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Advancing Knowledge and Evolving Society

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ABSTRACT

This chapter discusses the nature of research and innovation, two fundamentals processes that govern the development and growth of our society. Too often, these activities are loosely characterized or, conversely, overloaded with many interpretations and assumptions. This confusing vision is the underlying cause of the numerous unsatisfactory results and unfulfilled expectations that are experienced during the overall process in moving from basic research to societal impact. As a consequence, it is necessary to better understand the nature of research and innovation so as to address the many challenges and issues that our society is facing in a more effective and convincing way.

The chapter discusses the nature and characteristics of these two activities, by emphasizing their differences and distinguishing elements. Section 5.2 characterizes research and innovation according to a number of dimensions and aspects. Section 5.3 briefly discusses the relationship between innovation and technology transfer. Finally, Section 5.4 briefly discusses CEFRIEL, an innovation and technology transfer center, from which most of the observations and concepts discussed in this chapter originated.

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5.1 INTRODUCTION

Modern societies are centered on the creation, dissemination, and utilization or application of knowledge. Knowledge enables the design of new products and services, increases the competitiveness and efficiency of industries, and, in general, promotes growth and quality of life in society. Nowadays, any improvement depends on knowledge; therefore, it is essential to understand how to master and foster the processes through which knowledge is generated, shared, and eventually transformed into real products and services.

Traditionally, this process has been decomposed and analyzed by identifying a number of different activities and concepts, typically qualified using terms such as the following ones:

- Research and development (R&D)
- Applied research and industrial research
- Innovation
- Technology transfer and intellectual property management

These terms are quite familiar and well known to any professional or decision-maker operating in modern companies and institutions. Still, they appear increasingly inadequate, too generic, and overloaded with vague and generic interpretations. They are increasingly perceived as unable to really help understand and master the complex challenges that we are facing. In general, we need to rethink, access, and reconsider most assumptions and beliefs developed in the past years. Nowadays, what is the role and nature of concepts such as research, innovation, and technology transfer? How have they changed since 2002?

5.2 RESEARCH AND INNOVATION

5.2.1 A Misused Term

Innovation is a misused and overused term. Today, many people and companies are describing themselves as *innovative* and *innovation-driven*. Too often, unfortunately, plain conventional solutions are called *innovative* only as a gold-plating marketing strategy. The financial crisis that is striking worldwide economies has certainly diverted the attention of most media, policymakers, 1
politicians, and entrepreneurs to more urgent and critical issues. Nevertheless, innovation stands as one of the most cited and important issues for any company or organization that wants to compete in the worldwide market.

Innovation is often associated and/or confused with the word *research*. For many people, *research* and *innovation*, along with the term *development* (R&D), are more or less synonymous. *Doing research* and *innovate* mean to create something new. Certainly, innovation is associated with the notion of novelty. By innovating, we change something and introduce a discontinuity; it can be a new way of doing things, or the introduction of new features and products. Undoubtedly, *innovation* is associated with *change*; if nothing changes, it is difficult to argue that we are innovating.

Innovation is often associated with the term *applied research* also (Figure 5.1). The idea is that there are different types of research: long-term and exploratory research activities on one hand and medium/short-term and market-oriented *applied research* activities on the other. *Applied research* is often considered as synonymous with *industrial research*, assuming that long-term research is typically undertaken by universities and research centers, while industries are interested solely or primarily in short-term, application-oriented research that can directly impact their markets and performance.

Indeed, none of these observations is completely wrong. However, some of them are confusing, some are misleading, and others are unable to describe the real nature of the innovation process. Therefore, to better understand the facets and challenges of innovation, it is essential to provide a more in-depth characterization of the term. What do we really mean by *innovation*?

The question is not rhetoric, and the answer is not obvious at all. In particular, this is quite an important problem for universities and other academic institutions, which are constantly challenged to focus their research more closely to the needs and expectations of industries, and of society in general.

