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**Master’s Degree in Computer Science**

**Academic year 2023/2024**

**ECONOMICS AND MANAGEMENT**

**OF INNOVATION**

**Prof. Silvia Rita Sedita**

**Prof. Amir Maghssudipour**

Written by Michael Amista’

Based on “Strategic Management of Technological Innovation (Seventh Edition) –

Melissa A. Schilling”

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# **Chapter 1: Introduction**

**Technological innovation** is now the most important driver of competitive success in many industries.

* Many firms earn over one-third of sales on products developed within last five years.
* Product innovations help firms protect margins by offering new, differentiated features.
* Process innovations help make manufacturing more efficient.

**Advances in information technology** have enabled a faster innovation (CAD/CAM systems).

The importance of innovation and advances in information technology have led to:

* Shorter product lifecycles (more rapid product obsolescence).
* More rapid new product introductions.
* Greater market segmentation.

Innovation enables a wider range of goods and services to be delivered to people worldwide.

However, may result in negative externalities: for example, pollution, erosion, antibiotic-resistant bacteria.

[**Externalities**: “in economy environment is the set of effects, negative or positive, caused by a production or consumption activity of a subject”]

Successful innovation requires **strategies and implementation processes**. Most innovative ideas do not become successful new products; many projects do not result in technically feasible products and, of those that do, many fail to earn a commercial return.

The content of the course is divided into three parts:

1. **Part One: The foundations of technological Innovation**.

* C02: Sources of innovation.
* C03: Types and patterns of innovation.
* C04: Standards battles and design dominance.
* C05: Timing of Entry (non-attending students).

1. **Part Two: Formulating Technological Innovation Strategy**.

* C06: Defining the organization’s strategic direction.
* C07: Choosing innovation projects (non-attending students).
* C08: Collaboration strategies.
* C09: Protecting innovation.

1. **Part Three: Implementing Technological Innovation Strategy**.

* C10: Organizing for innovation (non-attending students).
* C11: Managing the new product development process.
* C12: Managing new product development teams.
* C13: Crafting a deployment strategy (non-attending students).

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# **Chapter 2: Sources of innovation**

Innovation can arise from many different sources, as:

* **individuals**, as users who design solutions for their own needs;
* **universities research**;
* **government-funded research**;
* **private** **nonprofit organizations**;
* the primary engine of innovation is **firms**. Firms have greater resources than individuals and they also face strong incentives to develop differentiating new products and services, which may give them and advantage over nonprofit or government-funded entities.

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Descrizione generata automaticamenteThe most important source of innovation, however, does not arise from any one of these sources, but rather the **linkages** between them. **Networks of innovators** that leverage knowledge and other resources from multiple sources are one of the most powerful agents of technological innovation.

**CREATIVITY**

Innovation begins with the generation of new useful ideas, what is called **creativity**. Novel work must be different from work that has been previously produced and surprising (not so intuitive).

An **individual’s creative ability** is a function of his/her *intellectual abilities, knowledge, personality, motivation,* and *environment*.

The creativity of the organization (**organizational creativity**) is a function of creativity of the individuals and a variety of social processes and contextual factors that shape how those individuals interact and behave.

The methods to encourage organizational creativity are:

* idea collection systems (e.g. Google’s idea management system);
* creativity training programs;
* culture that encourages.

**Innovation is the combination of a creative idea with resources and expertise able to transform the idea in a useful form**.

One 10-year study of **inventors** concludes that the most successful inventors possess the following characteristics:

1. They have mastered the basic tools and operations of the field in which they invent, but they have not specialized solely in that field.
2. They are curious and more interested in problems than solutions.
3. They question the assumptions made in previous work in the field.
4. They often have the sense that all knowledge is unified. They seek global solutions rather than local solutions.

Such individuals may develop many new devices or processes but commercialize few.

**INNOVATION BY USERS**

Innovation often originates with those who create solutions for their own needs.

Users have a deep understanding of their own needs, and motivation to fulfil them. While manufacturers typically create innovations to profit from their sales, user innovators often initially create innovations purely for their own use.

**RESEARCH AND DEVELOPMENT BY FIRMS (R&D)**

**Research** refers to both basic and applied research.

* *Basic* *research* aims at increasing understanding of a topic or field without an immediate commercial application in mind.
* *Applied* *research* aims at increasing understanding of a topic or field to meet a specific need.

**Development** refers to activities that apply knowledge to produce useful devices or processes.

There are two approaches for R&D by firms:

* *Science Push* approaches suggest that innovation proceeds linearly:

Scientific discovery → invention → manufacturing → Marketing.

