Science, Technology and Broad Industrial Policy: the co-evolution of policies at national, regional and European level

FINAL REPORT

Prepared by

Margaret Sharp
(Project Co-ordinator)
SPRU, Science and Technology Policy Research
University of Sussex

November 2001

FINAL REPORT

***Contract number*:**	**SOE1-CT97-1053**
***Project Number*:**	**PL97 1059**
***Title*:**	**Science, Technology and Broad Industrial Policy: the co-evolution of policies at national, regional and European level**
***Project Co-ordinator*:**	**Margaret Sharp, SPRU, University of Sussex, UK**
***Partners*:**	**Jacques de Bandt, IDEFI/LATAPSES, France** **Michael Reinhard, ifo Institut, Germany** **Tom Higgins, CIRCA Group, Ireland** **Alfonso Gambardella, CESIT, Italy** **Jon Sigurdson, IJS, Stockholm School of Economics, Sweden**
***Reference period*:**	**from December 1999 to June 2000**
***Starting Date*:**	**December 1997**
***Duration*:**	**30 months**
***Date of issue of this report*:**	**November 2001**

Project financed within the TSER programme

Contents

Abstract – Science, Technology and Broad Industrial Policy

This project has sought to trace policy development towards science and technology within the framework of broad industrial policy across six countries – France, Germany, Italy, the UK, Sweden and Ireland – through the last quarter of the 20th Century. Its aim has been to examine the inter-relationships (co-evolution) of these different strands of policy over time and in particular to observe how national policies have changed to take account of the emergence of a new player – the EU – on the policy stage. A central issue it addressed was how far it was necessary for the EU itself to act as a strong co-ordinator of policy or how far there existed a natural process of adjustment and adaptation (soft co-ordination) such as to make strong co-ordination unnecessary.

The project has stimulated the writing of 15 separate reports – an introductory report discussing existing literatures and approaches; six country-based studies charting the development of policy in the six countries in this area through the years 1975-1997; six reports on cross-cutting themes; and two 'synthesis' reports, one relating to the six country studies and the other attempting to summarise the findings across all 14 earlier reports and to draw from them the relevant conclusions and policy recommendations.

The main findings were of a continuing fragmentation of policy between the different levels of government and hence of continuing diversity in systems of innovation, with national governments still playing a prime role in policy-making and European policy, although more prominent (especially in regulatory matters), still marginal in most science/technology areas.

There were a number of general trends – from big handouts to large firms (in the late 1970s) to small handouts to small firms; from mission-oriented sectoral policies to diffusion-oriented support for generalised innovation; from top-down to bottom-up, with regions and regional policies growing in importance. These trends were, if anything, increasing the diversity of policy making, but the report endorses this development arguing that there are few areas where economies of scale justify policy making at the European level and that 'soft co-ordination', encouraging self-adjustment by national/regional institutions, was preferable to tough measures from the Commission to enforce conformity. A general plea to emerge from the studies was for the need for more open and explicit discussion of policy objectives and policy mechanisms at all levels of government, and for a more strategic and 'joined up' approach. It was at the national and regional levels of government, rather than at Community level, that more co-ordination was necessary.

The EU earns plaudits for the degree to which its programmes have stimulated R&D and encouraged collaboration and networking, now recognised as an essential mechanism of technology transfer. The studies cover a period of continuous structural change as the European economies shift towards the knowledge-based era. National champions have given way to huge, truly multi-national companies, outsourcing activities and looking to local supply chains. The report endorses the views of those who argue that in such a world, education, training and basic research are essentials, and constitute the minimum entry ticket for participating in leading-edge activities. But it also emphasises, again, that industry can only participate in such activities if it, too, is prepared to pay the entry ticket in terms of its own commitment to R&D. Policies to promote R&D and to encourage collaboration and networking between all participants, public and private sector, large and small, remain the essentials of the system.

Chapter 1

Executive Summary

1.1 BACKGROUND AND OBJECTIVES

This project had three main objectives:

(i) to undertake a series of studies on how *science, technology and industrial policies had developed in six countries of the European Union (EU) in the years 1975-97*, looking in particular at the inter-relationships (or co-evolution) of policy in the different areas;
(ii) to use these studies as the basis for a *series of cross-cutting studies* on issues such as the impact of globalisation and the challenge of technology transfer, but including studies on the role of regional policy and the emerging EU RTD policies;
(iii) in the light of these studies *to advise the Commission on how best to carry forward its Treaty obligations in relation to the 'co-ordination* of science and technology between the EU and member states'.

The countries chosen for detailed study were France, Germany, Italy, Ireland, Sweden and the UK. In the first stage of the exercise, a mainly chronological set of studies were undertaken detailing for each, over the period 1995-97, the main developments in science and technology policy; their links with industrial and other (eg, education) policy developments; the role of small and medium sized enterprises (SMEs) and venture capital; the impact of regional policy; the part played by large multinational companies (MNCs) and foreign direct investment (FDI); the impact of EU policies; developments in the policy making process, such as privatisation and liberalisation, and the role of different actors and institutions within that process over the course of the period under review.

The focal point of these studies were national policy developments. This was deliberate because, although EU policy developed and grew in impact over the course of the period in question, the key players in decisions over science and technology policies had been and remained national governments. Equally, it was a period in which national governments had switched from substantial and often nationalistic interventions in industry to less interventionist, more generic policies supporting science and technology. In addition, it was also apparent that, faced by similar global challenges, different countries had chosen to go different ways. Interest therefore lay, both in chronicling developments and studying the

inter-relationships in the policy making processes, and also in comparing developments between one country and another.

The cross-cutting studies highlighted in a number of common themes that emerged from the national studies. Globalisation and the role of FDI picked up developments with both MNCs and SMEs; technology transfer highlighted changing roles in the production of knowledge and the importance of networks linking different groupings; regional policy emphasised the changing role of regional governments within the innovation agenda; the study on the impact of EU policies focused on the evolving relationship between European and national policy; while the study on the changing objectives of policy stressed the need for a more strategic approach to policy making at all levels.

Underpinning all these studies was a common socio-economic model – that of *the new institutionalists* in which the policy making system is seen as a mix of institutions and organisations with policy makers as potential agents for change (North, 1990). The subset of these institutions and organisations which relates to innovation makes up what is often referred to as a 'system of innovation' (Lundvall, 1992). This varies from country to country reflecting developments over time in the institutional arrangements, attitudes, culture and history of that country.

The new institutionalist approach helps to explain the third objective of the project – namely the issue of co-ordination and how strong a line the EU should take. The new institutionalist approach would suggest that, confronted by the emergence of a new set of actors establishing new institutions at the European level (as indeed happened with RTD in the 1980s), national institutions would slowly adapt and adjust their position to accommodate the new player. What this implies is that, irrespective of action taken by the Commission, there would be a natural process of adjustment among member states to the emergence of an EU level RTD policy. This in turn suggests that strong co-ordination by the Commission is unnecessary and that a natural process of adjustment – soft co-ordination – over time achieves the same end. Indeed it could be regarded as the 'hypothesis' which this whole series of studies is testing. How far do we observe, in this retrospective review of policy development, a tendency for national policies to adjust of their own volition to the emergence of EU policies? If the answer is that we do observe such behaviour, then the case for strong co-ordination is the less.

1.2 PROJECT METHODOLOGIES AND FINDINGS

1.2.1 The six country studies

The first phase of the project consisted of six country-based studies tracing developments in science, technology and industrial policies over the years 1975-97. Each study took a mainly chronological approach, concentrating at core on science and technology policy, but interweaving, as appropriate, developments in industrial support, regional policy, defence, procurement policies and education and skill training, as well as attitudes to SMEs, MNCs and foreign direct investments.

A number of general trends emerged in all six countries:

(i) a shift from large scale support of large firms to small scale and targeted support for SMEs;
(ii) a shift from blanket subsidiaries/tax reliefs for capital expenditures to specific support for RTD, skill training and entrepreneurship;
(iii) a shift from sectoral support schemes for specific industries to generic support for innovation related expenditures;
(iv) a shift from top-down policies imposed by the centre to 'bottom up' policies emerging from regional initiatives;
(v) increasing concern about the need for risk taking and entrepreneurship;
(vi) general acknowledgement of a supportive role from the EU, with these areas – competition policy, collaborative RTD and help for poorer regions from the Structural Funds – making particular impact;
(vii) a blurring of boundaries between science, technology and industrial policies, with increasing pressure on universities and research institutes to share knowledge and experience with industry.

Equally, there were also developments and experiences that were individual to each country, illustrating and upholding the view that Europe remains a diversity of national systems of innovation. *France*, for example, experienced a sharp discontinuity of policy in 1983 which marked the watershed between the techno-nationalism of the 1960s and 1970s and acceptance of the dominant neo-liberalism of the European Community. In spite of this, the French government continued to put substantial resources into their *grand programmes* and the external perception of France as a country of high performance in technological fields has

much to do with the relative success of these programmes. *Germany*, with a much stronger tradition of diffusion-oriented policy, retained a surprisingly strong programme of sectoral support. There were questions too about whether policy towards the new Länder had not been too much a transposition of the former West German system upon the East.

Sweden in many respects offered an exemplar to others, with its highly successful MNCs and high levels of both public and private investment in RTD. But there were questions about how far these high expenditures gave value for money – were the universities getting too selective and too elitist? Was there enough interchange between the academic and industrial sectors? *The UK* provided the greatest contrast between the interventionist policies of the 1970s and the laissez faire approach of the 1990s. But the opposite was true of science policy, with the autonomous institutions of the early 1980s brought firmly within departmental control by the 1990s. Was the increasing emphasis on industrial relevance in science policy substituting for the R&D failures of British industry?

Of all six countries in the study, *Ireland* was seemingly the most successful and benefited, as Krugman (1997) pointed out, from "the mutually reinforcing effect" of policies from different spheres, operating over different time scales. Nevertheless, the Irish government succeeded in orchestrating these different forces to good effect, mobilising resources from the Structural Funds to support high levels of investment in training both graduate level scientists and engineers and also technicians and craftsmen, and complementing MNC investment with support for indigenous capabilities in new technologies. By contrast, *Italy* was the least successful of the six countries, with the lowest overall growth rate, lagging in its investment in R&D, in its education and training of scientists and engineers, and in its use and development of new technologies. The good news is that Italy is trying hard to put its house in order, with the establishment of a ministry spanning both universities and research, science and technology, and extensive reforms to higher education. The real test is whether it can use these new institutions to mobilise resources across both public and private sectors.

1.2.2 The Synthesis Report – points to carry forward

The Synthesis Report, bringing together the six country-based studies, provided an opportunity to set these reports within the wider framework of comparative performance between these six countries and the EU as a whole, the US and Japan, and to take a preliminary look at some possible conclusions. A number of interesting points arose:

(i) While most countries experienced a shift of policy from intervention to 'lighter touch' diffusion-oriented policies (see 1.1.2 above), *the shift was not continuous but came in two stages*. First, came the shift from supporting old (sunset) industries to supporting new technologies (sunrise industries); secondly, the shift from sectoral support for new technologies, to more generic policies supporting the use and application of these technologies (diffusion-oriented).

(ii) *This two-stage shift reflected the tide of globalisation*, the first stage reflecting the switch in the 1980s from national champions to the mobilisation of resources at a European level; the second, the merger and acquisition movement of the early 1990s which turned 'European' companies such as ABB, Alcatel or Hoechst into truly transnational firms.

(iii) The overall effect was to *transform the size, shape and structure of European industry* and take it from the 'resource-based' culture of the post-war world to the 'knowledge-based' culture of the 21st century. *The fastest periods of change* had come, interestingly, not in periods of boom but *in the deep recessions* of the early 1980s and 1990s during which the economies had, like a snake, cast off their old skins to grow, in the boom years, into their new ones.

(iv) The forces of globalisation and technological change which drove these changes were largely external to the economies considered in this study. *Governments, broadly speaking, were reactive to developments*, adjusting policy *ex post facto* to change that had already taken place. In this sense *most policy change was incremental*, making adjustments to changed circumstances. *Only rarely did policy take a radical turn* reflecting either sharp discontinuities in external events (the oil crisis, the fall of the Berlin Wall), or sharp discontinuities in political control – the election of Margaret Thatcher in Britain in 1979 or Mitterand in France in 1981 are examples of this. There were also one or two instances of *sharp policy change in the depth of crisis* – Sweden in the early 1990s was such an example.

(v) *European programmes had been helpful* but not seminal in promoting these changes.

(vi) Given these developments, *three clear policy implications* emerged:

(a) *the centrality of the science base* both as a generator of new ideas and as trainer of the highly skilled workforce necessary for the diffusion of new science-based technologies;

(b) *the importance of networking between the three key players – government, industry and academia* – together they constituted the 'triple helix' (Etzkowitz and Leydesdorff, 1997) of the innovation system, bonded together via institutional linkages which, as with DNA, gave each system its individuality. These inter-relationships provided the core dynamic to the system;

(c) *the complementarity of different levels of policy development* – each level of government, regional, national and EU, had their role to play and if well co-ordinated could become, as in Ireland, mutually reinforcing.

1.2.3 The cross-cutting thematic studies

The second stage of the exercise constituted a series of reports looking across the country perspective to six general themes: globalisation; foreign direct investment; technology transfer; regional policy; changing objectives of policy; interaction with European programmes.

The study on *globalisation* reinforced the earlier conclusions about the impact of globalisation, emphasising the degree to which the mergers and acquisitions of the 1990s had shifted control of MNCs away from family and/or national groups of shareholders and into the hands of international financial institutions. This had brought with it a distinct move away from the non-globalisation of R&D – outsourcing had become more prevalent as the MNCs sought the best, and lowest cost, sources of expertise. The policy messages were to re-emphasise the importance of investment in the science base and infrastructure if high value added jobs are to be retained, but also to raise questions about competition policy – is EU competition policy strong enough to 'control' these large trans-national businesses?

The study on *Foreign Direct Investment (FDI)* complemented that on globalisation, providing both statistical and case study backing for its conclusions. The focus of this study was, however, policy and it illustrated the success with which both the UK and Ireland had throughout the period pursued explicit policies to attract FDI. The only other country which had attracted a substantial MNC presence (proportionately) was Sweden, where Ericsson's telecom activities had acted as a magnet for electronics firms. France and Germany both hosted many MNCs, but the main attraction was market access. Italy provided the least attractive location. Policy conclusions pointed to the importance of embedding FDI within a broader context of technology/industrial policy, a message which Ireland had learned better than the UK.

The cross-cutting theme on *technology transfer* stressed that successful technology transfer is not about handing over blue prints but about hands-on learning by doing. Interaction – scientists and engineers working together and learning one from another – is the key issue. Too often policy makers take too linear a view of the process and assume that all that is

required is to set up intermediary institutions (eg, science parks) between the scientists and industry, when in fact a much more active interaction/collaboration is required. Two important policy messages emerged. First, autonomy for the science base and effective technology transfer are not mutually exclusive – there is no need to put industrialists in charge of scientists to get away from the ivory tower mentality. Secondly, successful technology transfer is as much about the readiness and willingness of scientists and engineers to seize opportunities as to promote them. Absorptive capacity is a key element. Countries and firms that give low priority to R&D are in danger of locking themselves out of new opportunities.

The *regional policy* study highlighted the shift from the capital intensive developments of the 1970s to the emphasis on innovation, SMEs and regeneration in the 1990s. It emphasised the importance of the EU Structural Funds, and especially the reforms of 1988, as a catalyst to new thinking by regional authorities while regretting the relatively small role played by regional innovation strategies in regional developments. Its main policy messages were that regional support for SMEs was simpler, faster and more efficient than top-down programmes that much more attention needed to be given to training competent and capable administrators at this level of government. The study re-emphasised the importance of policy at the three levels of government – EU, national and regional – working in unison.

The study on *the objectives of science, technology and industrial policy* found that governments seldom made explicit their objectives and priorities or for that matter the functional models that took them from objectives to policy proposals. Evidence-based policy with clearly thought-through and empirically robust functional relationships was conspicuous by its absence. As a result far too much policy was made in an *ad hoc* fashion in response to crisis. It called for a much more open, informed debate about policy objectives and ways to achieve these objectives, and for government at all levels to provide better strategic leadership.

The study on *the interaction between EU and national/regional policies* looked at three different areas of EU policy – state aids (competition policy), the Structural Funds and the Framework Programmes. It found that of the three, state aids legislation, which benefited from the sanction of the Commission being able to take an errant (national) government to the European Court of Justice, had been highly effective in changing national policies; the Structural Funds and Framework Programmes, which relied upon financial incentives to stimulate action, less so, although not totally without effect. The Structural Funds in

particular had encouraged a new sense of importance within the regions and had empowered them to look to innovation as a route to development. The Framework Programme had been prescient in promoting collaboration and networking between institutions and had helped to stimulate programmes in a number of important areas. Generally speaking, however, it had had little effect on national policies towards science and technology. Equally, there was some evidence to show that, over time, national governments had come to assume the continued existence of the Framework Programme and had adjusted national S&T programmes in such a way as to create an implicit division of labour between the two.

1.3 CONCLUSIONS AND POLICY IMPLICATIONS

The overall *conclusions and policy implications* to emerge from this study are:

(i) *A continued fragmentation of policy between different players*. While the countries of Europe have faced similar challenges from advances in technologies and from globalisation, the non-globalisation of institutions has led to a heterogeneity of experience and policy responses. Only in a very few high technology areas such as standards for mobile phones or patents for biotechnology has there been any attempt to build European institutions. In other respects, Europe remains, 10 years on from Lundvall's (1992) seminal study "a diversity of national systems of innovation".

(ii) *Diversity can be a strength as well as a weakness but there is a leadership role for the EU*. The study argues that within science, technology and industrial policy there are few areas where economies of scale would argue for policy to be decided at an EU level and that the principle of subsidiarity would suggest that much policy-making in these areas is best handled at national or regional level. Indeed, in a world of uncertainty, diversity has some advantages and can help to identify and highlight best practice experience. For the EU, however, there is an important leadership role, in leading the debate about objectives and the means to achieving objectives, and in stimulating action from policy makers at lower levels of government.

(iii) *Co-ordination is needed but at the national level*. A strong conclusion from these studies is that co-ordination between the three tiers of policy – EU, national and regional – is important so that they become mutually reinforcing, but that this co-ordinating role is more appropriately assumed by national governments than by the EU. The lesson is that if the EU is clear and explicit in its policy objectives, other policy players will, over time, adapt and adjust their own policy actions. The sooner they do so and recognise the need for complementarity, the more effective their policies will be.

(iv) *Maintaining investment in the science base is vital*. The science base remains the core of the science and technology system and it is vital that governments at all levels maintain their support for the science base. In this regard, the EU Framework Programme, which has traditionally promoted *applied* research might consider putting more emphasis on basic research, while continuing to support and promote collaboration.

(v) *Industry in general remains the weakest link*. The poor R&D performance of European-based firms (with one or two notable exceptions) makes them highly vulnerable to competitive pressures. In particular the poor performance of the SME sector is a cause for concern, for failure to invest in R&D (which amounts in reality to employing scientists and engineers) limits the degree to which firms can 'absorb', take-up and use knowledge gained from elsewhere. However well networked into knowledge systems a firm may be, if it is incapable of recognising relevant knowledge and using it to best advantage, little is gained.

(vi) *There is a serious governance issue in relation to MNCs*. The increasing concentration of power amongst MNCs has created a situation of global oligopoly which in some product/market segments raises serious issues of market dominance. The EU needs to work with national governments and international organisations such as OECD and the WTO to address these issues.

The report concludes with a *check list of action points* for all three levels of government – the EU, national and regional. The most important of these are as follows:

For the EU

(i) Open up the debate on innovation policy, expose (and discuss) the implicit trade-offs between objectives and take a lead in developing a more strategic and 'joined-up' approach to developing policy.

(ii) Maintain the collaborative/exchange approach of the Framework Programme but widen international linkages and consider how best to stimulate greater investment in basic research within the EU.

(iii) Practice subsidiarity, encourage decentralisation of responsibilities where feasible and in particular extend the regional innovation strategy programme from disadvantaged to all regions with the aim of catalysing action at the regional level to build innovation networks between SMEs and local universities, colleges, MNCs, banks, etc.

(iv) Use its financial/administrative muscle to ensure proper reciprocity from member states and work with OECD/WTO to consider the appropriate governance framework for MNCs.

For national governments

(i) Be more open about objectives, more strategic in policy development and make better use of social scientists.
(ii) Beware of ‘regulatory capture’ whether by lobby groups or MNCs.
(iii) Do more ‘joined-up thinking’ about innovation policy, promoting better networking between ministries as well as between academia, industry and government departments.
(iv) Practice subsidiarity and allow regional governments to develop their own regional innovation strategies, encouraging links across the EU to publicise and promote best practice.
(v) Give high priority to improving education and skill training programmes, invest more in basic research and consider how best to stimulate industrial expenditures in these areas.
(vi) Pay greater attention to the training of civil servants working on innovation policy and, in particular, give consideration to training a cadre of able public servants to promote innovation at regional and local government level.

For regional governments

(i) Develop a more strategic policy framework, involving the different local ‘stakeholders’ in innovation and encouraging a longer term approach to policy development.
(ii) Accept responsibility for promoting innovation amongst SMEs and reach out to involve local universities, colleges, schools, firms, chambers of commerce, banks, etc, as well as regional and local government officers to provide a dynamic network of support for them at local/regional level.
(iii) Examine developments in the more successful European regions and consider what benchmarks are appropriate/lessons may be learned from their experience.

Chapter 2
Background and Objectives

2.1 INTRODUCTION

This project formed part of the Targeted Socio-Economic Research Programme of the Fourth Framework Programme in the sub-area entitled "Analysis of the RTD situation in Europe and the Rest of the World". In its call for proposals under this subhead, the Commission indicated that, amongst other things, it was interested in "analysis of the relationships between S&T and other policies", in the "design and construction processes of policy" and in "policy relationships between European, national and regional levels" of policy making.

