Strategic Innovation Management

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Lecture 3. Types and patterns of innovation

- 1. Types of innovation
- 2. Technology cycles
- 3. Case-study: Tesla Motors

- The main **objective** of this lecture is to consider different types of innovation and technology S-curves.

TYPES OF INNOVATION

- Technological innovations are often described using dimensions such as “radical” versus “incremental.” Different types of innovation require different kinds of underlying knowledge and have different impacts on the industry’s competitors and customers.
- Four of the dimensions most commonly used to categorize innovations are described here: product versus process innovation, radical versus incremental, competence enhancing versus competence destroying, and architectural versus component.

Main types of innovation according to Oslo Manual

- 1) A **product innovation** is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. Product innovations can utilize new knowledge or technologies, or can be based on new uses or combinations of existing knowledge or technologies.
- 2) A **process innovation** is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. Process innovations can be intended to decrease unit costs of production or delivery, to increase quality, or to produce or deliver new or significantly improved products.
- 3) A **marketing innovation** is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. Marketing innovations are aimed at better addressing customer needs, opening up new markets, or newly positioning a firm's product on the market, with the objective of increasing the firm's sales.
- 4) An **organizational innovation** is the implementation of a new organizational method in the firm's business practices, workplace organization or external relations. Organizational innovations can be intended to increase a firm's performance by reducing administrative costs or transaction costs, improving workplace satisfaction (and thus labor productivity), gaining access to non-tradable assets (such as non-codified external knowledge) or reducing costs of supplies.

Product Innovation versus Process Innovation

Product innovations are embodied in the outputs of an organization—its goods or services. For example, Honda's development of a new hybrid electric vehicle is a product innovation. 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. For example, a process innovation at a biotechnology firm might entail developing a genetic algorithm that can quickly search a set of disease-related genes to identify a target for therapeutic intervention. In this instance, the process innovation (the genetic algorithm) can speed up the firm's ability to develop a product innovation (a new therapeutic drug).

Radical Innovation versus Incremental Innovation

One of the primary dimensions used to distinguish types of innovation is the continuum between radical versus incremental innovation. A number of definitions have been posed for **radical innovation** and **incremental innovation**, but most hinge on the degree to which an innovation represents a departure from existing practices. Thus 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. 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.

The radicalness of innovation is also sometimes defined in terms of risk. Since radical innovations often embody new knowledge, producers and customers will vary in their experience and familiarity with the innovation, and in their judgment of its usefulness or reliability. The development of third generation (3G) telephony is illustrative. 3G wireless communication technology utilizes broadband channels. This increased bandwidth gives mobile phones far greater data transmission capabilities that enable activities such as videoconferencing and accessing the most advanced Internet sites.

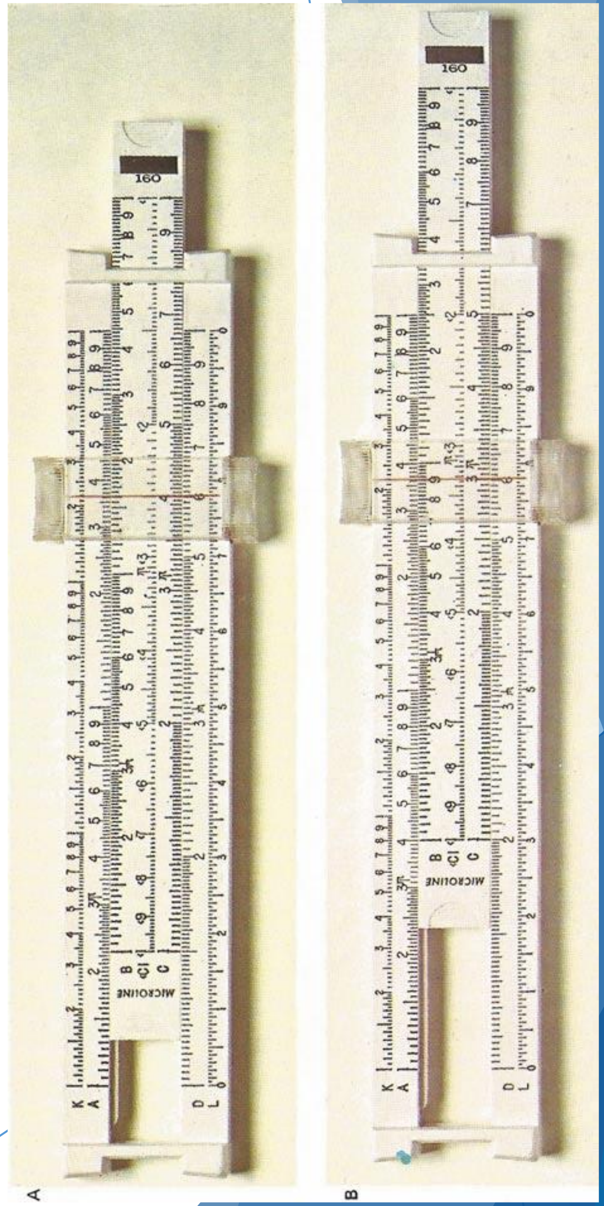
For companies to develop and offer 3G wireless telecommunications service required a significant investment in new networking equipment and an infrastructure capable of carrying a much larger bandwidth of signals. It also required developing phones with greater display and memory capabilities, and either increasing the phone’s battery power or increasing the efficiency of the phone’s power utilization. Any of these technologies could potentially pose serious obstacles. It was also unknown to what degree customers would ultimately value broadband capability in a wireless device. Thus, the move to 3G required managers to assess several different risks simultaneously, including technical feasibility, reliability, costs, and demand.

