

STRATEGIC MANAGEMENT OF **Technological Innovation**

Sixth Edition

Melissa A. Schilling

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Education

Sources of Innovation

Sources of Innovation

Innovation can arise from **many different sources** including individuals, firms, universities, government laboratories and incubators, and private non-profit organizations.

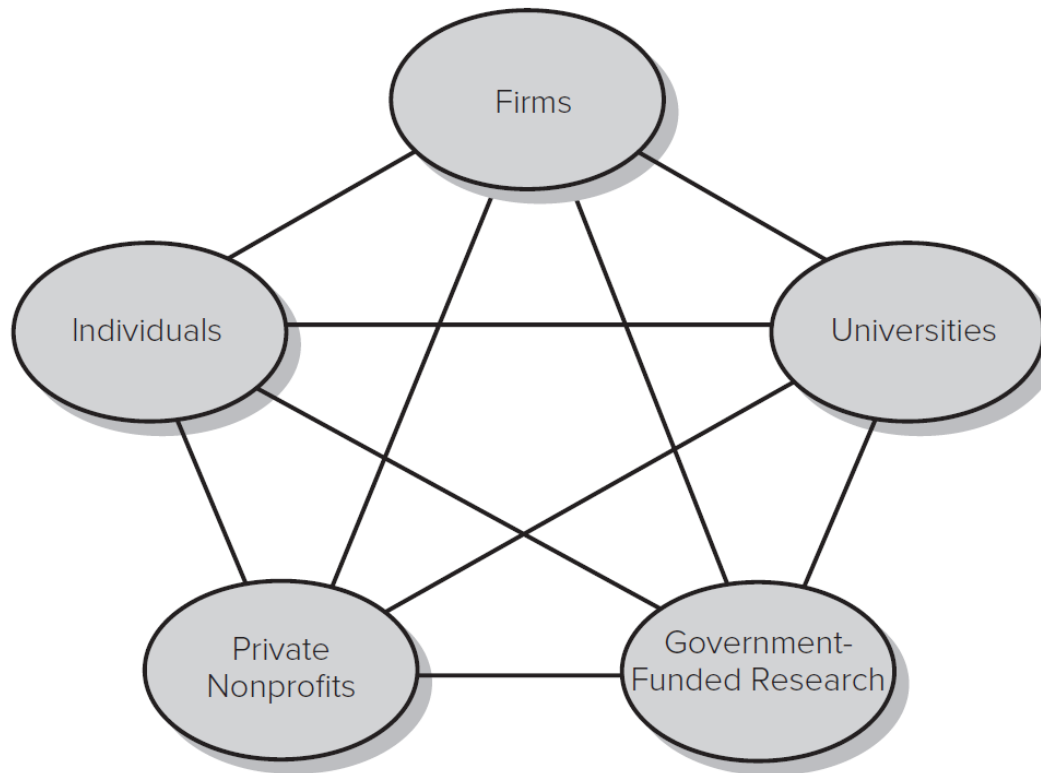
Firms are well suited to innovation activities because they are **highly motivated** by the need to remain competitive and because have the **management systems needed to organize their resources** to achieve an organizations' objectives.

Sources of Innovation

An **even more important** source of innovation is the **networks that link innovators** together. These networks leverage a **broader range of knowledge and resources** than an individual entity could.

Overview

Innovation can arise from many different sources and the linkages between them.



Creativity

Creativity is defined as the ability to produce work that is **useful** and **novel** (i.e. different and surprising when compared to prior work).

The most creative works are novel at the individual producer level, the local audience level, and the broader societal level.

Creativity

1. Individual Creativity

2. Organizational Creativity

1. Individual Creativity

- Individual creativity is a function of:
 - Intellectual abilities (for example, ability to articulate ideas).
 - Knowledge (for example, understand field, but not wed to paradigms).
 - Personality (for example, confidence in own capabilities).
 - Motivation (for example, rely on intrinsic motivation).
 - Environment (for example, support and rewards for creative ideas)

Researchers have argued that the most important capability is the ability to look at problems in **unconventional** ways.

Intellectual abilities

- **Intellectual abilities** include intelligence, memory, the ability to look at problems in unconventional ways, evaluate alternatives and articulate them to others.
- Some people are also better able to engage in **primary process thinking**, and to rapidly generate many associations or follow **paths of association** out more steps.

Knowledge

Too much knowledge can result in an **inability** to think beyond the existing logic and paradigms of a field while **too little knowledge** can lead to **trivial** contributions

The most creative individuals can **distinguish important problems from unimportant** ones

Personality

Self-efficacy, tolerance for ambiguity, and a willingness to overcome obstacles and take reasonable risks are the personality traits most important for creativity

Motivation

Intrinsic motivation has also been shown to be very important for creativity; extrinsic motivators (e.g., monetary rewards, awards) can sometimes undermine creativity.

