# Paradigms of Technological Innovation

## ألگوهای (دیدمان های) نوآوری

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# R&D

- As a practitioner I believe, there is nothing more practical than a well articulated and operational model.
- This presentation, in a nutshell, is about the R&D (Research and Development) model!
- I am not against the R&D model, rather I intend to explicate its background, context and scope of application.
- What is the origin of R&D? Where did it come from? When did it first appeared?
- R&D is not a divine entity! It is human-made model. Like all human models, it is created, and some day it will loose its dominance. It is a matter of WHEN, and not a matter of IF!
- If you know about a phenomenon in advance, then you could be ahead in the game!

# The R&D Model Applications

- We are so immersed in the R&D outlook, that it may take us a while to figure out that R&D is actually a model; and like all models it has a “context” – which means “where”, “when”, and “how” it is applicable.
- The Triple Helix Model for technology development (Academy, Business and Government) is also based on the R&D outlook toward innovation.
- The validity of the R&D model has been questioned in numerous studies.




# R&D-Based Companies

# R&D – Research and Development : A Brief Review

The R&D model makes a linear and one-way outlook between three consecutive stages: **Basic Research**, **Applied Research** and **Development Research**.


The R&D model also confines innovation to technology development, and it assumes that the outcomes of R&D "somehow" will lead to Commercialization.

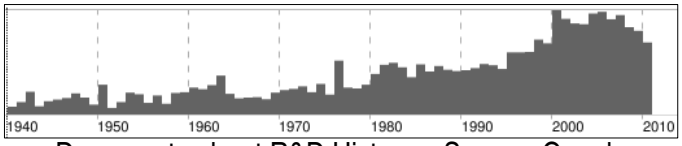


# Money Isn't Everything

"Money Isn't Everything" a paper published in 2005 describes a result of a study of 1000 publicly held companies that spent the most on Research and Development.

# Manhattan Project and the R&D Model

- The Manhattan Project was the codename for the efforts to develop the first nuclear weapons during World War II. The R&D model first developed for the Manhattan Project.
- During WWII, Vannevar Bush was the director of the Office of Scientific Research and Development which supported the Manhattan Project.
- In 1950 Bush became the founding director of the U.S. National Science Foundation - N.S.F. He used the same R&D Model to organize N.S.F.
- Since 1960s the R&D model has become a universal model for technological innovation, without noticing its context and scope of application. This chart shows R&D has received ever increasing references.

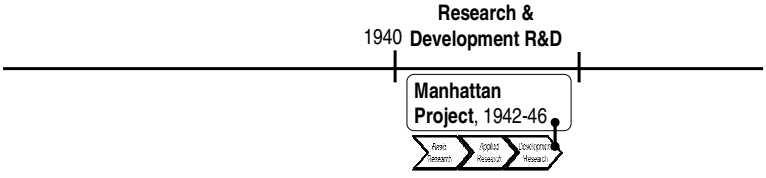



Documents about R&D History – Source: Google



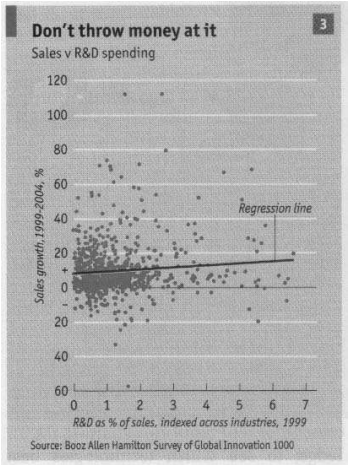
# The Paradigm of R&D

Examples are based on the U.S. Cases




- The Paradigm of R&D has roots in the Manhattan project (1942-46).
- Polaroid and De Pont used the R&D type of innovation, before it became a Paradigm.
- Since the 1960s the Paradigm of R&D has become the dominant outlook for technology development and investments in the scientific infrastructures in almost all countries.
- Since the mid-1990s shortcomings and limitations of this linear model and outlook have gained attention.
- Yet, the linear R&D has been able to continue to act like a default model for innovation.

