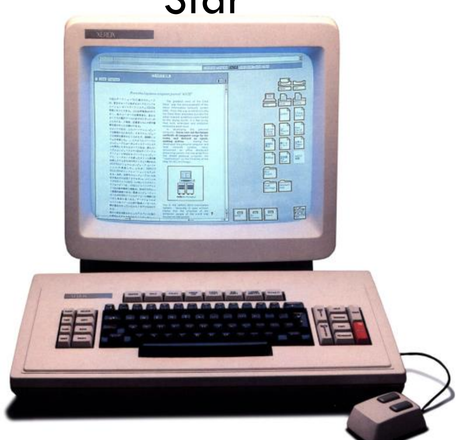
Technical Personnel and Business Personnel

- If technological innovation is so important, why hasn't everyone done it successfully?
- Invention is principally
  - a technical process (performing research) and
  - secondarily a business process (funding research).
- Commercialization is principally
  - a business process (investing in product development) and
  - secondarily a technical process (solving engineering problems).
- Thus, to understand the whole of innovation, one needs to understand:
  - how engineers and scientists think and
  - how marketing, production, and financial managers think.

Case Study: Altos PC System

- In the 60's, Xerox built Palo Alto Research Center (PARC) to pioneer new computational ideas for the Xerox's strategic technical vision of a " paperless office. "
- Early 80's, Xerox invented a PC (Altos)— with windows, icons, mouse, object-oriented operating system, networked, and laser-printing.
- Ten years before Macintosh (Jobs stole the idea in a visit and designed it for Mac)
- Instead of Altos, Xerox focused on Star Workstation (word processor).
- Xerox lost its opportunity to capture the new emerging personal computer market. Xerox might have become the future Microsoft and Intel combined.
- Failure of a manager with a short-term, money-oriented mind.

Star



Altos

Macintosh

Case Study: AT&T

- Lesson to be learned:

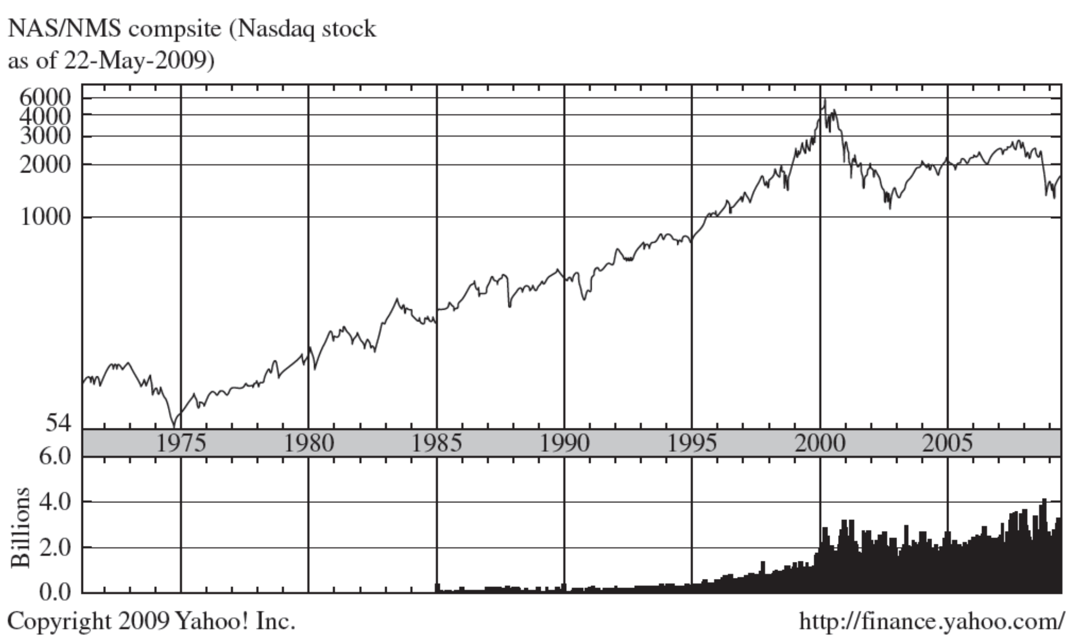
The long - term challenge of innovative high - tech companies is to keep innovative strategy going in a corporation through generations of leadership — in successive CEOs.

