February/2000

41

ISSN: 1025-9384

5 EURO
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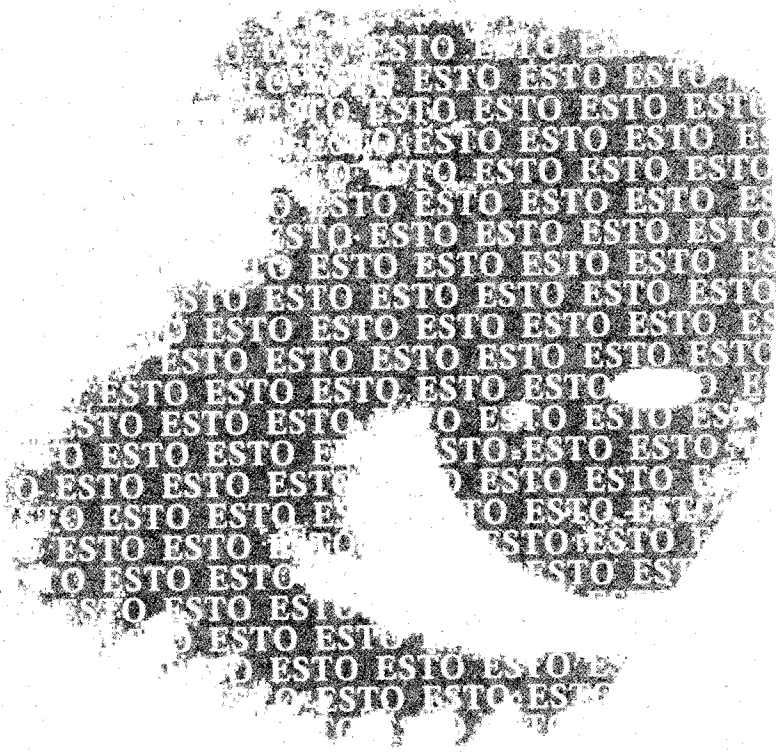
The IPTS REPORT

EDITED BY THE INSTITUTE FOR PROSPECTIVE TECHNOLOGICAL STUDIES (IPTS)
AND ISSUED IN COOPERATION WITH THE EUROPEAN S&T OBSERVATORY NETWORK



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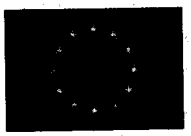

ENGLISH VERSION

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PUBLISHED BY THE EUROPEAN COMMISSION
Joint Research Centre
ISSN: 1025-9384
Catalogue Number CK-AA-00-001-EN-C
DEPOT LEGAL: SE-1937-95

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THE IPTS REPORT
is published in the first week of every month, except for the months of January and August. It is edited in English and is currently available at a price of 50 EURO per year, in four languages: English, French, German and Spanish.

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Republican campaigns may be indicative of Microsoft strategy in this regard. Perhaps aware of these possibilities judge Jackson, on the one hand buttressed his findings, laying a strong foundation for the edifice of court battles, which may ensue. And on the other hand, in order to revive the chances for a settlement, he assigned a highly respected judge and anti-trust scholar, judge Posner, to arbitrate between the parties.

In any case the next step – barring a settlement – is the judge's legal ruling next year, and the remedies/measures prescribed therein. There are two kinds of remedies. Conduct remedies would address the firm's behaviour, aiming to prevent future breaches of the law. Structural remedies would aim at changing Microsoft's position in the industry and/or its corporate structure.

Those conduct remedies which are easy to implement, and do not require cumbersome regulatory supervision will very likely be employed. They may not be enough however, and will likely be accompanied by structural ones, too. Moreover, conduct remedies have been tried before, and were flouted by Microsoft. For some of them, meticulous oversight by regulatory committees and the courts will have to be foreseen, given the scope of Microsoft activities, the technical complexity of the issues involved, and the multitude of ways in which rules can be bypassed. Moreover, Microsoft's recent forays into the telecoms and cable markets imply that conduct remedies may be focusing on yesterday's problem, and that even with oversight Microsoft's practices, as identified by the judge, may keep one step ahead of the law.

In any case the very severity of the findings of fact will make the goal of asking for structural remedies very tempting for the Justice Department. Structural remedies can include: 1) publishing the source code of the Windows operating system; 2) breaking up Microsoft into smaller clones of itself (the so-called Baby-Bills), competing with each other along all product lines; 3) breaking up of Microsoft into smaller firms along product lines; 4) a combination of the above. Compensating Microsoft for the Windows source code could cost as much as $US200 billion – which is not necessarily unaffordable, given the amounts quoted in recent buyouts (e.g. MCI-Sprint). The risk with the 'clones' remedy is they may buy each other out, rebuilding a giant company in the process. Note finally that the breakdown along product lines is more difficult after a recent reorganization in Microsoft; the judge of course could take the older structure as his starting point, to facilitate break-up along product lines.

