

# Paradigms of Innovation

## A Study of Innovation from the Perspective of Entrepreneurship

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## Introduction

- Since the mid-1960s the "Research and Development" model has become the dominant outlook for technology development and investments in the scientific infrastructures.
- Since the mid-1990s shortcomings and limitations of this linear model have gained attention. Yet, due to lack of alternative models for innovation, the linear R&D has been able to continue to act like a default model for innovation.
- This presentation reviews the R&D model in the context of a broader outlook, here named Paradigms of Innovation. It argues that the R&D approach is applicable to specific types of industries.
- This presentation suggests a new cycle-waves for innovation, where different paradigms of innovation can co-exist with each other, but they may have applications in the different types of industries.

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

This R&D model confines innovation to technology development, and then makes a linear and one-way outlook between three consecutive stages: **Basic Research**, **Applied Research** and **Development Research**.



This linear model assumes that the outcomes of R&D somehow will lead to **Commercialization**.

The Triple Helix Model for technology development (Academy, Business and Government) is also based on the R&D outlook toward innovation.

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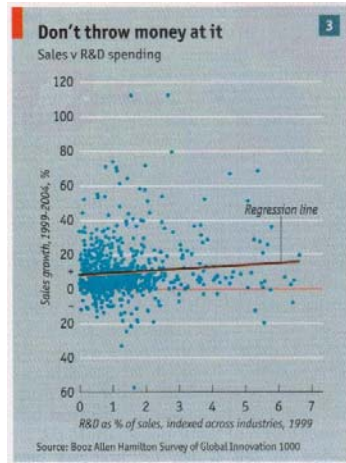
## History of R&D

- **It is said that the fish has no clue about water, as long as it has no experience of the world out of water!**
- 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.
- Since the mid-1960s, the R&D model has been the dominant model for technological innovation; as well as numerous Science and Technology Programs.
- The validity of the R&D model has been questions in numerous studies.
- "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.



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



The Economist, January 21-27, 2006

"Money Is Not Everything" concludes:

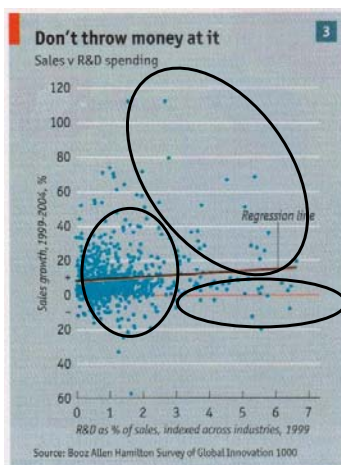
"There is no discernable relationship between R&D spending levels and nearly all measures of business success including sales, growth, gross profit, operating profit, enterprise profit, market capitalization, or total shareholder return." ...

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

Money Is Not Everything. 2005.

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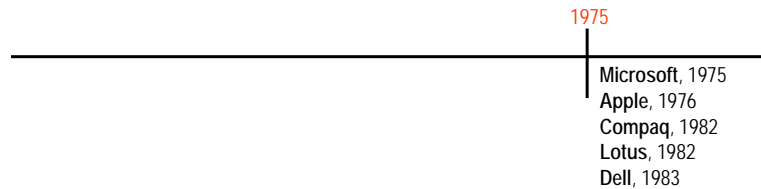
## Interpreting Previous Diagram



- 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.
- We do not need to abandon R&D, rather, we may look at in a new context!

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## A Paradigm Shift Around 1975?



A new context for R&D appeared from another study.

In my studies about innovation and entrepreneurship, and commercialization of new technologies, I noticed that around 1975, a major change happened. In the mid-1970s and later, new companies emerged such as: Microsoft, Apple, Dell, Compaq and Lotus Software. The founders of these companies did not have strong scientific background. Indeed the founders of Microsoft, Apple, CNN and Dell all were college dropouts. This was a very different pattern compared with the founders of previous successful ventures, that were dominant in the years before 1975.

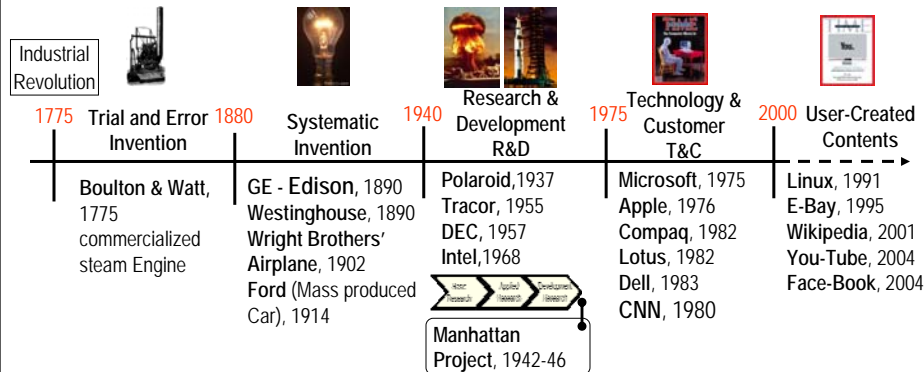
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## A New Outlook for Innovation and Entrepreneurship