- Another example: AT&T established a research lab, Bell Laboratories, which made major inventions, including transistor in the 1940s.
- In the 1960s it invented the basic concepts of cellular phone systems, but did not commercialize it.
- They divided their fixed-line phone business between one long-distance phone company (AT&T) and several regional local-phone services. The regional phone services thrived, but long-distance AT&T shrank.
- Eventually, AT&T went bankrupt.
- But two of the local phone services looked ahead and established cellular phone services as Verizon and Cingular. Then Cingular bought out the bankrupt AT&T

Economic Impact of Innovation

Case Study: US Dot.com Stock Bubble of the 1990s

- In the 1990s, the rapid growth of the Internet was exciting.
- In 1996 in the United States, 14% of the population used the Internet, 22% in 1997, 31% in 1998, 38% in 1999, and 44% in 2000
- It was believed, Internet was creating a "new economy", just market growth mattered
- But in the year 2000 this stock bubble burst. The "new economy" fell back to the principles of the old economy, which require profitable businesses.
- The Internet stock bubble was just one of many examples of *excessive financial enthusiasm* about technological innovation.

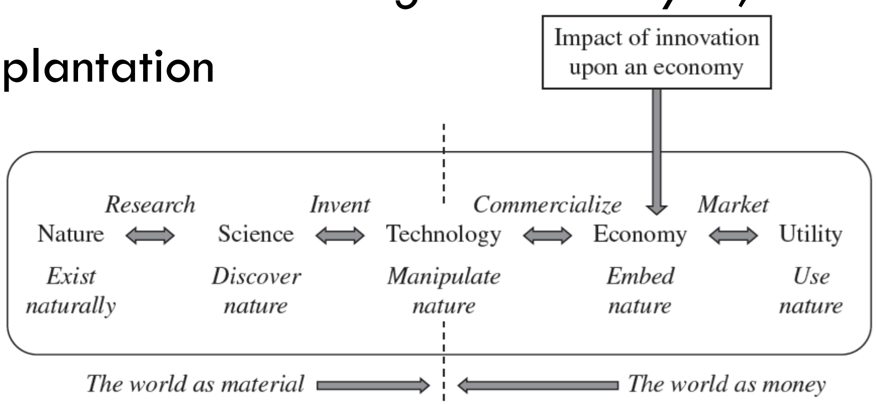


Lessons to be learned from Dot.com Bubble

- Scientific research provides the knowledge base for the invention of new basic technologies.
- New basic technologies create new economic opportunities.
- The path to wealth in economic opportunities is often rocky.
- However, rocky the entrepreneurial path, economic development from technological innovation does become a permanent feature of societal structures — for example, despite that stock bubble, the Internet and electronic commerce was there to stay.
- Technological innovation and economic development is neither simple nor inevitable.
- If progress in technology is to occur and be successfully implemented as a business opportunity, then technological innovation needs to be carefully managed.

Innovation and Economy

- The dot.com bubble was based on financial estimates of the impacts of the discontinuous innovation of the Internet — a **radical** innovation.
- This pattern of radical innovation stimulating financial investments and economic growth is a basic pattern in the history of modern economies.
- Nikolai Kondratiev asked the question: How was capitalism in England periodically renewed and overall expanding? Answer: *technology*.
- He plotted a correlation between times of basic innovation to times of economic expansion. Overall, the capitalistic economies were expanding rather than contracting because of periodic innovations of new technologies.
- This economic idea is now called a *long economic cycle,* or a *Kondratiev wave*.
- E.g. kiwi and onion plantation



Economic Long Waves

- Economic innovations can be of five kinds:
  - The introduction of a new good (product or service or new quality in a good) to a consumer (e.g., telephone, radio, airplanes, automobiles, plastics, computers, etc.),
  - The introduction of a new method of production of a good (e.g., new semiconductor chip production processes)
  - The opening of a new market to the sales of a good (e.g., e-commerce by means of the Internet)
  - The obtaining of a new source of supply (inventing or finding or developing new material or energy sources) (e.g., seismic techniques for discovering oil deposits or horizontal drilling techniques)
  - The implementation of a new form of organization in a business that provides a competitive advantage to the business (e.g., lean-manufacturing or Toyota Produciton System) (Schumpeter 1939).

New Technology Industries and Early Economic Expansion in Industrialization

1770 – 1800

The beginning of the Industrial Revolution in England and next in Europe was based on the new technologies of steam-engine power, coke-fueled steel production, and textile machinery factories.

1830 – 1850

A second acceleration of the European Industrial Revolution was based on the innovation of the new technologies of railroads, steamships, telegraph, and coal-gas lighting.

