Technological Forecasting & Social Change 111 (2016) 12–21

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

The knowledge production model of the New Sciences: The case of Translational Medicine

Giancarlo Lauto [a,*], Finn Valentin [b]

[a] Department of Economics and Statistics, University of Udine, Via Tomadini 30/A, I-33100 Udine, Italy
[b] Research Centre on Biotech Business – INO, Copenhagen Business School, Kilevej 14A, 3, DK-2000 Frederiksberg, Denmark

ARTICLE INFO

Article history:
Received 31 July 2015
Accepted 21 May 2016
Available online 11 June 2016

Keywords:
Organization of scientific research
Interdisciplinary research
Research technologies
Science-technology link
Cognitive complementarities

ABSTRACT

The tremendous achievements of life sciences research in the last 40 years have brought relatively little improvements to medical practice, suggesting a deficiency of the medical innovation system in capitalizing on these fundamental advances. We argue that a major cause of the poor innovative performance is the slow adaption of the scientific system to the novel research technologies made available by the progress in the life sciences – rather than resistance of practitioners. We interpret the changes in the organization of medical research through the lenses of the theory of New Sciences, which puts forward that the application of novel research technologies promotes new epistemological and methodological approaches to the investigation of complex phenomena, increasing interdisciplinary intellectual exchanges. In oncology, Translational Research, that embodies the features of a new science, coexists with the standard model of knowledge production in clinical medicine. Our comparison of the two approaches finds that Translational Research allows investigations across diverse and cognitively distant knowledge bases, thanks to the intensive use of research technologies that emerge from fundamental research. Unlike standard studies, the scientific impact of translational studies benefits from the adoption of an interdisciplinary approach. However, translational studies have an overall lower impact than their counterpart.

1. Introduction

An effective governance of medical innovation systems is a critical issue for policymakers in many countries – both in the developed and developing World – given the trends of increasing costs of healthcare provision, ageing population, escalation of technological interdependency, and intensification of science-industry linkages (Faulkner, 2009; Nicolini, 2010; Ryan, 2010; Peine et al., 2015). Indeed, medical innovations are the outcome of the co-evolution of different cognitive and institutional domains, such as fundamental biomedical science, clinical practice and medical technology (Gelijns and Rosenberg, 1999; Metcalfe et al., 2005; Morlacchi and Nelson, 2011; Nelson et al., 2011; Consoli and Ramlogan, 2012; Rafols et al., 2014; Kukk et al., 2015). Some studies have shown how advances in the treatment of specific diseases and the introduction of novel approaches, such as personalized medicine, have been based on novel combinations of medical technologies with clinical practices and fundamental research (Amir-Aslani and Mangematin, 2010; Tierney et al., 2013; Coccia and Wang, 2014; Faulkner, 2015). However, the great expectations brought by the so-called "biotechnology revolution" are still largely unmet. In the last four decades, basic life sciences have attained unprecedented achievements and have generated an entirely new class of research technologies, i.e. novel tools and instrumentation to be used in the process of knowledge production, generating expectations for disruptive changes in a broad range of sciences and industries; despite these advances, the ability of the medical innovation system to generate new and more effective drugs, devices, diagnostics and therapies has been poor (Henderson et al., 1999; Moran, 2007; Hopkins et al., 2007).

One explanation for this disappointing performance rests in the delay of the biopharmaceutical industry in identifying suitable business models and in shaping innovation ecosystems favorable to the exploitation these new technologies (Sabatier et al., 2012; Lehoux et al., 2014; Kukk et al., 2015). We argue that an equally important reason why medical innovation has progressed relatively slowly – if compared to the great opportunities disclosed by fundamental advances – is to be found in the "science side" of the system.

The availability of novel and more powerful research technologies and the policy pressures demanding an increase in productivity of the medical innovation system, have brought to the emergence of the new field of Translational Medicine. Advocates of Translational Medicine claim that the medical innovation would benefit from insights brought by an intensification of interdisciplinary linkages, the systematic utilization of clinical insights in basic studies, and the prioritization of the solution of patients' problems – rather than disciplinary priorities – in the life sciences research agenda (Marincola, 2007; Sablinski, 2014).

* Corresponding author.
E-mail addresses: giancarlo.lauto@uniud.it (G. Lauto), fv.ino@cbs.dk (F. Valentin).

http://dx.doi.org/10.1016/j.techfore.2016.05.018
0040-1625/

Translational Medicine attracts great interest both within the scientific community and among policymakers, who highlight it as a key strategy for scientific progress in the medical sciences (Grimes, 2011; McLeod et al., 2011; van der Valk et al., 2011; Douglas et al., 2014).

The aim of this paper is to gain insight in the model of knowledge production of Translational Medicine, compared to the "standard" approach that consists in clinically-driven studies that marginally rely on fundamental research; specifically, we compare the two approaches in terms of reliance on novel research technologies, creation of cognitive linkages across disciplines, and drivers of impact on the advance of medical sciences. We take as our case breast cancer research, where the translational approach is particularly prominent. However, also in this field, the "standard" model of research is widely employed and presents limited intellectual exchanges with the translational community (Cambrosio et al., 2006; Jones et al., 2011). For these reasons, breast cancer research is a case that allows the translational and the standard approaches to be rigorously compared. Our study is designed to capitalize on this methodological opportunity.

