

ANNEX D7

PITA Project: Policy Influences on Technology for Agriculture:
Chemicals, Biotechnology and Seeds

SMEs in the United Kingdom Agrochemicals,
Seeds and Plant Biotechnology Industries

Annex D 7

TSER Programme
European Commission – DG XII
Project No. PL 97/1280
Contract No. SOE1-CT97-1068

Nicholas J. Barnes

**Centre for Technology Strategy
The Open University
United Kingdom**

October 2000

Introduction to the PITA Project

Technological innovation in the agrochemical, biotechnology and seeds industries and in associated public sector research establishments (PSREs) has the potential to deliver more socially and environmentally sustainable farming systems and to improve the quality of life of citizens in Europe. This is particularly true of farms on the most fertile land. However, although policies developed in different areas may all aim to improve the quality of life, in practice, in their influence on company and PSRE strategies, they frequently counteract one another and so attenuate the desired effect.

Market-related factors also influence decision making in industry and PSREs, the most important for this project being the policies of food processors and distributors and also public attitudes and opinion, which often set more demanding standards than those of national governments and the EU.

The PITA project (see Project Structure) is developing an integrated analysis of policies and market-related factors relevant to the agrochemical, biotechnology and seeds sectors. The core of the project is an investigation of the impact of these factors on the strategies and decision making of companies and PSREs and the downstream implications of these decisions on employment, international competitiveness and environmental benefits. The final outcome will be feedback of our conclusions to policy makers and company managers.

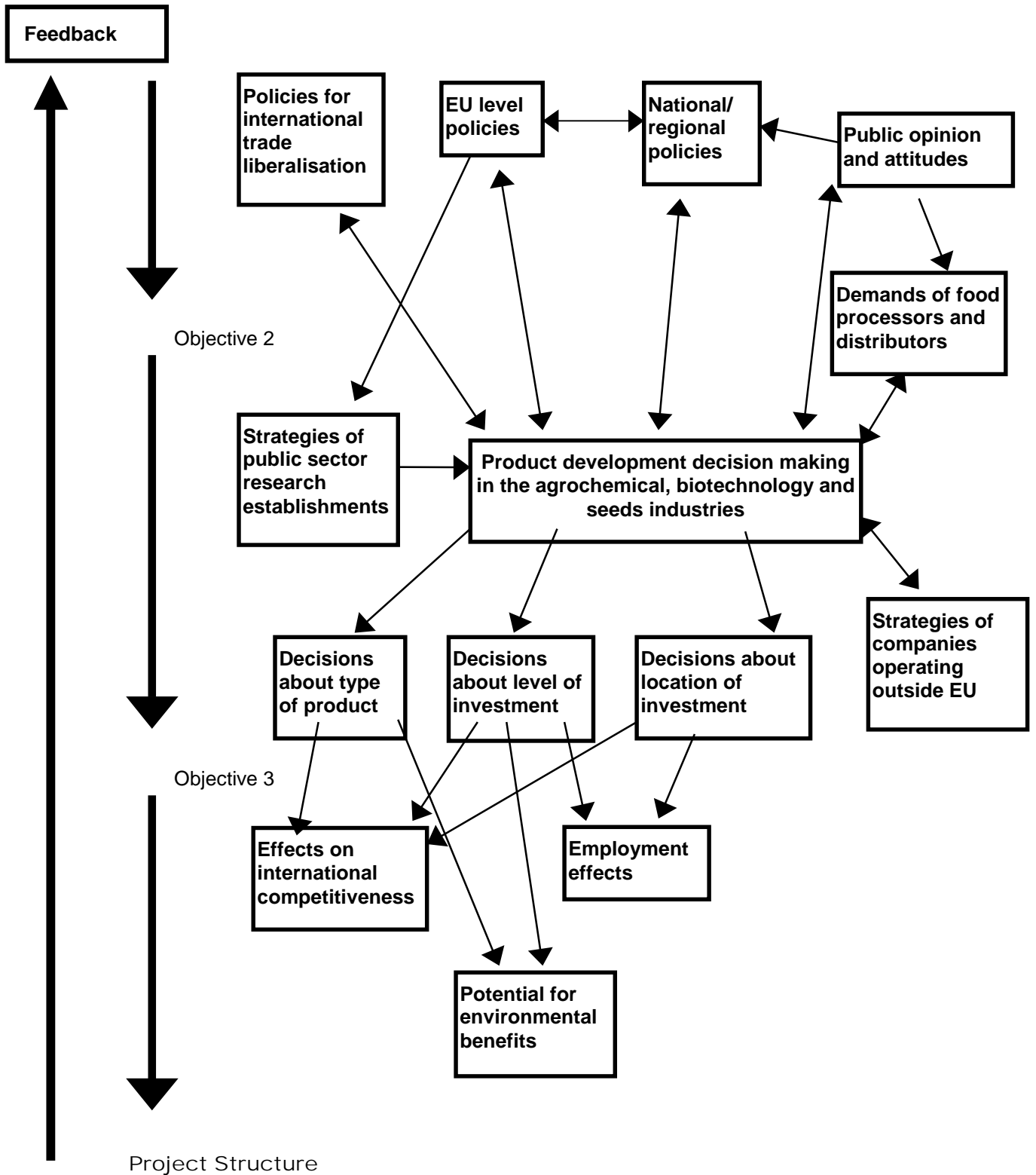
The range of policies and other influences studied includes:

- policies to stimulate innovation in the agrochemical, biotechnology and seeds industries;
- purchasing policies of food processors and distributors;
- policies for international trade liberalisation;
- policies for the regulation of industry and farming (for environmental protection and public health and safety, particularly for pesticides and biotechnology);
- agricultural and farming support policies, particularly for crop production;
- policies to promote environmental sustainability and wildlife biodiversity in arable farming areas;
- public opinion and attitudes.

