The effects of national policy on biotechnology development: the need for a broad policy approach

Jacqueline Senker*

Science and Technology Policy Research
University of Sussex
Brighton, BN1 9QE UK
E-mail: j.m.senker@sussex.ac.uk
*Corresponding author

Thomas Reiss

Fraunhofer Institute for Systems and Innovation Research
(Fraunhofer ISI) 76139 Karlsruhe, Germany
E-mail: Thomas.Reiss@isi.fraunhofer.de

Vincent Mangematin

UMR GAEL (INRA/UPMF)
Université Pierre Mendès France
38040 Grenoble Cedex 9, France
E-mail: vincent@grenoble.inra.fr

Christien Enzing

Innovation Policy Group TNO
2600 JA Delft, The Netherlands
E-mail: Enzing@tno.nl

Abstract: An assessment is made of the effectiveness of national policies for the biotechnology knowledge base and its commercialisation in 14 European Union member states. The assessment first reviews the various theoretical approaches that lie behind policies to promote the commercialisation of knowledge. It then discusses the EPOHITE study, including its aims, methodology and results. In the conclusions, the paper will use the results of the study to discuss any relationship between the policy approach of individual member states and their innovation performance. It will also discuss the application of the lessons learned from this study to the countries studied as well as to new member states of the EC and newly industrialising countries. Some of the difficulties to be overcome will also be tackled.

Keywords: innovation policy effectiveness; biotechnology; science base; commercialisation.

Reference to this paper should be made as follows: Senker, J., Reiss, T., Mangematin, V. and Enzing, C. (2007) 'The effects of national policy on biotechnology development: the need for a broad policy approach', *Int. J. Biotechnology*, Vol. 9, No. 1, pp.20–38.

Biographical notes: Jacqueline Senker is Senior Fellow at SPRU Science and Technology Policy Research, University of Sussex. Her biotechnology work focuses on large and small firm strategy, interfirm collaboration, university-industry links and policy evaluation.

Thomas Reiss is Head of Emerging Technologies at Fraunhofer Institute Systems and Innovation Research. His current research focuses on monitoring and assessing emerging technologies, national and sectoral innovation systems, industrial innovation, and the evaluation of innovation policies in biotechnology.

Vincent Mangematin is Senior Researcher at Grenoble Applied Economics Lab, National Institute of Agronomic Research at the University Pierre Mendès in France. His research interests include research collaboration in biotechnology, the growth and development of biotech firms, the impact of public policies for biotechnology and the early career stages of life scientists.

Christien Enzing is Deputy Head of the Innovation Policy Unit at TNO Quality of Life. Her research interests include the effectiveness of technology and innovation policies and technology forecasting and assessment of new emerging and converging technologies, especially those related to life sciences.

1 Introduction

There have been many contributors to a recent growth in knowledge about the complex role that science and technology play in boosting a nation's industrial development and competitiveness. One aim of this work is to help governments design appropriate policies to promote innovation and the exploitation of the knowledge base. There has been a growing understanding that the promotion of innovation requires more assistance than that offered by traditional policies, which focus on supporting scientific research and technology development. The new paradigm suggests that policy should address every part of the national system of innovation.

This paper will assess the extent to which individual member state's policies have assimilated new knowledge about the systemic nature of innovation as well as the effect on performance of policies based on the traditional and newer paradigms. This study is based on the findings of a recent European Commission funded study, 'Efficiency of Innovation Policies in High Technology Sectors in Europe' (EPOHITE), which is about the relationship between national policies for biotechnology and performance in 14 European countries (Reiss *et al.*, 2003). The paper will first review the various theoretical approaches that lie behind policies to promote the commercialisation of knowledge. It will then discuss the EPOHITE project, including its aims, methodology and results. In the conclusions, the paper will use the results of the study to discuss any relationship between the policy approach of individual member states and their innovation performance. This paper will also discuss the application of the lessons learned from this study to the countries studied as well as to new member states of the EC and newly industrialising countries. Also, some of the difficulties to be overcome will be tackled.

