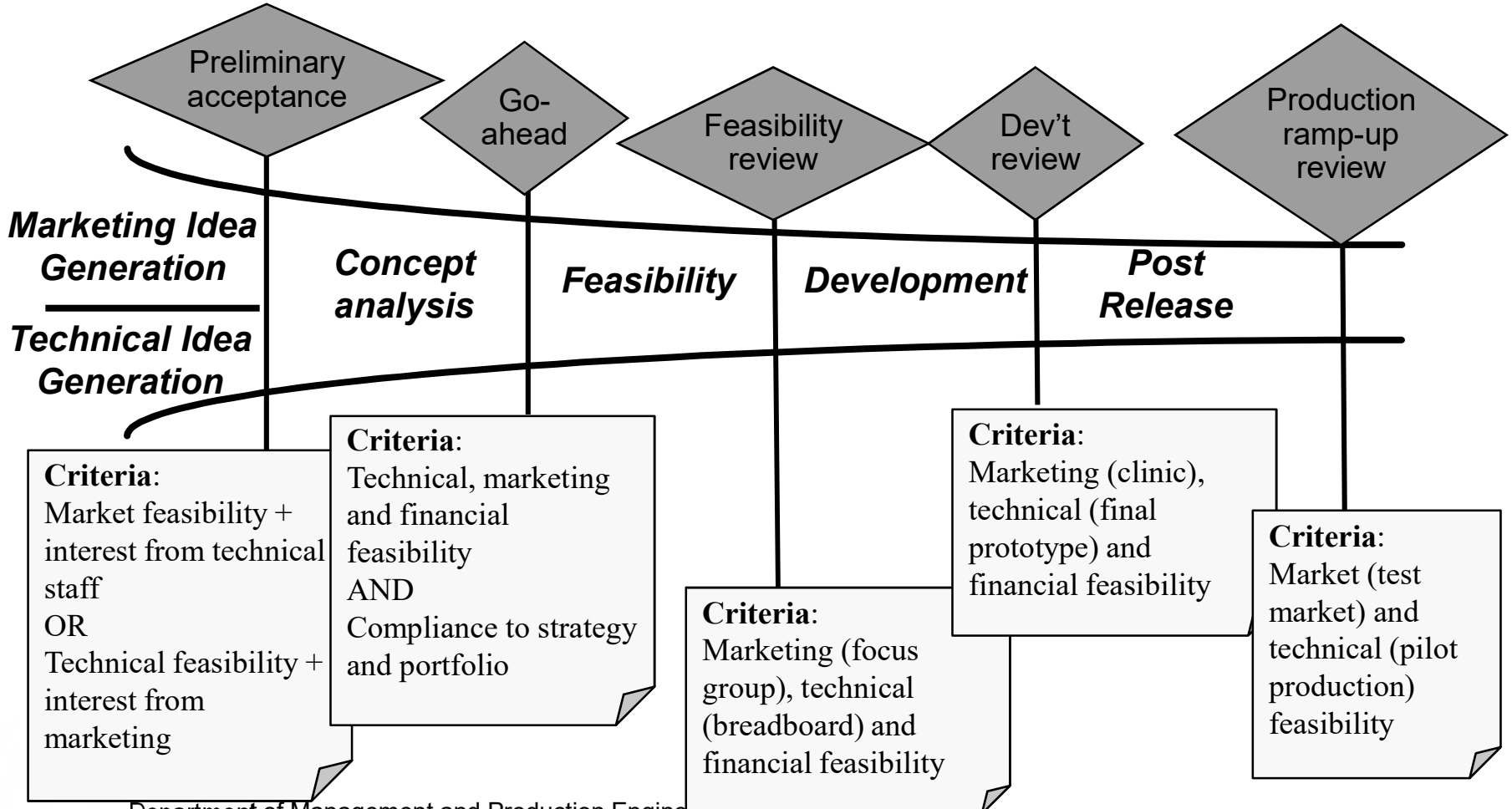
The innovation funnel

- What's the process like in your company?



The innovation funnel

- Stage-Gate® processes… based on the principle that costs grow and uncertainty decreases with time



The innovation funnel

- Stage-Gate® processes are widely used and often misused (Schmidt et al. 2009)
  - Many projects in and few ones out … funnels are not pipes
    - Entrance must be easy (stimulate idea generation!)
    - Go/no-go decisions must be for real
    - Clear distinction between early phases (discovery and incubation, aimed at exploring and scrapping bad ideas) and later ones (acceleration, aimed at ensuring business success)… e.g. Eli Lilly's Chorus organizational unit
    - The process may be different for radical and incremental innovations
    - Firm-level performance is positively correlated with broad exploration strategies in the early phases, **if** matched with selectiveness in the subsequent ones (Klingebiel and Rammer 2014)
  - Rejection rates must be initially low, and go up when costs are about to escalate (even more for radical and new-to-the-firm innovations)
  - Completeness of information required should follow the same pattern (if you try getting more than what you budget, you will kill lots of good projects)

The innovation funnel

- Other tips and tricks...
  - Set a reasonable number of gates (3-4, maybe 5 for radical innovations)
  - Use a good review team
    - ≈5 people, or more for late-stage reviews and innovative projects
    - peers at the beginning and senior management towards the end?
  - Capitalize on failed projects ("lessons learned" and salvage assets)
  - Regularly assess review proficiency and try to improve it

This choice has pros and cons!

Tools and methods for PPM

- Financial methods (es. NPV, IRR, payback time, productivity indicators), deterministic vs. stochastic (e.g., decision trees, Monte Carlo simulation)
- Optimization methods
- Multicriteria methods (from basic scoring or ranking methods to “sound” approaches such as AHP and Electre)
- Visual methods (e.g., bubble diagrams)

Prof. Marco Cantamessa

Innovation Management
Organizing for innovation
Part 1 – organizational design

POLITECNICO DI TORINO
Dipartimento di Sistemi di Produzione ed Economia dell'Azienda

Communication and organization in innovation

- Innovative activities need a specific organization
- The resource-based approach leads to viewing the organization as a set of routines (→ processes) rather than as structure (→ organization chart)
- Consequences
  - The “golden rule”: organizational proximity should be proportional to the intensity of communication flow
  - Tendency to neglect efficiency gains due to specialization and division of labor

Information channels in innovation

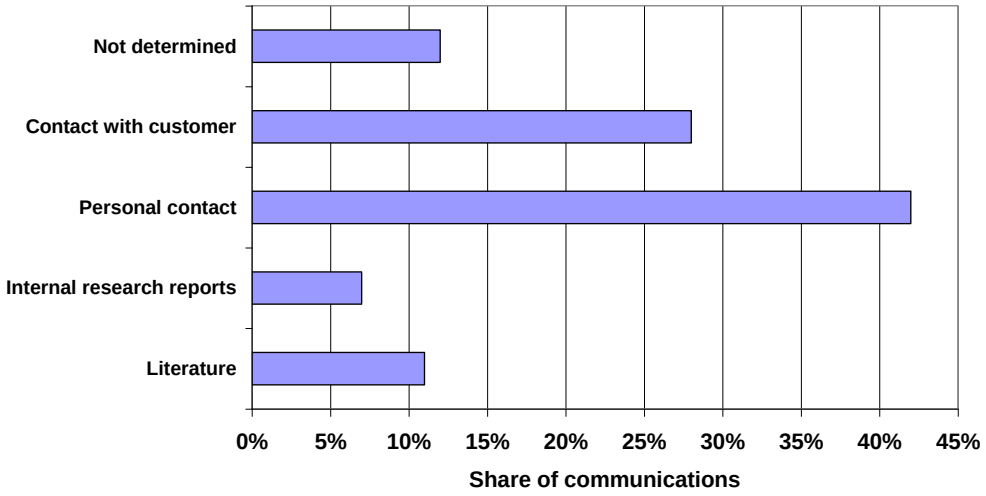
- Studies on R&D organizations date from the ’70s at MIT (T.J. Allen, “Managing the flow of technology”) and have repeatedly been confirmed even by taking recent advances in ICT into account (for how long?)
- These studies arise from the intuition that development activities are different from research ones
- Two phases of research
  - Twin projects (e.g., dual supply contracts) in order to study different problem- solving strategies
  - Communication network analysis to study interaction between personnel engaged in product design and development