* *Demand Pull* approaches argued that innovation originates from customer needs:

Customer suggestions → invention → Manufacturing.

Most current research argues that innovation is not so simple and may originate from a variety of sources and follow a variety of paths.

Firms often form **alliances** with customers, suppliers, universities, and even competitors to jointly work on an innovation project or to exchange information/resources. **External and internal sources** of information are complements. In fact, firms exploit external collaboration networks just to complete their in-house R&D research and not as a substitute of their work. Doing in-house R&D may help firms to build an ***absorptive capacity*** that enables them to better use the information obtained externally.

Many universities encourage research that leads to useful innovations. Revenues from universities inventions are still very small, but universities can also contribute to innovation through publication of research results.

Governments invest in research through their own laboratories; science parks and incubators; grants for other public or private research organizations.

Many nonprofit organizations do in-house R&D, fund R&D to others, or both.

**Collaborative research** is especially important in high-technology sectors where individual firms rarely possess all necessary resources and capabilities. As firms forge collaborative relationships, they shape a **larger network** that influences the diffusion of information and other resources. The size and structure of this network changes over time due to changes in alliance activity.

**TECHNOLOGY CLUSTERS**

Technology Clusters are regional clusters of firms that have a connection to a common technology (e.g. Silicon Valley’s); they may work with the same suppliers and customers.

🡺 **POSITIVE ASPECTS**:

* Proximity facilitates knowledge exchange.
* Cluster of firms can attract other firms to area.
* Supplier and distributor markets grow to service the cluster.
* Cluster of firms may make local labour pool more valuable by giving them experience.
* Cluster can lead to infrastructure improvements (for example, better roads, utilities, schools, etc.).

🡺 **NEGATIVE ASPECTS**:

* Increased competition.
* Knowledge leakage.
* Congestion.
* Pollution.

Agglomeration economies depend on the nature of the technology, industry characteristics and the cultural context of the technology.

**Technological spillovers** occur when the benefits from the research activities of one firm (or nation or other entity) spill over to other firms (or nations or other entities). Spillovers are thus a positive externality of R&D efforts. Evidence suggests that technology spillovers are a significant influence on innovative activities.

Whether R&D benefits will spill over is partially a function of

* the **strength of** **protection mechanisms**, such as patents and copyrights;
* the nature of the **knowledge base** (e.g., tacit knowledge may not flow readily across firm boundaries);
* the **mobility of the labour pool**.

# **Chapter 3: Types and patterns of innovation**

Several dimensions are used to **categorize innovations**. These dimensions help clarify how different innovations offer different opportunities.

The path a technology follows through time is termed “***technology trajectory****”*. Technology trajectories help us to understand how technologies improve and are diffused.

**PRODUCT VERSUS PROCESS INNOVATION**

*Product innovations* refers to the outputs of an organization, its goods or services.

*Process innovations* are innovations in the way an organization conducts its business, such as in techniques of producing or marketing goods or services.

Product innovations can enable process innovations and vice versa.

What is a product innovation for one organization might be a process innovation for another.

* For example, UPS creates a new distribution service (product innovation) that enables its customers to distribute their goods more widely or more easily (process innovation).

**RADICAL VERSUS INCREMENTAL INNOVATION**

The *radicalness of an innovation* is the degree to which it is new and different from previously existing products and processes.

*Incremental innovations* may involve only a minor change from (or adjustment to) existing practices.

The radicalness of an innovation is relative; it may change over time based on different observers. Radical innovation creates less companies, less economy, than the incremental one; we can count more incremental innovations, made by small step on a previously existing technology, than the radical ones. Radical innovation is destructive: it destroys what was previous leading to a new dominant design.



**COMPETENCE-ENHANCING VERSUS COMPETENCE-DESTROYING INNOVATION**

*Competence-enhancing innovations* are built on the firm’s existing knowledge base.

* For example, Intel’s Pentium 4 built on the technology for Pentium III.

*Competence-destroying innovations* renders a firm’s existing knowledge base obsolete.

* For example, electronic calculators rendered Keuffel and Esser’s slide rule expertise obsolete.

**ARCHITECTURAL VERSUS COMPONENT INNOVATION**

A *component innovation* (or modular innovation) entails changes to one or more components of a product system without significantly affecting the overall design.

An *architectural innovation* entails changing the overall design of the system or the way components interact. Most architectural innovations require changes in the underlying components also.

**SOCIAL INNOVATION**

There are also entirely new fields, like social innovation, which regards a wide range of activities addressing social problems, meeting social needs, and forming new collaborations according to the territory and the place they emerge (e.g., activism, crowdfunding).