This project sought to bring these interests together into one set of studies. At its core was a series of retrospective analyses of the evolution of science and technology policies in six member states over the course of the last quarter century of the 20th century – roughly speaking (since the proposal was made in 1997 and the studies written in 1998/99) 1975-1997. The studies were to be set within the context of "broad industrial policy" and to focus in particular on the relationships between science and technology policy and the wider issues of industrial policy. They were also to consider, where appropriate, the part played by regional authorities in policy development and policy implementation and they were to pay particular attention to the emerging relationship with European science and technology programmes.

In this respect, the project had three main aims:

(i) to undertake a series of studies in six member states on the development of science, technology and industrial policies over the period 1975-97, looking in particular at the inter-relationship between (or co-evolution of) policy in the different areas;
(ii) to use these studies as the basis for a series of cross-cutting studies on issues such as the impact of globalisation and the challenge of technology transfer, but including studies on the role of regional policy and the inter-relationships between national and, as the European Union gained strength, the emerging European policies in this area;

(iii) in the light of these studies to advise the Commission on how best to carry forward its Maastricht Treaty obligations in relation to the 'co-ordination' of science and technology policies between the EU and member states.

2.2 RATIONALE

As is clear from the description given above, the prime focus of these studies was on *national policies* and the evolution of *national policy making* within the context of the European Union. They were not, or only in the latter stages of the project, concerned with policy making at the EU level. It was hoped that the outcome of these studies would inform EU policy-making, but the inputs came primarily from developments at the national level of government.

Why this focus on national policies? There were three main reasons which, in their different ways, provide the rationale for this project.

First, as has been made clear in many different contexts, while much emphasis has been given to the Framework Programmes and the emergence of a strong strand of European policy making in science and technology, the actual amount of money spent by these programmes in relation to national or public sector spending at the member state level is paltry – at most 3-4 per cent of member states' own expenditures (except in the cohesion countries where Structural Fund expenditures can raise the Community contribution to as high as 20-30 per cent) (CEC, 1997). In English there is a saying, "He who pays the piper, calls the tune". In this sense, it is clear that, although incentive mechanisms, etc, within the Framework Programmes do give them greater leverage than the actual sums expended might imply, nevertheless policy making in this area has been and remains dominated by member state governments. If we want to understand how policy is evolving, we need to look first at developments at the national level.

Secondly, while a good deal of attention has been focused on the development of policy in specific sectors, for example, in ICT or biotechnology, and on the development of EU policy in relation to science and technology (see Peterson and Sharp, 1998, for detailed bibliography), there is a surprising dearth of work on *national* policy making. This is surprising given the wider developments in policy during the period in question – the impact,

for example, of the moves towards liberalisation and de-regulation, the whole ‘privatisation’ movement, the increased importance of entrepreneurial small firms, and last, but no least, globalisation. It is interesting, from a national perspective, to be able to take a long view of developments in policy making and to consider the relative success, or otherwise, with which national governments have dealt with these challenges and the lessons this might have for European policy making.

Thirdly, the national perspective adopted in this set of projects picked up the interest prevalent in the 1990s in “national systems of innovation” (Lundvall, 1992). This approach took from the new institutionalist theories being developed at that time. “Political institutions are collections of inter-related rules and routines that define appropriate actions in terms of relations between roles and situations. … When individuals enter an institution, they try to discover, and are taught, the rules. When they encounter a new situation, they try to associate it with a situation for which rules already exist.” (March and Olsen, 1989, p160.) In the context of nations systems of innovation, institutions are the key players in the process of learning and knowledge accumulation. They act as the ‘corporate’ memory, storing through rules and routines information gained from the processes of search and experience (learning by doing; learning by using).

Since these studies have been set within the context of this institutionalist approach to policy making, there were a number of different aspects that are worth exploring in more detail in providing the rationale for the project as a whole.

2.2.1 Institutions and organisations as agents for change

Nelson and Winter (1992) translated the idea of rules and routines into regimes which dominated corporate institutions and corporate behaviour. North (1990) applied the ideas to government and came up with the distinction between *institutions*, which might be defined as embodying the legislative and administrative framework, and *organisations*, which he defined as the agents or players in the system. Gregersen and Johnson (1997) extended this concept. Government institutions are the regimes and routines embodied in the framework of legislation and administrative fiat. Hence tax incentives or subsidies, part of the policy framework, are embodied in law, but so too are organisations such as research councils, set up as administrative agencies for allocating research funds, which in turn may have wide

discretion in decisions over the allocation of funds. Within such a system, it is the ministers and their advisers who are the *players and the agents of institutional change.* It is they who are responsible for running the system and making adaptations – changing the institutions – when for one reason or another they fail to deliver the desired outcomes. In looking at change, we need to focus on how change comes about – what triggers the demand for change? Who takes the decisions? And what happens if there is an absence of 'agents for change' or if those in such a position fail to cope with the demands?

2.2.2 Institutional learning

Institutional learning is important. In these studies, where the focus is on the evolution of policy – the process of change and adaptation – institutional learning can be seen as a two-stage process. First, it involves interaction between agents – in the case of government policy, civil servants and ministers – and then, as the outcome of this interaction, policy initiatives to change the legal/administrative framework (the institutions). The process of institutional learning is essentially the first phase in the process. It involves both the identification of the policy problem (for example, a mis-match between objectives and outcomes), discussion of possible solutions, evaluation (reflection on) the impact of possible solutions in the past and/or in other countries, and the selection of an appropriate model. The second stage is when this is put into practice by changes in 'institutional arrangements' (the legal/administrative framework). In this process there is, in-built in the system, a natural dynamic, which adjusts to changing circumstance. When objectives and solutions get out of line, the system rings alarm bells and triggers change. How far do we observe this happening in practice?

How far, for example, does it apply to the emergence of EU policy? Has there been, at the national level, a gradual process of assimilation? This has implications in relation to the problem of co-ordination for where there is a natural process of adaptation, there is less need for strong measures of co-ordination.

2.2.3 Incremental versus radical change

The implications of this view of the innovation system is that institutions, without the intervention of outside agents, tend to reproduce the status quo and resist change. The term frequently used is "institutional inertia". It is important, however, to distinguish between

incremental and radical change. The system has little difficulty coping with incremental change – indeed that there is an in-built mechanism for handling incremental change. Note the words in the earlier quotation from March and Olsen "When they encounter a new situation, they try to associate it with a situation for which the rules already apply" (March and Olsen, 1989, p160). Johnson argues this is not true of radical technical change, which provides a bigger challenge. "It may be argued that some kind of creative destruction of knowledge is necessary before radical innovation can diffuse throughout an economy. Old habits of thought, routines and patterns of co-operation, within as well as between firms, have to be changed before technical change can move ahead" (Johnson, 1992, pp29-30). The same could be said of public policy. Radical change may come from two different sources. One is external. Take, for example, globalisation. Arguably it has presented decision-makers at the national level with totally new parameters which has required the 'creative destruction' of old ways of thinking. The other source of radical change may come from within the system itself – from the politicians as 'agents of change'. Elections bring new politicians to power backed by promises of policy change (manifestos) which sometimes constitute radical breaks with the past, as happened when Margaret Thatcher came to power in Britain in 1979 or Mitterand to power in France in 1981. The new politics may in itself reflect the failures of the earlier system to respond to the pressures for change.

In studying the evolution of policy at the national and European levels, it is interesting to observe how different systems respond to the pressures for change. How far has change been incremental? Or, has there been a demand for radical change? And if so, how have the systems responded?

2.2.4 Europe as a 'diversity of national systems'

The concept of the national system of innovation derives from the notion that institutions are also culturally embedded. "Culture makes nations with the same kind of economic system, for example, Denmark, Sweden and Germany, different from each other, and cultural systems are governed by rules and rules about rules, including rules for breaking and changing rules". (Johnson, 1992, p39.) Each country, over time, develops its own rules and its own institutions. Britain, for example, developed in the nineteenth century the concept of the joint stock company, limited liability and equity-based finance. Germany, by contrast, developed its tradition of industrial banking. Both grew and adapted to the pressures of the twentieth

century but essentially retained their distinctive traditions. Again, Britain in the post-war period has grown a highly centralised administrative system whereas Germany, with its deliberately power-sharing constitution, has a de-centralised system. Johnson continues: "Since nations differ both with respect to how their institutional systems influence innovation, and with respect to the economic structure defining technological opportunities and bottlenecks, it is still possible to look upon Europe as a diversity of national systems of innovation". (Johnson, 1992, p39.) These studies will help to throw light on this 'diversity of national systems', on how far it is being perpetuated (different countries reacting differently to the same challenge) and how far the process of learning and assimilation within the EU framework is bringing a convergence of institutions and policies. Are we beginning to see anything that might be called a European system of innovation?

2.3 THE ORIGINAL OBJECTIVES

In line with the rationale explained in the previous section, there were three main objectives of this project.

2.3.1 The first objective: to undertake a series of national case studies which would focus on the evolution of science, technology and industrial policy over the period 1975-97 within each national context and examine the interactions between the different strands of policy

The partners within the project were each to undertake a study of the evolution of policy within their own countries, which would provide six case studies – Germany, France, Italy, the UK, Ireland and Sweden. Although limited in number, these six represented well the diversity of national systems within the Community.

Germany, France, Italy and the UK were all large economies with well established but very different systems of science and technology. Germany, France and Italy relied largely on institute-based research; the UK was university-based. Germany had a strong tradition of 'diffusion oriented' innovation based on its Mittelstand of small and medium sized firms; Italy, too, had a strong small firm tradition; France and the UK had a 'mission-oriented' tradition which relied heavily on large firms. The UK, however, had under the Thatcher regime, turned its back on state intervention and shifted rapidly to rely on laissez faire.

Sweden and Ireland were much smaller economies and Sweden was, in 1995, a new member of the EU. Sweden shared many of Germany's attributes: strength in the engineering industries; the emphasis on training; the attention to detail. But its strength lay in its large multinational companies not in SMEs and its scientific capabilities were increasingly being concentrated in its leading universities not in research institutes. Ireland, with only three and a half million population, in many senses might seem out of place in this study, with (in 1975) a largely agricultural economy seeking progress through industrialisation. Yet it is Ireland which has proved to the Europe's 'tiger' economy, rapidly building up its strength in science and technology.

All in all it was felt – as indeed it was to prove – that the diversity of experience within the six countries would provide sufficient material to illustrate the themes of study and to make for interesting and illuminating comparisons in experience.

The questions upon which each study was to focus were as follows:

1 What were the main developments in science policy over this period?
2 And in technology policy?
3 How did these relate to broad developments in industrial policy – eg, state aids, subsidies, tax breaks?
4 And to policy towards SMEs? Finance and venture capital?
5 What relationship did this have with regional policy?
6 What role has been played by large multi-national companies and what role, if any, did foreign direct investment play?
7 How, if at all, has privatisation and de-regulation affected policy?
8 Were there any other policies – eg, defence, education and training, competition policies which impinged on these relationships?
9 How have EU policies impinged on national policy and national priorities in these areas?
10 Looking across the whole period, what changes have there been in the process of policy formation? Who have been the main actors? Have they changed over the period?
11 What evidence has there been of institutional adaptation and 'learning' over this period?

12 What lessons, if any, are there to be learned from the analysis of this (national) experience over these years?

In general each study stuck to these objectives. The degree to which they discussed detailed issues of, eg, competition or training policy, varied but at core each study maintained the brief of describing developments in policy over the years 1975-1997 and discussing the interactions and linkages with broader industrial policies. Most authors found it necessary to set these developments within an historical context and therefore there are often (see for example the German, British and Irish studies (Reinhard, 1999; CIRCA, 1999; Sharp, 1999)) fairly substantial introductions which "set the scene". In most of the six countries, technology policy proved to be an adjunct of industrial policy, whereas science policy was more frequently a relatively independent set of policies. As a result the "interaction" was as much a matter of interaction between science policy and other policies as between "science and technology policy" and other policies.

In addition to the individual country studies, the project allowed for a *mid-way synthesis* of these studies (Sharp, 1999) which provided both for some preliminary conclusions to be drawn across the experience of the six countries, and for the studies to be set within a common statistical framework. The original aim of each country working with a common set of EU/OECD figures proved impossible to adhere to. Frequently statistical sources on the detail of policy were only available from local sources and in local currencies and, given the importance of time series to these studies (and the distortions to time series which variations in exchange rates and inflation rates create) it proved easier to leave each country study in its own currency, and to provide the general, comparable background statistics in the synthesis report. In this respect, besides summing up the findings in each country study, the synthesis report also provided a statistical overview of trends in the six countries in relation to the EU and the US and Japan.

2.3.2 The second objective: to undertake a series of cross-cutting horizontal studies to pick up some of the general themes emerging from the national case studies

Once the national case studies were completed, the second set of studies to be undertaken was to build on these to write a series of cross-cutting, thematic studies picking up some of the general issues arising from the case studies. There were to be five general cross-cutting

studies and one specific one (on interaction between national and EU policy) which was in effect to constitute the third objective of the project (see below).

The five general thematic case studies were to be as follows:

(i) Globalisation and its impact on science, technology and industrial policy (Sigurdson, 2000)

Decision-making in Europe, whether at the Commission, national, regional or firm level has to be within the context of global developments. With large corporations dominating production world-wide, a key issue is the location of R&D facilities. Up to the mid-1990s, research had pointed to the non-globalisation of R&D facilities, but as mergers amongst multinationals increasingly create huge trans-national companies, with a multiplicity of roots, so it was becoming more difficult to identify the 'home country' of those companies. The aim of this cross-cutting study was to take a broad comparative look at developments amongst multinationals, both those based on Europe and those based on the US and Japan, and to identify factors influencing the location of RTD facilities.

(ii) Foreign Direct Investment (FDI) (CIRCA, 2000)

As originally conceived the aim of this project was to undertake a direct comparison between the role of FDI in Ireland and the UK with particular attention being paid to supply-chain issues, the effectiveness of technology transfer through FDI and the vulnerability of different types of investment to pull-out in recession. In the event, the study took a broader format and looked at case studies based on the experience of foreign implants in all six countries involved in the study. In this respect it provided a good complement to the broader study on globalisation undertaken at (a) above.

(iii) SMEs, Regional Policies and the Structural Funds (Braga et al, 2000)

The aim of this study, undertaken by the Italian partners within the project team, was to use the example of Italy to examine how regional policy implemented in different regions of that country had influenced the innovation record in the region in question. The Italian experience would then be set in the context of developments in regional policy in other countries, with particular emphasis on the use of the EU's Structural Funds and the promotion of innovation.

The authors of this study found themselves involved in an immense wealth of detail in attempting to identify precise initiatives in all six countries which had promoted innovation among SMEs at regional level. Given the limited time (and funding) available for this part of the study, they retreated from the detail to more generalised comparisons. Broadly speaking, however, the objective of looking in detail at Italian experience and then making comparisons across all six countries was maintained.

(iv) Technology Transfer and Innovation Policy (Reinhard, 2000)

Science and technology policy tries to initiate technology transfer *ex ante* by funding joint research projects, or *ex post* by helping with the exploitation of existing knowledge. The situation varies from country to country within the EU and there are lessons to be learned about best practice. The aim of the study was:

(a) to consider the implications of recent analytical research about innovation and learning for the processes of technology transfer;
(b) to compare the structures and mechanisms of public-private interaction in S&T in the different countries involved in the study including EU programmes;
(c) to make recommendations to the EU with regard to what might be the most effective mechanisms to put in place.

In general the project was able to meet its original objectives, although its coverage of the EU programmes was somewhat less detailed than originally planned.

(v) The changing objectives of government policy (de Bandt, 2000)

Industrial policy has always been a contentious area of policy, especially for economists. Important and difficult questions are raised about the objectives of policy – what is the precise set of objectives being pursued by any one government; how might this (set of objectives) vary from government to government and how does it evolve over time? Most policies are, in one way or another, aimed at improving industrial performance – internally, in terms of growth of value added and profitability; externally in terms of trade performance. Science policy used to exist as a distinct area of policy. Today it has become increasingly annexed by competitiveness policy. This has long been true of technology policy. It is also true that industrial policy does not exist in a vacuum – it is usually integrated into a more or less consistent set of policies pursuing different but (hopefully) complementary objectives.

The aim of this horizontal theme was to try to untangle some of these complexities. By taking the different national case studies and analysing experience in the different countries, the aim was to look at:

(a) *The objectives and scope and industrial policy:* how have objectives changed; has industrial policy widened in scope, over the last 20 years?
(b) *The policy mix:* what are the relationships between industrial policy and science and technology policy with other complementary areas of policy such as competition policy?
(c) *Policy feasibility:* how far does European experience demonstrate that industrial policies are feasible?
(d) *Government and organisation failures:* S&T policies may take care of the dynamic dimensions of policy but do they allow sufficiently for government and organisational failures?
(e) *Bottom-up versus top-down:* top-down planning is out of fashion, but is it possible to redefine the required actions on the basis of bottom-up and/or decentralised initiatives?

Once again these broad aims proved easier to define than to implement, partly because, as the study highlights, many governments refrain from explicitly identifying objectives, preferring to rely upon implicit objectives. The analysis nevertheless attempts to identify the different types of policy pursued in different countries, to look at trends in policy over the 20-year period of the studies and to identify areas of strength and weakness in policy formation.

2.3.3 The third objective: a study of the interaction between national and EU policies

The aim of this final phase of the study was to pull together the country-based studies and the thematic studies into a broad study of the interaction between national and EU policy making and in particular to study how far national policy making had been affected by the emergence of a strong strand of EU policy in science and technology.

This phase of the project, to be completed by the project co-ordinator, also shifted its ground a little. Two problems presented themselves. First, it became apparent after the first phase was completed and the synthesis report written, that the study needed to look not just at

interactions with the Framework Programmes, but also at the impact of state aids' provisions and the Structural Funds, which had had just as much (if not more) impact on the development of national policy in the areas. Secondly, it also became clear that, with the exception of the regional policy module, there was little input of relevance from the thematic studies to this 'interactions between national and EU policy' module. It therefore became, in effect, a self-standing cross-cutting, thematic study in its own right, pulling on information in the country studies but also, importantly, bringing in new material for consideration.

Neither of these problems in themselves were insuperable. Indeed, meeting them made the study into a more coherent, independent study in its own right (Sharp, 2001). It does mean, however, that it no longer fulfils one of its original objectives, namely to act as the vehicle for presenting the overall conclusions of the full set of studies, providing in particular a chance to pull together the conclusions from the thematic studies. That task is left therefore for this report.

This report should therefore be seen as presenting the overall conclusions from the project. In particular, Chapter 4, Conclusions and Policy Implications, attempts to pull together and extrapolate from the analysis in all thirteen preceding reports in order to present a coherent set of "grand conclusions" from the exercise.

Chapter 3
Scientific Description of Results and Methodology

3.1 INTRODUCTION

This chapter brings together the results of this project on Science, Technology and Broad Industrial Policy. Details are set out in the 14 reports that constitute the 'deliverables' of the project, from the initial literature review (state of the art report) undertaken in the first six months of the project (Sharp, 1998), through the six country-based reports describing the evolution of science, technology and industrial policy in each of the six countries (de Bandt, 1999; CIRCA, 1999; Braga *et al*, 1999; Palonka, 1999; Reinhard, 1999; Sharp, 1999), the synthesis reports (Sharp, 2000), and the six thematic reports, including that examining the interaction between science, technology and industrial policy (de Bandt, 2000; CIRCA, 2000; Braga *et al*, 2000; Sigurdson, 2000; Reinhard, 2000; Sharp, 2001). All 14 reports have been completed and submitted to the Commission. Full details are included at Annex A.

The purpose of this chapter is briefly to describe each report and to highlight the main findings and conclusions drawn from these findings.

3.2 THE INITIAL LITERATURE REVIEW – WHAT IS INDUSTRIAL POLICY AND WHY IS IT NECESSARY? (Sharp, 1998)

This paper was prepared in the light of discussions at the preliminary meeting of the project group in November 1997 (before the project officially began in January 1998) and was cleared at the second workshop in May 1998. Its purpose was to discuss current academic approaches towards science and technology policy within the context of broad industrial policy and to explore the implications of these approaches for the methodologies to be adopted in the TSER project.

The paper began with definitions, making the distinction between industrial policy defined as a broad set of policies, and science and technology policies which are overlapping subsets of this broader policy, as indeed are other areas of policy such as competition policy, regional policy, public procurement, seen to touch on this project. Indeed, the situation was well illustrated by the following diagram taken from that paper.