5.2.2 The Meaning of Innovation

The notion of innovation has been discussed and studied extensively. Numerous studies illustrate the approaches and methods to be used by a company to support and promote innovation [3]. There are economic studies illustrating

Figure 5.1 Innovation *can be defined as the application of research results in society.*

the benefits of effective innovation practices and policies. Still, the impression is that too often we miss a clear understanding of this notion; what is research, what is innovation, what is technology transfer, and how do we characterize and relate these notions to each other?

To answer these questions, it is useful and interesting to consider the thoughts and considerations made by some of the fathers of modern sciences. In particular, a quite famous quote from Louis Pasteur (see http://en.wikiquote.org/wiki/Louis_Pasteur), often credited to Albert Einstein, and cited by Nobel Prize winners such as Carlo Rubbia, is appropriate here: "There does not exist a category of science to which one can give the name applied science. There are sciences and the applications of science, bound together as the fruit of the tree which bears it."

Pasteur's position is quite simple and, at the same time, extremely profound. It can really represent the baseline to explore and characterize the nature of innovation. His starting point is the notion of science (remember that Pasteur was a chemist and microbiologist and therefore was closely involved in physical sciences). The term *science* has two important meanings: (1) it is used to identify a systematic body of knowledge and (2) it also identifies the process through which this knowledge is produced.

In our society, the term *science* is typically associated with the notion of research, even though the latter has a wider meaning, as it includes disciplines that are seldom identified as science (e.g., all the different branches of technology). At the same time, it is important to remember that the word *science* refers not only to physics, mathematics, biology, and other areas of physical and natural sciences but also to social sciences and humanities (economics, history, etc.).

In general, we can say that science and—more generally—research, are the human activities devoted to *develop and enrich our body of knowledge*. A physicist (such as Einstein) would be interested in discovering the laws and principles governing the behavior of the physical world. A philosopher (such as Kant) would propose principles and concepts that explain our essence as human beings. A technologist and inventor (such as Edison) would be interested in producing new ways to solve problems or carry out specific activities. In all these different domains, knowledge assumes different facets and characteristics. Nevertheless, science and research aim at continuously developing this body of knowledge, independently of its mass-scale application to address practical problems and needs.

In his statement, Pasteur introduces the notion of *application of science*, pointing out this second important issue; namely, how we exploit our body of knowledge to improve our lifestyle and advance our society. This is not a marginal problem as it is not absolutely obvious how to transform knowledge into something practical and widely adopted and used.

Consider, for example, penicillin (*Penicillium notatum* or *chrysogenum*). The beneficial effect of that mold was observed by many scientists and finally confirmed by Fleming in 1928 (http://en.wikipedia.org/wiki/Penicillin). It was a grand scientific discovery that occurred as a combination of observation and chance. It was the result of decades of study and dedication. In the years following Fleming's discovery, pharmaceutical industries have spent considerable time and effort to transform that discovery into a product, usable by patients and physicians to treat diseases. This was not a simple process; it was necessary to understand the type of drug to be produced (e.g., ointment, intravenous treatment), the balanced combination of the different elements to be used in the drug, the proper dosage, and the assessment of any side effects it might produce. The transformation of a *research achievement* into a real solution, able to effectively treat specific diseases, was a long and complex process.

Edison invented the lightbulb in 1879. It was a brilliant, historic result that has changed our lives forever. However, nineteenth-century towns didn't have a power grid, which was not even a concept at that time. Edison's invention was basically useless. To bring it to the market, Edison had to create and put in place all the other factors and ingredients needed to exploit the invention; he formulated the electric power distribution grid and a company to build and manage it. Eventually, in 1882 Edison was able to bring his new service to 59 customers in Manhattan. In general, Edison's invention took years to materialize across the whole society, as it demanded the creation of a totally new industry and business sector.

