Technological Innovation

Nofie Iman


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INSIDE THE FAMILY FEUD
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DYING WITHOUT A WILL
Forbes
NOVEMBER 12, 2007 | WWW.FORBES.COM
Nokia
ONE BILLION CUSTOMERS—
CAN ANYONE CATCH THE CELL PHONE KING?
PLUS
11 GADGETS WE LOVE
Olli-Pekka Kallasvuo
Chief Executive

1.Lack of Innovation: Nokia failed to keep up with the rapid pace of technological advancements in the smartphone era. While competitors like Apple's iPhone and devices running Google's Android operating system introduced revolutionary touchscreen interfaces, app ecosystems, and multimedia capabilities, Nokia struggled to innovate at the same pace.

2.Failure to Embrace Smartphones: Nokia was slow to recognize the growing importance of smartphones and the shift in consumer preferences towards these devices. Nokia continued to focus on its traditional strengths in feature phones and resisted transitioning to smartphones until it was too late. By the time Nokia introduced its Lumia series of smartphones running Microsoft's Windows Phone operating system, it had already lost significant ground to competitors like Apple and Samsung.

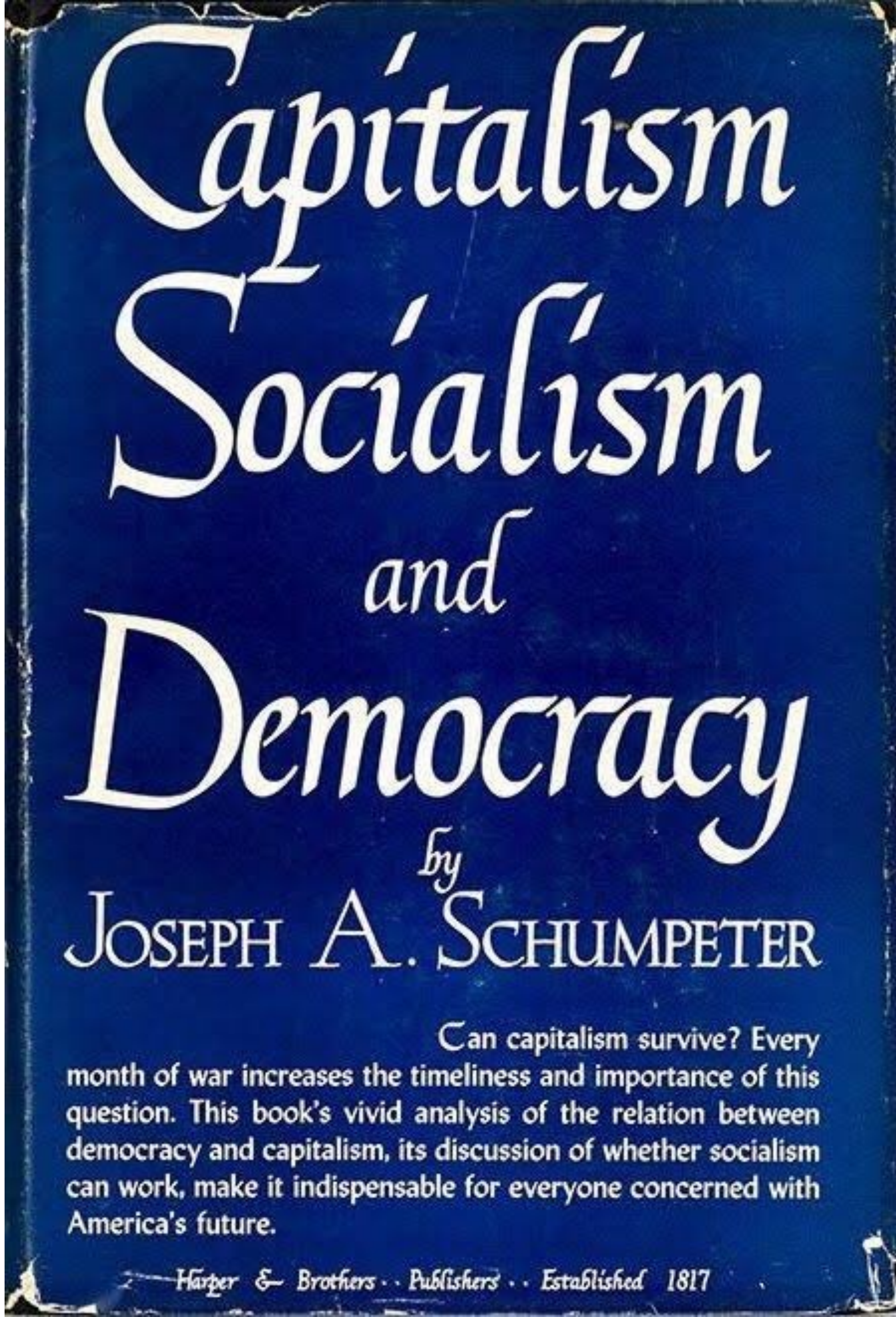
3.Strategic Missteps: Nokia made several strategic missteps that further exacerbated its decline. For instance, the decision to adopt Microsoft's Windows Phone as its primary smartphone platform instead of developing its own operating system or adopting Android limited its ability to differentiate its products and compete effectively in the market. Additionally, Nokia's acquisition of Siemens' stake in the Nokia Siemens Networks joint venture in 2013 and subsequent sale of its devices and services division to Microsoft in 2014 represented significant strategic shifts that failed to yield the desired results.

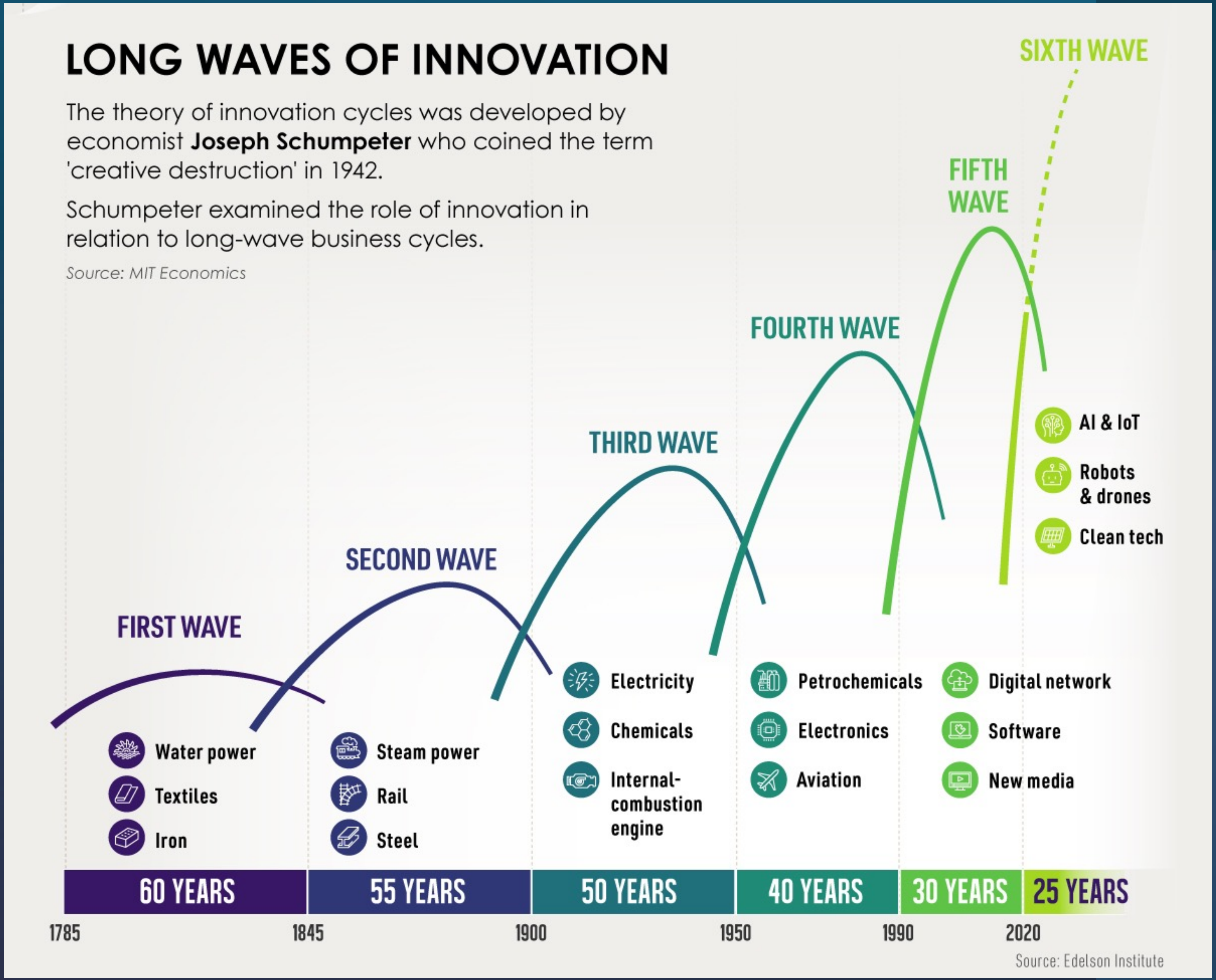
4.Competition and Market Dynamics: Nokia faced intense competition from rivals like Apple, Samsung, and Chinese smartphone manufacturers offering high-quality devices at competitive prices. Moreover, changes in consumer preferences, such as the growing demand for larger screens, better cameras, and longer battery life, posed additional challenges for Nokia in meeting evolving market expectations.

5.Organizational Challenges: Nokia's organizational structure and culture also hindered its ability to adapt to changing market conditions and execute effective strategies. The company faced internal challenges related to bureaucracy, decision-making processes, and cultural resistance to change, which impeded innovation and agility. Additionally, leadership changes and restructuring efforts failed to address underlying issues within the organization, further contributing to Nokia's decline.

Innovation as Creative Destruction

- "Innovation would **destroy** existing technologies and methods of production by newer and more efficient products."
- Digital economy's discontinuity, uncertainty
  - Telephone line » optical networks » wireless » the Internet protocol platforms
  - Mergers, acquisitions, investment and disinvestment worldwide
  - Social and political restructuring




LONG WAVES OF INNOVATION
The theory of innovation cycles was developed by economist **Joseph Schumpeter** who coined the term 'creative destruction' in 1942.
Schumpeter examined the role of innovation in relation to long-wave business cycles.
Source: MIT Economics
FIRST WAVE
Water power
Textiles
Iron
SECOND WAVE
Steam power
Rail
Steel
THIRD WAVE
Electricity
Chemicals
Internal-combustion engine
FOURTH WAVE
Petrochemicals
Electronics
Aviation
FIFTH WAVE
Digital network
Software
New media
SIXTH WAVE
AI & IoT
Robots & drones
Clean tech
60 YEARS
55 YEARS
50 YEARS
40 YEARS
30 YEARS
25 YEARS
1785
1845
1900
1950
1990
2020
Source: Edelson Institute

KEY BREAKTHROUGHS

FIRST WAVE

During the Industrial Revolution, the first factory emerged–a cotton mill in Britain.

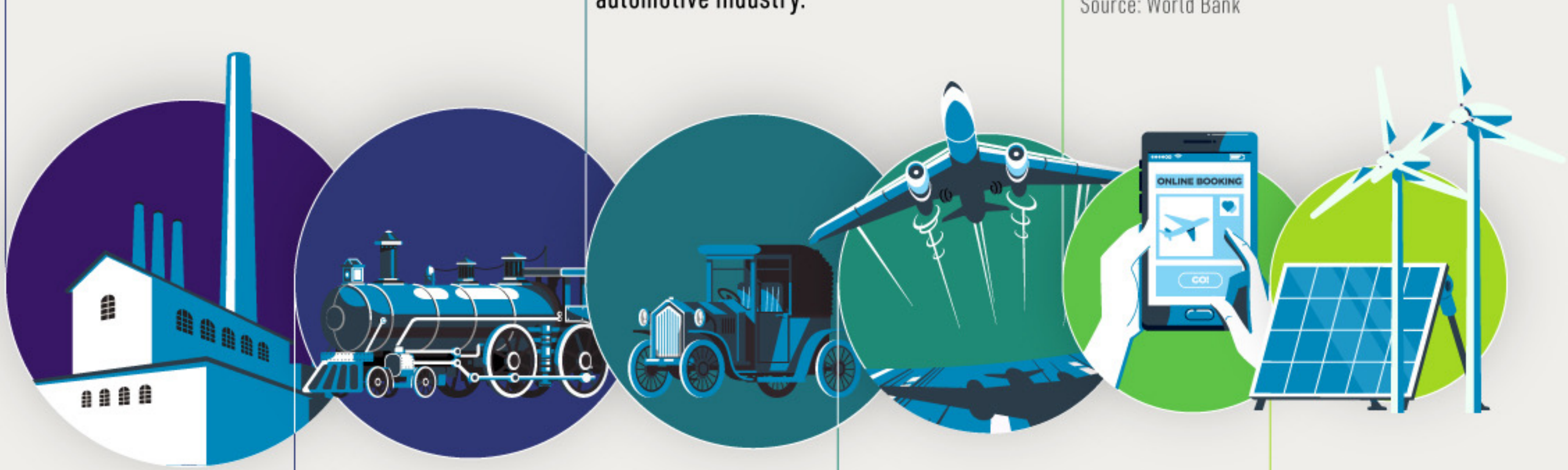
THIRD WAVE

Henry Ford's Model T introduced the assembly line, revolutionizing the automotive industry.