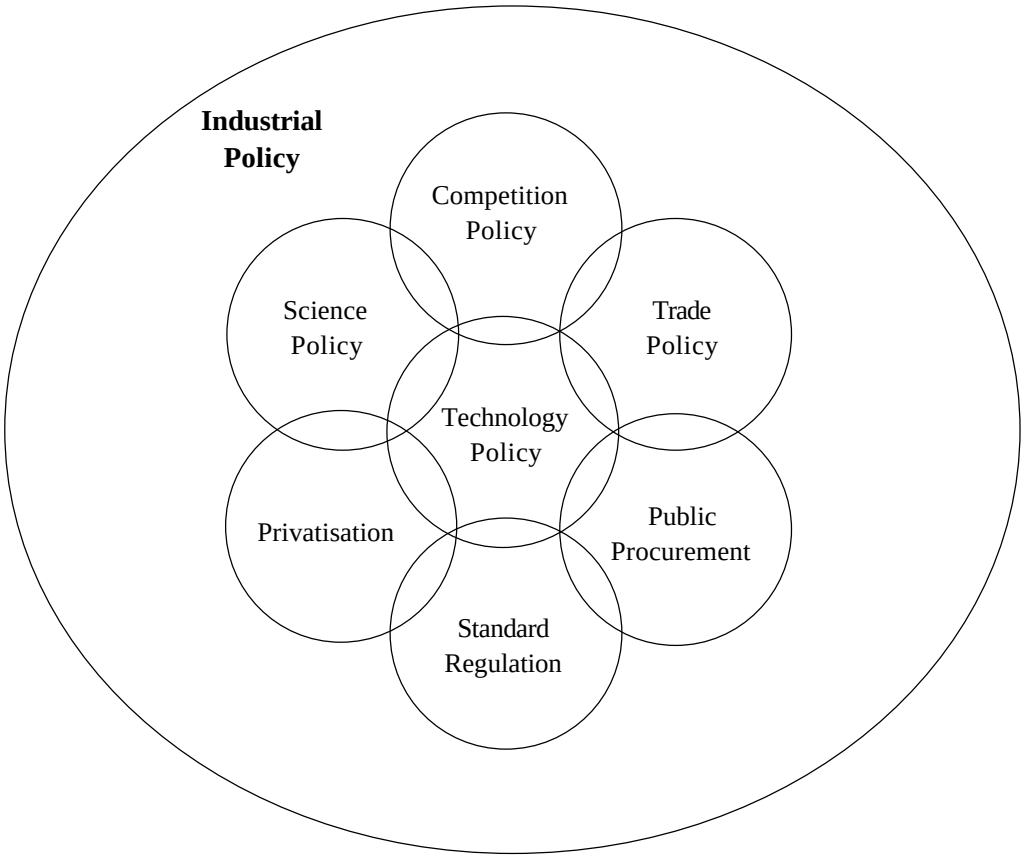

Figure 1: Industrial policy and complex of subsets around science and technology policy which interact to constitute innovation policy

Other descriptions of policy were also discussed, including terms such as positive and negative adjustment policies; near-market versus far-from-market or pre-competitive support; bottom-up versus top-down; supply-push versus demand-pull. It was noted that such definitions often came in mutually exclusive pairings and that splitting the pairing led to two different "packages" of policies, the one passive, reactive, negative, top-down, supply dominated (which generally speaking were seen to represent 1970s style industrial policies), the other active, positive, bottom-up, demand-led (which, it was claimed, represented the policies which emerged in the 1980s to dominate the 1990s).

The paper then examined the theoretical underpinning of policies in this broad subset of industrial policies which sought to intervene in market decisions. It developed the familiar neo-classical arguments of market failure and externalities and then went on to examine the ideas of new growth theorists (which it saw as a dynamic extension of externality theories) and the neo-Schumpeterian challenges to the new growth theorists focusing on the former

issues of uncertainty, rationality, exogeneity (of technology) and the role of institutions. At the end of the day the paper pointed out that a very similar set of policies were promoted by the two schools of thought, for very different reasons. Table 1 below sums up the conclusions.

Table 1: Policies and their rationales - the neo-classical and neo-Schumpeterian compared

	Policy	**Rationale**	
		Neo-Classical	**Neo-Schumpeterian**
(i)	Support for Basic Science	Wide spillovers	Spillovers plus technology transfer
(ii)	Patents	To promote appropriability	To enhance monopoly profits and encourage further investment in R&D
(iii)	R&D subsidies	Externalities associated with risk and uncertainty	To encourage R&D in its own right as an important part of system dynamic promoting absorption capacity of firms
(iv)	Collaboration	Indivisibilities - in big science or big projects (but dangers of collusion)	An important part of the learning process - interaction between players worth promoting in own right
(v)	Competition policy	To prevent abuse of monopoly power	To prevent abuse of monopoly power and to encourage competition between firms which is an important part of system dynamic
(vi)	Infant industry protection	To overcome major indivisibilities leading to important economies of scale	To help new technology-based firms develop and challenge older, well established players
(vii)	Free trade	As a stimulus to competition	To encourage competition, especially between large firms
(viii)	Promote education and training	As investment in intangible capital	An important part of the diffusion process where failure to act is frequently a cause for system breakdown
(ix)	Promotion SMEs	Action only where proven market failure - eg finance	an important part of system dynamic, especially in the diffusion of new technologies

Source: Table 2 from Sharp (1998): *What is Industrial Policy and Why is it Necessary?*

In discussing the application of these ideas to policy formation the paper says "… each country has tended to develop its own policies of adjustment and change. The precise policy mix has reflected both past history and current political preferences, which in turn is reflected

in the economic rationale used to justify intervention." (Sharp, 1998, pp24-5.) It goes on to point out that (in contrast to the UK Thatcher government's preferences for the laissez faire model), "The Commission have shown themselves to be closer to the neo-Schumpeterian model. More by luck than good judgement, the collaborative ethos of their programmes, initially conditioned by the need to shift national champions out of their home bunkers, proved prescient in a world where strategic alliances are ever more common".

The final section of the paper discusses the implications of these findings for the methodology to be adopted in the series of studies. Given the evolutionary approach, the neo-Schumpeterian framework, with its emphasis on institutions and adaptations, was more readily applicable, but clearly the starting point was, for each country, a chronological charting of the changes that had taken place in the different areas of policy. The paper mirrors the objectives set out in the original proposal by suggesting coverage of the following: industrial subsidies, general and sectoral; science, technology and RTD policies; higher education and university/industry links; MNEs, globalisation and FDI; SMEs, venture capital and technology transfer; regional policies and cohesion issues; education and training; and defence and public procurement.

Many of these issues echo the subject matter of the cross-cutting thematic papers to be written as the second stage in the exercise, but the paper stresses the need to set the analysis against a background of globalisation and the rise of the knowledge economy. It notes, "In policy terms during the period under consideration – 1975-1997 – there has been a major shift from traditional industrial policies (involving substantial subsidies to enterprises) to science, technology and innovation policies. Superficially, this appears a swing away from a rather messy version of neo-classical (market failure) policies towards neo-Schumpeterian policies."

It suggests that three more general questions need to be addressed: What broad shifts in policy have taken place and why? How far have governments pursued clear objectives and if so, what have they been? And finally, the organisational issues – how far have governments proved competent to implement the policies they wish upon their populations, or is government failure as prevalent as market failure?

3.3 THE SIX COUNTRY STUDIES

As already noted, the project proposal set the methodological framework for the country studies as, initially, a chronological account of policy developments in the main areas of interest, to be followed by an analysis by the broader thematic issues. Following the general neo-Schumpeterian (institutionalist) approach, there was also concern to focus on the issues of institutional change and identify both the changes taking place and the instigators (agents) of those changes.

Each country study amounts to some 100 plus pages of text. A summary cannot hope to do justice to the wealth of detail contained in each study. The aim here is merely to highlight some of the main conclusions to each study which in turn feed into the synthesis report discussed at 3.4 below. The studies are taken in alphabetical order and other than this there is no significance in their ordering in this report.

3.3.1 France (de Bandt, 1999)

The French study traces developments in policy between 1975 and 1995. There were two distinct phases of policy: the period 1975-83, characterised by, on the one hand, growing subsidies to declining sectors and, on the other, the continuing pursuit of technological independence. The second period 1983-95 saw the abandonment by the French government of its more nationalistic plans and strategies and its acceptance generally of the neo-liberal orthodoxy (in relation to state aids, subsidies, etc) of both the EU and OECD. Most significantly, from the point of view of this study, this second period saw France abandon its search for technological independence and throw its weight instead behind collaborative European efforts in the Framework Programme and EUREKA. It also saw a significant shift of policy control away from the centre (Paris) and towards the regions, with provincial governments playing an increasingly important role in relation to SMEs and technology transfer.

In the late 1980s, in the period of ‘cohabitation’ between Mitterand and Chirac, a programme of rapid and extensive privatisation was initiated and maintained into the 1990s, even after Chirac’s departure (as Prime Minister) as both recession and, subsequently, constraints on public sector finances in preparation for the launch of the single currency, put pressures on

the public purse. Nevertheless, in spite of privatisation, the French government managed to fund and maintain its *grands programmes* – the flagship of its technology policy – in aerospace, telecoms, nuclear energy and, subsequently (and less successfully) biotechnology).

Overall, looking across the changes that took place in the period 1975-1995, the study drew the following conclusions:

(i) the period concerned, 1975-95, witnessed very substantial changes in both the structure and organisation of the French economy, but structural change and policy are intertwined – the one reacts to the other – and it is often difficult to disentangle one from the other;
(ii) the process has been neither continuous nor incremental. There have been trends, but also sharp discontinuities;
(iii) amongst the trends, there has been a clear shift from strong industrial policy interventions to policies emphasising science, technology and innovation;
(iv) the sharp change (discontinuity) came in 1983 with the rejection of techno-nationalistic policies and acceptance of the dominant (European) neo-liberal approach. In spite of this, the French state continued to put considerable resources into their *grands programmes* through to the 1990s, and external perception of France as a country of high performance in technological fields has much to do with the relative success of these programmes;
(v) in other areas the new, broadly neo-liberal, era brought with it many different programmes and actions aimed at promoting R&D and bringing together scientific research and firm-based R&D activities. Both the EU Framework Programmes and the EUREKA programme played a part in this. In particular, these programmes opened the French system to international collaboration, which has played an important part in stimulating new activities in both academic and commercial sectors;
(vi) overall, however, post-1983, French governments of all political complexions have lacked a comprehensive strategic view of their role in either science or technology;
(vii) partly because of this (lack of a comprehensive view) the science system in France has changed surprisingly little over the same period. It remains institute-based, self-governing, run by scientists for scientists and with a predominantly linear view of the

innovation process. Attempts to change the system and to forge closer links between science and technology have made little impact;

(viii) another area of discontinuity, again dating from the early 1980s, has been the shift towards decentralisation with the Deferre Law of 1982 giving considerable economic power to regional councils. These powers have been reinforced by the mechanisms of the EU's Structural Funds which have demanded strategic planning in relation to innovation at the regional level. These initiatives have been particularly important in relation to SMEs.

All in all, the conclusion reached is that, while French policy changed during the 20 years from a predominantly top-down, mission-oriented approach to a bottom-up, diffusion-oriented one, the dominant influence was external (globalisation), and successive governments were reactive rather than pro-active to these developments. The influence of EU programmes had been benign, if relatively marginal.

3.3.2 Germany (Reinhard, 1999)

Germany, unlike France, has no tradition of industrial policy. Its post-war adherence to economic liberalism meant that successive governments have accepted that market forces are the dominant factor in the running of the economy and that state intervention has, at best, a minor part to play. Equally Germany, like the UK, was by the 1970s a mature industrialised economy with substantial capital, both physical and human, in industries such as ship-building, steel, and (bulk) chemicals which, post-oil crisis, were facing both relative and absolute decline. Like the UK, therefore, Germany entered the last quarter of the 20th century with substantial subsidies going to these industries, notionally geared to promoting structural adjustment but in reality there to protect and preserve jobs in areas already suffering from high unemployment.

The primary aim of Germany's *direct* or explicit industrial policy in the late 1970s was therefore to alleviate the negative consequences of structural change in declining sectors. Side by side with this explicit policy, however, Germany had pursued an *indirect* policy of maintaining high levels of investment in its workforce, science base and industrial infrastructure, including support from both large and small firms. It is this indirect policy that arguably has underlain Germany's strong competitive position as the manufacturer of high quality and high value added goods and services.

General conclusions to emerge from this study were:

(i) that, while there had been change, Germany benefited from strong elements of continuity in both the objectives and the instruments of policy. There was (and had been) strong backing in the population as a whole for investment in science and technology and an acceptance that this meant public sector expenditures on infrastructure (and human capital) as well as private sector support for R&D;

(ii) continuity in objectives and the instruments of policy did not, however, mean no change. The period began (1975) with technology policy largely concentrated on sectoral support schemes. While these were continued, the 'spectrum' of assistance was successively expanded to cover a wider range of sectors and to include schemes to promote the diffusion and application of new technologies. In Germany, as in other countries, the broad pattern has been a switch from extensive support for older, often declining, sectors to more generalised support for new technologies, but the terminology of from 'mission-oriented' to 'diffusion-oriented' does not apply. Much of Germany's *indirect* industrial policy had always been diffusion oriented: a surprising amount of assistance in the 1990s remained mission (sector) based;

(iii) there had been distinct changes too over the twenty years in the institutions and instruments of policy:

(a) a changing role for the federal government – as far as R&D was concerned during this period, industry, not the federal government, was 'the biggest player in town'. The federal government's role became increasingly that of facilitator – forging links between public sector laboratories and private firms; promoting networking; encouraging an expansion of the venture capital market; easing regulatory barriers to the diffusion of new technologies;

(b) a growing role for the regions – while Germany's decentralised constitution had always given the regions a significant role, in science and technology it had been mainly restricted to support for universities. The growing emphasis on diffusion, SMEs and the importance of networking had provided a natural niche for the expansion of regional responsibilities;

(c) the integration of the new Länder – this had been the main pre-occupation of the 1990s. In many respects it represented a transposition of the system (institutions and instruments) developed in the former West Germany into the new Länder of the East (this in itself reflected the relative consensus about their effectiveness);

(d) the increasing role of EU science and technology programmes – while Germany had initially been a somewhat reluctant supporter of EU activities and retained some doubts about objectives and organisation, it had come to recognise the importance of the collaborative message and the value to be gained in some areas from the EU acting together;

(iv) there were, nevertheless, a number of questions raised by these developments and left unanswered. All raised important policy issues:

(a) was there still too much emphasis on sectoral support? Although there had been a distinct shift towards more generic forms of support, 70 per cent of resources devoted to the promotion of innovation in Germany still went to sectoral schemes. Had enough thought been given to the trade-off between money spent on such schemes and, for example, effort put into easing labour market or banking regulations? Which were the more efficient promoters of innovation?

(b) while the institutions of the former West Germany had performed well, was it right just to transpose these into the new Länder? Had there not been an opportunity to experiment with new, possibly more efficient structures – for example, bringing universities and research institutes closer together, especially at post-graduate level; or developing closer links between academic and industrial research?

(c) had enough thought been given to the subsidiarity issue? There was danger of overlap and duplication between federal, regional and EU initiatives. Had enough thought been given as to what was best done at which level? Is the EU rigorous enough in asking what is best done at the European level? But equally has the Federal government in Germany really thought through what is best done by itself and by the Länder?

3.3.3 Ireland (Higgins/CIRCA, 1999)

Ireland stands out as the ‘tiger’ success story of Western Europe over the last 20 years. From a relatively backward, predominantly agricultural country in the 1970s, it emerged in the 1990s as a small (population of 3.5 million) dynamic, modern economy, home to some large multinational enterprises but also to many young, indigenous enterprises with double-digit growth rates. As Krugman said “No single factor can explain the economic turn-around. The success can be more easily understood if we recognise the mutually reinforcing effect of forces that were operating over quite different time scales.” (Krugman, 1997.)

The modern Irish economy dates back to 1958 when tariff-free access was opened up to the UK market and an industrial policy geared to attracting foreign investment and promoting exports was instituted under the IDA (Irish Development Authority). In effect, for much of the 1960s and 1970s, the IDA ran Irish industrial policy and its aims and objectives – to attract as much footless foreign direct investment (FDI) as possible to Irish shores – became Irish industrial policy. Research policy played little part - industrial research was considered 'a costly luxury' and a 'buy-in' policy was pursued to meet Ireland's industrial needs. University research activity was at a very low level, although the establishment during the 1960s of nine new regional technical colleges and two national Institutes of Higher Education greatly increased the supply of trained technicians and graduates.

Three reports in the period 1973-83 were seminal in changing the emphasis of policy from quantity to quality and in bringing science, technology and industrial policies together. All three questioned the benefit to Ireland of foreign affiliates attracted mainly by large grants and tax concessions and the lack of growth of indigenous Irish firms. They pointed to the low levels of industrial R&D in Ireland, to which most foreign affiliates were contributing nothing, and argued for a much more selective policy aimed at creating genuine competitive advantage.

The most influential of the three reports was the Telesis report of 1982, commissioned by the Irish government from the Boston Consulting Group at the height of the 1980 recession. Its conclusions in many respects echoed the earlier but less publicised Cooper-Whelan Report (1974). They led to the separation of policy-making from implementation but also, in the early 1990s, to the establishment of two separate agencies (Forbairt, for the promotion of indigenous industry, and Forfas, for the promotion of science and technology), leaving the IDA with responsibility only for FDI.

The 1974 OECD report stimulated the Irish Government to establish the National Board for Science and Technology (NBST), with a statutory remit to co-ordinate and promote science and technology. In the 1980s it was instrumental in encouraging and promoting participation by Irish academics in the developing Framework Programmes. This participation played a significant part in improving the quality of scientific output (as measured by publication and citation data) of the Irish universities and in increasing the internationalisation of Irish science and technology.

Two further reports were to be instrumental in shifting Irish policy towards a fully fledged innovation policy. The 1987 OECD report reiterated the criticisms of the Telesis report about reliance on foreign investment and stressed again the need to invest in human capital. The Culliton Report of 1992 followed the deep recession of the early 1990s which had brought in its wake the closure of a number of MNE subsidiaries. Culliton recommended a strengthening of the role of indigenous firms and, like OECD, greater emphasis on training and the quality of human capital.

These various recommendations came together in the late 1980s and early 1990s in the development of policies which began to show their impact in the mid-1990s. There were a number of other important initiatives:

(i) The reform of the EU's Structural Funds in 1988 led to a requirement for an overarching 'Operational Plan' for industry and the allocation of funds for investment in science and technology.
(ii) The Irish government itself gave high priority to vocational and professional training. It also introduced new and more co-ordinated structures for the management of science and technology.
(iii) The Programmes in Advanced Technology (PATS), based on university campuses (but not under the management of the universities), offered a formula for *both* the transfer of advance technology to industry *and* the enhancement of university capabilities.

The PATS were important and effective. They funded laboratories and equipment on-site, worked with university staff, trained post-graduates and contract staff, commissioned some university research but also, crucially, acted as a mechanism for securing both EU and industrial research funds. The expansion of the Framework Programmes provided an important means for linking these developments into high quality international science and technology, while the continued success of the inward investment policies brought investments to Ireland from some of the leading MNEs in computers, electronics, software, chemicals and pharmaceuticals. Most significant of all, this investment began to be reciprocated by the growth of indigenous investment in industries associated with meeting both the supply chain needs of MNEs and the growing prosperity of the domestic market.

By the mid-1990s, Ireland fulfilled all the requirements of a 'tiger' economy – low inflation, growing employment and productivity, and fast rising GDP and disposable income. Between 1990 and 1996, real disposable income per household rose 49 per cent. GDP growth over the three years 1995-97 has averaged 9 per cent.

Ireland's success, as Krugman noted, was multicausal. It was impossible to say *one* factor or *one* policy was alone responsible: rather a whole series of mutually re-inforcing forces have come together, some by chance, some by deliberate design, to bring success in the late 1990s. As far as technology and industrial policies are concerned, the study draws attention to four features:

(i) the length of time it takes for policy changes to have impact – only in the late 1990s were policies put into effect in the early 1980s beginning to pay dividends;
(ii) the importance of policy, and institutional, learning – when policies seemed to be having little effect, rather than throwing them out and establishing *new* policies and new institutional mechanisms to implement them, a process of incremental but cumulative adaptation and adjustment was followed. In science and technology, industrial and educational policy, successive reports brought successive but cumulative adaptation. It is the ultimate convergence of these different tracks of policy in the mid-1990s that has created this seemingly very successful mix of policy;
(iii) the importance of the Structural Funds in providing *both* the stimulus for the development of an overall strategy, *and* the funds to put that strategy into effect;
(iv) the advantages of linkage into international networks – at an industry-level through inward investment and MNEs; and for academia through the Framework Programmes. This has helped an essentially small, peripheral economy to focus on international competitiveness.

3.3.4 Italy (Braga *et al*, 1999)

Italy's rapid rise as an industrial state in the 1960s left a legacy of over-expansion and imbalance in the 1970s. Ambitious expansions in steel and chemicals in huge new complexes located in the Mezzogiorno brought new capacity on-stream at a time when world over-capacity had already depressed prices. The state, which had played an important part in creating Italy's new industrial prosperity, was also expected to play the lead role in sorting

out the mess. As a result in the early 1980s, some €26 billion – 5.5 per cent of Italian GDP (CEC, 1989) – went into public subsidies to industry.

Science, technology and innovation policy played little part in policy thinking. While there was some recognition of the importance of a co-ordinated national research and technology policy, in practice policy focused on the public research system. The main player was the CNR (National Research Council) which was responsible for running a large number of government research centres. Its focus was largely academic and it was controlled by academics.

The period 1975-97 essentially saw the transformation of policy from the concentration in the 1970s on large firm handouts and academic science, to the 'light touch' policies of the 1990s, based upon bringing together science, technology and innovation. Four factors were seen to be particularly significant:

(i) *The passing of Law N46 in 1982.* This law for the first time acknowledged the importance of *applied* research and development by the company sector and put in hand a series of actions to encourage and support such activities, including grants towards the cost of upstream R&D activities and the promotion of a series of national research programmes on strategic new technologies. However, implementation in its early years was plagued by bureaucracy and it was not until the 1990s, when the newly established MURST (see (ii) below) simplified and streamlined its procedures, that the programme came into its own. Action under this law has proved to be particularly important in helping SMEs.

(ii) *The establishment of MURST in 1989.* MURST (the Ministry for the Universities and Scientific and Technical Research) was established in 1989 and given responsibility for the co-ordination of science and technology policies in Italy. While CNR and the universities remained separate and semi-autonomous arms of the research system, MURST was given clear responsibility for the overall co-ordination of R&D policies. MURST's two three-year research plans (1992-94 and 1995-97) set clear targets for Italy to raise its commitment to R&D to 2 per cent of GDP and to improve the efficiency of the public scientific system. These included stream-lining the research centres within ENEA and the CNR and ensuring proper evaluation procedures. MURST also took over responsibility for promoting and running the national research programmes (NRP), a series of programmes in high tech sectors initially set up under Law N46 which brought together university researchers, public research

laboratories and firms to develop research ideas in specific areas ranging from the practical - eg textiles and clothing - to the theoretical - eg, bioelectronic systems. Every NRP has to have associated with it a programme of professional training for younger technicians and researchers. MURST also took over the running of the grants programme under Law N46, and introduced several new measures to encourage SMEs to take R&D and innovation seriously.