- This presentation looks for a new context for innovation that looks at R&D as a source of innovation, rather than the source of innovation.
- The new outlook for innovation concentrates on the “Confluence of Innovation and Entrepreneurship.”
- **The unit of analysis is ventures (new businesses) that were able successfully to commercialize a new technology and become large enterprises.**
- The following chart covers major new ventures in each time period that are consistent with the above description:
  - 1) They were new ventures,
  - 2) They commercialized a new technology, and
  - 3) They were able to grow from small size and became large enterprises.

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## Main Patterns for Innovation and Entrepreneurship



- 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.

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## Some Observations of Past Paradigms of Innovation

- Polaroid (established in 1937) was a pioneer in the new R&D paradigm, even before the R&D model became articulated.
- Mainframe computer was developed based on R&D Paradigm, but the development of the Microcomputers (PC industry) is an exemplary case of the T&C (Technology-Customer Development) Paradigm of Innovation.
- Pharmaceutical and Bio-Medical industries still mostly follow the R&D Paradigm of Innovation.
- A new Paradigm of Innovation does not discard the older ones; during the same time spans, different types of industries may follow different paradigms of innovation.
- Paradigms of Innovation are NOT mutually exclusive!

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## Influence of One Paradigm of Innovation on Another One

- Older Paradigms while keeping their main characteristics are influenced by some of the characteristics of new paradigms.
- For instance, the IDEO (the famous design and development firm) does not follow an R&D Paradigm, rather, it follows the "Systematic Invention" paradigm with an emphasis on Design and Development and a touch of market segmentation from the R&D Paradigm.
- The attempt by some businesses to incorporate the role of customers in their product development process can be interpreted as incorporating elements of the T&C or User-Created Content Paradigms into the Systematic Invention or R&D Paradigms.
- **Previous paradigms may be influenced by more recent paradigms.**

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## Some Observations of the Emerging Paradigm of Innovation

- The process of innovation is not necessarily and always linear, sequential predictable. The R&D model is not a default model.
- Technology is just one element in the process of innovation.
- Innovation commercialization (rather than technology commercialization) impacts the process of venture, business and economic development.
- Entrepreneurship is a conduit to link innovation commercialization and venture/business/economic development.
- Entrepreneurship is not confined just to new ventures with a high rate of growth just after start up (the so-called High-Growth/Rocket ventures).
- Entrepreneurship may happen in the context of existing businesses (intrapreneurship), as well as new ventures with a modest initial rate of growth, and in the context of civic entrepreneurship.
- An extensive amount of external capital is not a necessary condition for all economic development activities.
- ...

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### Five Main Paradigms of Innovation

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

- **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.**

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### Data Collection versus Data Interpretation

- A scientific study, among other things, includes two stages: 1) Data Collection and 2) Data Interpretation.
- Data collection is about gathering data to explore patterns. It is about What.
- Data Interpretation is about interpreting the data, how the patterns are connected to each other. Theory Development and Model Development. Metaphor/Analogy could be very useful to facilitate the process of Data Interpretation.
- The Innovation Map model is used to interpret the patterns of the Paradigms of Innovation. The unit of analysis is new ventures.

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# Innovation: A Non-Linear Configuration

Major enterprise activities are categorized into 4 main groups:

1. **How to Produce/Make:** Technology
2. **How to Sell:** Customer/Market
3. **How to Recruit and Retain Employees:** Human Resources
4. **How to Integrate all together:** Organization

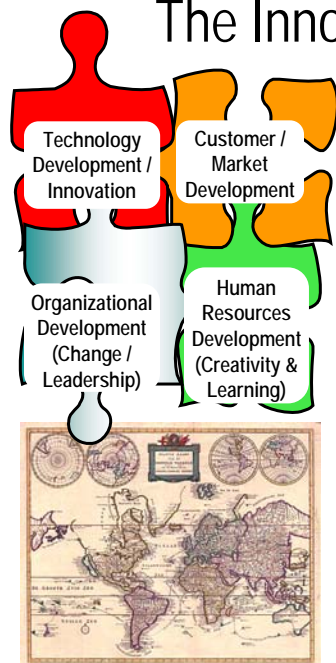
Development and innovation happen in all aspects of enterprise activities.

1. **Technology Development / Innovation**
2. **Customer & Market Development**
3. **Human Resources Development (learning and creativity)**
4. **Organizational Development (change and leadership)**

Innovation and development are not limited to technology.