**S-CURVES**

Both the rate of a technology’s improvement, and its rate of diffusion to the market typically follow an s-shaped curve.

**S-CURVES IN TECHNOLOGICAL IMPROVEMENT**

1. Technology improves slowly at first because it is poorly understood.

2. Then accelerates as understanding increases.

3. Then tapers off as approaches its limits.

Technologies do not always reach their limits. May be displaced by new, ***discontinuous technology***.

A discontinuous technology fulfills a similar market need by and it is shaped by a new knowledge base (e.g, carbon copying to photocopying, vinyl to compact discs).

Technological discontinuity may initially have lower performance than incumbent technology (e.g., first automobiles were much slower than horse-drawn carriages). Firms may be reluctant to adopt new technology because performance improvement is initially slow and costly, and they may have significant investment in incumbent technology.

**S-CURVES IN TECHNOLOGICAL DIFFUSION**

Adoption is initially slow because the technology is unfamiliar. It accelerates as technology becomes better understood.

Eventually market is saturated and rate of new adoptions declines.

Technology diffusion tends to take far longer than information diffusion.

* Technology may require acquiring complex knowledge or experience.
* Technology may require complementary resources to make it valuable (for example, cameras not valuable without film).

**S-CURVES AS A PRESCRIPTIVE TOOL**

Mapping the technology’s s-curve is useful for gaining a deeper understanding of its rate of improvement or limits, its use as a prescriptive tool is limited.

* True limits of technology may be unknown.
* Shape of s-curve can be influenced by changes in the market, component technologies, or complementary technologies.
* Firms that follow s-curve model too closely could end up switching technologies too soon or too late.

**TECHNOLOGY CYCLES**

Technological change tends to be 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.

Utterback and Abernathy characterized the technology cycle into two phases:

* The *fluid phase* (when there is considerable uncertainty about the technology and its market; firms experiment with different product designs in this phase).
* After a **dominant design** emerges, the specific phase begins (when firms focus on incremental improvements to the design and manufacturing efficiency).

Anderson and Tushman also found that technological change proceeded cyclically. Each discontinuity inaugurates a period of turbulence and uncertainty (era of ferment) until a dominant design is selected, ushering in an era of incremental change.

Anderson and Tushman found that:

* A dominant design always rose to command the majority of market share unless the next discontinuity arrived too early.
* The dominant design was never in the same form as the original discontinuity but was also not on the leading edge of technology. It bundled the features that would meet the needs of the majority of the market.

During the era of incremental change, firms often cease to invest in learning about alternative designs and instead focus on developing competencies related to the dominant design.

This explains in part why incumbent firms may have difficulty recognizing and reacting to a discontinuous technology.

# **Chapter 4: Standards battles and design dominance**

***Dominant design***: a product design that is adopted by the majority of producers, typically creating a stable architecture on which the industry can focus its efforts.

Many industries experience strong pressure to select a single (or few) dominant design(s).

There are multiple dimensions shaping which technology rises to the position of the dominant design. Firm strategies can influence several of these dimensions, improving the likelihood of their technologies rising to dominance.

**WHY DOMINANT DESIGNS ARE SELECTED**

One primary reason is that many industries exhibit **increasing returns to adoption**, meaning that the more a technology is adopted, the more valuable it becomes.

As a technology is used, producers learn how to make it more efficient and effective by accumulating experience and sales revenues that can be reinvested in further developments.

So, the technologies adopted earlier than others are likely to become better developed, making it difficult for other technologies to catch up.

A technology with a large installed base attracts developers of complementary goods; a technology with a wide range of complementary goods attracts users, increasing the installed base 🡺 a self-reinforcing cycle.

**GOVERNMENT REGULATION**: sometimes the consumer welfare benefits of having a single dominant design and this prompts government organizations to intervene, imposing a standard (e.g., color standard in television).

**RESULT**: Winner-take-all markets (natural monopoly) and firms supporting winning technologies earn huge rewards; others may be locked out.

A dominant design can have far-reaching influence; it shapes future technological investigation in the area.

**MULTIPLE DIMENSIONS OF VALUE**

In many increasing returns industries, the value of a technology is strongly influenced by both:

* Technology’s Standalone Value.
* Network Externality Value.

**TECHNOLOGY’S STAND-ALONE VALUE**

A technology’s standalone value refers to the things it can do that are not due to its installed base or available complements. For example, a videogame console’s standalone value might be a function of its speed, storage capacity, ease of use, or economical price, etc.

To help managers identify the different aspects of utility a new technology offers customers, a “**Buyer Utility Map**” has been developed. This map considers six different utility levers, as well as six stages of the buyer experience cycle, to understand a new technology’s utility to a buyer.

