Introduction

Technological entrepreneurship combines two main concepts. The first is technology, which is 'the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems' (Burgelman et al., 2004, p. 2). The second is entrepreneurship, which can be defined as 'the identification and exploitation of previously unexploited opportunities through the creation of new resources or the combinations of existing resources in new ways, to develop and commercialize new products, move into new markets and/or service new customers' (Hitt et al., 2001, p. 480).

According to these combined definitions, technological entrepreneurship can be conceived as recognizing, discovering and even creating entrepreneurial opportunities from technological developments. Entrepreneurial opportunities are the possibilities to create future economic artifacts originating from the divergence of beliefs towards the future value of resources – technologies in our case – given the possibility to transform them in future outputs, that is, technological applications (Kirzner, 1997; Venkatraman and Sarasvathy, 2001). Thus, (Casson, 1982) entrepreneurial opportunities are 'those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their costs of production' and differ from the larger set of opportunities to create profits as they require the discovery of new means-ends relationships, as opposed to optimization within existing means-ends frameworks (Kirzner, 1997).

Despite the number of success stories and available cases, new means-ends relationships such as this are not necessarily discovered by serendipitous entrepreneurs. Rather, their identification is often the result of a conscious and systematic entrepreneurial and collective action that transforms the opportunities arising in practical applications and economic and societal value. As a consequence, technological entrepreneurship is referred to herein as a matching process between imagination and needs and, most of all, as a process. In this perspective technological entrepreneurship is not something that results (mainly) from talented minds, but rather is the result of a combination of conscious individual and collective actions within appropriate conditions where talented individuals can

optimally contribute. These various conditions, as opposed to inherited individual traits, are something than can be acted upon and ultimately managed and given direction.

This is the rationale underlying the definition of technological entrepreneurship as the process that bridges technology development and business creation, from the recognition or even the creation of potential business value of new discoveries and technologies, to the matching with existing and/or potential market needs, and finally the transformation of opportunities arising in commercial products, services and new businesses.

According to these considerations, technological entrepreneurship has thus three main components, which are:

- An entrepreneurial component, which is the set of actions that individuals and firms perform to identify and harness the distinctive and disruptive potential of emerging technologies and business opportunities that may not be obvious to others.
- A management component, which refers to the actions done by individuals and firms to develop a compelling value proposition capable of rapidly entering a market, possibly with a proven business model, to exploit business opportunities identified.
- An environmental component, which is a set of formal and informal supporting institutions and resources that create the appropriate conditions for technology-based ventures. These factors include public policies, laws and regulations, industry standards and resource endowments (including human capital), knowledge-intensive enterprises and activities, supportive public or public-private institutions, cultures, communities and inter-organizational links.

To summarize, technological entrepreneurship can be assimilated into a type of 'entrepreneurial management' (Stevenson and Jarillo, 1990) – 'all management actions and decisions concerning the creation of new businesses and the related development of innovations from new or reconfigured resources, regardless of the scope of such development efforts (from small start-ups to large, established firms)' (Day, 1992, p. 117). This phenomenon occurs at the intersection of technology development (science and engineering) and business creation (management and business) involving individuals, businesses and governments that transform new ideas into economic and societal value. Such 'entrepreneurial management' functions in an innovative firm are discussed in the contribution by Lazonick (Chapter 1, this volume).

The technological entrepreneurship process incorporates four main sets of activities related to: the creation of new technologies or the identification

of existing (but previously unexploited) technologies; the recognition and matching opportunities arising from applications of these technologies to emerging market needs; technology/applications development; and business creation.

1. The creation or identification of technologies involves the recognition of relationships and connections that lead to discoveries (revealing something that was unknown) and inventions (the possible applications of discoveries into the real world). Regarding technology creation, Allen (2003) offers a straightforward explication of the aforementioned activities, using the example of the design of the canal systems for the city of Florence in Italy by Leonardo da Vinci. Allen notes that the relationship/connection da Vinci made was that canals might be compared to tree branches. He studied how nutrients and water flows in tree branches and discovered, through extrapolation, how water flows through canals. This understanding was the stimulus to the invention of a hydraulic device that controlled water levels in canals. This new theoretical and practical body of knowledge, skills and artifacts (this 'technology') then became applied generally, for example, in wind and water-powered mills. This example also suggests that the creation of new technologies is characterized by both creative and structured basic and applied research activities that involve thinking and insight (the relationship/connection between canals and tree branches) as well as generating and codifying new knowledge (how nutrients and water flows into tree branches and the functioning of canal systems) and solving particular technical problems (control water levels so that boats can pass under bridges). As for the identification of existing and previously unexploited technologies, value creation opportunities do not necessarily result from new technologies. Existing and previously unexploited technologies may also be an important trigger for the technological entrepreneurship process. To understand the relevance of these factors, one can refer to the study by Rivette and Kline (2000) who noted that IBM's systematic exploitation of its existing intellectual property resulted in increases in its annual royalty stream by 33 times in ten years. To achieve the same results in terms of profits, the authors estimated that IBM would have to increase worldwide sales by approximately one-fourth each year (an additional $20 billion of products). Moreover, as Wasserman shows in Chapter 6, a technology such as open source might generate a number of very different ways to create value.