As an additional example, let's consider object programming languages. In the 1960s, object orientation was a purely research result that had no practical impact. In the 1970s, Xerox PARC (Palo Alto Research Center) launched Smalltalk, which had a huge impact in the research community, but a limited market success. Eventually, the knowledge accumulated over the years was exploited in the 1990s, with development of a new breed of programming languages and systems, and bringing object orientation to market success with C++ and, later, with Java. In particular, C++ had a crucial role. From a scientific viewpoint, it was not (and still isn't) the best object-oriented programming language. But it had the merit of hybridizing object orientation concepts with the most popular conventional programming language: C. This strategy is not what a researcher or scientist would normally pursue (indeed, C++ was developed in an industrial lab: Bell Labs). However, it was the right move to bring a new technology to market success.

These examples support and explain Pasteur's theory that there are two distinct activities: knowledge creation and knowledge application. They have different characteristics and demand for different approaches and methods. This is the cornerstone in explaining the nature of innovation [2].

Indeed, despite the complexity, differences, and possible ambiguities that a unique characterization of the term might induce, the nature of innovation can be defined quite easily—there is science and applications of science; or, also, research and applications of research; or, simply, research and innovation.

This is not just an easy simplification or dialectic trick. It is really the heart of the matter; research is the creation of knowledge, whereas innovation is the application of research results to create new processes, products, and services.

In research, the focus is on knowledge creation and discovery; in innovation, the focus is on transforming knowledge into something usable by someone operating in a specific market or, in general, in some part of society.

5.2.3 Characteristics of Research and Innovation

Innovation is different from research. Certainly, the two concepts are connected and interrelated and should not be considered two sequential stages in a classical and rigid waterfall model. Nevertheless, they do exhibit different characteristics and intrinsic challenges. *Doing research* is different from *doing innovation*. It is therefore important and useful to compare these two notions in order to better appreciate their role and characteristics.

In general, the nature of innovation with respect to research can be characterized using the factors and dimensions illustrated in Table 5.1.

5.2.3.1 Motivating Factors The motivating factors for research and innovation are quite different. In research, the main motivating factor is the intellectual challenge, the curiosity, and the desire to excel from an academic, scientific, and technological perspectives. For someone, this might even be seem like vanity or personal career advancement. In innovation, the driver is much simpler; in market success (i.e., making a difference in the market), an innovation is successful if it has an impact on the market or society, irrespective of the specific form that this impact may eventually assume (economic, social, and cultural). Of course, innovations such as Apple iPhone are considered major successes because of their significant technological and economic impact on the market. But this has not always been the case. For many supporters of Linux and Open Source software, the goal is not just monetary; rather, it is to affirm a principle and a vision. For others, the impact might be the ability to positively influence the evolution of underdeveloped countries, or to introduce new environmentally sustainable processes and practices. In other cases, the ultimate goal is to improve the quality of life, even if this is not producing a tangible and immediate economic return. Therefore, the

TABLE 5.1 Nature of Research and Innovation

Characteristic	Research	Innovation
Motivating factors	Intellectual challenge; standing and reputation in scientific community	Market success; impact on society
Approach	Specialization	Cross-functional
Perspective	Medium–long	Short–medium
Risk	Intrinsic	Systemic
Funding	Typically public; visionary	Typically private; venture
Key abilities	Scientific excellence	Ability to deliver; execution
Nonfunctional requirements	Only those needed to prove the idea	Tailored to users' needs and expectations

impact of an innovation can be measured according to different criteria and viewpoints. Still, it is impossible to innovate without some form of concrete impact on the society. Certainly, even in research it is necessary to be conscious of, and somewhat concerned with, the potential application of the research results. Nevertheless, the driver remains substantially different.

5.2.3.2 Approach The typical attitude of researchers is specialization; they focus on the specific technological and scientific topics and challenges that characterize their research agenda. This often requires a multidisciplinary approach as, for example, in bioinformatics; still, the attitude of researchers is focused on the ultimate scientific or technological goal that they are addressing, and tends to ignore any other factor that might distract them from reaching the target.

