Technological Forecasting & Social Change 83 (2014) 194–207

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Running ahead in the nanotechnology gold rush. Strategic patenting in emerging technologies

Federico Munari [a,1], Laura Toschi [b,*]

[a] Department of Management, Università degli Studi di Bologna, Via Saragozza 8, 40123 Bologna, Italy
[b] Department of Management, Università degli Studi di Bologna, Via Capo di Lucca 34, 40126 Bologna, Italy

A R T I C L E I N F O

Article history:
Received 10 October 2012
Received in revised form 5 April 2013
Accepted 8 July 2013
Available online 4 August 2013

Keywords:
Nanotechnology
Emerging technology
Strategic patenting
Patent scope

A B S T R A C T

This paper provides theoretical and empirical contributions on how patent scope varies over time and by type of applicants in the initial phases of an emerging technology. We refer to the literature on technology life-cycles and on appropriability regimes in order to study the evolution of patent scope – as measured by the number of claims – in the specific case of nanotechnology. Our regression analyses, based on a sample of 58,244 nanotech US patents, show that – once time, sector and firm effects are controlled for – patent scope decreases over the subsequent phases of the technology life-cycle. Moreover, we find that university nanotech patents tend to be characterized by a broader scope than other patents. We conclude by discussing the managerial and policy implications of our empirical results.

1. Introduction

The history of past technological revolutions over the last two centuries – as in the case of electricity generation, telecommunications, software and biotechnology for example – shows that the emergence of major technological discontinuities tends to initiate an era of ferment in which both new entrants and established corporations flood into the market to exploit the promises of the new technologies [40,84,86]. In many cases, this period is accompanied by a real "boom" in patent filings, as companies strive to stake exclusive property rights over inventions that could have wide-ranging applications in the future [3,30].

The race to enter early and patent intensively and broadly in a new, fast evolving and highly uncertain landscape has often been compared to the earlier California "gold rush" of the nineteenth century. However, this phenomenon has also raised concerns that a proliferation of patents, especially broadly defined ones, could produce a thicket of conflicting legal claims, which could ultimately slow innovation rates and raise costs for companies and consumers due to increasing legal disputes [4,8,32].

The question of appropriate patent scope in the early stage of a new technology, and how this can change over time as the technology matures, thus represents an important condition for fully understanding the evolutionary and competitive dynamics of an industry. Previous literature on this issue has been mainly based on historical qualitative evidence, referring to pioneering patents in specific industries [53]. To our knowledge, the only quantitative studies that have empirically analyzed the evolution of patent scope in emerging industries are those of Lerner and Merges [46] and of Haupt et al. [30], respectively concerning biotechnology and software, and pacemaker technology. However, these studies suffer from some limits as to the definition of the different phases of the technology life-cycle, the identification of relevant patents and the lack of control for more general trends in patent scope. In addition to that, no

* Corresponding author. Tel.: +39 051 2098097; fax: +39 051 246411.
E-mail addresses: federico.munari@unibo.it (F. Munari), laura.toschi@unibo.it (L. Toschi).
[1] Tel.: +39 051 2093954; fax: +39 051 2093949.

0040-1625/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.techfore.2013.07.002

previous studies have tried to analyze whether the propensity to stake broad patent claims in an emerging technology varies according to the nature of the applicants.

In order to fill such gaps, this paper intends to provide theoretical and empirical contributions on how patent scope varies over time and by type of applicants in the initial phases of a new technology life-cycle. We refer to the literature on technology life-cycles [7,40,77,86] and on appropriability regimes and strategic uses of patents [10,23,47,80] to argue that: 1) the propensity to file broad patents significantly varies over the different phases of a novel technological field; 2) the observed changes in patent scope over the life-cycle of the new technology differ once the more general increase in the scope of patents observed over the last decades and across sectors is controlled for; and 3) there are significant differences in the breadth of patents filed by companies as compared to other types of applicants (in particular universities and public research centers), as a consequence of differences in the simplicity and complexity of underlying inventions.