The stages they identify are *purchase, delivery, use, supplements, maintenance*, and *disposal*. The six utility levers they consider are *customer productivity, simplicity, convenience, risk, fun and image*, and *environmental friendliness*.

**NETWORK EXTERNALITY VALUE**

In industries characterized by network externalities, the value of a technological innovation to users will be a function not only of its stand-alone value, but also of the value created by the size of its installed base and the availability of complementary goods.

NOTE: A new technology, that has significantly more standalone functionality, may offer less overall value than the incumbent technology because it has a smaller installed base or poor availability of complementary goods.

To successfully overtake an existing dominant technology, new technology should offer:

* Dramatic technological improvement (for example, in videogame consoles, it has taken 3X performance of incumbent).
* Compatibility with existing installed base and complements.

When users are comparing the value of a new technology to an existing technology, they are weighting a combination of objective information, subjective information, and expectations for the future. Objective dimension can matter as much as the subjective one.

**MODULARITY**

Modularity is used to create a platform ecosystem where many different firms contribute to the product overall system.

It allows generally for more customers choice which works in several ways affecting the market:

* **quicker innovation** by allowing companies to update or introduce new modules independently. This agility in product development can lead to faster time to market, giving a competitive advantage;
* **greater customization**, meeting diverse customer needs and preferences, offering a range of configurations, this way appealing to broader market and gaining an edge over competitors;
* **greater trust from customers**, bringing mor e involvement for final users and expanding options towards third party, even increasing collaboration;
* **collaboration across industries** creating a synergy and preferring competitive positioning, being ad aptable and responsive, while also expanding boundaries and market perception.

Internally, a firm can analyse modularity across various dimensions to understand its impact and optimize its implementation, understanding how to:

* **design flexibility**, how easy it is to add and replace/upgrade modules;
* **interoperability** between organizations and people alike, ensuring smooth communication between different components;
* **cost structure and supply chain management**, evaluating gains in management, manufacturing, logistics and possibilities of reconfiguration and dynamics;
* **risk management**, assessing failures and successes impact and development of contingency plans overall, specifically dealing with customer satisfaction and market factors.

# **Chapter 5: Timing of Entry**

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# **Chapter 6: Defining the Organization's Strategic Direction**

A coherent technological innovation strategy leverages the firm’s existing competitive position and provides direction for future development of the firm.

Formulating a company’s technological innovation strategy requires the firm to **assess its current position** and define its **strategic direction**.

**ASSESSING THE FIRM’S CURRENT POSITION**

To assess the firm’s current position, it is helpful to analyse the **external** and **internal** environment of the firm.

**EXTERNAL ANALYSIS**

External analysis is frequently conducted by applying **Porter’s Five-Force Model** and/or a **stakeholder analysis**.

**Porter’s Five-Force Model**:

1. *Degree of existing rivalry*. Determined by number of firms, relative size, degree of differentiation between firms, demand conditions, exit barriers.
2. *Threat of potential entrants*. Determined by attractiveness of industry, height of entry barriers (for example, start-up costs, brand loyalty, regulation, etc.).
3. *Bargaining power of suppliers*. Determined by number of suppliers and their degree of differentiation, the portion of a firm’s inputs obtained from a particular supplier, the portion of a supplier’s sales sold to a particular firm, switching costs, and potential for vertical integration.
4. *Bargaining power of buyers*. Determined by number of buyers, the firm’s degree of differentiation, the portion of a firm’s inputs sold to a particular buyer, the portion of a buyer’s purchases bought from a particular firm, switching costs, and potential for vertical integration.
5. *Threat of substitutes*. Determined by number of potential substitutes, their closeness in function and relative price.
6. Recently Porter has acknowledged *the role of complements*. Must consider:
7. how important complements are in the industry;
8. whether complements are differentially available for the products of various rivals (impacting the attractiveness of their goods);
9. who captures the value offered by the complements.

**Stakeholder analysis** begins with the identification of all parties impacted by the firm, what their interests are and what resources they contribute to the firm.

Stakeholders include stockholders, employees, customers, suppliers, lenders, the local community, government, and rivals.

**INTERNAL ANALYSIS**

The internal analysis is conducted by two steps:

1. **The assessment of a firm’s strengths and weaknesses** in each part of the company’s value chain. The value chain activities are often organized according whether they are primary (e.g. marketing, sales and service) or secondary (e.g. human resource management and infrastructure) activities.
2. The firm then identifies **which strengths** have the potential to be a source of **sustainable** **competitive advantage** (i.e. are rare, valuable, durable, and inimitable).

It is most important to emphasize what makes a competency a **core competency**.