2 Theoretical background to policy for commercialising biotechnology

Traditional views about government policy for research and innovation are based on a neoclassical paradigm that assumes a linear and causal relationship between science and economic growth. The basic premise is that the scientific knowledge produced by publicly funded research is nonrival (its use by others does not diminish the knowledge of the producers) and nonexcludable (it is not possible to restrict others from using the knowledge). It is anticipated that increased government funding for public research will expand the pool of useful information and opportunities for its economic exploitation. Government intervention is justified by the need to compensate for the firms' reluctance to undertake research because of their fear that the results will leak out and be used by their competitors (Salter *et al.*, 2000). This paradigm provided governments with a policy role only in case of market failure and this also led to technology policy based on the assumption that support for scientific research would lead to economic growth.

However, evolutionary economists, by showing that innovation is a systemic process embedded in national, social and institutional traditions, have influenced a shift towards a new paradigm – innovation policy (Biegelbauer and Borrás, 2003). This innovation paradigm suggests a wider role for government policy than the provision of funds for research or strategic technologies. The policy must also address systemic failures which block the functioning of the innovation process such as infrastructure inadequacy, network failure or capability deficiencies. These failures justify state intervention not only to support basic research but also to ensure that the innovation system operates as a whole. Thus, government policy needs to address many aspects of the system of innovation such as education and training to provide human capital with appropriate competences, support for the development of managerial capabilities in companies, the creation of innovative small and medium-sized enterprises (SMEs), the establishment of technology transfer offices to facilitate the exploitation of public sector knowledge, and the creation of favourable framework conditions connected to matters such as regulation, intellectual property and the availability of finance capital. However, as systemic failures are strongly connected to the interplay between the characteristics of an individual national system, it is not possible to formulate a simple rule-based policy. This requires national policy-makers to continuously identify and rectify structural imperfections (Enzing *et al.*, 2005).

A growing number of areas are addressed by innovation policy, with a major focus on policies addressing education, research and industry. At a national level, this creates the need to coordinate the policy of many government departments, each dealing with specific aspects of the innovation chain. There is also a need to integrate national policies with those of international and regional policy-making organisations. The quality of policy-making and its implementation can be improved through experimentation, search for best practices, international cooperation and performance benchmarking. These activities can support governments' learning processes if governments themselves are regarded as learning organisations (Enzing *et al.*, 2005).

Neoinstitutionalists point out that theories of national systems of innovation or national research systems do not take sufficient account of the socio-institutional and cultural factors that affect national science and technology performance. They argue that national culture matters. Innovation within a country is shaped and directed by the structures of the institutions and organisations involved in research, innovation and technological advancement as well as the norms and practices that sustain these institutions (Ney, 1999; Pohlmann, 2005).

3 The EPOHITE study

In the last decade, most European countries have given priority to support the development of biotechnology. Policymakers in every EC member state have developed a variety of different policy concepts and instruments to stimulate biotechnology research and foster innovation and economic growth in this field. EPOHITE aims to discover whether and under what conditions these innovation policies have been effective by linking two elements: the national policy approaches implemented (inputs) and the performance of 14 European Union member states[1] in developing the science base and in commercialising biotechnology (outputs). There are difficulties inherent in identifying direct links between specific policies and outcomes. For this reason, the assessment of policy effectiveness focused on overall national approaches to support biotechnology rather than on specific policies. The analysis also tried to take into account the fact that factors other than policy – the size and strength of the national economy, its industrial structure and R&D intensity – also have an influence on innovation processes and performance. The expectation was that large R&D intensive countries with strong firms in sectors that can benefit from the application of biotechnology and those that have a large internal market (*e.g.*, France, Germany and UK) would be among the best performers.

This section first presents the methodology used for the project and then goes on to discuss the main results. It then tackles how policy relates to both scientific and commercialisation performance. It concludes with a discussion of the other key issues affecting the development of biotechnology that emerged from the study.

3.1 Methodology

The methodology for the EPOHITE study draws on the Inventory of Public Biotechnology Research (Enzing *et al.*, 1999), which provides a categorisation of the biotechnology policy-making systems and institutions involved in funding and performing research in Europe from 1994 to 1998. This information provided background for preparing 14 national reports for EPOHITE. The national reports update inventory information to 2001, categorise all relevant policies and assess national scientific and commercialisation performance through both quantitative methods and on the basis of interviews with all the actors involved in the innovation process.

