Trends in UK Science Policy

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Trends in UK science policy[1]

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Introduction

From the formation, in 1986, of the pressure group *Save British Science* in response to higher education cuts and fears of a possible 'brain drain' through to the widely-publicised problems of research funding and infrastructure highlighted by a plethora of reports and inquiries, the late 1980s and 1990s are marked by continuing concerns over the health of British science. Whilst faced with the challenge of allaying or addressing these concerns in a situation of resource constraint, successive governments have also had to confront widely-held fears about the lack of investment in research and innovation by British firms relative to their competitors from nations such as the United States, Germany and Japan.

When, in 1992, the then Prime Minister John Major announced the formation of the Office of Science and Technology, it had been more than twenty years since any similar arrangements for science and technology had existed within Whitehall. According to the Government, the OST would provide a central focus for the development of government policy on science and technology, stewarding the research system in order to maximise its contribution to national economic performance and the quality of life. Soon afterwards, the Government published *Realising Our Potential: A Strategy for Science, Engineering and Technology*. This White Paper represented the first broad review of policies and mechanisms in the area since 1972, setting out a rationale (and a blueprint) for the support of science and technology which has shaped developments to date. The publication of *Realising Our Potential* represents a major restatement of the relationship between science and government in the United Kingdom. This chapter will attempt to place it, and subsequent events, in the context of broader trends in UK science and technology policy from the early part of this century. We will try to show how the institutional arrangements for government support and policy for science have gradually evolved over time, shaped largely by pragmatism rather than any long-term vision. We also hope to suggest how some of the pressing problems identified in more recent times may in fact have developed slowly, hand-in-hand with the system itself.

[1] The authors would like to thank the following people for advice relating to this chapter, and for their comments on earlier drafts: Mark Andrews, Paul Cunningham, Philip Gummett, and Paul Windrum, all from PREST, and Philip Dale of OST. Because we did not always heed their advice, we must stress that the views contained within this chapter (and any mistakes which remain) are our own.

Historical background

This section provides the briefest of overviews of developments in UK science policy up until the late-1980s, in order to set the scene for the discussion of more recent changes which will follow. The aim is to draw out the major issues which recur. Readers interested in a more detailed account of the evolution of the UK's structures for science and technology policy are urged to turn to Gummett (1980, 1991), from which much of what follows is drawn.

Though the relationship between science and government in the UK may be traced back much further, current governmental arrangements for science and technology have roots in developments which took place in the first half of this century. It can be argued that patterns for government support for science set at that time persisted throughout the period which followed, with little evidence of any attempts at a radical departure from these patterns except perhaps in the institutional innovations of the mid-1960s and mid-1990s.

At the outbreak of the First World War the extent of the nation's dependency upon the products of German industry became shockingly apparent. The Government's responses to this situation included the setting up, in 1915, of an Advisory Council on Scientific and Industrial Research, and the creation, in 1916, of a Department of Scientific and Industrial Research (DSIR). The latter was under the nominal control of a committee of the Privy Council, chaired by the Lord President of the Council, a non-departmental minister of Cabinet rank. The aim of DSIR was to mobilise British science in the support of the national war effort. This it did through its own laboratories, through its responsibilities for the industrial research associations, and through grants to scientists working in universities.

The creation of DSIR in the Privy Council[2] structure, rather than in a Ministry or Department, allowed for the disbursement of a steady stream of public funds, whilst giving the scientists it supported a great deal of flexibility to set their own priorities. This devolved arrangement for science policy-making was endorsed in 1918 by the Haldane Committee's *Report on the Machinery of Government*[3]. In recognising the importance of scientific research to government, the report distinguished between research relevant to the remits of particular government departments and more generally applicable research (i.e. that which would, today, be termed basic research). The report argued that departments should remain responsible for the former whilst advocating the use of a DSIR-type structure for the support of the latter. Such a semi-autonomous structure, it was felt, would remove any possibility of general research being driven by narrow departmental objectives. In the years following the Haldane report, new 'research councils' were set up to complement DSIR. First came a Medical Research Council (MRC) in 1920, followed in 1931 and 1949 by councils established to support agricultural and nature conservancy research, respectively. The model of loose co-ordination by a non-departmental minister, along with the development of particular scientific interests within individual government departments, set the pattern for many years to come.

[2] The Privy Council dates back to the thirteenth century, having its roots in the Monarch's circle of advisors. The inner Council in turn was the ancestor of the modern Cabinet. The Privy Council has a membership largely made up of present and former ministers.

[3] Cmnd 9230, December 1918.

The post-war years: the growth of science

By the time of the Second World War, there was little need to convince government of the importance of science. A committee of prominent scientists advised the war cabinet, and major research programmes were established in electronics, aviation, atomic energy and many other fields. Following the war, the advisory committee became the Advisory Council on Scientific Policy (ACSP), advising the Lord President in his capacity as minister responsible for overseeing government civil science policy. In addition to this high-level co-ordination, a great deal of science and technology decision-making remained widely dispersed across Whitehall. In the civil sphere, individual departments continued to build up their own research capabilities in support of their particular missions, whilst in defence, R&D responsibility was split between the Ministry of Supply, the Admiralty, the Air Ministry and the new Ministry of Defence (MoD) formed after the war.

The 1950s saw continued growth in government support for science and technology, not only through DSIR and the other research councils, but also through the expansion of the universities, the creation of new organisations such as the United Kingdom Atomic Energy Authority, and, of course, through the comparatively large sums spent by the MoD and its supply ministries. Science promised much, and was unquestioningly accepted as a force for good. Perhaps in response to increasing public awareness of the importance of science, in 1959 an Office of the Minister of Science was created, that minister being responsible for the DSIR and other research councils, atomic energy and space research, and all general matters of civil science policy (but excluding departmental research programmes).

In a sense, the post-war period represents a 'golden age' for science, with resources growing at an unprecedented rate. Perhaps more important for today's debate surrounding scientific autonomy, scientists were left largely to themselves in determining the criteria for choice within science; science policy focused on servicing their needs. However, it should be remembered that the major part of R&D funding went through mission-oriented government departments, predominantly those concerned with military, health and energy programmes. That said, even within those programmes, the emphasis was on science rather than technology. The main influence on the science policy discourse of the time was what is now called the 'linear model' of innovation, with developments in science seen as pushing or leading technology, and therefore industrial innovation (Elzinga and Jamison, 1995).

The 1960s: science and prioritisation

By the start of the 1960s, however, the question of prioritisation had become an issue. The ACSP had become increasingly concerned about the relatively high costs of certain areas of science, notably nuclear physics and space research. Difficult choices had to be made regarding the appropriate level of national engagement in these fields and about the kind of role which Britain should play in international collaborations. In its final report of 1964, the ACSP pronounced prioritisation to be the most pressing challenge to national science policy. A prime concern of that body was the way in which each research council negotiated its budget individually with the Treasury - which in effect became the only forum in which competing claims for funding of research were heard. Such a system did not seem well suited to the development of a coherent policy of prioritisation. From this point onwards, a recognition of the pressure to be selective about the kinds of research which should be funded (and the number of units or centres to which scarce resources for any particular type of research should be allocated) became a common component of science policy debates.

Running parallel to these discussions was an increasing focus on the potential role of science and technology in economic development, and of the possibility of directing research in certain directions in order to best achieve positive economic returns. Internationally, the newly-created OECD had published the Piganiol Report (1963) which had sought to mark a distinction between 'policy for science' and 'science for policy'. This document claimed that expenditures on both education and research represented long-term investments in economic growth. A similar message became central to the Labour opposition's programme to forge a 'new' Britain. Even before the election of the Wilson government (in 1964), it had become clear that the existing co-ordinating mechanisms were inadequate for dealing with the sorts of choices that needed to be made. An official Whitehall inquiry under senior Treasury civil servant (and later Cabinet Secretary) Sir Burke Trend suggested improved structures to address these issues[4]. One of its key recommendations was implemented just prior to the 1964 election. A new Department of Education and Science (DES) was established, which would take responsibility for the research councils. As Blume (1985, cited in Gummett, 1992) has pointed out, the view at the time was that getting the structures right would not only foster good science but would also generate innovation. Significantly though, despite the part played by this utilitarian reasoning, little emphasis was placed on the determination of research programmes by identifiable and immediate needs.

A few months later, the incoming Wilson government placed the industrial arm of DSIR under a new Ministry of Technology, whilst adding a Science Research Council (SRC) and a Natural Environment Research Council (NERC) to the councils now under the wing of the DES. An independent Council for Scientific Policy (CSP) would advise the secretary of state for Education and Science on science policy matters, including the allocation of resources to the research councils. In turn, the Minister of Technology had his own Advisory Council for Technology. In the years that followed a Social Science Research Council (SSRC) was also added to the DES portfolio of research councils. The Ministry of Technology ('Mintech') also continued to grow, embracing first the atomic energy authority, then in later years responsibility for electronics, engineering and aviation (in which field a large proportion of government R&D funding was spent). Mintech had been conceived as a response to the perceived technological shortcomings of British industry, and as a vehicle by which the distorting effects of the high levels of defence R&D could be countered[5]. By the time the decade drew to a close, Mintech had effectively become a ministry for industry[6].

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[4] *Committee of Enquiry into the Organisation of Civil Science*, Cmnd 2171, October 1963, HMSO.

[5] It was widely suspected that defence R&D 'crowded out' civil R&D by soaking up resources and manpower which might otherwise be devoted to the latter (see for instance Buck and Hartley, 1993).

[6] Edgerton (1996a and b) argues that, though the Labour government came to power advocating the central role of science and technology in economic restructuring, once in power there was 'a critical examination of the basis of science and technology policy' (p54). They cut defence R&D, cancelled a series of major projects, sought a return from public investments in

The 1970s: science, advice and accountability

In the mid-1960s, the first official, full-time Chief Scientific Advisor to the cabinet was appointed. After the Conservative election victory of 1970, Mintech became the Department of Trade and Industry. In 1971, as part of a comprehensive review of government activities, Lord Rothschild - the head of Prime Minister Heath's Central Policy Review Staff (CPRS) 'think-tank' - produced a report into the organisation and management of government R&D[7]. This included a recommendation that, in the interests of accountability, all applied research should henceforth be managed on a 'customer-contractor' basis under which Ministers, and their chief scientists and advisors, should specify the aims of their own departmental research policy, while a separate 'controller R&D' would be responsible for carrying out the policies. The creation of the latter post would allow departmental chief scientists to concentrate on their advisory role. However, the report also argued that the same principle should be extended to the 'applied' research sponsored by the research councils - such work, concentrated in the medical, agricultural and natural environment councils, should be directly commissioned by ministers from the relevant departments. These recommendations were widely seen as an attack on the autonomy of the research councils, as enshrined in the Haldane report - though as Gummett (1980) notes, this had sought to protect only 'generally applicable' research from control by departmental ministers.

That year (1971) also saw the publication of the Brooks Report by the OECD. It, too, emphasised the need for greater societal control over applied research but argued that economic growth alone was an insufficient goal for science policy. This was an interesting point to make given the doubts that had already been cast, particularly in the United States during the late 1960s, upon the ability of basic science to translate into economic deliverables in a linear fashion[8]. Nevertheless, both reports were to usher in a new era of social accountability, with the reach of the scientific community's peer review mechanism partially eroded. A new set of concepts - mission orientation, technology policy, social relevance - were henceforth brought to the forefront of science policy discourse (Elzinga and Jamison, 1995), and the position of 'science for policy' somewhat enhanced.

In the UK, the application of the Rothschild customer-contractor principle to the research councils can be regarded as a turning point, from which it was explicitly accepted that political direction could be applied to the work funded via the research councils. It has since been suggested that implementation of the Rothschild recommendations not only generated extra bureaucracy, but may also have altered the balance between applied, strategic and basic research funded by departments. In particular, a 1983 ABRC study concluded that, in a situation of pressure on funds, longer-term work would suffer, with the end result that more strategic research had to be funded from the science budget, which in turn squeezed the resources available to basic research (see Williams, 1988).

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civil technology (and proposed the near-privatisation of the public sector research establishments), and raised doubts about the existence of any straightforward relationship between R&D and economic performance.

[7] 'The Organisation and Management of Government R&D', published in *A Framework for Government Research and Development*, Cmnd 4814, November 1971, HMSO.

[8] Here, we are referring to Project Hindsight and TRACES. See Freeman (1982) or Coombs, Saviotti and Walsh (1987) for an overview.