Information channels in innovation

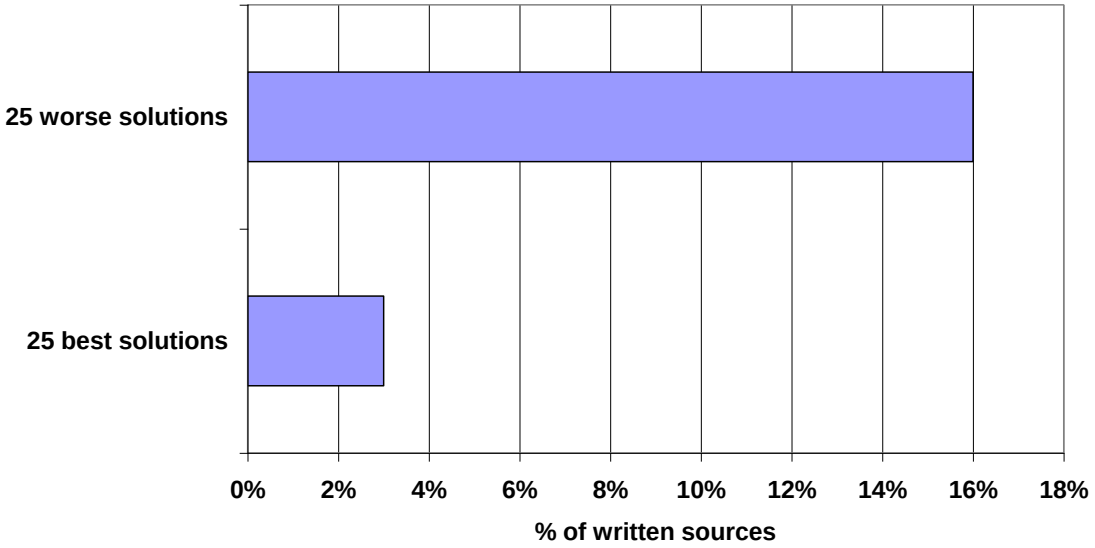
- Phase 1 – the role of literature
  - Hypothesis that literature has a key role in suggesting technical solutions, as it has in technical education
  - On the opposite, it has a limited role when one observes
    - Frequency of use
    - Usage by expert designers

Information channels in innovation

Source of 494 communications providing possible solutions to technical problems (on 17 projects)

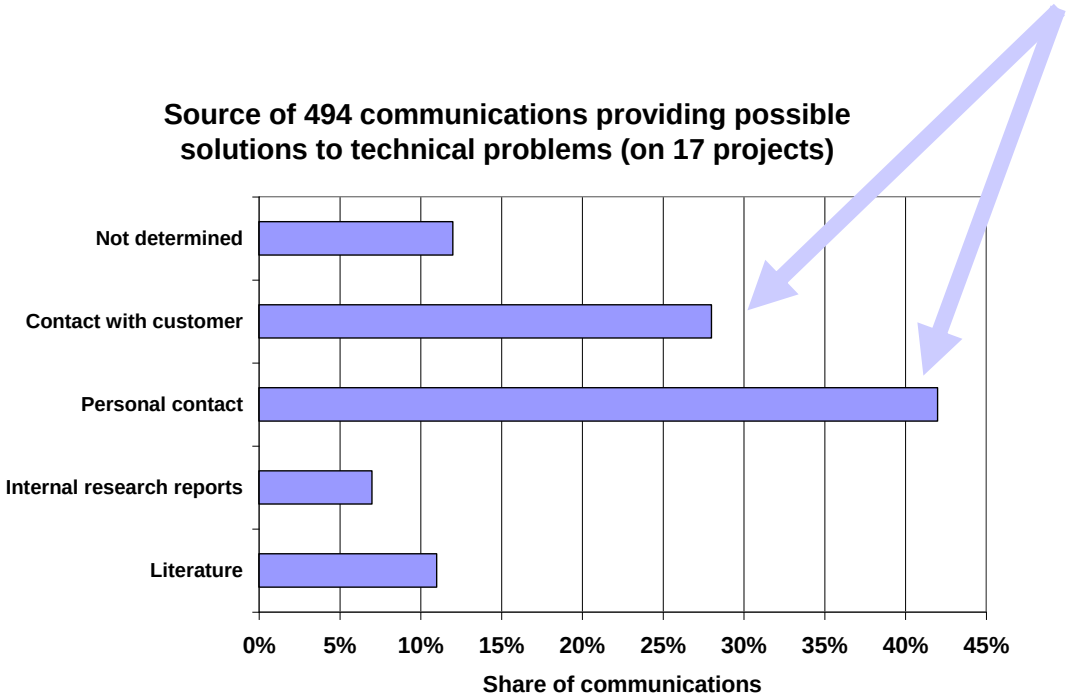


Association between quality of solution and information source



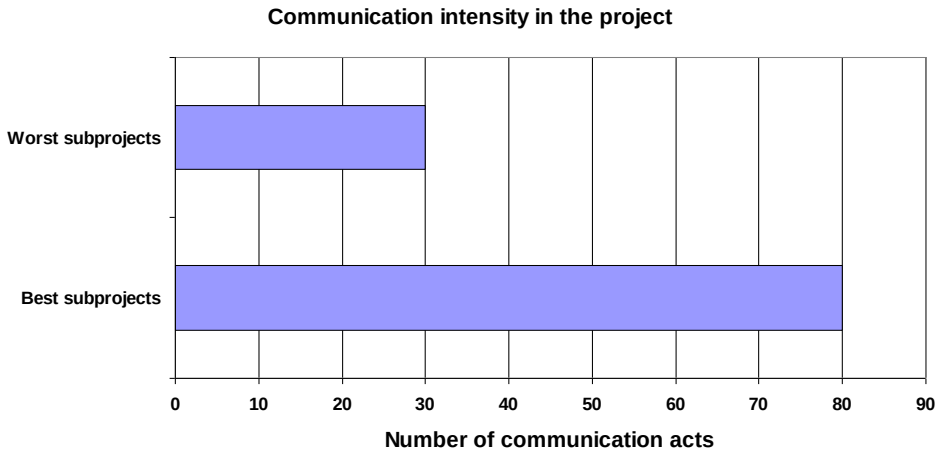
Information channels in innovation

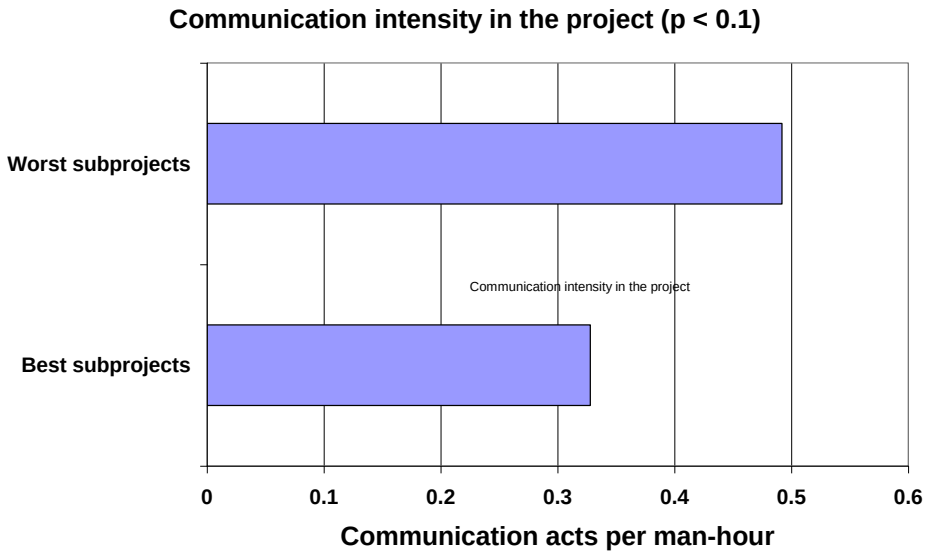
- Phase 2 – communication network analysis
  - Why? Because personal contacts are the main source of information



Information channels in innovation

- Phase 2 – communication network analysis
  - Hypothesis 1 – “communication intensity” (i.e. n. of communication acts) has a positive impact on project quality
  - … but that’s not confirmed by data, if related to project effort (n. of communication acts per man hour)

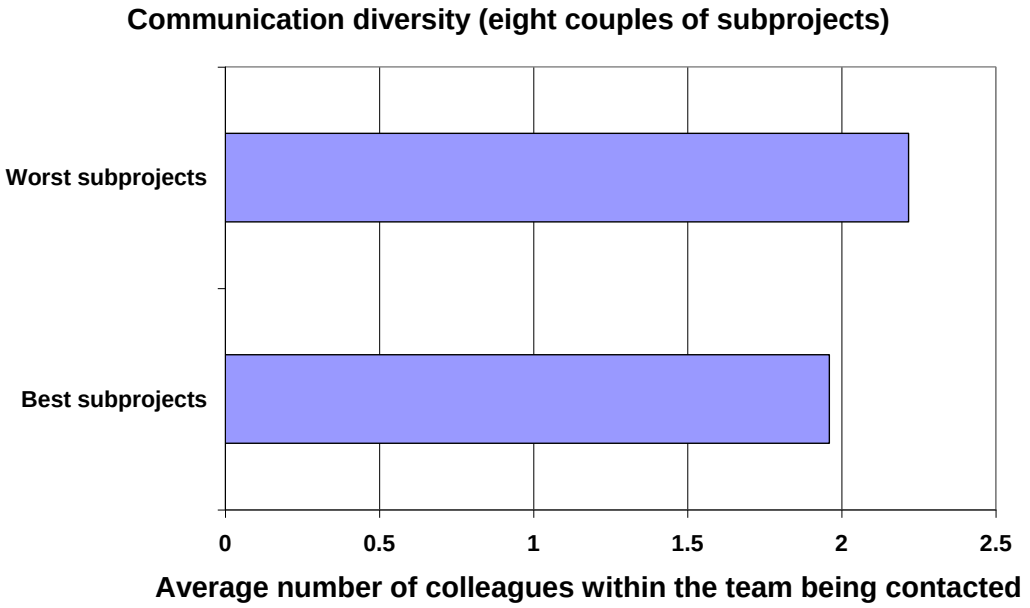




Information channels in innovation

- Phase II – communication network analysis
  - Hypothesis 2 – "communication diversity" (i.e., number of colleagues with which communication occurs) has a positive impact on the project…