Conversely, innovation requires a wider range of cross-functional methods and disciplines. The well-known innovation Apple iTunes/iPod, is a masterful combination of specific technologies, design skills, a smart business model, and a well-formulated marketing strategy. In innovation, it is not sufficient to "discover" or "invent" something interesting; it is mandatory to put in place all those actions that make it possible to successfully bring that invention to the market. The failure of Xerox in exploiting the many astonishing results produced by Alan Kay and Xerox PARC (http://en.wikipedia.org/wiki/Xerox_PARC) is systematically mentioned as a classic case study: Xerox PARC was a pioneer in inventing most of the modern IT products and technologies (graphical workstations, mouse, Ethernet), but the company was unable to bring them to market in time or successfully. At Apple, Steve Jobs, an exceptional innovator, transformed those research results in a market revolution.

5.2.3.3 Perspective Typically, research activities require a long completion time. In some cases, such as nuclear fusion, research may even last decades. Unforeseen or unexpected events may, of course, shorten the time needed to achieve specific results. In general, however, research activities are longlasting and difficult to plan.

Innovation is characterized by much more stringent time constraints. As innovation is measured by the ability to achieve market success, the time-to-market factor assumes a central and key role. Even an ingenious and useful innovation may become ineffective if it reaches the market too late, typically, when customers' requirements and needs have already been satisfied by competing, and possibly even less sophisticated, solutions.

It is interesting to note that different domains may have different timespans and dynamics. In the biopharmaceutical domain, bringing a new drug (i.e., the result of a research activity) to market may require even years, as the trial and certification processes have specific constraints and requirements. Nevertheless, in this case, time management during the research and innovation phases is totally different; in particular, the innovation process is guided by a strict sequence of steps and milestones that eventually get the new drug approved for market distribution.

5.2.3.4 Risk Research is, by definition, risky; many research initiatives fail to reach their objectives or achieve unexpected and unanticipated results. It is difficult to plan a research activity, as often it evolves in erratic ways. In general, risks in research are high and difficult to anticipate and handle. Nevertheless, in research risks are related, or intrinsic, to the scientific or technological challenge addressed by the researchers. In innovation, risks are systemic, as they pertain to the complex interrelation of technological, market, social, organizational, and economic challenges that the innovator is requested to face. Thus, even if both activities are "risky," each of them has its specific facets and characteristics.

5.2.3.5 Funding The specific characteristics of research and innovation have an impact also on the funding mechanisms. Typically, industries are increasingly interested in marketing new products and services. Therefore, industries are ready to invest in innovation projects that promise to produce significant results affecting their short–medium market performance. Industries are much less keen in investing in longer-term, exploratory, and risky research projects.

For this reason, the role of public bodies and the federal government is crucial in supporting and promoting research activities. Innovation cannot survive without a solid research background, as the latter provide the fuel and the rough material that is vital to support the former.

5.2.3.6 Key Abilities What are the key abilities needed to succeed in research and innovation? In research, the key factor to achieve superior performance is scientific excellence, that is, the intellectual ability to explore new areas and problems, exploit previous research results, and create new knowledge and scientific results.

On the flip side, a successful innovator possesses a strong ability to execute and deliver [2,4]. This ability requires attitude and skills that researchers do not necessarily exhibit, indeed, researchers tend to overlook all the issues related to time to market, engineering, production, usability, cost, reliability, marketing, and distribution. This is quite understandable; researchers are challenged to produce new and novel results, and publish their results in scientific venues. They are certainly interested in producing demonstrators and prototypes illustrating the effectiveness and viability of their research work, but this kind of accomplishment is quite different from the work typically done by innovators to market a new product or service on time and on budget.

5.2.3.7 Nonfunctional Requirements Typically, the goal of a researcher is to prove that an idea can really be useful to solve a specific problem. Researchers focus on the intellectual challenge posed by the problem and their ability to tackle it. In particular, they focus on the functional requirements that must be met to address the problem or issue successfully. In innovation, the focus is on making a specific solution available to the (often wide number of) potential users. Users are not researchers; they should be enabled to use the solution ignoring most of its details, dynamics, limitations, or technical characteristics. As a consequence, it is necessary to also consider a wide number of nonfunctional requirements that are rarely so important for a researcher. A first important nonfunctional requirement is usability; others are reliability, efficiency, safety, security, ease of management and maintenance, budget constraints, and price targets. These requirements have a significant impact on the innovator's approach, and mark a significant departure from the researcher's typical attitude.