1870 – 1895

Contributions to a third wave of economic expansion were made by innovations of new technologies in electrical light and power, telephone, and chemical dyes and petroleum production.

1895 – 1930

A fourth wave of economic expansion in both Europe and North America was based on innovations of new technologies in automobiles, airplanes, radio, and plastic materials.

Now, the economic contractions...

1800 – 1830

Temporary excess production capacity in iron production, steam engine production, and textile production increased economic competition and drove prices down for an economic recession.

1850 – 1870

Excessive investments in the new industries of railroads, steamships, and telegraph industries

1913

The third economic expansion from 1893–1913 was interrupted by the First World War in Europe.

1935

Then the economic expansion was renewed in North America and Japan, only to end in a worldwide depression — due, in part, to a collapse in the stock market in the United States and excessive inflation in Germany. The global depression did not end in several countries until military production in their economies restarted their industries — for weapons production.

Back to Kondratiev long wave

1. Science discovers phenomena that can provide for a new manipulation of nature by technological invention.

2. New basic technology provides business opportunities for new industries.

3. A new high-tech industry provides rapid market expansion and economic growth.

4. As the new industry continues to improve the technology, products are improved and prices decline and the market grows toward large volume.

5. Competitors enter the growing large market, investing in more production capacity.

6. As the technology begins to mature, production capacity begins to exceed market demand, triggering price cuts.

7. Excess capacity and lower prices cut margins and increase business failures and raise unemployment.

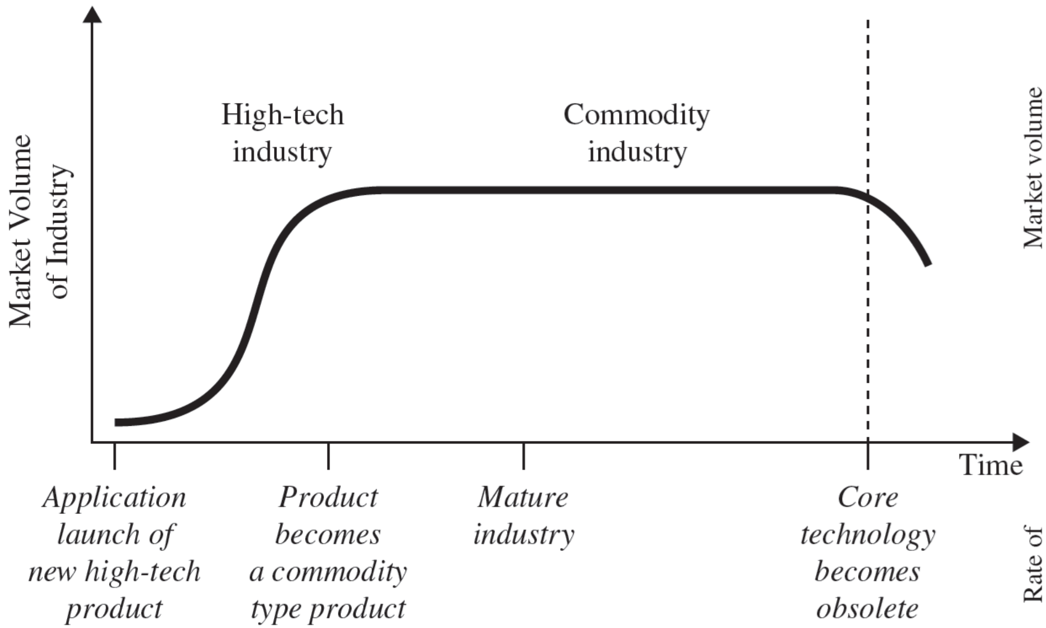
8. Turmoil in financial markets may turn recession into depression.