Finally, 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. For example, while the first steam engine was a monumental innovation, today its construction seems relatively simple. Furthermore, an innovation that is radical to one firm may seem incremental to another. Although both Kodak and Sony introduced digital cameras for the consumer market within a year of each other (Kodak's DC40 was introduced in 1995, and Sony's Cyber-Shot Digital Still Camera was introduced in 1996), the two companies' paths to the introduction were quite different. Kodak's historical competencies and reputation were based on its expertise in chemical photography, and thus the transition to digital photography and video required a significant redirection for the firm. Sony, on the other hand, had been an electronics company since its inception, and had a substantial level of expertise in digital recording and graphics before producing a digital camera. Thus, for Sony, a digital camera was a straightforward extension of its existing competencies.

Competence-Enhancing Innovation versus Competence-Destroying Innovation

Innovations can also be classified as **competence enhancing** versus **competence destroying**. 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. 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.

For example, from the 1600s to the early 1970s, no self-respecting mathematician or engineer would have been caught without a **slide rule**. Slide rules are lightweight devices, often constructed of wood, that use logarithm scales to solve complex mathematical functions. They were used to calculate everything from the structural properties of a bridge to the range and fuel use of an aircraft. Specially designed slide rules for businesses had, for example, scales for doing loan calculations or determining optimal purchase quantities. During the 1950s and 1960s, Keuffel & Esser was the preeminent slide-rule maker in the United States, producing 5,000 slide rules a month.



- However, in the early 1970s, a new innovation relegated the slide rule to collectors and museum displays within just a few years: the inexpensive handheld **calculator**. Keuffel & Esser had no background in the electronic components that made electronic calculators possible and was unable to transition to the new technology. By 1976, Keuffel & Esser withdrew from the market.3 Whereas the inexpensive handheld calculator built on the existing competencies of companies such as Hewlett-Packard and Texas Instruments (and thus for them would be competence enhancing), for Keuffel & Esser, the calculator was a competence-destroying innovation.

Architectural Innovation versus Component Innovation

- Most products and processes are hierarchically nested systems, meaning that at any unit of analysis, the entity is a system of components, and each of those components is, in turn, a system of finer components, until we reach some point at which the components are elementary particles. For example, a bicycle is a system of components such as a frame, wheels, tires, seat, brakes, and so on. Each of those components is also a system of components: The seat might be a system of components that includes a metal and plastic frame, padding, a nylon cover, and so on.

- An innovation may entail a change to individual components, to the overall architecture within which those components operate, or both. 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. In the example above, an innovation in bicycle seat technology (such as the incorporation of gel-filled material for additional cushioning) does not require any changes in the rest of the bicycle architecture.

