Chapter 2

Sources of Innovation

SYNOPSIS OF CHAPTER

In this chapter consideration is given to the role of creativity as the underlying process for the generation of novel and useful ideas. Individual creativity is considered to a function of intellectual abilities, knowledge, thinking styles, personality traits, intrinsic motivation and environment. Firm creativity is more than the sum of member creativity. Firm creativity is also a function of the organizational structure and the strategic management approach employed.

The chapter moves on to explore how creativity is transformed into innovative outcomes by the separate components of the innovation system (e.g., individuals, firms, etc) and the linkages between the different components.

The last part of the chapter focuses on the role of innovation networks in new product/process development. Firms are most likely to collaborate with customers, suppliers, and universities, though they also may collaborate with competitors, producers of complements, government laboratories, nonprofit organizations, and other research institutions. Emphasis is placed on developing an understanding of technological clusters including how they are formed and the benefits associated with them. The role of knowledge transfer in the creation of clusters is demonstrated in the context of Silicon Valley.

TEACHING OBJECTIVES

1. To help students understand the relationship between creativity and innovation.
2. To explore, quantitatively and qualitatively, the role played by individuals, firms, universities, governments, and non-profits in innovation.
3. The chapter highlights the role of collaborative networks in innovation, including technological spillovers, and technology clusters.

LECTURE OUTLINE

I) Overview

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

b. **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.

c. 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.

See Figure 2.1

II) Creativity

a. **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. When a product is novel to its creator but know to everyone else it is referred to as a **reinvention**.

b. **Individual creativity** is a function of **intellectual abilities**, **knowledge**, **style of thinking**, **personality**, **motivation**, and **environment**. Researchers have argued that the most important capability is the ability to look at problems in **unconventional** ways.

   i. **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

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

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

   iv. **Intrinsic motivation** has also been shown to be very important for creativity.

c. **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**.

i. 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).

d. **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 employees **thinking and autonomy is respected**. Employees can also be trained to use creativity tools such as using analogies or developing alternative scenarios.

III. Translating Creativity Into Innovation

a. Innovation occurs when new ideas are **implemented** into some useful form (e.g. new product or process).

b. **The Inventor** has been the focus of much study and there is **significant disagreement** over whether inventors are **born or made**. It is also important to note that the qualities that make an individual inventive do not necessarily make that individual entrepreneurial.

i. Inventors are often portrayed as **eccentric and doggedly persistent scientists**. One ten-year study of inventors showed that the most successful inventors:

1. Have **mastered the basic tools** and operations of the field in which they invent, but 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 s**eek global solutions** rather than local solutions, and will be **generalists** by nature**.** You may want to raise the example of **Dean Kamen** (from the Theory in Action) here and ask students how he illustrates these characteristics.

c. **Users** are another important source of innovation. Users are keenly aware of their unmet needs and have the greatest motivation to find ways to meet those needs. Innovation by users can blossom into wholly new industries because

i. You may want to raise the example of the "**Laser**" a small boat designed by three former Olympic sailors without any formal market research or concept testing that ultimately became very successful.

ii. Another example is the development of snowboards. A brief history of this industry is provided in the theory and action section in the text.

See Figure 2.2

d. **Firms** are a very important engine of innovation**.** Firms consider their own **research and development spending** to be their most important resource for innovation.

See Figure 2.3

i. "**Research**" can refer to both basic research and applied research.

1. Basic research does not focus on a specific immediate commercial application.

2. Applied research is directed at meeting a specific need or **commercial objective**.

ii. **"Development"** refers to activities that **apply knowledge** to produce useful devices, materials, or processes.

e. A **science-push** approach to research and development views the process as linear, moving from scientific discovery, to invention, to engineering, then manufacturing activities, and finally marketing. This approach has been shown to have little real-world applicability. The **demand-pull** model of research and development argues that innovation is driven by the demand of potential users. Scholars have concluded that **different phases of innovation** are likely to be characterized by **varying levels of science push and demand pull**.

IV. Firm Linkages with Customers, Suppliers, Competitors and Complementors

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

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

c. Although the Japanese may be somewhat more likely to collaborate extensively with their customers the use of collaborations is fairly consistent across North America, Europe, and Japan.

See Figure 2.4

c. 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.

   i. For example, **Kodak** competes with **Fuji** in both the camera and film markets, yet Fuji's film is also a complement for Kodak's cameras and vice versa.