FIFTH WAVE

In 1990, **2.3M** used the internet–by 2016 this reached **3.4B**.

Source: World Bank



SECOND WAVE

As railways proliferated, their networks strongly influenced urban growth.

Source: Nacima Baron, HAL

FOURTH WAVE

Aviation gains mass adoption on a global scale, providing a lever to economic integration.

Source: OECD

SIXTH WAVE

As climate challenges intensify, clean tech may reshape business models and consumption patterns.


TAKSI


GO CAR
TAKSI


Jl. Kemang Dalam 1
Rumah hijau pagar hitam
GO-CAR
GO CAR
LAYANAN TRANSPORTASI DARI GO-JEK
KINI SEMAKIN LENGKAP DENGAN GO-CAR*

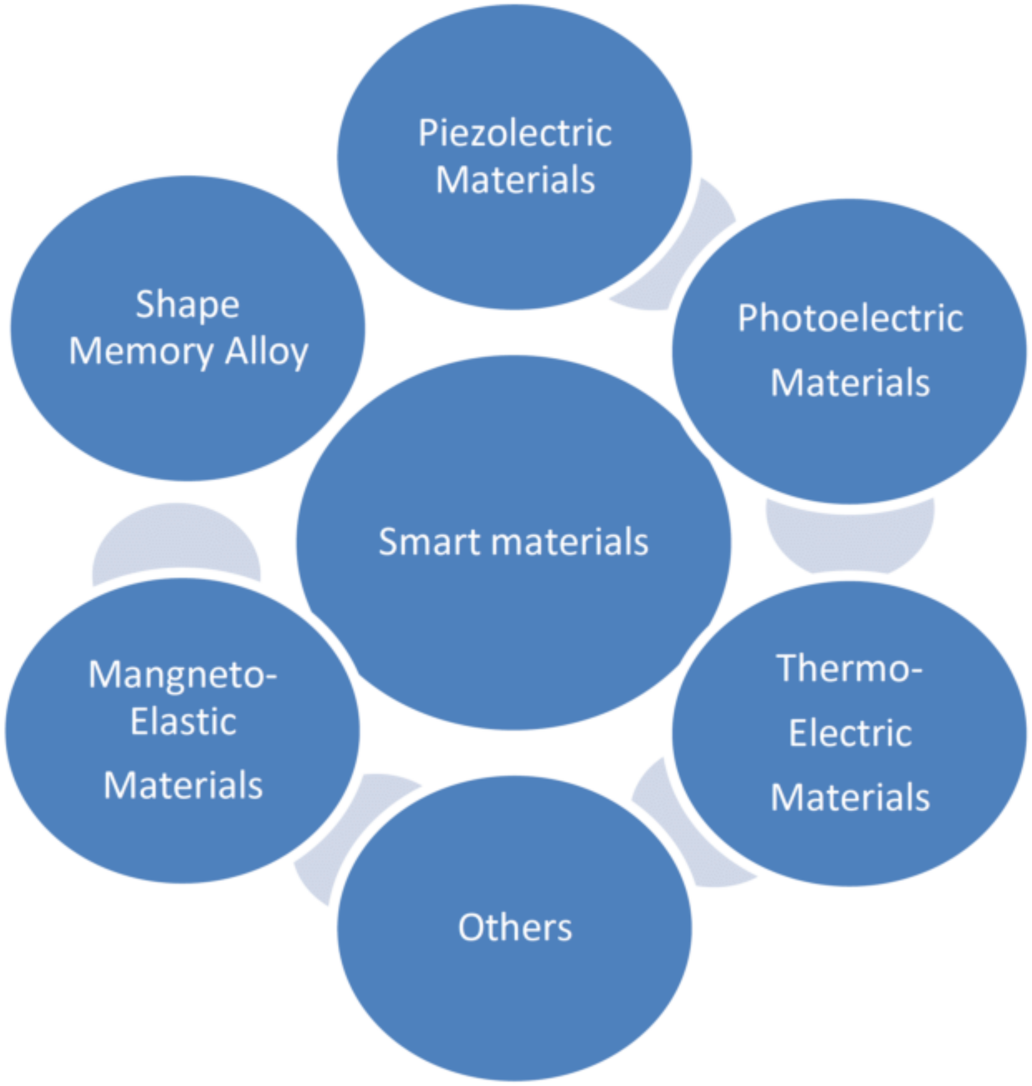

TikTok
TIKTOK SHOP BUKA LAGI, GANDENG
TOKOPEDIA SEBAGAI PARTNER

Production Revolution

- New production systems—3D printers and robotics are the *beginning* of new production systems:
  - – Speed and cost of production, including quality control, drop substantially as every manufactured products will be networked with sensors
  - – Information technology enables production breakthrough
- Smart materials are next step
  - Replacing plastics with metal oxides in 3D printers
  - Sensors embedded in materials

Smart Materials

- Sensing materials and devices
- Actuation materials and devices
- Control devices and techniques
- Self-detection, self-diagnostic
- Self-corrective, self-controlled, self-healing
- Shock-absorbers, damage arrest



Even Large-Scale Production Will Change

- Large scale production still requires complex engineering and high levels of quality assurance and reliability
- But even this is changing quickly

Tesla Auto Factory

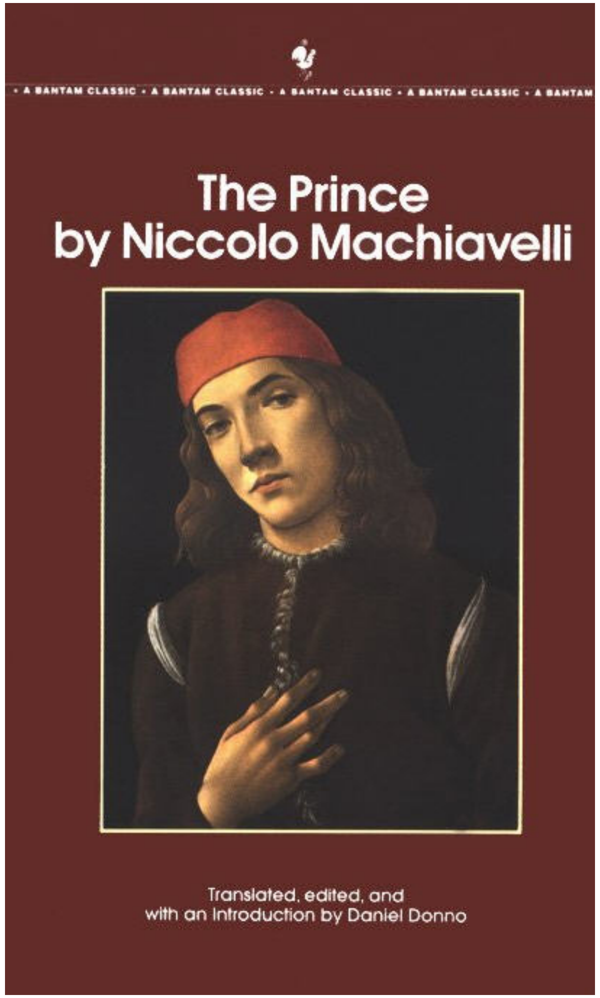
Robotics, new tech, materials, new business model reduced time from first design to product from the traditional 5 years to 2 years

Innovation Management

"Innovation management is a process which requires an understanding of both market and technical problems, with a goal of successfully implementing appropriate creative ideas.

A new or improved product, service or process is its typical output.

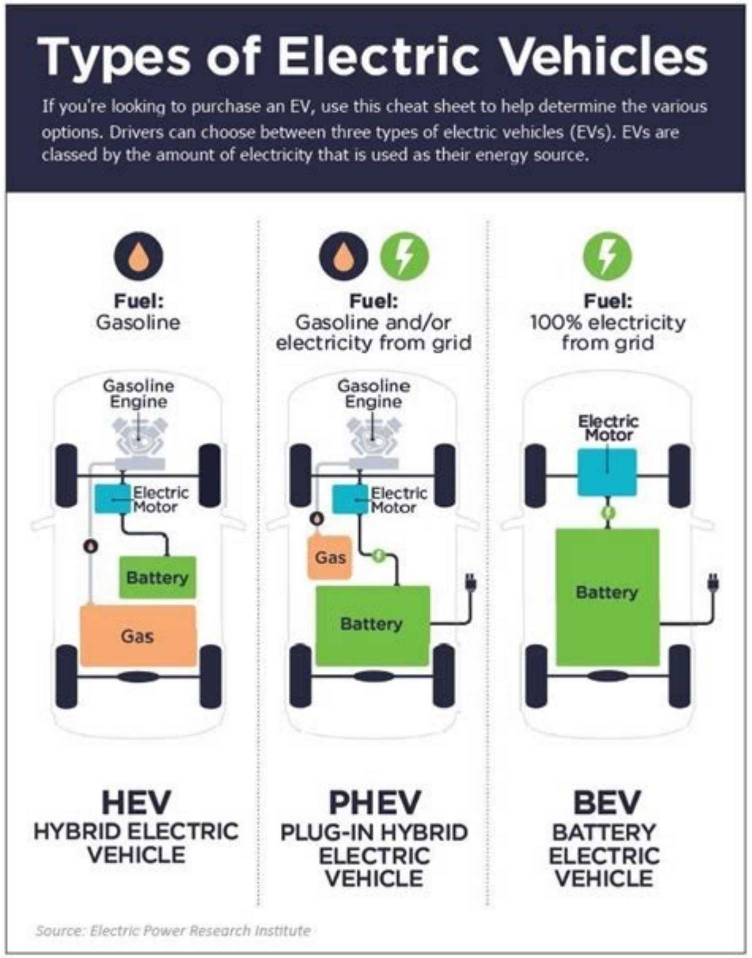
It also allows a consortium to respond to an external or internal opportunity."



"Whoever desires constant success must change his conduct with the times."

Honda and Hybrid Electric Vehicles

- Honda introduced its first hybrid electric vehicle (HEV) in Japan **in 1997**.
  - HEVs have increased fuel efficiency and decreased emissions
  - HEVs do not have to be plugged into an electrical outlet
- Honda chose a **different** hybrid engine design than Toyota and chose **not to collaborate** or **license** its technology to others.
- Toyota, which engaged in both collaboration and licensing, **sold far more** HEVs.
- Honda was also developing cars based on fuel cells, clean diesel, and natural gas.



Overview of Innovations

- Several dimensions are used to categorize innovations.
  - These dimensions help clarify how different innovations offer different opportunities (and pose different demands) on producers, users, and regulators.
- The path a technology follows through time is termed its **technology trajectory**.
  - Many consistent patterns have been observed in technology trajectories, helping us understand how technologies improve and are diffused.