A lighter version of a structural remedy calls for keeping the Windows source code proprietary but making public the interfaces with which applications latch onto and use the operating system. In this case, as well as in other measures mentioned above, it is crucial that all necessary technical requirements be met to guarantee that applications written for other operating systems can compete on an equal footing with applications written expressly for it.

As a result of effective structural remedies: 1) operating systems, including possibly several different versions of Windows, will compete among them on their merits, and not on the basis of how many are already installed and have captive users, or application providers; 2) hardware developers will be freer to produce hardware that is not built with Windows in mind, opening the way for more innovative designs; 3) finally, and more generally, a truly open system, not bound by the type of operating system, can be more feasible in a market not dominated by Windows. The implications and lessons for EU firms and for competition regulations are multifaceted and deserve to be examined closely and at length.

scholarly activity and has already put its stamp on the basic framework conditions of research, in particular with regard to the specific needs for ICT based infrastructure.

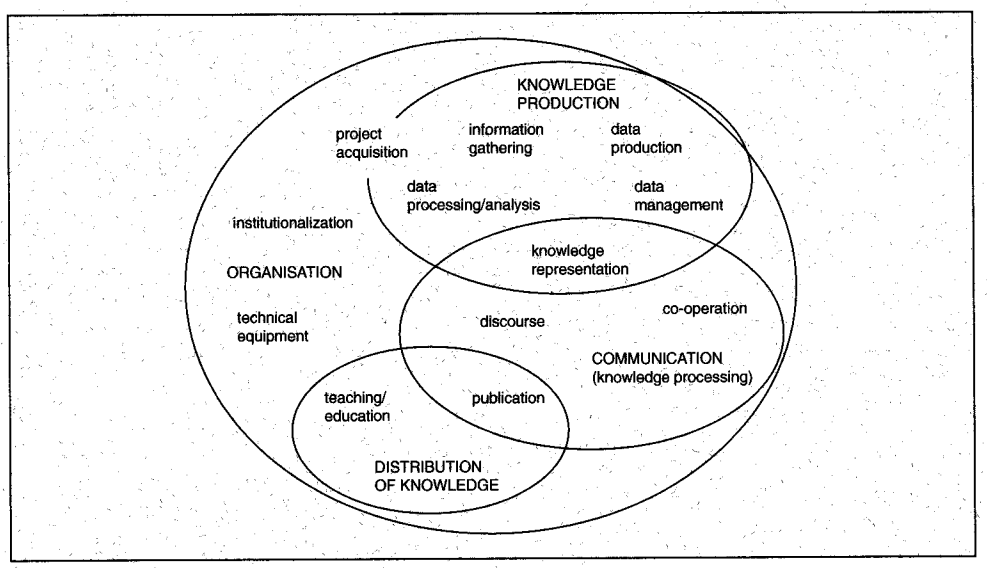
There are various types of scholarly activity: Seen from a procedural viewpoint, we may distinguish knowledge production (including information gathering as well as data production, analysis and management) from knowledge processing, i.e. scholarly communication (knowledge representation, discourse and co-operation), and knowledge distribution (publication and teaching). On an organizational level, scholarly activities need technical equipment and institutionalization. See Figure 1 for an illustration.

Using this terminology, we may analyse the changes in academia on the path from traditional science to cyberscience. Take information gathering as an example: while in the old days, libraries and documentation centres with card-file indexes and face-to-face interviews and conversations were the norm, off- and now on-line databases have revolutionized the way researchers explore the "data jungle". Recently the World Wide Web (WWW) has come to represent a new and powerful access point for information, with its specialized collections of links and pointers to resources further enhancing research tools. The first digital libraries already exist, soon virtual libraries (with no physical presence whatsoever) will follow. All this adds up to a digital information space to be searched by so-called knowledge robots ("knowbots") in the not so distant future. Or take scholarly discourse: Not so long ago, the one-to-one telephone call was the only means to communicate with fellow scholars unless you worked next door or met them in conferences and seminars. Now, scholarly communication is heavily influenced by ICTs: in particular, the internet with its various applications (email or web-based discussion lists), which has at least partly replaced the telephone, and online conferences begin to be a viable alternative to face-to-face gatherings. Table 1 shows that we are witnessing changes in all respects of scholarship (for a detailed analysis see Nentwich, 1999).