   Whether via creation and identification, the outcomes are technologies that can be used to develop products and services as well as their production and delivery systems (that is, applications).

2. The second set of activities involves the recognition of opportunities to match the potential applications of the technology created/identified with a market need or space – that is, a business opportunity – and decide about IP securing and protection to ensure the potential of value creation. In this context, recognition means both the identification of an existing need in the marketplace and a way to satisfy that need (for example, genetically modifying a plant to increase crop production), as well as the creation of demand for something people did not previously understand they needed (for example, mobile phones). There are a number of sources from which such business opportunities can be identified: applied research activities, familiar industries and businesses, social and professional networks, customers, universities' technology transfer offices and government agencies. In this volume, there are a number of contributions that address these issues:

    - Cobis (Chapter 2) addresses the policy-making approach, scientific research supporting mechanisms and related areas of actions of the Italian Ministry of Education, University and Research (MIUR).
    - Verrill (Chapter 3) discusses the role of universities for the transfer of research results into meaningful enterprises by presenting strategies used by the Massachusetts Institute of Technology (MIT), such as the 60-year-old Industrial Liaison Program, the Technology Licensing Office, and a set of dedicated centers and initiatives.
    - Hulsink, Elfring and Stam (Chapter 5) analyse the effect of networks and relationships in the discovery and development of innovations by drawing on empirical results described in the literature over the past ten years.

    Business opportunities arising from technologies created/identified are often reflected in a business concept that is the main output of this phase. It represents a necessary bridge between the idea(s) for the application(s) of the technology and feasible business(es). It is a necessary tool to test the market feasibility of the opportunity(ies) identified. Understanding the relevance of this activity is similar to trying to understand why so many technologies and applications are never commercialized, without talking about commercial success. The business concept is the key to undertaking the transformation of an idea into real value, of imagination into realization. Following Allen (2003), the business concept offers a formal description of an opportunity composed of four elements: the product/service being offered,

the target customer, the value proposition (that is, the benefits for the customer) and the means by which those benefits will be delivered to the customers (or distribution). The business concept, including a plan of how the business will make money and create value for its customers and partners, creates a business model. Similarly, a common mistake of aspiring entrepreneurs is to stick to a logical or default business model without considering the many other ways that revenues can be generated from the same technology. In this regard, Wasserman (Chapter 6) identifies as many as 11 business models for open source software.

Most of the time, value creation is a matter of doing things differently, innovating the business concepts and models or creating completely new ones, such as in the case of Eurotech Group, reported in Siagri, Barbaro and Buttolo (Chapter 7). Eurotech Group developed an innovative multi-option strategy, based on balancing exploitation and exploration of technologies/innovations and leveraging of knowledge networks that allowed the company to manage multiple business models. Eurotech Group became a 'pocket multinational', as defined by the authors, active on a global scale (in Europe, North America and Asia) with a compounded annual growth rate (CAGR) of more than 55 per cent over the last five years.

3. The process of developing activities begins after a business concept has been successfully tested and a feasible business opportunity has been identified. This process is described here as product and related business model design, development and prototyping. The goal is to test the technical and commercial feasibility of the technology/application and decide whether to license it, to sell it or to create a new company for its exploitation. If successful, the result of these activities is a technological application. Innovation and product development literature is full of such insights and cases. This volume will not particularly focus on these issues, as the contributions are directed more towards the task of determining and instituting the most appropriate system, and the organizational and individual level conditions for ensuring a successful transformation of ideas and opportunities into commercial success, rather than on the management of the process itself.
4. Finally, the process most often concludes with the creation of a new company that utilizes the technology/application developed to create new business (and societal value) that is the final outcome of this set of activities and the main rationale for the technology entrepreneurship process. This moves into topics related to the set-up, organization, equipping and financing (thereby, evaluation)

of a new technology-based venture. As such, the contributions of this monographs offer a number of insights related to:

- Financing actors and dynamics as in Verrill's (Chapter 3) and Olivier's (Chapter 4) contributions, who describe the role of angel funds in sustaining the first steps of a technology-based venture.
- The issues and mechanisms regarding the evaluation of ventures such as those mentioned in Siagri, Barbaro and Buttolo's contribution (Chapter 7).
- The human capital needs of new business developments, described in the contribution of Harris (Chapter 8) that details a joint initiative between Intel and UCLA Berkeley to spur entrepreneurship capabilities, and also its effect on economic development and social well-being, as in the contribution of Lazonick (Chapter 1) who discusses the role of system-level factors such as basic educational levels and 'brain circulation' that are the fundamental engines of growth and development of the 'Silicon Valleys' and 'Route 128s' around the world, reporting on the cases of Japan, South Korea, Malaysia, Taiwan, India and China.