The overall aim of the project is to contribute to the development of sustainable industrial and farming systems and an improved quality of life by encouraging the development and uptake of 'cleaner' technology for intensive agriculture. Its objectives are:

- to develop an integrated analysis of policies and market-related factors relevant to technological innovation in the agrochemical, biotechnology and seeds sectors, to study their interactions and to develop hypotheses about their impact on strategic decision making in industry and PSREs.
- to study the influence of policies and market-related factors on innovation strategies in the agrochemical, biotechnology and seeds industries and PSREs, and their impact on decisions about product development, levels of investment and location of investment.
- to study the outcomes of the industry decisions investigated under objective 2, in their effects on employment, on international competitiveness and on their potential to deliver environmental benefits.

Objective 1



Contents

1. INTRODUCTION	5
2. METHODS	5
3. OVERVIEW OF UK SMES	8
4. COMPANY PROFILES	9
5. TRADE ASSOCIATION VIEW	12
6. INNOVATION STRATEGIES OF SMES	14
7. ENVIRONMENTAL ISSUES	15
8. POLICY IMPLICATIONS	16
9. FINANCIAL ISSUES	17
10. CONCLUSIONS	17
11. REFERENCES AND OTHER SOURCES	19

1. INTRODUCTION

The objective of this part of PITA is to study the influence of policies and market-related factors on innovation strategies in small and medium sized enterprises (SMEs), operating in the key industry sectors of interest, namely, biotechnology, chemical and seeds. In particular, it is the impact of policies and market-related factors on decisions about product development, levels of investment and location of investment which is of central concern.

Unlike larger listed companies, SMEs are not required to publish company information such as Annual Reports but there is, nevertheless, a variety of literature, database and website sources available to draw on. These can provide a detailed picture of the variety and character of PITA-relevant companies. For selected SMEs, considered to be important for specific reasons or representative of a type of company, interviews may be conducted with senior personnel to supplement information and opinion derived from other sources. In addition, the collective views of SMEs may be gathered through interviews with relevant trade organisations.

The development and progress of small and medium sized enterprises operating in high technology sectors offer a fascinating and important area of study. Although SMEs are, by definition, relatively unimportant in terms of size-related characteristics they are usually considered to be potentially more creative and responsive to new markets, changing policies and evolving public attitudes. One objective of this report is to consider the extent to which this may be true in the United Kingdom.

In terms of number of companies and financial turnover, PITA-relevant SMEs are relatively unimportant in the UK market. This research confirms that there are relatively few SMEs actively innovating in PITA-relevant technologies. For example, biotechnology SMEs based in the United Kingdom are predominantly enterprises developing pharmaceutical, medical and diagnostic technologies. There are very few small companies operating in the agricultural chemicals and seeds sectors, although there are, however, a few exceptions in the form of very small companies.

This picture does not fully reflect the importance of SMEs in the innovation process for agricultural technologies in the United Kingdom though. Many small enterprises grow to a point where they are taken over by larger independent companies or Multi-National Corporations. Indeed, this is sometimes the business strategy of some SMEs, since the access to financial backing which is potentially available from larger companies may be seen as key to successful product development. SMEs also play an important role as catalysts for innovation, for example as spin-outs from the University sector, providing an initial platform for the commercial development of academic research ideas. The experience, development and success (or otherwise) of SMEs is therefore an important element of the overall evaluation of policy impacts on the evolution of agricultural technology.

2. METHODS

The following sources were used to identify PITA-relevant SMEs operating in the UK:

Trade Association membership

Three relevant trade associations exist in the United Kingdom, each representing a membership consisting primarily of private companies. These trade associations are The BioIndustry Association (BIA), The British Society of Plant Breeders (BSPB) and The British Agrochemical Association (BAA). Current membership lists available from Annual Reports, association websites and other sources were examined to identify relevant SMEs.

Biotechnology clusters

A number of regional biotechnology clusters exist in the UK offering collective support and incubation services for SMEs and larger companies. These include the Eastern Region Biotechnology Initiative centred around Cambridge, the Oxfordshire Biotechnology Net and the Manchester Biosciences Incubator. Other relevant networks include regional associations between certain universities and commercial organisations based in the area (e.g. Western Arc Bioscience Platform in the Bristol area). Some regional and national development agencies (e.g. Welsh Development Agency) also offer particular measures of support for technological companies.

Government initiatives to support biotechnology SMEs in the UK

There are a number of specific measures being undertaken by Government to support innovation in biotechnology and to promote research and development partnerships between the public and private sectors. For SME development, the most important are:

(i.) BioWise

The Department of Trade and Industry (DTI) operates the BioWise initiative (previously Biotechnology Means Business) which aims to promote the benefits of biotechnology to SMEs and larger companies. This DTI initiative provides regular newsletters and a website highlighting the potential benefits of biotechnology and case studies of innovation by companies operating in all sectors.

(ii.) LINK

The LINK Programme is the UK Government's principal mechanism for supporting collaborative research partnerships between UK industry and the research base, mainly universities. There are a number of programmes relevant to PITA including Technologies for Sustainable Farming Systems and Sustainable Arable Production through Precision and Input Optimisation (SAPPIO). A LINK website and newsletters (MAFF 1999) provide information about individual projects being supported and the participating private sector partners, including SMEs.

(iii.) Small firm Merit Award for Research and Technology (SMART)

SMART is the 'flagship' DTI initiative designed to provide significant financial assistance towards the development of pre-competitive innovative technology. Support from this scheme is specifically designed to assist SMEs and is not available to large companies. Directories with full listings of recent and current projects were examined to identify relevant companies that have been supported (DTI 1997 and 1998).

(iv.) BBSRC Industrial Case Studentships

The Biotechnology and Biological Sciences Research Council (BBSRC) offer a number of Industrial Case studentships each year to projects involving partnerships between private companies and universities. In the 1999/2000 round, 3 PITA-relevant SMEs were awarded support from this scheme, namely Advanced Technologies (Cambridge) Ltd, CPB Twyford Ltd and New Farm Crops Ltd. Full lists of industrial studentships are available at the BBSRC website.