Types of Innovation

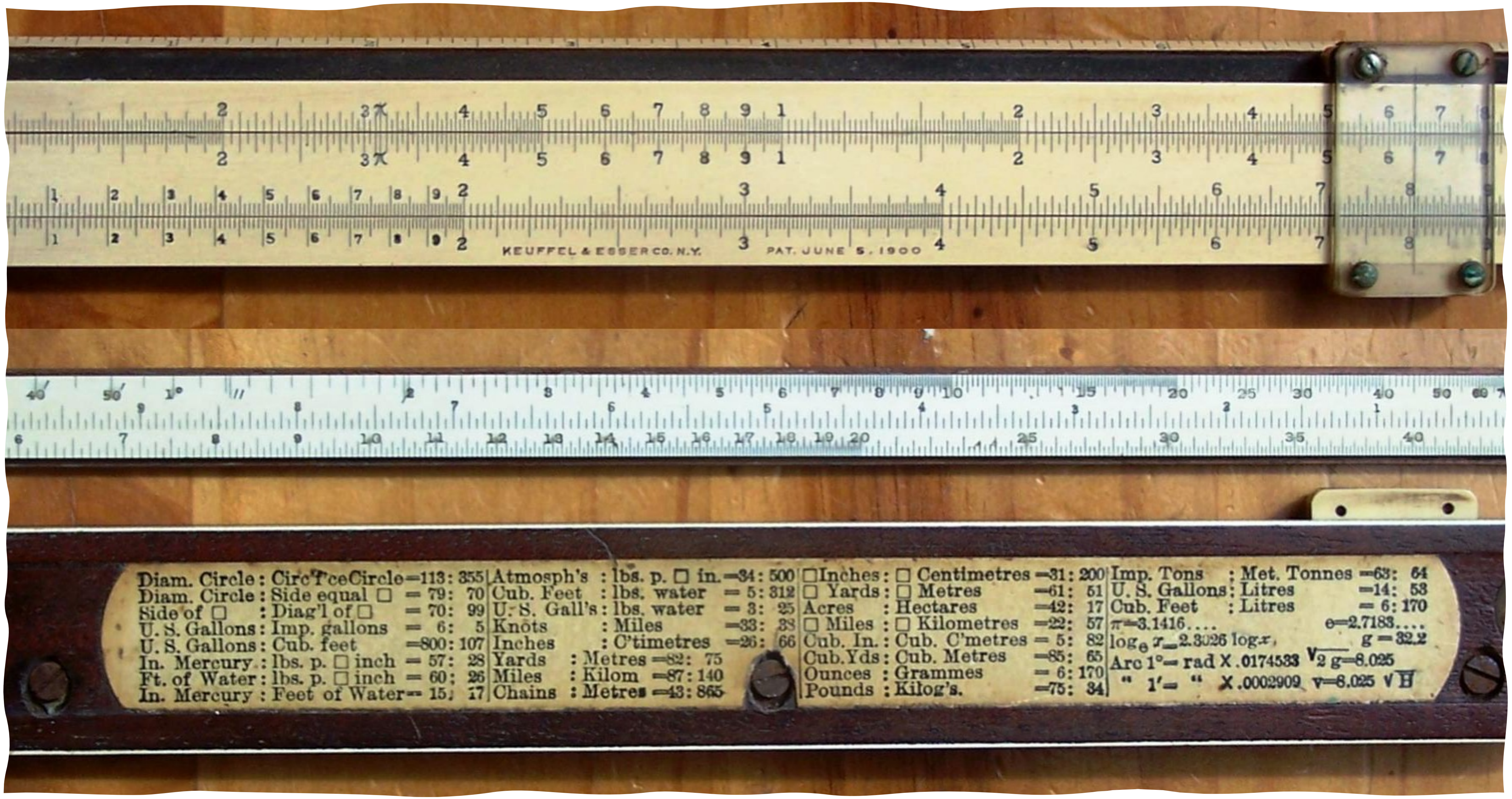
- Product versus Process Innovation
  - **Product innovations** are embodied in the **outputs** of an organization – its goods or services.
  - **Process innovations** are innovations in the way an organization conducts its business, such as in techniques of producing or marketing goods or services.
  - Product innovations can **enable** process innovations and vice versa.
  - What is a product innovation for one organization **might be** a process innovation **for another**
    - E.g., UPS creates a new distribution service (product innovation) that enables its customers to distribute their goods more widely or more easily (process innovation)

Types of Innovation

- Radical versus Incremental Innovation
  - The **radicalness** of an innovation is **the degree to which it is new and different** from previously existing products and processes.
  - Incremental innovations may involve only a **minor** change from (or adjustment to) existing practices.
  - The radicalness of an innovation is **relative**; it may **change** over time or with respect to different observers.
    - E.g., digital photography are more radical innovation for Kodak than for Sony.

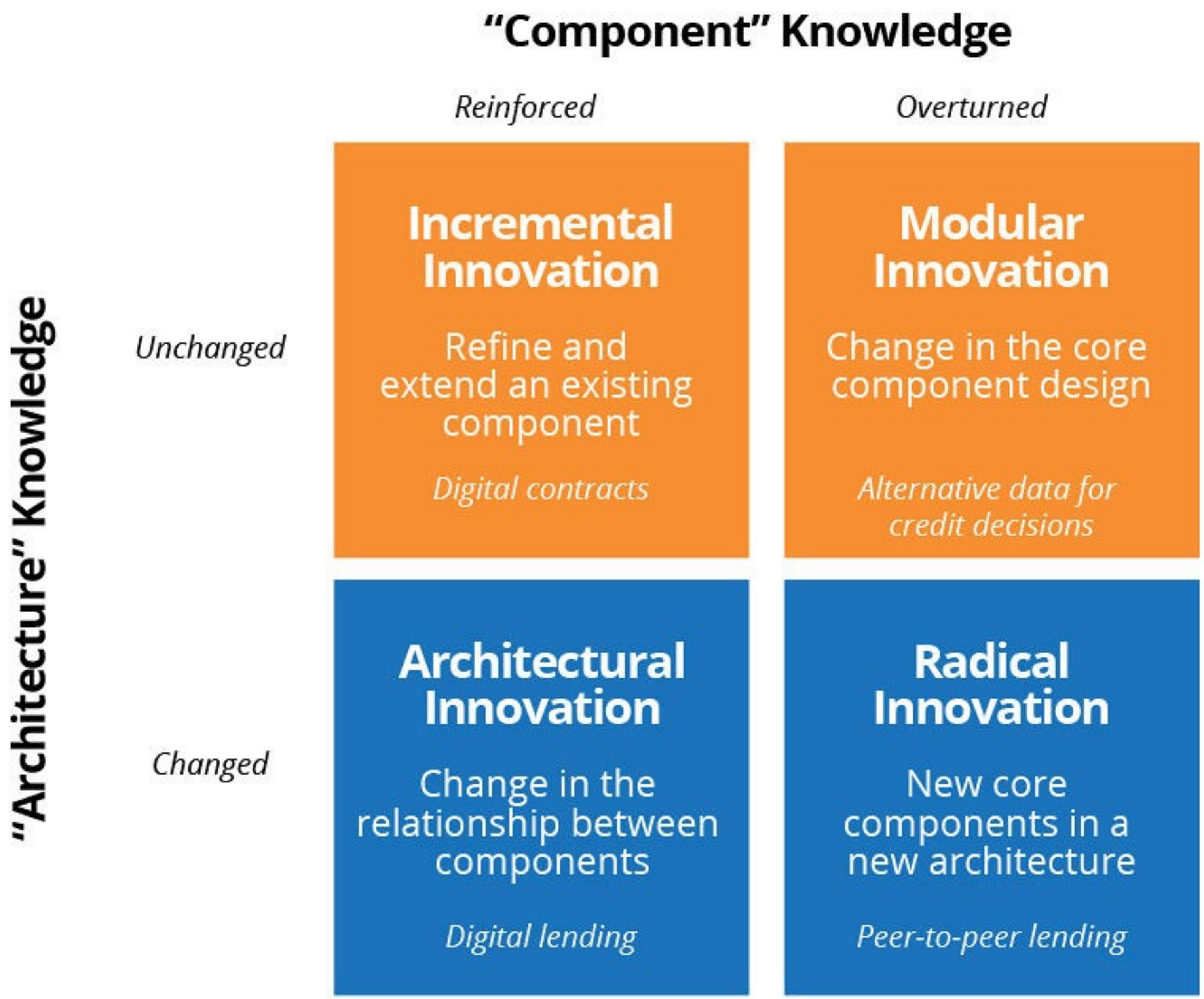
Types of Innovation

- Competence-Enhancing versus Competence-Destroying Innovation
  - Competence-enhancing innovations build on the firm's **existing** knowledge base
    - E.g., Intel's Pentium 4 built on the technology for Pentium III.
  - Competence-destroying innovations renders a firm's existing competencies **obsolete**.
    - E.g., electronic calculators rendered Keuffel & Esser's slide rule expertise obsolete.
  - Whether an innovation is competence enhancing or competence destroying depends on the **perspective** of a particular firm.


KEUFFEL & ESSER CO. N.Y.
PAT. JUNE 5, 1900
Diam. Circle : Circ'f'ce Circle =113: 355
Diam. Circle : Side equal □ = 79: 70
Side of □ : Diag'l of □ = 70: 99
U. S. Gallons : Imp. gallons = 6: 5
U. S. Gallons : Cub. feet =800: 107
In. Mercury : lbs. p. □ inch = 57: 28
Ft. of Water : lbs. p. □ inch = 60: 26
In. Mercury : Feet of Water = 15: 17
Atmosph's : lbs. p. □ in. =34: 500
Cub. Feet : lbs. water = 5: 312
U. S. Gall's : lbs. water = 3: 25
Knots : Miles =33: 38
Inches : C'timetres =26: 66
Yards : Metres =82: 75
Miles : Kilom =87: 140
Chains : Metres =43: 865
□ Inches : □ Centimetres =31: 200
□ Yards : □ Metres =61: 51
Acres : Hectares =42: 17
□ Miles : □ Kilometres =22: 57
Cub. In. : Cub. C'metres = 5: 82
Cub. Yds : Cub. Metres =85: 65
Ounces : Grammes = 6: 170
Pounds : Kilog's. =75: 34
Imp. Tons : Met. Tonnes =63: 64
U. S. Gallons : Litres =14: 53
Cub. Feet : Litres = 6: 170
π=3.1416.... e=2.7183....
log_e x = 2.3026 log x, g = 32.2
Arc 1° = rad X .0174533 √2g = 8.025
" 1' = " X .0002909 v = 8.025 √H

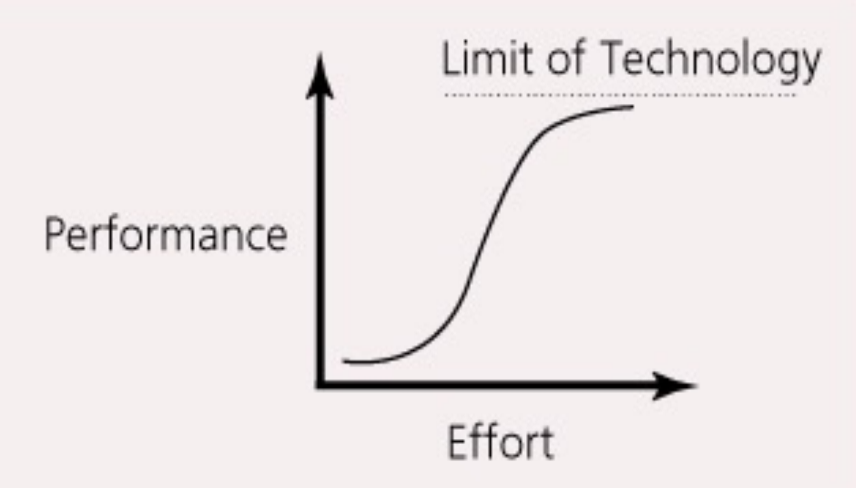
Types of Innovation

- Architectural versus Component Innovation
  - A **component innovation** (or modular innovation) entails changes to one or more components of a product system without significantly affecting the overall design.
    - E.g., adding gel-filled material to a bicycle seat
  - An **architectural innovation** entails changing the overall design of the system, or the way components interact.
    - E.g., transition from high-wheel bicycle to safety bicycle.
  - Most architectural innovations require changes in the **underlying components** also.


"Component" Knowledge
Reinforced
Overturned
"Architecture" Knowledge
Unchanged
Changed
Incremental Innovation
Refine and extend an existing component
Digital contracts
Modular Innovation
Change in the core component design
Alternative data for credit decisions
Architectural Innovation
Change in the relationship between components
Digital lending
Radical Innovation
New core components in a new architecture
Peer-to-peer lending

Technology S-Curves

- Both the rate of a technology's improvement, and its rate of diffusion to the market typically follow an s-shaped curve.
- S-curves in Technological Improvement



Technology improves slowly at first because it is **poorly understood**.

Then **accelerates** as understanding increases.

Then **tapers off** as approaches limits.

