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ScienceDirect
Research Policy 35 (2006) 1450–1464
research policy
www.elsevier.com/locate/respol

The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'

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Available online 7 November 2006

Abstract

This paper discusses, first, the properties of scientific and technological knowledge and the institutions supporting its generation and its economic applications. The evidence supports the broad interpretation that we call the 'Stanford–Yale–Sussex' synthesis. Second, such patterns yield important implications with respect to the so-called 'European Paradox', i.e. the conjecture that EU countries play a leading global role in terms of top-level scientific output, but lag behind in the ability of converting this strength into wealth-generating innovations. Some descriptive evidence shows that, contrary to the 'paradox' conjecture, Europe's weaknesses reside both in its system of scientific research and in a relatively weak industry. The final part of the paper identifies a few normative implications: much less emphasis should be put on various types of 'networking', and much more on policy measures aimed at strengthening both frontier research and European corporate actors.

JEL classification: D80; O33; O38

Keywords: Open science; European Paradox; Science policy; Technology policy; Industrial policy

1. Introduction

The present paper is intended to reappraise the tangled relationships between science, technologies and their industrial exploitation with reference to a popular interpretation concerning European weaknesses in industrial innovation known as the 'European Paradox'. Such a paradox – which sounds quite similar to an earlier 'UK paradox' fashionable around 30 years ago – refers to the conjecture that EU countries play a leading global role in terms of top-level scientific output, but lag behind in the ability to convert this strength into wealth-generating innovations. We shall argue, first, that the paradox mostly appears just in the flourishing business of reporting to and by the European Commission itself rather than in the data. Second, both the identification of the purported paradox, and the many proposed recipes for eliminating it, seem to be loaded with several, often questionable, assumptions regarding the relationship between scientific and technological knowledge, and between both of these and the search and production activities of business enterprises.

We begin by setting the scene and recalling what we consider to be the main properties of scientific and technological knowledge and of the institutions supporting its generation (Section 2). The proposed framework, we suggest, fits quite well with a series of robust 'stylized facts' (Section 3). Having spelled out the interpretative

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doi:10.1016/j.respol.2006.09.012

tools, we turn to the evidence supporting the existence of a ‘European Paradox’ (or the lack of it) (Section 4) and discuss European comparative performance in terms of scientific output, higher education characteristics, proxies for technological innovation, and actual production and exports in those lines of business that draw more directly on scientific advances. Here, one does not find much of a paradox. Certainly one observes significant differences across scientific and technological fields, but the notion of overall ‘European excellence’ finds little support. At the same time, one does find ample evidence of widespread European corporate weakness, notwithstanding certain success stories.

This interpretation also has far-reaching normative implications (Section 5). If we are right, much less emphasis should be put on various types of ‘networking’, ‘interactions with the local environment’, or ‘attention to user needs’ – current obsessions of European policy makers – and much more on policy measures aimed at strengthening ‘frontier’ research and, at the opposite end, at strengthening European corporate actors.

2. Science and technology: some interpretative yardsticks

Our interpretative framework stems from what might be called the *Stanford–Yale–Sussex* (SYS) *synthesis*, a phrase sure to displease almost everyone, but a convenient shorthand for the confluence between works on the economics of information (including Arrow (1962), David (1993, 2004), and Nelson (1959))[1] and works focusing on the specific features of technological knowledge (including Freeman (1982, 1994), Freeman and Soete (1997), Nelson and Winter (1982), Pavitt (1987, 1999), Rosenberg (1976, 1982), Winter (1982, 1987), and also Dosi (1982, 1988)). In such a *synthesis*, first, one fully acknowledges some common features of information and knowledge—in general, and with reference to scientific and technological knowledge in particular. Second, one distinguishes the specific features of technological knowledge and the ways it is generated and exploited in contemporary economies.

As to the former point, both information and knowledge share the following properties:

- *Some general features of public goods*: (i) non-rival access (i.e. the fact that one holds an idea does not constrain others from holding it too); (ii) low marginal cost of reproduction and distribution, which *in principle* makes it difficult to exclude others from having access to newly generated information (except through legal devices such as copyright and patents), as compared to high fixed costs of original production. (The latter point applies primarily to *information, stricto sensu*.)
- A fundamental uncertainty concerning the mapping between whatever one expects from search activities and their outcomes.
- (Relatedly) serendipity in the ultimate economic and social impact of search itself (Nelson, 2004).
- Quite often, very long lags between original discoveries and ‘useful’ applications.
  However, scientific and even more so technological knowledge share, to a different extent, some degrees of *tacitness*. This applies to the pre-existing knowledge leading to any discovery and also to the knowledge required to interpret and apply whatever codified information is generated. As Pavitt puts it with regards to technological knowledge,
- “most technology is specific, complex ... [and] cumulative in its development .... It is specific to firms where most technological activity is carried out, and it is specific to products and processes, since most of the expenditures is not on research, but on development and production engineering, after which knowledge is also accumulated through experience in production and use on what has come to be known as ‘learning-by-doing’ and ‘learning-by-using’” (Pavitt, 1987, p. 9).
- Moreover, “the combination of activities reflects the essentially pragmatic nature of most technological knowledge. Although a useful input, theory is rarely sufficiently robust to predict the performance of a technological artefact under operating conditions and with a high enough degree of certainty, to eliminate costly and time-consuming construction and testing of prototype and pilot plant” (Pavitt, 1987, p. 9).

A distinct issue regards the relations between scientific knowledge, technological innovation, and their economic exploitation. In this respect, note that the *SYS synthesis* is far from claiming any linear relation going from the former to the latter. On the contrary, many contributors to the *SYS* view have been in the forefront of arguing that the relationships go both ways (see Freeman (1982, 1994), Kline and Rosenberg (1986), Pavitt (1999), and Rosenberg (1982), among others).

In particular, it has been shown that, first, technological innovations have sometimes preceded science in that practical inventions came about *before* the scientific

[1] Note that Richard Nelson was at Yale when he produced the seminal contribution to which we refer.