Database searches

The ABI/Inform database allows searches of technical press, trade magazines and other specialist periodicals. Keyword searches were undertaken to monitor recent coverage of relevant SMEs in the technical press. The BIDS social science and science databases were also included in this part of the literature search.

Business and technical press

Key national press and technical journals were also regularly monitored including, The Financial Times, The Guardian, The Independent, The Times Higher Education Supplement, Chemistry & Industry and New Scientist.

Business directories

The Kompass Business Directory provides an extensive listing (by sector) of UK companies of all sizes, including SMEs. Relevant seeds, biotechnology and agrochemicals sectors were searched.

GreenNet monitoring of GM licence applications

The GreenNet organisation provides a website with collated lists of current and recent UK GMO release applications and details of registered UK GM test sites. These lists provide basic details of the companies involved in the advanced stages of development of these particular technologies.

Green Industry Biotechnology Platform

Membership of this European association comprises mainly large companies but also includes a small number of SMEs. All members share an active interest in developing and commercialising biotechnology specifically for environmental application. The Green Industry Biotechnology Platform website provides information about member companies, the current regulatory status of GM crops being developed and other relevant details.

PITA Employment Survey

Data from the PITA Employment Survey relating to UK companies was obtained from the survey undertaken by MERIT (Arundel 1999). This provided information about the type of innovation being undertaken by seeds and pesticides companies in the UK and the level of employment in each company.

Once relevant SMEs had been identified, the following specific sources were used to collect information about selected SMEs. Information on structure, history and products (etc) was obtained as well as information about key areas of interest to PITA, namely company innovation strategies, environmental objectives and perceived policy implications.

Company reports, other literature and websites

Company literature for relevant SMEs was obtained by collecting annual reports, product brochures, press releases and other material, where available.

Interviews

Several key SMEs and one trade association were identified and key senior management personnel selected for interviewing. Advanced Technologies (Cambridge) Ltd were selected because of their importance in terms of size and history in the UK agricultural biotechnology market. Dr Martin Ward, General Manager and Ms Susan Black, Commercialisation Manager, were interviewed on 24th November 1999.

Axis Genetics also have a long history of innovation in biotechnology with products that span the 'traditional divide' between agriculture and medicine. Having recently encountered financial difficulties they are currently in administration, an experience which offers particular insights for those seeking to understand the process of innovation in high technology SMEs. Mr Iain Cubitt, Chief Executive, was interviewed on 25 November.

A number of very small SMEs innovating in PITA-relevant areas were also identified during the study. These 'micro' SMEs typically have very few employees yet offer valuable insights

into the early stages of SME development. A good example of a micro SME is Crop Enhancement Systems (CES) Ltd. Dr Muree Groom is Managing Director, and was interviewed on 1 December. Another micro-SME is BioDiversity Ltd and a brief discussion was also held during early December with Dr Frances Giaquinto, Managing Director.

For a collective trade association view, an interview was also undertaken with Dr Roger Turner, Chief Executive of the British Society for Plant Breeders (BSPB) on 13 December. The BSPB represents a wide range of companies and other organisations concerned with plant breeding and crop production. Its membership includes seeds and biotechnology companies, as well as a limited number of research organisations. The BSPB is a founder member of SCIMAC (supply chain initiative on modified agricultural crops) which was established in 1998 to support the responsible development of GM crop technology in the UK, representing the complete supply chain (from seed stock to harvested crop).

3. OVERVIEW OF UK SMEs

A recent report from the DTI (1999) supports the widely held view that relatively few SMEs are innovating in PITA-relevant technologies in the United Kingdom (Chart 1). An overview of independent PITA-relevant UK SMEs is given in Table 1. Most biotechnology SMEs are active in the development of new pharmaceuticals and medical diagnostics technology. There are however, a limited number of companies which are involved in agricultural diagnostics. Very few UK SME seeds companies appear to be innovating in biotechnology, and in the chemicals sector, innovating SMEs are restricted to small, specialised pest-control businesses (e.g. developing and selling pheromone-based products).

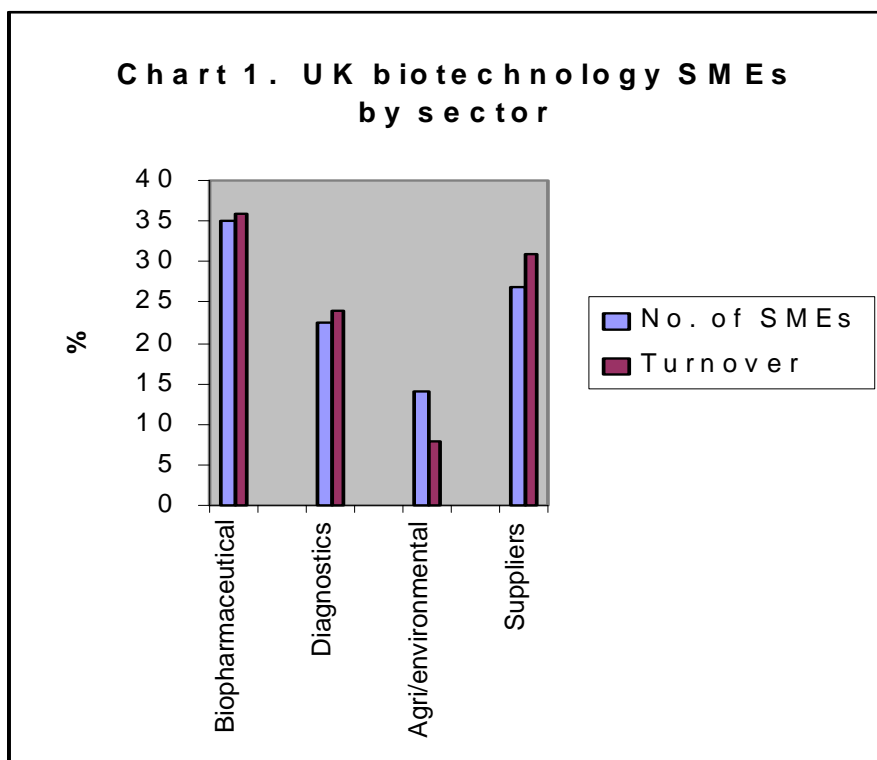


Table 1 Overview of independent UK SMEs innovating in PITA-relevant sectors.