Scholarly activity comprises knowledge production, knowledge processing or scholarly communication, and knowledge distribution

The first digital libraries already exist, soon virtual libraries (with no physical presence whatsoever) will follow, leading towards a digital information space searched by so-called knowledge robots ("knowbots") in the not so distant future

Figure 1. Types of scholarly activity and framework conditions



scientific abstract, the abstract for the wider public in a simpler language, the theoretical and the methodological parts, the empirical findings, the conclusions, the references etc.; see Kircz, 1998). Second, we may imagine an even more detailed modularization: the text unit would be a single argument or an example/proof while all arguments are linked together not only sequentially (as we do in present "linear" texts), but also according to their level of analysis. This will offer to the readers multiple ways to access their "texts". There may be a "path through the text" for the quick, but knowledgeable reader searching to understand the main thrust of the paper, other "paths" for the interested layperson, for fellow scientists of the same specialization looking for the core result etc. Furthermore, in a fully electronic, networked environment it would be possible to have multiple links between scientific hypertexts: Redundancy of research may thus be reduced: e.g. overviews on the history or the basics of the paper's topic or definitions etc. would not have to be repeated over and over again in each new paper but simply referenced via a link to either one's own previous hypertext publications or to those of other authors. In the long run, gradually large, specialized hypertext databases or "hyperbases" may evolve. Such combined knowledge databases might revolutionize the way we think of scholarly products.

Will cyberscience finally do without paper altogether? Latest developments in screen technologies and, in particular, electronic ink/paper technologies seem to remove at least one important obstacle to a complete shift since truly mobile reading and working devices are appearing on the horizon. Even assuming that there is still a long way to go, the ongoing "pricing battles" between the commercial publishers and the libraries might come to full stop since cyberscience might eventually lead to a completely different scholarly publication model which could be run by academia itself, simply in order to cut costs (e.g. Harnad *et al.*, 1998; Pew Higher Education Roundtable, 1998; Okerson *et al.*, 1995).

The Removal of Spatial Limitations

The use of networked computers is about to free scholars from spatial limitations at least to a considerable extent: the office resources may be used even if the scholar is not physically present. Online access to E-journals and other E-publications in remote digital libraries and access to various online databases may reduce the need to have a real library close-by. So-called "extended research groups" may co-operate in a virtual environment (e.g. in a virtual laboratory or "collaboratory") while meeting at best occasionally (e.g. Finholt et al., 1997). Groupware applications may support this joint research, and virtual or E-conferences may take place on a larger scale. By the same token, cyberscience may have considerable impacts on the way research will be done in the not-so-distant future: multi-authorship may increase; the oral scientific discourse might be largely replaced by written procedures; scientific communities may be more fragmented, i.e. specialized, but interconnected world-wide; research infrastructure requirements may shift; and the positioning of more peripheral research units may change due to this development (e.g. OECD, 1998: 198). Thus, the spatial structure of academia, its "geography", seems to present new opportunities as well as challenges in the age of cyberscience.

Changing Roles in Academia

The spreading of ICTs in academia and the related concentration of resources at the office desk is about to lead to new requirements for those working in a research environment. Since these qualifications are partially too demanding to be fulfilled, at all or at least sufficiently, at the individuals' level, this may also impact on the distribution of roles in academia. Due to the increasing digitalization of the libraries, the

In the long run specialized hypertext databases or "hyperbases" may evolve. Such combined knowledge databases might revolutionize the way we think of scholarly products

Online access to E-journals and other E-publications in remote digital libraries and access to various online databases may reduce the need to have a real library close-by

Keywords

information and communication technologies, internet, electronic publishing, future of academia, sociology of the sciences, digital libraries

Note

1. This paper is based on research carried out at the Institute of Technology Assessment of the Austrian Academy of Sciences in Vienna. The project homepage is: **http://www.oeaw.ac.at/ita/ebene4/e2-2a17.htm.**

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encouraged and structural changes made in a way that can contribute to socio-economic development and improvements in quality of life.

- *Constant demand for increased specialization* - The increased competitiveness of changing market conditions and continuous and rapid technological evolution make it essential for companies to adapt their skills to the constantly changing environment. Firms must therefore be able to respond rapidly to forces such as technological innovation, trade liberalization and market deregulation. This implies growing demand for specialized skills and higher levels of qualification in both the service and manufacturing sectors. This makes knowledge management an essential factor that strongly affects the learning process and the specialization of workers. Lifelong learning has now come to take on a strategic role for firms (Fergusson, 1999).

- *New working style and labour market* - Market globalization is producing huge changes in the labour market both at production process level and at organizational level. It has required dynamism and flexibility in company management and organization to fit in with the needs of the market. A changing market has meant jobs for life have given way to fixed-term contracts. This obliges workers to continuously update their professional knowledge and skills in order to remain employable.