(iii) *The reform to the EU's Structural Funds*. Until the mid-1980s, policy to the Mezzogiorno consisted largely of offering huge subsidies to capital-intensive projects. This began to change in the mid-1980s when a number of new measures, based on creating jobs and encouraging indigenous enterprise, were introduced. The major change came with the reform of the Structural Funds in 1988 which required the development of clear strategies for the use of funds. New grants were introduced with explicit selection criteria, including priority for job creation, the commitment of own resources from the enterprise and compatibility with existing regional objectives. Science and technology was identified as an important area for development. MURST took charge of these plans and encouraged a number of regions to develop quite sophisticated development plans, with an element of competition between regions. A number of regions have now developed considerable networking between academic and industrial players, helping to provide extensive support mechanisms for SMEs.

(iv) *Privatisation, Competition Policy and EU controls.* Italy's 'large firm' industrial policy lingered on through the 1980s as continued high unemployment and poor labour relations led to a succession of crises among the large firms who had grown used to a diet of subsidies. By the late 1980s, however, EU subsidy rules, public opinion and the need for increasing control over the public finances in the run-up to EMU, began to have effect, but it was not until 1992 that Italy finally began to dismantle its substantial public sector portfolio of industrial enterprises. At the same time Italy introduced, for the first time, laws to control the behaviour of monopoly enterprises, with the EU's competition authorities insisting on tougher reforms than first proposed. The combined actions, however, effectively marked the end to the era of large firm hand-outs.

Overall, the Italian experience over the last 20 years has both positive and negative aspects. The positive aspects are:

(i) the Italian government, and the regions, rose to the challenge and, from a situation of no clear, defined policy in this area, have put through a series of measures which have consistently, if gradually, constructed a coherent set of institutions and mechanisms for promoting science, technology and innovation;
(ii) these measures have systematically paid attention to two important features - SMEs and collaboration;
(iii) there has also been attention to training a cadre of people capable of understanding and managing the system, and to making the mechanisms of operation as simple and automatic as possible.

However, to date the Italian policies have not succeeded in a number of other important objectives:

(i) the system is not international enough - there is not enough exchange of personnel or international collaboration, nor does Italy attract MNE investment;
(ii) although attention is paid to SMEs, Italy lags in the use and development of ICT and knowledge-based industrial services;
(iii) the financial sector has been neglected and there is lack of provision for venture and start-up funds;
(iv) public administration, especially in the poorer regions, remains low quality, unambitious and inflexible.

Nevertheless, the achievements of the last 20 years are not negligible. To date they have resulted mainly in increased government (rather than industrial) investment in R&D, much of it into the higher education sector where there has been a considerable increase in the numbers being trained in science and engineering. The challenge for the next decade is to ensure that Italian industry makes full use of the incentive structures and mechanisms now in place to employ these new graduates and to expand its role within the system.

3.3.5 Sweden (Palonka, 2000)

Sweden is a comparatively small country with a population of 8.8 million. It developed fairly substantial industrial capacity in the late nineteenth century based on the iron and steel, shipbuilding and paper and pulp industries and it was renown for producing high grade

special steels for the engineering industry. Fast growth in the 1950s and 1960s brought considerable wealth and by 1970 Sweden was fourth in the OECD by GNP per capita. R&D expenditures were 1.6 per cent of GDP, tenth in OECD's ranking. By 1997 Sweden's ranking by GNP per capita was seventeenth; its commitment of 3.9 per cent of GDP to R&D put it top of this ranking. But the question which Swedes were asking was "if we are so clever, why aren't we so rich?"

For Sweden, as in other European countries, the oil crises of the 1970s marked the end of the era of fast growth. Shipbuilding, steel and engineering ran into trouble and were kept afloat by subsidies. Between 1972/3 and 1975/6, state aid to private businesses increased from 1.9 per cent to 7.8 per cent of the government budget, remaining at that level until 1983/4.

By the 1980s Swedish industry was dominated by a number of large Swedish-based multinational companies such as Ericsson, Saab, Volvo, Astra, Electrolux, Scania, Sandvik, SKF and ABB. As a small country, Sweden depended on exports and was vulnerable to international competition. As a high wage country it was also essential to develop products which would sell on quality rather than price. As subsidies were withdrawn from steel and shipbuilding, considerable sums were poured into R&D on the one hand, and training on the other, particularly technical and vocational programmes in computing and electronics. In this sense, Sweden's *indirect* industrial policies, like those of Germany, helped pave the way for adaptation and change.

The 1980s saw the first concern with research policy. A new bill laid down the principles to guide higher education policy in Sweden. It took the view that Sweden was a small country; that resources available for research and development were used as "rationally" as possible, which meant locating R&D in the universities rather than in separate research institutes. This 'rationalisation' led to a concentration of research activities in just six of the major state-owned universities - Uppsala, Lund, Gothenburg, Stockholm, Umeå and Linköping; in three technical universities, Chalmers, Luleå and the Royal Institute of Technology; and in the Karolinksa Institute (medical research), the Stockholm School of Economics and the University of Agriculture. Beyond this group of twelve universities and institutes, relatively little publicly-financed research is undertaken, and much of this is financed by municipal and regional governments, not the national government.

This ‘monopoly’ of publicly-financed R&D by the traditional ‘classical’ universities and technical and medical institutes is not without criticism. There are those who claim they have become a self-serving organisation, ill adapted to meet the needs of the modern industrial state (Landberg *et al*, 1995). These critics argue that a mixture of industry-based (sectoral) research institutes, and research based on the small and medium sized universities, would be more responsive to the needs of local business, particularly the SMEs. They also point to the fact that Sweden’s large MNEs are being forced to build up their own research capacity in areas once exclusive to universities. They instance the fact that only 4 per cent of industry research funding goes to the universities.

The strength of business sector R&D is the outstanding feature of the Swedish R&D system. By 1995 the business sector contribution to research funding had grown to over 65 per cent of GERD, with the government contribution dropping to 30 per cent. Between 1985 and 1995, industry’s contribution to total expenditures on R&D had jumped from 1.7 per cent to 2.4 per cent of GDP (whereas in Germany it had fallen from 1.7 to 1.4 in the wake of reunification; in France, it had risen from 0.9 to 1.1 and in the UK remained static at 0.9). These were years when Swedish industry experienced its worst post-war depression, hitting this time at Sweden’s core capabilities, with the motor vehicle, aircraft and heavy engineering sectors all in trouble, together with surplus capacity in the pulp and paper industries. In the recession of the early 1980s, unemployment had remained relatively low, partly because industrial subsidies had been used to retain jobs and fund retraining. On this occasion it jumped rapidly to 9 per cent a post-war high for Sweden, with adverse consequences for the public finances. This in turn led to substantial cutbacks in other areas of government spending, including R&D.

Recession also hit business sector R&D, but while manufacturing industry R&D stagnated, service sector R&D, especially in computing and telecommunications, expanded rapidly. In this sense the recession of the 1990s served as something of a watershed. Two industries - pharmaceuticals and telecommunications - emerged as major players, together with knowledge-based industrial services. All three underpinned Sweden’s strong showing in R&D in the 1990s.

Nevertheless, business sector R&D in Sweden remains highly concentrated in a small number of industrial groups. Swedish or foreign-owned MNEs now account for 4 per cent of

manufacturing firms; 60 per cent of employment in manufacturing; 70 per cent of investment in tangible assets; 80 per cent of exports; *and 96 per cent of R&D*. Predominantly they are still Swedish-owned. Companies such as Ericsson, Volvo, ABB, Electrolux still top the list, but the 1990s has seen a significant influx of foreign capital into Sweden and an increasing number of Swedish companies merging with foreign-based MNEs. All the groups remain R&D intensive, and the majority of R&D activities are still undertaken in Sweden. The worry is, however, that these companies will switch their R&D activities out of Sweden.

The key issue for industrial policy in Sweden in the 1990s was therefore – what policies would best keep this corporate R&D in Sweden? Has the policy of concentrating research in a super-league of research-based universities had the effect of isolating academic research too far from industrial research? Alternatively is Sweden a model that other countries should follow - where the academic sector gets on with what it is good at, namely academic research, in the process producing the product that is most valuable to science-based industries, namely well-trained researchers? The study points to tensions, especially over the allocation of resources between the larger and small universities, and between the large and small players on the industrial scene, and it suggests that it is not clear that the essentially linear model of research funding, with a super league of research universities on the one side, and a highly research-intensive corporate sector on the other but with the two not really meeting, is the right one to meet the challenges of the 21st century.

3.3.6 The UK (Sharp, 1999)

The UK, like all the other countries in this six-country study, shifted between 1975 and 1997 from a highly interventionist, subsidy-driven industrial policy to a ‘light touch’ policy, based on science, technology and innovation. As in Germany, France and Sweden, the deep recession of the 1970s, meant an inheritance of subsidy commitments to ailing industries which persisted through the early 1980s. Like the French, technology policy in the 1970s focused on large firms, with generous public purchasing contracts and additional *ad hoc* subsidies. The British government, however, had no *grands programmes*: on the contrary, except in the defence sector, by the mid-1980s its national champions were left to fend for themselves, the government actively encouraging competition by a policy of promoting foreign direct investment into the UK. Unlike the Irish government, the British government did not follow through the supply chain implications of this policy. There was no policy of

promoting technical and vocation education to upgrade skills; the science sector in universities was squeezed of funds. Nor did Britain have the German and Swedish traditions of an 'indirect' industrial policy with an infrastructure of support institutions on which to build a diffusion-oriented technology policy. As a result, in Britain, in contrast to all other five studies in this project, we see a much more decisive switch from intervention and laissez faire than in any other country.

In terms of industrial subsidies, the contrast is extreme. If the value of the pervasive tax incentives to investment are included, then Britain moved from a peak of industrial subsidies in the late 1970s which, in 1996 terms, amounted to over €30 billion a year, to a regime spending less than €700 million, of which less than one half was on industrial support.

The intensive industrial subsidy regime emerged as a result of the combined attempts of successive governments in the 1960s and 70s to stimulate industrial investment, compensate regions disadvantaged by industrial structure, and prevent the collapse of large, often nationalised, businesses. Even the Thatcher government had difficulties in preventing the complete collapse of companies such as British Steel and British Leyland. Once the recession was over, however, in the 1980s cuts proceeded apace with sell-offs and privatisation pushed through as rapidly as possible. The run-down of subsidies to ailing industries was initially compensated by the emergence of support for 'sunrise' industries, such as the 1982 Alvey initiative, helping to promote industries such as micro-electronics, biotechnology, optronics and robotics. All these schemes were abruptly terminated by the decision in the late 1980s to withdraw from all support from 'near-market' R&D, except that promoted by European collaborative programmes. Only in defence and aerospace did Britain seek to pursue anything that might be described as a '*grand programme*', but by the mid-1990s even defence had become a marginal player. Effectively by the mid-1990s, Britain had no technology policy.

If industrial and technology policy went from the extremes of intervention to laissez-faire, science policy went in the other direction – from relative independence to centralised control. Funding for academic R&D was gradually shifted from independent funding councils to control by central government departments. The universities remain theoretically independent, but constraints on funding throughout the period gave limited degrees of freedom. Instead, centrally-imposed selectivity has led, over time, to a concentration of

research funding and, as in Sweden, to the emergency of a ‘super league’ of research universities.

The other main thrust of science policy over this period in the UK was to secure ‘value for money’ from public sector research. This led, on the one hand, to a panoply of measures aimed at bringing academia and industry closer together, and on the other, to an increasing role for industry in decision making for science. By 1997, broad priorities for science were being set by the Foresight exercise, run as a joint exercise between government, academia and industry; industrialists chaired the research councils, new funding initiatives were tied to projects which demonstrated collaborative links with industry; and most public research laboratories had either been privatised or contracted out to private sector management. To a degree, therefore, science policy, with its increasing concentration of control and emphasis on value for money, was used to compensate for the lack of technology policy.

Regional policy might be regarded as the third leg of technology policy. In the UK, as in Italy, regional policy in the 1970s consisted of substantial grants to capital intensive industries such as chemicals and oil refining. The Conservatives shifted the focus almost totally to urban regeneration, slashing almost all industrial subsidies but experimenting with enterprise zones and tax breaks on venture capital schemes – neither of which worked.

The only positive policy pursued long term by the Conservatives was the active encouragement of inward investment. As a result, Britain became host to many MNEs. In some areas, especially computing software and biotechnology, small firms flourished in a business environment which rewarded self-help and self-promotion. Elsewhere, lack of investment by established SMEs in new equipment, new technology and new skills, made them highly vulnerable as competition to join MNE supply chains intensified. Britain signally failed either to upgrade the quality of the labour force necessary to attract the higher value added FDI operations, or to have mobile resources at the local or regional level to provide the broad network of support and incentives which meet SME needs.

Industrial, science and technology policy have all played a part in the changes that took place in the British economy between 1975 and 1997. The broad objectives of policy – to improve the underlying productivity performance of the British economy – remained the same, but the institutions and instruments of policy saw radical change in what the study describes as a

"daring experiment to change the culture". It is arguable, however, that the experiment involved too much change – a destabilisation of existing institutions and actors and a failure to allow new institutions to take root. Certainly for all its well publicised flexibility, Britain's growth and technological performance remained disappointing.

3.4 SYNTHESIS OF THE SIX COUNTRY STUDIES

The purpose of this report was to pull together the first stage of the project – the six country studies whose findings have been summarised above. It sought first, to set the six country reports in context; secondly, to provide an overview of findings, thirdly, to highlight similarities and differences between countries, and finally to present some preliminary conclusions.

3.4.1 The contextual framework

Chapters 1 and 2 provided the background and rationale to the six country studies. Chapter 1 described the rationale for the project and highlighted the issues to be explored. In particular it focused on the question of Europe as a 'diversity of systems of innovation' and its implications. How far do we observe, over these 25 years, different reactions in different countries to the same stimuli? How far are these differences becoming less significant? Is there any sense in which European integration is creating a European system of innovation? And in relation to institutions, whether new technologies are creating new institutions? How far institutional inertia is holding up adjustment? What evidence there is of institutional learning?

Chapter 2 explored the broad economic context of the country studies, looking at such issues as macro-economic performance, technological performance, evidence of structural change and adjustment and the role of government in relation to state aids to industry. In all cases, the performance of the six countries in this study were compared with the performance of the EU as a whole, the US and Japan. It concludes by making a three-way categorisation of the six countries: two star performers – Ireland and Sweden; three middle rank performers – France, Germany and the UK; and Italy, the laggard.

Of the two ‘star performers’ Ireland stands out in terms of both a consistent and improving growth performance, high productivity and an increasingly impressive technological performance. It is noteworthy, for example, that by the mid-1990s, Ireland had more scientists and engineers as a percentage of the labour force and a higher proportion of industry-financed R&D to GDP than the UK. Sweden, by contrast, had a poor overall growth performance, but high rates of productivity growth (especially in the 1990s). Its outstanding success came from shifting, during this period, out of an economy dominated by medium-tech, medium growth sectors such as pulp and paper, metals and engineering into fast growing telecommunications and pharmaceuticals. Sweden’s investment in R&D at 3.6 per cent of GDP is now double the EU average (1.8 per cent) and well above the 2.3 per cent achieved by Germany, the next highest contender. Of that 3.6 per cent over two-thirds (2.6 per cent) is financed by industry, whereas in Germany the equivalent figure is 1.4 per cent (and the UK, 0.9 per cent). Sweden now has more scientists and engineers as a proportion of the workforce (7.8 per cent) than any country in Europe and exceeds even the US (7.4 per cent) although it has yet to catch up with Japan (10.1 per cent). These investments have given it the capability and flexibility to make the very substantial adjustments to its industrial base.

The three ‘middle rankers’, France, Germany and the UK, recorded average growth rates of approximately 2 per cent over the whole period, but with variations over boom and slump. In the 1980s, productivity growth was considerably higher in the UK, but so was unemployment, whereas the opposite was true of the 1990s when much of the UK’s growth came from falling unemployment. This underlines the degree to which movements in productivity reflect short term (labour shakeout) rather than long term (investment in new technologies) factors. Equally, if anything Germany and France showed a greater propensity than the UK to shift from slow to fast growing industries in the 1980s, whereas the UK showed greater ‘flexibility’ in the 1990s. In other respects the UK’s record was poor. It recorded a sharp fall in R&D as a proportion of GDP, whereas France and Germany held their own in spite of pressures on public finances and (in Germany’s case) reunification. Business R&D was flat, patenting showed a sharp slump in shares of US patent and there was a falling proportion of scientists and engineers in the workforce. Indeed, while Britain, with its venture capital market and young biotechnology and IT firms likes to present itself as the California of Europe, its general technological performance is lack lustre.

Italy turns out to be the laggard amongst the six countries in the study, with a poor growth/productivity performance; continued low levels of R&D, especially from business; high (if falling) levels of subsidy and the largest proportion of firms in slow and medium growth sectors. Although it is increasing its investment in science and technology, numbers of scientists and engineers per thousand remain at half the levels of France and Germany, and (now) well below the levels of Ireland (which had started in 1981 well below Italy).

The striking feature of the comparative statistics was the 'dynamism' (in terms of moving out of old industries and into new ones) recorded by the Japanese economy in the 1980s and the US economy in the 1990s. Of the six economies in this study only Sweden in the 1990s begins to mirror this degree of flexibility.

3.4.2 The main findings

Chapter 3 presents a synopsis of each country study, shortened versions of which appear earlier in this report and are not therefore repeated here. Chapter 4 teases out some of the similarities and differences that emerge. The focus is, of course, on policies. First, what has happened to science, technology and industrial policy in the different countries over the period under review; secondly, what can we learn from the differences that emerge?

The *similarities* noted are as follows:

(i) in all countries a shift from large scale support for large firms to small scale and targeted support for SMEs;
(ii) a shift from blanket subsidies/tax relief on capital expenditure to specific support for innovation-related expenditures;
(iii) a shift from sectoral support for specific (and often declining) industries to generalised support for innovation;
(iv) a shift from protection and support for (often public sector owned) national champions to liberalisation, deregulation and encouragement of competition and a competitive environment;
(v) a new concern for entrepreneurship and risk taking;
(vi) recognition of the importance of education, training and human capital to capturing high value added activities;

(vii) a shift of policy away from the centre toward the region;

(viii) recognition of the supportive role of the EU;

(a) in terms of control over state aids;

(b) in helping, via the Framework Programmes, to refocus industrial support and promote learning via collaboration;

c) in providing via the Structural Funds, a catalyst for development and regeneration.

The differences reflected the different ways countries had reacted to similar stimuli and were many and diverse. In this respect Europe, or at least the six countries represented in this study, could be seen still as "a diverse set of systems of innovation" and there was scant evidence in the six case studies of any convergence of policy except in those few areas, such as competition policy, telecoms and biotechnology where the EU has sought to co-ordinate policy development. In general the studies found policy makers reacting to external pressures rather than leading the process of policy development. The following general conclusions were drawn:

(i) Many of the similarities (in policy reaction) stem from the fact that the external pressures have been same – world-wide pressures of globalisation; the strength of competitiveness in new technologies, first from Japan and East Asia and then from the US; the growing role of EU institutions.

(ii) The shift in policies was two-stage: first, between the 1970s and 1980s from sectoral support for sunset industries, to sectoral support for new technologies; secondly, between the 1980s and 1990s, from sectoral support to generalised support, encouraging *use* (rather than production) of new products and processes.

(iii) There has simultaneously been a two stage shift in the position of large firms – from 1970s to 1980s, from national champion to European MNE; from1980s to 1990s, further mergers to create genuine MNE operating on a global basis with world-wide sourcing and supply chains. Emphasis on SMEs reflects the importance of attracting MNE investment/involvement in supply chain activity.

(iv) While governments have meddled with industrial/technology policy, they have been more and more reticent about meddling with science policy, even though close links with the science (academic) sector have become an important part of the innovation process. Ireland and, to a lesser extent, Italy have been able to shape their science policies to this mould. Of

the other four countries, only the UK government has tried radically to reshape its science policy.

(v) Differences are revealed in both the timing of different measures and also in the processes of reform and change. These reflect not only differences in the institutions of the innovation system – for example, in banking systems or public sector research institutions – but also in the wider political and social frameworks of a country. The UK, for example, with its first-past-the-post electoral system which produces large majorities for political parties winning elections, has shown itself more willing to promote radical change (eg, privatisation) than systems where political parties need always to work with coalition partners.

(vi) Radical changes in policy come from three sources – external events (eg, the fall of the Berlin wall); sharp political swings (eg, the Thatcher government in Britain); the process of crisis and catharsis (the Swedish recession in the early 1990s). In general, with the exception of Britain, policy makers have eschewed radical changes in policy, preferring to pursue the incremental route to policy change.

(vii) Institutions learn both from their own experience and from others. To learn from their own experience, it is important not to change the framework of aims and objectives too frequently (ie, not to de-stabilise them). Benchmarking and best practice can help to inform the learning process, but it is naïve to think the experience in one country can be replicated in another.

3.4.3 Policy conclusions

The final chapter of the synthesis study explores some of the policy conclusions to emerge from the six country studies. It begins by drawing *four generalised conclusions* from the studies:

(i) The last twenty five years of the twentieth century were a period of considerable structural change effecting a shift of focus in the countries of western Europe (of which the six country case studies were representative) from resource-based industries to knowledge-based industries.