Technology S-Curves

- Technologies do not always get to reach their limits
  - May be displaced by new, **discontinuous technology**.
    - A discontinuous technology fulfils a similar market need by means of an entirely new knowledge base.
      - E.g., switch from carbon copying to photocopying, or vinyl records to compact discs
    - Technological discontinuity may initially have lower performance than incumbent technology.
      - E.g., first automobiles were much slower than horse-drawn carriages.
  - Firms may be reluctant to adopt new technology because performance improvement is initially slow and costly, and they may have significant investment in incumbent technology

Technology S-Curves

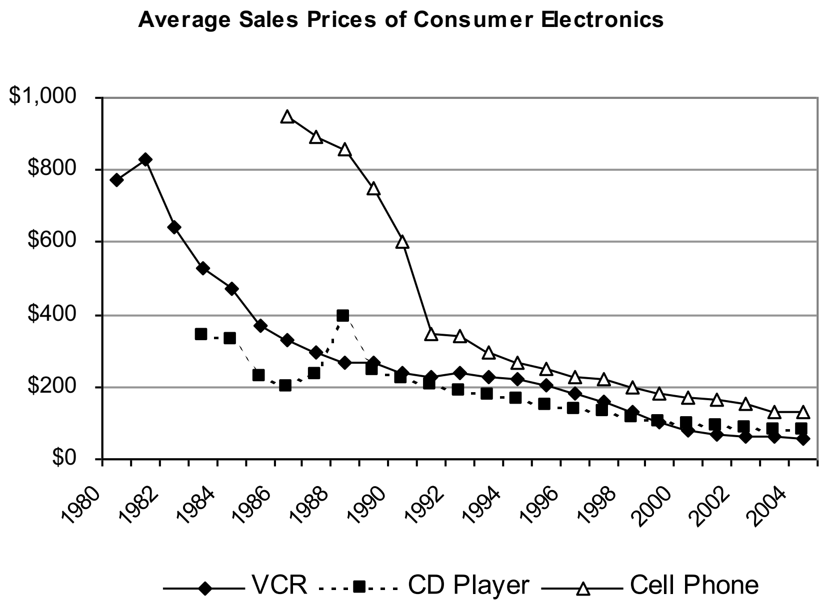
- S-Curves in Technology Diffusion
  - Adoption is initially **slow** because the technology is unfamiliar.
  - It **accelerates** as technology becomes better understood.
  - Eventually market is **saturated** and rate of new adoptions **declines**.
  - Technology diffusion tends to take **far longer** than information diffusion.
    - Technology may require acquiring **complex knowledge** or **experience**.
    - Technology may require **complementary resources** to make it valuable (e.g., cameras not valuable without film).

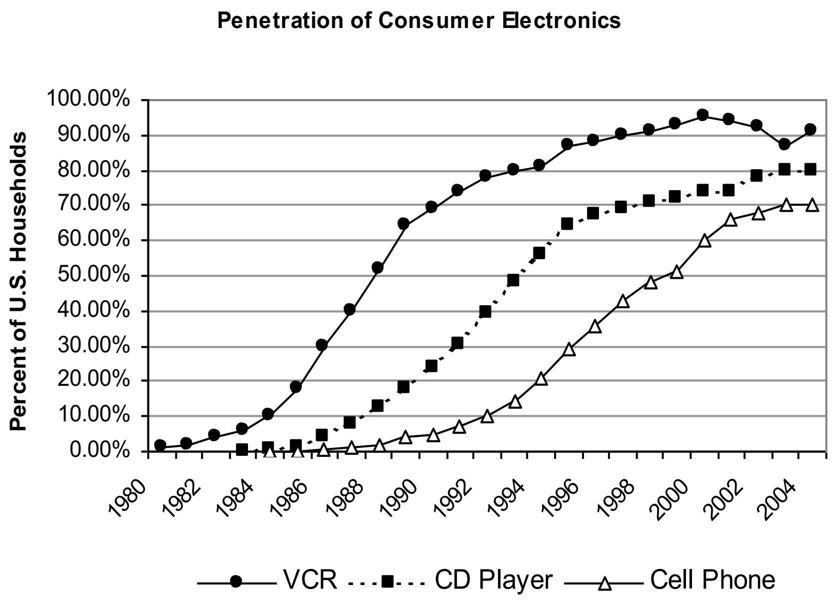
Technology S-Curves

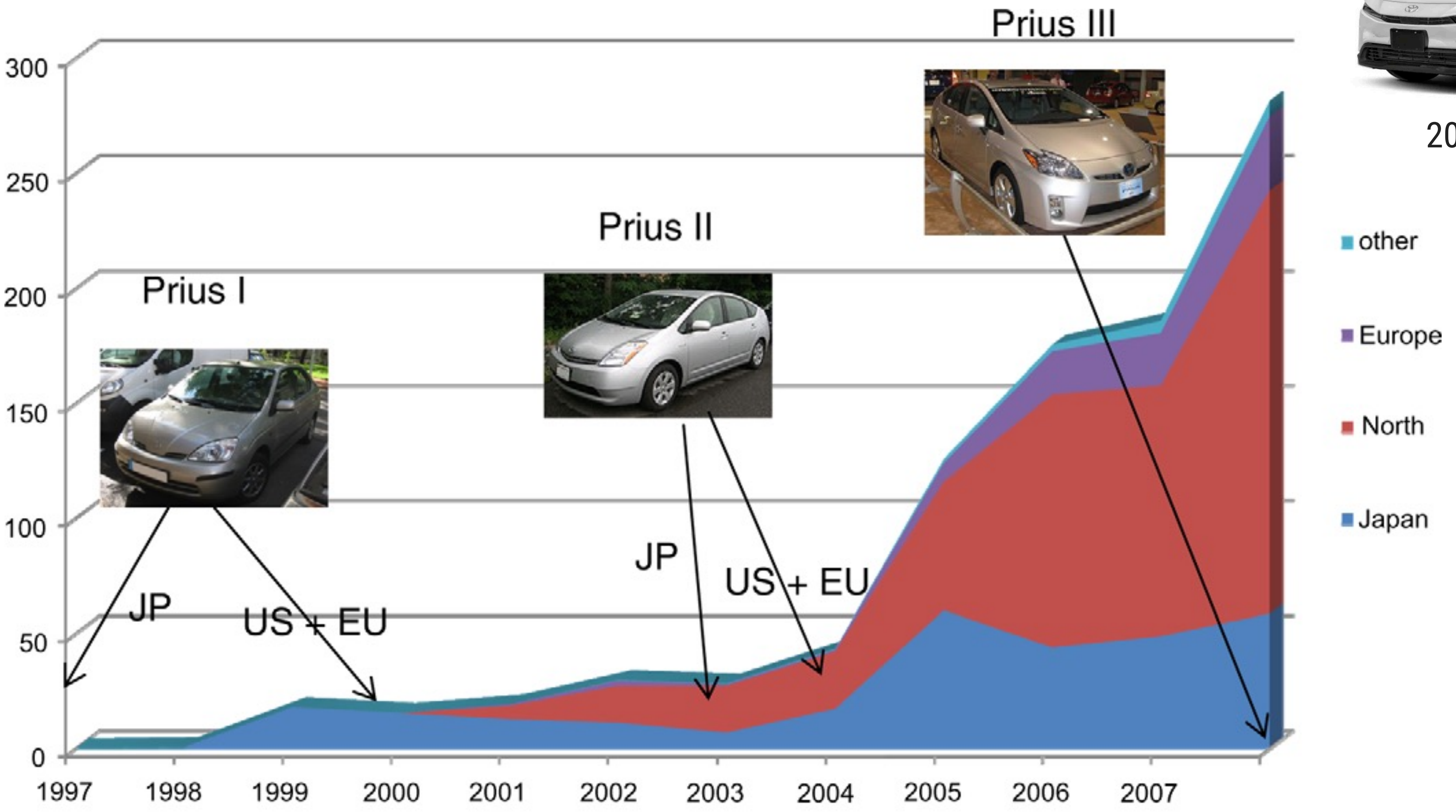
- S-Curves as a Prescriptive Tool
  - Managers can use data on investment and performance of their own technologies or data on overall industry investment and technology performance to map s-curve.
  - While mapping the technology’s s-curve is useful for gaining a deeper understanding of its rate of improvement or limits, its use as a prescriptive tool is **limited**.
    - True limits of technology may be **unknown**
    - Shape of s-curve can be **influenced** by changes in the market, component technologies, or complementary technologies.
    - Firms that follow s-curve model **too closely** could end up switching technologies too soon or too late.

Technology S-Curves

- **S-curves of diffusion** are in part a function of **s-curves in technology improvement**
  - Learning curve leads to **price drops**, which **accelerate diffusion**



