Public Policies to Support Basic Research: What Can the Rest of the World Learn from US Theory and Practice? (And What They Should Not Learn)

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The information-based theoretical model for public support of basic research, developed in the USA at the end of the 1950s, has held up well in political practice, in spite of its neglect of training benefits, of necessary prior investment in research infrastructure and of its consequently limited relevance outside the USA. At the same time, US practice in basic research has often been misinterpreted as being driven by short-term usefulness, whereas its key features are massive and pluralistic government funding, high academic quality, and the ability to invest in the long-term development of new (often multi-disciplinary) fields. Challenges for the future include greater (and often ill-judged) pressures from governments for demonstrable usefulness of the basic research it supports, the entirely separate development of direct links to application in biomedical and software fields, and more complicated links between national basic research and application resulting from the changes in the internationalization of corporate R&D. And perhaps we can learn as much from successful practices in Scandinavia and Switzerland as from the USA.

1. Introduction
At least since 1945, the USA has been dominant in both the practice of basic research and the development of underlying evidence and theories about its social value and public policies for its support. The former is reflected in Nobel Prizes, scientific papers and citations, the strong attraction exerted on foreign researchers, and—more recently—the spectacular growth of US firms and industries based directly on basic scientific research [e.g. biotechnology,
and information and communication technology (ICT)]. The second is reflected in the strong influence of US scholars (especially in economics) in the development of models of how basic research becomes useful, and in the more diffuse but still powerful influence on the world’s policy makers and practitioners of perceptions (which may be more or less accurate) of what makes for the success of the US system.

Richard Nelson is one of the most influential and long-standing contributors to our understanding, beginning with the simple economics of basic research in 1959, through the first Yale survey of corporate R&D practitioners (Nelson and Levin, 1986; Klevorick et al., 1995) and his historically based analysis with Nathan Rosenberg of the economic role of US universities (Rosenberg and Nelson, 1994), to his most recent work with David Mowery and other colleagues on the reasons behind the recent growth of licensing activities in the US research universities (Mowery et al., 2001). His insights will figure largely in this paper, which tries to separate smoke and mirrors from substance in our understanding of the economic and social benefits of basic research, and the nature and the international applicability of the US experience. It turns out (fortunately, given the occasion for which this paper was prepared) that his contribution has been positive, in two important senses: first, in pioneering early on an economic justification for the public support of basic research in the USA; and secondly, in stressing in his later empirical work that the paths from basic research to its application are complicated—including the direct and the indirect, the codified and the tacit, with the relative weights of each varying across fields of knowledge and across time.

At the same time, I shall argue that the assumption that the output of basic research is easily transmissible information (or ‘ideas’ or ‘discoveries’) has been pushed beyond the context of useful applicability (which was in the USA in the late 1950s), and has become positively misleading and harmful in an interconnected world made up of countries with very different sizes of population and levels of economic development. It also lost sight of one of the main purposes of basic research, namely, to contribute through the training of researchers to the solution of technical problems.¹ I shall further argue that a tendency to underplay the role of the US Federal Government in contemporary US successes in biotechnology and ICT is leading some foreign governments (particularly in Europe) to learn the wrong lessons from the US experience.

¹ ‘The responsibility for the creation of scientific knowledge—and for most of its application—rests on that small body of men and women who understand the fundamental laws of nature and are skilled in the techniques of scientific research’ (Bush, 1945, p. 7).
Section 2 discusses the validity of the US-developed case for government support of basic research in the light of the experience of the past 40 years. It concludes that the case has held up well in political practice, even if the original theory looks shaky in the light of evidence and experience. Section 3 argues that there are increasing pressures to make such government support conditional upon foreseeable practical applications, and that these reflect a partial misreading of the US experience. Other growing challenges include the direct practical usefulness of basic research in the biomedical and software fields, and the effects of the internationalization of corporate R&D. Section 4 summarizes the main conclusions and argues that we need a better understanding of the dynamics of the interactions between basic research and practice.