At the end of 1972, the CSP was replaced by a new body with a similar remit to advise the secretary of state. The Advisory Board for the Research Councils (ABRC), however, was less obviously independent than its predecessor, counting government scientists amongst the industrialists and other scientists comprising its membership. Meanwhile, the central co-ordination mechanisms overseeing science advice to government had been progressively overhauled. The scientific advisor, based in the Cabinet Office, was supplemented by a Science and Technology group, charged with providing a focus for advice to ministers and with monitoring trans-departmental S&T issues. In 1976 these advisory functions, including the chief scientist role, were transferred to the CPRS think-tank also located within the Cabinet Office. Meanwhile, a new official committee of departmental chief scientists and permanent secretaries was established under the Cabinet Secretary to further improve co-ordination of policy. Lastly, an Advisory Council for Applied Research and Development (ACARD) was to be formed, which would advise ministers on all UK applied R&D, both public and private, and on the relationships between this research and the scientific work supported through the research councils. ACARD would also advise on the future development and application of technology.

The 1980s: science and innovation

In 1979, the Conservative Party, now led by Margaret Thatcher, returned to power. Whilst she made much of her scientific background, having trained as a chemist, the Thatcher years are marked by the intensification of fears that British science was in serious trouble. Once in power, the Conservatives set about progressively transforming the nation, 'rolling back the frontiers of the state' in the belief that market forces provided the most effective, and the morally most acceptable, means for allocating resources of every kind.

In 1981, just as the Thatcher programme was beginning to take shape, the House of Lords Select Committee on Science and Technology produced a report, *Science and Government*[9], containing a series of recommendations again aimed at strengthening co-ordination, advice and policy making. These included:

- the re-establishment of the post of chief scientist at Permanent Secretary level (the post had been originally created at this most senior level, though recent incumbents had been appointed at lower levels);
- the creation of a new cabinet-level Council on Science and Technology;
- the introduction of an annual report on the state of science and technology;
- the imposition of stronger departmental advisory mechanisms, and stronger interdepartmental co-ordination mechanisms;
- the production of an annual review of government funded research; and,
- the appointment of a minister for science at cabinet level.

The committee felt that it was for the government to decide upon the precise structures within which their recommendations should be implemented, but warned that the 'upheavals in civil science' experienced after the Rothschild Report constituted a severe warning against change for change's sake.

[9] 1st Report, Session 1981-82, HL 20, November 1981

The government's response to *Science and Government*[10], published in 1982, accepted the argument that a strengthening of central co-ordination of science and technology matters, rather than a wholesale reorganisation of the machinery of government, was necessary. In regard to the particular recommendations, it left unchanged the status of the government's chief scientist, but agreed to provide a small unit, within CPRS, to support the chief scientist in his duties. It also retained ABRC but expanded the remit of ACARD, freeing it to comment on the annual public expenditure round and explicitly making it responsible for advice to government concerning the links between basic and applied research. A new committee of departmental chief scientists was formed, to be chaired by the government's chief scientist and an annual review of publicly funded research was introduced. However, the government rejected the committee's proposal for a science minister, insisting that the strengthening of official co-ordination mechanisms, and the Prime Minister's general responsibility for any trans-departmental issues, made such a change unnecessary. Further, it was argued that a co-ordinating science minister would inevitably blur the responsibilities of departmental ministers.

From 1983, a Review of Government funded R&D appeared annually. Its existence forced departments to focus on clarifying the objectives of their research spend. In the same year, the chairmen of ABRC and ACARD produced their first joint report, identifying key policy issues to be addressed to protect and enhance a science base useful to and exploitable by British industry. These issues were: selectivity in basic research; selectivity and direction in applied research; better international links; the need for stable, long-term science policy; the need for improvements in the market environment - which could be brought about by the intelligent use of government purchasing power, and by creating suitable fiscal, financial and regulatory climates; the importance of *design* to industrial innovation; the question of whether R&D priorities addressed the requirements of the growing service sector; and the need for a more 'responsive' education system.

By 1986, the House of Lords Select Committee, in its report *Civil Research and Development* (House of Lords, 1986), was voicing grave concerns about the state of UK science, in the face of a series of severe financial cutbacks in the universities and the declining volume of civil R&D due to expenditure restrictions in government departments over the preceding years. The ABRC too was making its own warnings of low morale, and in the following year its report *A Strategy for the Science Base* (ABRC, 1987) contentiously advocated a division of labour between research and teaching within the university system (see Chapter 5). Also in 1986, the pressure group *Save British Science* (SBS) was launched with an advertisement in *The Times*. Several thousand scientists responded to the advertisement in the first few weeks after its publication. Based on these responses, SBS tried to provide a voice for the 'grass roots' of science in the UK. In its evidence to the Select Committee inquiry, the group highlighted career, resource and infrastructure problems[11], holding out the prospect of a serious decline in British science.

It was clear that drastic cuts in resources were the cause of low morale within the scientific community, and no shifting of the government 'furniture'

[10] Cmnd 8591, July 1982, HMSO.
[11] All issues which continue to dominate the agenda, and which had finally come to a head in the mid-1980s

could distract attention from this reality. It is worth reflecting further on the ideology that underlay government action on science during this period, as it remains salient into the 1990s. As we have already seen, earlier periods were also marked by ideologies of sorts. The post-war 'boom' years were characterised by the belief in scientific autonomy, a position reflected in the accounts of science of scholars such as Robert Merton and Michael Polanyi[12]. The mid-1960s up until the late 1970s in turn were characterised by the realisation that priorities would have to be set for science, given its ever-rising costs, and that these priorities could somehow be informed by the diverse policy objectives of a modern industrial state. Gibbons *et al* (1994) have distinguished these periods as 'policy for science' and 'science in policy', respectively[13]. However, they go on to identify a third period, beginning in the late 1970s, which they call 'policy for technological innovation'. The dawn of this new era coincided with deteriorating economic performance in the UK, as well as increased global competition. Consequently, policy makers were driven to 'narrow their perspective on the role of science in achieving national goals to the single question of how to hitch the scientific enterprise to industrial innovation and competitiveness' (Gibbons *et al*, 1994, p158). Moreover, Japanese success in many branches of industry, especially electronics, focused much attention on the characteristics of the Japanese R&D policy approach with its strong industrial orientation (Elzinga and Jamison, 1995).

The 'regime' that emerged can be characterised as having the following features:

- with industrial innovation itself becoming the central priority for R&D, science was regarded as a source of strategic opportunity, underpinning new areas of technology;
- the new areas of technology identified were generic in terms of their potential to underlay what was perceived to be a new 'techno-economic paradigm', e.g. biotechnology, new materials, semiconductors. Emphasis was placed on supporting these infrastructural technologies as opposed to stimulating innovation through specific product and process developments;
- the science underpinning these new technologies often cut across the boundaries of established disciplines. Moreover, the relationships between science and technology became ever closer, a defining feature of the supposed new techno-economic paradigm;
- the emphasis on science underpinning industrial innovation saw the encouragement of new linkages at the university-industry interface. This strategy was accompanied by a range of new, powerful metaphors such as 'technology transfer' and 'bridging the academic-industrial divide', all of which drew upon the notion of a world-class 'science base' needing to get 'better connected' to a UK industry that had, up until now, largely failed to

[12] Their call for an autonomous science, free from political, economic and social meddling, was heavily informed by a reaction to communism.
[13] These labels closely align with those proposed in the Piagnol Report (OECD, 1963). It should be noted that many other eminent scholars in the science policy field have also provided similar periodisations of science policy. Most appear to agree on the essential elements, and we ourselves have utilised more than one account. For examples, see Blume (1985), Freeman (1987), and Elzinga and Jamison (1995).

realise the potential of this national asset[14]. Thus, the 1980s are marked by a steep increase in the levels of academic-industrial collaboration, driven not only by this new thinking, but also by increased competition for limited resources coming from the government's science budget. Inevitably, the orchestration of academic and industrial research was to undermine still further the older doctrine of relative autonomy within the scientific community;

- resource constraints, and the subsequent need for greater selectivity and prioritisation, dictated the requirement for better developed control mechanisms over the science being conducted. Significantly, peer review alone was seen as inadequate in meeting these new demands, mainly on account of its narrow internal selection criteria and its inability to deal with the perceived need to cut existing activities in favour of new ones. Thus, the 1980s are marked by the emergence of research and programme evaluation[15], an activity which typically uses broader socio-economic criteria than those employed in traditional peer review;
- international collaboration became more important, especially at the European level, with the establishment of both the European Community's Framework programmes and EUREKA[16];
- unlike the model Japanese research system, British industry still tended to under invest in R&D. Indeed, during this period, industry narrowed its commitment to basic research so as to cut costs and hence improve competitiveness.

When, in 1987, the government published its response to *Civil Research and Development*[17], no commitment to an increase in resources was forthcoming. Instead, further changes in the machinery of government were announced. The major component was the establishment of an Advisory Council on Science and Technology (ACOST), which absorbed ACARD and which included four additional members (drawn from the academic community). Its remit was wide - to embrace all aspects of S&T, domestic and international, and to advise the government on priorities for S&T in the UK, on the application of S&T in line with national needs, and on the co-ordination of S&T activities. The ACOST secretariat remained in the Cabinet Office, and continued to report to the chief scientific advisor. Unlike ACARD, which had to work jointly with ABRC on matters relating to basic research, the new body was free to provide direct advice on all research. Meanwhile, ABRC was undergoing changes of its own; in 1989 it was restructured and given explicit executive control over the research councils and the allocation of resources between them, powers which had previously been exercised by the secretary of state with ABRC advice (see Chapter 5).

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[14] It was often argued that foreign firms were better able to appropriate the benefits of UK science than British ones. Included in the dazzling array of technologies listed in support of this argument are monoclonal antibodies, medical scanners and liquid crystal displays. However, the reasons why individual firms do or do not take up particular innovations may be very complex, and the usefulness of such anecdotal evidence must be questioned.

[15] Despite this activity being present in the research system since the 1960s, its prominence and scope were now to become more significant.

[16] A European (but not European Community) research programme initiated in the mid-1980s as a civil response to the US Strategic Defence Initiative

[17] Cmnd 185, July 1987, HMSO.

As ACOST prepared to offer its first advice, the government announced its decision to end support for all research judged to be 'near market' - the support of which, it believed, was not a job for government. The stated aim of the change was to switch the funds to basic research. However, it has been suggested that the cost of this restructuring, for instance in redundancy payments, swallowed up much of any savings, and it is not clear whether basic science benefited to any substantial degree (Cunningham and Nicholson, 1991). The government's programme was also well underway by this time, and the 'New Public Management' philosophy was increasingly being extended to the conduct of science and technology in the public sector. As detailed in Chapter 4, Public Sector Research Establishments (PSREs) were to be severely and repeatedly scrutinised in order to determine whether they should remain in the public sector, and if so, in what form. As a result, many laboratories were turned into 'arms-length' executive agencies, given performance targets, and expected to increasingly find work outside government. By the late 1990s, a series of PSREs had been privatised in one form or another, the whole process constituting perhaps the most important structural change in public science in the UK over the last 20 years.

ACARD had published *Exploitable Areas of Science* in 1986, which had recommended the development of a process of identifying exploitable areas for UK research, to inform the process of prioritisation. In the judgement of the committee, the UK lacked any forum in which to hold debates about directions in science and technology and its associated policy. Moreover, the information that would allow this to be managed effectively was said to be dispersed and essentially non-interactive. The report's proposals were much influenced by the work of Irvine and Martin (1984) on mechanisms of 'technology foresight'. Thus, it was suggested that such an activity would have to be continuous, with sufficient resources committed in terms of quantity and time to ensure a consistency in judgement. As regards potential impact on science policy, a structure would have to be created, capable of gathering, analysing, prioritising, and directing relevant information into the decision-making machinery. A small management group was envisaged, independent of public or private bodies, to steer the whole process, whilst proceedings would be linked to the Annual Review of Government funded R&D, so as to increase the likelihood of implementation. As regards industrial R&D priorities, whilst many of the large manufacturing firms in the UK had their own foresighting activities, a more wide-ranging foresight exercise throughout the whole R&D system would be required. Interestingly, the report saw no role for government in such an activity and proposed instead that 'industry itself should set up the mechanisms for undertaking long-term research forecasting on a permanent and routine basis' (ACARD, 1993, p45).

In his report to the UK Government in 1993, Martin discusses the reasons why ACARD's recommendations were never implemented. Many had expected that the Centre for Exploitation of Science and Technology (CEST), set up in 1988 with government support (and private funding) would act as the forum sought by ACARD for identifying and prioritising exploitable areas of science - especially given the key role of industry in setting it up. However, Martin sees this large industrial stake in CEST as the reason why it failed to commit itself fully to true research foresight. Its earliest attempts at foresight were felt to be flawed in conception and since then, its industrial paymasters have been 'more interested in the applied end of the research spectrum and in activities aimed at meeting company needs' (Martin, 1993, pp. 20-21). Thus, CEST slipped into the role of a technology consultancy, and it is notable that the organisation is barely mentioned in the 1993 White Paper. Nor has CEST played any significant role in the Technology Foresight programme which was subsequently introduced - at least until after the initial panel reports had been published (see below).

