

Innovation, Technology, and Knowledge Management

Series Editor

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Neslihan Aydogan-Duda

Editor

Making It to the Forefront

Nanotechnology—A Developing Country
Perspective

 Springer

Editor

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*To my husband Thomas Francis Duda
who taught me how love and courage
can be sustainable ...*

Series Foreword

The Springer book series *Innovation, Technology, and Knowledge Management* was launched in March 2008 as a forum and intellectual, scholarly “podium” for global/local, transdisciplinary, transsectoral, public–private, and leading/“bleeding”-edge ideas, theories, and perspectives on these topics.

The book series is accompanied by the Springer *Journal of the Knowledge Economy*, which was launched in 2009 with the same editorial leadership.

The series showcases provocative views that diverge from the current “conventional wisdom” that are properly grounded in theory and practice and that consider the concepts of *robust competitiveness*,¹ *sustainable entrepreneurship*,² and *democratic capitalism*,³ central to its philosophy and objectives. More specifically, the aim of this series is to highlight emerging research and practice at the dynamic intersection of these fields, where individuals, organizations, industries, regions, and nations are harnessing creativity and invention to achieve and sustain growth.

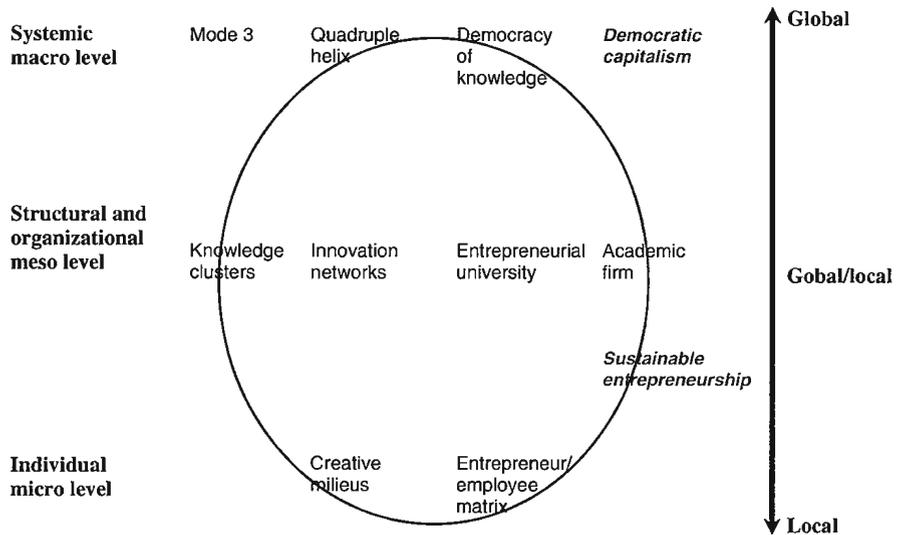
¹ We define *sustainable entrepreneurship* as the creation of viable, profitable, and scalable firms. Such firms engender the formation of self-replicating and mutually enhancing innovation networks and knowledge clusters (innovation ecosystems), leading toward robust competitiveness (E.G. Carayannis, *International Journal of Innovation and Regional Development* 1(3), 235–254, 2009).

² We understand *robust competitiveness* to be a state of economic being and becoming that avails systematic and defensible “unfair advantages” to the entities that are part of the economy. Such competitiveness is built on mutually complementary and reinforcing low-, medium-, and high-technology and public and private sector entities (government agencies, private firms, universities, and nongovernmental organizations) (E.G. Carayannis, *International Journal of Innovation and Regional Development* 1(3), 235–254, 2009).

³ The concepts of *robust competitiveness* and *sustainable entrepreneurship* are pillars of a regime that we call “*democratic capitalism*” (as opposed to “popular or casino capitalism”), in which real opportunities for education and economic prosperity are available to all, especially – but not only – younger people. These are the direct derivative of a collection of top-down policies as well as bottom-up initiatives (including strong research and development policies and funding, but going beyond these to include the development of innovation networks and knowledge clusters across regions and sectors) (E.G. Carayannis and A. Kaloudis, *Japan Economic Currents*, 6–10, January 2009).

Books that are part of the series explore the impact of innovation at the “macro” (economies, markets), “meso” (industries, firms), and “micro” levels (teams, individuals), drawing from such related disciplines as finance, organizational psychology, research and development, science policy, information systems, and strategy, with the underlying theme that for innovation to be useful it must involve the sharing and application of knowledge.

Some of the key anchoring concepts of the series are outlined in the figure below and the definitions that follow (all definitions are from E.G. Carayannis and D.F.J. Campbell, *International Journal of Technology Management*, 46, 3–4, 2009).