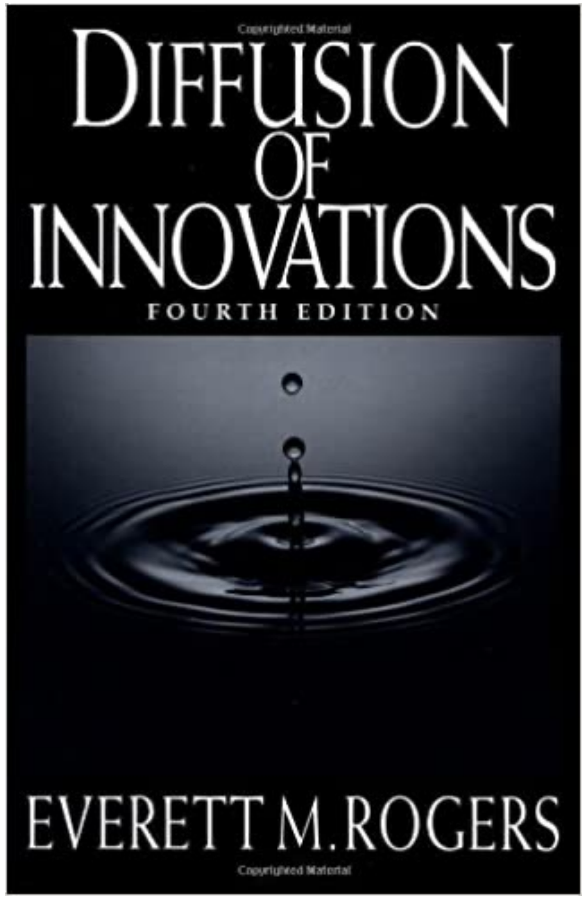


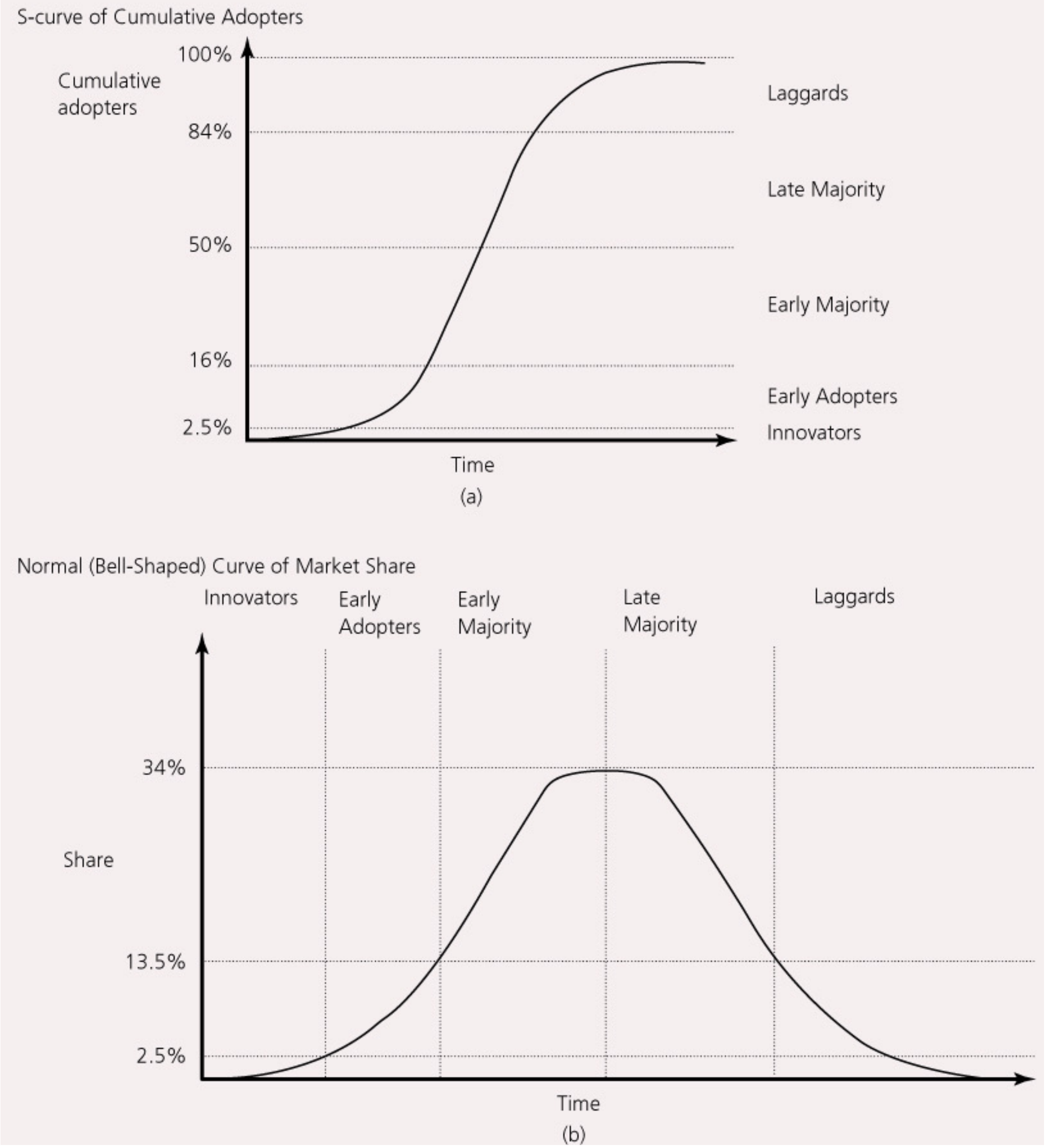


2024 Toyota Prius

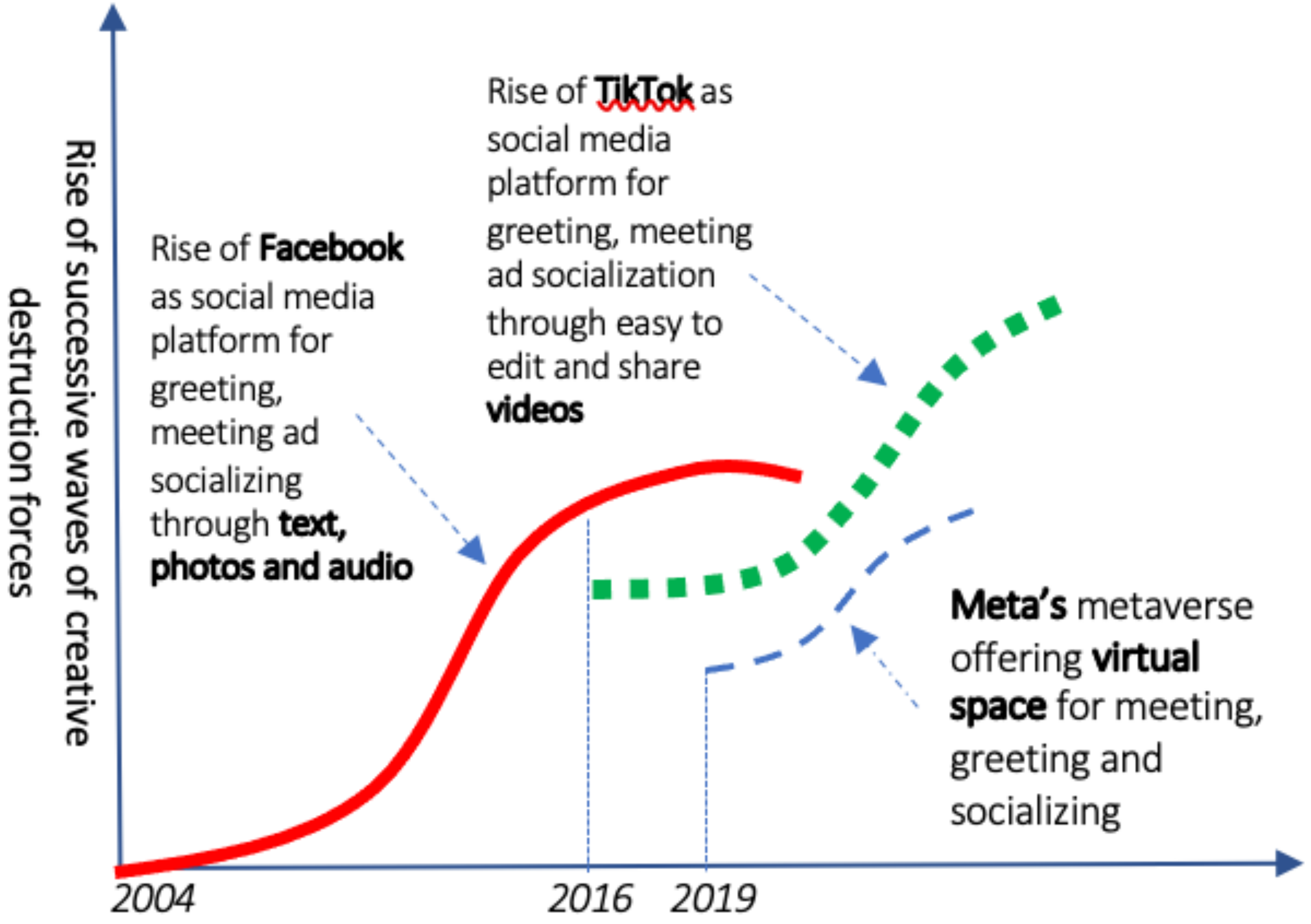
Typology of Adopters

- **Innovators** are the first **2.5%** of individuals to adopt an innovation. They are adventurous, comfortable with a high degree of complexity and uncertainty, and typically have access to substantial financial resources.
- **Early Adopters** are the next **13.5%** to adopt the innovation. They are well integrated into their social system and have great potential for opinion leadership. Other potential adopters look to early adopters for information and advice, thus early adopters make excellent "missionaries" for new products or processes.
- **Early Majority** are the next **34%**. They adopt innovations slightly before the average member of a social system. They are typically not opinion leaders, but they interact frequently with their peers.
- **Late Majority** are the next **34%**. They approach innovation with a sceptical air and may not adopt the innovation until they feel pressure from their peers. They may have scarce resources.
- **Laggards** are the last **16%**. They base their decisions primarily on past experience and possess almost no opinion leadership. They are highly sceptical of innovations and innovators and must feel certain that a new innovation will not fail prior to adopting it.



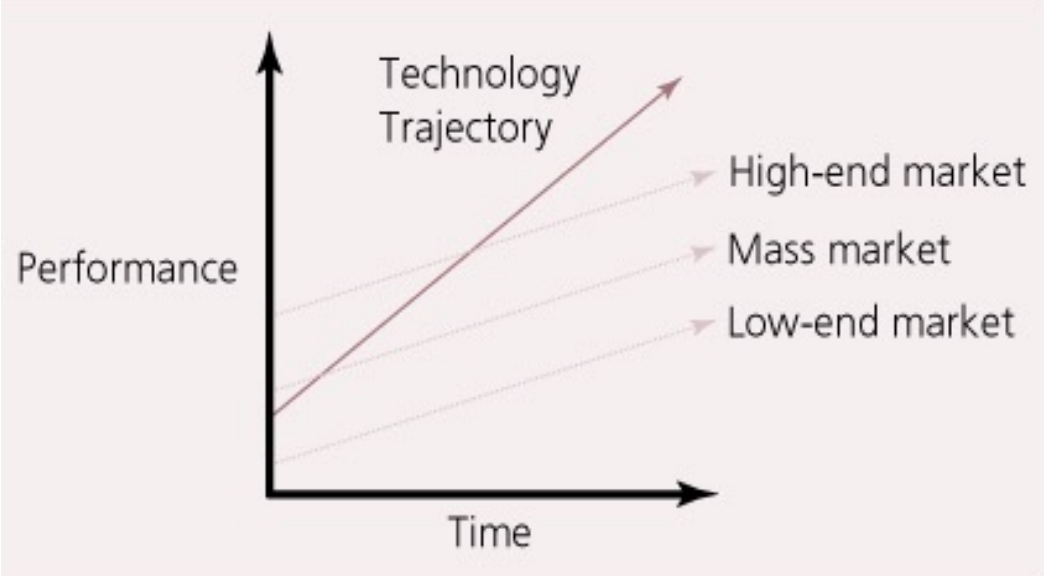


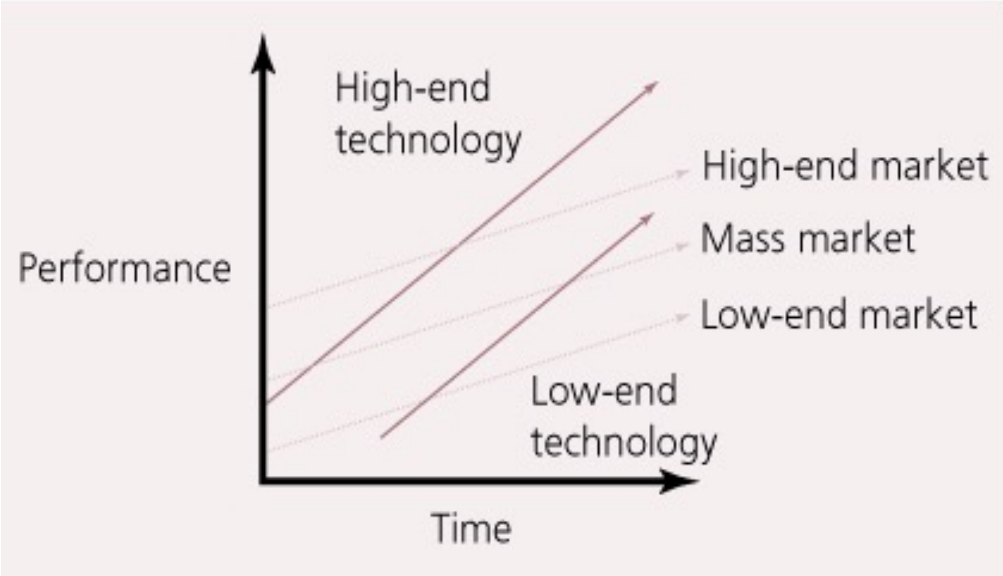
Diffusion of Innovations


Rise of successive waves of creative destruction forces
Rise of **Facebook** as social media platform for greeting, meeting ad socializing through **text, photos and audio**
Rise of **TikTok** as social media platform for greeting, meeting ad socialization through easy to edit and share **videos**
Meta's metaverse offering **virtual space** for meeting, greeting and socializing
2004
2016
2019

Disruptive Innovation

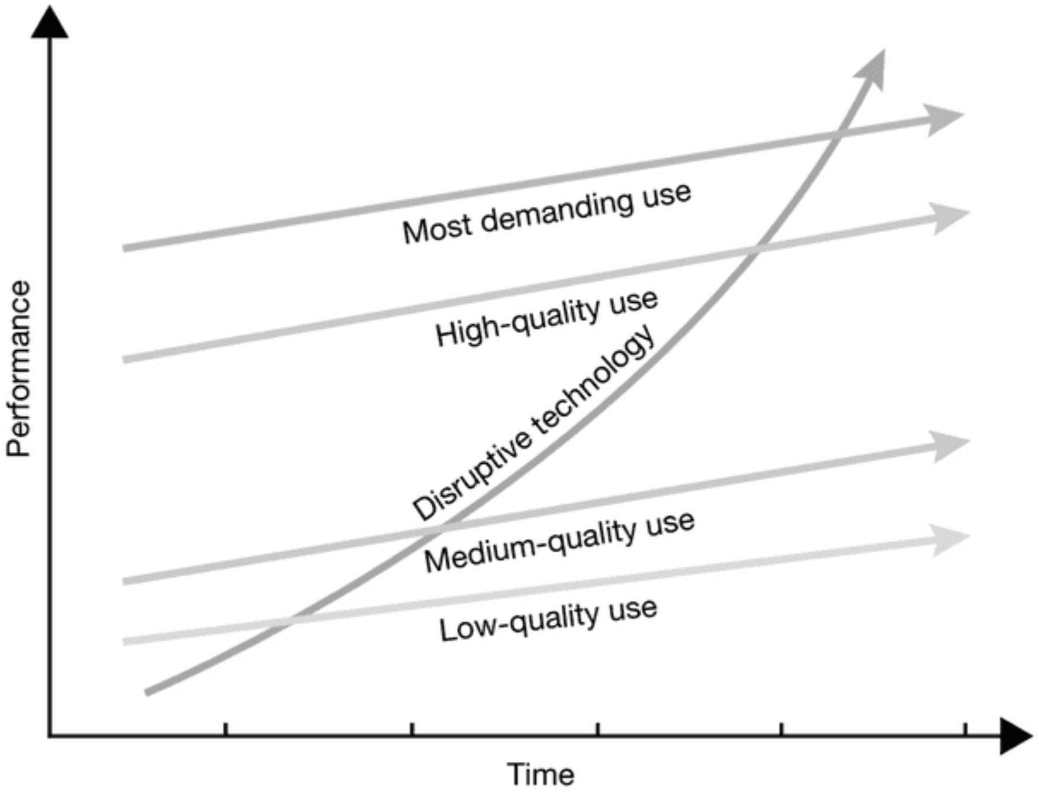
- Technologies often improve **faster** than customer requirements demand
- This enables **low-end** technologies to eventually meet the needs of the mass market.