Science policy in the 1990s

The government machinery for science remained largely unchanged from 1987 until 1992, when the Conservatives were again returned to power for a fourth consecutive term in office. Immediately after the general election victory, the government announced the creation of a new Office of Science and Technology (OST) to be headed by the Chief Scientific Adviser, its mission being to act as the mechanism for developing and co-ordinating government policy on S&T, to establish better links between government-funded S&T and industry, and to ensure an adequate supply of well trained and skilled scientists and engineers, all with a view to making the maximum contribution to the nation's economic performance and quality of life (*Forward Look*, 1995, p1). OST was to be assisted in this role by a process of mass consultation with the science and engineering communities, industry, the research charities, interested trades unions, and those who had responsibility for the management of R&D in the private and public sectors. This process culminated in the publication of the 1993 White Paper, *Realising Our Potential: A Strategy for Science, Engineering and Technology*, the first major thorough review of science policy in more than twenty years.

The OST was located within the Office of Public Service and Science (OPSS) in the Cabinet Office, the department responsible for the Civil Service, from where it was hoped an overview of the total budget for science could be obtained together with some sort of mechanism for the development of overall priorities across government departments. Most importantly, science was to enjoy representation by a single minister at Cabinet level for the first time in thirty years with the appointment of the Chancellor of the Duchy of Lancaster as the minister responsible for the OPSS[18]. The announcement at the time claimed that the Chancellor would take day-to-day responsibility, acting on behalf of the Prime Minister, for science and technology policy and co-ordination, thus marking a break from the Thatcher administrations where the Prime Minister herself insisted that responsibility for S&T across government should reside with her alone. Nevertheless, the Prime Minister retained chairmanship of the Cabinet Committee on science and technology.

This shift in ministerial responsibility was broadly in line with the recommendations made by the House of Lords in 1982 and 1986, although they had not recommended the creation of a separate department devoted to science. The new department was in fact created out of the former science and technology secretariat within the Cabinet Office and the Science Branch of the

[18] In addition, a House of Commons Science and Technology Committee was established, constituting a new legislative check on the new executive department, and complementing the existing House of Lords committee which had for some time been the only body to scrutinise science and technology issues broadly defined.

DES, which had been concerned with the Research Councils. The Cabinet Office S&T secretariat had already been responsible for some co-ordination of the S&T activities of the various government departments, chiefly through the advice provided to the Prime Minister by both the Chief Scientific Advisor and ACOST, but it was now felt that this needed strengthening. The new arrangements were not intended to centralise the management of the R&D supervised by the various departments, since that would run contrary to the support provided by S&T in the pursuit of departmental policy objectives, as enshrined by the Haldane and Rothschild 'principles'. As regards the shift of the Research Councils, the House of Lords Select Committee had expressed concerns about the DES' stewardship of the science budget, and questions about the degree of co-ordination between the universities funding bodies and the research councils had also been acknowledged in several education White Papers (see Chapter 5). The government further claimed that it had become increasingly difficult for the Secretary of State for Education and Science to act as the voice of S&T in Cabinet and Cabinet Committees whilst carrying the heavy workload of ongoing educational reforms[19]. In this context there was widespread support for the establishment of the OST across the scientific community.

As a direct consequence of the move of the Science Branch of DES into the OPSS, the minister found himself with two major advisory bodies, ABRC and ACOST, providing advice on overlapping matters. It should be noted that from the late 1980s onwards both bodies had come under increasing criticism - ABRC because of its overly managerial handling of the research councils and the secretive way in which it came to its decisions, and ACOST because of its failure to achieve the hopes and expectations which were held out for it in terms of its broader strategic input into policy making. That said, it was recognised that both bodies had produced some excellent individual reports. The failure of ACOST, in particular, was ascribed to the lack of a sufficiently influential central structure charged with taking forward the interests it had identified, and which the establishment of OST was meant to rectify. The role and relationship of these advisory bodies was reviewed in the process of preparing the 1993 White Paper, a document which was finally to seal their fate.

Given these new arrangements, it should be noted that the OST was in fact put in charge of less than 20 per cent of the government's spending on R&D. Even discounting military R&D funding, the new department still directly controlled only about one third of the civil S&T spend. For reasons already discussed, the majority of funding capacity remained with individual departments. This raised the issue of how the OST was expected to extend some sort of harmonising influence over S&T conducted elsewhere, particularly that which was widely diffused across other government departments. The White Paper was to instigate a number of mechanisms through which it was hoped the OST could fulfil this co-ordinating role.

[19] In announcing the establishment of the OST, William Waldegrave, the newly-appointed Chancellor of the Duchy of Lancaster, indicated that the changes were motivated by the wish to have a high-ranking minister representing British science in Brussels, and by the government's desire to deal, centrally, with those S&T issues which cut across government. It should be said that the Conservatives had spurned any idea of a separate department and/or minister for science during the 1992 election campaign, though the Labour Party's manifesto did contain a commitment to appoint a minister for science. Thus, the Conservative announcement had come as something of a surprise.

The 1993 white paper

Realising our Potential was the first major policy statement for science and technology since the publication of the Rothschild Report in 1971. It reaffirmed the need for priority-setting, envisaging a science and engineering base (SEB) that would be more responsive to the needs of industry, thereby enhancing national wealth creation. In this respect, it was broadly in line with previous government thinking. Its significance lay in the number of policy mechanisms and structural changes which it prescribed to improve the exploitation of the public sector science base.

As already mentioned, the White Paper was informed by a mass consultation exercise in which the government received more than 800 submissions from a variety of interested parties. The responses focused particularly on the following:

- the widely perceived contrast between the UK's excellence in S&T and its relative weakness in exploiting it to economic advantage;
- the absence of a clear statement of government objectives, with the consequent transmission of mixed and sometimes contradictory signals to the scientific and engineering communities;
- within what most respondents recognised must be limited resources, the need to manage government investment in S&T to better effect;
- the need for more effective mechanisms for implementing policy; and
- the problems in relation to the management of careers in science and engineering.

Given this background, the White Paper's main points are set out below:

The need for priorities

As had been apparent since the 1960s, no one nation could afford to sustain a significant independent presence in all of the burgeoning fields of scientific research. The government therefore emphasised the need to work closely with the scientific and industrial communities to determine the appropriate mechanisms for setting priorities both in terms of the areas of research to support, and the level of funds to be committed to them. Moreover, decisions on priorities for support would be much more clearly related to meeting the country's needs and enhancing the wealth-creating capacity of the country (it should be noted that for the authors of the White Paper; 'the major challenge facing the UK today is an economic one'). It claimed that for many in the universities and research councils, there had been a presumption, confirmed by reward and management systems, that by far the most significant criterion to be applied when judging priorities amongst research proposals was research excellence. Whilst conceding that excellence was very important, the White Paper asserted that there need not be any conflict between quality and relevance or appropriability. Indeed, the research councils were already taking account of multiple criteria when allocating funds. However, there was now a need to take more fully into account the extent to which outcomes could be taken up by potential users. Consequently, when setting priorities and allocating resources, the research councils would, henceforth, be more responsive to the needs of their particular user communities.

ACOST, created in 1987 to advise government on priorities, was now to be replaced by a 'more influential' body, the Council for Science and Technology (CST)[20]. This would bring together customers of publicly-funded research, industrialists, academics and business people as well as the chief scientists (or equivalents) of the departments most directly involved. Moreover, its membership was to be largely independent of government, chaired by the Chancellor of the Duchy of Lancaster on behalf of the Prime Minister, and with the Chief Scientific Adviser as deputy chairman. The OST was to provide the Council's secretariat. Finally, the White Paper indicated that, unlike ACOST, its advice to ministers would normally be made public.

The need to better engage business

Whilst recognising that S&T is just one of the large number of interdependent factors which bear upon industry's competitiveness, the White Paper asserted that the capacity to put S&T to commercial use through innovation plays a significant part in successful modern industry. The key to success lay in increased innovation; thus, government would be engaged in a long-term effort to:

- promote a greater awareness of the importance of innovation throughout all sectors of the economy;
- improve the effectiveness and efficiency with which firms innovate;
- facilitate access to S&T relevant to business whatever its source;
- ensure that the needs of firms are fully taken into account in decisions on the direction, nature and content of publicly funded S&T.

It should be noted that the government rejected the call for general tax incentives for spending on R&D in firms. Rather than using this mechanism as a way of engaging industry, it preferred a systematic interchange between industry, scientists, engineers and science policy makers which, it believed, would improve mutual understanding and allow each group to make its decisions against a better-informed background. The chief mechanism to be used in achieving this aim would be a national Technology Foresight Programme which would be jointly conducted by industry and the science and engineering communities (see Coda at end of this chapter). Such mechanisms had already been successfully employed in other countries, and the UK had flirted with the idea in the mid-1980s with the publication of *Exploitable Areas of Science*, although as already discussed, this report came to little. Technology Foresight was to be used to inform government's decisions and priorities, the aim being to achieve a key cultural change.

The need for better co-ordination of government funded S&T

As noted above, the Government's previous attempts at prioritisation had led to efforts to increase both accountability and co-ordination of government-funded S&T. With even greater emphasis placed upon priorities in the White Paper, it came as little surprise that changes to the central government machinery for

[20] This should not be confused with the Cabinet Committee for Science and Technology (known by the Whitehall shorthand of 'EDS') which operated until 1995, and which was composed of ministers.

S&T were also announced. To begin with, the Government's use of funds and its effort in S&T were to be made more explicit and open through the annual publication of a *Forward Look*. This was intended to replace the *Annual Review of Government Funded R&D*, and was supposed to provide the industrial and research communities with a clear and up-to-date statement of the government's strategy. Specifically, it was to give a longer term assessment of:

- the portfolio of publicly-funded work best suited to the broader scientific and technological needs of the country at a time of increasing economic competition, rapid scientific advance and accelerating technological change;
- the extent to which individual Departmental S&T programmes were matched to that portfolio, and the prospects of bringing about a closer alignment between the two.

Significantly, the *Forward Look* was to be prepared by the OST which would seek contributions from government departments through the ministerial Committee on Science and Technology. The document would also draw on the findings of the Technology Foresight Programme, as well as seek the views of the new Council for Science and Technology. Its stated purpose was to set strategic objectives over a five to ten year perspective and to consider: any gaps or imbalances in the education, training and research effort; how the UK's efforts compare with those of its principal competitors; the balance between civil and defence research; opportunities for achieving synergy across programmes; and the scope for greater concerted action and collaboration.

A further mechanism for greater co-ordination promoted by the White Paper was the concept of concordats between research councils and government departments. These had been previously pioneered by MRC and the Health Departments and allowed each organisation to articulate their expectations and obligations and to provide a framework for the systematic development, review and evaluation of their respective needs, priorities, activities and progress. The Government proposed that each of the new research councils should work with the government departments with which they had a significant policy connection in order to draw up and publish concordats. The Government also sought to increase cross-membership between the research councils and Higher Education Funding Councils (HEFCs) through the establishment of the new Science and Engineering Base Co-ordinating Committee (SEBCC) to be chaired by the Chief Scientific Adviser. This was viewed as essential given that responsibility for the research councils now resided with the OST whilst the HEFCs remained under the control of the DES[21]. This committee could, as necessary, refer issues to the ministerial and official committees on S&T.

The common factor in all these changes was the OST. Its role in preparing the *Forward Look*, its responsibility for the Technology Foresight Programme, its drawing up of concordats with other government departments

[21] It is interesting to note, however, the amount of criticism previously levelled at DES claiming that the two legs of the dual support system failed to talk to one another whilst residing in the same department for more than twenty years.

via the research councils, and its new responsibility for the LINK programme[22] meant that it would be taking an active role in bringing together Government initiatives. It was thought that its central position would also allow it to promote opportunities for collaboration between departments, identify areas of overlap or duplication, and encourage departments to develop relevant output measures and performance indicators to evaluate the success of programmes they commission. The extent to which it has actually done this is discussed below.

Reorganisation of the research councils

The White Paper was also to usher in the most far-reaching reorganisation of the research councils since the splitting up of DSIR in the 1960s. The government gave consideration to a number of options, from the creation of a single all-encompassing research council to the setting-up of separate funding bodies for curiosity-driven and mission-oriented research. It dismissed both of these, the first on the basis that such an overarching organisation might find it more difficult to be receptive to its multiple user communities than smaller organisations operating in distinct fields[23]. The idea of separate funding bodies for different types of research was dismissed on the grounds that the government did not want to run the risk of separating basic researchers from those concerned with application. Instead, it wished for the whole research effort to be brought into closer contact with potential users. It therefore favoured research councils which would be able to identify areas for cross-fertilisation and integration along the continuum of basic, strategic and applied research.