Conceptual profile of the series *Innovation, Technology, and Knowledge Management*

- The “Mode 3” Systems Approach for Knowledge Creation, Diffusion, and Use: “Mode 3” is a multilateral, multinodal, multimodal, and multilevel systems approach to the conceptualization, design, and management of real and virtual, “knowledge-stock” and “knowledge-flow,” modalities that catalyze, accelerate, and support the creation, diffusion, sharing, absorption, and use of cospecialized knowledge assets. “Mode 3” is based on a system-theoretic perspective of socio-economic, political, technological, and cultural trends and conditions that shape the coevolution of knowledge with the “knowledge-based and knowledge-driven, global/local economy and society.”
- Quadruple Helix: Quadruple helix, in this context, means to add to the triple helix of government, university, and industry a “fourth helix” that we identify as the “media-based and culture-based public.” This fourth helix associates with “media,” “creative industries,” “culture,” “values,” “life styles,” “art,” and perhaps also the notion of the “creative class.”

- **Innovation Networks:** Innovation networks are real and virtual infrastructures and infratechnologies that serve to nurture creativity, trigger invention, and catalyze innovation in a public and/or private domain context (for instance, government–university–industry public–private research and technology development cooperative partnerships).
- **Knowledge Clusters:** Knowledge clusters are agglomerations of cospecialized, mutually complementary, and reinforcing knowledge assets in the form of “knowledge stocks” and “knowledge flows” that exhibit self-organizing, learning-driven, dynamically adaptive competences and trends in the context of an open systems perspective.
- **Twenty-First Century Innovation Ecosystem:** A twenty-first century innovation ecosystem is a multilevel, multimodal, multinodal, and multiagent system of systems. The constituent systems consist of innovation metanetworks (networks of innovation networks and knowledge clusters) and knowledge metaclusters (clusters of innovation networks and knowledge clusters) as building blocks and organized in a self-referential or chaotic fractal knowledge and innovation architecture (Carayannis 2001), which in turn constitute agglomerations of human, social, intellectual, and financial capital stocks and flows as well as cultural and technological artifacts and modalities, continually coevolving, cospecializing, and cooperating. These innovation networks and knowledge clusters also form, reform, and dissolve within diverse institutional, political, technological, and socioeconomic domains, including government, university, industry, and non-governmental organizations and involving information and communication technologies, biotechnologies, advanced materials, nanotechnologies, and next-Generation energy technologies.

Who is this book series published for? The book series addresses a diversity of audiences in different settings:

1. *Academic communities:* Academic communities worldwide represent a core group of readers. This follows from the theoretical/conceptual interest of the book series to influence academic discourses in the fields of knowledge, also carried by the claim of a certain saturation of academia with the current concepts and the postulate of a window of opportunity for new or at least additional concepts. Thus, it represents a key challenge for the series to exercise a certain impact on discourses in academia. In principle, all academic communities that are interested in knowledge (knowledge and innovation) could be tackled by the book series. The interdisciplinary (transdisciplinary) nature of the book series underscores that the scope of the book series is not limited a priori to a specific basket of disciplines. From a radical viewpoint, one could create the hypothesis that there is no discipline where knowledge is of no importance.
2. *Decision makers – private/academic entrepreneurs and public (governmental, subgovernmental) actors:* Two different groups of decision makers are being addressed simultaneously: (1) private entrepreneurs (firms, commercial firms, academic firms) and academic entrepreneurs (universities) interested in optimizing knowledge management and in developing heterogeneously composed

knowledge-based research networks and (2) public (governmental, subgovernmental) actors that are interested in optimizing and further developing their policies and policy strategies that target knowledge and innovation. One purpose of public *knowledge and innovation policy* is to enhance the performance and competitiveness of advanced economies.

3. *Decision makers in general*: Decision makers are systematically being supplied with crucial information, for how to optimize knowledge-referring and knowledge-enhancing decision making. The nature of this “crucial information” is conceptual as well as empirical (case-study-based). Empirical information highlights practical examples and points toward practical solutions (perhaps remedies), conceptual information offers the advantage of further-driving and further-carrying tools of understanding. Different groups of addressed decision makers could be decision makers in private firms and multinational corporations, responsible for the knowledge portfolio of companies; knowledge and knowledge management consultants; globalization experts, focusing on the internationalization of research and development, science and technology, and innovation; experts in university/business research networks; and political scientists, economists, and business professionals.
4. *Interested global readership*: Finally, the Springer book series addresses a whole global readership, composed of members who are generally interested in knowledge and innovation. The global readership could partially coincide with the communities as described above (“academic communities” and “decision makers”), but could also refer to other constituencies and groups.

Elias G. Carayannis
Series Editor

Preface

Disruptive technologies and their economic and social impacts have recently been frequently discussed. Nanotechnology is one of them and it is one that has wide range of implications: may be wider than economists and the business world recognize. Given this and the fact that developing countries, though equipped with an understanding of this technology, lag behind in the commercialization of such technology motivate this book. There are a variety of reasons, we ascertain, this is an issue: lack of a supportive institutional and legal structure, lack of vision, cultural idiosyncrasies and alike.

