Chapter 7
Nanosciences and Nanotechnologies: Evolution Trajectories and Disruptive Features

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ABSTRACT

Nanotechnologies and nanosciences are one of the most important novelties in the panorama of sciences and technologies. This work presents: their evolution since their first emergence; their most important scientific and technological features; the analysis of their role in society and economics in the socio-economic literature; their main areas of scientific and technological evolution and deployment; the motivations of the interests towards them in science and society. Nanotechnologies and nanosciences originate from a recombination of pre-existing research fields; they have the character of being a general-purpose technology and are linked to classic scientific areas. The character of Disruptive Technology of nanotechnologies and nanosciences is assessed also with the use of experimental data from a bibliographic analysis. Several examples of nanotechnological items are presented, either yet in the hands of consumers or showing promising features for the near future. The accurate description of this newly expanding area of sciences and technologies can provide important insights to the scholars and practitioners who are engaged in the study of this field of science, technology, and innovation, or aim at comparing this with related fields.

BACKGROUND

Nanosciences and Nanotechnologies (NST) have emerged in the last decades of the 20th century as one of the most scientifically intriguing and technologically promising novelties in the vast panorama of pure and applied research. They raise growing interest and citations both on scientific journals and on popular magazines (Bainbridge 2002). This witnesses the still much unexplored potentialities of NST towards society. It is then important to resume in short their features for the use of all interested in the topic, and to build a reference for their needs. Present contribution

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aims at a description of NST and of their main features, of their past evolution and of their future potentialities. A selection of on topic literature is also presented; a further element of novelty is the reasoned accounting for the features of General Purpose Technology and of Disruptive Technology of NST.

NANOSCIENCES AND NANOTECHNOLOGIES: INTRODUCTION TO THEIR MAIN FEATURES

Features of NST are an important stimulus for innovation in several sectors (Tolles and Rath 2003). Several hard science journals having the stem "nano" and articles about NST topics are published[1]. Moreover also special issues of journals on economics and management are published on NST[2], showing the interest towards the analysis of their effects on economic activities and on society. The debate on "nanoethics"[3] is also growing: possible effects upon human health of nanostructured objects have to be fully described, and thus the need for an assessment of their effects in a major request of ethicists.

NST are described as fluid and a cross-borderer, and inserted in the paths of knowledge-created "creative destruction" (Bozeman et al. 2007, p. 811). NST are at the convergence of several scientific and technological fields and might influence the behaviour and the technological paths of both entrant firms and big incumbents in several industries (Avenel et al. 2007, p. 865). Moreover, NST academic spinoffs are gaining importance and playing a role in their development (Libaers et al. 2006). NST also need infrastructures in order to be performed, thus generating the creation of *platforms* geographically related to research units in order to build a value chain (Robinson et al. 2007); this means that such NST generate clustering of resources under the common denominator of new knowledge production and exploitation. NST are also in a cutting-edge position in order to enhance new system for environmental control and remediation (Rickerby and Morrison 2007). NST great potentialities have started to deploy into innovation. Nanosciences are in fact a new vision and a novel approach towards materials: thus they can open unexplored research perspectives, promising of applications in several (old or new) industries, either creating new technologies or being applied in existing ones.

Common knowledge of NST has not grown much alongside with the spread of "Nanosciences" and "Nanotechnologies" terms. A wide Italian national survey shows high popular acceptance of NST but very little knowledge of their features, independently on scholar attendance, age and status (Caputo et al., 2009). Similar facts were described by Waldron et al. (2006) studying a U.S. sample of children and adults. Features attributed to NST (assimilating them to microtechnologies), show the great difficulty to understand that the dimensional ratio between micrometer and nanometre is the same existing between kilometre and meter.

Such premises are essential when talking about NST as their field of action is essentially dimensional: in fact they are defined with a dimensional prefix, nano. NST definition from the American National Nanotechnology Initiative[4] states: "Nanoscience involves research to discover new behaviours and properties of materials with dimensions at the nanoscale which ranges roughly from 1 to 100 nanometres (nm). Nanotechnology is the way discoveries made at the nanoscale are put to work. […] Nanotechnology is more than throwing together a batch of nanoscale materials - it requires the ability to manipulate and control those materials in a useful way". This definition discriminates between science and technology, and describes precisely and briefly the fundamental characters of NST: they act in a well defined dimensional field; their purpose is discovering new behaviours and new properties distinctive of nano-measured materials. Technologies will then transform the new knowledge in techniques