A number of actors with various diverse and overlapping roles are involved in the process of making an 'entrepreneurial ecosystem' that is composed of a network of:

- interacting individuals, that is, academics, engineers, entrepreneurs, company managers, civil servants and new graduates;
- companies, such as Eurotech (Chapter 7) or Intel (Chapter 8);
- academic and research institutions, such as UCLA Berkeley (Chapter 8) or the Technology Licensing Office and the Deshpande Center at MIT (Chapter 3);
- government ministries and/or agencies involved in technology transfer, such as the Ministry of Education, University and Research in Italy or the Ministry of Education, Culture, Sports, Science and Technology in Japan (Chapter 2) or mission-oriented international organizations, such as the United Nations Industrial Development Organization;
- private investors, including business angels like the BAMS Angels Fund (Chapter 4); and
- other organizations, which include non-profit organizations/movements, such as the Free Software Foundation or the Open Source Initiative (Chapter 6).

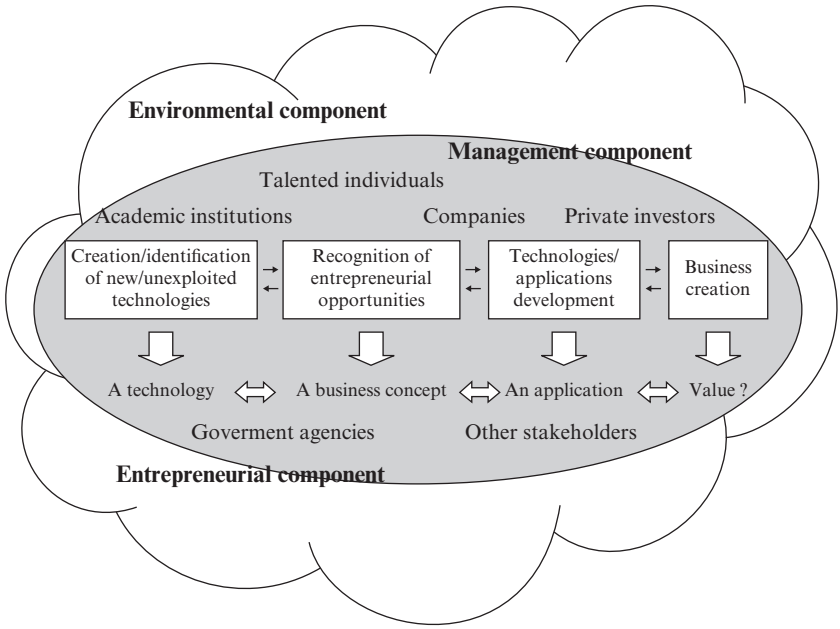

Figure 1 A systemic view of technological entrepreneurship.

Figure 1 represents the aforementioned considerations of technological entrepreneurship as related to its components, activities, outputs and actors.

This volume attempts to shed light on some practical issues related to the underpinnings of the functioning of such a system by discussing a number of experiences and field insights on how various elements interrelate within the technological entrepreneurship process. These elements affect different actors (from government bodies to private investors and companies), at different levels (national policies, networks and collaborations, single companies) and at different stages in their life cycle (from start-up to incumbents), in Europe as well as in the USA. More specifically, the main themes of the cases and empirical analyses reported in this volume are:

- the role of entrepreneurship and innovation for economic growth and social well-being;
- the role of governments, universities and private investors in starting and supporting this process;
- the role of networks as the fuse and the fuel in discovery and innovation;

- some possible business models for transforming technological innovations into profits; and
- the diffusion of technological entrepreneurship culture and skills.

Table 1 reports a synthesis of the main issues (in rows) related to technological entrepreneurship as discussed in the different chapters (in columns) to help the reader identify where they can find cases, examples and insights related to such issues.

This volume is useful for both academics and practitioners in that it presents a range of concepts combined with practical and empirical origins of contributions. Nevertheless, the potential of fostering both economic growth and societal well-being, as well as the difficulty of converting emerging technologies into both business and social value, makes this work most useful to international practitioners. In particular, it is most useful to those practitioners fostering and practicing technological entrepreneurship for and/or inside organizations in Europe and in emerging economies who address such questions as 'Where do good ideas come from? What is a good idea? How do ideas become opportunities? How do I seize a business opportunity? Where and how do I get money?'