(ii) This process of structural change has been accompanied by the process of globalisation, namely a shift towards more internationalisation in the production and distribution of goods and services. In this process big firms have got bigger, national champions have been assimilated into international groups and many SMEs swept up in

localised supply chains servicing those groups. (Although many SMEs also still operate in their traditional role of meeting local service/commercial needs.)

(iii) In general, the institutional/regulatory frameworks through which these firms operate have changed surprisingly little. They remain largely national in origin and rooted in complex inter-relationships with national institutions.

(iv) Policy has followed, not led, change. Policy makers have in general been content with a re-active role and only exceptionally sought a pro-active role in stimulating rather than just managing change.

The policy conclusions that emerge from these findings are discussed in the second part of the chapter. Three main policy points emerge:

(i) *The centrality of the science base* which becomes in effect an 'entry ticket' to the knowledge-based economy. This emphasises the importance of governments supporting the science base. It is argued that this is best left, as now, as the responsibility primarily of national governments, but it is suggested that the EU might:

(a) play a more prominent role in supporting basic as well as applied research;

(b) introduce measures which prompt national governments to increase their support for the science base;

(c) increase their support for measures which encourage greater mobility among researchers between countries, including with non-EU countries.

(ii) *The complementary roles of government, academia and industry to the process of innovation*. The so-called 'triple helix' relationship between government, industry and academia has also become the more important. The key issue is the inter-relationships – no one sector can perform satisfactorily on its own. Recognition of this inter-dependency is vital to the smooth functioning of policy. Where this inter-dependency is recognised and all three sets of players work in unison toward agreed objectives, the benefits are mutual. Industry, however, has to play its part. Failure to invest in science and technology and research and development effectively excludes firms from participating in the new knowledge-based economy and they cannot look to either government or academia to make up the difference.

(iii) *The complementarity of roles between different tiers of government*. Just as all three main 'players' in the innovation process have complementary roles, so do the main players in the policy process. Given the emphasis on SMEs, the role of regional government in providing both support and links (between business; with local colleges and universities)

should be recognised. Equally, national governments have a role both in supporting the science base and in providing the broad fiscal/monetary framework, including tax incentives/subsidies, with which business has to operate. There is a growing role for the EU in setting the regulatory framework, especially for new technologies; in supporting large scientific facilities and new databases, and in acting as a catalyst for new activities. As the Irish experience illustrates, when all three tiers of government, with their respective policies, are aligned in the same direction, they can be a very effective stimulus to action.

3.5 THE CROSS-CUTTING THEMATIC STUDIES

The next stage of the project was to use the country studies as the basis for six cross cutting thematic studies. The main findings are discussed below.

3.5.1 The objectives of industrial and science and technology policies (de Bandt, 2000)

This study uses the six country studies as a means of analysing the way policy objectives are set and how they changed during the period 1975-97.

3.5.1.1 Definitions and categorisations

The study begins by defining three types of policy objective:

(i) *meta-objectives* – such as increasing the role of the market;

(ii) *system objectives* – such as improving industrial performance which in turn can be disaggregated into a host of 'way and means' objectives such as raising R&D expenditures; improving training; making technology transfer more effective;

(iii) *political economy objectives* – which reflect the interests of one particular lobby or interest group such as trades unions, MNEs, etc.

All three types of objective are observed playing a part in the period 1975-97. The issue of (government) intervention versus market forces was a recurring theme. At the system level there was constant concern with competitiveness and system performance. Likewise, on the 'political economy' front, the influence of various lobby groups – whether MNEs (Davignon's Round Table), unions (anti-privatisation) or environmentalists (anti-GM foods) was observable.

Cutting across these broad definitions by objective, the paper introduces six further categorisations of policy action:

(i) *policies aimed at macro-economic phenomena* – growth, unemployment, inflation, oil shocks, etc;
(ii) *policies aimed at changing the rules of the game* – privatisation, liberalisation, deregulation, etc;
(iii) *policies concerned with adaptation and adjustment* – restructuring, networking, clustering, etc;
(iv) *policies aimed at seizing technological opportunity* – in relation to specific sectors such as nuclear power, ICT, biotech, the internet;
(v) *policies aimed to meet new challenges* – the rise of knowledge-based business services; computing and the 'control' revolution;
(vi) *policies predicated on 'more debatable hypotheses'* – ideas such as the productivity paradox, the concept that 'small is beautiful', etc.

It points out that at any moment in time, governments are likely to be operating a mix of some or all categories of policy, and for a variety of motives.

3.5.1.2 Developments in policy 1975-97

The paper then looks at broad developments in industrial, science and technology policies over the period concerned, developments illustrated in detail in the various country studies. It identifies five main trends in policy:

(i) *industrial restructuring* – the need to restructure and rationalise both old and newer (chemicals, cars, consumer electronics) industries is a theme that runs through all studies. They were particularly prevalent in the period 1975-85 and link with (iii) above, especially at this time with OECD's attempts to promote 'positive adjustment policies;
(ii) *from industrial intervention to market oriented policies* – there is enormous variation from country to country, but perhaps the sharpest swings were seen in Britain with the shift from the interventionism of the later 1970s to the privatisation of the Thatcher era. But France also had its moment of heart searching (1983) and even in Germany there have been tensions between the neo-liberalism of the Ministry of Economics and the more interventionist ideas of the BMFT/BMBF;

(iii) *from industrial policy to science and technology policy* – the logic of OECD's positive adjustment policies pointed towards support for new, rather than old technology areas, while Henry Ergas' (1983) plea for 'diffusion' rather than 'mission oriented' policies suggested generalised rather than sectoral programmes of support.

(iv) *the rise in support for SMEs* – the paper points to the paradox of the SME being cast in the 1960s as old-fashioned and inefficient whereas by the 1980s it has become the thrusting champion of new technologies;

(v) *decentralisation and the shift to regional development policies* – there were many different influences behind this shift in policy including the need for regeneration policies in both urban and rural areas, the rise of new organisational systems based on networking and the cult of the SME.

Two further issues of policy are also identified as emerging during this period. First, ideas about *national systems of innovation* as each country went down a similar learning curve (often explicitly borrowing policies one from another) only to come up with different results. This factor is, the study suggests, at the heart of the European paradox and focuses attention of Europe's fragmentation into a series of national systems with diverse performances. Secondly, it points out that while globalisation has been undermining the degrees of freedom enjoyed by the nation state in relation to industrial policy making, it also meant that *attracting foreign investment,* especially when it brought high quality jobs, suddenly became an objective in its own right.

3.5.1.3 How policies evolve and take shape

Using the six country studies to analyse the question of how policies evolve and take shape, the report reaches the following conclusions:

(i) Although the announcement of a new policy may be preceded by a wide policy debate, *actual objectives of policy are often implicit rather than explicit*.

(ii) Even when policy objectives are made explicit, they are *frequently very generalised*, shrouded in vague terminology without clear statements of the functional relationships which underpin expectations of outcomes.

(iii) There is often *an implicit hierarchy of objectives* built into the system which is accepted and never discussed. For example, macro-economic policies (eg, to contain inflation) take precedence over micro-economic policies (eg training to meet skill shortages)

in spite of the fact that it is accepted that meeting the micro-economic objective may contribute substantially to promoting flexibility (adjustment) in the economy and limiting inflationary pressures.

(iv) There is seldom any explicit spelling out of *the way a system of objectives is expected to function*. To take the previous example of the link between improved performance and training, the full chain linking performance, productivity, output per hour, to incentives necessary to encourage training is very seldom spelt out. As a consequence the assumption is that policies can easily be turned on and off at will.

(v) *Objectives are seldom quantified or defined*. Too often they are couched in terms of 'promoting scientific excellence', 'establishing entrepreneurial attitudes' or even 'encouraging research and development', without clear specification which allows *ex post* evaluation.

3.5.1.4 Conclusions

These findings point to a number of strong conclusions:

(i) Whether deliberately or because they are ignorant of and/or do not understand the workings of the innovation system, ministers and civil servants who formulate policy frequently fail to be explicit about policy objectives; fail to spell out the system dynamics implicit in their policy thinking, or the implicit hierarchy of objectives implicit in their programmes.

(ii) As a result, too often policy is implemented through a series of dispersed measures introduced on a 'trial and error' basis. (This picks up one of the conclusions of the synthesis study which was that policy development tended to be incremental and evolutionary rather than radical.)

(iii) This lack of clear thinking about policy and policy objectives makes it all too easy for policy makers to be captured by lobbyists and special interest groups intent on achieving their own agenda.

(iv) One of the reasons for this very generalised approach to policy making would seem to be a lack of knowledge on the part of policy makers about the workings of the science and technology system. (Or perhaps too often a naïve view of relationships as linear, ignoring the important inter-dependencies within the system.) This suggests that more emphasis needs to be given to the now substantial body of social science research which has explored these

relationships so that ministers and civil servants are better advised when formulating and developing new policies.

3.5.2 The globalisation of science and technology (Sigurdson, 2000)

3.5.2.1 Rationale

Since the process of innovation involves not just the generation of scientific and technological ideas, but their take up and exploitation, the issue of globalisation (the increasing internationalisation of the processes of production and distribution) poses interesting policy questions. If production and distribution systems are increasingly in the hands of large multinational companies (MNCs) then what role is played by *national* science and technology institutions? How far are national R&D resources critical for industrial R&D? What policy instruments can regulate such a trend if it exists? What forces, if any, are encouraging a clustering of R&D activities? What policy challenges does this pose for the EU? These are the questions raised by this report.

3.5.2.2 Background – non-globalisation or globalisation of R&D?

The paper begins with a discussion of the inter-relationship between company systems of innovation (CIS) and national innovation systems (NIS). It points out that until recently much of the evidence pointed to the non-globalisation of R&D. Corporate R&D, like corporate administration, tended to remain in the MNC's home country and although available patent studies indicated that some R&D was carried out outside home countries, they showed clearly that a majority of R&D was still located in home country laboratories. This was true particularly of Japanese MNCs, but also of US, French and German firms. In general it was the smaller countries – Belgium, the Netherlands, Sweden and Switzerland – where foreign MNCs contributed substantially to patenting, but the UK in the 1970s joined this group, with nearly half its patenting activities deriving from outside national borders.

The last decade of the twentieth century has, however, brought substantial changes.

(i) *The restructuring and re-organisation* of MNCs through mergers and acquisitions has dramatically altered the control of companies, away from country (and often also family) based management systems towards international businesses run by professional managers

and institutional investors. In such MNCs location of function is driven by economics, not sentiment.

(ii) *The downsizing of central functions* which in turn has led to what are variously referred to as 'hollow' corporations and/or 'lean and mean' organisations, with all but central management functions hived off to outside specialists. Where this happens to R&D, the central organisational core will tend to buy in specialist knowledge from around the globe. This in turn has led to the emergence of clusters of specialist firms, themselves sometimes spin-offs from an MNC laboratory, competing for MNC contacts.

(iii) *The shift towards collaborative R&D* which has led to joint ventures with other companies, including small specialist firms, or with public sector/academic research laboratories. Such collaborations have been particularly associated with new technologies (ICT and biotech) but apply also to mainstream sectors such as cars and chemicals. Collaboration means a sharing of the costs and risks associated with the innovation process.

All these factors mean that at the end of the twentieth century policy makers are having to face new challenges. Countries with strong science and technology bases may well find large, cross border MNCs are operating in their country, vying for key resources. Sweden, for example, finds Ericsson's success in mobile telecommunications has brought to Sweden a large number of ICT affiliates – Microsoft, Nortel, Motorola, Sun Microsystems, Oracle, Intel, Nokia and Hewlett Packard. The UK finds a similar clustering of firms in the pharmaceutical sector. This clustering of activities brings with it both benefits (high value added jobs) and costs (intensive competition for those with skills in advanced technologies).

The result can be summed up by the fact that OECD has recently revealed (OECD, 1999) that 95 per cent of industrial R&D is performed in just 14 countries.

3.5.2.3 The Policy Response

Responses to R&D globalisation vary from country to country. Many governments are apprehensive about the globalisation of R&D, fearing a 'hollowing out' if innovation activities become as mobile as production has become. Of the six countries in the project, the UK and Ireland have both welcomed this increased mobility and see themselves as net beneficiaries. But for both these countries the net R&D intensity of the MNCs entering the market is greater than the R&D intensity of indigenous firms. For Sweden the problem is different. The degree to which it is becoming a focal point for the IT industry raises serious

issues in terms of the supply of specialist labour from universities and colleges and the 'poaching' of staff from existing companies. Many companies are asking for lower taxes on key foreign staff in order to facilitate recruitment of specialists from overseas.

The report notes that the Clinton administration in the US supported "the creation of the technology-based competitive assets that are internationally mobile, while placing far less weight on the ability of US firms and workers to absorb and apply technological advances from foreign sources" (Sigurdson, 2000, p51). The EU too is criticised for too insular a focus. "If one considers the dramatically increased needs and possibilities for rapid and international cooperation and information exchange, this *de facto* intra-European focus needs a more extended, complementary extra-European focus." (Sigurdson, 2000, p57.)

3.5.2.4 The Policy Advice

The study repeats the policy advice given in a recent Germany study (Jung Mittag *et al*, 1999, pp74-75), "Not only leading edge research, but also the opening up of new (lead) markets by anticipatory future-oriented pilot projects is decisive for the international attractiveness of the national innovation system. The target group for technology policy has altered: research driven enterprises are engaging in a change of strategy and are giving more consideration to the conditions of lead markets and production networks … The results of our study underline the necessity for better networking between the different areas of policy." And it goes on to list policy areas such as venture capital; regulatory frameworks and standards; transport, environment and health and safety policies; competition policy; and, last, but not least, civil service policy to provide "flexibility in institutionally-supported research establishments".

Two important conclusions emerge for the national policy perspective:

(i) public policy should direct its efforts on the broader conditions for entrepreneurship and competitiveness, including labour markets, the environment for promoting knowledge-based industries and the general infrastructure for innovation.

(ii) The focus on the nation or the company as such is less important than providing support for productive systems such as value chains, clusters and industrial districts. It is, as the report reiterates, "essential to understand the network character of companies" (Sigurdson, 2000, p61).

These conclusions reinforce three of the conclusions that emerged from the country studies:

(i) that in Europe, as in America, benefits derive not just from being involved in the *production* of new technologies, but from being able to absorb and apply technological advances from elsewhere. Education and training and support for the science base are important aspects of this;
(ii) that networking between industry and academic or government-sponsored research institutes is an important part of any innovation system – the triple helix relationships remain vital;
(iii) that it matters less who is responsible than that the combination of EU, national and regional government *delivers* a broad infrastructure of support and regulation which helps promote innovation.

3.5.3 Foreign Direct Investment (TH/CIRCA, 2000)

This paper provides an overview of foreign direct investment (FDI) flows into and out of the six countries featured in this project and considers in particular the degree to which policy deliberately sought to attract/develop FDI.

3.5.3.1 A statistical overview

In the EU as a whole for the 10 years 1986-95, inflows and outflows of FDI were more or less in balance. Inflows totalled €227bn, outflows €270bn. The US was the main recipient. In that country inflows totalled €440bn whereas outflows totalled €170bn. Japan was the main provider of funds. Inflows into Japan were only €5bn, whereas outflows totalled €220bn.

In relation to FDI with non-EU countries, the UK was the largest investor abroad accounting for 27.5 per cent of the outflows. It was also the main recipient of inflows, taking 35 per cent of the whole. Germany and France contributed sizeably to outflows, contributing 20 per cent each, followed by the Netherlands (13 per cent) and Sweden (5 per cent). By contrast on inflows, after the UK's 35 per cent, the only sizeable recipient was France (15 per cent). The Netherlands, Spain and Belgium each received approximately 8 per cent; Sweden and Germany, 6 per cent; Italy, 5 per cent; and Denmark and Ireland each 2 per cent (although in the case of Ireland FDI amounted to 5 per cent of GDP).

France and Germany topped the tables for intra-EU outflows, each investing some €83bn (22 per cent of total) over the ten years (1986-95), followed by the Netherlands, Belgium, the UK and Sweden in that order. France topped the list of intra-EU recipients (20 per cent of total), followed by Spain, Belgium, the UK, the Netherlands and Germany (6.5 per cent of total). As a percentage of GDP, the smaller countries, especially Belgium, the Netherlands and Ireland benefited from the intra-EU flows; Ireland and the UK from the extra-EU flows.

3.5.3.2 Policies to promote FDI

The evidence from the six countries studied is so varied that synthesis is difficult. In general a distinction can be made between those countries which have no especial policy towards FDI (Germany, France, Sweden and Italy) and the UK and Ireland which have pursued positive, proactive and interventionist policies favouring FDI.

(i) Countries with no positive policies towards FDI

The Federal German government has had no explicit policy on FDI. Foreign investors have equal access with German investors to the range of incentives and subsidies available, but there is no particular link with innovation. The government has made it clear that in its view, Germany does not need FDI inflows, but it encourages the Länder, especially the new Länder of former East Germany, to take a more active role. For its part, Germany has not been a major recipient of funds. The relatively high valuation of the DM and perceptions of Germany as a high cost business location may have played some part in this, but so too may the business tradition which has discouraged mergers and takeovers.

The French government, coming from an earlier position of resistance and protectionism, has more recently softened its policies and attitudes towards inward investment. France is now a big player in the FDI stakes, finally acknowledging the inevitability of globalisation, and attitudes towards FDI are now more positive. The underlying reasons however are not explicit or clear and may simply be based on the supportive conjunction of many decisions, public and private. There is no clear and specific national strategy in France for the support of FDI.

Swedish policy towards FDI may be best described as indirect. Policies to support the growth of an advanced IT technology sector in Sweden, have attracted the attentions of many of the major international IT companies, many of whom are locating R&D facilities in Sweden, as a

direct result of these policies. Other indirect measures of relevance to FDI in Sweden include instructions to various agencies, the National Tax authority, the Patent Office and others to be mindful of the needs of foreign industry and to use English language for communication and correspondence.

Italy has not been attractive to FDI although if anything the level of inflows has been slightly above that of outflows. There has been a slight increase in recent years associated with developments within the single European market and privatisations, but generally speaking the perceived inflexibilities of the Italian market and inefficiency of its public sector have discouraged potential investors. Nor is there any policy to attract FDI, although many have called for such a policy in recent years and the general inducements in favour of investment in the south of Italy apply as much to foreign as to Italian investments. The fact that most FDI entering the country goes to the north suggests that even this policy has little effect.

In all these countries, FDI appears primarily a market and commercially driven phenomenon. Market entry strategies are seen as the key drivers behind decisions of companies to locate in Germany and France, proximity, access to customers and to key markets. In Italy, movements in FDI, in and out, appear to be based on considerations of scale economies and to fluctuate with the economic cycle. Swedish FDI movements appear to be related to trends in industrial restructuring, mergers, acquisitions, etc. In contrast to Italy, FDI in Sweden appears to be motivated by the presence of technology competency, especially in IT, which is attracting R&D investment by incoming foreign firms.

(ii) Countries with positive policies towards FDI

Of the six countries only the UK and Ireland are following explicit and interventionist FDI policies. In both cases, FDI policies are closely linked with industrial policy objectives. The approach is managed and the policy linkages are quite strong, both in industrial and RTD policies. Linkages to and concerns about the adequacy of the national RTD/science system are also strong. In both countries foreign firms are concerned about the quality of the RTD infrastructure and about likely developments which might influence this. In particular, concerns are evident about the capacity of the university system to produce the skilled manpower required. In both countries, the availability of skilled manpower is a major attraction, and policies are responsive to these concerns.

The evidence indicates that, on the whole, the positive and proactive policies towards FDI in the UK and in Ireland are working. The incoming companies are becoming embedded, performing R&D and valuing the national system of innovation. In the UK there is some evidence that the quality of the national science base, and government policies towards its development, are of major interest to foreign firms. In Ireland, the selective focus on high growth sectors which is being followed is producing a high quality, technology intensive FDI. In both countries there is clear evidence of developing linkages with the research system, although interaction with universities is still somewhat problematic. In both countries also there is a keen interest on the part of the foreign firms in developments in national policies, which are closely monitored.

In the case of Ireland, a closely integrated triangular relationship between industrial, RTD and FDI policies is evident, closer than is evident in any of the five countries studied. There is close co-ordination between these policies, especially between the responsible government and executive agencies, with FID policy possibly occupying the dominant position. Science and technology policies are very sensitive and responsive to FDI requirements. In addition, there are good communications between the development agencies and the incoming firms, with strong aftercare and maintenance support for the newly established firm.

3.5.3.3 Conclusions

Overall, this evidence suggests that, given the political will, governments can turn globalisation to their advantage. MNCs are attracted by high quality facilities and a skilled labour force, but for their part are willing to contribute to the system. In both the UK and Ireland the record suggests that MNCs spend proportionately more on investment, R&D and training than their local counterparts.

3.5.4 Knowledge and technology transfer and innovation (Reinhard, 2000)

The key issue examined by this paper is the changing nature of technology transfer as the corporate sector shifts from in-house R&D to outsourcing key requirements from outside, specialist suppliers. As a result, innovation is no longer an internal activity but one that involves developing external links and working relationships. In turn, these relationships can no longer be ‘arm’s length’ – effective technology transfer requires direct, working co-operation between those concerned (because so much knowledge is tacit and passed on by

word of mouth and learning by doing) – and requires a willingness on the part of both sides to work together and an ability on the part of the recipients to 'absorb' knowledge.

3.5.4.1 The concept of absorptive capacity, spin-offs and intermediaries

The paper puts much stress on the concept of absorptive capacity because it sees this as a substantial barrier to technology transfer in the SME sector and in those member states where the corporate sector fails to invest sufficient in R&D resources. Being able to absorb state-of-the-art knowledge means, the paper stresses, being able to understand how to use and apply the ideas being developed by scientists and engineers working at the leading edge of developments. This means that a company needs to have *in-house* scientists and engineers with sufficient knowledge and calibre to be able to do this. Firms which fail to invest in R&D, whether large or small, do not have this capability. Their scientists may well lack the specialised knowledge required or, for that matter, have to spread themselves so thinly across all the functions of the firm, that they do not have the time or resources at their disposal to make effective use of knowledge they require.