The boundary changes that were enacted are covered in detail elsewhere in this volume (Chapter 5) so only a brief summary is given here. SERC and AFRC were replaced by a Biological Sciences and Biotechnology Research Council (BBSRC), a Particle Physics and Astronomy Research Council (PPARC), and an Engineering and Physical Sciences Research Council (EPSRC). The ESRC, NERC, and MRC were to remain largely unchanged. As well as formulating mission statements which would take account of the needs of user communities, each Research Council was expected to appoint a part-time Chairman and a full-time Chief Executive and Deputy Chairman. The Chairmen were to be selected with a view to securing representation for the 'users' of research, as well as bringing in relevant experience from the industrial and commercial sectors most closely related to the council's missions.

As regards the governance of the research councils, the Government reaffirmed its commitment to the Haldane principle in that day-to-day decisions on the scientific merits of different strategies, programmes and projects should be taken by the research councils, without government involvement. However, the White Paper also pointed out that a preceding level of broad priority-setting between general classes of activity should exist, where a range of criteria must be brought to bear, as well as a need for a mechanism to co-ordinate research council activities. This task had been carried out

[22] LINK, the UK's main programme for supporting collaboration between industry and academia, had been previously administered by the DTI (see Chapter 3)

[23] In fact, it was the level of this distinction that led to calls for a single research council, since the boundaries between the existing Councils often seemed to be somewhat artificial and to discourage interdisciplinary research.

previously by the ABRC, but the White Paper now gave notice of the government's intent to abolish the ABRC and to bring this function into the OST, wherein a new Director-General of Research Councils (DGRC) was to be appointed. This individual would in turn be advised by a small standing group of independent experts selected to allow him or her to draw upon the requisite scientific, economic, industrial and management expertise in considering the baseline programmes, corporate plans, longer-term prospectuses, and performance of the research councils.

Other main points

The White Paper also set out further government intentions, which are only listed here since other chapters in this volume deal with these issues in greater detail:

- a commitment to the dual support system under which research is funded partly by grants for specific projects from research councils and partly via block funding of HEIs by the funding councils;
- a shake-up of post-graduate training, with PhD training better managed, and preferably underpinned by an MSc qualification;
- commitment to better develop links between defence and civil R&D;
- better co-ordination of the Government's negotiating position across the range of European and international S&T programmes;
- commitment to review the PSREs again, with privatisation the preferred option;
- a new campaign to improve the public understanding of science.

The move of the OST into DTI

To most observers, the move of the OST from the Cabinet Office (OPSS) into the DTI in 1995 came as a complete surprise. There had been no indication of the move prior to its announcement, nor any form of consultation in the wider community (nor within government it would seem). To make matters worse for the government, it was unable, in the first instance, to provide convincing arguments for the move. Later, however, the government pointed out that the 1993 White Paper had clearly set out the logic of such a move. This idea that the reorganisation was a well planned and natural development was carefully cultivated by government thereafter. At the centre of its justifications lay the need to implement, within industry, the priorities identified by the Technology Foresight Programme. It was argued that whilst the OST had done a magnificent job in delivering the main Foresight stages, the delivery mechanisms and demonstrator projects that would ingrain Foresight into industry and the country as a whole were key DTI competences which the OST lacked. Bringing OST into DTI would therefore bring Foresight closer to industry. Moreover, the reorganisation would help industry get better connected to science and engineering in general. However, in its attempts to placate a highly critical scientific community, the government promised that the OST would remain 'ring-fenced' within the DTI, inadvertently contradicting and thus calling into question the supposed benefits of reorganisation. It later emerged that the reorganisation was probably undertaken to adapt the OPSS to better suit the Prime Minister's plans for the incoming First Secretary of State and Deputy

Prime Minister, Michael Heseltine. It was this apparent overarching concern for administrative tidiness, which the government then struggled to present as a well thought-through reorganisation, that was to so infuriate the scientific community.

It should be noted that there were further knock-on effects as a result of the reorganisation. Significantly, S&T was again without a Cabinet level minister with day-to-day responsibility, with the President of the Board of Trade (the minister responsible for the DTI) becoming the Cabinet spokesperson for S&T along with his other ministerial responsibilities. A junior minister within the DTI was appointed to take care of day-to-day S&T matters, including the OST. This move, in particular, was seen by the scientific community as a demotion of the importance of S&T by the Government. The other major development was the absorption of the ministerial Committee on Science and Technology (EDS) into the ministerial Committee on Competitiveness (EDC), similarly interpreted by the scientific community as making science subservient to industry. The Chief Scientific Advisor was to be invited to attend the meetings of this new committee, thus retaining his ability to access Cabinet Ministers and ultimately the Prime Minister at his own discretion. His chairing of, or participation in, other relevant committees of officials was to continue unaffected - something seen as important in maintaining the trans-departmental overview envisaged in the White Paper. Similarly, the DGRC would be unaffected by the reorganisation. Finally - after much concern had been expressed by the scientific community - it was announced the House of Commons Science and Technology Select Committee, which had been created at the same time as OST, was to be retained. This constituted a significant break with convention, since Commons committees normally reflect the organisation of government departments. With the OST now a part of DTI, it was unusual for the committee to remain in existence, rather than have its remit transferred to the Trade and Industry Select Committee.

The reorganisation sparked an early assessment by some commentators of the OST's successes and failures in light of the ambitions set out for it in the White Paper. In particular, its capacity to set overall priorities for government R&D spending was questioned, with its potential as a co-ordinating body coming under critical scrutiny. There seemed to be general agreement that the OST had been unsuccessful in developing the relationships across government departments that were required for any sort of co-ordination along the lines of national strategic priorities to be enacted. The fear expressed in the scientific press was that since the direct influence of OST extended only as far as the research councils, it was tending to tinker with the 'wrong bits' for lack of influence elsewhere (the implication being that the 'right bits' were located in industry). Much of the blame for this lack of influence was, ironically, put on the DTI. The House of Lords had been reassured by government ministers, in 1992, that the OST and the DTI would work closely together, despite the intentions of the Chancellor of the Duchy of Lancaster for the OST to nurture its own links with industry. However, it would seem that the DTI persistently failed to co-ordinate its plans with the new department, and even abolished its chief scientist position, thereby leaving limited scope for the OST's Chief Scientific Advisor to liaise with the DTI and to realise his co-ordinating role. Furthermore, the DTI's spend on R&D also plummeted quite dramatically during this period, as it chose instead to give higher priority to accessing and exploiting existing technology, rather than developing new technology. The net result was that the

DTI's activities now concentrated more on influencing the broad environment which would allow innovative firms to flourish, and less on the explicit development of technology.

The extent to which the OST's relationship with other government departments has flourished, for example, through the LINK programme, the *Forward Look*, Technology Foresight, and research council-Departmental Concordats, is unclear. There were certainly criticisms of the *Forward Look* by the House of Commons Select Committee on Science and Technology in this respect. The impact of the Technology Foresight Programme has been widely scrutinised, although not systematically. The research councils appear, at first sight, to have substantially re-oriented their strategies in light of the findings of Foresight. However, much of this apparent re-orientation might have occurred in any case and some of it represents nothing more than re-labelling with the Foresight 'badge'. Critics of Foresight suggest that the process really has influence only within the spending jurisdiction of OST. This argument is supported by the relatively weak uptake of Foresight findings by other government departments, despite the existence of a cross-departmental Whitehall Foresight Group and a requirement that all departments report their Foresight-related activities in the annual *Forward Look*.

Despite all this, it could be argued that OST had failed to fulfil expectations only because it had been given insufficient time to realise its potential. Nevertheless, as we have already seen, there were a variety of potential barriers to the realisation of the goals set for OST. Many had seen its location in the Cabinet Office as essential if the new department was to have any influence across government departments. How the OST's co-ordinating role is likely to evolve within the DTI remains uncertain.

The 1997 election and beyond

On May 1st 1997, the Labour Party returned to power after 18 years in opposition with an enormous majority and an apparently strong mandate for change. Though science had, as usual, played virtually no role in the campaign[24], 'New Labour' and Tony Blair had made much of the importance of education for the state of the nation, and of the role technology, particularly the new information and communications technologies, might play in improving educational standards and thus competitiveness. Many in the scientific community relished the idea of a change in regime, aware that Labour had consistently and vocally opposed many of the major changes of recent years, not least the privatisation of public sector laboratories and the move of the OST to DTI.

Despite Labour's previous criticism of the move, OST remains within DTI. Following the election the new government announced a comprehensive spending and policy review, covering OST and all science and technology policy matters, and starting from the assumption that nothing is sacred (save the basic principle that the government will continue to support basic science).

[24] A minor exception being the promise of a National Endowment for Science, Technology and the Arts (see Chapter 3). As far as S&T are concerned, NESTA would not support any project for which likely funding mechanisms already exist. This appears to rule out most basic research but would leave open the possibility of funding 'public understanding' and science communication work, as well as more applied projects which could demonstrate their inability to gain funding elsewhere (*Research Fortnight,* 9 July 1997). Since the election, public pronouncements about NESTA seem to have concentrated largely on the Arts.

Margaret Beckett, trained as a scientist herself, became President of the Board of Trade, and was explicitly identified as the cabinet minister responsible for science. In day to day charge of science and technology matters is John Battle, appointed at Minister of State level, rather than junior minister as under the previous administration - which could be interpreted as a promotion for science in government. However, Battle's responsibilities extend beyond those of his Conservative predecessor to include energy matters.

The incoming government inherited an economic recovery - and yet another apparent crisis in science. Concerns about imbalances in the dual support system had been growing for some time. A high profile survey of the research equipment stock of UK universities commissioned by CVCP and the funding councils had concluded that *at least* £474 million investment in equipment was required to make good the deteriorating research infrastructure (PREST/CASR, 1996). Other reports produced similar estimates of the 'research funding gap'. The Parliamentary Office of Science and Technology, investigating the strains under which dual support was now operating, produced a set of policy options which in many ways presaged those of Sir Ron Dearing's National Committee of Inquiry into Higher Education, set up to deal with the whole question of higher education funding by the Conservative government.

The cumulative effect of all this scrutiny has been to promote the widespread acceptance that the current research funding system operates in such a way as to encourage the conduct of more research in universities than can be supported by the resources available. Amongst a whole raft of recommendations on the future of the higher education sector and its funding, the Dearing Committee (see Chapter 5) stressed that research council grants should meet the full indirect costs of research, preferably through the provision of extra resources, but alternatively via a transfer of resources from the research budgets of the funding councils, or through a reduction in the overall volume of research conducted.

Trends and issues

In this section, recent institutional and policy changes are examined in some detail. This discussion will be informed not only by what appear to be the most salient issues that face science policy today, but also by the earlier account of the trends and issues underlying the evolution of science policies and structures.

Continuity and change

Many of the patterns (and mechanisms) for government support of science set in the first part of this century have persisted, shaping the direction and pace of developments right up to the present time. The emergence of a devolved science policy machinery, with only loose central co-ordination, can itself be seen in the context of the broader evolution of administrative structures within the UK. Thus, the lack of a strong, central planning body can be attributed to the functional organisation of government along departmental lines (Gummett, 1980). The co-ordinating role of the Lord President or Lord Privy Seal (from the time of the first World War until the early 1960s) bears some resemblance to the co-ordinating role of the Chancellor of the Duchy of Lancaster from 1992 until 1995. It is no coincidence that the Privy Council and Cabinet Office were seen as the natural home for the co-ordination aspects of science policy both in the first and in the last part of this century: both were seen as somehow 'outside' and 'above' the functional organisation of government along departmental lines, with the latter responsible for an overview of the Civil Service. The two major departures from this pattern occurred in 1964, with the creation of the DES and Mintech, and in 1995, with the move of the OST into the DTI.

The central theme in terms of the machinery of government is thus one of gradual change and evolution, with largely incremental developments occurring in response to the particular pressures of the day, or to criticisms from parliamentary select committees concerned with strengthening the co-ordination mechanisms[25]. One measure of how persistent some patterns are in British science policy is the continuing proportion of government R&D expenditure accounted for by defence (see Chapter 8). An explicit policy objective of the 1964 Wilson government was to reduce this proportion in favour of civil applications. As Figure 2.1 shows, this attempt was only partially successful. In today's post-Cold War world, defence R&D spending remains high, though the rhetoric of defence research policy has certainly changed[26].