The categorisation of all national policies (in operation between 1994 and 2001) that could have an impact on biotechnology includes both policies with a specific focus on biotechnology (*e.g.*, support for genome sequencing) as well as more general policies that support science and technology development *per se* and those that improve the conditions

for innovation (*e.g.*, tax credits for companies involved in research). The policy categorisation is informed by the European Biotechnology Innovation System project (Senker and van Zwanenberg, 2001; Senker, 2004), which identifies the factors influencing innovation, the actors involved and the interactions between them; the categorisation covers the following four areas:

1 the knowledge base (through research funding)

2 the supply side (through industrial and innovation policy)

3 the demand side (through socioeconomic measures and regulation)

4 financial and industrial capabilities (through policies connected with investment capital and industrial development).

Table 1 shows the categories of policies identified.

Table 1 Types of national policy impacting on biotechnology development

Policy types
A. Biotechnology-specific policies
Policies for university and Research Institute (knowledge base) research
Instruments to encourage basic research
Instruments to encourage industry-oriented (and applied) research in PSROs
Instruments for strengthening academic cooperation among PSROs and disciplines
Policies for commercialisation support
Instruments to build up technological capabilities for the industry
Instruments to encourage the commercialisation of scientific results from public research institutions
Instruments to encourage the collaboration between public and industrial research
Policies with a socio-economic and ethical dimension
Policies connected to regulatory matters
B. General policies
Science and technology policies
Instruments to support the knowledge base, including mobility of researchers
Instruments to support the commercialisation of technologies
Instruments to support firm creation
Legislation on Intellectual Property Rights (IPR)
Measures to assure the availability of financial capital for high growth sectors

Desk research was undertaken to gather data from publicly available information[2] on all relevant policy instruments for the 14 countries and to make a subjective assessment of the relevance of the different policy instruments in the national policy system. Analysis was carried out to assess policy evolution between two periods: 1994–1998 and 1998–2002. For each country, policies were also set in the context of the organisation of policy-making and the research system, taking particular account of the importance of research activities and the priority given to biotechnology in those research activities.

After identifying indicators that could measure the effects of policy on the knowledge base and commercialisation performance of the 14 member states, data was collected for those indicators using the publicly available data and online databases shown in Table 2. The use of indicators was limited to the data that had been gathered using a common definition and to those available for every country. Indicators were adjusted on a *per capita* basis to avoid any effects of country size.

Table 2 National performance indicators and their sources

Indicators	*Source*
Knowledge base indicators	
Indicators to measure the scientific performance	
Share of biotechnology publications to all scientific publications	Based on Science Citation Index (SCI) data 1991–2000*
Total biotechnology publications over time	Based on SCI data
Total biotechnology publications per capita	Based on SCI and population data (GFS**, 1999–2001)
Percentage of basic-research-oriented publications to all publications	Based on SCI data
Indicators to measure the scientific impact	
Citations to biotechnology publications	SCI data
Indicators to measure international scientific collaboration	
Share of internationally co-authored biotechnology papers	Based on SCI data
Commercialisation indicators	
Number of biotechnology companies per capita	Ernst and Young annual reports
Amount of venture capital invested in biotechnology per capita	European Venture Capital Association Yearbooks
The number of Initial Public Offerings (IPOs) per capita 1995–1997 and 1998–2000	Ernst and Young, websites by Nasdaq, Neuer Markt, London Stock Exchange, Euronext
Patent applications in biotechnology per capita	Based on European Patent Office data 1991–2000***

Notes: * Data retrieved online via host STN
** German Federal Statistical Office
*** Data retrieved online via host Questel

Knowledge base indicators are based on scientific publications, which were analysed by various bibliometric methods to measure scientific performance in several ways:

- The share of biotechnology publications to all national scientific publications provides an impression of the significance of biotechnology within all scientific activities in a country.
- Development of total biotechnology publications over time indicates general trends in biotechnology-related scientific output.