2. Organizational Creativity

- **Organizational creativity** is a function of creativity of the **individuals** within the organization and a variety of **social processes and contextual factors** that shape the way those individuals interact and behave.

2. Organizational Creativity

- The creativity of individuals can be amplified or thwarted by an organization's **structure, routines, and incentives**.
- Common methods of tapping employee creativity include 1) the suggestion box, 2) idea management systems (Google, Honda, BankOne).

2. Organizational Creativity

Idea collection systems such as suggestion boxes, or idea management systems are only a **first step**. Managers can be **trained** to signal (through verbal and nonverbal cues) that each employee **thinking and autonomy is respected**. Employees can also be trained to use creativity tools such as using analogies or developing alternative scenarios. (see the various ways that Google inspires creativity as described in the Theory in Action box) p. 24

Theory in Action₁

Inspiring Innovation at Google.

- Google uses a range of formal and informal mechanisms to encourage its employees to innovate, including:
 - 20% Time (all engineers are encouraged to spend 20% of their time working on their own projects).
 - Recognition awards.
 - Google Founders' Awards.
 - Innovation reviews.

2. Organizational Creativity

- Organizational Creativity is a function of:
 - Creativity of individuals within the organization.
 - Social processes and contextual factors that shape how those individuals interact and behave.
- Methods of encouraging/tapping organizational creativity:
 - Idea collection systems (for example, suggestion box; Google's idea management system).
 - Creativity training programs.
 - Culture that encourages (but doesn't directly *pay* for) creativity.

Translating Creativity into Innovation

Innovation is the implementation of creative ideas into some new device or process.

Requires combining creativity with resources and expertise.

Who are the inventors?

- One ten-year study found that inventors typically:
 1. Have mastered the basic tools and operations of the field in which they invent, but they will have not specialized solely on that field.
 2. Are curious, and more interested in problems than solutions.
 3. Question the assumptions made in previous work in the field.
 4. Often have the sense that all knowledge is unified. They will seek global solutions rather than local solutions and will be generalists by nature.
- Such individuals may develop many new devices or processes but commercialize few.

Theory in Action₂

Dean Kamen.

- The Segway HT: A self-balancing, two-wheeled scooter.
- Invented by Dean Kamen.
 - Described as tireless and eclectic.
 - Kamen held more than 150 U.S. and foreign patents.
 - Has received numerous awards and honorary degrees.
 - Never graduated from college.
 - To Kamen, the solution was not to come up with a new answer to a known problem, but to instead reformulate the problem.

Dean Kamen

https://www.youtube.com/watch?v=9gYvDmea5kU&list=PLc6EeKrKYKCIN48ow3Irlj_sO0zQEY-Vwu&index=33

Innovation by Users

- Users have a deep understanding of their own needs, and motivation to fulfill them.
- While manufacturers typically create innovations to profit from their sale, user innovators often initially create innovations purely for their own use.
- For example, Laser sailboat developed by Olympic sailors; Indermil tissue adhesive based on Superglue; early snowboards.

Research and Development by Firms

- **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, materials, or processes.

Research and Development by Firms

- *Science Push* approaches suggest that innovation proceeds linearly:
 - Scientific discovery → invention → manufacturing → marketing.
- *Demand Pull* approaches argued that innovation originates with unmet customer need:
 - 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.

Firm Linkages with Customers, Suppliers, Competitors, and Complementors

Collaboration can occur in alliances, research consortia, licensing arrangements, contract research and development, joint ventures, and other arrangements.

The **most frequent collaborations** are between **firms and their customers, suppliers, and local universities.**

Firm Linkages with Customers, Suppliers, Competitors, and Complementors

- Most frequent collaborations are between firm and their customers, suppliers, and local universities.

	North America (%)	Europe (%)	Japan (%)
Collaborates with:			
Customers	44	38	52
Suppliers	45	45	41
Universities	34	32	34

Firm Linkages with Customers, Suppliers, Competitors, and Complementors

Firms may also **collaborate with competitors and complementors** and the **line between** complementor and competitor can become **blurred** making the relationships between firms very complex and difficult to navigate.

Firm Linkages with Customers, Suppliers, Competitors, and Complementors

In some circumstances, **bitter rivals** in one product category will **collaborate** in that product category or in the development of complementary products.

- For example, Microsoft competes against Rockstar Games in many video game categories, yet also licenses many Rockstar games to play on the Xbox.