Sector / activity	Micro-SME / startup	University spin-out	Medium / large SME
Seeds	0	0	1
Agrochemicals	2	0	0
Biotechnology	0	1	2
Niches:			
Biopesticides	0	2	0
Agri-diagnostics	1	0	0

Source: DTI (1999).

Note: Only independent UK SMEs are included here (i.e. SMEs wholly owned or controlled by MNCs or by non-UK based companies are excluded).

4. COMPANY PROFILES

Advanced Technologies (Cambridge) Ltd (ATC)

This plant biotechnology SME is located at Cambridge Science Park and innovates in three main areas, namely: starch and sugar biotechnology, forestry biotechnology and plant biotechnology for nematode resistance. The company vision is to provide downstream delivery of consumer benefits through enhanced processing characteristics. The ATC business strategy comprises four elements:

- (a) The application of biotechnology to improve green plants for processor and consumer benefits.
- (b) Close collaboration with selected market partners who have the capability to take technology to the market and who will ensure that technology remains appropriate to that market.
- (c) A willingness to conduct research with collaborators on a shared cost / shared benefit basis.
- (d) The development of expertise in metabolic engineering targeted for use in the food industry.

ATC has a board of directors whose main concern is with budgetary control rather than directing technical strategy. Senior staff therefore have considerable freedom (and responsibility) for decision-making and innovation strategy. ATC started approximately 12 years ago as a very small tissue culture company and has grown to a point where it now has 34 employees, of which 27 are engaged specifically on scientific and technological work. ATC generally develops and markets biotechnology products designed to benefit processors and consumers as opposed to developing agricultural trait benefits (e.g. herbicide tolerance). The selected technologies are seen as being “relatively easy” to produce and are considered to be independent of the plant system. The aim is to “nudge” plants towards the production of specific downstream benefits (for example, better processing of carbohydrate products from GM potatoes). This is a ‘processor onwards’ strategy.

Contrary to this strategy however, ATC have developed one important agricultural-trait product for nematode resistance (NemaGene). They consider this to be a niche product missed by the MNCs (which is what ATC is continuously looking for). The NemaGene product provides a “good story” for the development of agricultural biotechnology, with nematode infection being a worldwide problem.

ATC also innovate in forestry products but GM forestry work has now effectively stopped due to difficulties in attracting funding for the development of this technology. Lack of uptake on forestry products has also been a contributory problem, as has trying to get the relevant players to talk together (e.g. pulp processors, paper processors, biotechnologists). This is primarily due to a lack of understanding of the different sectoral issues (for example, due to the different time cycles needed: e.g. 12 years for wood, 2 weeks for paper).

ATC believe the best approach to successful development of their company is to try and retain core competencies and know-how. One approach which they regard as a sensible strategy is to look closely for new opportunities to apply the same technology, rather than develop a scattergun approach into new technologies (for example, on the modification of carbohydrates). Towards this aim, ATC work closely with a number of other organisations and regard alliances as important, (they are currently at the end of negotiations about a significant new alliance which is part of a technological programme and a move towards establishing a “a way to market”). ATC think BBSRC CASE studentships and LINK are useful to get work done and to establish necessary links and networks with academics and others. Usually they have about six studentships a year plus student placements (for example, with Cambridge University). ATC specifically use these to link into areas “where they want to go” (e.g. to gain access to specialist university facilities). Recently they have tried to utilise specialist cell wall expertise to further develop new paper technologies. Although ATC consider they have good in-house expertise on biochemistry and carbohydrates they need technical input on cell wall technology and have approached York University and Royal Holloway University. This type of alliance is important to ATC’s innovation process.

On a European dimension, ATC have been involved in Framework IV but think EC funding is “difficult to manage”. There is lots of administration and they wonder if it has been worthwhile. The key is to get good co-ordination so that the laboratories work effectively in teams. There has been some synergy but generally the projects have not worked. EC model contracts are not worded adequately and do not accommodate the process whereby Universities are “being privatised”. This is not a “one way flow” so there needs to be an adequate feedback process (e.g. on cell technology).

Financial backing for ATC came early on from BAT industries as venture capital (this is public knowledge). Continuing to attract significant money for investment for research and development has always been a problem, but more so now. ATC believe SMEs need to consider carefully how MNCs are spending their research funding.

Axis Genetics

This highly innovative SME has recently gone into administration, following a long history of development in the UK and more lately in the US where a clinical trials officer was based. Axis (formerly Agricultural Genetics Company Ltd) was created originally by a management buy-out. Since 1994 Axis has moved away from being a purely agricultural biotechnology company and was, until recently, completely involved in the development of new vaccine technology (although this uses crops to produce the vaccine). In 1994-5 a new business plan was agreed with the backing of institutional funding, that moved away from conventional agricultural products. Prior to administration the focus was on high value, orally delivered vaccine technology, based on innovative biotechnology for human use (as compared with the relatively low value and fragmentary market for veterinary products). Since 1995 the company has successfully attracted £13M for development and grew to a size where it employed some 50 staff.

In recognition of their high degree of innovation, Axis Genetics secured one of the few SMART Exceptional Development Project Awards (from DTI, worth £443,000). The technology has “moved well” and Axis were in the early clinical trials phase of development prior to administration. This process was proving very expensive. Axis Genetics have also secured at least £5M of private investment funds for innovation in an area seemingly blurring the divide between medical and agricultural products. This type of innovation may be of particular interest because it offers potentially new value for ‘traditional’ crops.

'Micro-SMEs'

A small number of 'micro SMEs' (a term coined for SMEs with very few employees and a limited product range) have recently come into existence, often benefiting from SMART support packages or other Government aid. Although small in financial and manpower terms, these SMEs are potentially important to PITA because of their capacity to innovate and develop niche products. These companies are characterised by a relatively small but highly innovative product range. A good representative company is Crop Enhancement Systems (CES) Ltd.