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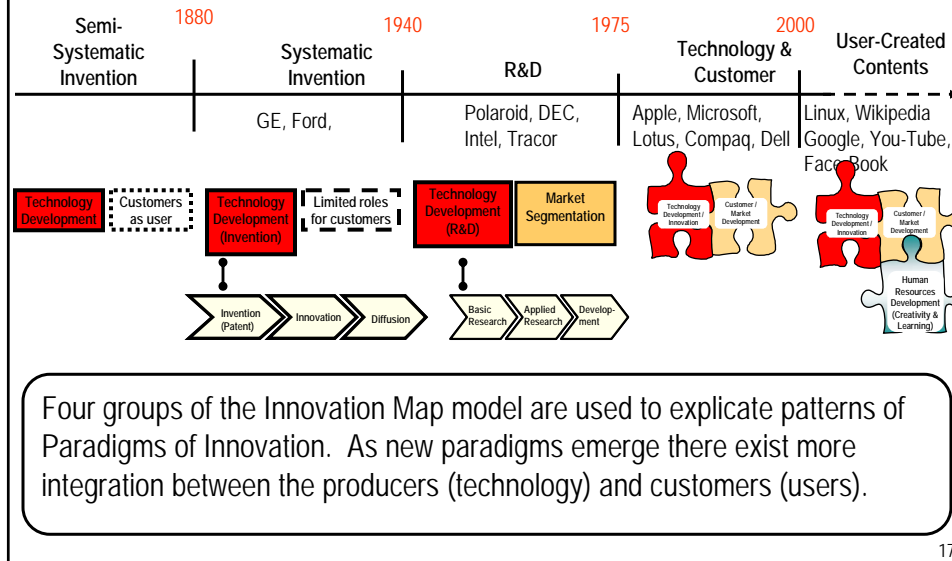
## The Innovation Map Model



- The four aspects of innovation have nonlinear relationship with each other. They are distinct; though they are linked. Organizational development often plays the role of linking those to each other.
- Technology often holds the most visible aspect of innovation and development. Technology, however, is not necessarily always the most important aspect of innovation. Examples: Dell, Southwest Airlines, Wal-Mart, Virgin Group.
- The four aspects of innovation are analogous to the continents of the World

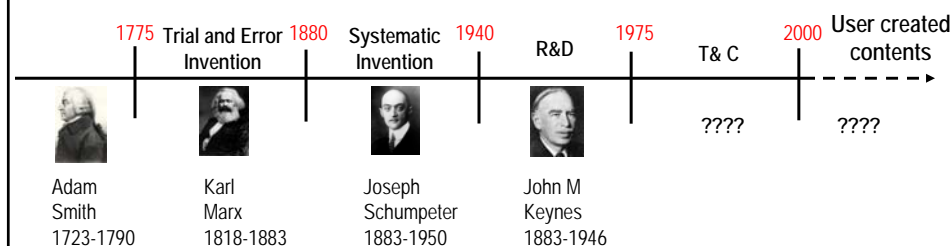
# Interpreting the Paradigms of Innovation

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## Potential Future Theoretical Studies Related to Paradigms of Innovation?



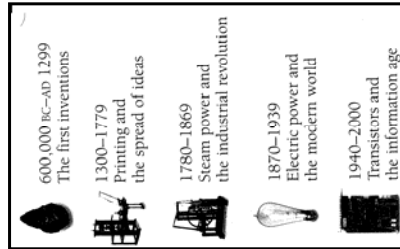
The first three of prominent economists reviewed the characteristics of the first three paradigms of innovation. Each of them, however, considered the paradigm that they studied as the default pattern of technology development.

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

It seems no major economist has elaborated yet the theoretical basis of the two recent paradigms of innovation! Will someone dare to do?

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# Technology/Artifact Development Timeline



Looking for a time-line for technology/artifact development is not new. Timeline of Inventions (copied from *Smithsonian Timeline of Inventions*) depicts the different time lines from 600,000 BC to 2000 and the tools that symbolize each era. This classification bundles the 1940-2000 period in one group, labeled .

The above outlook at technology development covers only the hardware confines technologies.

Jeffrey Moor's prediction that the capacity of micro-processors increases two folds every 18 months is along this view of technology timeline.

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## 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 – ?
<b>Kondratieff Waves</b>	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.
<b>Science, Technology, Education, and Training</b>	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
<b>Transport Communication</b>	Canal, carriage roads	Railways (Iron) telegraph	Railways (Steel), telephone	Motor highways, radio and TV, airlines	Information highways, digital networks
<b>Energy Systems</b>	Water power	Steam power	Electricity	Oil	Gas/oil
<b>Cheap Key Factors</b>	Cotton	Coal, iron	Steel	Oil, plastics	Microelectronics

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