5.2.3.8 Summary The above mentioned observations are not intended to introduce a sort of mathematical or formal definition of the terms *innovation* and *research*. Of course, in same situations the differences and distinctions between these two notions are blurred and tend to disappear. Nevertheless, these characterizations of research and innovation appear to be quite useful and indicative of the nature and intrinsic dynamics of these two different, even if related, activities. Undoubtedly, research and innovation are part of an integrated, iterative feedback loop, where the creation and discovery of knowledge stimulate innovation, which, in turn, produces new stimuli and requirements to drive and enrich the research agenda. However, even if strongly related to each other, research and innovation do have specific differences and characteristics that need to be carefully assessed and understood. It is not just a sort of intellectual or philosophical distinction: research and innovation do require different methodological approaches, expertise, human capital, and operational models.

5.3 INNOVATION AND TECHNOLOGY TRANSFER

5.3.1 A Misleading Association

Frequently, the notion of innovation is associated with technology transfer; innovation is supposedly accomplished by adopting and exploiting some new technology. Is this true? What do we mean by *technology transfer*, and what is the real connection with innovation?

As a preliminary consideration, it is essential to emphasize that innovation involves more than just adopting and exploiting some novel and interesting technology. Potentially, innovation involves technology, knowhow, organization, business models, marketing strategies, business process reengineering, cultural change, talent management, and still more. A company innovates when it is able to introduce a discontinuity in its operation, behavior, and presence in the market. Take Apple as an example. It has innovated through technology with multitouch interfaces on the iPhone, through new business models with iTunes, through design and marketing with the iPod, to mention only a few examples. It has also radically changed customer and public perception about the company. In 1995, Apple was considered a "deadman walking." A few years later, Apple became one of the most admired companies worldwide. In general, innovation is the coherent combination of different ingredients. It does not occur simply because there is some new technology at hand.

Nevertheless, most innovations do require advance technologies such as new materials, software, controlling devices, and telecommunication channels. Therefore, even if it would be inappropriate to strictly associate innovation with technology transfer, technology transfer undoubtedly plays an essential role in innovation. Thus, it is worthwhile to understand how technology transfer can be approached and managed to promote effective innovation initiatives.

5.3.2 The Nature of Technology Transfer

Wikipedia defines technology transfer as follows:

> Technology transfer is the process of sharing of skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among industries, universities, governments and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services.

In practice, the notion of technology transfer addresses a quite important problem, namely, how we can guarantee that technological knowledge and achievements are shared among all the different actors involved in research and innovation activities—or, how we can guarantee that knowledge is eventually transformed into practical and useful innovations. Indeed, this interaction is too often poor and unfruitful; research results produced by universities and research centers are rarely exploited by industries to create or improve their products, processes, and services.

For this reason, over the years public bodies, industries, and academic institutions have studied the problem and pursued a number of different strategies:

1. *Direct Access to Knowledge* This occurs when industries' business divisions and design centers are able to interact directly with researchers to exploit their work and results. This is typically the exception and not the rule.

2. *Patents and Technology Transfer Offices (TTOs)* Most universities have created TTO, and associated patenting strategies and processes. Their goal is to protect the knowhow and intellectual property (IP) generated in the universities, and to formalize the process through which companies can

access and exploit such IP. This approach is not able to fill the gap between industry and academia completely, as it does not change the nature of the information and knowledge being transferred, or the capabilities of the industries that should be exploiting such information and knowledge. Certainly, establishing a TTO and IP management procedures is an important and necessary step to facilitate the interaction between industries and academia, but it does not address the main facets of the problem in a radical and comprehensive way.

3. *Spinoffs and Startups* These are initiatives that aim at exploiting a specific piece of technology or IP developed in a research center. Technology transfer is achieved by creating a company that operates on the market, selling the products and services associated with the knowhow generated by the research activity. This is another important form of technology transfer. However, a startup aims at promoting and selling its specific asset and, in general, does not directly impact the majority of companies that need assistance in selecting and adopting the most appropriate technology able to fulfill their needs, regardless of the identity of its developer.