Crop Enhancement Systems (CES) Ltd

CES is based at the new EcoTech Centre near Norwich, and works primarily in the UK as a producer and provider of innovative analytical technology for the agricultural, food processing and environmental industries. CES is a distributor for Bt toxin diagnostic kits and has an unusual perspective on the development of agricultural technology based on the experience of Muree Groom (Director) gained over the previous eight years, working at a research farm, prior to establishing the company. This experience is seen as critical to the credibility of CES, allowing coherent arguments to be based on a sound understanding of the agricultural market. "Business volume is moving up" now for CES.

CES produce innovative diagnostic technologies and decision support services for the agricultural sector. Products include pesticide detection kits, antibody diagnostics for soil pathogens and decision-support information. These products have been designed following a long history of involvement in agriculture and CES is trying to promote and respond to the need for a more responsible management of the environment ("CES actively attends conferences and promotes responsible resource management and is getting interest").

Membrane technology products are produced and distributed in collaboration with Alchemy Laboratories based in Dundee and EnviroLogix, a US company which develops and manufactures immunoassays for agricultural, food and environmental markets. An emerging area is the testing of crops and foods for the many transgenic traits now coming onto the market. For example, lateral flow and plate format kits are designed to detect BT11 and Mon810 in grain, and Bt11, Mon810 and Bt176 in corn and cotton tissue. The market is "showing interest".

CES has two employees and uses licences and transfer packages for their company partnerships/alliances. They have links with continental businesses (e.g. in France) and they are also trying to establish some more strategic alliances (but were reluctant to elaborate). The management structure of CES is simple and comprises a board of four shareholder 'directors' (MG is one) plus one other independent (chemist) member to give a wider perspective and a greater degree of independence.

CES has received no venture capital input or any "statutory" regional assistance either, relying solely on the shareholder capital of the directors. They are "extremely focussed" on agricultural diagnostics and expect the decision support service to evolve well. CES are looking for "additionality" as opposed to (say) a big grant. The membrane technology being developed with Alchemy laboratories is "critical" because there is a wide range of potential applications. Diagnostics technologies are not restricted to agricultural application and are not a segmented market tool.

Other micro-SMEs currently trading in the UK are:

Biodiversity Ltd

This small SME (two employees) is based at Brunel Science Park in Middlesex and the Managing Director is Dr Frances Giaquinto. BioDiversity exploits the chemical diversity of natural products produced by micro-organisms for the discovery of new biologically active molecules for pharmaceutical and agrochemical application. The technology involved is an analytical tool to assist with the development of new compounds rather than an agrochemical application *per se*. In 1998 they were awarded a SMART Award.

SafeDip Ltd

This small company is in the early stages of developing products for direct and indirect treatment of animal welfare problems. These products are designed to be 'safe' in the environment and not to pose health problems for human operatives. SafeDip Ltd also received a SMART Award in 1998.

Insect Investigations Ltd

Insect Investigations Ltd is an associated company of Cardiff University, linked directly (and based at) the School of BioSciences. This SME is supported by the Welsh Development Agency and is active in several LINK projects. It undertakes innovative research relevant to pest management and aims to develop environmentally friendly products for the pest control industry. The company is currently going through a process of "restructuring and refocusing preceding major capital investment". As a consequence, they felt unable to be interviewed.

Ecological Sciences Ltd

This SME is a 'spin-out' company from Exeter University developing a range of plant disease suppression products using composted recycled organic materials. Targeted diseases include potato blight, downy mildew in oilseed rape and cereal diseases such as mildews, rusts and leaf blotches. The company won a SMART Award in 1995 and retains strong links with the Wolfson Laboratory at Exeter University.

In addition, a number of PITA-relevant SMEs have been identified which are wholly owned or controlled by large companies or PSREs:

New Farm Crops Ltd is owned by Novartis and works on GMO technology.

Biogemma UK Ltd is wholly owned by Limagrain.

Seed Innovations Ltd has been owned by Cebeco since 1992.

Maribo UK Ltd is part of Danisco.

CPB Twyford is owned by a European consortium of plant breeding specialists comprising Lochow-Petkus (part of the German KWS group), the French organisation SIGMA and NPZ Lembke, also German. This company also works on GMO technology.

AgriSense-BCS Ltd is wholly owned by the large US company Thermo Electron Corporation. It produces biopesticides, Bt insecticides and behaviour modifying chemicals.

MyInfield Research Services Ltd is the commercial organisation of the Scottish Crops Research Institute based in Dundee. They act as a service company, managing GM crop test sites.

Although these companies innovate in PITA-relevant technologies their relationship with large companies or PSREs means they cannot be considered as independent UK SMEs. They are not therefore considered further in this UK SME report (though the history of some of these companies may be of interest, since some (e.g. AgriSense) have originated as 'true' UK SMEs prior to acquisition).

In the seeds sector, only one innovating SME was identified. **Elsoms Seeds Ltd** has some 80 employees and is active in several LINK Projects. It utilises assisted breeding techniques.

5. TRADE ASSOCIATION VIEW

For the BSPB, the crucial issue facing SMEs and other member companies is the lack of investment and other practical support for plant biotechnology. The UK is considered a centre of excellence for these emerging technologies and has been "hugely successful" in some

areas, yet there is perceived to be a cultural attitude problem in the UK towards success generally and towards successful business development in particular. Finance and (increasingly) specialist personnel are increasingly mobile, both seeking potentially better returns elsewhere. In the case of investment finance this is moving more towards US and German companies and away from UK (the case of Axis was cited as a good example). Scientists and other key personnel are also attracted to other countries with better support. These issues were aired by RT in the *Financial Times*. There is a need for financial assistance both at the start up phase and also during the process of bringing the product to market ('mezzanine' funding).

For RT, it is important to recognise two distinct types of SMEs in agbiotechnology. First, the 'classic' entrepreneur with a good idea who pushes on regardless of support, policy or anything else. These have the highest rate of failure. Second, entrepreneurs who have previously worked for an MNC who have access to patents and other help. These essentially spin-off with support and awareness of the 'mother' company. The MNC might, for example, retain rights and then have first right of refusal on licences (etc) from new technologies. This approach can provide a better foundation for new SMEs.