Empirically, we focus on the case of nanotechnology, given that it provides a clear example of an emerging technology [51,54,75,90] and we analyze a unique dataset of all nanotechnology patents issued at the United States Patent and Trademark Office (USPTO) in the period 1976–2005, corresponding to 58,244 patents. Following previous literature, we measure patent scope in terms of the number of claims included in the patent [43,81,87]. Moreover, we compute time and industry-adjusted indicators of patent scope, in order to control for the dynamics in patent filing strategies over time and across sectors [88].

Our paper provides the following additional contributions to previous literature. First, the adoption of a novel and comprehensive database allows us to identify all nanotechnology US patents and measure their scope, both in absolute terms and in comparison to a wider set of science, as well as technology patents filed in the same years and in the same sectors. In this way, we are able to control for various factors which may affect the evolution of patent scope, as suggested by previous research [27,87]. Second, our paper investigates whether the scope of patents varies with respect to the type of applicants. We argue that different patenting institutions might have different capacities and incentives to stake broad patent claims in the early days of a new technological trajectory.

The rest of the paper is organized as follows. Section 1 presents the theoretical framework. Section 2 describes the context of our study – nanotechnology as an emerging technological field – and the different approaches to identifying nanotechnology patents. Section 3 discusses the dataset, the variables and the methods applied in our empirical study. Section 4 shows the findings of our analyses and Section 5 presents additional robustness checks. Finally, Section 5 discusses the theoretical and managerial contributions of our study and some indications for future research.

2. Background

2.1. Technology life-cycles and patenting activity

According to technology life-cycle theories, technological innovation proceeds along well-defined cumulative and path-dependent technological trajectories. Technology life-cycle models argue that technology development and the degree of market competition vary across different phases of the life-cycle [2,13,15,40,77,86].[2] A recent review of the literature on technology life-cycles has highlighted numerous contributions which can be grouped into two main perspectives – the so-called macroview and the S-curve – characterized by a multiplicity of terminologies used and by the identification of different stages [79]. The former perspective is concerned with the macrolevel of technological progression and technological trajectories [2,58,86]. According to such view, a technology cycle begins with a technological discontinuity, i.e. a breakthrough innovation affecting either a product or a process,[3] followed by a period of ferment during which competition among variations of the original breakthrough eventually leads to the selection of a single dominant configuration [1,2,58,86]. Following the emergence of the dominant design, an era of incremental evolution of the selected technology constitutes the remaining stage of the cycle, up to the eventual emergence of a further discontinuity.

Studies grouped under the S-curve perspective, on the other hand, have highlighted that technological progression in the majority of cases conforms to the general form of an S-curve [13,14,19,28,30,67], since it typically "advances slowly at first, then accelerates, and then inevitably declines" ([19]: 20). Patenting activity seems to follow similar patterns of development across the different phases of a new technological trajectory. Existing studies in a variety of emerging technologies, such as antibacterial medicines [3], pacemakers [30] and CNC technologies in the machine tool industry [17], suggest that the number of patent applications seems to follow an S-curve distribution in the various phases of the technology life-cycle. In the introductory phase of a new technology's development, the number of patent applications tends to be low and only increases slowly and to be typically concentrated in a limited number of pioneering firms. As the technology enters the growth phase, and major technical and market uncertainties are resolved, there is a rapid growth in the number of patent applications, which tends to level off as the technology matures and the opportunities for product innovation diminish. Moreover, it is not only the number of patent applications that changes over the different phases, but also the filing strategies and the characteristics of filed patents [30].

A characteristic that has received particular attention in the literature is patent scope, defined as the breadth of protection provided to the applicant by the patent claims [45,52,56,89]. The innovator, through the number and the nature of claims made in the patent application, specifies the technological territory over which protection is claimed. The economic value of a patent thus inherently depends on its scope, given that competing products and processes have a higher likelihood of infringing patents characterized by broad claims [45,52,56]. Therefore, the choice of patent breadth is a strategic decision for the innovator, especially in the early days of an emerging

[2] A detailed review of the literature on technology life cycles is beyond the scope of this article. A recent and exhaustive review of this stream of literature is provided by Taylor and Taylor [79].

[3] The innovations representing a discontinuity are also labeled in this literature as revolutionary, breakthrough, radical, emergent, paradigm changes [79].