Figure 2.1

At the other end of the R&D spectrum is the basic research funded via the research councils. To a certain extent, the expensive sciences of the 1960s remain the expensive sciences of the 1990s, despite the rhetoric surrounding strategic, industrially-relevant research in the 1980s and 1990s. Nuclear physics and astronomy are still contentious because of the high costs of research in those fields, although Figure 2.2 shows that the proportion of research council funding directed to nuclear physics and astronomy declined markedly over the period 1977-1990, whilst support for engineering research in particular increased. Further, it would be nonsense to pretend that the basic research funded by the research councils over the last fifteen years had escaped the policy makers' drive for greater relevance and appropriability. Some 50 per cent of the research budget of the EPSRC, for instance, is now spent through managed programmes as opposed to the responsive mode[27].

Figure 2.2

[25] An observation which might be made in regard to the British system concerns the way in which policy choices made, presumably, to deal with problems and circumstances prevailing at the time, so often seem to subsequently become enshrined as inviolable and eternally-binding 'principles' - the key recommendations of the Haldane and Rothschild reports spring readily to mind.

[26] Though some commentators predicted a decrease in defence R&D expenditures following the end of the Cold War, others have argued that research spending must remain high, not least to counter falls in the overall levels of defence expenditure. Increasingly important in debates on defence technology policy are the concepts of 'spin-off' and 'dual-use' technologies, partly used to justify continuing high research expenditures (see Chapter 8).

[27] The term 'responsive mode' refers to the funding of unsolicited research proposals, rated on the basis of their scientific excellence as measured by peer review.

Whilst the mechanisms for government support of science have seen relative continuity, the discourse of science policy has, unsurprisingly, seen greater change. Attempts to identify different 'periods' of science policy have already been discussed, as have some of the attributes of the current period, which emerged in the late 1970s and which is probably best described as one characterised by a concern with 'innovation policy'. To recall, the current era is marked by relative resource contraction, academic-industrial collaboration, the growing internationalisation of science, a concentration on generic technologies such as IT and biotechnology (which, in turn, have encouraged the rise of interdisciplinary research), the increasing use of evaluation (reflecting an interest in value for money as well as research quality), and the privatisation of government laboratories. The massification of higher education in the last ten years or so can also be added to this list, with university student numbers almost doubling over this time.

Pressures on the system

If anything, the aforementioned features have become even more pronounced in the 1990s than in the 1980s. The tensions in the research system, it might be argued, are the by-product of trying to adapt a set of institutions, policies and practices largely designed in the first half of this century to meet a series of different cultural and economic goals, including: the growth of knowledge for its own sake; the practice of research as an integral part of a high quality system of higher education; and the exploitation of science a source of opportunities for wealth creation - at once[28]. In the words of Gibbons *et al* (1994, p159), the goals of science policy 'have been broadened without questioning the fundamental presuppositions it entertained from the beginning'.

Identifying the ultimate goals of national research policy is important because without any consensus about what they should be, it becomes impossible to answer the key question: how much science should we do as a nation, and how much do we need to do?[29] British science, as Sir Robert May has recently shown[30], may well account for a higher proportion of world science (as measured by publication rates) than might be expected from population or resources expended. Yet what is the explanation for the 'efficiency' in the production of knowledge which May identifies in the British system? He ascribes it to the fact that research is largely conducted in universities rather than in specialised research institutes or academies. Critics suggest that the strong position of British science today is the legacy of past investment and past successes, and is no guarantee of future success. The above-average performance (for a given investment) in science demonstrated by these bibliometrics and the research infrastructure and funding deficit highlighted by the CVCP and other bodies may be thought of as two sides of the same coin, the result of the operation of a decentralised system of 'dual support' which has

[28] The support of government policy and improvements in quality of life also feature as lesser explicit policy goals.

[29] The obvious corollary to this question is: How many scientists do we need? The journalist Simon Jenkins has argued for some time that the long-standing efforts to encourage British youngsters to study science subjects constitute a largely wasted effort. See, for instance, Jenkins' column in *The Times* of 16 August 1997, entitled 'Power to the Pupils'.

[30] May (1997) uses bibliometric analysis of UK papers and citations thereof to demonstrate the strength of the British science base.

tended to encourage HEIs to do too much research for the overall resources available.

The most common response to this crisis is to seek further concentration of, and selectivity in, funding, and to call for still more intense prioritisation. However, the research system in which all these problems have developed is already a markedly concentrated, selective one. In 1995-6, the five biggest universities by research income received 25 per cent of the total spent in *all* (over one hundred) UK universities. The top 15 received approximately half of all funding (*Research Fortnight*, 25 June 1997). These patterns are broadly repeated in expenditures on research equipment (PREST/CASR, 1996). The regular Research Assessment Exercises conducted by the HEFCs are intended to bring about further concentration of resources in the top-rated departments, by assigning to them the bulk of the research funding provided by the councils (see Chapter 5).

Essential elements for prioritisation

As already said, calls for prioritisation have been driven largely by concerns over resources and an ever-growing scientific enterprise. We would argue that at least three elements are essential if prioritisation is to be pursued:

1) An overview of the research already being funded is essential. The OST has undertaken this activity of late (through the *Forward Look*) although such efforts go as far back as the 1960s.
2) Priorities need to be shaped. Ideally, this activity should at least have the appearance of being informed by independent advice. In recent times, this advice had been provided by ABRC and ACOST. After publication of the 1993 White Paper, however, ABRC was replaced by a new Director General of the Research Councils, whilst ACOST was succeeded by the CST, chaired by the minister for science, or, in his absence, by the Chief Scientific Adviser. At the time of writing, little is known of the workings of the CST as its advice to government has never been published and it has yet to provide any public output besides some evidence to the Dearing Committee. We can only speculate as to why this should be, but it may be that the CST has had even less impact than ACOST on the shaping of publicly-funded science and technology[31]. This is not to suggest that government has been without any independent advice in shaping its priorities: one of the explicit aims of the Technology Foresight Programme was to aid government in setting priorities for the public sector science base.
3) There needs to be an ability to influence the overall spend, an ability which has been called, euphemistically, co-ordination. However, we must be clear about the scope of co-ordination: for instance, are such efforts to include the whole of the government spend on R&D? This would seem to have been implied by the 1993 White Paper. However this has proved difficult in practice because of the functional organisation of government, whereby departments have responsibility for R&D which serves their function. To

[31] Some suggest that the CST is more influential than its predecessors precisely because all its advice is given in secret, with no temptation to dilute its recommendations for public consumption. Unfortunately the truth of such an assertion is difficult to verify. For its part, the National Committee of Inquiry into Higher Education reported that it had not been able to develop a satisfactory understanding of the workings of the CST, and proposed the establishment of an independent Advisory Council on national research policy (NCIHE, 1997, para. 11.105 and Recommendation 35).

what extent is their R&D spend influenced by any overall national priorities set by the OST? The answer is probably not much at all. Nevertheless, there are undoubtedly synergies to be found and probably benefits to be had from some co-ordination, for example, through collaboration. Thus, when speaking of the need for prioritisation in UK science and technology, policy makers often tend to be referring to that spend for which OST is directly responsible, primarily the research councils[32].

Priority-setting within the research councils

Through mechanisms of competitive bidding for funds, the research councils have had the ability to steer the direction in which research turns. At the same time, they have had to justify politically their existence, and have adopted a broad range of socio-economic selection criteria in order to do so. In addition, with a sizeable proportion of research council funding spent on 'managed' programmes, the impact of the scientific community's own priority-setting mechanism, peer review, has been somewhat circumscribed[33]. These managed programmes tend to encourage interdisciplinarity and are largely shaped and determined by a range of boards and committees within each council, the details of which will not be entered into here. Critics argue that such programmes encourage selectivity and concentration, features which are ultimately damaging to the maintenance of variety and flexibility within the research system. These attributes are generally thought to be virtuous since they provide the potential for new disciplines and new research centres to emerge. There are, of course, counter arguments: for instance, a system based on peer review alone can be conservative in the proposals it recommends given the largely disciplinary framework within which the process operates. Thus peer review could potentially stifle variety[34], whilst a case could be made that managed, interdisciplinary programmes offer at least the possibility of generating 'new combinations'.

Who decides?

In truth, the debate centres on who is best placed to decide on priorities: the scientists themselves, the government, or perhaps some other third party? Despite apocalyptic warnings from scientists about the dangers of trying to direct research, much control over agenda-setting remains within the research community. Government also continues to play an important role, not least as a result of the Rothschild principle. As for other parties influencing the process, the most favoured group has been industry, particularly as each research council now has a part-time industrial chairperson, along with identified user groups whose opinions and needs must be taken into account. These changes were ushered in as a result of the 1993 White Paper, a document which explicitly sought to strengthen the role of industry in the formulation of science

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[32] The HEFCs might also be included in such considerations, although these are managed by the successor to DES, the Department for Education and Employment (DfEE).

[33] It should be noted that even within managed programmes, peer review still operates, but within a framework of directed calls for proposals.

[34] Windrum and Birchenall (1997) use simulation techniques to explore the effects of the peer review system, which can be regarded as a selection process, on the evolution of scientific disciplines. Their results suggest that 'credibility-driven' peer review itself results in the progressive concentration of resources in the hands of elite groups of researchers. Selectivity results from the 'normal' operation of the research system.

and technology policy, and were further augmented by the Technology Foresight Programme, a process in which industry played a significant part, and whose findings were incorporated into research council strategy making. It should also be noted that many major research programmes require that industry provides matching funds to public monies, which provides a further route by which industry can influence the direction of research.

Industry setting the agenda?

Some critics foresee problems with giving industry such a leading role: UK industry has traditionally been a poor investor in R&D, relying instead on methods such as rationalisation and take-overs in its drive for competitiveness. It is also widely held to have a short-term outlook, a situation ill-suited to a scientific enterprise characterised not only by its uncertainty and serendipity, but also by its long-term pay-back and indirect benefits. Is industry really best-placed 'to determine the appropriate mechanisms for setting priorities, both in terms of the areas of research to support and the level of funds to be committed to them', as advocated by the White Paper? Though successive governments have struggled to convince industry of the potential value of increased investments in R&D, they have largely failed. The DTI's annual *R&D Scoreboard* shows little sign of increase in the amount of R&D conducted by business throughout the 1990s[35]. However, whilst government has failed to nurture the diffusion of knowledge-based values into industrial society, knowledge-based communities have been thoroughly permeated by industrial values (Fuller, 1995). Finally, while industrial interests are playing a greater role than ever in setting spending priorities for the science base, it should be emphasised that industrial money itself still only accounts for a small proportion of the total spent on R&D by HEIs and research council facilities - about 6 per cent in 1995/96.

Economic returns from state-funded R&D

The 1993 White Paper argues that relevance and appropriability of research need not be in conflict with quality[36]. Whilst this might be true, this instrumental view of research has its critics, not least those from the innovation studies field. To recall our earlier historical account: from the early 1980s in particular, but also present from the 1960s, there has been a strong concern with ensuring that Britain gets the best return from its considerable investments in R&D. In the 1960s, this led to attempts to switch resources for R&D (and research capacity) from defence to civil applications, and to the creation of new structures and arrangements for organising government-funded and intramural research. In the 1980s and 1990s, the question of maximising the economic return from state funded R&D resurfaced, this time in the context of the emerging Thatcherite programme. Thus, the vocabulary of science policy debates began to change: 'science' became 'SET'[37], now more than ever seen as a resource to be 'exploited'. The chief aim of policy would

[35] Of course, it could be argued that British industry is more efficient in using the knowledge produced by R&D, with the result that it need not invest to the levels of international competitors - needless to say, few find this argument convincing
[36] Less than 40 per cent of 'alpha rated' (that is, judged excellent by peer review) proposals are now funded by the research councils, supposedly an indication of the ever-increasing quality of the proposals they receive.
[37] Science, engineering and technology.

henceforth be to better harness SET in the service of British business, with improvements in 'the quality of life' a subsidiary goal. Also, it was science that would have to adapt to this new situation, since the prevailing ideology ruled out any sort of coherent industrial policy. It is in some ways ironic that, as political pressure has continued to grow for the exploitation of the output of the research system, academic studies of the relationships between science, technology and the economy have concluded that the links are exceedingly complex and uncertain, with investment in R&D by no means leading to certain improvements in economic performance of firms or nations[38]. Some have taken this to imply that government should abandon its role as a funder of basic science (Kealey, 1996), though most, notably those from the innovation studies field, point to the invaluable indirect benefits of basic research, such as skills, tacit knowledge, and access to international networks of experts and information (e.g. Pavitt, 1991). In short, to view basic research as merely a source of codified, exploitable knowledge is not only simplistic, but misleading.