# "R&D Spending" Versus "Sales and Profit"




The Economist, January 21-27, 2006

**Money Is Not Everything** concludes:

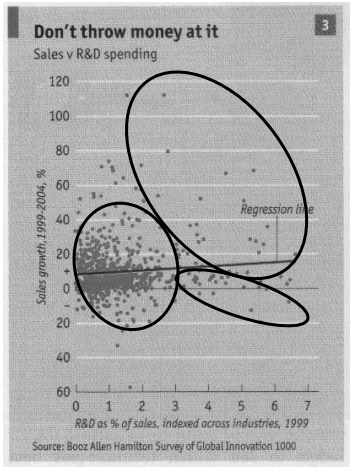
"There is no discernable relationship between R&D spending levels and nearly all measures of business success including sales, growth, gross profit, operating profit, enterprise profit, market capitalization, or total shareholder return." …

"No relationship exists between the number of patents issued to an organization and its business results."

Original Source: Money Is Not Everything. 2005.



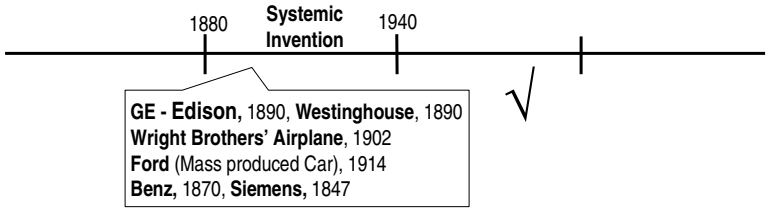
# Interpreting Previous Diagram




- Previous diagram – sufficiently insightful – could be interpreted in the context of more than one cluster.
- While the conclusion – lack of discernable relationship between R&D spending levels and all measures of business – may hold for the overall businesses that were studied, the diagram may actually show more than one pattern.
- If we regroup those cases into clusters, we may find unexplored patterns.
- <u>We do not need to abandon R&D, rather, we may look at in its context!</u>

# The Paradigm of Systemic Invention

Examples are based on the U.S. and Germany Cases

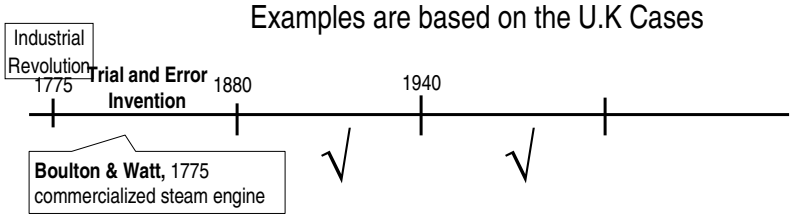



- The Paradigm of Systemic Innovation existed before the R&D Paradigm.
- Richard Harrison (in the U.K.), Thomas Edison, George Westinghouse and Wright Brothers (in the U.S.) Karl Benz and Werner Siemens (in Germany) were pioneers of this Paradigm of Innovation.
- This Paradigm of Innovation started in the U.K. Inventors (individual and businesses) in other countries adapted it this Paradigm.



# The Paradigm of Trial and Error Invention

Examples are based on the U.K Cases




- This Paradigm started in England (U.K.) with the re-invention of Steam Engine by James Watt (1750).
- Germany, U.S. and Japan were successful in adapting this Paradigm, later.
- The Paradigm of Trial and Error Invention was instrumental in the further development of the Industrial Age, as it actually happened.

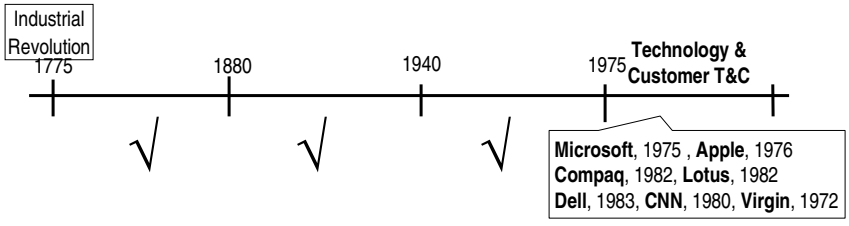
# Marine Chronometer' Systemic Invention

- John Harrison invented Marine Chronometer 20 years ahead of Watt's Steam Engine. Chronometer was made by using the Systemic Invention method, which re-emerged 150 years later. The scientific community of England, specifically Sir Isaac Newtown, opposed Harrison's views (Harrison was just a carpenter!). The scientific community actually blocked Harrison's method of innovation to flourish. The blockade continued for 1 ½ century.