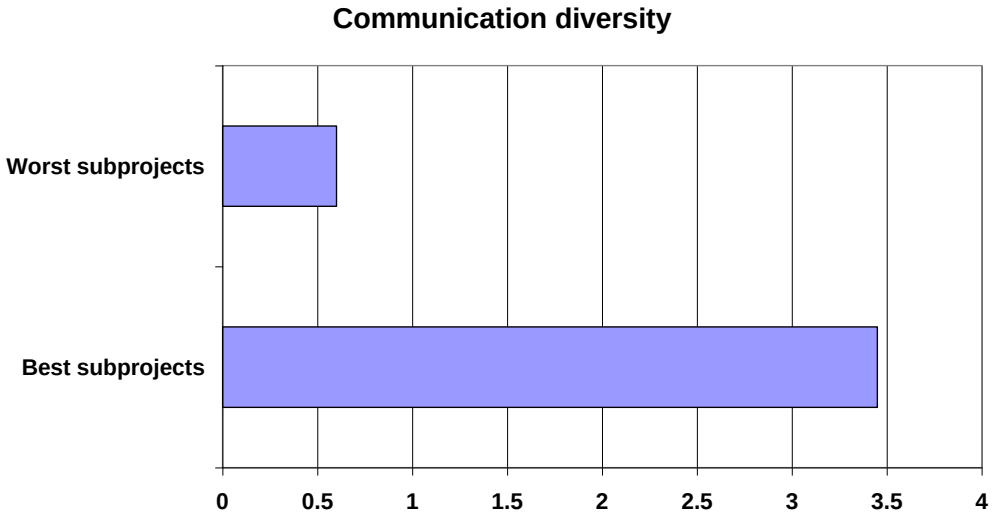
…not confirmed



Information channels in innovation

- Phase 2 – communication network analysis
  - Hypothesis 3 - “communication diversity” with respect to the colleagues not on the project team but belonging to the same functional area has a positive impact

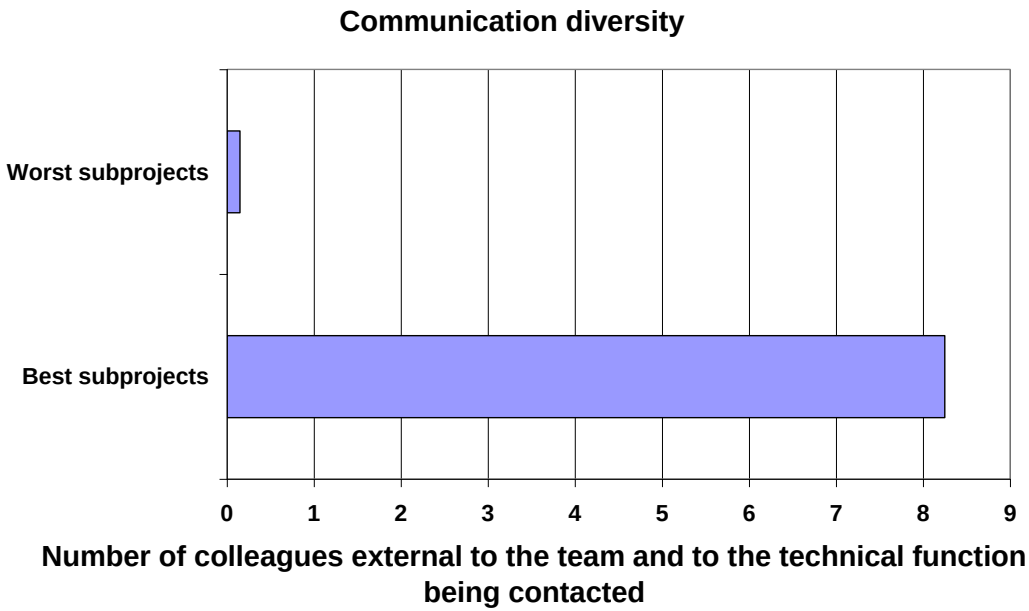
… TRUE



Information channels in innovation

- Phase 2 – communication network analysis
  - Hypothesis 4 – “communication diversity” with respect to colleagues not on the project team and not in the same functional area has a positive impact

… VERY TRUE



Information channels in innovation

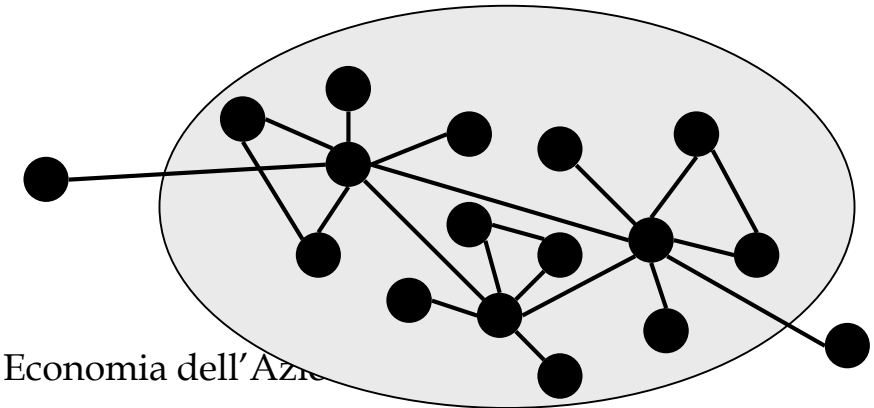
- Phase 2 – communication network analysis
  - In short, it's important to create information links
    - Outside of the individual's organizational context,
    - Not necessarily outside of the firm (results are often poor)
  - Internal consultancy is difficult to perform because
    - Designers often compete among themselves
    - Designers are often overloaded with work (don't have time for it)
    - Asking for help implies an admission of one's own technical ignorance
  - In short, internal consultancy works well among the more skilled designers
    - Because the one being helped will probably be able to return the favor
    - Because the one being helped has a strong reputation and is not afraid of asking for help once in a while

Information channels in innovation

- Phase 2 – communication network analysis
  - Tapping in externally-available knowledge is important, but
    - Direct contact often is ineffective (specificity of knowledge, technical problems and language)
    - Hiring new personnel often leads to failure
  - Allen discovers an alternative vehicle for absorbing knowledge: the technological gatekeeper