- In contrast, an **architectural innovation** entails changing the overall design of the system or the way that components interact with each other. An innovation that is strictly architectural may reconfigure the way that components link together in the system, without changing the components themselves. Most architectural innovations, however, create changes in the system that reverberate throughout its design, requiring changes in the underlying components in addition to changes in the ways those components interact. **Architectural innovations often have far-reaching and complex influences on industry competitors and technology users**.
- For example, the transition from the high-wheel bicycle to the safety bicycle was an architectural innovation that required (and enabled) the change of many components of the bicycle and the way in which riders propelled themselves. In the 1800s, bicycles had extremely large front wheels. Because there were no gears, the size of the front wheel directly determined the speed of the bicycle since the circumference of the wheel was the distance that could be traveled in a single rotation of the pedals. However, by the start of the twentieth century, improvements in metallurgy had enabled the production of a fine chain and a sprocket that was small enough and light enough for a human to power. This enabled bicycles to be built with two equally sized wheels, while using gears to accomplish the speeds that the large front wheel had enabled. Because smaller wheels meant shorter shock-absorbing spokes, the move to smaller wheels also prompted the development of suspension systems and pneumatic (air-filled) tires. The new bicycles were lighter, cheaper, and more flexible. This architectural innovation led to the rise of companies such as Dunlop (which invented the pneumatic tire) and Raleigh (which pioneered the three-speed, all-steel bicycle), and transformed the bicycle from a curiosity into a practical transportation device.

Using the Dimensions

Though the dimensions described above are useful for exploring key ways that one innovation may differ from another, these dimensions are not independent, nor do they offer a straightforward system for categorizing innovations in a precise and consistent manner. Each of the above dimensions shares relationships with others—for example, architectural innovations are often considered more radical and more competence destroying than component innovations. Furthermore, how an innovation is described on a dimension often depends on who is doing the describing and with what it is being compared.

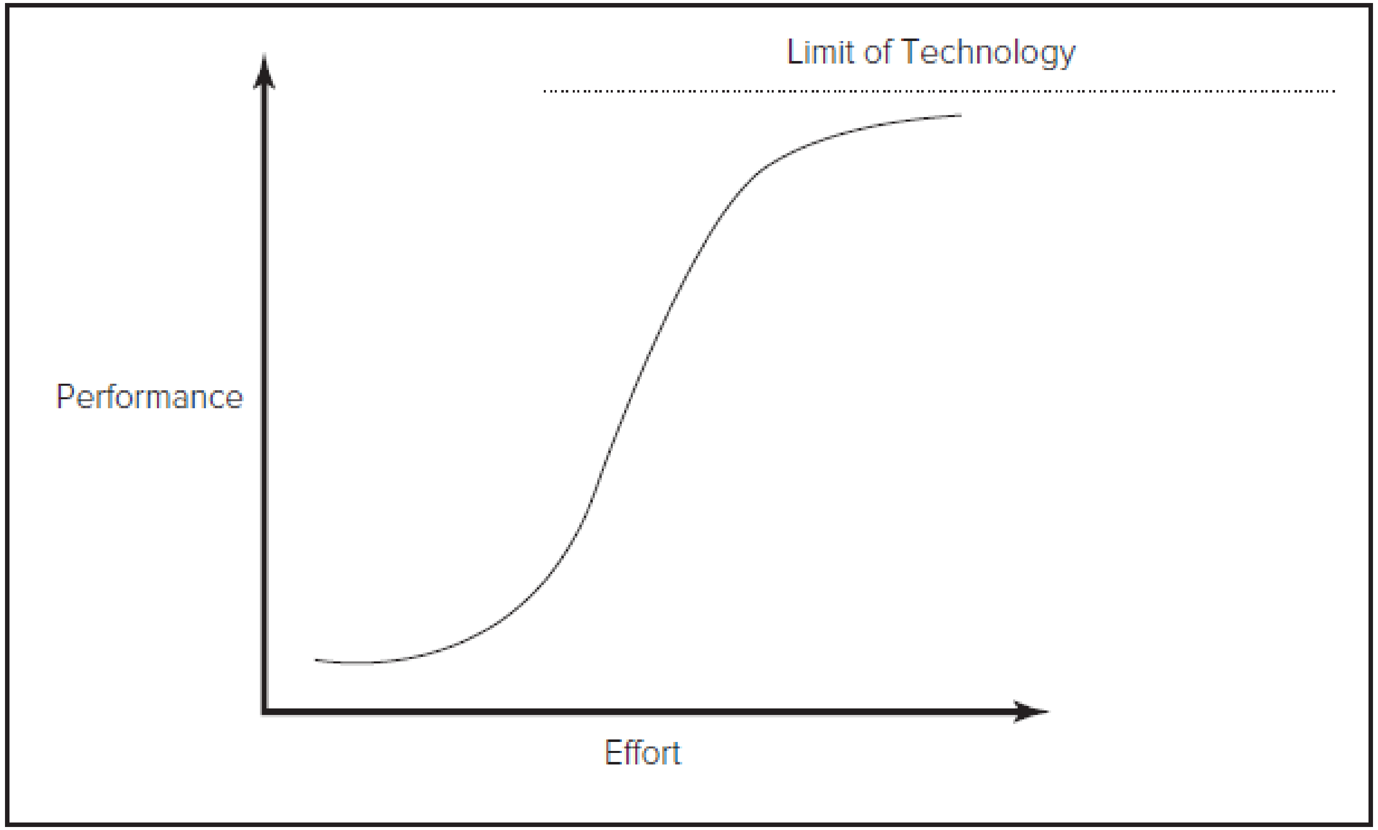
An all-electric vehicle, for example, might seem like a radical and competence destroying innovation to a manufacturer of internal combustion engines, but to a customer who only has to change how they fuel/charge the vehicle, it might seem like an incremental and competence-enhancing innovation. Thus, while the dimensions above are valuable for understanding innovation, they should be considered relative dimensions whose meaning is dependent on the context in which they are used. We now will turn to exploring patterns in technological innovation. Numerous studies of innovation have revealed recurring patterns in how new technologies emerge, evolve, are adopted, and are displaced by other technologies. We begin by examining technology s-curves.