In the past, the paper explains, too much attention has been given to the *spin-off exploitation* model of technology transfer. This derives from the linear view of the relationship between science and technology, with failures to exploit scientific discoveries blamed on the lack of linkage between, on the one hand, scientists in their research establishments and, on the other, the scientists and engineers in the corporate sector. The tendency was to assume that the problem was solved if a suitable *intermediary institution* was established. Hence the plethora of science parks, technology centres and industrial liaison offices established in the 1980s and 1990s. The paper argues, however, that such an approach is fundamentally ill-conceived because the key element in technology transfer is direct contact between the two institutions. Intermediary institutions only work if, like the small, dedicated biotechnology firms, they involved scientists working closely together (often those in biotech spin-offs retained links with their former laboratories) and exploitation was either in the hands of the small firm itself, or the team involved were effectively transferred over to the corporate laboratory for the period of exploitation. Intermediaries which just transferred blue-prints and did not involve direct hands-on experience were much less effective.

3.5.4.2 The six country studies

Looking across the six country studies, the paper notes a number of common elements. In all six countries there have been problems in 'integrating' the idea of technology transfer with the internal values and objectives of scientists. For many scientists the pursuit of knowledge for its own sake is the ideal and the idea of pursuing science for profits is an anathema. The exploitation of research is therefore seen as an *ex post* activity, once the scientific research has been completed, published and verified via peer review. This, of course, conflicts with the interests of those who wish to see rapid exploitation, because publication prevents patenting, and patents are necessary to ensure profits and early exploitation. In all countries, therefore, governments have tried to set up 'exemplary' structures bringing universities and research institutes together with industry and trying to create incentive structures which give researchers a personal interest in applied, innovation-oriented research.

The main inhibitor to effective technology transfer is, time and again, lack of absorptive capacity on the part of the enterprise. This involves the paper stresses, not just technical knowledge and capabilities, but managerial capabilities and a willingness to innovate. Few national programmes tackle this issue and even when they do, as in the UK Business Links scheme, too often it is predicated on the top-down consultancy model. *Decentralised structures* are vital. Insofar as direct learning comes from co-operation and networking, local knowledge of people and institutions which engenders *trust* between players is essential.

The UK is the country where government (policy) has gone furthest in trying to create structures which bring the academic sector and industry together, with a large range of incentive schemes encouraging joint research initiatives, academic spin-offs and new enterprise. Britain is let down by its corporate sector, however, which invests less in R&D than most of its competitors, and by the almost non-existent R&D on the part of its non-high-tech SMEs.

France and Germany both have substantial research institute sectors where the problems of autonomy are considerable. But experience shows that autonomy and effective technology transfer are not mutually exclusive. Both countries have examples of best practice here. Nevertheless, there is to great a tendency to set up intermediary institutions to help bridge the gap, too many of which remain as intermediaries and play little part in the production or exploitation of science.

The regional governments in France are also helping to promote ‘technopoles’ based on bringing together the scientific resources of the region with new, young enterprise. In Germany, the Länder government have also helped exploit local scientific resources, but the long history of organisations like the Fraunhofer Institutes, set up after 1945 to help SMEs understand and exploit new technologies, has given Germany a substantial lead in developing ‘diffusion-oriented’ technology policies.

In Sweden, where most of the scientific research is undertaken now in universities not research institutes, there is surprisingly little joint research between universities and industry. This is the major challenge for that country.

Italy is the country among the six considered in this project which has done least to promote technology transfer. To date too often the answer to technology transfer has been the establishment of science parks with little real linkage between scientists and enterprise. It is hoped that the new ministry, MURST, bringing together as it does the university, research institutes and industrial R&D, will be more innovative in its approach.

Ireland, while new to industrialisation, has a university sector of relatively high standing as well as technical colleges well matched to the size of the country and its industry. Although the university sector proved a slow mover, the Programme of Advanced Technologies (PATs) has helped to build centres of excellence in specific sectors which, it is hoped, will catalyse further growth. To date, as in the UK and Italy, the main problem lies with the corporate sector and its ability both of absorb and to manage new technologies.

3.5.4.3 Policy conclusions

The policy conclusions to emerge from this study are:

(i) Technology transfer is a two-way game. It requires an ability and readiness to engage in technology transfer at research institutes and universities *and* absorptive capabilities and competencies on the part of the enterprise. To date, while much emphasis has been put on the difficulties and inhibitions felt by academic scientists, they have often in the event proved more flexible than their corporate counterparts.

(ii) Willingness to work collaboratively with industry is a necessary but not sufficient condition for effective technology transfer. It also requires decentralised structures, so that

those involved have a sense of ownership of the programmes and can build up trust in each other, and it means widening the education of scientists and engineers to include such things as science and technology marketing.

(iii) There are no clear 'recipes' for successful technology transfer – different institutional frameworks work well in different countries. It is important, however, that where incentive structures are created (eg, to link up with industry) that evaluation procedures should reflect these goals.

(iv) A key issue is the absorptive capacity of the enterprise – its ability to identify, adopt and convert scientific and technological knowledge into innovativeness. This is reflected not just in R&D expenditures, but in broader process competency. There is a particular problem in relation to SMEs. Again, there is no obvious remedy, although the German 'model' which combines local support from Länder and chamber of commerce advisers, with specialist support from a sectoral or Frauenhöfer research institutes, has a good track record.

(v) The dominant technology transfer model remains too often the linear model which sees the problem solved by an 'intermediary' to liaise between researchers and industrialists – the 'spin-off' exploitation model. While spin-off firms and new technology-based enterprises (which often involve those who have worked on the research in the process of exploitation), can prove very effective mechanisms of technology transfer, the key element is personal interaction between those working on the research and those seeking to exploit it. Intermediary institutions such as science parks which do not provide for this interaction may prove expensive mistakes.

(vi) European programmes have been valuable in establishing a collaborative and co-operative approach to research but:

(a) they must recognise that they have to be complementary to national and regional measures;

(b) where intermediaries, such as the Innovation Relay Centres, are established, their functions must be precisely formulated. In particular, such intermediaries should not seek to provide advice, eg, on patent issues, which is better provided by the private sector.

(c) the EU cannot seek to 'run' the science policies of member states, but it can help by establishing bench marks, best practice guides, etc. An annual European prize rewarding best practice in technology transfer might, for example, provide an effective incentive to encourage new approaches.

3.5.5 Regional policy (Braga *et al*, 2000)

The report on regional policy seeks, first, to describe the evolution of regional policy in the six countries involved in this project, focusing on the period 1975-97 and on initiatives relevant to science, technology and innovation policy, and, secondly, to consider these developments in the context of the growing role of the EU through the administration of the Structural Funds.

3.5.5.1 Evolution of regional policies in the six countries

(i) Germany

Germany is the only country among the six to have deeply rooted regional structures. These date back to the post-1945 constitution which deliberately divided responsibilities between the federal and regional governments. However, it was not until the late 1970s that the Länder governments began to use their powers to promote a positive shift towards structural change. Nord Rhein Westfalia and Baden Würthemberg were particularly influential in setting the example of what could be achieved by a determined 'bottom up' approach. By the late 1990s, 14 out of the 16 Länder had followed the example with laws and institutions aimed at helping local firms, especially SMEs, exploit new opportunities. Expenditures were not however great. The combined spending of the Federal and Länder governments on SME support amounted in 1994 to DM3 billion (€900 million).

(ii) Italy

Italy is the other country among the six which might claim a 'tradition' of regional activity, with the Cassa di Mezzogiorno established in the 1950s to promote the development of the poorest regions of Sicily and Southern Italy. The Cassa created jobs by subsidising large capital intensive industrial and infrastructure projects. The relative ineffectiveness of this strategy was shown up in the early 1980s by the success of the Emilia Romagna region in pump-priming small scale local businesses. The Cassa was finally abolished in 1986, while simultaneously the powers of regional governments were expanded. But it was not until the early 1990s that these changes began to have effect and then, as in other countries, it was the more dynamic regions of central and northern Italy that had seized the opportunities offered by decentralisation. While one or two of the poorer regions (Abruzzo is the prime example)

have prospered under the new regime, most lack the leadership and administrative capabilities to make the most of new opportunities.

(iii) The UK

The UK, like Italy, has a history of top-down regional policy geared to subsidising capital-intensive activities. The ineffectiveness of the policy was exposed in the 1970s when it was found to be heavily subsidising the North Sea oil industry but creating very few jobs. This led to a sharp switch of policy towards urban regeneration – in effect from a regional industrial policy to regional social policy, a trend reinforced by the EU's Structural Funds programmes, which provides substantial Objective 2 (declining industrial areas) funding for the northern regions. The shift of industrial/innovation policy towards SMEs has brought renewed interest in regional links but until the late 1990s (when the new Labour government created regional development authorities in the English regions), only Wales and Scotland had the regional framework to support these moves. In most respects they remained top-down initiatives, lacking the local networking frameworks necessary for success.

(iv) France

France, always perceived as a country with a highly centralised administrative machine, in fact made a positive move towards decentralisation in the early 1980s, inspired in part by the EU's new found interest in regional disparities. (The accession of Greece, Spain and Portugal at that time focused interest on regional disparities and the Structural Funds were established primarily to help eliminate the differences.) Through the mechanism of 'contrâts du plan' negotiated between the central government (represented by the prefets at regional level) and the respective regional authorities, a relatively satisfactory joint planning approach emerged, with SMEs, technology transfer and university/industry high on the agenda. As in Italy, the best results have come from the most dynamic regions.

(v) Ireland and Sweden

Ireland and Sweden are both much smaller countries in population terms than the other four and both have come to regional policy late, stimulated by membership of the EU and pressures to access the Structural Funds. Indeed Ireland's (successful) industrial policy agenda, based on the building up of indigenous capabilities alongside targeted multinational activities, mirrors the types of policies pursued at a regional level elsewhere. As it is, Ireland's own regional policies are deemed to be somewhat fragmented and untargeted.

Sweden, a country of 8 million with a substantial but thinly populated land mass (qualifying for the specially created Objective 6 status under the Structural Funds), while having a strong base in decentralised local government, has only in the late 1990s begun to decentralise industrial policy. As the Swedish country study made clear, the highly centralised programme for the period under consideration (1975-97) has come under some criticism for ignoring the needs of SMEs and the municipalities.

3.5.5.2 EU Regional Policy

The study describes the development of the Structural Funds as "one of the most important changes of approach in Community policy making". In particular it identifies three aspects of the 1988 Reforms as important:

(i) the underlying principles of subsidiarity (devolving responsibilities down to lower tiers of government unless there are strong arguments for not doing so), partnership, co-funding and additionality;

(ii) concentration on intervention in the poorer, less developed areas;

(iii) the requirement for a multi-annual planning framework, so that projects are set within a framework of long term objectives.

Of the six countries involved in this study, Italy received the highest amounts of support from the EU, while Ireland received the highest sum per capita. In the period 1992-4, Italy received a total of €14.96 billion in Objective 1 funding whereas the UK received €2.14bn in Objective 2 funding. While all such funds require co-funding by national and regional authorities, they are, nevertheless, substantial in relation to national spending and it is not surprising that the requirement for regional planning and regional involvement in decision taking has helped to rewrite the regional agenda in Europe.

3.5.5.3 Conclusions

The concluding section of this study highlights the following points:

(i) the diversity of roles, structures and evolution in the regional support regimes that has developed in the different countries;

(ii) within this diversity, convergence towards support at the local level for SMEs, and an increasing awareness of the need to link this support with support for innovations;

(iii) that such support (ie, local level support promoting innovation among SMEs) is simpler, faster and more efficient than other methods of support and *therefore should be fostered and encouraged*;

(iv) that the overlap of national and regional programmes can be read as wasteful lack of co-ordination, but can also hide a useful reinforcement of message from one level to another. Careful planning between authorities can help to develop policies which, while avoiding duplication, offer mutual reinforcement with benefits on both sides;

(v) that EU programmes under the Structural Funds have provided a stimulus to the development of regional programmes, in particular encouraging the regional tier of government to become "the thinker and manager" of its own development. This in turn raises a number of important issues:

(a) it points to the power which the 'conditionality' principles (subsidiarity, partnership, co-funding, CSF framework planning) have in shaping the policy agenda and raises the question as to whether innovation and RTD are prominent enough objectives or whether too many projects still look to infrastructure development as the norm.

(b) it leads to a situation where precisely those regions which are the most innovative and dynamic seize the opportunities available, reinforcing their advantages over less dynamic regions. It is important, while not dampening the enthusiasm of the go-ahead regions, to find some mechanism which ensures that the less advantaged do not miss out;

(c) in this regard, one clear advantage of the more dynamic regions is being able to attract people of vision and capability. This suggests that national governments and the EU should pay more attention to training a corps of administrators who can be assigned to work in less advantaged regions to develop institutional structures and train capabilities.

3.6 THE INTER-RELATIONSHIP BETWEEN NATIONAL AND EU POLICIES (SHARP, 2000)

3.6.1 Aims and objectives

As explained in the introduction, the original intention of this report was to act as a synthesis report for the whole exercise. In the event two factors inhibited this. First, many of the second

stage, cross-cutting reports had not been completed at the time when this report was due to be written. Secondly, many of the first stage country studies contained little detailed material on the impact of EU policies which could be used in developing this particular study. Given constraints on time and resources, it was decided to make this study itself in effect into a cross-cutting report, leaving the final report to provide the synthesis.

This study examined three different sets of policy which impinge on the science, technology and industrial policy theme – state aids policy, the Community Structural Funds and the Framework Programme. The purpose was to look at the interactions between national and community policy and specifically at how far the emergence, in all three cases, of a strong strand of Community policy has affected domestic policy-making. Have national governments accepted the developments at Community level and accommodated national policy to encompass Community initiatives? Or have they continued to make national policy decisions without regard to what is happening at Community level?

3.6.2 The general impact of EU policies

The story revealed by this study is mixed. In all three areas the impact of policy has been substantial. *State aids legislation* has constrained profligate subsidies to crisis sectors, limited the degree to which member states can out-bid each other in attempts to attract footloose foreign direct investment and helped redirect subsidies towards RTD and regional objectives. A notable achievement was the fact that, in spite of the depth of the recession in the early 1990s, there was no re-emergence of the subsidy wars which had plagued the early 1980s in sectors such as steel and shipbuilding. *The Structural Funds*, significantly reformed in 1988, had not only provided help for the most disadvantaged regions of the Community, but had instigated an approach which required the development of an integrated planning framework, bringing national and regional governments together and stimulating initiatives, beyond the traditional 'roads and bridges', to recognition of the importance of innovation and the knowledge and skills necessary to promote successful innovation. Finally, *the Framework Programme* had provided an "avenue of opportunity" for countries to develop and expand that knowledge and skill base in conjunction with firms, universities and research institutes in other countries. By encouraging collaboration, both between institutions in different countries and between academic and industrial partners, the Programme was prescient in recognising

the importance of networking in knowledge creation and transfer and in recognising that new technologies were changing the boundaries of applied and basic research.

3.6.3 Impact on different countries

The study reveals that the impact of policy has varied from country to country. While, for example, *France* has perhaps fretted most at the constraints imposed by *state aids legislation*, its impact has probably been greater on a country such as *Italy* where subsidies, as a proportion of manufacturing value added, have fallen from 9.5 per cent in the early 1980s to 4.4 per cent in the period 1996-8. They remain, still, the highest amongst the six countries studied, but, without the threat of sanctions and ultimately being taken before the European Court of Justice, it is doubtful whether successive Italian governments would have had the clout to limit sectoral subsidies, just as, for their part, both French and UK governments have been able to fall back on Community regulations to limit demands from motor car and steel producers for help in recession.

With the *Structural Funds*, the biggest impact is judged to have been on *Ireland* (which on a per capita basis has also received most from the Funds), where the 1988 reforms reinforced the moves already in hand towards an industrial policy based upon innovation and gave high priority to the development of skills and the knowledge economy. By contrast, *Italy* has signally failed to shift priorities, leaving a disproportionate share of funds received still going to traditional partners to provide the 'roads and bridges' infrastructure rather than the knowledge infrastructure necessary for the new economy. The other four countries in the study – Germany, France, Sweden and the UK – have benefited less from the Structural Funds, although *Germany* has received substantial sums to help rebuild the facilities in the new Länder, and both *France* and *the UK* have received significant help for the old industrialised areas now suffering from de-industrialisation. While the development of the Structural Funds has undoubtedly stimulated these countries to recognise the importance of regionally-based initiatives (and the role that innovation can play in these initiatives), only in Ireland has the government sought to shift policy in a deliberate attempt to align national policy objectives alongside those of the Structural Funds. In other cases, all too frequently the Funds are absorbed within a framework dominated by national priorities.

In relation to the *Framework Programme*, the study suggests that, of the six countries studied, the policy impact has been greatest in Italy and Ireland. In *Italy* the FP provided shock therapy. It was a means of benchmarking Italian science and technology against its counterparts in the EU, and it was shown to perform rather badly – so badly, in fact, that, as a result, there has been a major shake-up and re-ordering of policies and institutions; with the establishment for the first time of an overall, integrated ministry dealing with the universities and research in science and technology. For *Ireland*, too, the FP has also provided a bench mark, but one against which the Irish government can measure the success of its own policy of upgrading Ireland's skills and competencies in science and technology, while the collaborations themselves provide a route both to upgrade skills and to provide Irish scientists and engineers with experience in leading-edge international research laboratories.

However, for the other countries in the project, the *policy* impact of successive Framework Programmes has been slight. *For France*, where most of its leading technology-based firms and research institutions participated in collaborations of one sort or another, the benefits were judged substantial but, and this is the key issue, did not result in any significant policy changes by the French government. Likewise, in *Britain*, we can observe the government implicitly assuming that the European collaborative programmes would continue to support applied (near market) R&D (and withdrawing its own support from this area), but there are few explicit policy initiatives which acknowledge the existence of the Framework Programme. This is true also of *Germany and Sweden*. It is not that the FP is not acknowledged or seen to perform a valuable function in promoting RTD and encouraging collaboration, just that, for all its initiatives, it has not caused these governments to change the course of their own policies.

3.6.4 Conclusions

The study draws the following main conclusions:

(i) In terms of *policy response*, the Community policy that has provoked the biggest changes has been the *state aids policy*, which has had major impact on policy in three countries – France, Italy and Ireland. (The UK might also have been included in this list had not the direction of policy – limiting state aids – accorded closely with the policy objectives of UK governments over this period.)

(ii) Successive *Framework Programmes* are judged to have been effective in encouraging RTD and, particularly, in stimulating intra-European collaboration and promoting university/ industry links. But their effectiveness has come partly from the establishment over time of a common core of policies – they have become, so to speak, 'part of the furniture' and national governments now assume their continuation and plan accordingly.

(iii) The *Structural Funds* have been very effective in stimulating a more strategic approach to regional planning and encouraging regional planners to take on interest in innovation and SMEs. Success, however, has depended upon the receptiveness of those taking decisions at regional level to recognise the opportunities. The contrast between the use made of Objective 1 funds in Ireland and Italy illustrates this point well. It is disappointing how few governments at national or regional level have used the opportunity offered by the reform of the Structural Funds in 1988 to shift the regional development agenda from 'roads and bridges' to innovation.

(iv) One conclusion to draw from this experience is that it helps to secure changes (in national policies) when there are clear sanctions for failures to comply with Commission guidelines. In this respect, the 'all carrots' (incentives, but no sanctions) menus of the Framework Programmes and the Structural Funds have their limitations.

(v) It might also be useful for the Commission to develop some elements of policy where they have greater discretion to reward those authorities who work to promote EU objectives. Vice versa, it is also clear that some governments have flouted the spirit, if not the word, of the additionality provisions of both Structural Funds and Framework Programmes. At the very least the Commission should use its powers to expose these practices and make clear its condemnation of these practices.

(vi) Where EU policy relies on a 'carrots but no sticks' policy (ie, incentives without sanctions) policies need to be well understood and well publicised, so that national (and regional) policy-makers are aware of their existence. It is also clear that, given the inevitable time lags in policy making, it takes time for national policies to recognise and adapt to new policy developments at EU level. It is therefore necessary for EU policies to continue for a reasonable period of time. It is no good trying to change two sets of goal posts simultaneously.

(vii) There are dangers, however, in allowing EU institutions themselves to become too inflexible. Policies, such as the Framework Policy, become 'institutions' in their own right, with substantial lobbies dependent on their continued existence. There is a nice balance to be achieved between being 'well understood and well publicised' and being 'institutionalised'.

Chapter 4
Conclusions and Policy Implications

4.1 INTRODUCTION

The purpose of this chapter is to pull together the conclusions from the different 'modules' in this project, whose reports were summarised in Chapter 3, and to present these alongside the policy implications/recommendations that emerge.

As was made clear in Chapter 3, the Synthesis Report (Sharp, 2000) provided an opportunity to present an intermediate set of conclusions based on the six country-based reports completed in the first phase of the project. This chapter begins by re-iterating those conclusions and then considers them in the light of the six subsequent cross-cutting reports written in the second and third phases of the project. The final section of the chapter presents the policy implications that emerge from these conclusions and makes recommendations accordingly.

4.2 RECAPITULATION – THE CONCLUSIONS TO EMERGE FROM THE SIX COUNTRY-BASED REPORTS ON THE EVOLUTION OF SCIENCE, TECHNOLOGY AND INDUSTRIAL POLICY 1975-97

The Synthesis Report on the six country-based reports (Sharp, 2000) provided an opportunity to review conclusions at the half-way stage in this exercise. It is worth recalling those conclusions and the implications that were drawn from them.