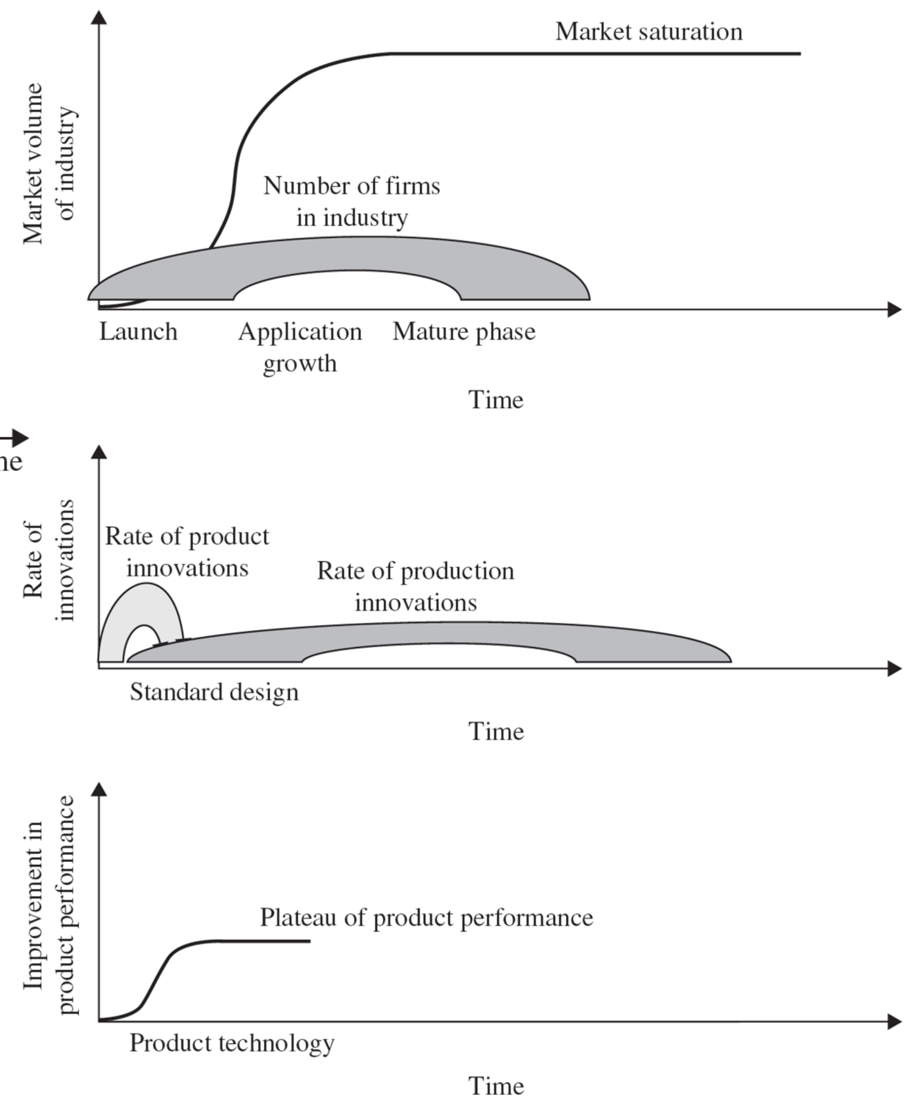
9. New science and new basic technologies may provide the basis for a new economic expansion.

Case Study: US Auto Industry

- The auto industry was created by the radical innovation of putting an engine onto the bicycle technology.
- J. Frank Duryea made and sold thirteen identical cars in Springfield, Massachusetts.
- In 1902, a gasoline-powered car defeated electric and steam cars at a racetrack in Chicago, establishing the dominance of the gasoline engine.
- Ford had in mind a large market — a car for people living on farms (50%).
- His commercial strategy was price and his technical strategy was durability.
- The key to his technical innovation would be in the weight and strength of the chassis of the automobile structure.
- It was a technological breakthrough that allowed Ford to imagine an innovative new product design: In 1905 he saw a French automobile wrecked in a smash-up. Looking over the wreck, he picked up a valve stem, very light and tough . . . it proved to be a French steel with vanadium alloy.
- Result: the overall weight of the **model T** was about half that of existing automobiles.
- Ford maintained about a 50 percent market share through 1924
- Take-home message: Performance, timing, market, price are the four factors for commercial success in innovation.