Specifically, the book intends to cover the reasons behind the entry barriers in the nanotechnology industry in these countries. Having done this due to the success of such entry in the United States, relative to the other developed countries, the study is benchmarked against the United States. Obviously this relatively new wave of major technological change is likely to have critical consequences for the developing as well as the developed world. As we suggest above, we naturally expect issues surrounding the development of the nanotechnology industry to be different, proposing completely new challenges for the developing world. In completing this task, we analyze the issue from several angles: ranging from cultural issues to capital markets and industrial clusters to government policy. We also describe the industry from a perspective where its strategic nature and its importance for consumer welfare and homeland security are laid out.

Our task is to give a cross-cultural account of the current developments in the nanotechnology industry based on the above issues and provide with policy suggestions. In doing this, we lay out the importance of knowledge transfer from universities to the market and hence emphasize the interface between science and its commercialization. The book lays out an institutional perspective in doing this. Precisely, we describe the characteristics of nanotechnology and its organizational interface between universities and the market in the context of developing countries. As such the book provides an unprecedented theoretical and empirical account of the developments in the nanotechnology industry in the developing world cautioning for the consequences of lacking a vision to cultivate the sector.

In the first chapter, the author intends to provide with a thorough account of nanotechnology as a science giving a vast array of examples to its nature in the research and product markets. In doing this the importance of the external environment in terms of the role of a vast array of institutions such as culture, the patent system, and universities is discussed. This is an introductory chapter that prepares a background for the entire book in terms of providing an understanding to the reader as to what issues concern this industry.

In the second chapter, authors intend to clarify the role of nanotechnology in effecting the development of other industries in different environments. The general aim is to study the effect of different economic approaches to the dissemination of such knowledge to the rest of the economy. Obviously not all economic approaches are conducive for the development and progress of such industry that involves a disruptive technology with the power to affect the rest of the economy in significant ways. The chapter provides with an understanding of how with the right approach nanotechnology can have a multiplier effect on the rest of the economy.

The third chapter focuses on the highly collaborative nature of nanotechnology in product and process markets accounting for the difficulty of attaining the stability of such collaboration due to the tacit nature of this technology. Given the background that is laid in the first three chapters this chapter adds an additional requirement to the development and progress of this sector: namely the ability of different institutions to collaborate at the research and development stage of any product that involves nanotechnology.

The fourth chapter defines the current situation in the developing countries in terms of their education, science and technology policies. The similarities and differences among different countries are outlined. The chapter lays a background to the country-specific accounts that follow in the rest of the book.

The fifth chapter focuses on the impact of culture and the role of the intermediary institutions among which clusters are discussed in cultivating the private market entry, innovation, and growth. In this chapter, the Turkish example is given mainly as it provides an interesting account as to how the ability to form clusters and the interface between the academia and research are curbed by cultural and institutional hang-ups.

The sixth chapter focuses on how important differentiation strategy has become for many countries to concentrate on. Given this and given the strategic nature of the nanotechnology sector along with the role that this sector could play in increasing the welfare of nations, knowledge assets and their importance in achieving and sustaining the economic development are discussed.

The seventh chapter analyzes the current situation of the Turkish nanotechnology industry by focusing on the legal framework, the scope of research in the universities and nanotechnology companies. The intention is to trace out the discontinuities among these bodies and to understand how far Turkey might be behind in the nanotechnology race and whether it is too late for the country to catch the ongoing nanotrend.

The eighth and ninth chapters focus on the policies related to nanosciences and nanotechnologies and current activities in the nanotechnology field in Latin

American countries. The aim of the chapter is to understand the challenges along with explaining the existing and potential obstacles for the development of the nanotechnology sector.

The tenth chapter focuses on the research and development activities, investment, and commercialization of nanoproducts and research publications of China in the nanotechnology field. This chapter intends to analyze the future potential of the country to develop itself as a leader in the global nanotechnology industry.

The 11th chapter focuses on the Iranian example. In developing countries, it is often observed that emerging technologies are discovered when the markets are already saturated with these products. Nanotechnology is an exception for Iran. Planning for the development of this technology started in the year 2001 at a time when Iran did not have any nanotechnology products. The results of such planning proved itself as successful. This chapter concentrates on the past progressions, adopted policies of the National Iranian Nanotechnology Initiative (NINI), the outcomes, and the critiques of this initiative. The chapter also includes the lessons learned from this experience for Iran and other developing countries.

The 12th chapter focuses on the research publications and research and development activities, investment, and commercialization of nano products of India in the nanotechnology field. This chapter intends to analyze the future potential of the country to develop itself as a leader in the global nanotechnology industry.

The 13th chapter focuses on comparing the social and ethical implications of nanotechnology in the global North and global South, including the unequal distribution of risk and benefit, on several dimensions: north–south, rich–poor, and by gender, ethnicity, and ability status.

The 14th chapter focuses on the origins of nanoscience and technology policies in the United States and, particularly, the approaches taken to coordinating research among the wide variety of federal government agencies and other institutions involved in funding, priority-setting, and performing research. This chapter helps us forming a well-informed perspective by comparing the US example with the developing countries, thereby completes the work.

The book ends with a chapter that ties all the above in a meaningful way and provides with the agenda for future work.

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