2. The Case for Government Support of Basic Research

2.1 The Original Case

'The simple economics of basic scientific research' (Nelson, 1959) gave an underlying economic justification for US government support of basic research, namely the existence of external economies in the form of multiple potential applications and new combinations which (given conditions of uncertainty) would not be fully explored or exploited, if the business firms undertaking the basic research tried to capture all the benefits for themselves, either through secrecy or property rights. The paper gave more attention to the nature of the benefits of basic research (e.g. reduced search costs, unexpected applications) than their form (e.g. information, training, instrumentation). It also concluded that large multi-product, multi-technology firms would be the most likely in a market system to be able to exploit the benefits of any basic research that they supported. The subsequent and complementary paper by Arrow (1962) stressed much more strongly that the output of basic research was in the form of information that was costly to produce, but virtually costless to reproduce and reuse, and therefore had the properties of a public good and deserved public support. The case of basic research subsequently became a classic application in welfare economics, and a much cited example of how academic social science can influence public policy.

But, like all models, it made simplifications. In particular, it assumed just one country (the USA), which was mainly concerned to pursue technological opportunities at the technological frontier and large enough to do so across
all fields. It also came to assume that the main (or only) useful output of basic research was easily reusable information. These assumptions were appropriate for making a persuasive case for public support for basic research in the USA of the 1950s. But, as we shall now see, they could not be properly applied in later circumstances in an interdependent world with countries of different sizes and different levels of economic development.

2.2 The Changing International Context

The standard model was accepted well into the 1970s, but then began to be questioned after the emergence of a significant number of technologically active countries in continental Europe and East Asia. In these circumstances, the very characteristics of the supposed output of basic research that justified public funding (i.e. the costless transfer and reuse of information) could in principle allow some countries to become ‘free-riders’ on the basic research funded by others. This line of reasoning led logically to one of two unpalatable policy conclusions: either to restrict access of supposedly parasitic foreigners to the output of the national science base, or to stop national funding of basic research and use results emerging from other countries. However, it is not a line of reasoning that has been followed by economically more successful countries—in particular, the small countries of north-west Europe, and the newly industrialized countries of East Asia.

2.3 Technologically Advanced Small Countries

Table 1 shows that, when corrected for differences in population and GDP, the small north-west European countries are the world’s biggest investors in academic research and have some of the world’s biggest outputs, in spite of the fact that an information-based model would predict that they could benefit, without heavy investments of their own, from easy access to the world’s pool of knowledge (i.e. information). The reason has been most forcefully expressed by Callon (1994): the output of basic research may have attributes of a public good, but it is not a free good: the capacity to understand and use the results of basic research performed elsewhere requires a

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2 Table 1 shows that the USA leads the OECD countries in citations per paper, which is often considered an indicator of quality. However, Katz (2000) has recently demonstrated a power law such that, other things being equal, the citation rates of a country’s published papers increase with the number of papers published by the country. US papers are therefore advantaged in citations, given that there are many of them. Katz shows that, after the application of a correction factor, the same small European countries emerge as the leaders in citations per paper.
considerable investment in institutions, skills, equipment and networks. If, as in the Scandinavian countries, Netherlands and Switzerland, basic research also provides inputs into world class business firms in engineering, medical products, electronics and mobile telephony, these investments could be considerable.

Further evidence of the difficulties that firms have in accessing foreign public knowledge has been provided. Table 2 emerges from the results of a survey of technological strategies of large European firms. It shows that the decline in importance of foreign sources of knowledge, compared with national sources, is greater for public than for private knowledge. This suggests that the increases in the costs of access to foreign, non-market-based networks could be greater than the increases for the more straightforward purchase of foreign proprietary knowledge.

Table 1. Indicators of National Performance in Basic Research

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<tbody>
<tr>
<td>Switzerland</td>
<td>0.66</td>
<td>1.471</td>
<td>0.960</td>
<td>11.73</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.87*</td>
<td>1.297</td>
<td>0.833</td>
<td>10.54</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.40</td>
<td>1.074</td>
<td>0.741</td>
<td>9.95</td>
</tr>
<tr>
<td>Finland</td>
<td>0.48</td>
<td>0.964</td>
<td>0.548</td>
<td>7.72</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.60</td>
<td>0.962</td>
<td>0.510</td>
<td>9.40</td>
</tr>
<tr>
<td>UK</td>
<td>0.36</td>
<td>0.912</td>
<td>0.678</td>
<td>9.76</td>
</tr>
<tr>
<td>USA</td>
<td>0.40</td>
<td>0.886</td>
<td>0.750</td>
<td>12.07</td>
</tr>
<tr>
<td>Norway</td>
<td>0.47*</td>
<td>0.817</td>
<td>0.563</td>
<td>7.73</td>
</tr>
<tr>
<td>France</td>
<td>0.37</td>
<td>0.621</td>
<td>0.428</td>
<td>7.28</td>
</tr>
<tr>
<td>Germany</td>
<td>0.43</td>
<td>0.569</td>
<td>0.554</td>
<td>7.32</td>
</tr>
<tr>
<td>Japan</td>
<td>0.55</td>
<td>0.416</td>
<td>0.251</td>
<td>6.65</td>
</tr>
<tr>
<td>Italy</td>
<td>0.27</td>
<td>0.362</td>
<td>0.171</td>
<td>6.44</td>
</tr>
</tbody>
</table>