On STI policies, these are generally considered to be alright but there needs to be more flexible support, particularly in the early stages (for example, via tax breaks). The situation has got better in the UK but is still not as good as the US where "they are more comfortable with risk". On innovation there is (again) perceived to be a general cultural issue about 'failure'. For IPR policies, the BSPB is comfortable with existing policies. The UK situation is good because it uses a good mix of patents, plant variety rights and licences (unlike the US where this is dominated by patents).

On environmental issues, BSPB believe that we need to agree as a society what we mean by sustainability, since there are many potential meanings. It would be best to model changes first, perhaps in a few small-scale areas across Europe. Many farmers already have environmental measures in place and this could therefore cause differentials. There is a need for more coherence ('joined up thinking') because, for example, wildlife and rights of way issues do not recognise farm boundaries.

On agricultural policies, Agenda 2000 has badly frustrated plant breeders because of the issue of 'wall to wall' cereals. There is a deficit in plant oil crops (linseed / flax etc) in the UK. BSPB has talked to the UK Government about this, and there is a need to get the balance right. Also on CAP reform, there is also a general need to shift gradually from support for production to support for income diversification. Jumping from production to environmental protection in one go is "too much".

Environmental regulations are not seen as a problem and BSPB recognise that they often stimulate the development of new SMEs to address particular environmental concerns. Regulation needs to be clear though and to change only gradually (EC Directive 90/220 GM crop release regulation was cited).

On public attitudes, BSPB members take note primarily via the market. Public opinion can change quickly and the GMO problem might change "overnight". Part of the problem is that the UK government has no strategic vision. We need to highlight the potential benefits of biotechnology (ATC's nematode programme was offered as an example). BSPB also recognise a range of other environmental benefits arising from the new technologies. Biomass crops for example are being developed with breeding techniques (not GM) applied to Willows to improve energy return (Zeneca is working on this).

BSPB believe that it is critically important that we underpin all policy with sound science and attempt to build consensus. This could be achieved via a roundtable approach allowing agreement on some issues and disagreement on others.

6. INNOVATION STRATEGIES OF SMEs

UK SMEs are clearly unable to compete directly with MNCs. One critical reason for this is the lack of resources for innovation and the difficulty in accessing external funding. The role of alliances is therefore very important, potentially allowing access to facilities, expertise and other essential technological resources. SMEs need to develop niche products (which are perhaps 'missed' by MNCs) and, as private companies, are wholly consumer driven.

ATC use targeted small groups for decision-making for innovation strategy, seeking to reflect a balanced corporate culture. This balances commercial goal-oriented outcomes with "intellectual freedom" and opportunities for development. ATC innovate on their own (via patents) and via alliances, and only in biotechnology since they believe "there is no alternative" technology. Establishing appropriate protection is critical and for ATC Intellectual Property Rights issues are proving very time consuming. For example, an issue surrounds the perception that "universities want to own everything" and are obsessed about having their own patents (this has arisen partly because patents are seen as a measure of success in universities and other research institutions). The feeling is that universities are now generally behaving like the private sector (this 'problem' is not confined to the UK).

In Axis, a small management team undertakes decision-making on research and development issues. This team comprises four executive directors (finance, business development, research and development, intellectual capital), together with a clinical trials and product management specialist. Axis has recently benefited from public funding for innovation via both LINK and SMART and think they are "both fine but too inflexible" and that "fast moving SMEs need more freedom". They have moved away from EC support/funding which has had problems. For example, the application process was considered laborious and the administration can be difficult. There is very little, if any, freedom and the company can become "tied in" which is seen as counter productive. Therefore, EC funding for innovation support is seen as unattractive and even unhelpful.

Links with PSREs are useful and Axis has a long history of collaborating with universities and research institutes. Most recently these alliances have been in the US with centres which are much more appropriate to the particular technologies concerned. This is not a consequence of UK policy in any sense rather "just the way its gone" since US research institutes / PSREs are much more relevant. On IPR policies, UK patents and other IP requirements are not "unduly onerous", rather clinical trials is the main issue in terms of cost and time involved.

CES Ltd's innovation strategy is driven by the current lack of deliverable analytical technology at field/farm sites. The decision making approach is based on a "sound understanding of the needs of farmers". In particular, the need for better information concerning resource management, pesticide levels etc. They see a shift beyond Integrated Pest Management into 'responsible natural resource management' as the need for better environmental performance evolves in response to consumer concerns.

For CES, synergy with outside companies or through establishment of new SMEs is seen to be a key part of successful innovation strategy. This is because it can be difficult for one SME to possess the necessary skills, technological resources and know-how for specialised biotechnological development. For example, CES is developing a sister company (EcoSpray Ltd) which will deliver improved technology for better application of chemicals. A recent SMART Award has made a big difference to CES's innovation strategy, bringing enhanced reputation and significant financial resources for product development.

On intellectual property, CES see this as a "prickly" subject and have ambivalent views. It may be important to protect ideas but are patents the best way to do this? (MG has patents but is unsure). Some SMEs (and universities) are so concerned with establishing patents that they are "not getting on with selling things". For SMEs, patents can be really problematic because it is easy to lose focus and there are up front costs. It is also time consuming. There is also an issue surrounding patent infringements ("it is alright for MNCs because they can

cluster the technology”). However, CES appreciates that IPR policies are vital but are unsure of how to best protect their new technological ideas.

For SMEs the role of Government support for innovation is clearly important. Would some small SMEs exist without SMART awards and other tangible support available for innovation? This is difficult to say, but it is also clear that alliances and other collaborative partnerships are critically important to the successful development of SMEs and their technologies.