We address these issues taking the theory of the "new sciences" as conceptual reference. The "new sciences" that emerged during the last decades of the 20th century, such as life-, nano- and computer sciences, exploit new and powerful research technologies that allow scientists to investigate the elementary building blocks of extremely complex phenomena such as the human body and its diseases. Systematic application of these research technologies gives rise to a unique model of knowledge production (Bonaccorsi, 2008, 2010). The concept of "new science" is used increasingly to gain insights into the features of interdisciplinary fields (e.g. Jansen et al., 2010; Lepori, 2011; Heimeriks, 2012; Heimeriks and Leydesdorff, 2012; Horlings and Gurney, 2013).

We contribute to this debate by offering one of the first empirical tests of the theory based on fine-grained comparison of the research conducted in the same medical field according to the principles of new and established sciences. In this way, we bring to light some of the micro-level mechanisms producing tensions and delays in the acceptance of new scientific paradigms (Lakatos and Musgrave, 1970). In particular, our finding that translational studies are systematically penalized in terms of impact on subsequent research compared to standard studies adds insights on why scientific communities are slow in adopting interdisciplinary approaches. We suggest that science-internal hindrances represent a major cause of the scarce efficacy of the medical innovation system.

Furthermore, our study contributes to the more general literature on the economics of innovation and technological change, by giving new light on the effect of technological development on the dynamics of science. Studies on the effects of technology on science highlight that research technologies bridge scientific and industrial communities, underpin the emergence of new professional groups and shape new models of collaboration across existing disciplinary boundaries (De Solla Price, 1963; Rosenberg, 1992; Stokes, 1997; Joerges and Shinn, 2001; Shinn, 2005; Meyer, 2007). This paper relates the use of research technologies to the differences in the institutional and epistemological dynamics of science, as it shows that only translational studies make an extensive use and contribute to the development of knowledge in the fundamental fields that generate novel research technologies.

The remainder of this paper is organized as follows: we start by defining the theoretical framework from which we derive our hypotheses. After presenting our research design and data, we test the hypotheses, and then discuss our findings.

2. How research technologies stimulate scientific change

2.1. Research technologies and New Sciences

Scientific instrumentation plays a dual role in the process of knowledge production: first, it provides researchers with the technical tools to carry out investigations by enabling the collection and analysis of empirical data; second, it opens up the possibility of investigating new phenomena, thus paving the way to epistemic change (Rosenberg, 1992; Collins, 1994). The literature on research technologies emphasizes the contribution to epistemic change brought by research tools that emerge from advances in fundamental research. Research technologies offer sets of methods, techniques, standards, and associated concepts that can find application in various settings across disciplinary boundaries. Furthermore, they offer substantial improvements in computing power, accuracy, and precision of research tools (Shinn, 2005). Research technologies have been studied mainly from a sociological perspective which looks at how they are invented, their circulation across geographic and institutional settings (primarily, industry and academia), and their contribution to the reconfiguration of occupational groups across disciplines (Joerges and Shinn, 2001). Recently, they have been proposed as a major factor underpinning the emergence of a class of "new sciences" representing a model of knowledge production that is radically different from that of the established sciences (Bonaccorsi and Thoma, 2007; Bonaccorsi, 2008, 2010; Bonaccorsi and Vargas, 2010).

The theory claims that, following an established tradition in the core disciplines of natural sciences, "new sciences" are predicated on reductionist reasoning, especially in terms of methodological stance; however the application of a reductionist approach to complex phenomena (such as the human body or diseases) leads, differently from established sciences, to the proliferation of theories, each addressing different levels of analysis of the phenomenon (e.g. the gene, the molecule, the organ) – typically corresponding to a scientific field. The New Sciences' attempt to understand also the linkages between theories and observations developed within each of scientific fields. For this reason, a key feature of new sciences is the establishment of cognitive and institutional complementarities, defined respectively as the integration of knowledge developed in heterogeneous disciplinary areas or in multiple institutional settings, such as academia, industry and medical practice. The creation of systematic linkages among concepts and phenomena at the interface between different levels of analysis is a driver of the emergence of novel areas of research that does not imply a weakening of disciplinary boundaries, but rather an increase in the knowledge flows among disciplines (Bonaccorsi, 2008; Bonaccorsi and Vargas, 2010).

2.2. Translational Medicine as a new science

Translational Medicine can be regarded as an example of a new science because it relies on the exploitation of novel research technologies, embraces a reductionist research strategy, and progresses by establishing connections among concepts, methods and insights relative to different disciplines by means of research technologies based on fundamental life sciences and computer sciences (Bonaccorsi, 2010).

Traditionally, the cognitive exchange between clinical medicine and the fundamental life sciences has been limited; in fact, medical practice has advanced through cumulative learning on the functioning of specific organs or diseases, or through the systematization of empirical information on patients, without clear guidance from theoretical principles. One of the reasons for the limited reliance of clinical studies on fundamental theories is recognized in the organization of medicine around tight disciplinary specializations defined by diseases (Nelson et al., 2011; Thagard, 1999; Bonaccorsi, 2010). This applies also to the case of Oncology, which is organized in sub-disciplines defined by the different types of cancers.

However, the many interrelated factors affecting the objects of analysis of clinical research – the patient, the organism, the organ – impede the identification of causal explanations of phenomena addressed by distinct disciplines. For instance, in oncology, advances in our understanding of the disease may come from the integration on information on how social or environmental factors affect the mutation of the genes responsible for the occurrence of the disease, that is produced in distinct disciplinary domains – molecular biology, biochemistry,