Industrial Life Cycles and Dynamics





Industrial Standards

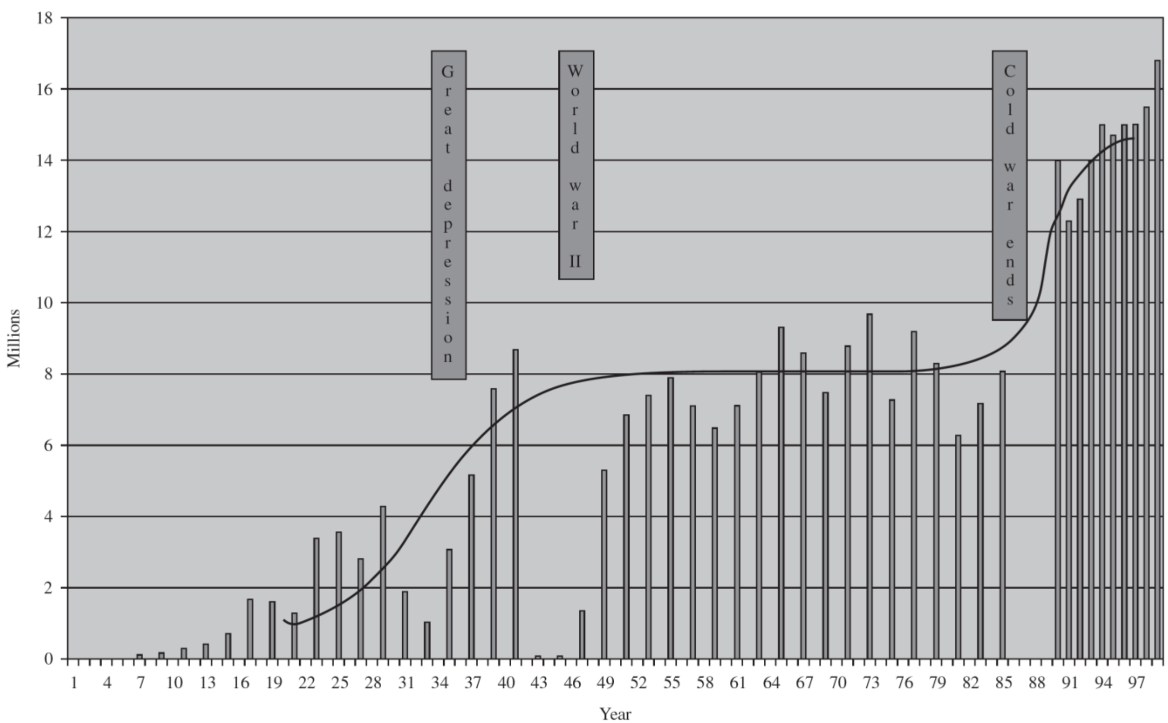
- In a new industry, a product-design standard defines the standard features, configuration, and performance of a **product line** in a new industry.
- A product-design **standard** is necessary for the high-volume growth of a new market around that product.
- Sometimes design standards arise not from an innovative product but from a deliberate act of cooperation between industry and government to set safety standards.
- Do you remember how long it took and how complex it was for Turkey to start the 3G era?

First movers

- In a new-technology industry, a first-mover firm is the first to complete its national business system to gain economic advantages of scale and scope.
- The necessary investments for a firm to become a first-mover in a new industry are:
  - Investments in advancing technology
  - Investments in large-scale production capacity
  - Investments in national (and international) distribution capability
  - Investments in developing management talent to grow the new industry
- What are the advantages and disadvantages of a first mover company?
- How about second movers? Books.com vs. Amazon.com

Case Study: US Auto firms over time

- Management focus from 1950 turned to refining existing technology, automating production techniques, styling and reducing numbers of parts.



Japanese cars + effect of end of cold war + introduction of electronics in control

- 1923: 8 firms (GM, Ford, Crysler, American Motors) survived, 24 failed
- 1960: 4 companies remaining, 1980: 3 remaining, 2008: all saved by the government
- Take-home message: How a company manages innovation and its product development process is critical to its competitiveness and to its long-term survival.

Any other industries with the same pattern?

- autos,
- televisions,
- vacuum tubes,
- typewriters,
- supercomputers,
- calculators, and
- IC chips

Commodity industries

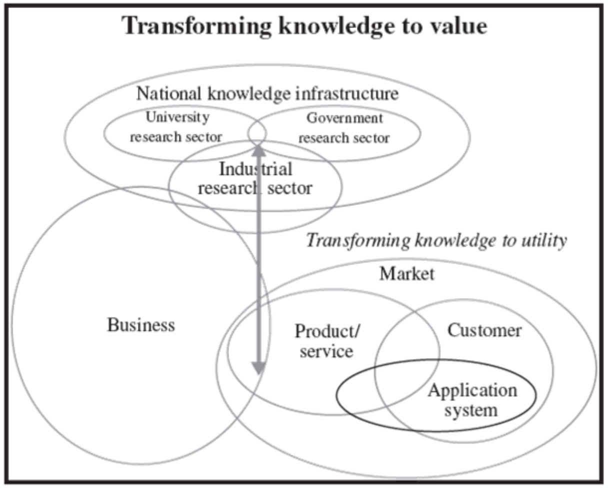
- As the core technologies in an industry mature in performance, products become relatively undifferentiated technically.
- Then, price and quality of the production become the primary competitive factors.
- *High-tech industries:* when the core technologies in their products and production are rapidly changing.
- *Mature (commodity) industries*: when the technologies in their products and production are no longer changing rapidly or much at all.