4.2.1 There were three main conclusions to emerge from the country-based reports:

(i) *25 years of structural change* – the years 1975-97, spanning effectively the last quarter of the twentieth century, were years which had witnessed very considerable changes in the structure of the economies of the six countries involved in this study, which were in their turn broadly representative of the countries of Western Europe. Policy makers had had to grapple with the demise of industries such as shipbuilding and the bulk production of steel and heavy chemicals and the emergence of new industries such as computing and telecommunications (strictly speaking the information, telecommunications and computing,

or ICT, industry) and biotechnology. This shift marked the transition from resource-based industries predicated upon the exploitation of national resources, especially coal, iron ore and oil, to knowledge-based industries predicated upon the exploitation of science and technology. It put knowledge and access to knowledge at the centre of the economy, hence the growing role of science and technology policy (and the diminishing role of industrial subsidies) and increasing concern with linkage between science and industry.

(ii) *Globalisation* – simultaneously, the processes of trade liberalisation and deregulation pushed the internationalisation of the world economy (globalisation) a notch upwards. Large companies, which had dominated the production and distribution of goods (and some services) for much of the century, switched their focus from national to international production and likewise the focus of government policy switched from mercantalist pre-occupations with what national firms were producing to wider concerns about the use and application of new technologies amongst the myriad of small and medium sized enterprises which supplied the needs of the increasingly dominant trans-national enterprises (or as referred to in this report, multinational corporations – MNCs). In a world in which technology and capital were mobile, national governments had limited ability to influence decisions by MNCs except that clearly the quality and capabilities of the labour force (education and training policies), the flexibility and adaptability of SME supply chains, and access to the science base (university/university links) were all of importance. This helps to explain the switch of emphasis from large firm national champions to SMEs, and from sectoral subsidies for production to more generic support encouraging the uptake and application of new technologies. Hence also the increasing concern with the infrastructure of the economy, from transport systems to the venture capital availability.

(iii) *The non-globalisation of institutions* – while globalisation was pushing mergers and acquisitions among MNCs and influencing the broad focus of policy development, it was also clear that the institutions which did so much to shape policy in each country were changing little in the face of these pressure. And because institutions varied from country to country (largely reflecting the historical developing of that economy), so similar trends in policy development often led to very different outcomes. For example, initiatives to promote industrial training and retraining in Sweden, with its long tradition of employer involvement in such issues, have a very different impact from those in the UK where employers had traditionally seen education and training as a state function. In a number of areas, often associated with new technologies, we see the beginnings of establishment of supra-national, often EU institutions. The GSM standard in mobile telephone; the discussions around patents

in biotechnology, are both examples of this phenomenon. Generally, however, national institutions predominate and adapt/are adapted on an *ad hoc* basis to meet the demands of the moment. The outcome is a heterogeneity of institutions and policies. Governments cannot hold back the tides of structural change or globalisation but they can – and do – affect the way these tides of change impact on their own country. Governments are the key agents of change in relation to institutions. National policy still matters because institutions matter. Shifting institutions in this way or that can make considerable differences in the way a country – or in the case of the EU, a group of countries – adapt, adjust and take up the challenges facing them.

4.2.2 The policy implications of these three conclusions were outlined as follows:

4.2.2.1 The centrality of the science base

In the knowledge-based economy, the science base becomes a key resource as (a) the generator of knowledge (although the blurring of boundaries between what have traditionally been regarded as pure and applied science means it is {and never has been} the only generator of knowledge); (b) the assimilator of knowledge – in most European countries 95 per cent or more 'knowledge' comes from outside national boundaries. The science base plays a vital part in assimilating, filtering, and 'translating' this knowledge into useful facts and figures for the rest of society to use; and (c) in training those who act as the 'eyes and ears' in industry, ready to pick up useful information which may have relevance to the business of the company.

The term *'absorptive capacity'* is sometimes applied to (b) and (c). The implication is obvious. Without scientists and engineers who can understand what is happening at the leading edge of scientific and technical advance neither countries nor companies have the ability to 'absorb' (ie, make good use of) that knowledge and apply it to the benefit of productive or service activities. In this sense scientists and engineers in the research base – whether public or private sector – are important 'receptor points' for knowledge being generated elsewhere.

4.2.2.2 The complementary roles of government, industry and academic

The term 'the triple helix' is used to describe the dynamic relationship between government, industry and academia in generating and using knowledge to promote innovation. Industry

looks to government (research institutes) and academia to generate knowledge, although it may also generate some of its own. Academia looks to government and industry to fund its activities and (in return) to use the knowledge it generates. Increasingly it is looking, too, to interaction with scientists in government and industry to act as catalysts in the discovery of knowledge. Government is the core funder of the science base but through its role in the development of policy plays an important role in setting the framework of incentives within the system. It is the interaction of the three strands that creates the dynamic of the system. None can function without the other two. Their roles are thus complementary to each other. At its best, when each partner is playing the full role, it creates a highly effective innovation machine – the pharmaceutical industry provides a good example.

4.2.2.3 The complementarity of the different tiers of government

While the relationships between the partners in the triple helix may generate an innovation machine, it is also worth recognising the complementarity of roles between the different levels of government. Given globalisation, there are some issues of policy – for example, issues of control in relation to MNCs – that are best dealt with at the EU level (or even, above that, via world-wide institutions such as the WTO). Equally, the principle of subsidiarity, suggests that where there are no good reasons for action at the supra-national level, action should be taken at the national or even sub-national (regional) level. Indeed one of the interesting aspects of EU Structural Funds policy is the degree to which the principle of subsidiarity (together with those of partnership and cofunding) has stimulated regional awareness and action. As with the triple helix relationships, maximum benefit is reaped where policy is mutually consistent and mutually reinforcing so that action at each level of government serves to reinforce action at other levels. Ireland is the prime example of such relationships between the different tiers of government, with the EU, national and local government policies conceived within a single strategic framework.

4.3 POLICY RECOMMENDATIONS DERIVED FROM THE DIFFERENT CROSS CUTTING PAPERS

Given these broad conclusions coming from the synthesis of the country studies, what policy implications emerge from putting these together with the cross cutting thematic studies of the second stage of the exercise.

4.3.1 Cross cutting study on *Globalisation*

Broadly speaking this study reinforced the conclusions on globalisation, emphasising the degree to which the mergers and acquisitions of the 1990s had shifted control of MNCs out of the hands of national or family groups of shareholders and into the hands of international financial institutions. It also suggested that the 1990s had seen a distinct move away from the 'non-globalisation' of R&D, with a larger number of MNCs becoming, under the influence of their institutional managers, 'lean and mean', cutting back on R&D and/or outsourcing non-core functions. The other side of that coin is, of course, that as large, trans-national companies they have the resources to seek out the knowledge they need from the best sources world-wide and to network it into their R&D function. Whichever view is taken, the fact remains that the R&D function in MNCs is today more likely than before to be shared around amongst a group of laboratories in different countries, with a substantial amount outsourced to specialist laboratories either in universities or public sector research establishments or in private research institutes or specialist new technology small businesses.

The policy implications of these developments are as follows:

(i) *It reinforces the message about the importance of the science base* – in a world of footloose multinationals, the high value added jobs will go to those countries which can provide the skills and capabilities in the labour force to support such jobs. To attract the R&D jobs it is essential to have both a core of people capable of contributing to leading edge developments in science and technology and a means of training people to that level of skills. Education and training, and the ability to take that training to post-doctoral levels within the science base, become key elements of the infrastructure necessary to support MNCs.

(ii) *It is not just the science base but also other elements of the infrastructure that play a part in attracting MNCs* – besides the skill profile of the population, MNCs are looking for an environment which encourages innovation and stimulates innovative thinking. In this respect the triple helix relationships – the degree of interaction between public and private sector science; the regulatory climate; availability of venture capital to stimulate spin-offs and specialist small firms; openness of banking system to enterprise – which lie at the core of any system of innovation, are vitally important. Many of these wider elements are still a matter of *national* institutions and therefore national (or regional) policy, although some (such as standards, patenting for new technologies) are within the remit of the EU. The EU, national

and regional levels of government need to recognise the importance of these issues in attracting innovating MNCs, sort out responsibilities and decide on action.

(iii) *Who controls the MNCs? Is EU competition policy strong enough?* – The total sales of many of the largest MNCs exceed the national incomes of many small states. The power of these companies in terms of the jobs that they command (and the desire of governments to attract those jobs – see the next section on foreign direct investment), lead to dangers of regulatory capture – national or regional governments offering favours in order to attract the jobs. The EU has, through its state aids policies, limited the explicit subsidies that can be paid. The implicit power remains, however, considerable. Take, for example, the power of the pharmaceutical industry lobby in relation to biotechnology. Although many governments rail against the attitude taken by the Greens, their presence in Parliaments and as a lobby group has given voice to consumer concerns which it is right that governments address alongside the concerns of business.

There is a further issue which arises in the more narrow competition policy arena. In the process of merger and acquisition that has taken place through the 1990s, much of which has consisted of buying conglomerate organisations and selling on assets which do not fit the envisaged shape of the new company, many MNCs have ended up by concentrating more narrowly on a range of activities than before. For example, whereas for most of the post-war period Europe's chemical industry was dominated by a series of nationally-based chemical conglomerates, many of these have been transferred in the 1990s into trans-national companies often concentrating on just two or three industry sectors. In other words what was national oligopoly in the 1960s, and became European oligopoly by the 1980s, is now global oligopoly. In any one speciality area, whereas in the 1980s there may have been 12, even 20, firms world-wide competing with each other, today there are five or six, sometimes even fewer. The ability of these companies to abuse their monopoly positions is considerable and competition authorities need to be vigilant to ensure that consumers are not being exploited. Given the trans-national base of these firms, however, there are dangers in the overlap of responsibilities. Do national governments and/or the EU have sufficient powers to control such firms? Should we be worried by the rise of these global oligopolies?

4.3.2 Cross-cutting study on *Foreign Direct Investment*

The cross-cutting study on foreign direct investment picks up similar themes to those explored in the globalisation study. In particular the case studies illustrate the growing importance for MNCs of linkage with the science base and broader innovation system. The focus of the study was specifically on policy and as it made clear, of the six countries in the study, only the UK and Ireland had throughout this time pursued explicit policies to attract inward investment, although Sweden, mainly thanks to Ericsson, had proved an attractive location for electronics investments from both large and small companies. France, having until the early 1980s spurned such investments, was proving an increasingly attractive location to MNCs, while Italy and Germany were the least popular locations, Germany perhaps because its stricter banking laws limited the scope for mergers and take-overs.

The policy lessons to be learned from this study reinforce the points made above under 4.3.1. In particular:

(i) *Linking FDI with the wider aspects of industrial policy* – the Irish experience illustrates the importance of linking FDI with a broader strategy promoting indigenous capabilities in science and technology. While its policy of pursuing MNC investments has remained a central tenet of Irish policy, its early failures serve to illustrate well the limitations of that policy alone. Success has come from the gradual establishment of a broad range of policies, from education and training through encouraging the banking and knowledge-based service sectors, which mutually reinforce this position. It is notable that Ireland today has more scientists and engineers per 1,000 population in the 25-34 age group than any other European country. It is also worth noting how vulnerable the UK economy may be in a number of sectors (eg, motor cars) where the main source of attraction has been low wages and government grants. Given the clarity of the message that emerged, even in the 1980s, that to benefit from FDI, investments needed to be made in education and training and the science technology infrastructure, it is amazing that the British government should have neglected such investments.

(ii) *The attractions of agglomeration* – the experience of Sweden, which has not sought to attract FDI but become a centre for electronics/telecoms investments spawned around the Ericsson's plants and laboratories, illustrates the continuing pull of agglomeration. The UK's experience with the pharmaceutical industry are similar, its strengths in this sector

encouraging companies such as the merged (US-Swedish) Upjohn-Pharmacia, to locate its headquarters in the UK.

4.3.3 Cross-cutting study on *Technology Transfer*

This study stressed that successful technology transfer is not about handing over blueprints, but about hands-on learning by doing. Inter-action – scientists working alongside each other at the laboratory bench; working side by side with engineers in developing new applications; each learning from the other – is the central issue. But interaction takes participation on all sides. This is why the triple helix set of relationships are so important. It requires both the willingness and readiness of the research institute/university to engage in technology transfer activities and the ability of the enterprise to absorb the knowledge. There are no standard recipes to achieve this. Autonomy on the part of the science base does not necessarily mean it concentrates only on ivory tower research; an independent science sector and effective technology transfer are not mutually exclusive. Equally, the implicit model is too frequently the linear one in which technology transfer is "solved" by establishing an intermediary institution.

The policy implications/recommendations to emerge from this study are:

(i) *The key to successful technology transfer is getting people to learn by working together* – this is why programmes such as the British Teaching Company Scheme which gets academic scientists working alongside their industrial partners in their laboratories has been so successful. The German system of technical support has also traditionally been good at the 'learning by doing' aspects of technology transfer. Beware, however, of the science park phenomenon which sees the answer in setting up an intermediary institution, ignoring what it actually does.

(ii) *European Programmes have been a useful catalyst to collaboration amongst EU countries* – the benefits derived from collaboration are the most highly rated benefits from successive Framework Programmes. It would be useful, however, to mark best practice by, for example, an annual prize or series of prizes, which could then be used as bench marks. It is also for consideration whether the time has not come to open up EU programmes to full international collaboration. Much leading edge science and technology is now found in the

US or East Asia. EU firms and universities need to be encouraged to learn from these sources, not just from their European counterparts.

(iii) *Technology transfer depends upon the willingness and readiness of scientists and engineers to seize opportunities when they arise* – although many academic scientists and engineers are getting better at being entrepreneurial, they remain slow at recognising opportunities for exploitation. It would be helpful if their training included courses which taught them about innovation and how best to manage and exploit new ideas.

(iv) *The major hurdle to successful technology transfer lies not with the academics but with the absorptive capacity of firms* – far too many firms are in a position to make full use of the science and technology which is available for exploitation. Often they do not have scientists and engineers capable of understanding and using the new ideas and do not know how to access the support networks which might help them. German firms are better than those in most other countries because they have a tradition of technical support networks for SMEs which the SMEs for their part are not afraid to use. There is a real question mark as to whether the general run of Italian, Irish or UK firms have the capabilities necessary to meet modern day technological demands.

(v) *Top down technology transfer schemes are not effective* – successful technology transfer mechanisms are not things that can be imposed 'top-down' by national governments or the EU. As indicated, the key issue is networking and working together. Such networks grow much more satisfactorily 'bottom-up' than top-down because in doing so they acquire a sense of ownership of the institutions. This is where the strength lies in the Germany system, which has grown up over time. But it illustrates again that one player in the triple helix relationships cannot do it all – the dynamic lies in the bonds – the interactions – between the players.

4.3.4 Cross-cutting study on *Regional Policy and SMEs*

The regional policy cross-cutting study highlights the shift of regional policy from the "hands on" interventions and vast capital subsidies of the 1970s, to the "hands off" technology and innovation policies of the 1990s. The rise of new technology has focused attention on the role of the small new technology-based firm, but they remain a small minority of the SME sector. Globalisation stimulated the attention of national policy makers to the importance of SME supply chains, but it was policy makers in regions such as Emilia Romagna and Baden

Wurtemberg who pointed the way to the new innovation-led regional policy that marks new developments.

The main policy messages to emerge from this study are:

(i) *regional support for SMEs is simpler, faster and more efficient than other methods and should therefore be encouraged* – that if well conceived and well administered, regional level support manages *both* to mobilise the support groups and networking that is so important to technology transfer, *and* to retain the sense of ownership that helps motivate the SMEs themselves. In essence it's all about knowing and trusting those you are working with. With SMEs this can be achieved at the local/regional level in a way that is impossible at the national level, other than in small countries such as Ireland (whose population is much lower than many regional populations in bigger countries).

(ii) *management and administration of regional programmes is important and more needs to be done to train capable people* – the contrast between the achievements of Ireland and Italy, both of which have benefited from substantial grants from the CSF, illustrates well the difference that good civil servants can make. The Commission and national governments should pay more attention to attracting and training high quality applicants to work for regional administrations. At their best, as has been shown in regions such as Emilia Romagna, they can become the 'thinkers and managers' behind modern industrial policy.

(iii) *the EU, national and regional administrations have yet to get their act together and co-ordinate policies so that they are mutually reinforcing each other* – duplication of policy at the different tiers of government does not necessarily matter if policies are mutually reinforcing. Too frequently, however, policies are implemented without consultation with other tiers of government so that initiatives cut across each other, often seeming to negate the purpose of one or the other and creating a legacy of scepticism and distrust. All three tiers of government – the EU, national and regional governments – have a role to play but, to put it bluntly, in most cases they have yet to get their act together. Again, Ireland provides a good example of how effective action can be when all three tiers of government are pulling in the same direction.

(iv) *the EU has an important role to play as a catalyst in the development of regional innovation policies* – already the Structural Funds have played an important role in stimulating regional awareness with the conditionality principles (subsidiarity, partnership, co-funding, the CSF Framework Plans) stimulating involvement of regional authorities and,

for Objective 1 countries, ensuring that plans are conceived within a broad strategic framework. The downside of these procedures is that it is the more dynamic and go-ahead regional authorities that have seized the opportunities offered, while the less dynamic continue to spend most of the money on physical infrastructures. The Commission should do more to develop its regional innovation strategy programme and to ensure that national governments and national priorities do not dominate the agenda. In particular they should use their financial muscle (ie, the threat to withhold Community payments) to secure proper additionality for Community funding.

4.3.5 The objectives of science, technology and industrial policy

This cross-cutting study picks up many of the themes that have emerged in other studies but considers them specifically within the framework of policy formation. The findings of this study echo the theme of the non-globalisation of institutions discussed earlier in this chapter. And the recommendations echo the plea for the different levels of government to co-ordinate activity more effectively. It finds a wide diversity of practice – different countries have different objectives; even where they share objectives, they go different ways about achieving them. But perhaps the most important finding was that in all this diversity, very few governments at any level were explicit above matching policy to objectives. Few governments enunciated clear priorities or discussed implicit policy models linking policy action to priorities; evidenced-based policy, with clearly thought through (and empirically robust) functional relationships was conspicuous by its absence. As a result, far too much policy was made in an *ad hoc* fashion in response to crisis. And governments/ministers were too open to capture by lobby groups and dogma.

The recommendations that stem from this shocking indictment of the policy making process in the six countries studied are as follows:

(i) *There needs to be much more open debate at all levels of government about policy objectives and the range of achieving those objectives*. Such a debate would of itself help to expose the implicit functional models that link action to objectives and help to promote consideration of evidence-based relationships and demote the role of dogma. Social scientists, whose job it is to gather evidence and expose underlying relationships, obviously have much to contribute, but the key action is to open the debate to public scrutiny.

(ii) *Governments should develop policy within a wider strategic framework*. The cross-cutting study notes that frequently there is an implicit hierarchy of policy in which, for example, macro-economic objectives such as limiting inflation, always take precedence over micro-economic objectives such as improving skill training, even though the former may contribute to the latter. It advocates a strategic planning framework in which such hierarchies (and inter-connections) are exposed and conflicts eliminated. As the regional policy module made clear, the EU has helped to achieve this broader strategic approach in Objective 1 areas by insisting that regional projects are set within a strategic planning framework. Such an approach helps to ensure consideration of the two sets of complementarities highlighted at the beginning of this chapter – complementarity between the actions of the three main players within the triple helix and complementarity between the different tiers of government. Pleas that the different levels of government and different departments of government should "get their act together" point in the same direction. Both require agreement in the first instance on the broad objectives of policy and how best to achieve these.

(iii) *Diversity in itself does not matter; what does matter is unnecessary conflicts of policy*. A diversity of institutions and policies does not in itself matter. Indeed it can be seen as a necessary part of the learning dynamics of the system. Only by experimenting with different types of policy will there be evidence of what is successful and what is not successful. Such an approach does, however, require, first, the elimination of internal inconsistencies of policy (points (i) and (ii) above) and, secondly, a consistent monitoring of policy outcomes and publicising of best practice. It is important, however, that such benchmarking is seen in a dynamic context. As this series of studies underlines, policies have to change to match the circumstances.

4.3.6 Cross-cutting study on the interactions between EU, national and regional policies

This study examined interactions with three sets of EU policies affecting the broad spectrum of science, technology and industrial policy – namely state aids policy, the Structural Funds and the Framework Programmes. It found that, of the three, state aids policies had been the most effective in terms of causing national governments to switch their policies and conform to EU norms. Equally state aids policy was the only one of the three where the Commission was able to threaten the sanction of taking recalcitrant states to the European Court of Justice if they failed to comply with Commission requests. With both the Structural Funds and the

Framework Programmes, the Commission relied upon the positive incentives of the availability of extra funding and the need to conform with the conditions attached to that funding to secure policy co-operation. The Structural Funds proved the more effective of the two, perhaps not surprisingly given that the sums to be distributed were ten times larger than those distributed under the Framework Programme and that the Commission was dealing directly with national and regional governments. By contrast, receipts from the successive Framework Programmes (FPs) constituted for most countries less than three per cent of total R&D expenditures, and less than five per cent of government expenditures. Moreover, the FPs are administered by the Commission who deal directly with firms, universities and research institutes rather than via local or national governments. Nevertheless, it was apparent that, over time, national governments had come to accept (and indeed take for granted) the presence of the Framework Programme and to plan their policies on the basis of its continued existence. In this sense there was implicit, if not explicit, adjustment of policy by national governments.

The policy conclusions to emerge from this study were as follows:

(i) *Commission policies have been highly effective in stimulating collaboration between institutions in different countries of the EU*. In this regard they have been an important catalyst in promoting the networking (interaction) so necessary for effective technology transfer. This has applied both to networking between similar institutions (eg, university laboratories) indifferent EU countries and between different types of institutions (eg, university laboratories and firms) in different countries.