Other voices

There are, of course, 'third parties' playing significant parts in the system, and each of these have their own mechanisms and criteria for determining the research they choose to fund. For instance, the research charities are major players, particularly in the medical sciences, with the research spend of the Wellcome Trust now exceeding that of the MRC. In fact, the research charities, together with other private funders, accounted for 12 per cent of the R&D funds received by the HEIs and research council facilities during 1995/96. The European Union's Framework Programmes also account for some 5 per cent of the civil public R&D spend in the UK. These are of interest for several reasons: firstly, the European Commission has a quite different agenda for supporting R&D than the UK Government, most notably its drive for greater European integration and industrial competitiveness. Secondly, the projects funded by Brussels are invariably international collaborations, and often involve industrial partners. Finally, funding from the Framework Programmes is partially off-set by a decrease in government's spend on R&D through a complex system of attribution to departmental budgets (see Chapter 13). The origins of attribution can be traced back to the 1980s, a time of ministerial concern over the growth of the EC budget, including likely R&D expenditures. As this growth would have to be funded by the Member States, it would place further pressure on resources. As Georghiou *et al* explain, '[I]n order to accommodate this expenditure within public expenditure totals, and recognising that some of the activity was likely to substitute for work previously done at national level, the decision was made to attribute programmes to the relevant [government] departments' (1993, p71).

Ironically, taken together with the Government's efforts at devolving agenda-setting through the use of Foresight and collaborative research programmes, these features suggest that government has left itself less and less scope to steer the system, irrespective of whether steering is felt to be

[38] Government itself can hardly be unaware of the emergence of this strong consensus, and it is an indication of the effectiveness of current mechanisms for co-ordination of research funding that no less than three government departments have, between 1993 and 1996, commissioned separate reports into the relationships between R&D and economic growth (these being OST/PREST, 1993, commissioned by OST: Martin and Salter *et al*, 1996, commissioned by HM Treasury; and Swann, 1996, commissioned by DTI).

desirable or not[39]. Yet, this devolved control over research agendas remains largely the preserve of those groups that can afford to fund science themselves - industry, the European Union, and the healthcare charities. Other societal groups, such as environmental or consumer organisations, tend to be without a voice in the formulation of science policy. Even within the mass consultation exercises that were to inform the Technology Foresight Programme, there was very little scope for such organisations to be heard.

Concluding remarks

According to groups like *Save British Science,* British science is in an ever-worsening state of crisis. This is certainly the case if you rely on Nobel prizes as performance indicators[40]. Yet according to others, notably the current chief scientific advisor Sir Robert May, it is 'punching above its weight'. Williams (1988) questions the degree to which there was any real evidence of a decline in British science into the 1980s, although recognising the periodic concerns over 'brain drains' which had occurred since the 1960s. Similarly, Edgerton (1996a) argues that the proponents of UK scientific and technological decline generally neglect to recognise the relative nature of 'decline' - an inevitable consequence of a world in which nations industrialise at different times and different rates.

Yet, it would be wrong to pretend that the scientific enterprise has escaped the economic straitjacket of the 1980s and 1990s, with the universities particularly hard-hit. At the same time, leading-edge science has become more expensive to conduct. As we have discussed, the structural imbalances that have resulted, exemplified by an unsustainable 'research gap' in the universities, are in urgent need of redress. If the answer lies in carrying out less research, the pressures for further concentration and prioritisation will clearly be immense.

The other commonly proposed solution to these problems, prioritisation, has been on science policy agendas since the 1960s. It is difficult to argue against broadening the selection mechanisms through which research paths are chosen beyond questions of scientific excellence and the competence of the applicant to include economic and other criteria, given the huge amounts of public funding injected into research. Similarly it is difficult to raise convincing arguments against increased accountability. The real issues are not about whether prioritisation should occur, but rather about who gets to influence the agenda - scientists, politicians, users? Who are the 'users' of publicly-funded research in any case? In the UK the term has thus far been used in a rather restricted sense to mean industry, rather than to enfranchise wider social groups.

What is clear is that the policy landscape has been transformed of late by the idea of 'strategic' decision-making in science and technology, both by

[39] Policy innovations such as CEST and later Technology Foresight explicitly involve the 'privatisation' of some or other aspect of science policy formulation. Added to this trend must be the increasing use of outside consultants for policy assessment and evaluation of research programmes.

[40] Newspaper cuttings libraries hold mountains of press reports analysing Britain's performance in the Nobel prize awards. For instance: Robin McKie and Matthew Kalman's demonstration of the failure of the nation to produce 'world-class winning science': 'We're a flop in the Nobel Olympics, too', *The Observer*, 11 August 1996.

government and, to some extent, industry. In fact, some policy analysts have coined the term 'strategic turn' to characterise recent changes in the research system (Cozzens *et al*, 1990). As we have seen, Gibbons *et al* (1994) have suggested the current period is characterised by 'policy for technological innovation', with government ending support for all near-market research, preferring instead to promote an innovation environment, with network development between the various 'poles' of the research system becoming a policy aim in itself. The Technology Foresight Programme is the latest manifestation of this trend but with the added feature that it explicitly sets out to identify emerging key technologies which could figure in the UK's future prosperity. It is recognised that these technologies will be shaped by a number of factors, including research, markets, the fiscal climate, and regulation, which will all have to be re-examined to some extent in light of Foresight's findings. This process is currently ongoing, although with mixed results (Georghiou *et al*, 1998). The net effect of all this has been to blur the distinctions between different categories of research financed by government - how is it possible to differentiate basic, curiosity-driven research and research which is still 'basic' but which is also 'strategic'? Such concerns might be dismissed as unimportant: as long as the science is carried out, why should we be worried about the labels attached to it? In truth though, the allocation and use of these labels is highly political.

On a more practical note, Gibbons *et al* (1994, p159) emphasise that the key issue concerns the contribution to economic performance that can be realistically expected from disciplinary-based sciences, performed largely in universities, and still driven largely by internal, scientific considerations. Should it be any surprise to find a 'national system of research' developed to meet the training and research needs of an earlier time sometimes struggling to meet the often contradictory requirements placed upon it today? The relative permanence of so many features of the British S&T system - the structural bias towards defence, for example - might testify to the difficulty of steering that system onto another course.

This is not to make a simple-minded case for wholesale change, though the extent to which we can continue to tinker with the system must be questionable. We believe that several important issues must be addressed if long-term solutions are to be found: First, a better understanding of the operation of the research system and its many and complex feedback loops is desperately needed, so as to better predict the systemic effects of change[41]. Second, far more must be known about what 'returns' can realistically be expected from the investment in science. Only armed with this knowledge can society confront the political questions of exactly what it wants from its science and scientists, and, just as importantly, who it trusts to control and direct the whole process of knowledge production.

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[41] Leading academics from the research evaluation field have recently called for greater consideration of systemic features in attempting to understand the interaction between policies and the net effects of intervention (for example, see Georghiou, 1997).

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Coda: The United Kingdom technology foresight programme

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Aims

The Technology Foresight Programme (the 'Programme') was announced in the Government's 1993 SET White Paper '*Realising Our Potential*.' The context of the Programme was the harnessing of science and technology to promote wealth creation and quality of life. Thus, within this context, the broad aims of the Programme were:

- to forge a new working partnership between scientists and industrialists who were able to assess emerging market opportunities and technological trends;
- to inform decisions on the balance and direction of publicly funded science and technology.

Preliminary studies

Prior to publication of the SET White Paper, exploratory studies were undertaken to prepare the ground for the Foresight Programme. One study reviewed recent experience of the use of Foresight in other countries. The long-running sequence of Delphi-based[42] forecasts in Japan and the more recent German version of the exercise, relied upon responses from a balanced cross-section of experts representing the industrial, academic and government communities. Critical reviews of some panel based exercises in the US, without this element of wide consultation, suggested that the credibility of the outcome was related to the demonstrable independence of the participants. Also, a pilot study reviewed and tested potential approaches; from this study it emerged that a degree of scepticism existed in the UK similar to that found in the US. However, the message from the pilot study was that the Programme should cast its net beyond the then current sources of advice to government.

Preparatory stage

One of the earliest decisions taken was to base the Programme on the use of both expert panels and widespread consultation, based on a national Delphi survey and on a limited number of workshops. To meet this need the relevant communities themselves identified those who should take part both as members of the panels and as 'respondents' to be consulted. An electoral process was not appropriate and instead a co-nomination process (see Nedeva *et al*, 1996) was adopted to identify potential panel members and a pool of respondents. The pilot survey had established that this could provide an

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[42] The Delphi technique is a process of widespread consultation designed to elicit expert opinion on a particular issues or range of issues, deriving its name from the location of the oracle of Apollo in ancient Greece. A suitable reference for further information is Linstone and Turoff (1975).

adequate response rate with answers of sufficient quality, and the decision was made to proceed with the co-nomination approach during the full Programme. Thus, the twofold objective of building a database of experts who could be consulted by the panels in the later stages of the programme and the identification key figures who would serve as panellists were both achieved. The patterns of nominations that emerged provided an indication of the networking in the 'expert' community at the start of the Programme.

While the prime purpose of the co-nomination method was to identify potential panel members and respondents, it was always expected that panellists would also be appointed through other routes, to ensure that key areas of expertise were covered. Final responsibility for Panel appointments lay with the Steering Group, who also identified Chairmen for the panels. About 60 per cent of the panellists were identified through the co-nomination process, while the remainder were drawn from professional registers; this was the starting point for the database used in the Delphi survey. Evidence suggests that those who entered the Programme via the co-nomination survey had a substantially higher propensity to respond to later surveys (including the Delphi), thus indicating the benefit of early involvement in the Programme.

The panel areas selected are shown in Table 2.1 and reflect the UK's industrial and commercial activities, with the intention of representing a meeting point for technological and market perspectives. Notable was the inclusion of three panels explicitly concerned with service sectors (Financial Services, Retail and Distribution and Learning and Leisure, which covered topics such as education technology and tourism).

Table 2.1

The mechanics of the Programme are illustrated in Figures 2.3, 2.4 and 2.5. In the preparatory stage the Steering Group was appointed, the main elements of the process were established and the panel members were appointed and taken through a training programme. Initial consultative seminars, held around the country, enabled the invited audiences to offer constructive criticism on the scope of the Programme. Partly as a result of these consultations, it was decided to make the Programme less technology-driven and more market-oriented than similar programmes had been in other countries. The option of simply making use of other countries' results was considered and rejected because it would fail to reflect issues of particular importance to the UK and would not capture the network benefits.

Figure 2.3

The main stage

In the Main Stage the panels were free to conduct their own research, but they were required to prepare the questions for the Delphi survey relevant to their sector. Typically the panels prepared scenarios for their areas, identified key issues and trends and consulted in unspecified ways with relevant communities (it was recognised from the outset that all the necessary expertise was unlikely to be accessible within panels of a manageable size).

The successful use of the Delphi approach elsewhere influenced its adoption for the Programme; support for this decision also came from the pilot study and from the consultative seminars held in the preparatory stage. Use of the questions from the Japanese Delphi Survey (the course adopted by Germany and France) was ruled out since the questions were considered to reflect the agenda of Japanese industry, and scientists, and would not necessarily correspond to the specific aims of the UK programme. In particular it was felt that this approach: 1) enabled a national effort to capture the benefits of forming new networks between the scientists and technologists in the public domain and industry; 2) reflected the greater emphasis placed, in the UK, on the market dimension and on quality of life, and 3) identified areas where the benefits would be appropriable by the UK.

The Delphi survey was conducted in the conventional way and had the specific objectives of:

- accessing the business and S&T communities' views on future developments in markets and technologies;
- assisting the achievement of commitment to results and consensus on developments; and,
- informing the wider business and S&T communities about the major issues being addressed in the Programme and how their peers assessed those issues.

The Delphi survey also aimed to involve large numbers of experts who would otherwise be excluded from the Programme thus widening the constituency of participants who had a feeling of ownership of the results and with a consequent commitment to their implementation. Receipt of the questionnaires also gave the respondents early feedback on the topics deemed to be of interest by their peers on the panels. The second iteration of the survey extended this feedback by providing early access to the views of all respondents on these topics. Experts were then able to benchmark and revise their own views. In parallel exercises most panels held a series of regional workshops that enabled face-to-face discussion of the questions listed in the relevant Delphi questionnaire. Two criteria governed the selection of the target population to be sent each panel questionnaire. First, that there should be sufficient expertise to answer the questions posed, and second, that there should be a reasonable balance of sources of respondents between industry and academia, and between regions.

Figure 2.4

The formulation of the questions included in the Delphi survey represented an early output from the panels' deliberations. Initially the sector panels concentrated on identifying the areas of principal interest in the light of their remit. In this they were assisted by a postal survey, targeted at 50 to 80 respondents per panel, which requested respondents to follow a 'logic chain,' of linked questions designed to identify:

- trends or issues and their driving causes, which respondents believed might influence the sector up to 2015;
- possible new market opportunities arising from trends or issues and driving causes;
- possible new products, processes and/or services to meet the needs of some of the market opportunities;
- technologies, breakthroughs, scientific advances or innovations needed to underpin products, processes or services.