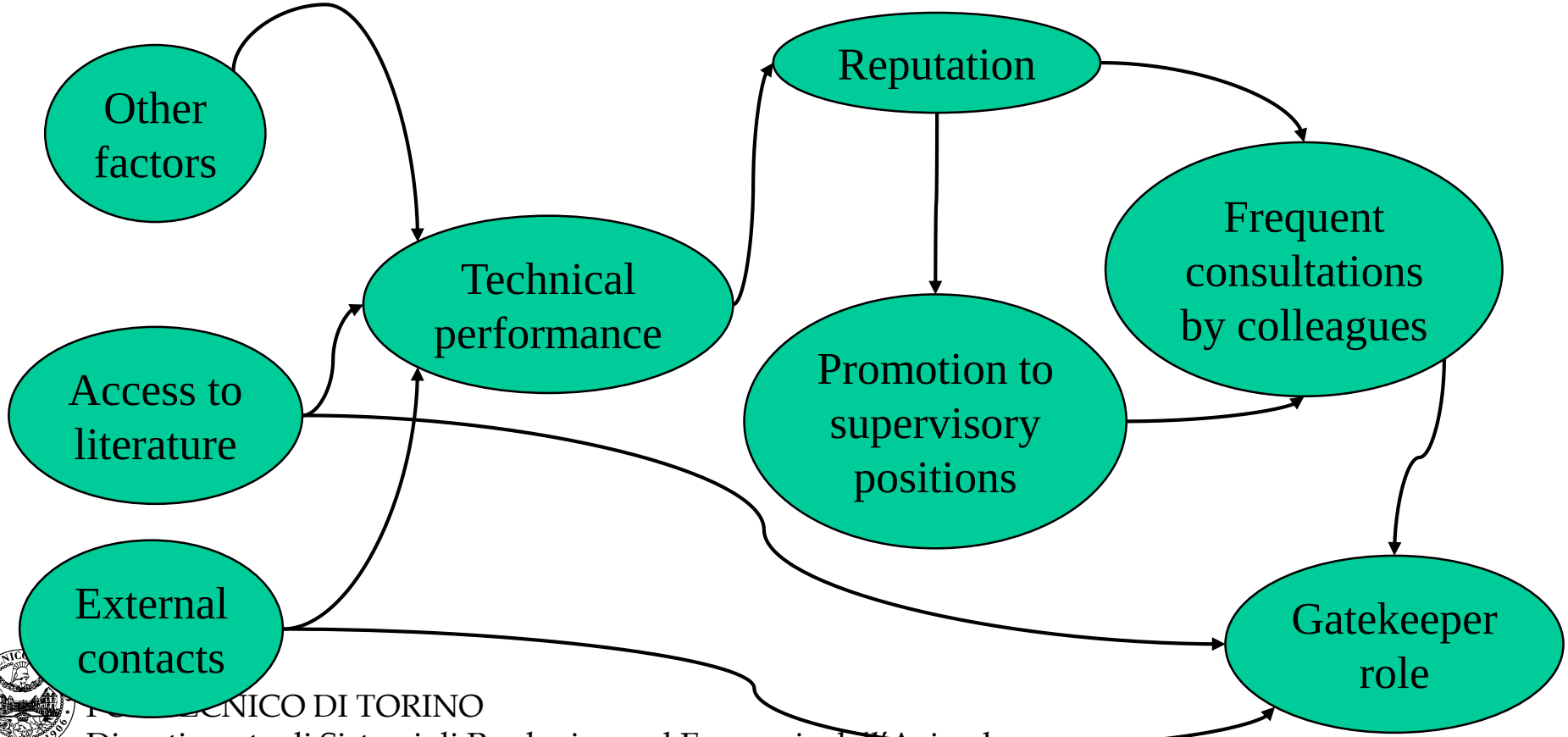
Information channels in innovation

- Technological gatekeepers
  - Are located at focal points of communication flows (hub-spoke)
  - Are exposed to communication flows coming from beyond the firm's boundaries, thanks to
    - frequent contacts with colleagues outside the firm
    - Knowledge and readership of literature
  - Are continuously on the lookout for contacts, both externally and internally (especially with other gatekeepers)
  - Are engaged in "translating" external knowledge (generally explicit and codified in nature) so that it may be effectively used within the firm



Information channels in innovation

- Technological gatekeepers
  - Arise following a causal model



Information channels in innovation

- Technological gatekeepers
  - The role can easily disappear because of
    - Failed recognition (the gatekeeper gets overloaded with work, because of his technical efficiency)
    - Excessive recognition (the gatekeeper loses contact with internal routines)
    - Conflicts with project and line managers
    - Promotion to management positions → "dual ladder" career paths

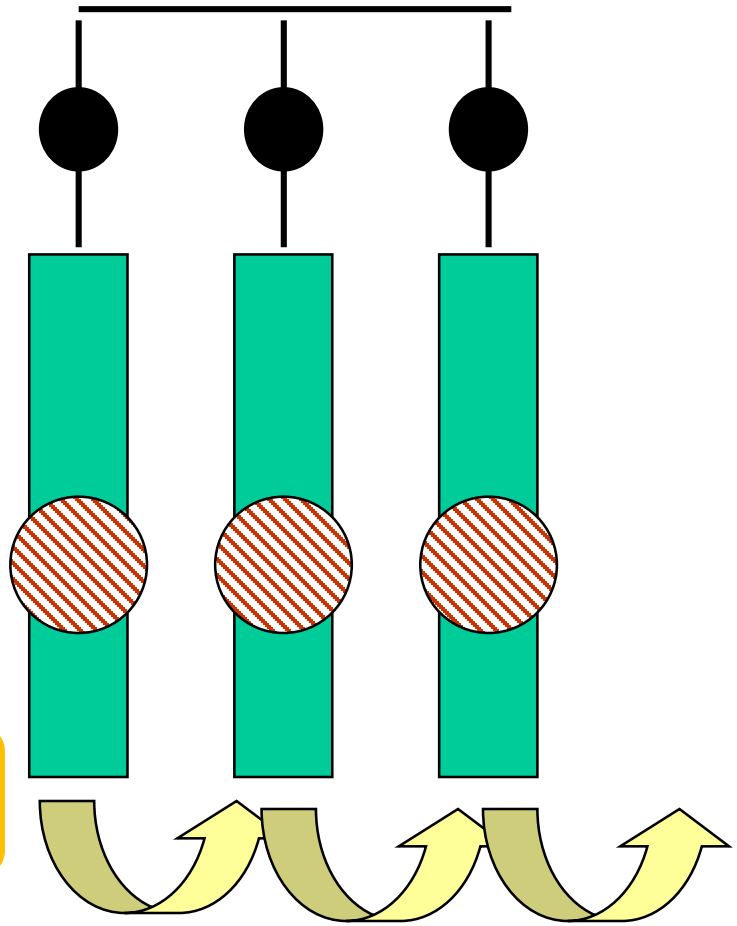
Information channels in innovation

- Are technological gatekeepers enough to ensure innovation?
  - Gatekeepers facilitate innovation from a technical point of view, but firms also need entrepreurial innovators to lead and inspire the process (Cohn et al. 2008)
  - Innovators solve problems top-down (broad vision to execution, without getting stuck into details)
  - The management team must include innovators ("*brainy and creative people may come up with ideas, we make the decisions and our functional managers will execute them*" does not work)
  - Some firms (e.g. the original HP, Apple, fashion houses) are formally or de-facto structured with dualistic leadership functions
  - Innovation talent is rare, complex (visionary thinking out of the box + capability to sell and execute the idea) and difficult to identify
  - Career management is tricky (is there an innovation function?)

Organizational design

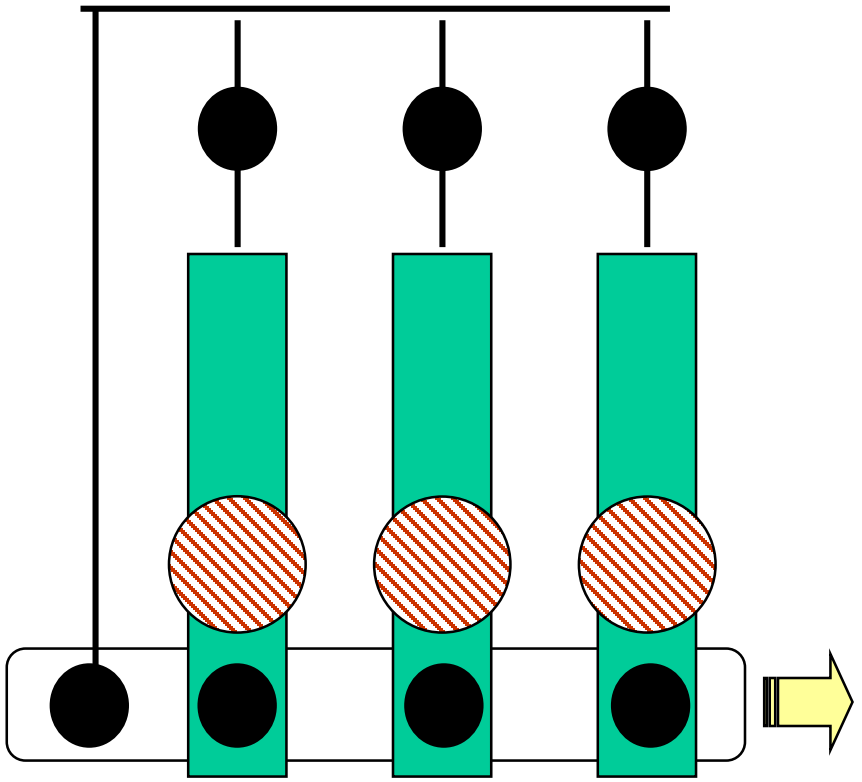
- Standard organizational forms: functional organization
  - Work is performed within functions
  - Coordination is performed by line (functional) managers
  - "Over the wall" information transfer
  - Specialist competencies focusing on detail, rather than integrative competencies
  - Internal efficiency (resource pooling)
  - Simple coordination (unique authority)