Firm Linkages with Customers, Suppliers, Competitors, and Complementors

The line between competitor and complementor can be tricky to manage.

Firm Linkages with Customers, Suppliers, Competitors, and Complementors

- External versus Internal Sourcing of Innovation.
 - External and internal sources are complements.
 - Firms with in-house R&D also heaviest users of external collaboration networks.
 - In-house R&D may help firm build *absorptive capacity* that enables it to better use information obtained externally
- **Public research institutions** such as universities, government laboratories and incubators enable companies to develop innovations that they would not have otherwise developed.

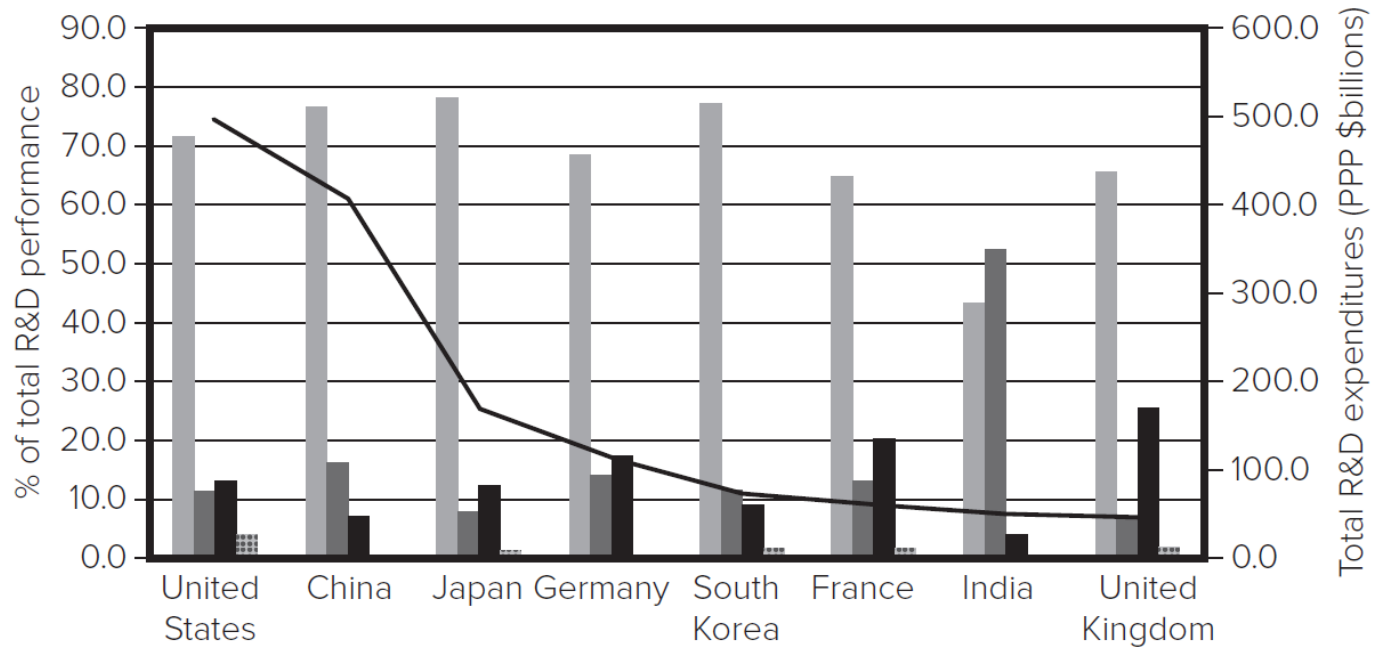
Universities

- **Universities.**
 - Many universities encourage research that leads to useful innovations.
 - Bayh-Dole Act of 1980 allows universities to collect royalties on inventions funded with taxpayer dollars.
 - Led to rapid increase in establishment of technology-transfer offices.
 - Revenues from university inventions are still very small, but universities also contribute to innovation through publication of research results.

Government-Funded Research.

Government Funded Research is actively supported in many countries but the ratio of R&D funding provided by industry and government varies significantly by country.

Total R&D Expenditures and Percent of R&D Funds by Performing Sector, by Country 2015



- R&D performance: Share of total (%) Business
- R&D performance: Share of total (%) Government
- R&D performance: Share of total (%) Higher education
- R&D performance: Share of total (%) Private nonprofit
- Total R&D Expenditures (PPP \$billions)

[Access the text alternative for these images](#)

Government-Funded Research.

