CHAPTER 3

Types and Patterns of Innovation

Based on Schilling (2013)
Today We Will

• Identify different types of innovation

• Understand technology improvement pattern

• Understand technology diffusion pattern

• Discuss about discontinuous / disruptive innovation

• Understand technology cycle
Product 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 the techniques of producing or marketing goods or services.

Process innovations are often oriented toward improving the effectiveness or efficiency of production by, for example, reducing defect rates or increasing the quantity that may be produced in a given time.
New product innovations and process innovations often occur together.

First, new processes may enable the production of new products. For example, the development of new metallurgical techniques enabled the development of the bicycle chain, which in turn enabled the development of multiple-gear bicycles.

Second, new products may enable the development of new processes. For example, the development of advanced workstations has enabled firms to implement computer-aided manufacturing processes that increase the speed and efficiency of production.

Finally, a product innovation for one firm may simultaneously be a process innovation for another. For example, when United Parcel Service (UPS) helps a customer develop a more efficient distribution system, the new distribution system is simultaneously a product innovation for UPS and a process innovation for its customer.
Radical Innovation

- **Radicalness** might be conceived as the combination of *newness* and the degree of *differentness*. A technology could be new to the world, new to an industry, new to a firm, or new merely to an adopting business unit.

- A technology could be significantly different from existing products and processes or only marginally different.

- The most radical innovations would be new to the world and exceptionally different from existing products and processes.

- The introduction of wireless telecommunication products aptly illustrates this—it embodied significantly new technologies that required new manufacturing and service processes.
Radical Innovation
Radical Innovation
Radical Innovation
Radical Innovation
Radical Innovation
Incremental Innovation

- **Incremental innovation** is at the other end of the spectrum. An incremental innovation might not be particularly new or exceptional;

- It might have been previously known to the firm or industry, and involve only a minor change from (or adjustment to) existing practices.

- For example, changing the configuration of a cell phone from one that has an exposed keyboard to one that has a flip cover or offering a new service plan that enables more free weekend minutes would represent incremental innovation.
Incremental Innovation

Does not swell in water, so your swimmer can focus on fun
Incremental Innovation
Incremental Innovation
Incremental Innovation
Radical Innovation Vs. Incremental Innovation

• The radicalness of innovation is sometimes defined in terms of risk. The development of third generation (3G) telephony is illustrative.

• For companies to develop and offer 3G wireless telecommunications service required a significant investment in new networking equipment and an infrastructure capable of carrying a much larger bandwidth of signals.

• It also required developing phones with greater display and memory capabilities, and either increasing the phone’s battery power or increasing the efficiency of the phone’s power utilization. It was also unknown to what degree customers would ultimately value broadband capability in a wireless device.
Radical Innovation Vs. Incremental Innovation

• The radicalness of an innovation is relative, and may change over time or with respect to different observers.

• An innovation that was once considered radical may eventually be considered incremental as the knowledge base underlying the innovation becomes more common. Example – Steam engine

• Furthermore, an innovation that is radical to one firm may seem incremental to another. Example: Sony vs Kodak in digital camera technology
Competence Enhancing Innovation

- An innovation is considered to be competence enhancing from the perspective of a particular firm if it builds on the firm’s existing knowledge base.

- For example, each generation of Intel’s microprocessors (e.g., 286, 386, 486, Pentium, Pentium II, Pentium III, Pentium 4) builds on the technology underlying the previous generation.

- Thus, while each generation embodies innovation, these innovations leverage Intel’s existing competencies, making them more valuable.
Competence Enhancing Innovation
Competence Destroying Innovation

- An innovation is considered to be competence destroying from the perspective of a particular firm if the technology does not build on the firm’s existing competencies or renders them obsolete.
Competence Destroying Innovation
Competence Destroying Innovation
Architectural Innovation

In contrast, an architectural innovation entails changing the overall design of the system or the way that components interact with each other. Architectural innovations often have far-reaching and complex influences on industry competitors and technology users.
An innovation is considered a **component innovation** (or **modular innovation**) if it entails changes to one or more components, but does not significantly affect the overall configuration of the system.
Types of Innovation

- Each of the dimensions / types shares relationships with others—for example, architectural innovations are often considered more radical and more competence destroying than component innovations.