e.g., Apple and its 17 functions (led by experts) and reporting to the CEO



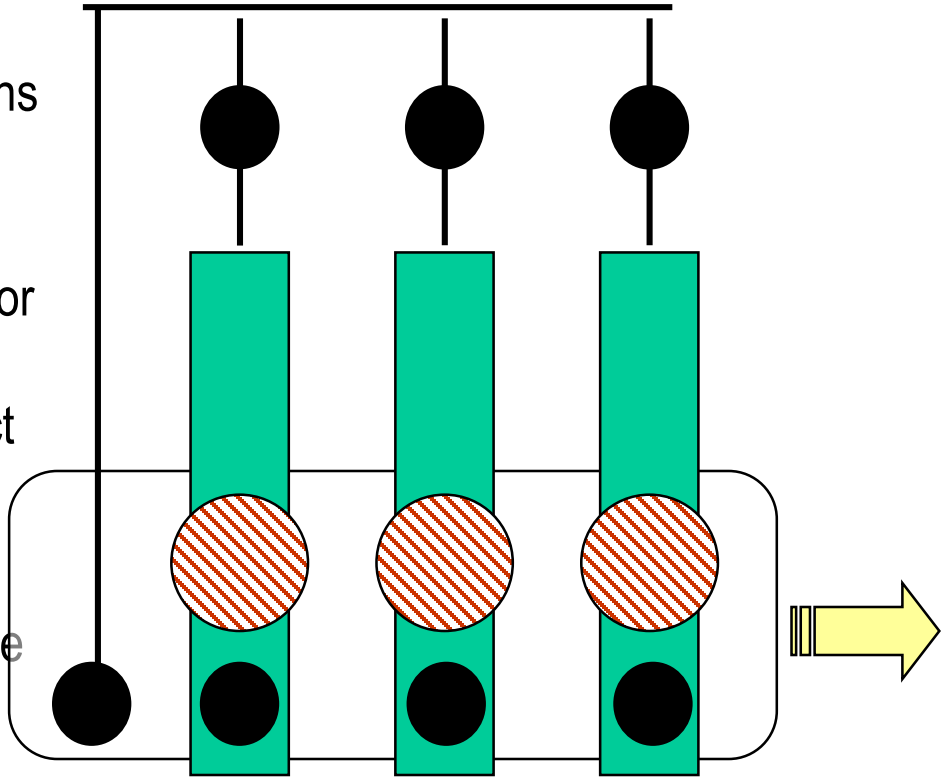
Organizational design

- Standard organizational forms: “lightweight” teams and project managers
  - Work is performed within functions and under line managers
  - Coordination is performed by project managers and liaison officers
  - Specialist, rather than integrative technical competencies
  - Internal efficiency (resource pooling)
  - Coordination problems because of dual authority structure and lightweight project managers (often juniors)



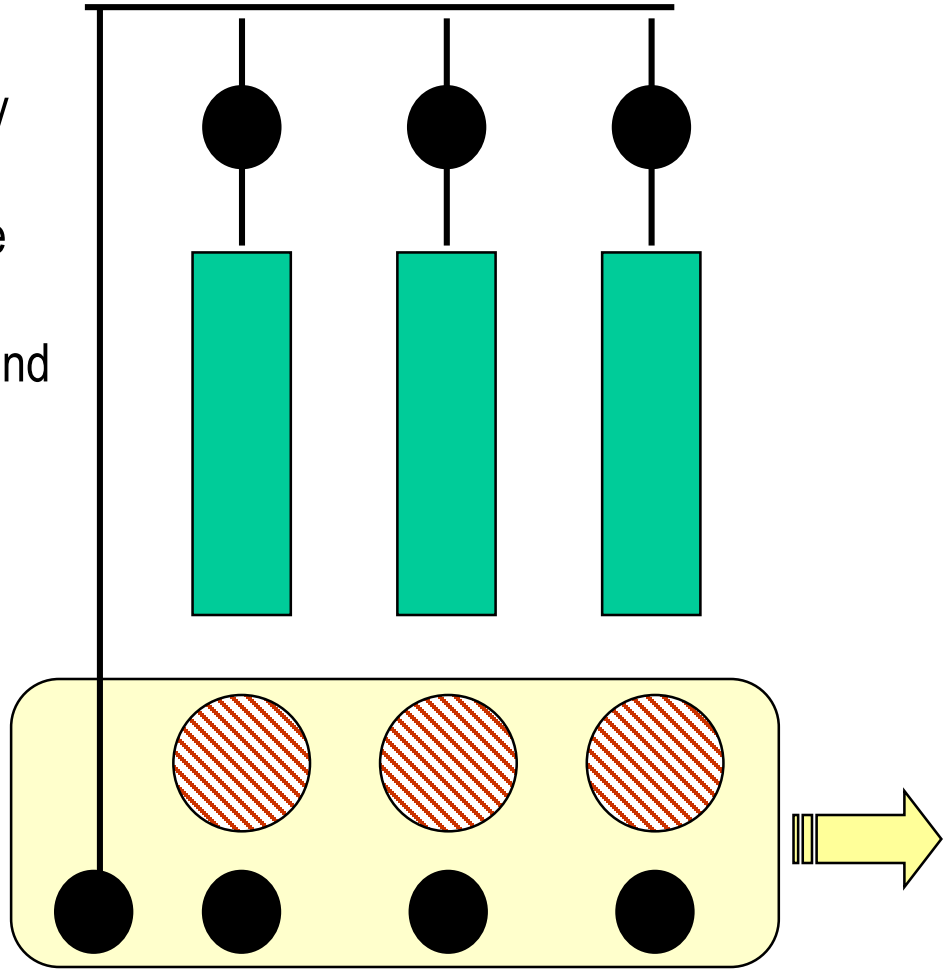
Organizational design

- Standard organizational forms: “heavyweight” teams and project managers
  - Work is performed within functions under the authority of project managers
  - Line managers are responsible for the technical proficiency of resources assigned to the project
  - Coordination is performed by project managers
  - Integrative competencies become stronger
  - Lower internal efficiency
  - Coordination problems (well-balanced dual authority)



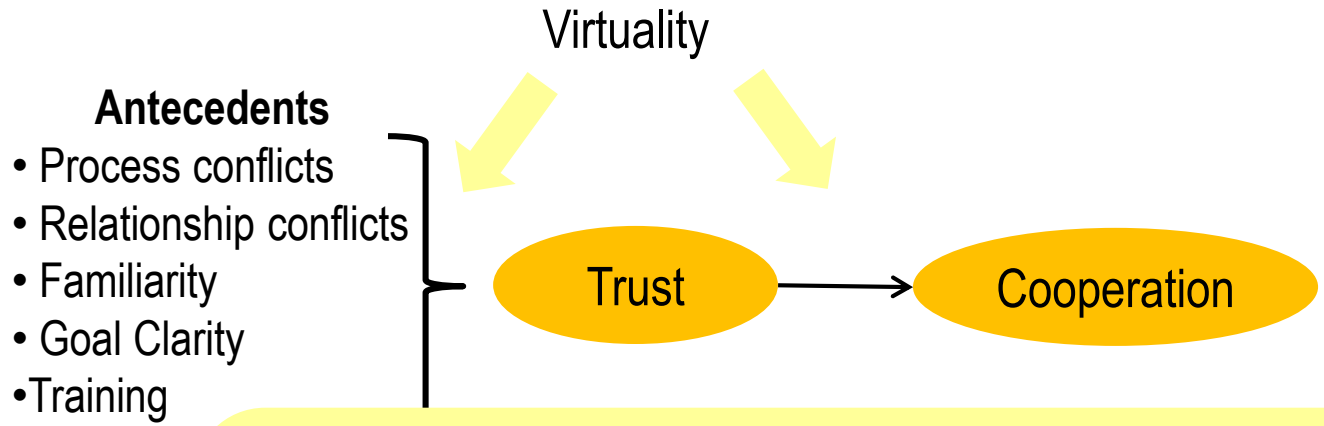
Organizational design

- Standard organizational forms: autonomous teams
  - Work is performed outside functions and under the authority of the project manager
  - Coordination is performed by the project manager
  - Integrative competencies grow and specialist ones decrease
  - Procedures are ad-hoc and “project based”
  - Low efficiency
  - Coordination problems (dual authority)



Organizational design

- An emerging issue is connected to the management of virtual, distributed teams (Bierly et al. 2009)
  - It is important to use the IT tools appropriate to the task
  - Literature insists on the importance of trust among team members



- Virtuality makes it more difficult to generate trust…

  … *however*,…
- … virtuality reduces the role of trust in generating cooperation
- Virtuality creates greater independence, which makes goal clarity very important for team effectiveness
- Physical meetings or temporary co-location can be used to sort out problems arising from virtuality, should IT not be enough

Prof. Marco Cantamessa

Innovation Management
Organizing for innovation
Part 2 – the development process

Outline

- Innovation as a process
- Product development processes
- From sequence to concurrency
- Reducing time to market
- Formalizing the process

Innovation as a process

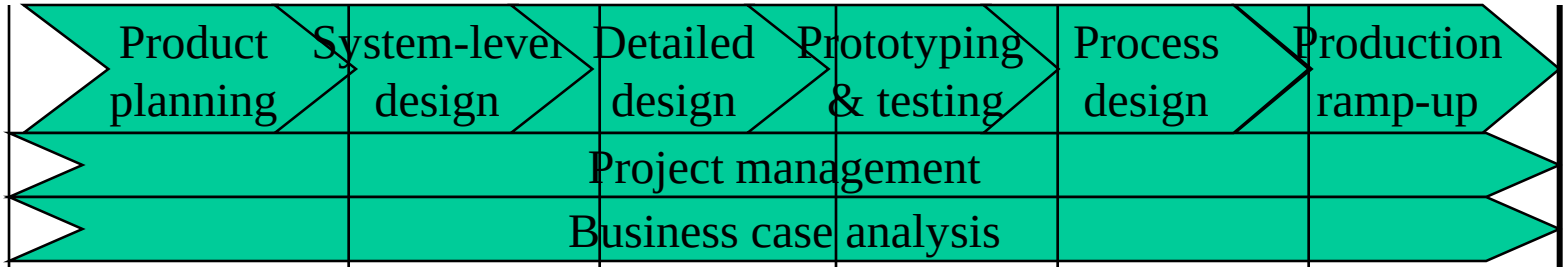
- "Innovation as a process" is coherent with
  - Current management practice
  - Modern theories of the firm
- Limitations are due to the artificial separation between
  - Subject and object of the process
  - Problem-setting and problem-solving
- Divergent from the "reflection in action" paradigm (Schon)
- Fully acceptable in case of
  - Medium to large firms
  - Moderate innovative content