TECHNOLOGY S-CURVES

- Both the rate of a technology’s performance improvement and the rate at which the technology is adopted in the marketplace repeatedly have been shown to conform to an s-shape curve. Though s-curves in technology performance and s-curves in technology diffusion are related (improvements in performance may foster faster adoption, and greater adoption may motivate further investment in improving performance), they are fundamentally different processes. S-curves in technology improvement are described first, followed by s-curves in technology diffusion. This section also explains that despite the allure of using s-curves to predict when new phases of a technology’s life cycle will begin, doing so can be misleading.

S-Curves in Technological Improvement

- Many technologies exhibit an s-curve in their performance improvement over their lifetimes. 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



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 com

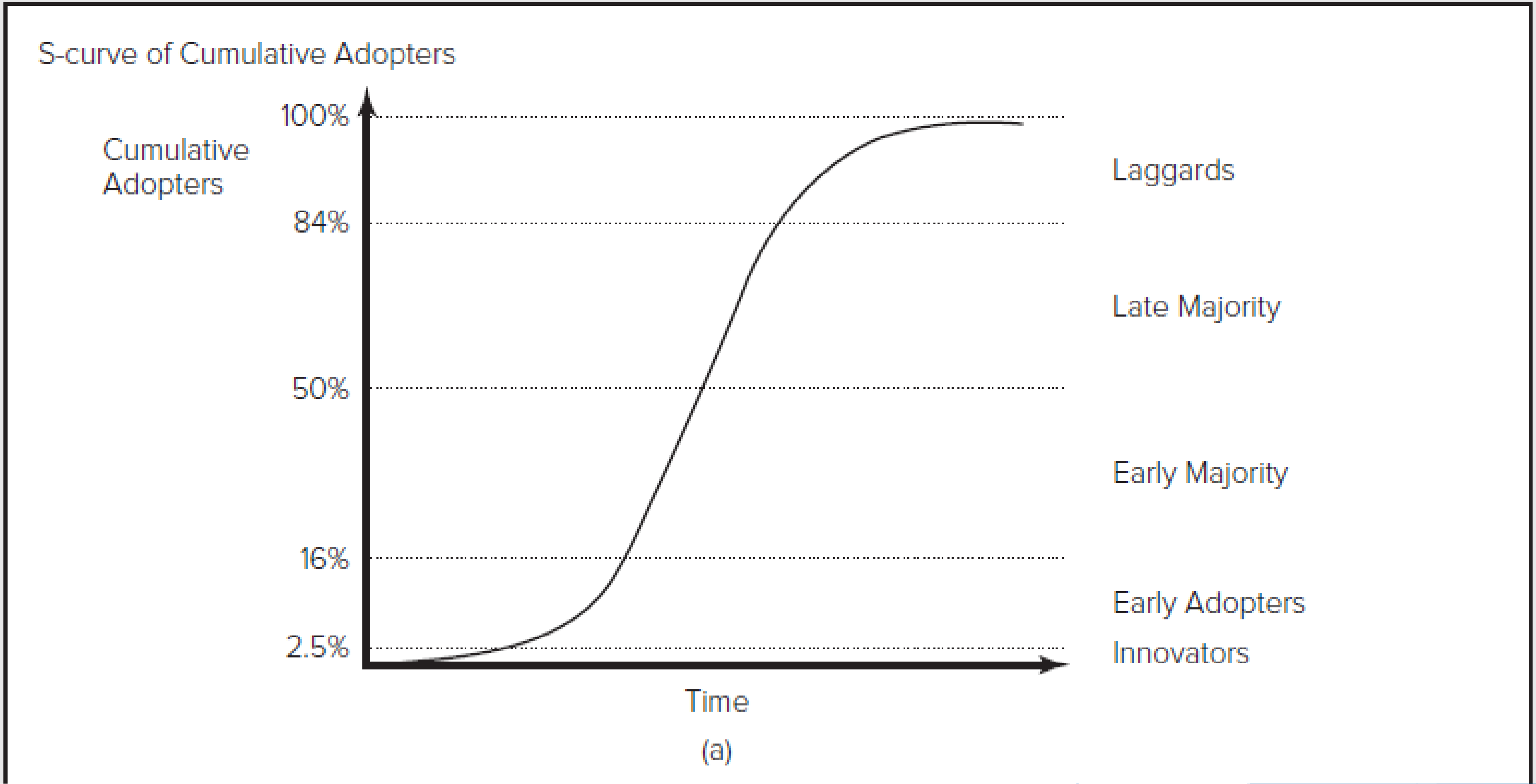
Initially, the technological discontinuity may have lower performance than the incumbent technology. For instance, one of the earliest automobiles, introduced in 1771 by Nicolas Joseph Cugnot, was never put into commercial production because it was much slower and harder to operate than a horse-drawn carriage. It was three-wheeled, steam-powered, and could travel at 2.3 miles per hour. A number of steam- and gaspowered vehicles were introduced in the 1800s, but it was not until the early 1900s that automobiles began to be produced in quantity. pact discs were all technological discontinuities.