4. *Brokering Services* Many public bodies have developed organizations that act as a sort of broker between industry and academia. Their goal is to help companies find those research institutions that possess the knowhow and technology instrumental to solving their problems. Again, these initiatives are certainly useful in improving the relationship between industry and academia, but they do not change the characteristics and operational behavior of the *endpoints*; matching is useful, but it is insufficient if the matched endpoints are structurally unable to interact effectively.

5. *Public Funding* Funding innovation and research is, of course, a critical issue. Public bodies and federal agencies have developed numerous strategies to support companies and universities in accomplishing innovation and research activities. Some of these initiatives are specifically designed to facilitate interaction and technology transfer. For instance, in the United States some state governments have established a dollar-match program; for each dollar assigned by a company to a university through a contract, the state adds one more dollar to support the project. Again, this is very interesting and useful strategy to promote innovation and industry–academia interaction, but it does not impact the operational characteristics and attitude of the two parties. If they were unable to talk and interact on the specific technological issues to be solved, they still remain in the same condition, despite the financial support.

As a general comment, we may observe that all of these approaches show the same underlying characteristic; they support the interaction between industry and academia by matching interests and problems, but they all assume that the result of the research activity carried out by the university is more or less ready to use, or, conversely, they take for granted that once some knowledge is made available to industries, they will be able to adopt and modify it for their own needs and purposes. This approach does not work, or does not work in many situations and contexts.

Our experiences have demonstrated that the most effective means of supporting technology transfer are based on shared experiences that make it possible to (re)combine and refine the expertise, knowledge, and competence of the involved parties. In particular, the most effective models to support technology transfer appear to be the followings:

1. *Technology Transfer by Head* In this scenario, knowledge is exchanged by allowing people of one organization to work within projects and initiatives of their counterparts. When experts of different companies work side by side, their knowhow can be refined and adapted to the needs and requirements of the partner.
2. *Technology Transfer by Project* This an advanced form of cooperation, where there is more than simply intercompany expertise; the two parties engage in a joint project, where both teams are committed to achieving joint goals and milestones.
3. *Structured Cooperation* This is the evolution of technology transfer by project. It is based on joint labs and ventures that provide a continuous and systematic cooperation framework among partners. Typical examples are joint consortia and framework programs.
4. *Technology Scouting* Many solutions and technologies are already available on the market. Often, the problem is not to invent new "things," but to adapt, integrate, and exploit existing technologies and solutions to address the specific needs of the target company. Technology scouting focuses on identifying the technologies and solutions that can be instrumental to solve a specific innovation problem. Technology transfer by head and by project usually include some form of technology scouting to identify the existing technologies and solutions that can be exploited in the project, at least as a starting point.

There are two key characteristics of these approaches: (1), they adapt the knowledge available on one side so that it can be received and exploited by the counterpart, and (2) this adaptation is accomplished by considering the needs and requirements of the receiver, not just the attitude of the producer. While most conventional approaches to technology transfer (e.g., TTO and patents) are intrinsically based on a sort of *push* model (from research to industrial exploitation), the models introduced above exploit a *pull* attitude, where the needs, challenges, and requirements of the exploiter drive the selection, integration, and further development or refinement of technology. In reality, technology scouting, and technology transfer by head and by project, go even further, as they help establish a bidirectional, mutual enrichment, consolidating a common ground of cooperation and development. Of course, in presenting the observation above, we do not want to confute the value of the other form of technology transfer such as TTO or startups. Simply, the observation points out that in many contexts and circumstances, conventional forms of technology transfer are unable to effectively tackle the in-depth nature and complexity of the problem.