Government research takes place in **government laboratories** and through the funding of **science parks** (fostering collaboration between national and local government institutions, universities, and private firms) **and incubators** (focusing on new business development) and **grants for other public or private research entities.**

A science and technological park

https://www.youtube.com/watch?v=M8Px9HqsPPI&list=PLc6EeKrKYKClN48ow3Irlj_sO0zQEY-Vwu&index=34

https://www.youtube.com/watch?v=u7tgCLfWM-c&list=PLc6EeKrKYKClN48ow3Irlj_sO0zQEY-Vwu&index=35

https://www.youtube.com/watch?v=KGxK-IJSXUk&list=PLc6EeKrKYKClN48ow3Irlj_sO0zQEY-Vwu&index=36

Private Nonprofit Organizations

- Many nonprofit organizations do in-house R&D, fund R&D by others, or both.
- The top nonprofit organizations that conduct a significant amount of R&D include organizations such as the Howard Hughes Medical Institute, the Mayo Foundation, the Memorial Sloan Kettering Cancer Center, and SEMATECH.

Innovation in Collaborative Networks₁

Collaborations include (but are not limited to):

- Joint ventures.
- Licensing and second-sourcing agreements.
- Research associations.
- Government-sponsored joint research programs.
- Value-added networks for technical and scientific exchange
- Informal networks.

Collaborative research is especially important in high-technology sectors where individual firms rarely possess all necessary resources and capabilities.

Innovation in Collaborative Networks₁

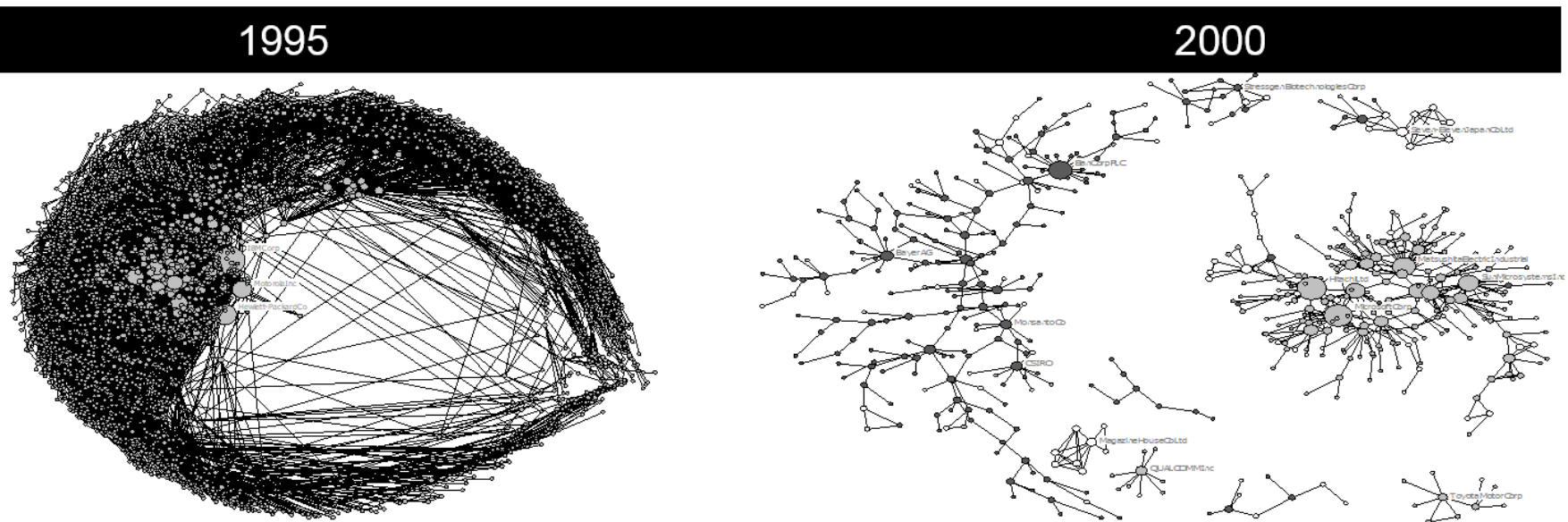
There is a **growing recognition of the importance of collaborative** research and development **networks** for successful innovation

The structure of such networks influences the flow of information and other resources through the network. The size and density of the network can thus influence the innovation of organizations that are embedded in the network.

Innovation in Collaborative Networks₂

As firms forge collaborative relationships, they weave 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.



[Access the text alternative for these images](#)

Innovation in Collaborative Networks₂

Firms in **close geographic proximity** are more likely to collaborate and exchange knowledge (e.g. Silicon Valley's semiconductor firms, lower Manhattan's multimedia cluster, or Modena Italy's knitwear district).