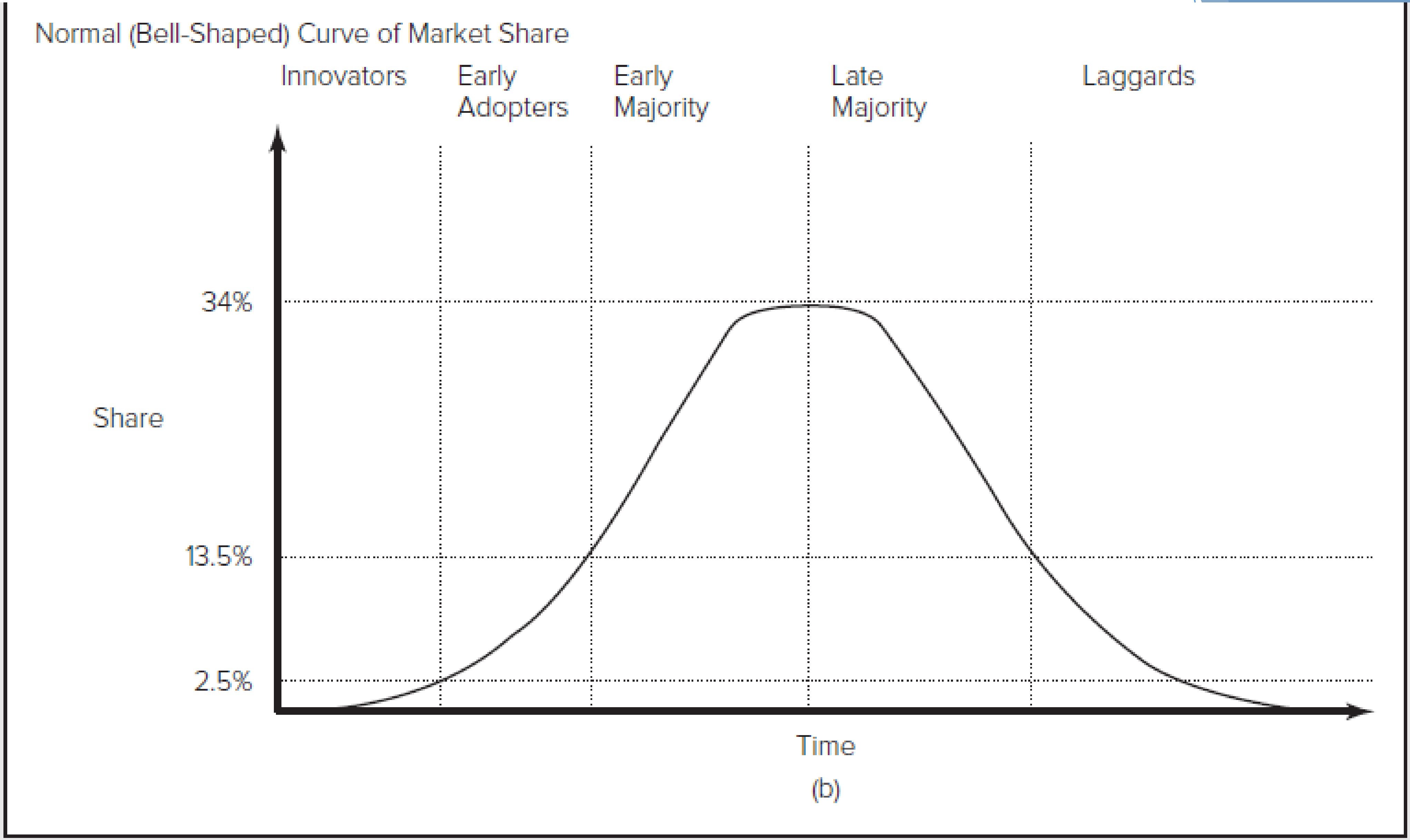
S-Curves in Technology Diffusion

S-curves are also often used to describe the diffusion of a technology. Unlike s-curves in technology performance, 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.

Technology Diffusion S-Curve with Adopter Categories




Normal (Bell-Shaped) Curve of Market Share
Innovators
Early Adopters
Early Majority
Late Majority
Laggards
34%
Share
13.5%
2.5%
Time
(b)

S-curves in technology diffusion are often explained as a process of different categories of people adopting the technology at different times. One typology of adopter categories that gained prominence was proposed by Everett M. Rogers.*a* Figure 1-2 shows each of Rogers's adopter categories on a technology diffusion s-curve. The figure also shows that if the noncumulative share of each of these adopter groups is plotted on the vertical axis with time on the horizontal axis, the resulting curve is typically bell shaped (though in practice it may be skewed right or left).

INNOVATORS

Innovators are the first individuals to adopt an innovation. Extremely adventurous in their purchasing behavior, they are comfortable with a high degree of complexity and uncertainty. Innovators typically have access to substantial financial resources (and thus can afford the losses incurred in unsuccessful adoption decisions). Though they are not always well integrated into a particular social system, innovators play an extremely important role in the diffusion of an innovation because they are the individuals who bring new ideas into the social system. Rogers estimated that the first 2.5 percent of individuals to adopt a new technology are in this category.

EARLY ADOPTERS

The second category of adopters is the early adopters. Early adopters are well integrated into their social system and have the greatest potential for opinion leadership. Early adopters are respected by their peers and know that to retain that respect they must make sound innovation adoption decisions. Other potential adopters look to early adopters for information and advice; thus early adopters make excellent missionaries for new products or processes. Rogers estimated that the next 13.5 percent of individuals to adopt an innovation (after innovators) are in this category.