5.4 THE CEFRIEL EXPERIENCE

5.4.1 Supporting Innovation

Universities and academic institutions are requested to facilitate and promote their relationship with industries (see graph in Figure 5.2), so that the benefits of research can be more easily transferred to the market. The European Union (EU), for instance, has always developed its R&D funding programs with a strong emphasis on university–industry collaboration, industrial exploitation of research results, and maximization of the market impact of each funding initiative. A similar attitude has guided many federal and state programs launched in the United States and in other developed countries.

Few of these initiatives have achieved the results and impact that the promoters had envisaged. In particular, the results of many research programs have failed to reach the market. Why? Is it because the projects were unfeasible

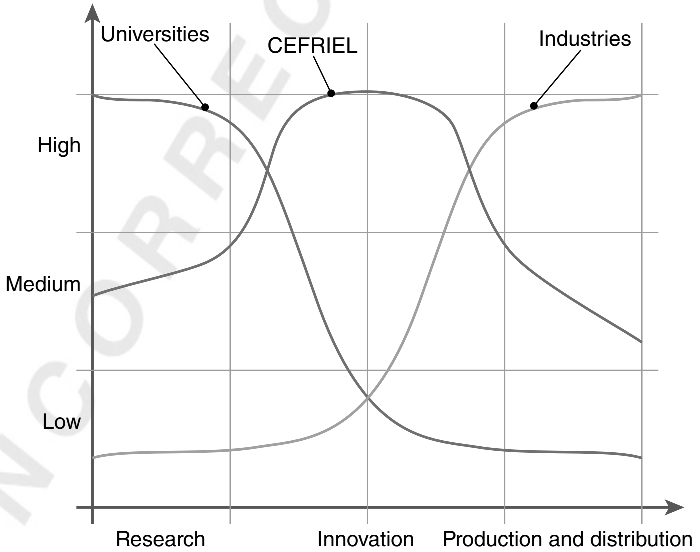

Figure 5.2 *Trends among universities, industries, and CEFRIEL.*

or the partners inadequate? Certainly, in a number of cases these were the difficulties faced by many projects. However, there are also other problems to consider. In many situations, the real issue is the lack of alignment and fit between the results of a research initiative and the ability of the receiving company to exploit them in the market. Typically, the situation is illustrated in Figure 5.2, which represents in a quite simple form most of the observations proposed in previous sections.

Universities tend to focus on research activities, where the main goal is to explore new areas and problems. The results of their work are typically papers, algorithms, theories, methods, prototypes, formulas, or new materials. Few of these results can be directly used by companies. They are either too immature or too specific, that is, not aligned with the potential exploiter's needs, requirements, and market constraints. On the other hand, industries are seldom involved in research activities. They focus mainly on production and distribution of their goods and services. In reality, the same problem arises in the relationship between the research departments of a company and its own business units directly involved in market operations.

Thus, the problem is not just academia versus industry: rather, it is research versus industrial development (even within the same company).

Innovation can be seen as the activity that attempts to bridge the gap illustrated in Figure 5.2. Many universities and research centers claim to focus on innovation. However, they seldom realize that innovation is different from research (as discussed in detail in the previous sections) and hence requires people, resources, and organizations that are significantly different from classic academic units (departments, institutes, schools, etc.). Innovation also does more than simply support patent creation and registration, or broker competences. To support and promote innovation an organization must exhibit a number of characteristics:

- It must be staffed with professionals who thoroughly understand the market as well as the technology; generic expertise on innovation processes alone is not sufficient.
- It must have the right connections into the research world.
- It must be able to accomplish technology scouting on a worldwide scale.
- It must be able to design, develop, and deploy solutions or components of solutions, not just to sketch proposals, ideas, or prototypes.
- It must be organized to accomplish challenging projects, taking into account the customer's timeframe and economic constraints.