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

   i. For example, when **Palm Computer** developed its Palm Pilot, the company licensed its Palm OS to various companies to support their objective of establishing the dominant design. However, the products produced by these companies were also competitors for Palm's own hardware and applications products, putting the company in a tricky position.

e. **External and Internal Sources of Innovation** are likely to be complements rather than substitutes. Research by the Federation of British Industries shows that firms conducting internal R&D were also the heaviest users of external collaboration networks. Presumably doing in-house research and development helps to build the firm's **absorptive capacity** (i.e. the firm’s ability to understand and make use of new information).

f. **Public research institutions** such as universities, government laboratories and incubators enable companies to develop innovations that they would not have otherwise developed.

i. **Universities** encourage their faculty to engage in research that may lead to useful innovations but maintain sole discretion over the rights to commercialize the innovation. A rapid growth in **technology transfer offices** occurred after congress passed the **Bayh-Dole Act** in 1980.

ii. **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. 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**.

See Figures 2.5 and 2.6

ii. **Private non-profit organizations** including private research institutes, non-profit hospitals, private foundations, professional or technical societies, academic and industrial consortia, and trade associations, also conducte their own R&D activities. U.S. nonprofit organizations spent $10.5 billion on R&D in 2006.

See Figure 2.7

V. Innovation in Collaborative Networks

a. There is a **growing recognition of the importance** of **collaborative** research and development **networks** for successful innovation including joint ventures, licensing and second-sourcing agreements, research associations, government -sponsored joint research programs, value-added networks for technical and scientific interchange, and informal networks.

b. 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 (see Figure 8.X).

c. 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).

d. **Technology clusters** often emerge because:

   i. There are often **economies** of having buyers, suppliers, and complementors located in close proximity.

   ii. 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.

   iii. People (to a large extent) hold knowledge 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

iv. **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.

v. Successful firms create a **valuable labor pool** that is attractive to new firms that desire similar labor skills.

d. 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.

e. The benefits firms reap by clustering together in close proximity are known as "**agglomeration economies**."

f. 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.

g. 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.

h. **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**.

i. Adam Jaffe and his coauthors found that the R&D spending of other firms and universities in its geographical region influenced a firm's patenting activities and p profit's.

g. **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

i. Fulton recognized that steam engines could be used to propel steamboats.

ii. Edison was known for borrowing from different industries to create products such as the telegraph, telephones, generators and vacuum pumps.

ANSWERS TO OPENING CASE QUESTIONS

1. What factors do you think enabled Iddan, an engineer with no medical background, to pioneer the development of wireless endoscopy?

Counterintuitive though it may seem, sometimes NOT being an expert in a particular field is conducive to creating breakthrough innovation in that field. Because Iddan was not a gastroenterologist, he was not "trapped" in the paradigm that the bowel must be scoped using a camera attached to a flexible rod (an endoscope). Instead, he applied concepts from his own background in guided missile technology to the problem and developed a device that was more like a tiny guided missile to traverse the bowel without

being attached to anything. Iddan's expertise in optics was definitely useful for this development, as was his familiarity with charge coupled devices and CMOS technology.

2. To what degree would you characterize Given's development of the camera pill as "science-push" versus "demand-pull"?

The camera pill illustrates the fact that many innovations are not strictly science-push or demand-pull, but rather are a more iterative combination of the two. When Scapa approached Iddan about the problem of viewing the small bowel, that represented demand pull. However, at that time science had not really yielded a solution that was apparent to Iddan. Later, however, developments in optics technology and charge-coupled devices suggested a possible solution to Iddan (just as the availability of miniature spy cameras did for Swain's team); thus science revealed a new potential response to an existing problem.

3. What were the advantages and disadvantages of Iddan and Meron collaborating with Dr. Swain's team?

Iddan was likely more familiar with the mechanical engineering aspects of the camera pill, but Swain's team was probably much more familiar with the anatomical demands that would be placed upon the device, and the diagnostic objectives. The two teams thus had complementary skills. Furthermore, by collaborating, they avoided competing to be

first to patent and introduce the device and thus avoided needless costs and price competition.

ANSWERS TO 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?

This is an ideal time to create a table on the board and encourage students to contribute advantages and disadvantages of each source individually, such as the one below:

	Advantages	**Disadvantages**
Individuals	Many creative ideas originate individuals; Users may best understand their own unmet needs; Users may have great incentive to solve their own problems; Etc.	Individuals often have very limited capital resources to invest in an innovation project; Many innovations require a broader range of knowledge and skills than any individual possesses; Etc.
Firms	Significant capital to invest; Complementary assets to produce, distribute, etc.; Management systems to organize innovative efforts, Etc.	May reject projects that don't appear to have an immediate commercial return; May base project choices on commercial return rather than importance to customers or society; Etc.