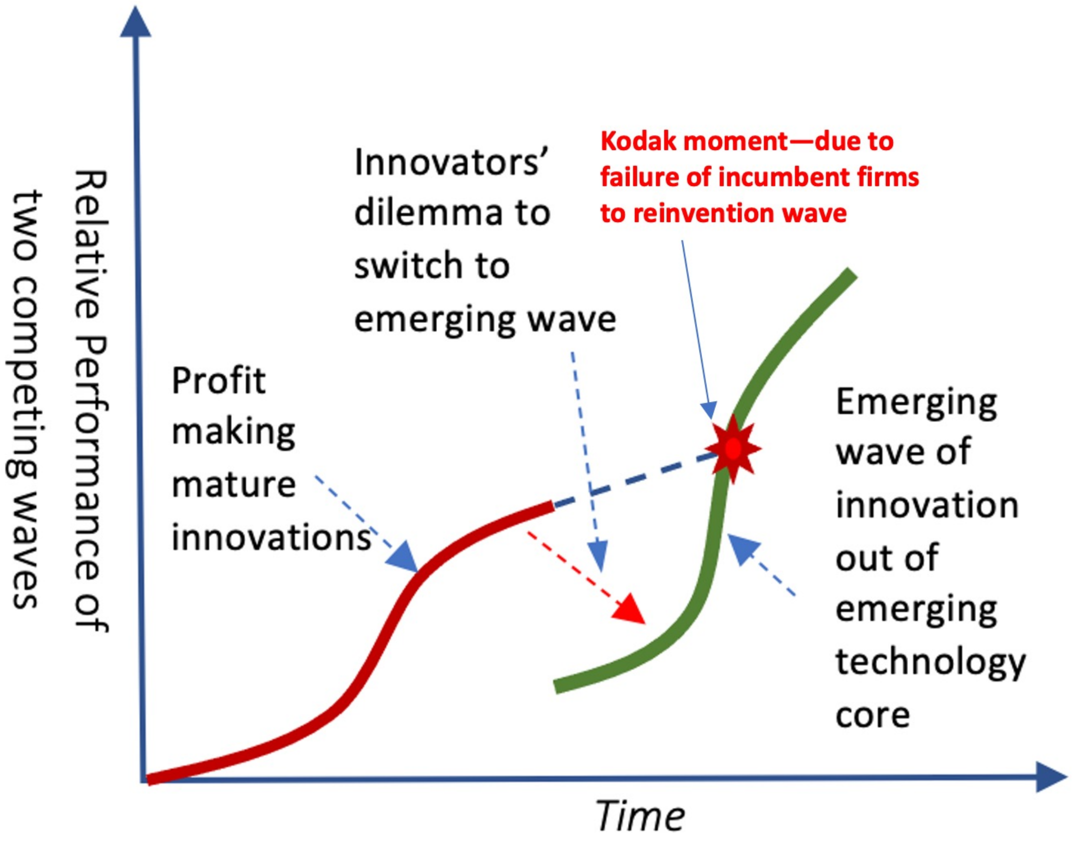


Disruptive Innovation

- From 1980 to 2011, Microsoft was the dominant personal computer operating system. However, operating systems for smartphones and tablets were improving to the point where they could replace many personal computer functions.
- In 2011, Apple’s iPhone operating system and Google’s Android collectively controlled about 60% of the market for smartphone purchases. Microsoft’s Windows Phone held a share of only 11%.
- As tablets based on these systems became fully functional computers, would Microsoft’s dominance evaporate?



Performance
Most demanding use
High-quality use
Disruptive technology
Medium-quality use
Low-quality use
Time



Relative Performance of two competing waves
Kodak moment—due to failure of incumbent firms to reinvention wave
Innovators' dilemma to switch to emerging wave
Profit making mature innovations
Emerging wave of innovation out of emerging technology core
Time

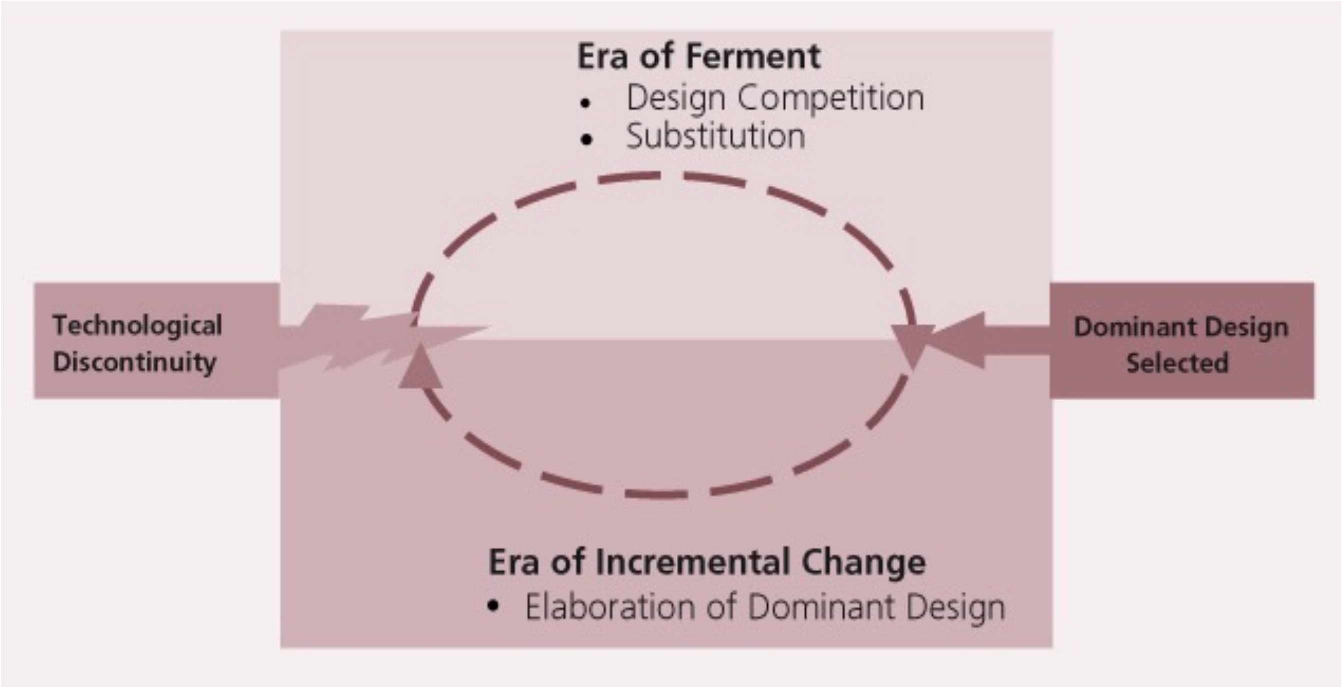

Google
14:07
THU 23 AUG

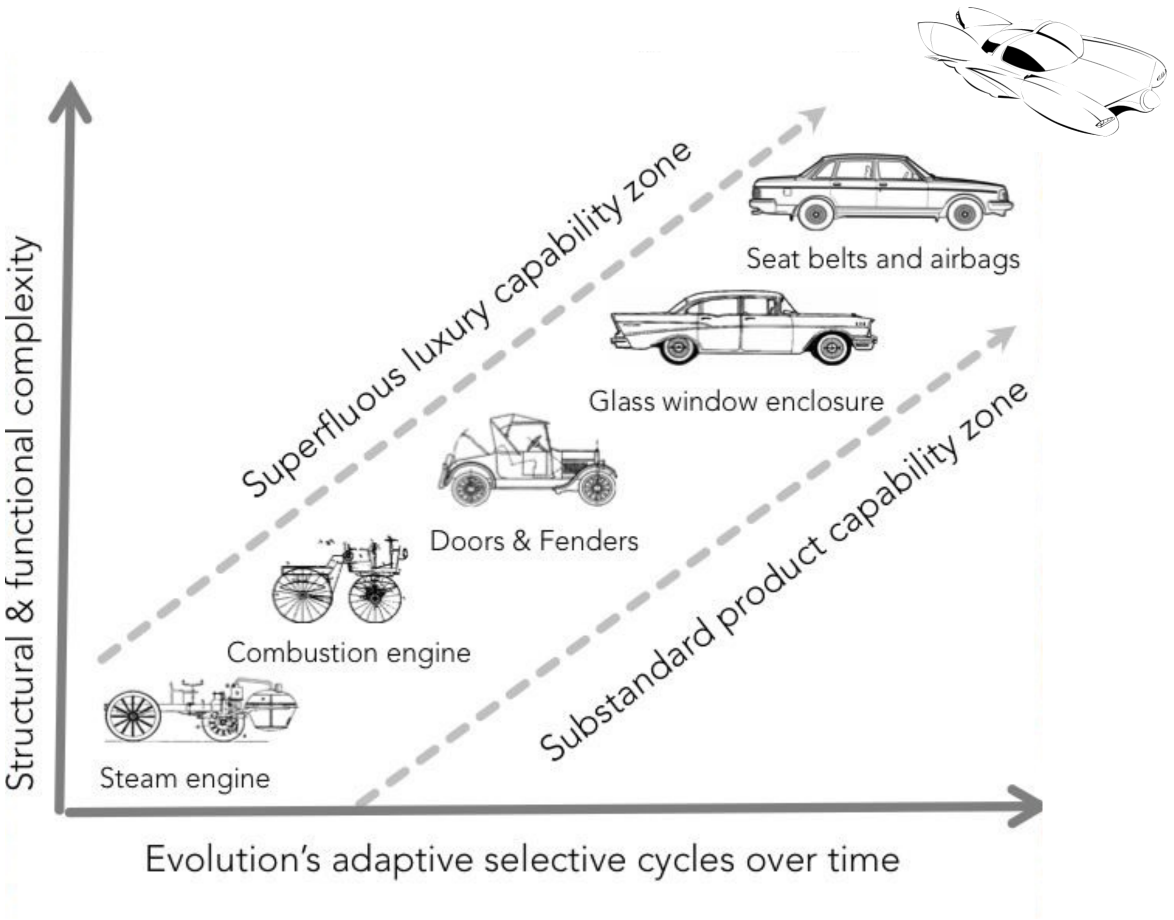
Technology Cycles

- Technological change tends to be cyclical:
  - Each new s-curve ushers in an initial period of turbulence, followed by rapid improvement, then diminishing returns, and ultimately is displaced by a new technological discontinuity.
  - Utterback and Abernathy characterized the technology cycle into two phases:
    - The **fluid phase** (when there is considerable uncertainty about the technology and its market; firms experiment with different product designs in this phase)
    - After a **dominant design** emerges, the **specific phase** begins (when firms focus on incremental improvements to the design and manufacturing efficiency).

Technology Cycles

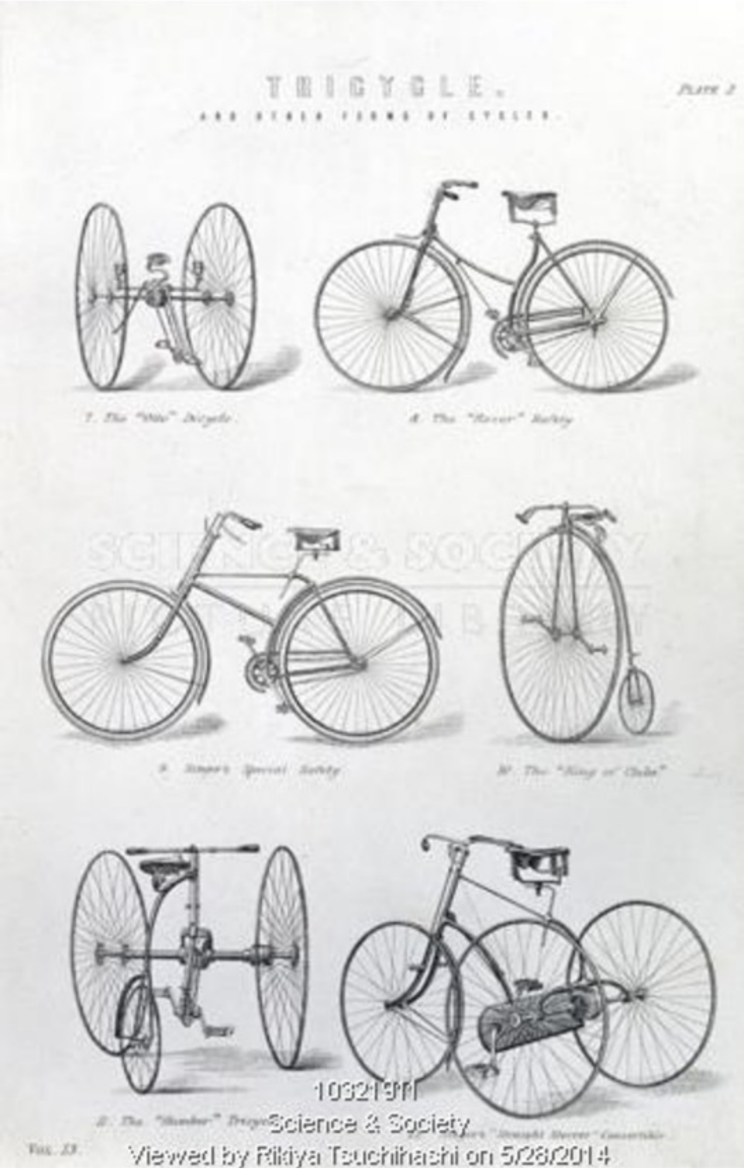
- Anderson and Tushman (1986) also found that technological change proceeded **cyclically**.
    - Each discontinuity inaugurates a period of turbulence and uncertainty (era of ferment) until a dominant design is selected, ushering in an era of incremental change.