7. ENVIRONMENTAL ISSUES

UK SMEs recognise the potential importance of the environmental impacts of their activities and the technologies they are developing. This is partly about responding to consumers as awareness of (agriculture-related) environmental problems increases. This concern is shaping the products and services being produced by UK SMEs and also the way in which these companies are doing business. It is also clear that environmental problems are seen as potential opportunities for new innovations either as possible solutions or through improved information provision.

An important environmental consideration for ATC relates to the development of their modified carbohydrate technology. This will enable potatoes to be stored more effectively and remove the need for the energy consuming blanching processes which are currently used. This blanching process produces polluting effluents, e.g. with a high biological oxygen demand, yet there is a hold up with technology development due to the concerns surrounding the cross pollination from GM crops in general. For ATC, globalisation of business and CAP reform are seen as indirect environmental issues, though they may have important impacts on ATC’s customers, e.g. by reducing input costs (for the NemaGene programme). ATC is developing technology which aims to replace soil fumigants (which are highly toxic) but is unable to proceed due to the public attitude ‘problem’ concerning biotechnology generally – “It doesn’t add up”. ATC have also been working on *Eucalyptus* clones, which could have an important environmental impact, potentially making forestry more efficient and (the implication being) more sustainable. “ATC need to wait”.

For Axis, the main environmental issue is the “general paranoia” surrounding GM technology, though “in reality there may be very little difference from the original plant or plant breeding techniques which have been used for some time”. Axis recognise that there are only a few small ag-biotech players, and that the new technologies are mainly being developed by MNCs. “Its OK for them, they can keep their heads down...but one wonders for how much longer”. MNCs have the necessary financial ‘clout’.

Sustainability issue were not thought to be “particularly relevant” to Axis, given the particular products they were developing. IC talked about the “elegance” of the ATC technology being developed to control parasitic nematodes and obviate the use of highly toxic fumigants. He thought it was a “very elegant solution” and that it was a “tragedy” that misunderstanding is generating fear, which in turn is causing a real “loss for mankind”.

For CES, they see the company vision as clearly focusing on the process of moving towards environmental sustainability with more responsible natural resource management. For them, this is mainly about developing products which offer the potential to provide better information and therefore more informed decision making. It is also about improving environmental monitoring processes and widening the potential for greater confidence in environmental performance of companies and others. By improving environmental monitoring technology, making it more rapid and much simpler CES hope a wider range of users will be “empowered”, including ‘ordinary’ consumers. CES also want to mover further into an educational process through the development of these technologies, hoping that many students (and school children) could be involved in (for example) pesticide monitoring or other pollutants (“biotech in action”). This is part of the wider company vision and also involved in the decision to move to the EcoTech centre where many visitors can learn about their new environmental technologies.

CES innovation is safety driven, so the role of environmental / health regulation and policy is important. CES aims for better monitoring of key pesticides and pesticide residues allowing farmers (potentially) a much more 'real-time' decision making framework (e.g. one hour or even less), allowing farmers to know when crops are safe to harvest. This technology will bring "stakeholder empowerment" and CES want this to be a reality. There is also perceived to be an urgent need to monitor downstream (of farm) environmental impacts of (say) pesticides on, for example, estuarine wildlife.

8. POLICY IMPLICATIONS

The interviews and other research undertaken have highlighted a number of important policy issues now facing SMEs working in the UK to develop new agricultural technologies. These issues concern finance and other support for innovation, public attitudes, the role of alliances and the influence of MNCs.

For ATC, it seems as though policy makers and big companies are "the same". For example, the relationship between one large company and Government was seen as "worrying" with important implications for SMEs. For CES, big companies are also seen as too powerful. They "can accelerate policy development but can do more harm than good".

ATC also identify a lack of coherence from EC policy (e.g. Directive 90/220). The lack of agreement has fuelled debate, concern and unease, creating uncertainty which is now a key issue (compared to the States where the situation is much clearer). More speed is needed on Directive 90/220 revisions, since this has now effectively halted all decisions about GM products for 18-24 months.

ATC also feel that EU policy on STI is good but not executed well. For example, is Framework 4 feeding properly into FW5? The rules are changing and the administration is proving very time consuming. They believe there is an urgent need for a framework for negotiation which would enable policy to be practicable.

On IPR, SMEs identify the need to go faster because the UK patent system can take 2 years to complete and the EU patent system can take as long as 10 years. This delay can become a disproportionate obstacle to SMEs. There is also a need to harmonise US and UK IPR policies. This is important because the 'playing field' is not considered to be level at the moment.

For ATC, the overall need is for policy, regulation and legislation to be realistic and clear for both the sake of public confidence and for business development. CES believe that "biotechnology has got to get unbunged". For example, there is a need to close the loop so that consumers pull technology development more. How are we going to do this? CES believe that greater educational awareness of the benefits and possibilities of biotechnology will play an important role. CES also think that environmental policy is being driven by the supermarkets which have considerable power. Although the Pesticides Safety Directorate provides the law of the land, "commercial reality is being driven by big companies". There is an emerging consumer-driven concern (as witnessed recently in the Seattle riots).

For CES global warming is also a real issue. When the interview was undertaken (1st December), there had been no frost which was causing problems to farmers. Ordinary people want to be able to provide a more tangible and practical input into addressing environmental problems. Consumers are beginning to "apply the breaks" and this is starting to effect the big companies.

9. FINANCIAL ISSUES

For 'true' SMEs, attracting start-up finance and development funding has always been difficult and this continues to be the case. Private investors are now being deterred because early SMEs did not deliver returns, and this is causing real problems for those SMEs still attempting to operate in today's market.

This is an important policy issue for Axis since it relates directly to the financial environment for biotechnology companies at the middle stages of their development (predominantly pharmaceutical rather than agricultural). The important problem is the total lack of middle funding because this is a critical stage of bringing products to the market. For example, "better tax breaks are required". Although some limited venture (start up) capital is still available, institutions are not investing in middle stage development. This funding need is critical yet the route to the public market has now closed. It is "simply not possible" to go public now. This withdrawal of city funding has been caused by "early players failing to deliver" any successful products and the city has consequently become very cautious. For Axis, this is the principal issue, it is not an issue of shifting public attitudes. There is "no more euphoria" for biotechnology companies and it is a very difficult environment for biotechnology companies to develop in. Now, private investors are heavily attracted to internet stocks and other new sectors. What is the future for Axis? "There is none", administration will provide some returns for original investors but the shareholders will get nothing.