Any Delphi question must be a concise expression of the event, achievements or other phenomenon upon which views are sought. In as few words as possible, an unambiguous expression of the event the questioner has in mind must be achieved, incorporating any key conditions, but excluding separate issues that warrant one or more additional topics. Opinion on the expected time of occurrence of each question necessitates an indication of the state of development. For example, the time of occurrence of a laboratory phenomenon is almost certainly well in advance of the first practical application and a further substantial delay may occur before the innovation is widely diffused. To assist this, standard terms have evolved in most foresight programmes. Typically each Delphi questionnaire contained 80 questions.

At the end of the Main Stage (Figure 2.4), after undertaking a synthesis of the evidence gathered from the Delphi surveys, regional workshops and other sources of consultation, each panel produced a report covering its own area; these reports formed the main input to the Steering Group, which was responsible for synthesising these findings and identifying national priorities across all areas. The Steering Group's report presented these priorities and distilled out recommendations for use later in the implementation. The results of the Delphi surveys were also collated and published as a separate report (Loveridge, *et al*, 1995).

Outcomes

Following a period of heightened speculation and anticipation, not to mention a considerable degree of pre-publication publicity from the Office of Science and Technology, the Technology Foresight Programme Steering Group Report, *Progress Through Partnership*, was finally unveiled in May 1995. The Steering Group's report had been preceded by the publication of the reports from the fifteen sectoral panels, thus the large number of conclusions and recommendations drawn up by the panels was already known. However, the Steering Group synthesised these into a number of sectoral highlights and key recommendations. It then went on to outline a number of conclusions on generic priorities. These were divided into twenty-seven generic science and technology priorities and eighteen generic infrastructural priorities. A generic topic was defined as 'a concept, component, or process, or the further investigation of scientific phenomena, that has the potential to be applied to a broad range of products and processes'. The generic S&T priorities and their broad areas of concern are given in Box 2.1. The Steering Group also made a relative assessment of these priorities according to feasibility and attractiveness, resulting in a three-level categorisation of emerging areas, intermediate areas and key priority areas meriting urgent attention (Figure 2.6). The generic infrastructural priorities, identified as constraints and bottlenecks to longer term market objectives are shown in Box 2.2.

Box 2.1

Figure 2.6

Box 2.2

Finally, the report's recommendations focused on maintaining and developing the networks and panels, and broadening the sectoral coverage; taking forward the findings of Foresight, with specific recommendations for Goverment (particularly the OST), industry, the universities, the research councils; enhancing partnerships; and monitoring the outputs of Foresight. Implicit in these recommendations was the fact that the report represented only one of the first objectives of the Foresight Programme. The process was conceived to continue, and still does, with the ongoing operation of the Foresight Panels and networks and with government attention and action on the SET priorities identified. As noted at the time, the process of Foresight did not and does not attempt to make detailed predictions about specific events and developments in 10-20 years hence, rather it aims to attempt to understand ways in which the future may unfold in order to be better prepared for the longer term.

Implementation

Before the Panel Reports were published, it was decided by the OST that the sector Panels should be retained for the implementation phases of the programme. The logic behind this decision lay in the fact that these Panels had already engaged their communities, developing networks of contacts in the process, networks which would hopefully prove useful if the Programme was to have far-reaching effects. Shortly after the reports were published, Panel Chairmen bolstered the membership of their Panels to reflect the emphasis on dissemination rather than consultation. The general route followed was one of assigning individual Panellists to take forward key recommendations, although the Panels have been allowed greater autonomy than in the consultation phases in orchestrating their own activities.

At the same time as the decision was made that the Panels should be retained, the OST decided to set aside £40 million from the science budget to directly fund Foresight-related research. The funding was packaged as the Foresight Challenge competition, and was launched in late 1995. Bids were invited from academic-industrial consortia which proposed work reflecting Foresight recommendations. The bidding process was split into two competitive stages, with the first attracting more than 500 bids. Eventually, just over 60 consortia were invited to submit full bids in the second stage, of which 24 were successful, securing £30 million of public money against more than £60 million coming from the private sector. A second Challenge competition has since been launched in late 1997 in which the remaining £10 million of public money set aside will be spent.

Besides the modest, though high profile, projects funded through the Challenge competition, a number of LINK programmes are said to have been launched or enhanced to reflect Foresight priorities, amounting to more than £100 million. In fact, it is reported that around £700 million of research council spend is Foresight-related, although it should be pointed out that this figure does not refer to either Foresight-inspired or -enhanced spending; instead, it represents the amount of research council spend that 'maps' on to Foresight priorities.

Another dissemination instrument established by the OST was the Whitehall Foresight Group consisting of senior civil servants drawn from across the departments of government. These individuals were deemed to be departmental Foresight Action Managers and tasked to act as foci for all the Foresight-related initiatives within their respective departments. Their role was to review the recommendations from the Foresight Reports, to identify the further actions required, and to coordinate activities across departments. In its first year of operation, the Group has been judged to have not been very effective and it now has a ministerial equivalent shadowing its work, a reflection of the difficulties of implementing priorities *across* government departments. A more promising route for influencing the agendas of not only the departments, but also the research councils, has been to involve them at the Panel level. This has been done through encouraging these bodies to have their own representatives on the Panels, as well as through the efforts of individual Panellists pursuing the implementation of their recommendations.

In late 1996, the programme was reinvigorated with a renewed drive to interest the business community in the programme. A number of measures were taken, including the re-naming of the programme to simply 'Foresight': the rationale being that the term 'Technology' might be a turn-off for the Boardroom. Up until this time, much effort had been spent on trying to influence the agendas of the research councils and, to a lesser extent, government departments. It was recognised that the programme, chiefly through the Panels, had gone some way to engaging the business community, but only as far as the R&D function of firms in most cases. It was felt that if Foresight networks were to function more effectively and influence investment decisions, then a broader range of business participants, including marketing, business strategy, procurement, human resources, etc. would have to be engaged. Reflecting the diversity of target audiences, it has been left to the Panels to devise their own mechanisms for engaging business. As well as these efforts, the Foresight banner was used to 'brigade' a range of already existing government-funded, technology-related, business support schemes. Again, the intention is to promote wider business participation in Foresight.

To conclude, these activities can be said to represent considerable progress (see Figure 2.5 for an outline). However, the real effect of the Programme has yet to be evaluated. Some questions remain to be answered, particularly concerning the additionality of these activities, that is to say, which ones would have happened without the Foresight Programme. It is likely that a degree of re-labelling has taken place as those responsible for research and its management seek to get their schemes and activities endorsed by the Foresight label. Indeed, there is some evidence that the acknowledged success of Foresight has resulted in its use as a brand name to endorse aspects of technology policy which are some way removed from its original aims. There is also general consensus that the implementation of Foresight lost some momentum in the period immediately following the publication of the Steering Group Report. This coincided with a change of Chief Scientific Adviser, accompanied by a hiatus before the present incumbent took office. Furthermore, the OST was moved from the Cabinet Office to the Department of Trade and Industry during this period, another source of potential disruption.

Figure 2.5

References

Loveridge, D., Georghiou, L. and Nedeva, M. (1995) *UK Technology Foresight Programme: Delphi Survey* Report to Office of Science and Technology, September 1995.

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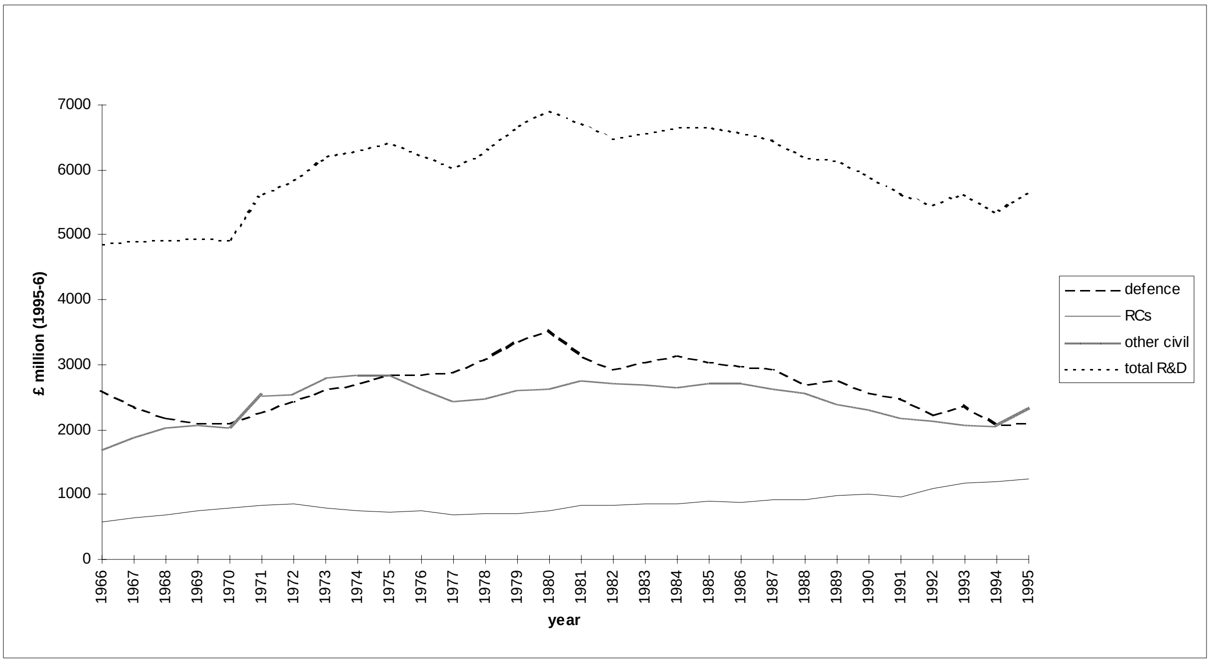
Linstone, H. and Turoff, M. (1975) *The Delphi Method: Techniques and Applications*, Addison-Wesley.

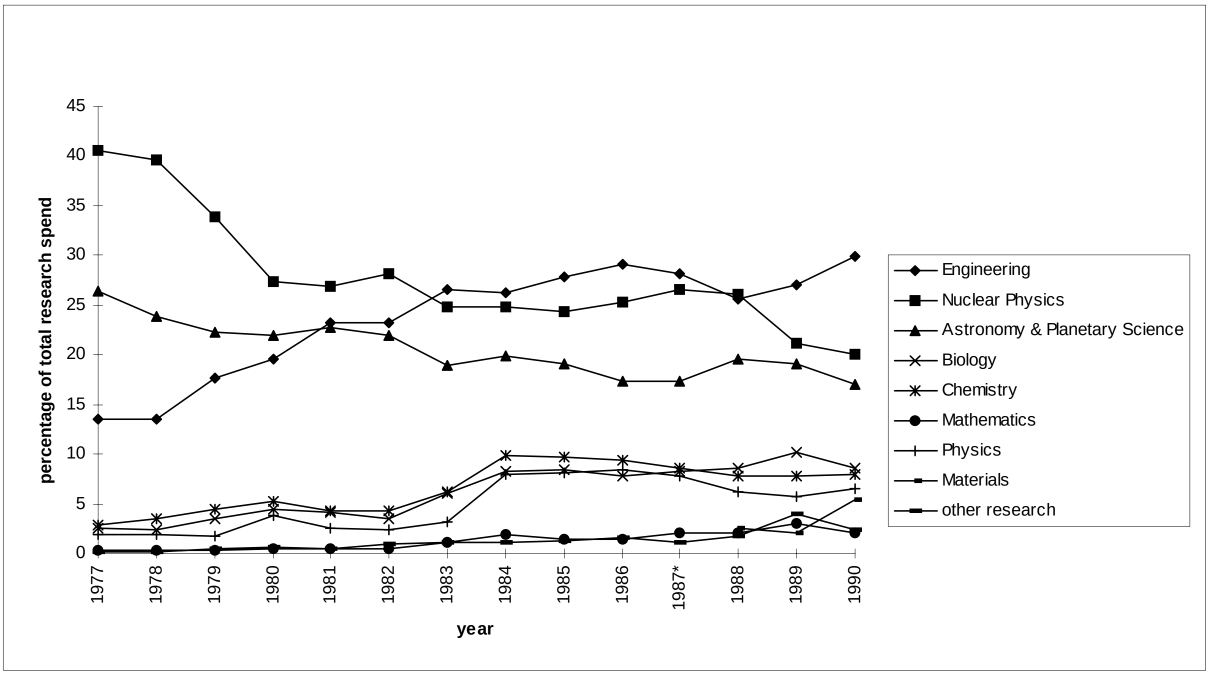
Figures and Tables

Figure 1: Trends in Government R&D Expenditure 1966-1995



Source: SET Statistics 1997

Figure 2.2: SERC funding breakdown 1977-1990



Source: Annual Reviews of Government-funded R&D

NB: a note of warning about changes in the way the data is presented in the Annual Reviews (i.e. data for 1977-83 appear to be calculated slightly differently for the individual disciplines to that from 1983 onwards. The broad trends still seem clear, however).