Structural & functional complexity
Superfluous luxury capability zone
Substandard product capability zone
Seat belts and airbags
Glass window enclosure
Doors & Fenders
Combustion engine
Steam engine
Evolution's adaptive selective cycles over time


Cadillac
1948
1950
1953
1954
1956
1957
1958
1965
1959
1960
1961
1962
1963
1964


TRICYCLE.
3. The "Dandy-Horse."
6. The "Bone-shaker."
10420614
Science & Society
Viewed by Rikiya Tsuchihashi on 5/28/2014


TRICYCLE.
8. The "Rover" Safety
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Science & Society
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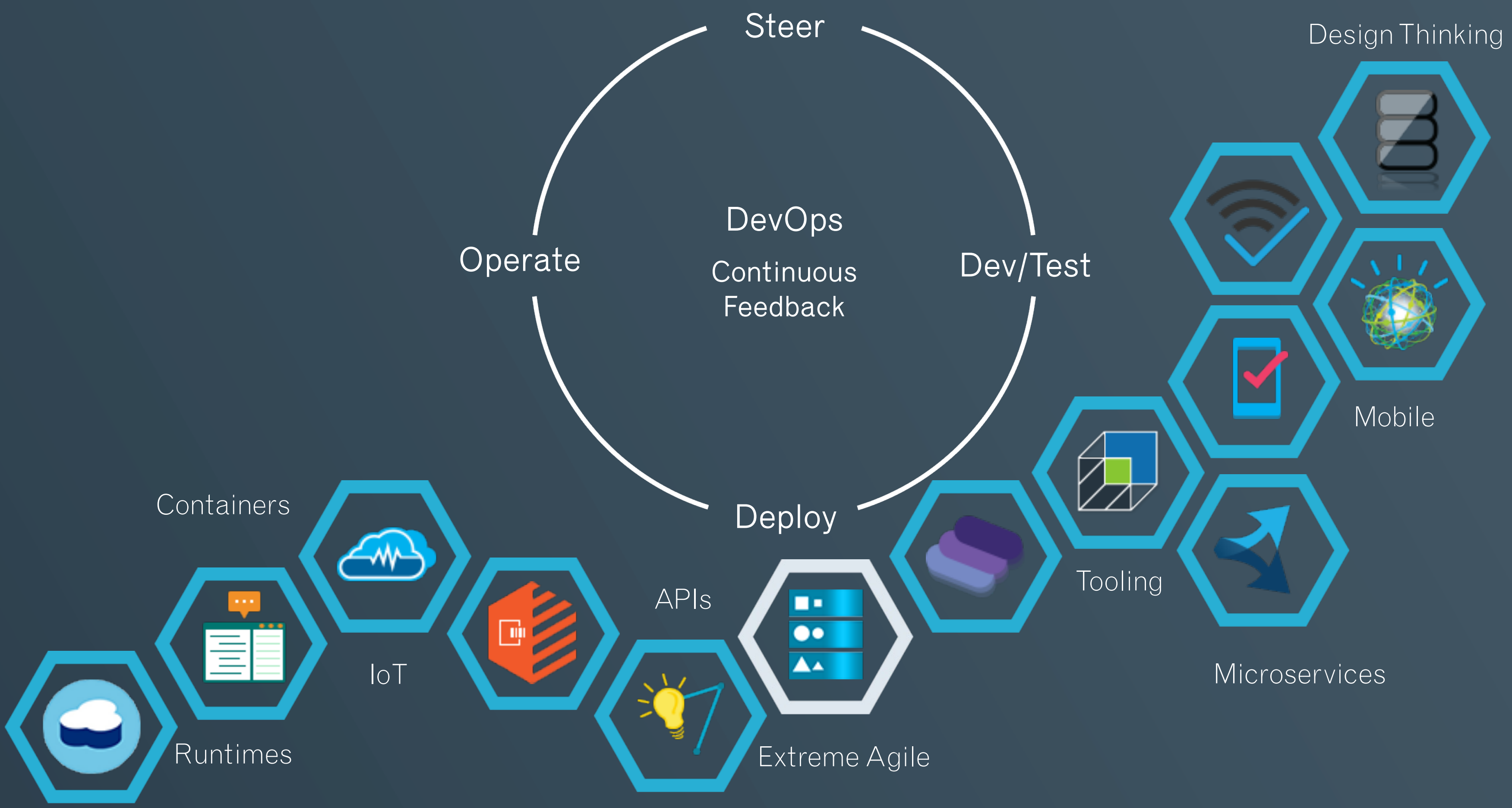
Dominant design in app development?



Cloud provides developers with instant access to the APIs, services and infrastructure they need to launch their ideas into the present.

Technology Cycles

- Anderson and Tushman (1986) found that:
  - A dominant design always **rose to command** the majority of market share unless the next discontinuity arrived too early.
  - The dominant design was **never in the same form** as the original discontinuity but was **also not on the leading edge** of technology. It bundled the features that would meet the needs of the majority of the market.
- During the era of incremental change, firms often cease to invest in learning about alternative designs and instead focus on developing competencies related to the dominant design.
- This explains in part why incumbent firms may have difficulty recognizing and reacting to a discontinuous technology.

Speeding Up Innovation

- **Shrinking overhead costs** and head counts reduces start-up costs
  - Radical drop in cost of IT: WhatsApp has 450 million users and only 34 IT engineers
- **Non-rivalrous data use**: Information derived from products can create a collateral revenue stream
  - Ads
  - Using Facebook "likes" to predict behaviour
  - Privacy issues
- **User-co-invention**: The ongoing, networked interaction of product suppliers and users allows for a continual re-invention of the product/business model
  - Includes use of open-source software
  - Users have flexibility in using product—play lists for music

Speeding Up Innovation

- Financial **alternatives for funding** innovation combines experimentation and discovery model with new distribution models:
  - Crowd sourcing—traditional marketing yields to co-invention
  - “The Store”—e.g., Apple and Amazon
  - Alibaba — Alternative Funding Mechanism
- **Batch-oriented production** become more common, even in mass production.
- **Commercial scientific innovation** processes are changing
  - Emerald Therapeutics — networked robots operate lab testing equipment

More Complex Types and Patterns of Innovation?

- BMW warns that new cars are networked—should information about its performance be shared? Consumer privacy?
- Progressive Insurance: If you install a vehicle monitoring device, good driving conduct (no sharp braking, less nighttime driving) will yield discounts. Changes in valuation method and actuarial practices?
- Facebook “likes” better predict consumer smoking and drug use than other techniques—Facebook in insurance industry? Reshape marketing and research industries?

Technological Ethics

- Would it be unethical to make learning addictive?
- Hint: TV, music, game, drug, pornography, gambling and other industries do not understand the question
- Time=Value=Mind Share=Learning where the time goes, the mind goes

Technological Ethics

- What about when we can digitally and elementally duplicate the pleasurable to achieve the difficult?
- As we identify the electrochemical processes and stimulants that are involved with pleasure, spirituality, comfort, fun, etc., will the vice and commercial industries be the only ones willing and able to use them?
- If we can make learning to solve quadratic equations feel like eating junk food, gaming, and skateboarding all at once, what is wrong with that?

Creative Deconstruction Destruction

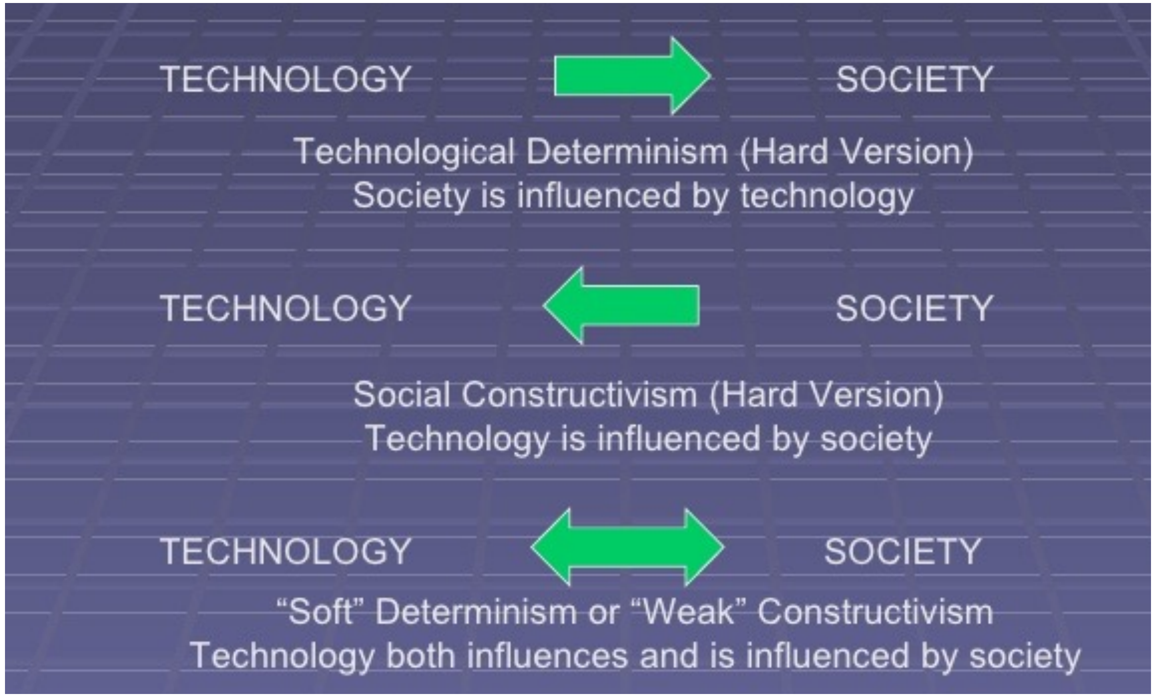
- Modern science and technology
- Humanity's Great Quest: Being able to observe, identify, model, manipulate, create, form and combine the parts of anything
- Cosmos, atoms, genes, cells, brains, bodies, ecosystems, knowledge, work, processes, markets and institutions

Key Effects of Digital Age

- Digitalization
- Automation
- Robotization
- Miniaturization
- Specialization
- Customization
- Globalization
- Mutation
- Commoditization
- Disintermediation
- Modularization
- Technological Determinism

Technological Determinism

- Technological systems are interconnected webs.
- The history of such systems shows a consistent repeating pattern.
- Changes in the speed, power or complexity of one part causes comparable changes in all other parts to which it is connected.



The Internet and Social Interaction

- The widespread adoption of the internet has significantly transformed how people interact socially. Social media platforms, messaging apps, and online communities have become integral parts of daily life for billions of people around the world. Technological determinists argue that the rise of the internet has fundamentally altered social dynamics, communication patterns, and interpersonal relationships.
- In this example, the internet's technological advancements, such as the development of social networking sites like Facebook, Twitter, and Instagram, have reshaped the way individuals connect, communicate, and share information. People now have unprecedented access to instant communication, global networking, and virtual communities, transcending geographical boundaries and time zones.