Source: OECD (1999, table 47) and Lattimore and Revesz (1996, tables 2.2, 4.10).
\*1993.

Further evidence of the difficulties that firms have in accessing foreign public knowledge has been provided. Table 2 emerges from the results of a survey of technological strategies of large European firms. It shows that the decline in importance of foreign sources of knowledge, compared with national sources, is greater for public than for private knowledge. This suggests that the increases in the costs of access to foreign, non-market-based networks could be greater than the increases for the more straightforward purchase of foreign proprietary knowledge.

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3 One of the first . . . results of social studies of science has been to show that an isolated statement of theory is quite simply useless. You might print thousands of copies of an article or book and air-drop copies in Lapland or in Bosnia-Herzegovina. You might similarly send well-trained students or well-calibrated instruments to the far corners of the earth. However, if all these elements do not come together in a single place at the same time, then the dissemination will have been a waste of time (Callon, 1994, p. 402). Scientific knowledge is indeed durable, but only at the price of the heavy investments needed to maintain it. In order to make the law \( f = ma \) available in Singapore, a large number of textbooks had to be published and sold, teachers had to drum the message into stubborn heads, research institutions and enterprises had to develop, researchers had to be paid and trained. Compared to the cost of maintaining a so-called universal law, the cost of maintaining the American army in Kuwait pales into insignificance (Callon, 1994, p. 406).
2.4 Technologically Catching-up Countries

The information-based model has also been used on some occasions as the basis to advise developing countries to give low priority to public support of basic research, given their free and easy access to the world’s information-based pool of knowledge. These arguments have sometimes been reinforced by a similar notion, prevalent amongst some sociologists of science, that the sole justification for basic research is peer recognition through cited publications. Since scientists in developing countries can rarely aspire to such cited recognition, they should—it is so argued—give basic research low priority.

Again, this advice has apparently been ignored by the economically most successful of the Asian tigers. More specifically, the two countries with the highest rates of increase in scientific publications in the 1980s and early 1990s were South Korea and Taiwan, the two countries that also had the highest rates of increases in corporate R&D and US patenting (Lattimore and Revesz, 1996, table 4.1). It is probable that the two sets of trends have been strongly interdependent, with the massive increase in corporate R&D requiring the provision of qualified scientists and engineers, the training of which required acquaintance with—and mastery of—research methods and techniques resulting in the publication of papers, but (at least to start with) of no great international impact.

This points directly to the other major weakness of the information-based model, namely, its neglect of trained researchers as another (and perhaps the most important) social benefit of basic research. This was perceived by Nelson and his colleagues in interpreting the results of the first Yale survey of corporate R&D (Nelson and Levin, 1986; Klevorick et al., 1995). It has been amply confirmed by subsequent surveys of corporate and other practitioners (Salter and Martin, 2001). Such person-embodied knowledge is nowhere near

| Source: Arundel et al. (1995). |
as footloose as information: numerous empirical studies have shown that the links between basic research and application are inversely related to distance and directly related to common nationality (Hicks et al., 1996; Jaffe, 1989; Narin et al., 1997). As a consequence, many of the benefits of nationally funded basic research stay at home.

2.5 Continuing Government Support for Basic Research

To sum up, the original information-based justification for public support for basic research has neglected two essential elements influencing its social utility: as an input, the heavy infrastructure (trained people, institutions, networks) required for assimilation of the results of research performed elsewhere; and as an output, training researchers to know how to solve technical problems. In this era of rampant privatization, one might have expected these weaknesses to have undermined the case for public support. There has been at least one concerted attempt to do so [see Kealey (1996, 1998) and the critique of David (1997)]. But, although the share of business firms in the funding of academic research has increased in most OECD countries over the past ten years, it generally remains below 10% and government funding remains predominant (Geuna, 1999).