Universities	Typically have extensive knowledge and other resources; Can often invest in long-term or risky projects for purposes of advancing science (rather than being pressured for immediate commercial return); Often have ties to multiple other external entities (e.g., government, non-profits, etc.)	May pursue esoteric projects rather than those with immediate applications; May lack skills or resources to implement innovations in the marketplace, Etc. Lack of financial discipline may lead to less efficient development processes.
Government	Like universities, may have extensive knowledge and other resources; and Can often invest in long-term or risky projects for purposes of advancing science (rather than being pressured for immediate commercial return); Typically has great influence over other stakeholders or contributors to innovation (e.g., universities, firms, non-profits); Etc.	May lack complementary resources to implement innovation in the marketplace; Lack of financial discipline may lead to less efficient development processes, Etc.
Nonprofits	Often have ties to multiple other external entities (e.g., universities, non-profits, etc.); May have mission-based focus that enables them to pursue long-term or risky projects; May have credibility advantages for eliciting the cooperation of other stakeholders; Etc.	May be reliant on external sources of funding such as charitable donations or grants, which can constrain capital resource; May lack complementary resources to implement innovation in the marketplace; Etc.

2. What traits appear to make individuals most creative? Are these the same traits that lead to successful inventions?

An individual's creative ability is a function of their intellectual abilities, knowledge, style of thinking, personality, motivation, and environment. In addition, an individual with only a moderate degree of knowledge of a field might be able to produce more creative solutions than an individual with extensive knowledge of field. The most creative individuals prefer to think in novel ways of their own choosing, and can discriminate between important problem and unimportant ones. The personality traits deemed most important for creativity include self-efficacy, tolerance for ambiguity, and a willingness to overcome obstacles and take reasonable risks. Intrinsic motivation has also been shown to be very important for creativity.

Innovation is, however, more than the generation of ideas. It is the implementation of those ideas into some new device or process. Evidence suggests that not all inventors are innovators. In fact many ideas have been left on the drawing board, so to speak, or in the inventors garage. The entrepreneurial skills necessary to convert an idea into a new product or process are very different from the skills and thinking orientation that generated the original idea. An inventor usually will have a tendency toward introversion that may make it difficult for them to convey their ideas to others. As we saw in the Segway case the company addresses the need to incorporate both sets of skills to achieve innovation by forming teams with a mix of "ideation" and "execution" people in acknowledgement of finding all these skills in one individual.

3. Could firms identify people with greater capacity for creativity or inventiveness in their hiring procedures?

Individuals can be tested for factors indicative of creativity such as intrinsic motivation, intellectual abilities, knowledge, style of thinking, and personality traits. Of course these types of tests are no guarantee of performance in the job. Firms hiring for creative jobs are likely to find their best information comes from an individuals work history especially if that history includes activity that can be characterized as entrepreneurial.

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?

Students should be encouraged to debate the role of innate individual creativity versus the firm structure, routines, incentives and culture that can nurture or thwart such creativity. Many students will volunteer companies such as 3M (reknown for its practice of permitting “bootlegging”), Apple (which encouraged a rebellious and free-thinking culture) or companies from their own experience as examples of companies that do a good job of nurturing and leveraging creativity.

5. Several studies indicate that the use of collaborative research agreements is increasing around the world. What might be some of the reasons that collaborative research is becoming more prevalent?

The increasing prevalence of collaborative research agreements can be attributed to several factors. First, there is an increased awareness of the benefits of knowledge sharing. When individuals or firms participate in innovation networks, formal or informal, they are exposed to new information and ideas. Greater knowledge leads to the identification of more recombination opportunities. The network can also bring to bear knowledge regarding which of these recombinations is most likely to become a new product or process. Second, rapid advances in information technology have greatly facilitated collaboration by reducing the cost (and increasing the pace) that information can be transmitted. Email, videoconferencing, groupware programs, etc. all enable organizations to collaborate much more effectively and efficiently than in the past. Information technology has also reduced the search costs of locating a suitable collaboration partner, as well as the monitoring costs of ensuring that partner behaves as agreed. Third, as the pace of innovation has quickened (as discussed in chapter 1), firms have needed to obtain capabilities and resources for innovation more quickly than before; collaboration provides a way to rapidly gain access to other organizations knowledge and resources, enabling the organizations to collectively bring innovations to market faster than any individual organization could alone.