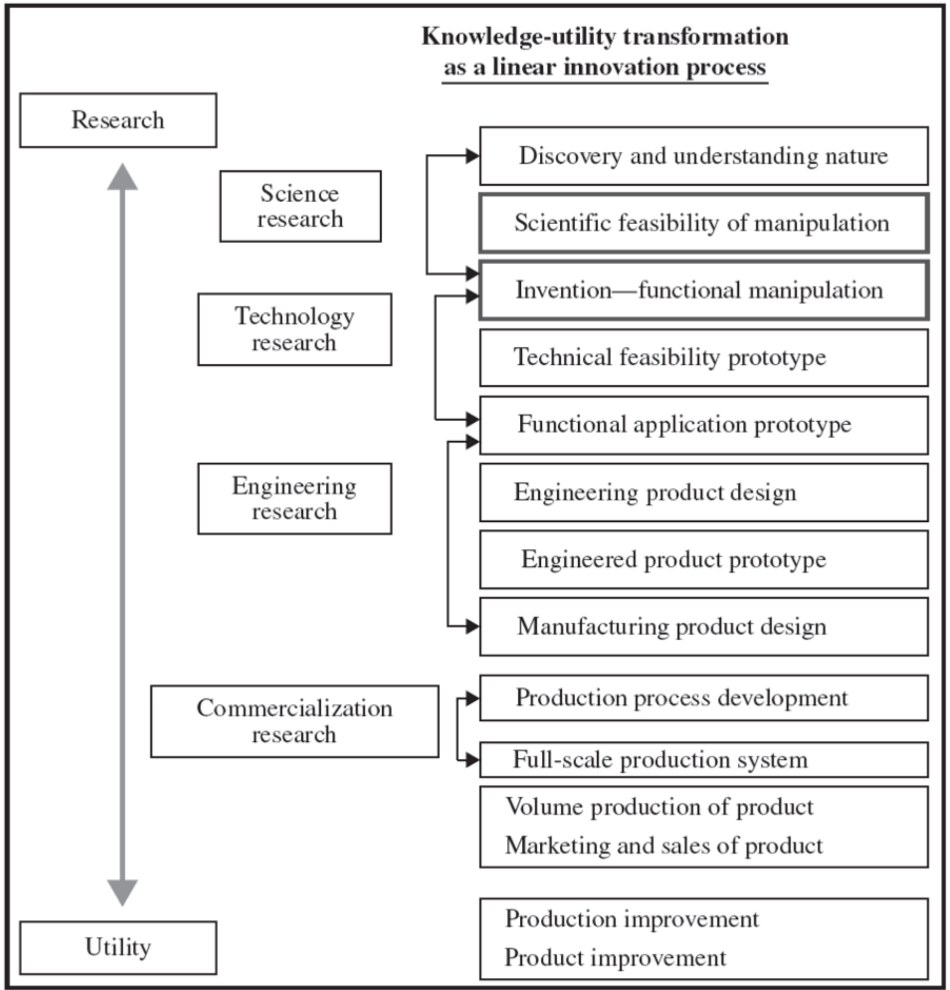
Commodity industries cnt'd

- Is the car industry a commodity industry? What can revolutionize it?
- Businesses in high-tech industries can compete based on their superior technical performance of product, whereas businesses in commodity industries can only compete on price and quality.
- The profit margin for any firm's product lines are determined by two conditions:
  - The internal conditions consist of the efficiency of the firm and the strategy of management.
  - The external conditions are the balance of supply to demand in the industry.
    - the number of competitors,
    - how rapidly technology is changing, and
    - how rapidly the market is growing.
- For all industries, there are two different business strategies over time, due to technological innovation: first a high-tech product strategy and later a commodity product strategy.