Figure 2.3. Preparatory phases of Foresight Programme

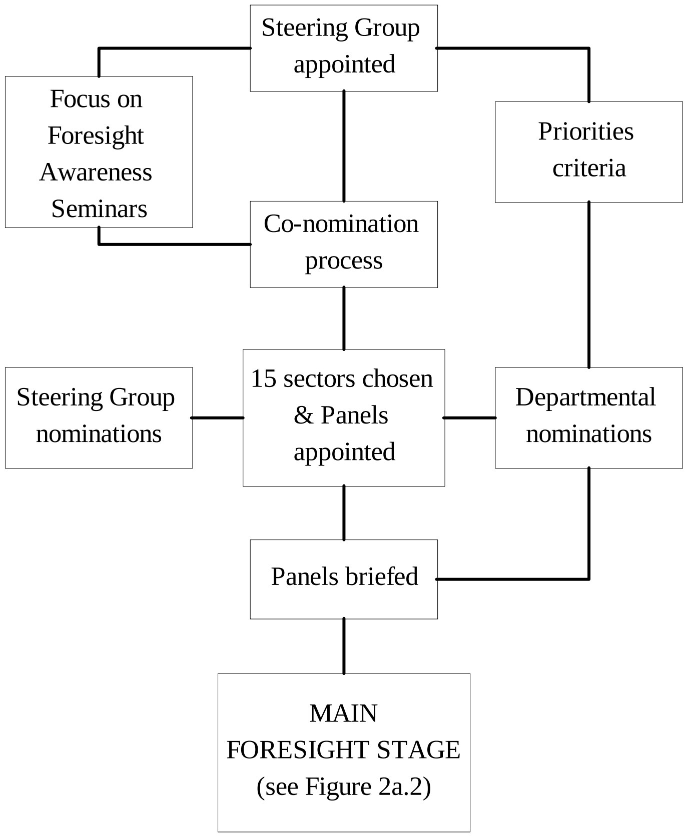


Figure 2.4. Main Foresight Programme stages.

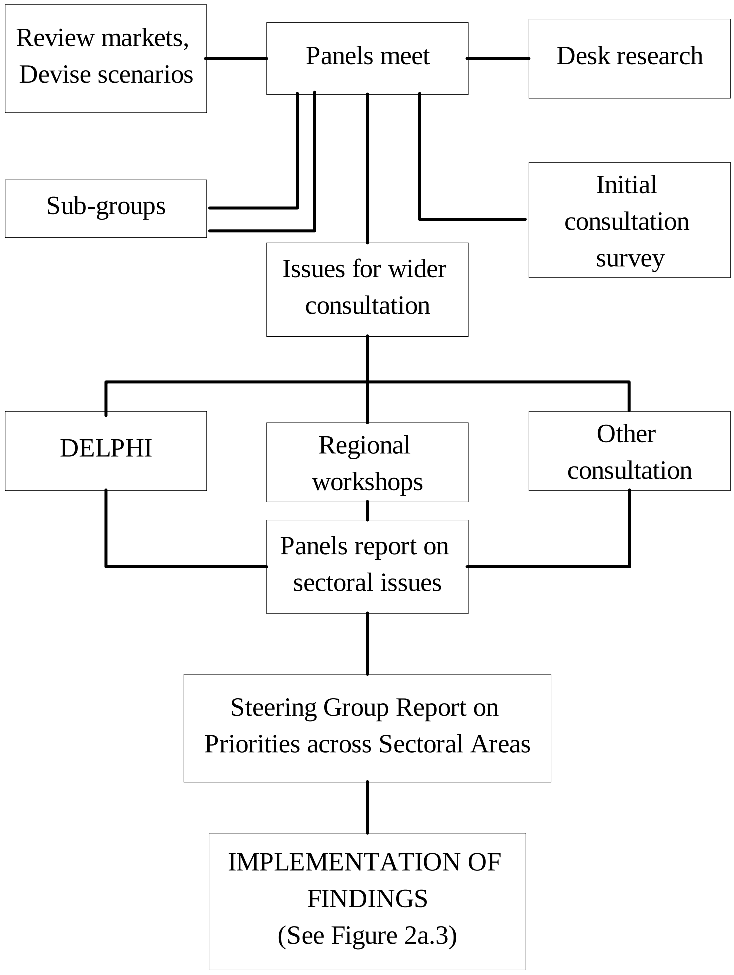


Figure 2.5. Implementation of Foresight findings

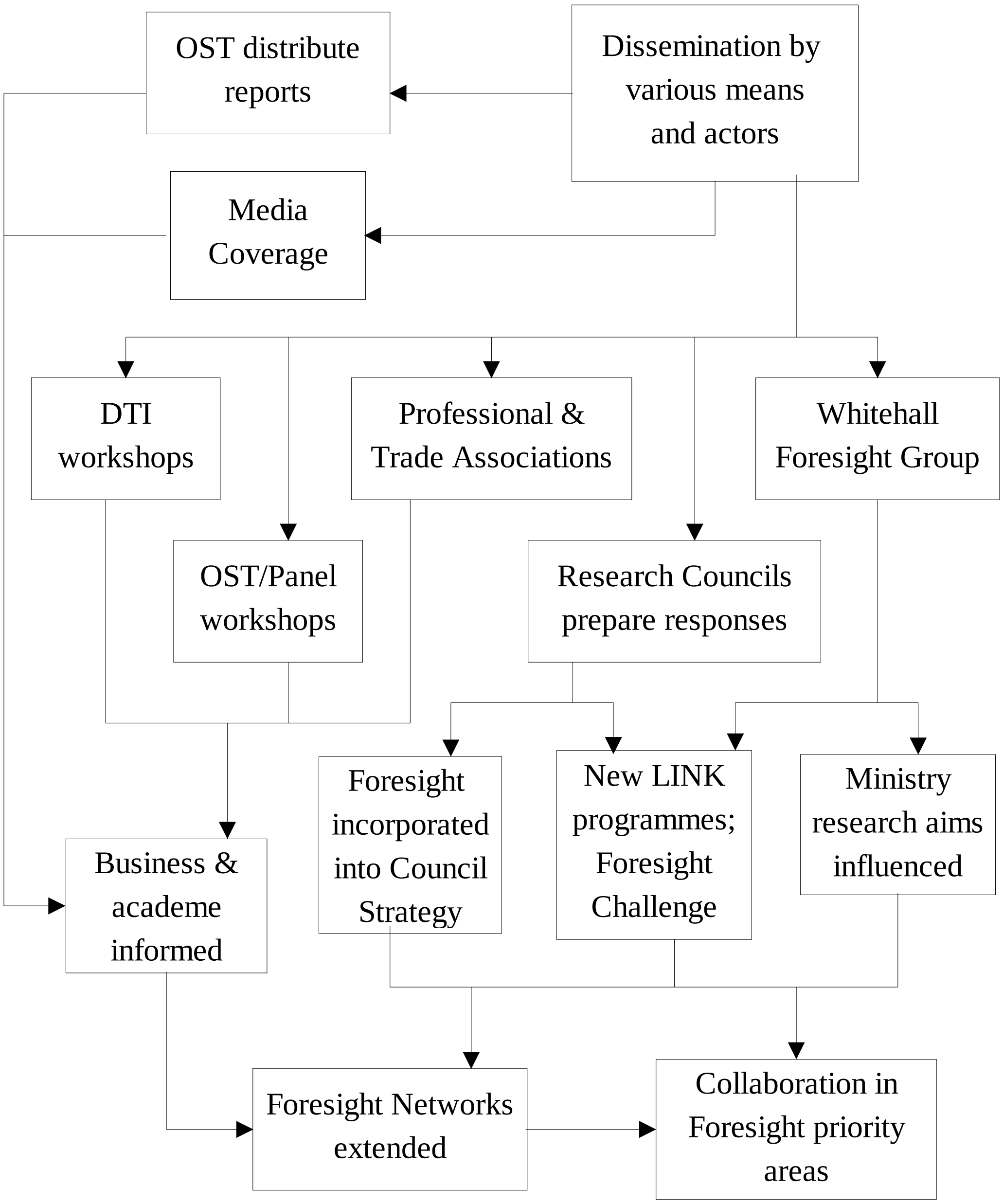
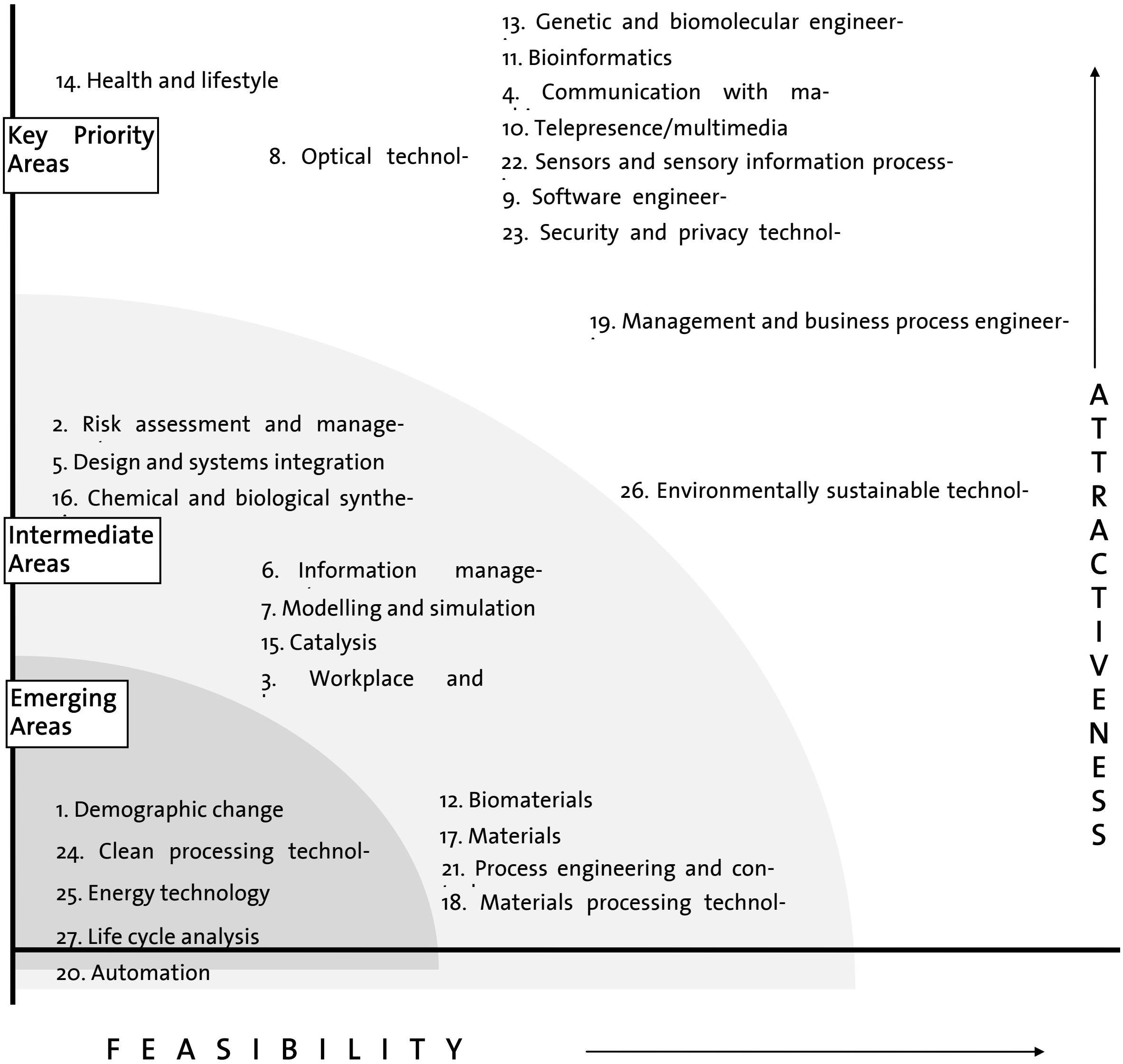


Figure 2.6 Generic priorities in science and technology - relative assessment of attractiveness and feasibility



Source: adapted from *Progress through Partnership* Report of the Technology Foresight Programme Steering Committee, 1995.

Table 2.1. Panels in the UK Technology Foresight Programme (1993-1995)

Construction	Health and Life Sciences
Chemicals	IT and Electronics
Communications	Learning and Leisure
Agriculture, Natural Resources & Environment	Manufacturing, Production & Business Processes
Defence and Aerospace	Materials
Energy	Retail and Distribution
Financial Services	Transport
Food and Drink	