Innovation as a process

- The product development process is
  - Part formalized, partly based on informal and unobservable aspects
  - Path dependent
  - Highly specific with respect to
    - The firm and its past history
    - Products
    - Upstream and downstream interactions

Innovation as a process

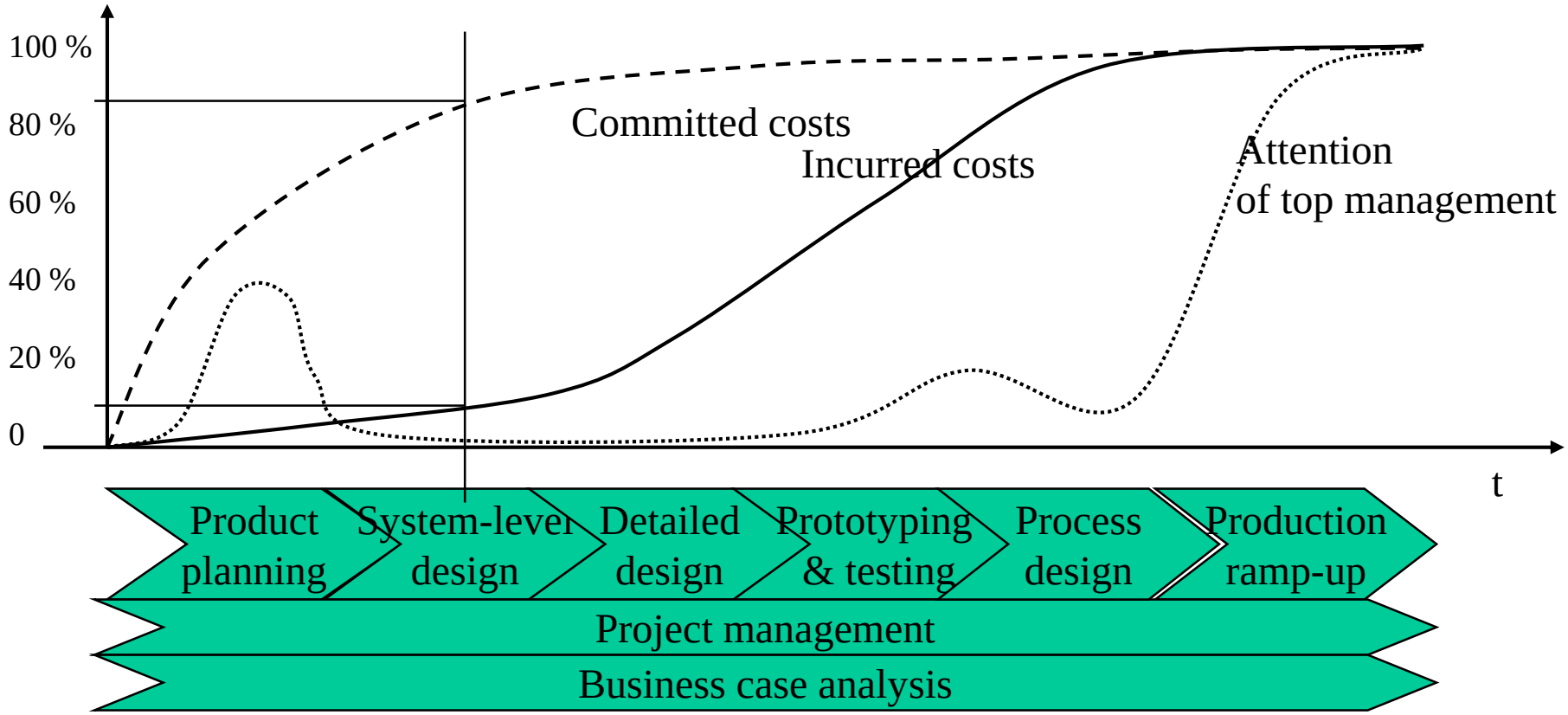
- Example of a stylized product development process



Marketing	XX	X				XX
Purchasing	X	XX	X			XX
Finance	X	X	X	X	X	X
Product design	XX	XX	XX	XX	X	X
Process design	X	X	X	XX	XX	XX
Production	X				XX	XX

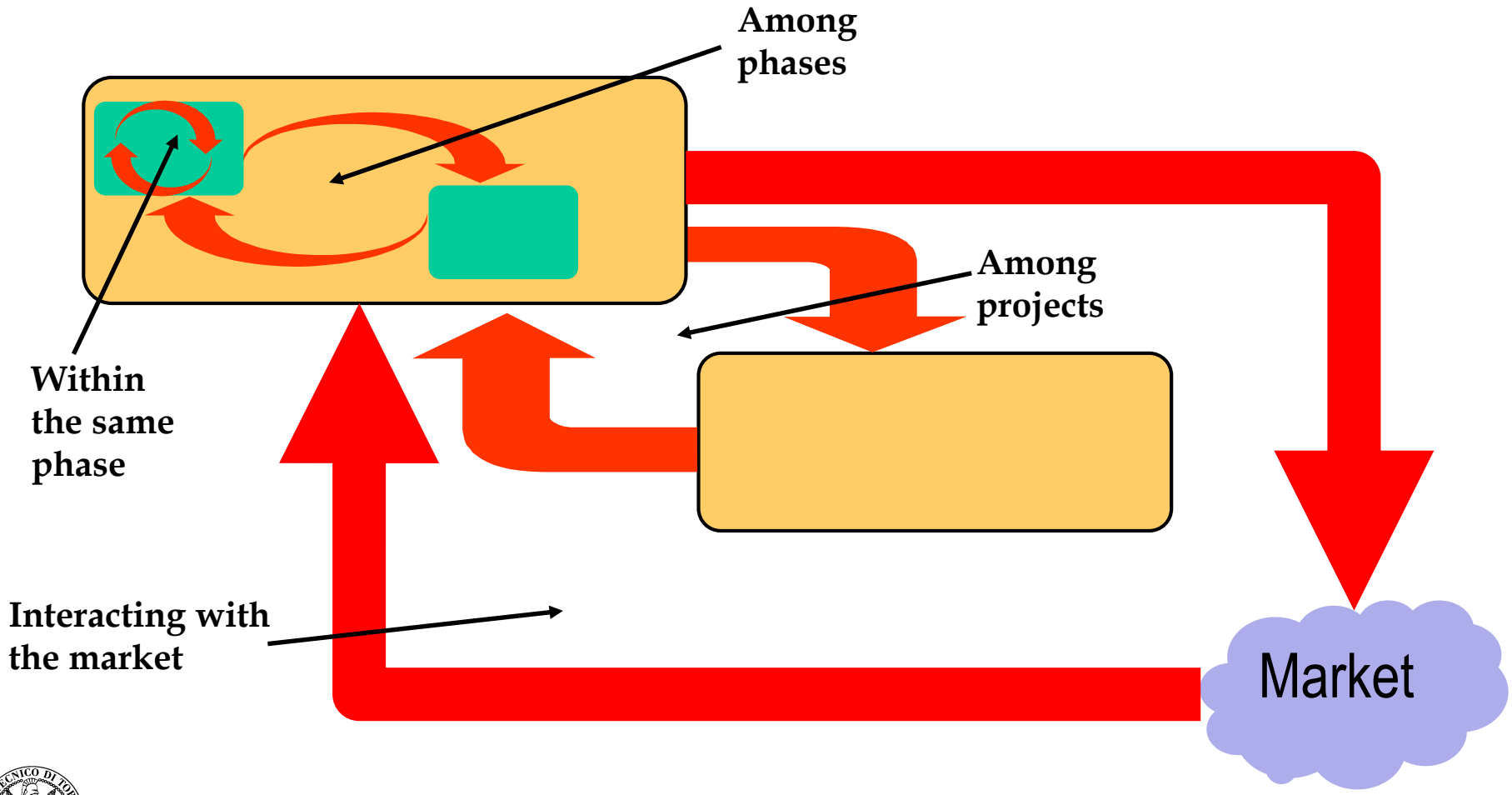
Innovation as a process

- The first steps of the process have a strong “lever effect”