I can only speculate about the reasons why. One is that our increased understanding of the benefits of basic research serves only to add to the original case for public support. Many of the research training benefits are likely to remain within national boundaries, and—as with other aspects of training—a strong case can be made for public support; similarly for the investment in infrastructure necessary for assimilation of research performed elsewhere.

Another (less comforting) conclusion is that government decision makers are not assiduous in listening to policy advice from academic economists, especially when there are more authoritative and powerful voices to be heard elsewhere. In this context, the north-west European countries are particularly intriguing. They have no doubt been fully aware of the latest thinking in the US economics profession, but none apparently has applied the logic of the information-based model and reduced commitments to basic research. One can speculate that an alternative point of view has been advanced vigorously by the business community, namely, that strong support for basic research and associated training was and is a necessity for providing the skills and knowledge to keep up with developments, and thereby to compete in world

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4 See, in particular, Dasgupta (1987) on the benefits of open and public accreditation of trained researchers.
markets on the basis of innovation and change. Similarly influential corporate voices can be heard in the USA (see e.g. Committee for Economic Development, 1998).

Thus, we may conclude that the public support for basic research is probably here to stay. As we shall now see, the policy problems, challenges and puzzles lie in the forms which such public support will take, when there is growing pressure for relevance and results, the emergence of new technological opportunities with new forms of research collaboration between universities and business, and the growing internationalization of the links between basic research and application.

3. Future Policy Challenges and Puzzles

3.1 The Quest for Greater Relevance

The scale of public expenditures on basic research is now such that governments, politicians and electorates are inevitably asking for convincing evidence about the benefits of publicly funded basic research. In Europe (and particularly in the UK) this has led to a greater emphasis on demand-side factors in the allocation of public funding of basic research (Pavitt, 2000). Research proposals are expected to identify possible practical as well as scientific benefits; higher priority is being given to user involvement (including partial funding), universities are being invited to extract more revenue for licensing their intellectual property, and substantial public funds are being spent in ‘foresight’ exercises designed to create exchange and consensus around future opportunities for application.\(^5\) The research policy of the European Union pushes even further in the search for usefulness. Support for basic research in itself is virtually non-existent. It is concentrated instead on networks of firms—and sometimes including public laboratories—to pursue mainly incremental applied research and development activities (Petersen and Sharp, 1998).

Nelson’s work points to the dangers of such demand-driven strategies in basic research. Already, in 1959, he argued that social and economic demands

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\(^5\) For example, the recently published White Paper by the UK Government (2000) acknowledges the economic importance of curiosity-driven research, and increases funding for it. But it also establishes a ‘Higher Education Innovation fund . . . incorporating the Higher Education Reach Out to Business and the Community fund to build on universities’ potential as drivers of growth in the knowledge economy’ (p. 10) as a permanent new stream of university funding. In addition, ‘the new Cambridge MIT institute (CMI) will play a key role . . . , adapting MIT’s expertise in entrepreneurship, competitiveness and productivity to the UK environment’ (p. 33).
are often satisfied through major contributions from unexpected scientific and technological opportunities opened up in fast-moving and previously distant fields. He has also argued more recently with Rosenberg (Rosenberg and Nelson, 1994) that the route from discovery to application is often long and tortuous, involving the movement of knowledge, techniques and instruments from one discipline to another.

All this makes the forecasting and planning of applications of basic research a difficult, if not impossible, task. However, Rosenberg and Nelson (1994) have also rightly argued that the basic research system is in fact responsive to society’s needs, since universities have been instrumental in the establishment and growth of research and teaching in response to practical concerns, and particularly in practically oriented disciplines—like engineering, medicine, agricultural science, geology—where a high proportion of public funds for basic research are spent.6

The evidence of such feedback from societal demand to basic research is also evident in countries other than the USA. The growth of published papers for Korea and Taiwan, mentioned above, has been relatively concentrated on engineering, physics and chemistry—precisely the disciplines that underpin technological skills in manufacturing industry (Lattimore and Revesz, 1996). Similarly, Australia and South Africa show relative strengths in scientific fields that underlie agriculture and the exploitation of other natural resources (see Science Watch, 1993, 1995; Lattimore and Revesz, 1996).