For CES, biotechnology is also seen as a "graveyard" for investment opportunities. Whilst some elegant and potentially valuable agricultural biotechnology has (and is) being developed in some SMEs there is a feeling that final, profitable products have not been delivered. This obviously has implications for potential investors looking at the past records of SMEs when making investment decisions.

The UK is proving to be an extremely difficult trading environment for PITA-relevant SMEs, with critical issues surrounding the availability of public and private finance, together with uncertainty about the development of regulation and the future evolution of public attitudes.

The UK Government has, however, introduced a number of measures to encourage investment in SMEs with a particular emphasis on high technology businesses, including venture capital trusts and tapered relief on Capital Gains Tax. The Government has also announced plans a UK High Technology Fund and regional Venture Capital Funds. Further measures announced in the 1999 autumn Pre-Budget Report include a proposed R&D Tax Credit and targeted tax incentives to help recruit and retain key staff through equity remuneration (DTI, 1999).

10. CONCLUSIONS

This research, like other studies, highlights the limited number of UK SMEs currently working on the development of PITA-relevant technologies. SMEs are limited in terms of the number of companies trading and in terms of their size (turnover and number of employees). The research also confirms that several longstanding difficulties continue to face independent SMEs, particularly in the area of access to middle-level finance and regulatory uncertainty surrounding GM technology. Key conclusions are:

1. SMEs continue to find it difficult to access finance at critical times of product development. This is particularly true for companies seeking middle-level (or mezzanine) funding needed to bring products to market. Finance from the City has dried up as a consequence of some SMEs failing to deliver returns. Better tax breaks are also required.
2. Considerable importance is placed on the establishment and maintenance of successful alliances and co-operative working. Typically, this is with Universities or PSREs, but

ANNEX D7

also with other companies. SMEs rarely, if ever, have all the expertise or resources required to develop successful innovative products and services. Policies to promote such co-operation (for example via the LINK scheme) are seen as valuable, but more freedom is sometimes needed in the way collaborative projects are managed.

3. Regulatory uncertainty continues to make planning difficult, particularly in relation to the development of GM technologies. Future policy development is seen as unpredictable, partly as a consequence of the strength of public opinion about GMOs. There is a feeling that there is a general lack of strategic vision from the UK Government on this issue.

These factors, and others, have conspired to create difficult conditions for SMEs seeking to develop innovative technologies for agricultural application. This has been recently highlighted by one larger 'flagship SME' (Axis) going into administration. On the other hand, a number of highly innovative 'micro-SMEs' are emerging. These very small companies are developing niche products and services, often aided in their early development by finance from SMART innovation awards. It is likely, however, that these will face similar problems as they develop unless change occurs in the financial, regulatory and public-opinion arenas.

11. REFERENCES AND OTHER SOURCES

- ABI/Inform database of technical reports and trade press: <http://www.umi.com>
- Arundel, A. (1999). Technology Investment Options and Employment: results of a survey of European seed and pesticide firms. MERIT. (This study is part of PITA (Policy Influences on Technology for Agriculture), funded by the TSER Programme of the European Commission (DG XII) as Project PL 97/1280.)
- Axis Genetics Ltd website: www.axisgenetics.co.uk
- BioIndustry Association (1999). Industrial Markets for UK Biotechnology – trends and issues. BioIndustry Association.
- BioIndustry Association (1998) Annual Review.
- BioIndustry Association (1999) Website <http://www.bioindustry.org>
- Biotechnology and Biological Sciences Research Council (1999) Website at <http://www.bbsrc.ac.uk>
- British Agrochemicals Association (1999). Handbook.
- British Agrochemicals Association (1999). Website at <http://www.baa.org.uk>
- Chapman, T. (1999). Biotech to benefit from budget bonanza. *Chemistry & Industry*, 5 April, p255.
- DTI (1997 and 1998). Funding Innovation – Directory of SMART Award Winners.
- DTI (1998). Closing the gap – the performance of UK SMEs within the United Kingdom Benchmarking Index.
- DTI (1999). Genome Valley: The Economic Potential and Strategic Importance of Biotechnology in the UK. Report.
- DTI Bio-wise initiative website at <http://www.dti.gov.uk/biowise>
- Eastern Region Biotechnology Initiative. Cluster website at <http://www.bioportfolio.com/erbi/page22.html>
- Ecological Sciences Ltd website at <http://www.exeter.ac.uk/ecosci/pds.htm>
- Green Industry Biotechnology Platform website at <http://www.gibip.org/>
- GreenNet organisation website at <http://www.gn.apc.org/pmhp/dc/genetics/colist.htm>
- Insect Investigations Ltd website at <http://www.cf.ac.uk/insect/company.html>
- Joly, P.-B. (1999) Innovating through networks: a case study in plant biotechnology. *International Journal of Biotechnology*, 1, 1, 67-81.
- LINK Collaborative Research programme website at <http://www.dti.gov.uk/ost/link>
- MAFF (1999) Agriculture Link: the Newsletter of the Agriculture and Horticulture Industries. LINK Collaborative Research. Produced by Ministry of Agriculture, Fisheries and Food.
- Martin, P. (1998) Inventory and analysis of biotech programmes and related activities in all countries participating in the Biotechnology Programme 1994 – 1998: national report of the UK. SPRU.
- Ministry of Agriculture Fisheries and Food (1998 and 1999) Agriculture LINK. Newsletter of the Agriculture and Horticulture Industries. (LINK collaborative research programme).
- Oxfordshire Biotech Net. Cluster website at <http://www.biotechnet.co.uk>
- Teece, D.J., Pisano, G. and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18, 7, 509-533.

ANNEX D7

Wield, D. (Ed.) (1999) State of the Art of Knowledge including Research Activities, part 2.
Report