(ii) *The EU should, however, now switch to funding more basic science programmes and encouraging international collaboration*. The funding of the science base has been traditionally seen as a national policy responsibility with the Framework programmes concentrating on applied research and development. Given the importance of the science base to the knowledge-based economy and the tendency for national governments to cut back their public expenditures in this area, there is a strong case for the EU to take the lead, especially in areas where there are substantial economies of scale to be gained from pooling research efforts. There is also much to be said, as mentioned earlier, for encouraging collaborations with groups in non-EU countries, especially the US.

(iii) *The Commission should consider shifting part of Framework Programme funding from the direct funding of institutions (such as firms and university laboratories) to indirect*

funding via national and regional governments. This is because, as policy stands, the EU has no way of influencing national policies in the science/technology area other than by persuasion/exhortation and co-operation. Such policies have proven to have little effect, least of all on changing the emphasis of existing national/regional policies. This contrasts with the Structural Funds where, for example, the requirement on those receiving Objective 1 funds to work with a strategic, planned framework, has helped to shape national policies towards Community objectives. Given the EU's concerns about SMEs and the need to up-grade SME innovation performance, a policy which saw the Commission working with regional governments along the lines of the regional innovation strategies has much to recommend it.

(iv) *There should be much greater emphasis on innovation within Structural Fund programmes*. Given the relative effectiveness of the Structural Funds framework since the reforms of 1988, it is an anomaly that they still fund an agenda dominated by infrastructure investment in roads and bridges, with innovation having so low a priority. As suggested int e conclusions to the section on regional policy, the EU should use its financial muscle to force through some rethinking in this area.

(v) *The Commission needs to recognise the importance of innovation and the innovation agenda in other areas of policy*. While the Commission may have little success in persuading national governments to follow its lead within the Framework Programme, there are other areas of policy – regulatory frameworks; standards; patents; company law – which impinge on innovation and where, as in state aids legislation, the Commission has strong powers of enforcement. A full study of EU policy, and its interactions with national policies, really needs to embrace this wider agenda.

4.4 OVERALL CONCLUSIONS AND POLICY RECOMMENDATIONS

At the beginning of this series of studies a number of questions were raised. The central question to be considered was, in the light of the findings, what advice should be given to the Commission as to how best to fulfil its [Maastricht] Treaty obligations in relation to the co-ordination of science and technology policies between the EU and member states? The subsidiary question related to how far, over the course of the years, some kind of European system of innovation was beginning to emerge or whether Europe remained, as it had been in the early 1990s, a diversity of systems of innovation? Implicit in these two questions was a third one – did this matter? So what if Europe continued to support different institutions and different traditions in different countries.

These studies have made it clear that while the countries of Europe have faced similar challenges from advances in technology and globalisation, their response has not been uniform and that the "non-globalisation of institutions" has led to a heterogeneity of policy responses and experience. Only in a very few high technology areas such as standards for mobile phones are European policies and institutions beginning to make their mark. In other respects the fragmentation of the system remains. National policies and national institutions predominate. European policies and institutions remain marginal and marginalised.

Does this matter? The answer that emerges from these studies is in general "no". There are few areas in the science, technology and innovation field where economies of scale are sufficiently important that they demand action at the EU level. In most areas the principle of subsidiarity would suggest that policy is in fact best handled at the national or even the regional level. This does not preclude action at the EU level – as experience with the Framework Programmes and Structural Funds shows, such action can be an important catalyst, stimulating other actors into response. In this sense, there is an important leadership role for the EU, prodding member states into action. There may even be some benefits in diversity. At its most fundamental, diversity allows for experiment, and it is only by experimenting and identifying at any moment of time where best practice lies, that the in-built dynamic of the system becomes apparent. Uniformity kills creativity.

What then of co-ordination? Given a diversity of national systems of innovation, is strong co-ordination demanded? Should the EU, for example, be able to require member states to raise their R&D efforts or to help fund venture capital funds? Or is there instead a natural process of assimilation which means that, without explicitly recognising the fact, policies at different levels of government do adapt and adjust to take account of developments elsewhere? The evidence from these studies points firmly in the direction of the second 'soft' route of co-ordination. National sensitivities are sufficiently strong that any attempt at strong co-ordination – forcing national governments down specific policy routes – would be heavily resisted. Equally, it is also clear that once the lines of EU policy have been delineated and there is confidence in it continuing, national and regional governments adapt their policies to take account of EU actions. In this sense, soft co-ordination works quite well.

Soft co-ordination works *quite* well – but could it work better? From these studies of policy formation and policy process in the different countries, a number of recommendations emerge which, if implemented, would improve the policy-making process.

(i) *There needs to be a more open debate about the objectives of policy and the means to achieving those objectives*. Here lies a clear leadership role for the EU in 'orchestrating' this debate which needs to take place not just amongst the science and technology (policy) community (the former DG XII/DG XIII fraternity) and their counterparts in national governments, but as an important part of the economic policy debate. Ten years ago, with the launch of the 1991 Delors White Paper (CEC, 1993) innovation was presented as a major plank in the Community's future economic policy, but it was rapidly overtaken by the debate on monetary union which has dominated the economic agenda. Supply side issues have been dominated, not by the adaptability of economies to learn about and use new technologies, but about the flexibility of labour and capital markets. As these studies have indicated, the promotion of education and training, and investment in the extensive networking required to learn about modern day technologies requires building long-term relationships of mutual trust and respect, which does not necessarily fit happily beside the inherent uncertainties of highly flexible markets. Now that monetary union is about to be achieved, we need to revisit and re-open the Delors agenda on innovation and debate again how Europe's performance may be improved. And we need our leaders at the EU level, to provide strategic leadership, to show consensus over objectives and how those objectives may be achieved.

(ii) *Co-ordination needs to come at the national policy level*. It has been argued earlier in this chapter that provided the EU shows a clear lead on policy, soft co-ordination, allowing member states to make their own adjustments to policy, is preferable to 'hard co-ordination' – extending the EU's remit over areas which had traditionally been handled at national level. In effect, this places responsibility for co-ordination on member states rather than on the EU itself. A clear message from these studies is, however, that national governments need themselves to take a more strategic view of policy and think more clearly about how best they may integrate policy/actions from the different tiers of government – EU, national, regional and local – into their own objectives. The success of the Irish innovation system, as the Irish country study in this project shows so well, comes from the integration of policy objectives and policy actions from the three tiers of government so that each mutually reinforces the other. Other national governments would benefit from following suit and actively seeking to co-ordinate policies so that they all work in the same direction.

(iii) *Maintaining investment in the science base is vital*. Governments in the 1990s, beset by worries about unemployment and already high levels of public expenditures, allowed public investment in the science base to slip below the levels (in terms of percentage of GDP) achieved at the end of the 1980s. Although it is true that with new technologies the traditional boundaries between basic and applied science have slipped, as Michael Reinhard in his study of technology transfer puts it, "Basic research remains the 'logistic' foundation for new knowledge" (Reinhard, 2000, p75). As has been stressed in all these studies, it not only generates the new ideas fuelling the science and technology system, but provides the "receptor system" through which ideas generated elsewhere can be understood, interpreted and, where appropriate, applied. In this sense it provides one core element in the 'absorptive capacity' of an economy to use modern science and technology in its industrial systems. (The other core element is industrial R&D.) From an EU perspective, it is worrying that in his study Reinhard suggests that three of the six countries studied in this project – the UK, Italy and Ireland – may not be investing sufficiently in their science and technology systems to be able to maintain the absorptive capacity necessary to participate in the competitive global economy.

(iv) *But industry, too, must increase its spending on R&D and recognise the need to work in collaboration with others*. Industry cannot hope to maintain its understanding and use of developments at the leading edge of science and technology unless it maintains substantial investments in research and development. These translate into scientists and engineers working in modern well-equipped laboratories. Increasingly it is clear also that to maintain leading-edge capability requires continuous 'interaction' (networking, collaboration) with other scientists and engineers working in similar areas in other firms, or university/government research laboratories around the world. This applies as much to small as to large firms and, given globalisation, it is on this sector in particular that policy initiatives may impinge. It has been argued earlier in these conclusions that the most effective measures are likely to come from regional rather than national or EU governments.

(v) *There is a serious issue of governance in relation to MNCs which requires action at an international level*. While the focal point of policy in this area of science, technology and industrial policy may be SMEs (because in a global environment, it is they, not MNCs, that may respond to such policy initiatives), the issue of control over MNCs is a real one. These studies have highlighted, in particular, the shift of control that has taken place in the last 10 years from nationally-based MNCs to international corporations controlled by financial institutions. For national governments this poses possible dangers of asset stripping – that

these companies will establish themselves to take what they can of science and technology assets but give little. In this sense it is important to ensure reciprocity and to avoid regulatory capture. At the international level, the workings of global oligopoly is still not fully comprehended. It is not obvious that present regulatory systems, whether at national or EU level, are sufficient to control this phenomenon, or that the WTO, as an international body, has the necessary powers.

References

Braga, M C; Cini, D and Gambardella, A (1999): *Country Study: Italy*, for TSER Study on Science, Technology and Broad Industrial Policy, mimeo, CESIT, University of Urbino, Urbino, Italy.

Braga, M C; Cini, D and Gambardella, A (2000): *Cross Cutting Study: Regional Policy*, for TSER Study on Science, Technology and Broad Industrial Policy, mimeo, CESIT University of Urbino, Urbino, Italy.

CEC (1989): *First Survey of State Aids in the European Community*, Luxembourg, Office of Official Publications of the EU.

CEC (1993): *Growth, Competitiveness and Employment: The Challenges and Ways Forward into the 21st Century* (Delors White Paper), COM(93) 700 (final).

CEC (1997): *Second European Report on Science and Technology Indicators*, Luxembourg, Office of Official Publications of the EU.

CIRCA (1999): *Country Report: Ireland*, TSER Study on Science, Technology and Broad Industrial Policy, mimeo, CIRCA Group, Dublin, Ireland.

CIRCA (2000): *Cross Cutting Study on Foreign Direct Investment*, TSER Study on Science, Technology and Broad Industrial Policy, mimeo, CIRCA Group, Dublin, Ireland.

de Bandt, J (1999): *Country Report: France*, for TSER Study on Science, Technology and Broad Industrial Policy, with collaboration from Elise Tosi, mimeo, IDEFI/LATAPSES, Sophia Antipolis, France.

de Bandt, J (2000): *Cross Cutting Study: Objectives of Industrial and Science and Technology Policies*, for TSER Study on Science, Technology and Broad Industrial Policy, mimeo, IDEFI/LATAPSES, Sophia Antipolis, France.

Etzkowitz, H and Leydesdorff, L (eds) (1997): *Universities and the global knowledge economy: a triple helix of university-industry-government relations*, London, Pinter.

Gregerson, B and Johnson, B (1997): 'Learning Economies, Innovation Systems and European Integration', *Regional Studies*,

Johnson, B (1992): 'Towards a New Approach to National Systems of Innovation', Chapter 2 in Lundvall, B: *National Systems of Innovation*, Pinter, London.

Jungmittag, A; Meyer-Kramer, F and Reger, G (1999): 'Globalisation and R&D in Technology Markets – Trends, myths and consequences', in Meyer-Kramer, F (ed): *Globalisation of R&D in Technology Markets – Consequences for National Innovation Policies*, Physica Verlag, Heidelberg.

Krugman (1997): 'Good news from Ireland: a Geographical Perspective', in Gray, Alan (ed): *International perspectives on the Irish Economy*, Indecon Consultants, Dublin.

Landberg, H; Edqvist, O and Svedin, U (1995): *Parliament, Government and Research*, Swedish Council for Planning and Co-ordination of Research.

March, J G and Olsen, J P (1989): *Rediscovering Institutions: the Organizational Basis of Politics*, New York, The Free Press.

Nelson, R R and Winter, S G (1982): *An Evolutionary Theory of Economic Change*, Cambridge, Mass, The Belknap Press of Harvard University Press.

North, D (1990): *Institutions, Institutional Change and Economic Performance*, Cambridge, Cambridge University Press.

Palonka, K (1999): *Science and Technology Governance and Industrial Policy in Sweden*, Swedish Country Report for TSER Study on Science, Technology and Broad Industrial Policy, European Institute for Japanese Studies, Stockholm School of Economics, Stockholm, Sweden.

Peterson, J and Sharp, M (1998): *Technology Policy in the European Union*, Basingstoke, MacMillan Press.

Reinhard, M (1999): *Country Report: Germany*, TSER Study on Science, Technology and Broad Industrial Policy, mimeo, ifo Institut, München, Germany.

Reinhard, M (2000): *Knowledge, Technology Transfer and Innovation Policy*, TSER Study on Science, Technology and Broad Industrial Policy, mimeo, ifo Institut, München, Germany.

Sharp, M (1998): *What is Industrial Policy and Why is it Necessary?*, a state-of-the-art review of the arguments underlying government involvement in promoting science, technology and innovation policy, mimeo, SPRU, University of Sussex, UK.

Sharp, M (1999): *Country Study: The United Kingdom*, TSER Study on Science, Technology and Broad Industrial Policy, mimeo, SPRU, University of Sussex, UK.

Sharp, M (2000): *Synthesis Report of the Six Country Reports*, TSER Study on Science, Technology and Broad Industrial Policy, mimeo, SPRU, University of Sussex, UK.

Sharp, M (2001): *Cross Cutting Report: The Inter-relationships between EU and national Policies*, TSER Study on Science, Technology and Broad Industrial Policy, mimeo, SPRU, University of Sussex, UK.

Sigurdson, J (2000): *The Globalisation (Triadisation) of Science and Technology: an attempt to identify the effects on nations, the EU and their policy responses*, EIJS, Stockholm School of Economics, Sweden.

UK Government (1993): *Realising our Potential: A Strategy for the Science Base* (Waldegrave White Paper), Cmnd 2250, London, HMSO.

UK Government (1994): *Competitiveness: Helping Business to Win*, Cmnd 2563, London, HMSO.

UK Government (1995): *Competitiveness: Forging Ahead*, Cmnd 2867, London, HMSO.

UK Government (1996): *Competitiveness: Creating the Enterprise Centre for Europe*, Cmnd 3300, London, HMSO.

Annex A
Full Details of Deliverables under Project

All the fifteen reports detailed below under the project have been completed and submitted to the Commission in written and electronic formats.

1 Initial 'state-of-the-art' review of literature report: Sharp, M (1998)

What is Industrial Policy and Why is it Necessary? A state-of-the-art review of the arguments underlying government involvement in promoting science, technology and innovation in industry. Prepared by Margaret Sharp, May 1998, SPRU, University of Sussex, mimeo.

2 The Six Country Studies

A de Bandt, J (1999): *Country Report: France*, with the collaboration of Elise Tosi, IDEFI/LATAPSES, Sophia Antipolis, France, mimeo.

B Reinhard, M (1999): *Country Report: Germany*, ifo Institut, Munich, mimeo.

C CIRCA (1999): *Country Report: Ireland*, written by Tom Higgins for CIRCA Consultants, Dublin, mimeo.

D Braga, M C; Cini, D and Gambardella, A (1999): *Country Study: Italy*, CESIT, University of Urbino, Urbino, Italy.

E Palonka, K (2000): *Science and Technology Governance and Industrial Policy in Sweden*, European Institute for Japanese Studies, Stockholm School of Economics, Stockholm, Sweden.

F Sharp, M (1999): *Country Study: The United Kingdom*, SPRU, University of Sussex, UK, mimeo.

3 Synthesis of Six County Studies

Sharp, M (2000): *Synthesis Report on Six Country Studies*, SPRU, University of Sussex, UK, mimeo.

4 The Six Thematic Studies

A Sigurdson, J (2000): *The Globalisation (Triadisation) of Science and Technology: an attempt to identify the effects on nations, the EU and their policy responses*. European Institute for Japanese Studies, Stockholm School of Economics, Stockholm, mimeo.

B CIRCA (2000): *Cross-Cutting Report on Foreign Direct Investment*, written by Tom Higgins for CIRCA Consultants, Dublin.

C Reinhard, M (2000): *Knowledge, Technology Transfer and Innovation Policy*, ifo Institut, Munich, mimeo.

D Braga, M; Cini, D and Gambardella, A (2000): *Cross-cutting Study: Regional Policy*, CESIT, University of Urbino, Urbino, Italy, mimeo.

E de Bandt, J (2000): *Cross-Cutting Report: Objectives of Industrial, Science and Technology Policies*, IDEFI/LATAPSES, Sophia Antipolis, France, mimeo.

F Sharp, M (2000): *Cross-Cutting Report: The inter-relationships between EU and national policies*, SPRU, University of Sussex, Brighton, UK, mimeo.

5 The Final Report (this report)

Sharp, M (2001): *Science, Technology and Broad Industrial Policy*, Final report for TSER Project, SPRU, University of Sussex, Brighton, UK, mimeo.

Annex B

Publications based on reports

Braga, M C; Cini, D and Gambardella, A (2000): *Italian Economic Policy in the 1990s*, paper presented at the CNR-ISRDS seminar, Rome.

Braga, M C; Cini, D and Gambardella, A (2001): *S&T Policy in Italy during the 1990s, and its Relationships with the Broader Economic Policy*, Working Paper, Sant'Anna School of Advanced Studies, Pisa, Italy.

Palonka, Krystyna (2000): 'The role of big international corporations in the globalization process of European economy - Swedish example (in Polish)', *Quarterly Journal of Warsaw University of Technology*, College for Social Sciences, Vol 18, pp 57-74

Sharp, M (2000): 'The UK Experiment, science, technology and industrial policy in Britain 1979-2000', chapter prepared for Beigelbauer, D and Borras, S (eds): (forthcoming).

Sharp, M (2000): *The UK Experiment: science, technology and industrial policy 1995-1997*, Paper prepared and presented to the Triple Helix Conference, Rio de Janeiro, 26-29 April.

Sharp, M: 'British Industrial Policy since 1975', paper prepared for submission to *Industrial and Corporate Change*.

Sigurdson, J, with Cheng, Alfred Liping (2001): 'New Technological links between National Innovation systems and Corporations', Special Issue of the *International Journal of Technology Management*, Vol 22, No 5/6.

Sigurdson, Jon (2000): 'Knowledge Creation and Innovation in Geographically Dispersed Organisations', *Asia Pacific Journal of Management*, Vol 17, pp 297-330.

Annex C
Acknowledgements

This series of reports has been compiled with the help of many different people in the worlds of business, politics, the civil service and colleagues in the academic disciplines of science and technology policy studies.

Italy

As regards the Italian study and the cross-cutting study on Regional Policy, we would like to thank Giorgio Sirilli of the Italian National Research Council (CNR-ISRDS) for helpful comments and suggestions. We also want to acknowledge fruitful discussions in the development of these reports with several collegues, and in particular Ashish Arora, Carnegie Mellon University, Pittsburgh, Fabrizio Cesaroni, Sant'Anna School of Advanced Studies, Pisa, Italy, Marco Cioppi, University of Urbino, Italy, Andrea Fosfuri, Universitat Carlos III, Madrid, Myriam Mariani, University of Maastricht, NL, Fabio Pammolli, University of Siena, Italy, Mario Pianta, University of Urbino, Alberto Silvani, CNR-ISRDS, Salvatore Torrisi, University of Camerino, Italy, Riccardo Varaldo, Sant'Anna School of Advanced Studies, Pisa, Italy.

Germany

Regarding the Germany study and the technology transfer study Michael Reinhard would like to thank Dr Christian Uhlhorn at the BMBF for his helpful comments; Engelbert Beyer, BMBF, Dr Helmut Ennen at the SMWA, Dresden; Dr Norbert Kampmann from the BMWi.

Sweden

Major parts of the thematic report on Globalisation were drafted while visiting researcher at the European University Institute in Firenze in late 1999. I am grateful to Professor Yves Mény, Director of the Robert Schuman Centre/European Forum, and Professor Colin Crouch for having invited me – with funding provided by the then Swedish Research Council for Humanities and Social Sciences. In preparing the report I benefited greatly from receiving ideas, information and encouragement from a number of colleagues. In particular I would like to thank Dr Olle Edquist, Planning director at the Swedish Foundation for Strategic Research, Dr Hariolf Grupp of the Fraunhofer Institute for Systems and Innovation Research, and

Professor Pohkam Wong, director of the Centre for Management of Innovation & Technopreneurship at the University of Singapore. I am also very grateful by Dr Michael Reinhard of the IFO Institut für Wirtschaftsforschung, at the same time partner in this TSER project, who took great efforts to assist me in finding relevant literature and necessary references.

The report on Science and Technology Governance and Industrial Policy in Sweden was prepared with the significant support from Dr Olle Edqvist of the Swedish Foundation for Strategic Research, Ms Gunnel Dreborg from then NUTEK, now The Swedish Agency for Innovation Systems, Professor Stig Hagström of the Swedish Council for Higher Education, Professor Jon Sigurdson of the European Institute of Japanese Studies (EIJS) at the Stockholm School of Economics and the staff of Swedish Statistics Office.

The UK

As regards the UK study and cross-cutting EU policies study, Margaret Sharp would like to thank Dr J L Smith and John Barber at the DTI; Will Hutton at the Industrial Society; Philip Goldenberg from the CBI Council; Terttuu Lukkonnen, VTI, Helsinki, Finland; Bengt-Åke Lundvall, Aarhus University, Denmark; Susanna Borras from Roskilde University, Denmark; colleagues at SPRU – Ben Martin, Pari Patel, Jacqueline Senker, Nick von Tunzelmann, Keith Pavitt, Michael Hopkins; Ulrike Hotopp (now DTI) and Peter Holmes from the Sussex European Institute; John Peterson (Glasgow University) and Luke Georghiou (PREST, Manchester. She would also like to extend thanks to the Librarians at the House of Lords who have helped in numerous ways to locate documents and reports.

In relation to the whole project, special thanks to Janet French who has acted as secretary to the group throughout and managed to keep abreast of the many vintages of draft that have been circulating through the electronic airwaves.