# The Paradigm of T&C

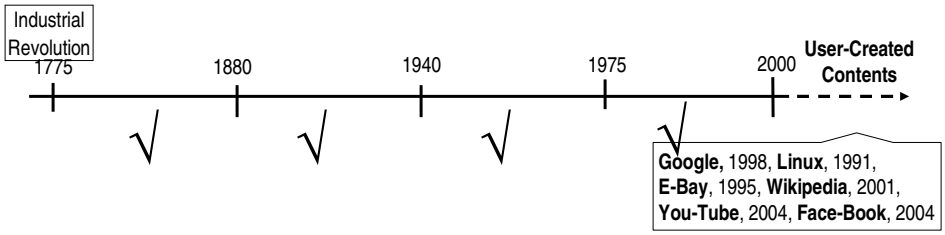
Examples are based on the U.S. and U.K. Cases




- The Paradigm of Technology & Customer (T&C) Development incorporates Technological Innovation and Customer Development.
- The forerunners of this Paradigm (Gates, Jobs, Dell, Warner) were all colleague dropouts without scientific, technical or managerial achievements. PC and Apple were not based on prior R&D projects.
- This Paradigm first appeared in the mid-1970s in the U.S. Later UK, Japan, Italy and some other countries have been successful in adapting this Paradigm in other types of industry.

# The Paradigm of User-Created Content

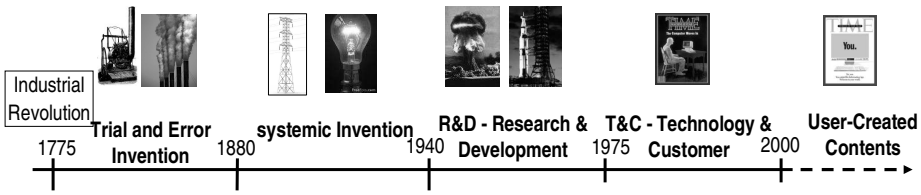
Examples are based on the U.S. Cases




- The Paradigm of User-Created Content Development let the users act as producers. As such Customer Development and Human Resources Development merge.
- The forerunners of this Paradigm (Linus, Omid-yar,… ) had strong technical (not scientific) background. Their initial products were crude, but user-centered.
- This Paradigms first appeared in the late 1990s and early 2000s in the U.S. Later on Germany, UK, and may be China have been successful in adapting this Paradigm. Japan has not been active, so far.
- It is too early to make final conclusions for this Paradigm.

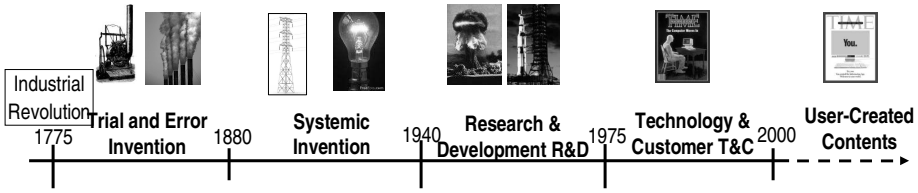


# The Paradigms of Innovation – Summary




1. **Trial and Error (Semi-systemic) Invention**: Represented by the steam engine.
2. **Systemic invention**: Represented by the, chronometer, light bulb and electricity.
3. **Research and Development - R&D**: Represented by the A-bomb, rockets and main-frame computers.
4. **Technology and Customer Development – T&C**: Represented by personal computers.
5. **User-Created Contents**: Represented by User-Created Contents such as Linux, Wikipedia, You-Tube and Face-book.