Lattimore and Ravesz (1996) have taken our understanding a significant step forward by arguing that national patterns of research specialization by field in the relative share of scientific papers reflect societal requirements.7 In Table 3, they propose four categories of country, according to fields of scientific specialization: medical, natural resource based, industry based and mixed, according to their fields of relative research strength.

3.2 Misinterpretations in Support of More Relevance

It is not clear that this pressure in European countries for more practical relevance in government-funded basic research comes from business firms,

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6 The breakdown of university research by discipline is difficult to estimate. According to the OECD (1997), the share of university research funding in the engineering, medical and agricultural sciences in the early 1990s was 69% in Finland, 51% in Germany, 50% in Japan, 41% in Norway and 80% in Sweden.

7 This interesting and original analysis by Lattimore and Revesz is based on access to unusually detailed data from the Science Citation Index. Unfortunately, it is not widely known or accessible, having been performed by an Australian Government Agency that has since been disbanded.
many of whose managers in fact fully understand the benefits of publicly funded basic research activities complementary to their own applied research and development activities. It often comes instead from those in governments (and particularly in ministries of finance) who are responsible for the accountability and effectiveness of public expenditures, and who cannot (or do not want to) understand the complexities of tracing the benefits of basic research.

Their position has been comforted, and even reinforced, by a persuasively written claim that the nature and locus of knowledge production is changing. According to Gibbons and his colleagues (1994), the nature and locus of research activities are changing from mode 1 (based on academic institutions and disciplines, homogeneous and hierarchical) to mode 2 (undertaken in a variety of transient contexts of application, transdisciplinary, heterogeneous and networked), and this change should be reflected in the public support of research activities. However, critics point out that mode 2 research has existed for a long time, and is a complement to publicly funded and validated research rather than a substitute for it (David et al., 1999; Etzkowitz and Leydesdorff, 2000). To concentrate on mode 2 would lead to ‘cut-price research motels’ (David et al., 1999, p. 334), and to the neglect of fundamental research. In addition, a number of writers have pointed to the lack of any evidence about the relative growth of mode 2 at the expense of mode 1 (Pestre, 1997; Weingart, 1997; Godin and Gingras, 2000; Shinn, 2000).

Another set of misinterpretations that reinforce policies for greater relevance are the supposed causes of the US successes in turning basic research into commercial successes. Assertions of the following kind are now common:

<table>
<thead>
<tr>
<th>Major societal requirements (fields of relative research strength)</th>
<th>Countries</th>
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<tbody>
<tr>
<td>Medical (clinical medicine, immunology, molecular biology and genetics, pharmacology)</td>
<td>→ Denmark, Sweden, Finland, Switzerland, UK</td>
</tr>
<tr>
<td>Natural resources (agriculture, ecology, geoscience, plant and animal)</td>
<td>→ Australia, Canada, Chile, Indonesia, Malaysia, Mexico, New Zealand, Norway, Philippines, South Africa</td>
</tr>
<tr>
<td>Industry (engineering, computing, chemistry, materials)</td>
<td>→ India, Singapore, South Korea, Taiwan</td>
</tr>
<tr>
<td>Mixed</td>
<td>→ France, Germany, Japan, Italy, Netherlands, USA, Thailand</td>
</tr>
</tbody>
</table>

Source: Lattimore and Ravesz (1996, figure 2.2).
‘US universities do more applied research, with more private funding, and are more entrepreneurial and risk-taking.’

‘European universities should follow the US example, and increase their income through the protection and licensing of intellectual property.’

It is reasonably easy to find evidence that refutes most of these claims. In particular:

- US firms mostly use university research that is performed in high quality research universities, published in quality academic journals, funded publicly and cited frequently by academics themselves (Mansfield, 1995; Narin et al., 1997; Hicks et al., 2000).
- The proportion of university research that is business-financed in the USA is smaller than in most European countries (Geuna, 1999).
- US strength in biomedical- and ITC-related fields of university research is based on massive government funding of basic research and related postgraduate education over a number of years (Zucker and Darby, 1996; Ballantine and Thomas, 1997; Computer Science and Telecommunications Board, 1999).
- Expansion of US university patenting has resulted in a rapid decline in patent quality and value (Henderson et al., 1998; Mowery and Ziedonis, 2001).
- Increases in licensing income in leading US universities is concentrated in biotech and software, and preceded the Bayh–Dole Act (Mowery et al., 2001).