- Furthermore, where an innovation lies on the dimension of competence enhancing versus destroying, architectural versus component, or radical versus incremental depends on the time frame and industry context from which it is considered.
Patterns in Technological Innovation

• Two main patterns have been observed –
  • the rate of a technology’s performance improvement
  • the rate at which the technology is adopted in the marketplace

• Both patterns take an s-shape curve

• But these are two DIFFERENT processes
S-Curves in Technological Improvement

• When a technology’s performance is plotted against the amount of effort and money invested in the technology, it typically shows slow initial improvement, then accelerated improvement, then diminishing improvement.

• Why is the performance at the beginning slow for a new technology?
  • Poorly understood
  • No established routines about how to evaluate the performance if it is a radical innovation
  • Do not attract other researchers to further develop it because everyone is still suspicious of its legitimacy / functionality etc.
S-Curves in Technological Improvement

- These problems disappear when the technology gains some foothold / legitimacy – funds, researchers all are coming through which improves the performance of the technology.

- After certain point (money / effort) rate of return diminishes. As the technology begins to reach its inherent limits, the cost of each marginal improvement increases, and the s-curve flattens.
S-Curves in Technological Improvement
Discontinuous Technologies

- Technologies do not always get the opportunity to reach their limits; they may be rendered obsolete by new, discontinuous technologies.

- A new innovation is discontinuous when it fulfills a similar market need, but does so by building on an entirely new knowledge base.

- For example, the switches from propeller-based planes to jets, from silver halide (chemical) photography to digital photography, from carbon copying to photocopying, and from vinyl records (or analog cassettes) to compact discs were all technological discontinuities.
Discontinuous Technologies
Discontinuous Technologies
Discontinuous technologies

- Initially, the technological discontinuity may have lower performance than the incumbent technology.

- For instance, one of the earliest automobiles, introduced in 1771 by Nicolas Joseph Cugnot, was never put into commercial production because it was much slower and harder to operate than a horse-drawn carriage.

- It was three-wheeled, steam-powered, and could travel at 2.3 miles per hour.

- A number of steam- and gas powered vehicles were introduced in the 1800s, but it was not until the early 1900s that automobiles began to be produced in quantity.
Discontinuous technologies

Technology S-Curves—Introduction of Discontinuous Technology

![Graph showing S-curves for first and second technologies](image)
S-Curves in Technology Diffusion

• S-curves in **technology diffusion** are obtained by plotting the cumulative number of adopters of the technology against time.

• This yields an s-shape curve because adoption is initially slow when an unfamiliar technology is introduced to the market; it accelerates as the technology becomes better understood and utilized by the mass market, and eventually the market is saturated so the rate of new adoptions declines.
S-Curves in Technology Diffusion
(Adopter Categories)
S-Curves in Technology Diffusion (Adopter Categories)
S-Curves in Technology Diffusion

- One rather curious feature of technology diffusion is that it typically takes far more time than information diffusion.

- For example, Mansfield found that it took 12 years for half the population of potential users to adopt industrial robots, even though these potential users were aware of the significant efficiency advantages the robots offered.

- If a new technology is a significant improvement over existing solutions, why do some firms shift to it more slowly than others?
S-Curves in Technology Diffusion

• Complexity of new knowledge

• Knowledge base only possible to develop through experience with the technology

• Tacit knowledge passable only from person to person

• Development of complementary resources
  • Example of electric light – How did Edison build on the complementary assets?
S-Curves in Technology Diffusion

• S-curves of diffusion are in part a function of the s-curves in technology improvement

• As technologies are better developed, they become more certain and useful to users, facilitating their adoption. Furthermore, as learning curve and scale advantages accrue to the technology, the price of finished goods often drops, further accelerating adoption by users.
S-Curves in Technology Diffusion
S-Curve as a Prescriptive Tool

• Several authors have argued that managers can use the s-curve model as a tool for predicting when a technology will reach its limits and as a prescriptive guide for whether and when the firm should move to a new, more radical technology.

• Firms can use data on the investment and performance of their own technologies, or data on the overall industry investment in a technology and the average performance achieved by multiple producers.

• Managers could then use these curves to assess whether a technology appears to be approaching its limits or to identify new technologies that might be emerging on s-curves that will intersect the firm’s technology s-curve. Managers could then switch s-curves by acquiring or developing the new technology.
Limitations of S-Curve as a Prescriptive Tool

- First, it is rare that the true limits of a technology are known in advance, and there is often considerable disagreement among firms about what a technology’s limits will be.

