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Designing foresight studies for Nanoscience and Nanotechnology (NST) future developments

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Abstract

Nanoscience and Nanotechnology (NST) is widely considered as one of the most promising areas of scientific and technological development for future decades. As a consequence, almost every country in the world has chosen to invest significantly in this area. This choice, however, is only a first step in the investment decision process, given that almost any scientific discipline can be taken at the scale of a nanometre. In this paper, it is argued that foresight studies to decide where to invest in the nanotechnology area should be designed in a different way from what is normally done. Nanotechnology, in fact, has specific characteristics that should be taken into account when evaluating its expected impacts and potentialities.

Keywords: Nanoscience; Nanotechnology; Foresight process; Foresight methodology; Quantitative analyses

1. Introduction

During the last few decades, there has been increasing interest in science and technology at the nanometre scale. Significant resources are being invested in this direction by governmental institutions, public research centres, universities and firms throughout the world. At the same time, nanotechnology is still at an early stage of development and future scientific and technological results are difficult to foresee and pursue, given the broad extent of the disciplines involved and the possible technological advancements. In this context,

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foresight methodologies can play a pivotal role by individuating, inside this wide spectrum of nano-research, the most promising fields of enquiry and exploitation for nations, firms, research centres etc.

Although it is widely agreed that emerging technologies like nanotechnology, biotechnology etc., will have increasing socio-economic impacts, there are significant boundaries in terms of available economic resources and social and political accountability ("value for money") [1]. This has led to the necessity of setting research priorities not only at a macro-level (e.g. choosing between broad fields like biotechnology, nanotechnology, ICT, etc.), but also at a lower level, especially for fields that encompass many different subfields as is the case of nanotechnology. The individuation of research priorities through foresight studies [2], together with an analysis of the strengths and weaknesses of the actors involved, is paramount for increasing global economy competition. While foresight studies to identify research priorities at a macro-level are widely diffused and in many cases lead to similar conclusions in terms of macro-fields, studies aimed at understanding where to focus the efforts within these macro-fields are less developed. This instead is especially important for nanotechnology because: a) almost every country in the world has decided to invest significantly in this area, b) this decision is only a first step, given that almost any scientific discipline can be studied at the nanometre scale with new and interesting effects. The term 'nanotechnology' in fact encompasses such a wide range of tools, techniques and potential applications that some feel if is more appropriate to refer to 'nanotechnologies' [3].

In this paper it is argued that foresight studies to decide where to invest in the nanotechnology area should be designed in a different way from what normally happens in terms of methodologies and tools as nanotechnology has specific characteristics that should be taken into account when evaluating its expected impacts and potentialities.

In the first part of this paper, after underlining the importance and the development of nanotechnology, the main peculiarities of nanotechnology are presented. In the second part, the main decisional variables involved when preparing foresight studies are highlighted on the basis of the most recent literature and studies. In the final part, the peculiarities of nanotechnology are considered as the driving elements for the design of a new approach for foresight studies for this area.

2. NST and its peculiarities

The beginning of the path which has led to what is now called "nanotechnology" is usually traced back to a famous lecture proposed by the 1965 Physics Nobel Prize winner, Richard P. Feynman, who, in 1959, explained to the world that "There's plenty of room at the bottom" [4]. Feynman's ideas concentrated on the absence of any intrinsic physical limitation to scaling down to the manipulation of the single atom. More than 20 years later, a group of researchers at IBM in Zurich presented the first apparatus capable of "seeing" and manipulating a single atom: the Scanning Tunnelling Microscope (STM) [5] which was followed, a few years later, by the Atomic Force Microscope (AFM) [6]. These tools paved the way to what was once considered utopian, but is now regarded throughout the world as "the next big thing".

As is now widely recognized, NST does not merely concern with extreme miniaturization. It is now possible to say that "conceptually, nanotechnology refers to science and technology at the nanoscale of atoms and molecules, and to the scientific principles and new properties that can be understood and mastered when operating in this domain. Such properties can then be observed and exploited at the micro- or macro-scale, for example, for the development of materials and devices with novel functions and performance" [7].