Technology Clusters are regional clusters of firms that have a connection to a common technology.

Technology Clusters :

- There are often **economies** of having buyers, suppliers, and complementors located in close proximity.
- Proximity facilitates **knowledge transfer**. The exchange of **complex** or **tacit** knowledge typically requires frequent and close interaction. Proximity influences a firms' **willingness** to exchange knowledge and firms' **ability** to develop common ways of understanding and articulating knowledge.

Technology Clusters :

- Knowledge is held, to a large extent, in people, and **people tend to be reluctantly mobile**. As a result knowledge tends to be regionally localized. For example, Annalee Saxenian found that engineers in **Silicon Valley** were **more loyal to their craft** than to any particular company, but they were also **very likely to stay in the region** even if they changed jobs.
- Successful firms create a **valuable labor pool** that is attractive to new firms that desire similar labor skills.

Technology Clusters : agglomeration economies

- The increase in employment and tax revenues in the region can lead to improvements in infrastructure (such as roads and utilities) schools, and other markets that service the population.
- The benefits firms reap by clustering together in close proximity are known as **“agglomeration economies.”**

Technology Clusters: negative effects

- The **downsides to geographical clustering** are that competition between the firms may reduce their pricing power, increase the possibility of competitors gaining access to each others' proprietary knowledge.
- Clustering can also lead to traffic congestion, high housing costs, and higher concentrations of pollution.

Technology Clusters : some factors

- Studies have shown that the **degree** to which innovative activities are **geographically clustered** depends on things such as: the **nature of the technology, industry characteristics**, and the **cultural context** of the technology (e.g. population density of labor or customers), **infrastructure development**, or **national differences** in the way technology development is funded or protected.

Technological spillovers

- **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).
- The rate at which technology spillovers will occur is a function of the **strength of protection mechanism** and the **nature of the underlying knowledge**.

Knowledge Brokers

Knowledge Brokers are firms or individuals that play a particularly important role in an innovation network because they transfer information between different domains and exploit synergies created by combining existing technologies.

Hargadon and Sutton identify **Robert Fulton** and **Thomas Edison** as knowledge brokers

- Fulton recognized that steam engines could be used to propel steamboats.
- Edison was known for borrowing from different industries to create products such as the telegraph, telephones, generators and vacuum pumps.

Knowledge Brokers

Knowledge Brokers.

- Hargadon and Sutton point out that some firms (or individuals) play a pivotal role in the innovation network – that of *knowledge brokers*.
- **Knowledge brokers** are individuals or firms that transfer information from one domain to another in which it can be usefully applied. Thomas Edison is a good example.
- By serving as a bridge between two separate groups of firms, brokers can find unique combinations of knowledge possessed by the two groups.

Innovation in Collaborative Networks

Likelihood of innovation activities being geographically clustered depends on:

- The nature of the technology.
 - For example, its underlying knowledge base or the degree to which it can be protected by patents or copyright, the degree to which its communication requires close and frequent interaction;
- Industry characteristics.
 - For example, degree of market concentration or stage of the industry lifecycle, transportation costs, availability of supplier and distributor markets; and.
- The cultural context of the technology.
 - For example, population density of labor or customers, infrastructure development, national differences in how technology development is funded or protected.

The Rise of “Clean Meat”

In late 2017, Bill Gates, Jeff Bezos, Jack Ma and others began funding efforts to grow “clean meat”.

- Growth in demand for meat expected to outpace supply.
- Animal production has large negative impacts environment: greenhouse gasses, heavy water and energy use.
- Animal production is inefficient: 1 calorie of beef requires 23 calories of inputs versus 3 required for one calorie of “clean meat”.

Developing clean meat.

- Jason Matheny founded New Harvest to promote research; collaborated with Dutch scientist and government.
- Early efforts were very expensive (\$1200 for first meatball).
- By 2016 there were several startups and Tyson and Cargill were investing in it.
- <https://www.youtube.com/watch?v=29GFYxl4tek>

Discussion Questions

1. What are some of the advantages and disadvantages of a) individuals as innovators, b) firms as innovators, c) universities as innovators, d) government institutions as innovators, e) nonprofit organizations as innovators?
2. What traits appear to make individuals most creative? Are these the same traits that lead to successful inventions?
3. Could firms identify people with greater capacity for creativity or inventiveness in their hiring procedures?
4. To what degree do you think the creativity of the firm is a function of the creativity of individuals, versus the structure, routines, incentives, and culture of the firm? Can you give an example of a firm that does a particularly good job at nurturing and leveraging the creativity of its individuals?