- Second, the shape of a technology’s s-curve is not set in stone. Unexpected changes in the market, component technologies, or complementary technologies can shorten or extend the life cycle of a technology.

- Furthermore, firms can influence the shape of the s-curve through their development activities.
Limitations of S-Curve as a Prescriptive Tool

- Whether switching to a new technology will benefit a firm depends on a number of factors, including:
  - The advantages offered by the new technology,
  - The new technology’s fit with the firm’s current abilities (and thus the amount of effort that would be required to switch, and the time it would take to develop new competencies),
  - The new technology’s fit with the firm’s position in complementary resources (e.g., a firm may lack key complementary resources, or may earn a significant portion of its revenues from selling products compatible with the incumbent technology), and
  - The expected rate of diffusion of the new technology.

- Thus, a firm that follows an s-curve model too closely could end up switching technologies earlier or later than it should.
Technology Cycle

• The s-curve model suggests that technological change is 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.

• The emergence of a new technological discontinuity can overturn the existing competitive structure of an industry, creating new leaders and new losers.

• Schumpeter called this process *creative destruction*, and argued that it was the key driver of progress in a capitalist society.
Phases of Technology Cycle (Utterback & Abernathy, 1975)

- Utterback and Abernathy (1975) observed that a technology passed through distinct phases.

  **Fluid phase**
  - Considerable uncertainty about technology
  - Considerable uncertainty about market / user
  - Products and services based on the technology are crude, unreliable, expensive
  - Focus on the needs of some market niche only
  - Product and service design are in experimental stage

  **Specific Phase** – *Specific to the dominant design*
  - Consensus among producers and customers about product attributes
  - Emergence of dominant design
  - Stable architecture
  - Firms focus on process innovation / incremental innovation for the components
Phases of Technology Cycle (Utterback & Abernathy, 1975)

Fossil Fuel Technology – Specific Phase
Phases of Technology Cycle (Utterback & Abernathy, 1975)

Renewable Resource Technology – Fluid Phase
Technology Cycle
(Anderson & Tushman, 1990)

Era of Ferment
- Design Competition
- Substitution

Era of Incremental Change
- Elaboration of Dominant Design

Technological Discontinuity
Dominant Design Selected
Phases of Technology Cycle (Anderson & Tushman, 1990)

- Anderson and Tushman studied the history of the U.S. minicomputer, cement, and glass industries through several cycles of technological change.

**Era of Ferment**
- Technological discontinuity start the stage
- Period of turbulence and uncertainty
- New technology might provide breakthrough capabilities
- Little or no agreement about the major subsystems

**Substitution**
- New technology displaces the old
- Considerable design competition among firms
Phases of Technology Cycle (Anderson & Tushman, 1990)

- **Rise of Dominant Design**
  - Dominant design arise and it controls majority of the market share unless there is
    - an unexpected discontinuity resulting from disruptive technology
    - Patent battles among different firms
  
  - Dominant design was never the same as the original discontinuity but it was also not something which was leading edge

  - Instead of maximizing performance on any individual dimension of the technology, the dominant design tended to bundle together a combination of features that best fulfilled the demands of the majority of the market.
Phases of Technology Cycle (Anderson & Tushman, 1990)

• Era of Incremental Change
  • Dominant design is already in the market
  
  • Firms focus on efficiency and market penetration
  
  • Firms may attempt to achieve greater market segmentation by offering different models and price points
  
  • Production costs may become lower due to design simplification or process innovation
  
  • This stage of incremental change continues until the next discontinuity
Technology Cycle and Firm Inertia / Resistance to Change

• During the era of incremental change, many firms cease to invest in learning about alternative design architectures and instead invest in refining their competencies related to the dominant architecture.

• Most competition revolves around improving components rather than altering the architecture.

• As firms’ routines and capabilities become more and more wedded to the dominant architecture, the firms become less able to identify and respond to a major architectural innovation.

• As the firm’s expertise, structure, communication channels, and filters all become oriented around maximizing its ability to compete in the existing dominant design, they become barriers to the firm’s recognizing and reacting to a new technology architecture.
Should every industry possess dominant design?

• In some industries, heterogeneity of products and production processes are a primary determinant of value, and thus a dominant design is undesirable.

• For example, art and cuisine may be examples of industries in which there is more pressure to do things differently than to settle upon a standard.