Logic of Innovation Research

- The kind of research to both invent and commercialize high-tech products/services has been called a *logic of innovation research.*
- It consists of 11 stages





Logic of Research for Innovation

- **Stages 1 and 2 — Scientific Understanding and Feasibility of Manipulation**
  - These stages show that the scientific basis of nature exists upon which a technological invention could be created. (Observation+ experimentation + analysis)
- **Stage 3 — Invention**
  - A basic invention shows how a particular function by the manipulation of nature can be accomplished by a new technology.
- **Stage 4 — A Technically Feasible Prototype**
  - A technically feasible prototype shows that the invention will perform a particular function but is not necessarily ready for an application.
  - Invention and problem solving are the two major research activities of technology-focused research.
- **Stage 5 — Functional Application Prototype**
  - A functional-application prototype demonstrates that the technical performance of the invention is sufficient to be successful for a particular commercial application.
- **Stage 6 — Engineering - Product Design**

Logic of Research for Innovation

- **Stage 7 — Engineering Product - Prototype**
  - The engineered-product prototype is the design of a product of sufficient performance that can be sold in large volume into the marketplace.
  - Research in the engineering stage of innovation can be research for improving technical performance for an engineering design and/or research for providing engineering design aides.
- **Stage 8 — Manufacturing - Product Design**
  - A manufacturing-product design modifies the engineering-product design to be volume-produced with production processes.
- **Stage 9 — Production Process Development and Full–Scale Production System**
  - Production-process development may require research focused on commercialization of a new high-tech product by inventing and developing new production technologies.
- **Stages 10 and 11 — Volume Production of Product & Product and Production Improvement**
  - Continuing research in commercialization for improving product quality and lowering product cost is necessary to remain competitive.
  - Research in the commercialization stage may be performed to establish product standards.