The experiences and field analysis presented herein represent good sources for scholars teaching technology and innovation management, economics of innovation, strategic management of technology and innovation.

CHAPTER OVERVIEW

This volume is a collection of eight contributions whose contents are summarized below.

In Chapter 1 William Lazonick identifies the roles of entrepreneurship in the formation of new firms and identifies the basic roles of the entrepreneur. Examples are used to point out that in the advanced economies successful entrepreneurship in knowledge-intensive industries has depended heavily upon a combination of two factors: (1) business allocation of resources to innovative investment strategies, and (2) government investment in the knowledge base, state-sponsored protection of markets and intellectual property rights and state subsidies to support these business strategies. National economic development is explained through the interaction of the 'developmental state' and the dynamics of innovative enterprise that makes entrepreneurial activity an important engine for the process of economic development as related to a number

Table 1 Monograph concept map

Issues	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8
Creating new technologies (through research)		X					X	
Identifying and exploiting existing technologies			X			X	X	
Developing value proposition and business model						X	X	
Devising a set of formal and informal institutions	X	X			X			
Leveraging collaboration and social networks		X	X		X	X	X	
Innovating business concepts/models						X	X	
Setting up, funding and growing new company		X	X	X		X	X	
Valuing a technology-based venture							X	
Generating impacts and effects on economic development	X		X					X
Developing knowledge, human capital and networks	X	X			X			X
Developing and diffusing entrepreneurship			X					X
Entrepreneurs' role	X		X					
Governments' role	X	X						
Universities' role		X	X					
Private investors' role			X	X				

of cases in developed (USA, Italy and Japan) as well as in developing countries (India, China and the Asian Tigers), in high-tech (for example, biotechnology) and more traditional sectors (for example, textiles and machinery).

In Chapter 2 Fabrizio Cobis analyses recent public policies of France, Japan and especially Italy, and advocates for the emergence of a new model of innovation based on a constant and thorough interaction among enterprises, universities and government institutions. The action of these three subjects is depicted as a sort of 'triple helix'. The ways in which this approach are being applied is described in a thorough analysis of MIUR's policies, especially related to the model of technological districts and the procedures followed for their concrete realization.

David Verrill in Chapter 3 describes the role and mechanisms of universities like MIT as important engines of innovation and business creation for the areas in which they are located. The Boston/Cambridge area example is used to discuss the ingredients that make such areas a dynamic ecosystem of innovation and the roles of the different actors in such ecosystems. Finally, the research areas for great innovations are highlighted with the analysis of venture capital investment.

In Chapter 4 Maurice Olivier draws on lessons learned with the BAMS Angel Fund in Belgium and parallel experience with a similar fund in the USA to explore why collectively organized angel groups may be more effective in responding to the needs of 'late early stage' (or 'first stage') start-up companies.

The premise is that these groups can harness the collective wealth, wisdom, knowledge, talent, time available and commitment of a larger group of motivated individuals who – in addition to positioning themselves naturally in the €0.7–2.5 million investment 'equity gap' range – are able and willing to mentor and guide the management of the investee companies. Conditions for success include subtle leadership of the group by dedicated leaders, clear structures and rules, empowerment, mutual respect, cross-fertilization, professionalism, available templates and models, the ability to converge and decide quickly on important issues, and, last but not least, the important factors of friendship and fun.

In Chapter 5 Willem Hulsink with Tom Elfring and Wouter Stam discuss key network concepts, such as social capital, relational embeddedness (strong and weak ties), structural embeddedness (structural holes) and a number of empirical analyses collected in relevant literature developed over the last ten years. They identify the central role of knowledge in the discovery and realization of innovations, social networks and their potential for knowledge brokering and the relationship between particular network characteristics and innovation.

Tony Wassermann in Chapter 6 addresses the case of open source software to discuss a wide variety of business models that have been used, including dual-licensing, professional services and support, and multiple product lines. Each of these models is described, along with examples of companies that are following each approach and some insights for choosing the appropriate business models for launching a new business in this field.

In Chapter 7 Roberto Siagri with Andrea Barbaro and Nicola Buttolo illustrate the multi-option strategy used at Eurotech Group to develop and sustain its business model(s). In particular, after reviewing the characteristics and advantages of the different mechanisms at the basis of Eurotech's multi-option strategy, the company's strategy is presented as a new high-tech company paradigm driven by systematic value-based scenarios of the future, upon which related optimal strategies are designed and executed in an organizational setting able to manage different and multiple portfolios of options.

Finally, in Chapter 8 Mark Harris, starting from the technical and entrepreneurial shortage of science-based professionals, presents a detailed joint program between Intel and UCLA Berkeley that focuses on accelerating the rate of innovation and economic growth in key markets around the world via the diffusion of entrepreneurship culture and skills in academic faculties.

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