Automobile and Urbanization

- The widespread adoption of automobiles in the 20th century is often cited as a classic example of technological determinism. The invention and mass production of automobiles revolutionized transportation, leading to the expansion of road networks, the development of suburbs, and changes in urban planning. Critics argue that the automobile’s dominance in transportation systems has shaped cities around the world, prioritizing car-centric infrastructure over public transit and pedestrian-friendly environments.

CAR

Car ONLY

No opportunities for people to get around without a car.

Car FIRST

Vehicles still dominate the landscape, but a conscious effort is made to support other modes and give people options to get around.

Car EQUAL

All modes competitive with driving, for example by restricting driving on key transit corridors.

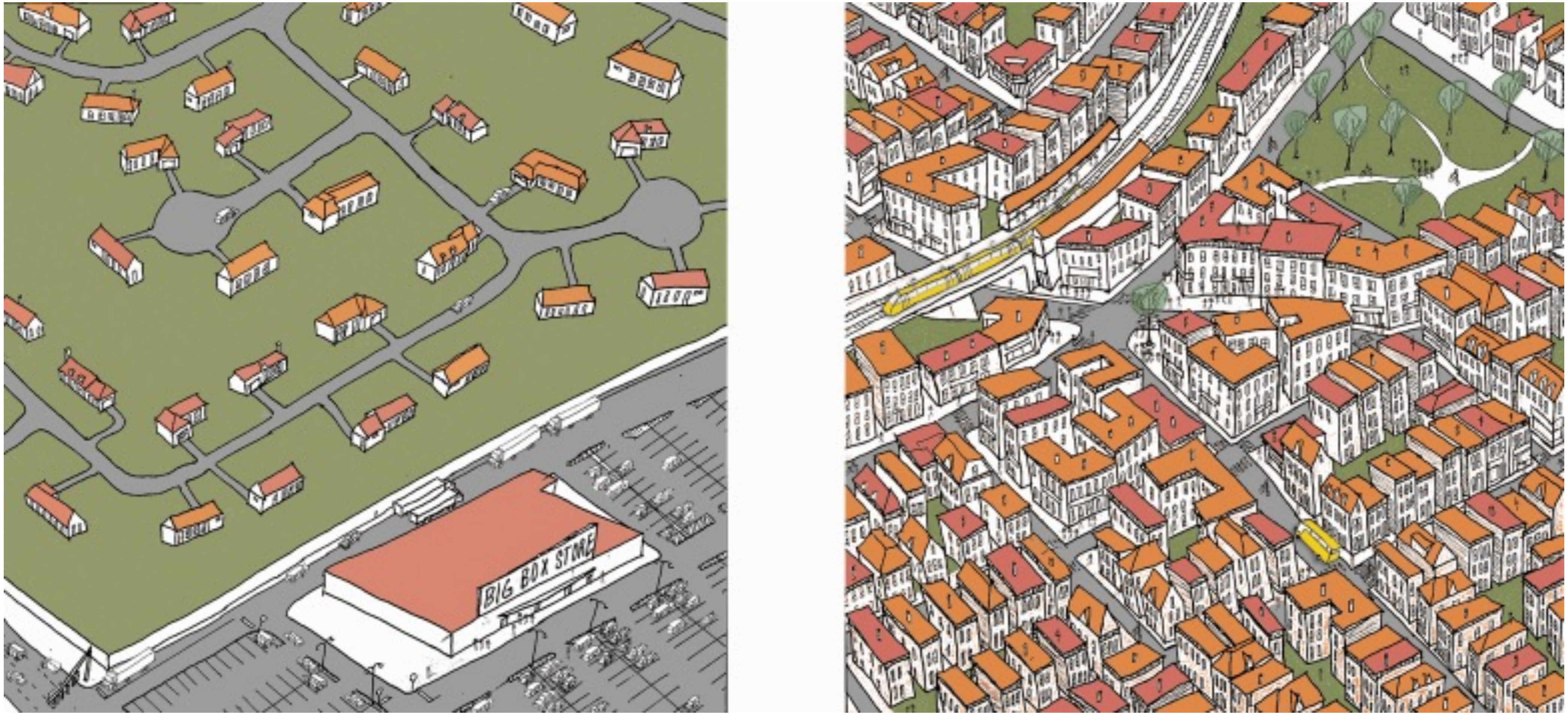
Car LAST

The car is the least desirable mobility option. It's simply more convenient to get around on foot, by bike, or using public transit.

Car FREE

Prioritize an exceptional walking experience.

PEOPLE



Auto-centric transportation systems go hand-in-hand with sprawling development patterns that make it difficult (or, in some cases, impossible) to walk or bike to common destinations, contributing to sedentary lifestyles that lead to substantial health risk. Walking, biking, and public transportation, on the other hand, lend themselves well to compact development of the kind found around the world in the pre-car era. (Image credit: Antonio Huerta)

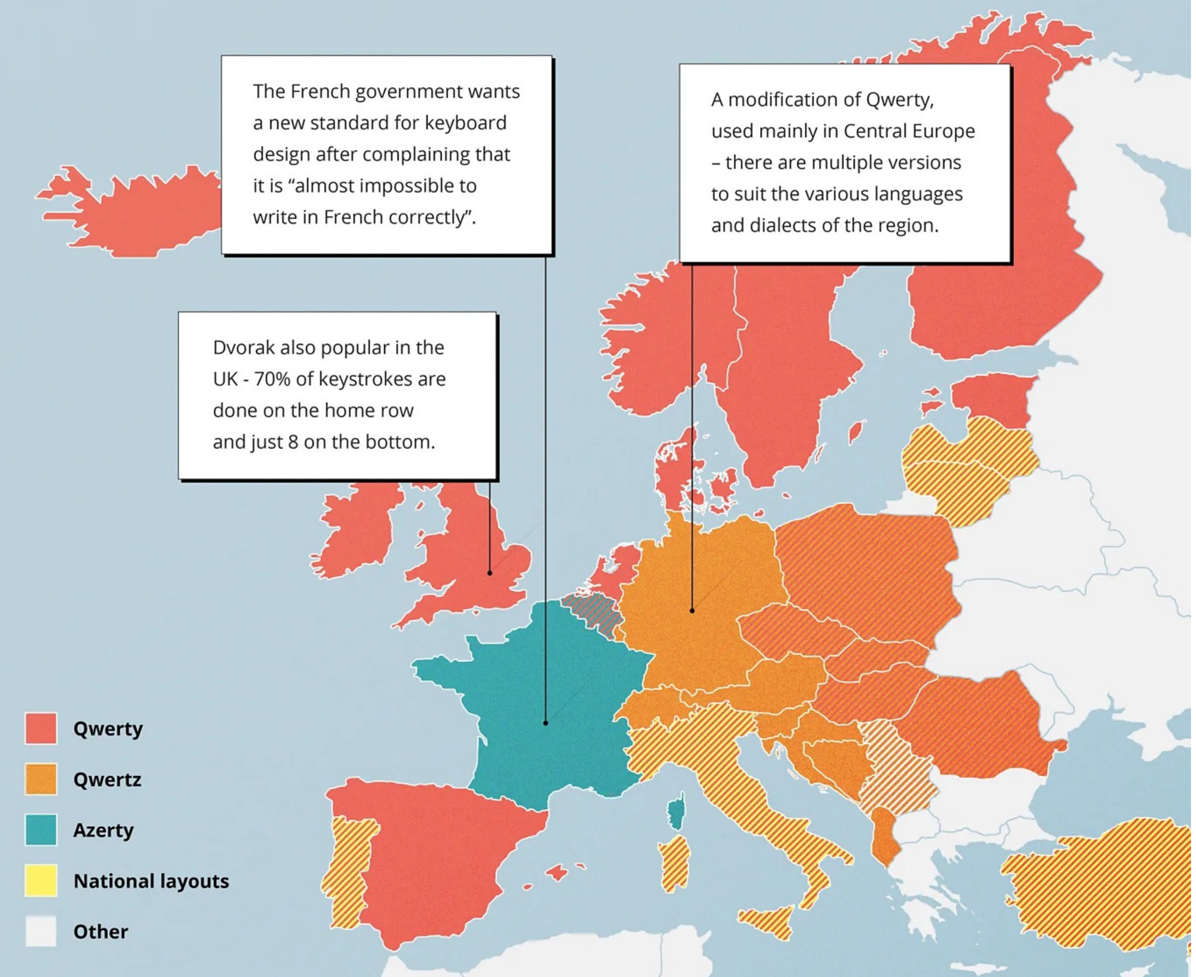
The QWERTY Keyboard Layout

- The QWERTY keyboard layout, commonly used in English-speaking countries, is a classic example of the social construction of technology. Although the QWERTY layout was originally designed in the 19th century to prevent mechanical typewriter jams by spacing out commonly used letters, its continued dominance in modern computer keyboards is not solely due to its technical efficiency. Instead, the QWERTY layout's widespread adoption and persistence are largely attributed to social factors, such as user familiarity, industry standards, and network effects. Despite the existence of potentially more efficient keyboard layouts, the QWERTY layout remains the standard due to its entrenched social and institutional support.

Lost in translation

While Qwerty is dominant in English-speaking countries, those speaking other languages have changed the layout of their keyboards

BBC capital

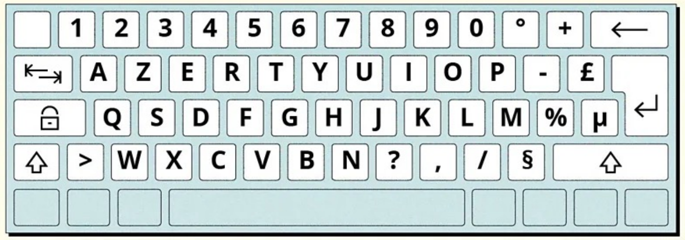


Sources: Luboslov Yezykin, Windows Keyboard Layouts

Keyboard contenders

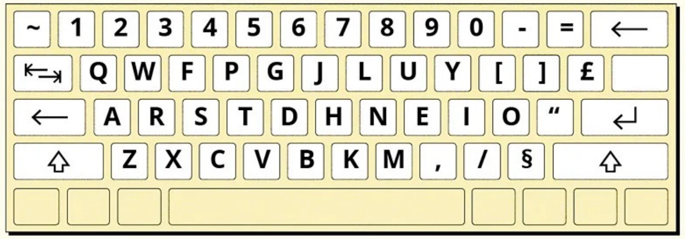
Alternatives to Qwerty used around the world

BBC capital



Azerty

A French twist on the Qwerty layout used in French-speaking countries, thought to have emerged on typewriters at the end of the 19th Century.

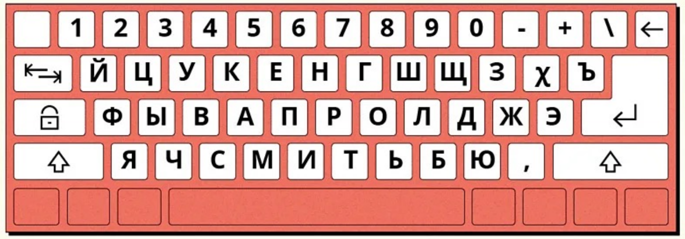


Colemak

A direct replacement for Qwerty it halves the amount of finger movement needed - 35 times as many words can be typed using only the home row.

Dvorak

This keyboard places the least common letters on the bottom row and makes the right hand do more work.



JCUKEN

Cyrillic layout for Russian language, dominant since the alphabet was changed following the 1917 revolution.

Sources: www.colemak.com, www.dvorak-keyboard.com, www.culture.gouv.fr

Some Policy Implications of Digital Innovation

- **Older industries transformed**: Digital innovation revolutionizes even traditional industries. Can state owned enterprises change fast enough?
- **Small is beautiful:** It rewards flexible exchange of ideas and talent. Need smaller flexible places to meet, like universities, rather than huge technology parks (less important for Japan than China)
- **Public policy should emphasize small scale infrastructure of services:** Public investment in technical testing & quality certification systems for smaller entrepreneurs helps

Takeaways?

- Faster, cheaper innovation with more specialized products and new business models is **much easier**
- New innovation system transforms industries that largely escaped the **first wave** of the Internet revolution
- Changes in innovation pose challenges for **public policy**
- Big technological/economic disruptions create political conditions to consider big **policy changes**
  - Trusted digital environment
  - Trade and competition policies

Takeaways?

- A new system of innovation is emerging that transforms a broad range of industries and products. What should we do?
  - Silicon Valley model ("Regional Clusters") emerged in 1980s: Research university, start-ups, VC, and outsourcing combine into specialized regional clusters.
    - This approach re-established US leadership in high tech
    - Successful clusters mainly focus on ICT or biotech
    - Disrupts traditional industry leaders

Danke schön

See you anytime soon!