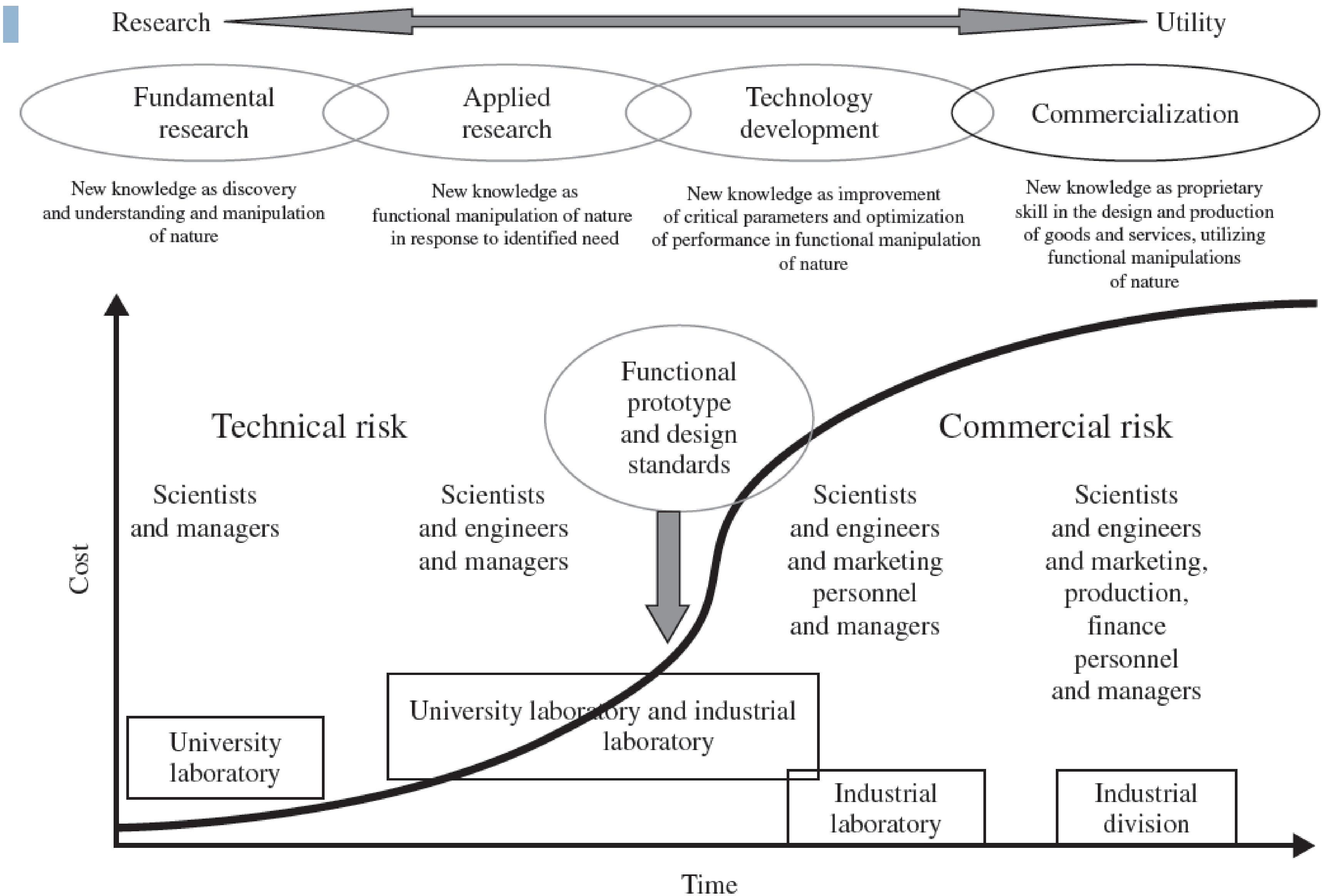
Research Issues and Costs of Innovation

- Each category of research focuses on different kinds of research issues:

Science *Discovery* *Theory*	*Technology* *Invention* *Problem-solving*
Engineering *Design* *System*	*Commercialization* *Standards* *Production*

- **Most of the money a business may lose** upon the commercial failure of a new product or new service occurs **in the commercialization stage**, when the new product **fails** to deliver a performance or price advantage to a customer against competitive products.
- This is the **commercial risk** in innovation.

Radical new product realization process



Highlights from Corporate Research

- In 1989, the NEC Corporation in Japan spent 10 percent of sales on research and development, performing R&D in the corporate research laboratory and in divisional laboratories distributed in the 190 businesses of NEC
- In 1992, the United States had about 1,000,000 R&D engineers and scientists, with Japan having about 800,000 and Germany about 600,000.
- The fraction of gross domestic product spent for R&D has been around 2.5 percent for the United States, Japan, and Germany. (TR: 0.8%)
- H.P. now runs a yearly online contest, soliciting grant proposals from universities worldwide. The H.P. grants are typically about $ 75,000 a year, and many of the collaborative projects are intended to last three years. In June (2009), the company announced 61 winners from 46 universities and 12 countries . . .

How about the planning for incremental innovation?

- Incremental innovation can be planned differently, more directly as a set of projects, a portfolio of technology-focused projects — with the research logic focused on technology

Quote: [**http://en.wikipedia.org/wiki/Technology_readiness_level**]

1. Basic principles are observed and reported.

2. Technology concept and/or application is formulated.

3. Analytical and experimental critical function and/or characteristic proof-of-concept are investigated.

4. Component and/or breadboard validation is done in a laboratory environment.

5. Component and/or breadboard validation is done in a relevant environment.

6. System/subsystem model or prototype is done in an operational environment.

7. Actual system is completed and “ operationally qualified ” through test and demonstration.

8. Actual system is tested in successful mission operations (Mankins 1995).

Research Lab vs. Business Division

- Stages in evaluation of research projects and/or joint research and business personnel evaluation of R&D projects work well for incremental innovation because current businesses can provide a clear market focus for innovation.
- But, the cultural challenge remains:

Perspectives	R&D Org	Business-Unit Org
Time horizon	Long term	Short term
Financial	Expense center	Profit center
Product	Information	Goods/services
Method	Technology push	Market pull

Evaluating Corporate R&D

- R&D is an investment in the corporation's future, and so should be ultimately evaluated on **Return On Investment (ROI).**
- However, in practice, this is **difficult** to do because of the time spans involved.
- **The more basic** the research, **the longer** is the time to pay off. The more developmental the research, the shorter is the time.
  - The times from basic research to technological innovation have historically varied from **seventy years to a minimum of ten years.**
  - For applied and developmental research, the time from technological innovation to break even has been from **two to five years.**
- Accordingly, budgeting corporate R&D is difficult because it is **a risky investment** of different kinds and over varying periods of time-to-return of investment.
- For this reason, most R&D is usually **deducted as a current operating expense** and treated as a **part of the administrative overhead**.
- In practice, most R&D budgeting is done by incremental budgeting, **increasing research a little when business times are good, cutting research when profits drop**.
- For example, high-tech firms spend in the range of **6 percent to 15 percent of sales**, whereas mature technology firms may spend **1 percent of sales or less.**