# The Paradigms of Innovation – Main Conclusions

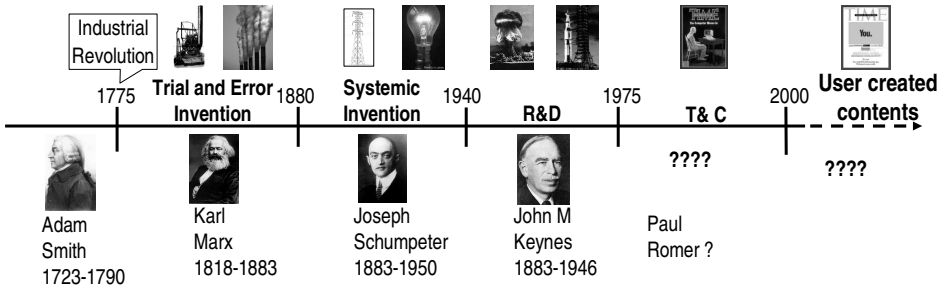



- **Research and Development – R&D is one of the five main Paradigms of Innovation, since the start of the Industrial Revolution.** There are at least four other paradigms of innovation.
- **Paradigms of Innovation are NOT mutually exclusive!** During the same time span, different types of industries may follow different paradigms of innovation.
- **Previous paradigms may be influenced by more recent paradigms.**



# Paradigms of Innovation and Economic Theories:

Potential Future Theoretical Studies Related to Paradigms of Innovation

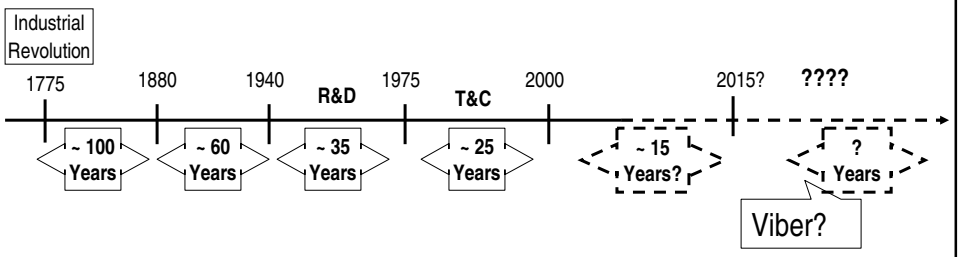



Adam Smith, Karl Marx and Joseph Schumpeter studied the process of technology development. Each of them, however, considered the Paradigm that they lived in as the universal method of technology development.

John Maynard Keynes was instrumental in the development of the R&D-based technology development, but he actually did not study the R&D paradigm.

No major economist has elaborated yet the theoretical basis of the two recent paradigms of innovation! Will someone do?

# Toward the Next Paradigm of Innovation?




The dominance period of each Paradigm of Innovation has decreased: 1) Trial and Error Invention: ~ 100 years. 2) Systemic Invention: ~ 60 years. 3) R&D: ~ 35 years. 4) T&C: 25 years.

When will emerge the next paradigm? What could be its structure?



# Economic Waves

Economics of Industrial Innovation (1997) by C. Freeman and L. Soete

| Cycle number, Approx. Timing. | **First Wave, 1780s - 1840,** | **Second Wave 1840s – 1890s** | **Third Wave 1890s – 1940s** | **Fourth Wave 1940s – 1990s** | **Fifth Wave 1990s – ?** |
|---|---|---|---|---|---|
| **Kondratieff Waves** | Industrial revolution, factory production | Age of steam power and railways | Age of electricity and steel | Age of mass production of automobiles and synthetic materials | Age of microelectronics and computer networks. |
| **Science, Technology, Education, and Training** | Apprenticeship, learning by doing, dissenting academies, scientific societies | Professional mechanical and civil engineers, institute of technology, mass primary education | Industrial R&D labs, chemicals and electrical, national laboratories, standards laboratories | Large-scale industrial and government R&D, mass higher education | Data networks, R&D global networks, lifetime education and training |
| **Transport Communication** | Canal, carriage roads | Railways (Iron) telegraph | Railways (Steel), telephone | Motor highways, radio and TV, airlines | Information highways, digital networks |
| **Energy Systems** | Water power | Steam power | Electricity | Oil | Gas/oil |
| **Cheap Key Factors** | Cotton | Coal, iron | Steel | Oil, plastics | Microelectronics |