Innovation as a process

- Product development exhibits iterations at different tiers



From sequence to concurrency

- Taylorism in new product development (1920-1970)
  - Efficiency achieved through specialization
  - Sequential “over the wall” management
- Design reviews (1970-1990)
  - Reviews carried out at project milestones
  - Management reviews and peer reviews with colleagues, customers and “downstream representatives”
- Concurrent engineering (1990-…)
  - Development activities performed in parallel
  - Role of IT systems (3D CAD, Model-Based Engineering)
- New paradigms deriving from software engineering (lean/agile)

Digitalization and "lean" approaches

- Virtual prototyping and digital products lead to a paradigm shift in product development w.r.t. management and cognitive approach
  - Virtual models / products are cheap to create and modify → development by *trial and error*
    - Experimentation is used for learning (not only verification)
    - Ex-ante knowledge becomes less important
    - Higher tendency to explore innovative solutions
  - Problems can be spotted earlier (*front loading*)
  - Faster experimentation can be used to
    - quicken the development process (with the same number of iterations)
    - Improve product performance (with the same lead time)
    - Place product development *in parallel* to sales
  - Rapid prototyping / manufacturing as complement / alternative to simulation

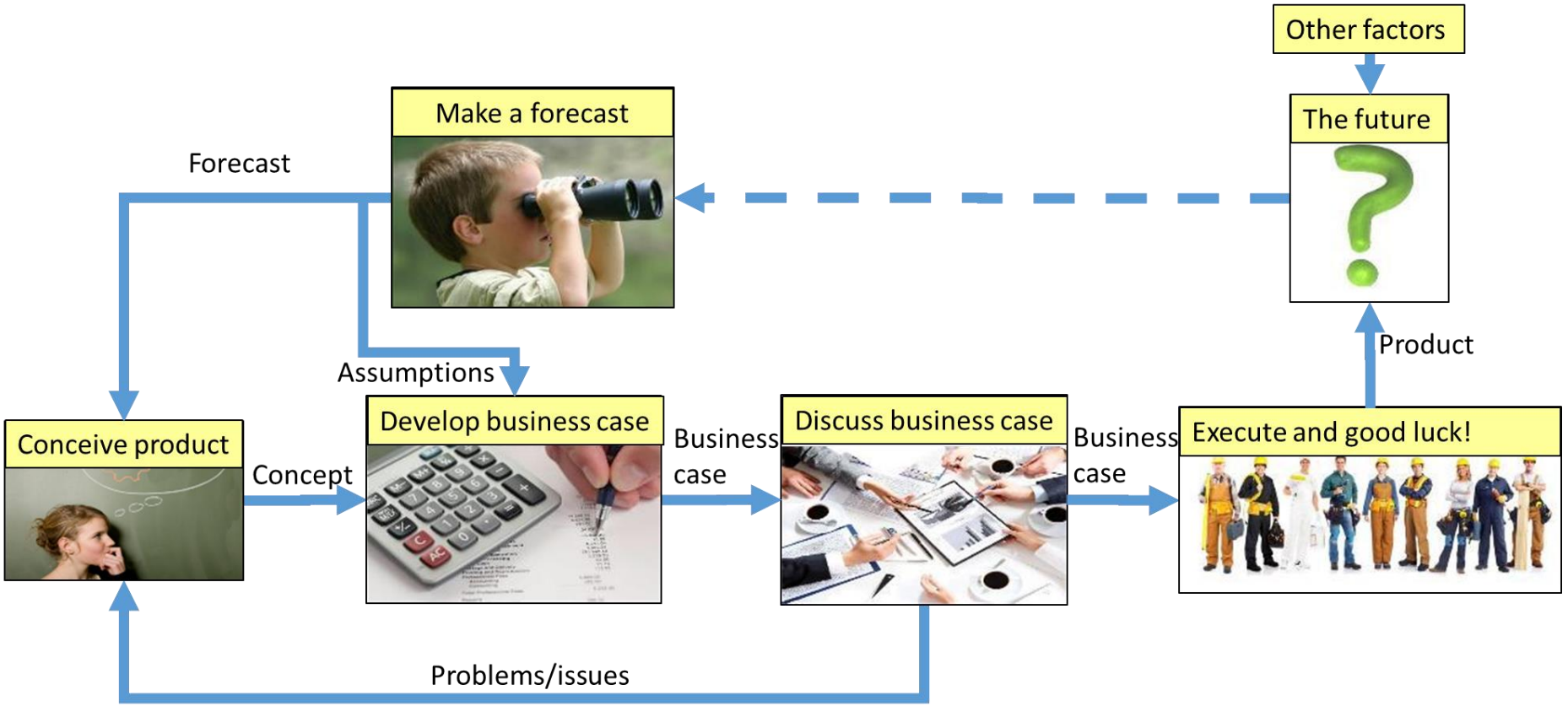
Digitalization and "lean" approaches

- Flexibility is important in new-product development ("flexibility α marginal cost of a design change $^{-1}$")
  - Low flexibility (Thomke 1997) leads to actions aimed to reduce the risk of taking wrong decisions (e.g., market research, stage-gate systems, etc.). These methods
    - are costly
    - can even be harmful in turbulent environments
  - It is possible to use late commitment strategies
    - Rapid and virtual prototyping, soft tooling
    - Real-time market research actions (e.g. Minimum Viable Products in Internet companies)
    - Decoupling development activities (e.g., inner engineering vs. styling, hardware development vs. firmware updates)
  - All this is leading to a paradigm shift (**lean / agile innovation**)

What is the "last responsible moment" for a given decision?

"Individuals and interactions over processes and tools.
Working software over comprehensive documentation
Customer collaboration over contract negotiation
Responding to change over following a plan"

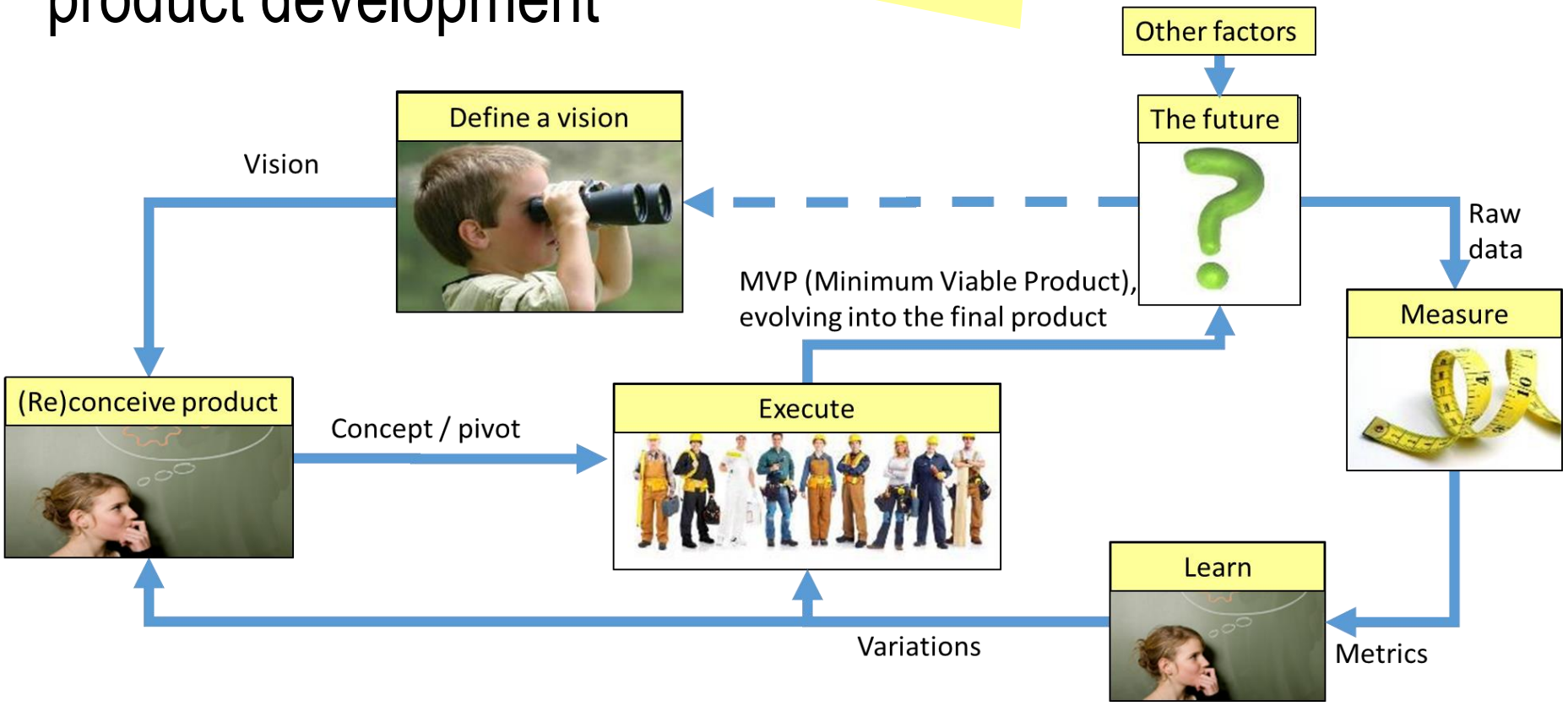
Traditional approach to product development



Lean approach to product development

Where can you profit from "Lean"?