However, at least two features of the contemporary scene deserve more attention since they may be signs of important changes for the future: first, the emergence of ‘new science’-based firms closely linked to the universities; and second, the increasing internationalization of the links between basic research and application.

3.3 Universities and the ‘New Science’-based Technologies

The emergence of new firms in high technology fields in the USA is well documented. Until the 1980s, most of the key personnel in these new firms had worked previously in other firms or public laboratories with primarily applied R&D missions. The past twenty years has also seen the emergence of
new firms started by university scientists and engineers. As we have already pointed out, Mowery and his colleagues (2001) have shown that the parallel growth of licensing income cannot be explained by changes in incentive structures in universities to encourage research of greater practical relevance. Reasons must be sought in the increasing opportunities for practical exploitation. These have been clear in molecular biology, where spectacular advances in basic understanding have opened up major technological opportunities in medicine, where the links between basic research and application have always been strong (Orsenigo et al., 2001). But new firms are also now emerging from universities in a variety of software related fields, and in nanotechnology and combinatorial chemistry (Meyer and Persson, 1998; Malo and Geuna, 2000).

Surya Mahdi and I have argued (Mahdi and Pavitt, 1997) that these are ‘new science’-based firms, in that they are based on new fields, involving new journals and new disciplines in the Scientific Index. In addition to those linked to molecular biology, they include many where old disciplines have been re-invigorated with the application of massive and increasingly cheap computing power [e.g. physical chemistry + IT = computational chemistry; acoustics + IT = speech recognition; see Mahdi and Pavitt (1997) and Koumpis and Pavitt (1999)].

‘New science’-based firms typically consist of both new and small firms providing specialized services, techniques and products, and established large firms with multiple technological capacities exploring whether and to what extent the new technology should become part of its own technological armoury. They often have supply agreements with the small specialized firms to explore specific fields of technological opportunity. As a consequence, it appears that the traditionally direct links between large, multi-technology firms and university-based research are increasingly being mediated through small university-based firms. This is because decreasing costs of experimentation now enable university-based competencies to explore technical concepts and products to a much greater extent. The decreasing costs of experimentation are a consequence of improved scientific understanding (e.g. molecular biology), more finely grained systems of measurement and manipulation (e.g. nanotechnology, combinatorial chemistry), and the greatly reduced costs of computation and simulation (e.g. computational chemistry, speech recognition).

These trends open a wider range of technological opportunities for established firms, but they also increase the technical and commercial uncertainties...
surrounding each potential path to be explored. Given this increasing range and uncertainty of technological opportunities that they must monitor, multi-technology firms see increasing advantages in ‘loose coupling’,⁹ in which they outsource experimentation to small specialized firms, and maintain in-house capacity for monitoring and systems integration. As Pisano (1991) has argued in the case of biotechnology, such arrangements allow firms to explore uncertain options without the difficult-to-reverse commitments associated with in-house developments.

Table 4 represents the new division of labour in knowledge production that appears to be emerging in the ‘new science’-based technologies. In addition to the greater opportunities for technical advance described above, it also presents a number of dangers and difficulties: distinguishing what is public and what is private (of which the most spectacular are the current controversies about intellectual property rights in biotechnology); assuming that the changes are consequences of deliberate public policy rather than of autonomously changing technological opportunities; and trying to generalize the model to sectors where the costs of experimentation remain high, and where the main benefits of basic research remain indirect.

### 3.4 Internationalizing the Benefits of Basic Research

We have shown above that it is mistaken to assume that the useful results of basic research move easily across national boundaries. But business firms are increasingly doing so, and they are progressively learning how to join foreign networks and to benefit from foreign basic research. This remains a rather exclusive activity, being restricted to large firms—mainly from Triad countries—active at the world technological frontier, and to their exploratory research activities—given that the management advantages of physical agglomeration in more expensive product development activities remain con-

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⁹ See Brusoni et al. (2000) for discussion of the nature and role of loose coupling in a world of increasingly complex systems.
siderable (Niosi, 1999; Patel and Pavitt, 2000). It is nonetheless a trend with major implications for public and corporate policies.