EARLY MAJORITY

Rogers identifies the next 34 percent of individuals in a social system to adopt a new innovation as the early majority. The early majority adopts 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

The next 34 percent of the individuals in a social system to adopt an innovation are the late majority, according to Rogers. Like the early majority, the late majority constitutes one-third of the individuals in a social system. Those in the late majority approach innovation with a skeptical air and may not adopt the innovation until they feel pressure from their peers. The late majority may have scarce resources, thus making them reluctant to invest in adoption until most of the uncertainty about the innovation has been resolved.

LAGGARDS

The last 16 percent of the individuals in a social system to adopt an innovation are termed *laggards*. They may base their decisions primarily upon past experience rather than influence from the social network, and they possess almost no opinion leadership. They are highly skeptical of innovations and innovators, and they must feel certain that a new innovation will not fail before adopting it.

Questions:

- 1. What are some reasons that established firms might resist adopting a new technology?
- 2. Are well-established firms or new entrants more likely to (*a*) develop and/or (*b*) adopt new technologies? Why?
- 3. Think of an example of an innovation you have studied at work or school. How would you characterize it on the dimensions described at the beginning of the lecture?
- 4. What are some reasons that both technology improvement and technology diffusion exhibit s-shape curves?
- 5. Why do technologies often improve faster than customer requirements? What are the advantages and disadvantages to a firm of developing a technology beyond the current state of market needs?
- 6. In what industries would you expect to see particularly short technology cycles? In what industries would you expect to see particularly long technology cycles? What factors might influence the length of technology cycles in an industry?

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Thank you for your attention!