- Must flexibility be low or high?
- Would you expect the "digital" content to be low or high?
- Low or high uncertainty?
- Technology or market uncertainty (or could it be either of the two, but then the iterative process will measure different metrics)?

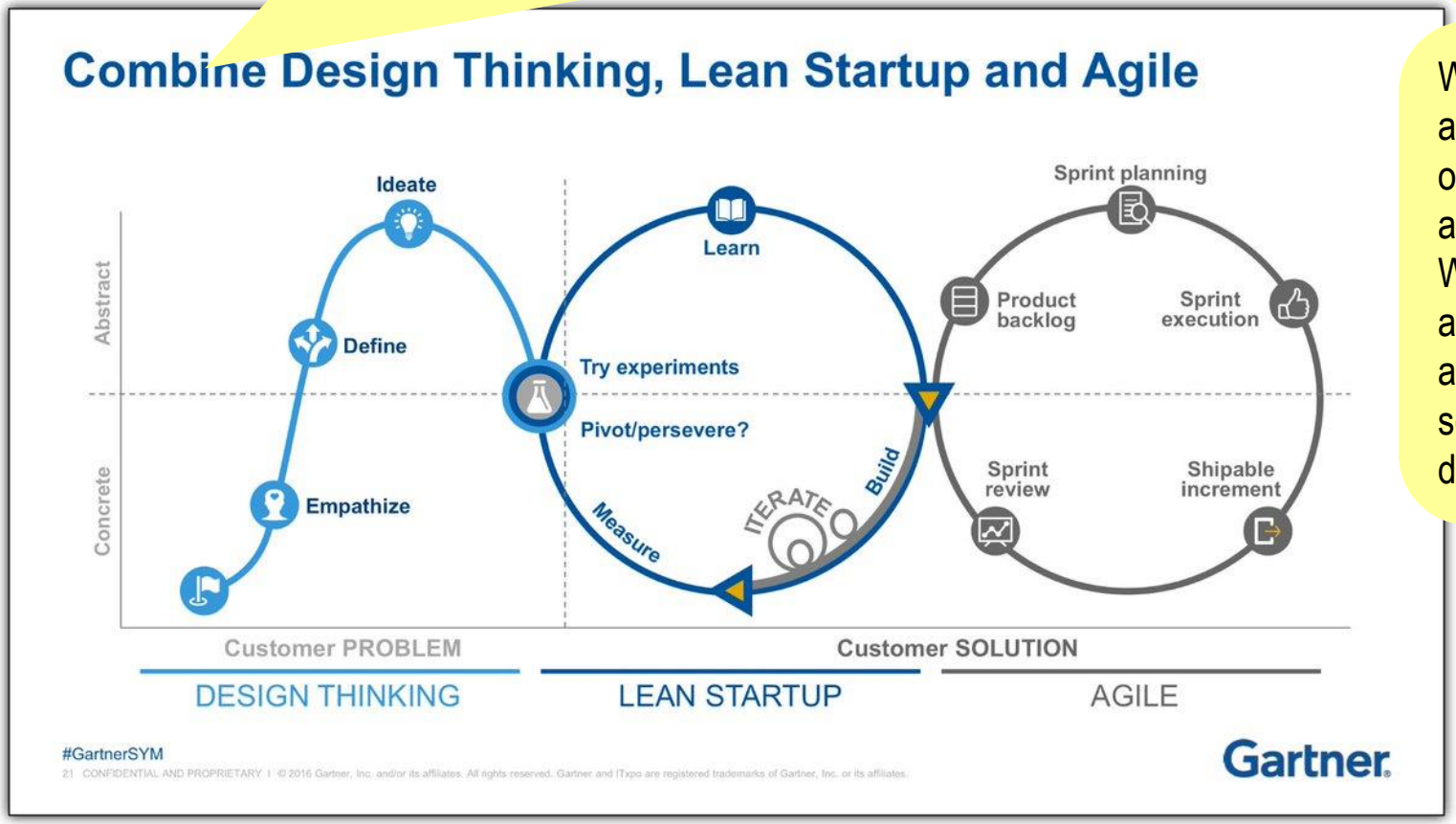


Design thinking = a design approach which is particularly suitable for *wicked problems*, based on

- deep and experimental interaction between designer and problematic situation
- separation between problem setting/finding and problem solving

Lean = a product development approach / business strategy allowing progressive development of sustainable solutions through iterations and pivoting

Agile = a project management approach allowing the progressive / iterative development of complex systems



With traditional approaches, project objectives are given and time/cost follow
With lean/agile approaches, time/cost are usually given, and scope varies/is discovered on the fly

Digitalization and "lean" approaches

Prototypes and MVPs can be of different nature

Representation of VPs

- Data sheets or brochures
- Storyboards
- Landing pages or product boxes
- Videos

Functional MVP

- Preliminary functional prototypes
- Wizard of Oz prototypes (real front end, fake back-end)

Life-size MVPs

- Near-final prototypes
- Mock sales and pilots
- Presales

Innovation games

- Design the product box and try selling it
- Buy a feature

Digitalization and "lean" approaches

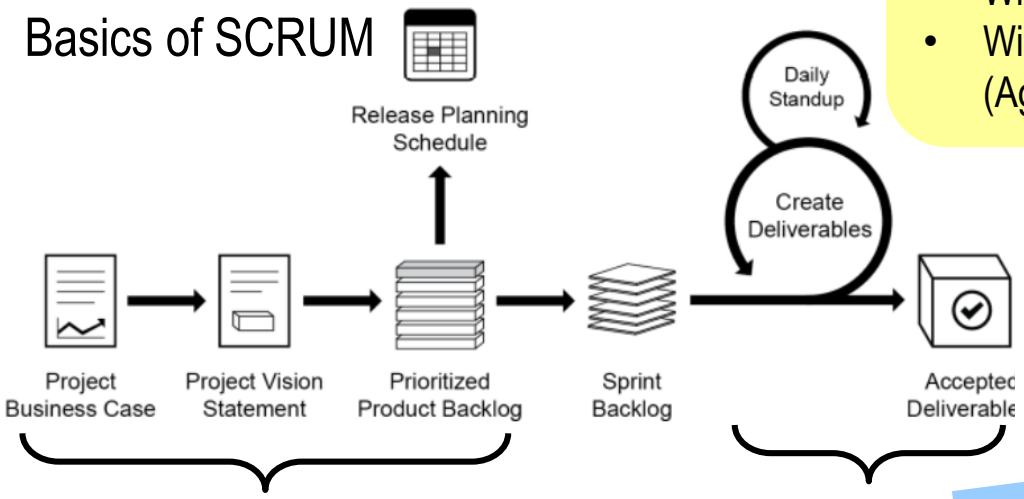
- Specific management methods inspired by Agile SW development and Internet startups
  - Rolling-wave planning
    - Rough plan for entire project + detailed plan for the next 4 weeks
    - Updates every 2 weeks or when needed
  - Progressive discovery / development / validation of customer-facing processes (sales, onboarding, growth engines, A|B testing, etc.)
  - Loose-tight planning (loose for creative phases, tight for repetitive work)
  - Timeboxing
    - Project is partitioned in fixed time boxes and the scope of each timebox is defined
    - No delays allowed, but flexibility in scope (a good way to avoid overengineering)
  - Variants of Agile project management / software development
    - Extreme programming (frequent releases, iterations, face-to-face meetings)
    - SCRUM (empowered teams, self-organized in 2-4 week “sprints” with clear objectives, daily standup meetings, constant monitoring of backlog / progress)

Digitalization and "lean" approach

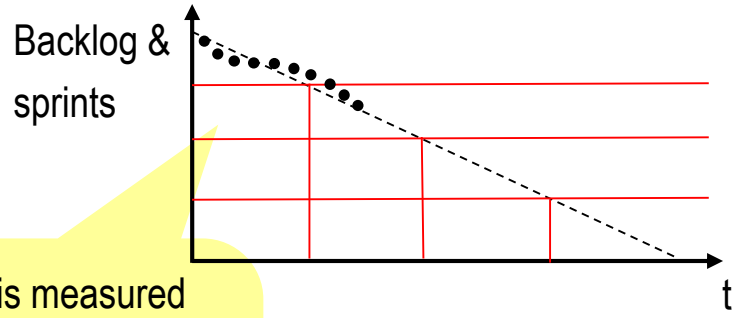
SCRUM can be used with physical products too, despite the "Constraints of Physicality" (Schmidt et al, 2017)

- To their "digital" parts
- When developing modular products
- Within each phase of a traditional, sequential process (Agile Stage-Gate, Cooper & Sommer, 2016)

- Basics of SCRUM



Backlog Refinement



Progress is measured visually via the backlog of tangible outcomes, not activities performed (e.g., bugs, FMEA issues, % of components designed)

Visual planning and control of activities via Kanban boards

Backlog section	To do	In progress	Done