Core competencies differentiate a company strategically from its competitors and are usually a combination of different kinds of abilities (e.g. advertising, distribution, process design). It is the harmonious combination of abilities that makes core competencies **difficult to imitate**.

**DEFINE THE FIRM’S STRATEGIC DIRECTION**

A firm’s strategic intent is an **ambitious long-term term goal** (10 to 20 years in the future) that requires all levels of the organization to improve the firm's existing core competencies to close the gap between strategic intent and current position.

A firm’s strategic intent takes the focus away from current markets and meeting current customer requirements so that **the organization can focus on future markets and customer requirements**.

# **Chapter 7: Choosing innovation projects**

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# **Chapter 8: Collaboration Strategies**

Firms must often choose between performing innovation activities: **alone** or in **collaboration**.

Collaboration can enable firms to achieve more, at a faster rate, and at less cost and risk. However, collaboration also entails sharing control and rewards, and may risk partner malfeasance.

**Reasons for Going Solo**:

* firm possesses all the capabilities and resources in house that it needs;
* the development of the new technology is an opportunity to develop new competencies;
* the risk of transferring knowledge to a partner is too great;
* the firm wants to control the trajectory of the technology’s development;
* if an appropriate partner is not available.

Solo internal development is relatively slow and expensive, it is appropriate when a firm has strong competencies related to the new technology, access to capital, and is not under great time pressure.

**Advantages of collaborating**:

* *Acquiring Capabilities and Resources Quickly* to gain rapid access to complementary and useful capabilities from partners.
* *Increasingly Flexibility*.
* *Learning from Partners*: transfer of knowledge from partners and creation of new knowledge that individual firms could not have created alone.
* *Resource and Risk Pooling*: sharing costs and risks of a project.
* *Building a Coalition around a Shared Standard*: development of a project with a collaboration that facilitates the creation of a shared standard.

**TYPES OF COLLABORATIVE ARRANGEMENTS**

1. **Joint Ventures**: a particular type of strategic alliance that entails significant equity investment and often establishes a new separate legal entity.
2. **Licensing**: a contractual arrangement that gives an organization (or individual) the rights to use another’s intellectual property, typically in exchange for royalties.
3. **Outsourcing**: when an organization (or individual) procures services or products from another rather than producing them in house.
4. **Collective Research Organizations**: organizations formed to facilitate collaboration among a group of firms (e.g. involving universities).

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**CHOOSING AND MONITORING PARTNERS**

Partner selection is crucial to success. Key factors fall into two dimensions:

1. **resource fit** (e.g. partner’s relative size and strength, resources);
2. **strategic fit** (e.g. alignment of objectives and similarity of values and culture).

Successful collaborations require clear yet flexible monitoring and governance mechanisms.

* May utilize legally binding **contractual arrangements**:
* helps ensure partners are aware of rights and obligations;
* provides legal remedies for violations.
* May also use **shared equity ownership** (that is, each partner contributes capital and owns a share of equity in the alliance).
* May rely on **relational governance** (self-enforcing governance based on the goodwill, trust, and reputation of partners).

# **Chapter 9: Protecting Innovation**

Firms must decide whether and how to protect their technological innovations.

Protecting innovation helps a firm retain control over it and appropriate the rents from it.

However, sometimes not protecting a technology is to the firm’s advantage – it may encourage others to support the technology and increase its likelihood of becoming dominant.

**Appropriability** refers to the degree to which a firm is able to capture the rents from its innovation. Appropriability is determined by how easily or quickly competitors can copy the innovation.

**HOW CAN FIRMS PROTECT THEIR INNOVATION**

There may exist some protective measures over innovation:

* **Patents**, given by governments, providing exclusive rights for a specified duration, preventing others from making, using, or selling the patented invention. They are often regulated by patent laws, which vary from country to country (famous ones include PCTor Paris Convention). They can create power between similar companies (patent thickets) or are just made to earn revenues (patent trolling).
* **Trademarks**: a word, phrase, symbol, design, or other indicator that is used to distinguish the source of goods form one party from goods of another.
* **Copyright**, usually granted to works of authorship, preventing from reproducing the work or creating some derivative ones. Registering copyrights provides legal rights to control the reproduction and distribution of the protected work.
* **Trade secrets**, basically industrial secrets, keeping certain aspects of an innovation as trade secrets is another approach. This involves maintaining confidentiality around specific processes, formulas, or methods that provide a competitive advantage.

# **Chapter 10: Organizing for innovation**

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# **Chapter 11: Managing the new product development process**

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# **Chapter 12: Managing new product development teams**

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# **Chapter 13: Crafting a deployment strategy**

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