The trend reflects the growing competitive pressures on firms to keep up with the latest advances in basic research, and the increasing probability that these will first emerge outside the firm’s home country. This is in part an inevitable consequence of the continuous growth of new centres of scientific competence, but it also reflects country-specific circumstances, such as:

- the small population of the company’s home country and its inevitably restricted basic research competencies (e.g. for Dutch, Swedish and Swiss multinational firms);
- the inadequacies in local research competencies in fields of growing opportunity (e.g. in the 1980s, molecular biology in Germany and software in Japan);
- the inadequacies in local entrepreneurship that leave local research resources particularly accessible to foreign firms (e.g. physics and electronics in the UK).

Policy analysis and prescription that ignore this process of internationalization can reach misleading conclusions. For example, the common belief amongst European policy-makers is that there is a ‘European Paradox’, according to which Europe is strong in basic research, but lacks the entrepreneurial capacities of the USA to transform it into innovation, growth and jobs. An alternative reading of the evidence is as follows (Pavitt, 2000):

- European research is not as strong as in the USA, especially in the fields associated with biotechnology and ICT;
- relatively less business R&D is being performed in Europe because European firms are performing an increasing share of their R&D in the USA;
- improved access to US basic research, particularly in biotechnology and ICT, is one of the principal reasons for doing this.

In any event, the USA has joined other and smaller countries in that its publicly funded science base no longer provides almost exclusively for US-owned firms. Government support for basic research in all countries will be increasingly shaped by the context of international economic competition (Etzkowitz and Leydesdorff, 2000). The international distribution of the benefits of basic research is likely to return to the forefront of public debate, a key feature of which will be how business firms themselves reconcile the
increasing dispersion of their knowledge networks with the geographic and organizational concentration required for effective product development and commercialization.

4. Conclusions and Unanswered Questions

Our analysis shows that the largely US-developed theory for the public support of basic research has had a powerful influence on the practice of government funding. The theory has, however, concentrated almost exclusively on informational benefits, to the neglect of training in problem-solving skills, and on the required investment in supporting institutions, equipment and networks. Any attempt to apply the original model in countries other than the USA should therefore carry the following mandatory health warning:

To be used only very sparingly. Consult local practising scientists and users beforehand.

More recently, successful US practice in exploiting 'new science'-based technologies has often been interpreted as a consequence of the higher market orientation of universities than in other countries. In fact, the most striking feature of the US achievement is that it is based on research and institutions that are ranked highly by purely academic standards. Massive and pluralistic government funding in health- and defence-related research has been part of the story. But, as has been suggested by Rosenberg (2000), universities can be viewed as economic institutions responding to changing opportunities and needs, and US universities have apparently been more effective than most at launching ambitious research and teaching programmes in new (and often multi-disciplinary) fields.

Internationally, comparative research to establish whether this is the case, and why, would therefore be most welcome. At the same time, further thought should be given to answering the following five questions:

1. Is the increasing pressure for accountability in the public funding of basic research likely to stifle experimentation with new fields in universities? Paradoxically, will unfettered private endowments and income, together with private foundations, increasingly provide the resources for such experimentation in future?

2. Does the capacity of the US universities to launch and experiment with
new fields extend to the social sciences? (From my very limited experience with the economics of technical change, the answer is ‘no’).

3. As a result of reductions in the costs of technical experimentation, US universities are becoming more directly involved in inventive activities in ‘new science’ fields like biotechnology and software-related activities. Does this signal an enduring new style of interaction between universities or application? Are they necessarily applicable to other fields and other countries?

4. What are the analytical and policy implications of the growing foreign-controlled share of US corporate R&D activities? Here, US practitioners and scholars probably have much to learn from the analyses and practices of smaller countries that have had a longer experience with the internationalization of corporate R&D (Zander, 1999).

5. Finally (and most important), should we necessarily assume that the USA is the only model of good practice in support of basic science, from which the rest of the world can learn? As we have seen in Table 1, Scandinavian countries and Switzerland are able to mobilize considerable resources for high quality basic research, without the massive defence and health expenditures of the world’s only superpower. Maybe the larger European countries, and the European Union itself, have more to learn from them than from the USA.

Acknowledgements

This paper was originally prepared for the celebration of Richard Nelson’s seventieth birthday, held in NYC on 13–15 October 2000. I have since benefited from comments by Stefano Brusoni, Ben Martin, Ammon Salter and an anonymous referee. Final responsibilities for the content are entirely my own.

References


OECD (1999), Main Science and Technology Indicators. OECD: Paris.