This type of organization is more similar to a consulting company rather than a TTO or a brokerage service. Universities rarely have this kind of structure. Except for a few differences, the same applies to industries. 3

There have been many unsuccessful attempts to promote innovation and 4
support university–industry cooperation. Universities and industries approach

innovation with the same principles that they apply in their mainstream activities. 5

We need new approaches and models to support innovation. An example is described below. 6

5.4.2 CEFRIEL

CEFRIEL [1] is a leading Italian ICT center for research, innovation, and education. CEFRIEL shareholders are universities (Politecnico di Milano, University of Milano, University of Milano-Bicocca, and Università dell'Insubria), public administrations (Regional Council of Lombardy), and industries (Alcatel-Lucent Italia, RCS, Compunetix Inc., Elettronica Industriale, Engineering Ingegneria Informatica, Fastweb, Hewlett-Packard Italiana, Italtel, Microsoft, Pirelli, Nokia Siemens, Industrie Dial Face, STMicroelectronics, Telecom Italia, Vodafone). CEFRIEL's mission is to fill in the gap between university research activities and the innovation needs of industries and public administrations. The focus is on exploiting ICT as a strategic factor to innovate products, processes, and services. Multidisciplinarity, evaluation of customers' needs and requirements, and execution effectiveness are the key factors guiding CEFRIEL operations.

The activities carried out by the center are summarized as follows:

- Assessment of customers' products, processes, and operations
- Technology scouting
- Applications of research results and innovative technologies to new processes and products
- Development of components and solutions
- Innovative education programs

CEFRIEL is organized and staffed quite differently from a university department, a generic consultant, or a brokerage agency. The human capital of the center includes 140 professionals (with the highest education degrees): highly qualified experts, project managers, developers, and support staff capable of conducting innovation projects, taking into account customers' constraints (time, resources, etc.) and requirements. CEFRIEL actively cooperates also with non-ICT researchers and experts to ensure the coverage of all skills needed to carry out complex multidisciplinary projects.

CEFRIEL is organized and managed as an independent company, with a budget based totally on contracts and research grants. CEFRIEL activities are specific for center shareholders and other companies. All CEFRIEL activities are managed contractually, with the required and agreed level of IP management and protection.

In general, CEFRIEL was created, organized, and managed to work with customers, understand their problems and needs, and formulate and deploy multidisciplinary solutions, exploiting the best technologies and practices available on the market.

5.5 CONCLUSIONS

Research and innovation are vital and essential elements of our society. They are (necessarily) instrumental to promoting growth, societal development, and quality of life. It is therefore crucial to understand the problems, critical aspects, and essential factors that distinguish and characterize them.

Over the years, research and innovation have evolved to account for the evolution of science and technology and, even more important, changes in culture and socioeconomic trends. It is easy to travel and communicate. The Internet has enabled a global approach to human interaction, manufacturing, distribution, and in general, operation. Most processes have been accelerated and increasingly widely distributed. The rate of change in technology is very high and often unpredictable. In general, we need to confront a very dynamic and evolving scenario where the role of universities, research centers, public institutions, and private companies has to be continuously reconsidered and reshaped.

In this chapter the author has emphasized the need to carefully identify and confront the different characteristics and dimensions of research and innovation. Research is the process through which we generate new knowledge. Innovation is the process through which we apply knowledge to create new products, processes, and services. Each of these activities is characterized by specific properties and challenges that cannot be confused or underestimated. Accordingly, it is essential to promote and develop means and tools that are aligned to the specific characteristics of these fundamental activities. Technology transfer must be supported as a critical phase of innovation, by complementing conventional approaches such as patents and TTOs with more structured means such as technology transfer by heads and by projects.

The considerations proposed in here are based on the experiences developed at CEFRIEL, an innovation and technology transfer institution created in Italy by universities, industries, and public administration. The center is managed as a private company and operates in the market by addressing the fundamental business needs of its clients. The results achieved by the center confirm the validity of the criteria and guiding principles discussed in the chapter; the focus of the center is on a multidisciplinary approach enriched by strong technology scouting processes, technology transfer by projects, and the ability to quickly propose effective solutions capable of addressing the ultimate and fundamental challenges of CEFRIEL's customers.

In conclusion, we need to carefully rethink the attitude and principles governing the overall innovation process, from fundamental research to industrial application and exploitation. This is vital in addressing the challenges and opportunities that society is facing in this period of radical and continuous transformation.

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