  Moreover, a new model of work organization stimulates a new approach to work which is more independent in terms of time and location, e.g. home-working and tele-working, which produce an independent and flexible working style requiring continuous individual learning.

- *The need for continuous adaptation and active participation as society evolves into a highly technological information society* - This means involving people not sufficiently computer-literate to benefit in full from the possibilities offered by the penetration of technology in a social context (electronic commerce, smart houses, intelligent cities etc.) in continuous informal learning so as to satisfy the desire for the knowledge offered by the information society (virtual museums, library access, etc.) and to seize every opportunity to maintain and enhance their social integration.

The library in the new lifelong-learning scenario

In the scenario described above it is clear that the school years are no longer sufficient by themselves to equip individuals with all the knowledge they will need during their life. The traditionally strict temporal sequence —from schooling to higher education, education to work, etc.— also needs to be re-examined. Today these phases are becoming more closely integrated into a lifelong-learning scenario, based on a horizontal technological approach in terms of methodologies, tools and services.

In this increasingly complex environment, in which both individuals and organizations are faced with a growing need for information, libraries can actively contribute to the process of change. An example of how libraries can play a central role as a core social institution for lifelong learning is given by the "learning city" projects in the UK: "Learning Cities explicitly use learning as a way of promoting social cohesion, regeneration and economic development which involves all parts of the community." (Learning Towns and Cities). Learning Cities libraries provide spaces for the access to innovative learning products, tools and telematic networks. This "learning place" can be attended by citizens, students, workers, the unemployed, pensioners, consumers (Morrison &

Traditional education concentrated in the years before joining the job market is no longer adequate to meet the demands of the current scenario

- Mechanisms to perform content-based search;
- Methods to integrate various search engines and to "mine" data from heterogeneous collections;
- 'Ontologies' to allow users to search for information using terms from domains with which they are most familiar.

Several applications are being developed based on user modelling to improve the filtering and interactive search experience in Web-based environment (Brajnik and Tasso, 1994). A user model is a knowledge source which contains explicit assumptions on all aspects of the user that are relevant to the interactive behaviour of the software application. User modelling technology has also been integrated into information filtering system (Ambrosini, *et al.*, 1997), (Schick, *et al.*, 1990).

Classification and indexing: Manual methods for classification are inadequate for digital libraries. Automated classification systems differ significantly in their approaches, depending on the type of content under consideration. The classification of audio, musical notation and maps presents additional research challenges.

Query expansion and refinement: Queries may span multiple digital libraries systems and, if not filtered, may return excessive amounts of data that can overwhelm networks and systems as well as the user's cognitive abilities. Query expansion and filtering techniques would allow users to refine queries and reduce the size and complexity of the information they seek.

Securing information and auditing access: Mechanisms must be provided to allow multiple authorized users to operate in a distributed digital libraries environment while preserving privacy, integrity and intellectual property rights.

User interfaces: User interfaces must incorporate a wide variety of techniques in order to provide rich interaction between users and the information they seek. A digital library's presentation systems must be flexible and highly customizable.

Several US agencies, including NASA, DARPA, and NSF, have, over the past few years, set aside a considerable amount of money to support research into digital libraries. Other countries, including Canada, the UK, France, Italy, and The Netherlands have also invested in this field. As a result of these activities, a number of recent symposia, workshops, and conferences have been devoted either wholly or in part to digital library issues. Such strong encouragement from governments, industry and professional associations has already produced high level results in the sectors mentioned above. An example is furnished by IDL, a prototypical intelligent digital library service (Semeraro, *et al.*, 1997). This system integrates learning tools and object-oriented techniques in order to effectively and efficiently perform the task of capturing the information to be stored and indexed by content in a digital library. In this way all the tasks relating to information capture and semantic indexing can take advantage of the use of learning systems for layout analysis, document classification and understanding. Three different groups or categories of people can interact with IDL either to modify or query its contents: the library administrator, the librarian and the end users. Thus, the interaction with IDL requires new approaches at both the professional and user levels.

In the European scenario, since 1990 the Telematics for Libraries programme (DGXIII) has helped increase cooperation between libraries from different countries by supporting a number of projects involving the development of standards, prototypes and pilot environments.

Some of these projects improve active participation in defining common standards for document identification, data communication,

In order to make optimal use of their material, digital libraries need more sophisticated classification and query systems

Mechanisms are needed to ensure privacy, integrity and intellectual property constraints are observed in multi-user, distributed systems

technologies and to use them to implement effective and efficient didactic tools.

These studies address both integrating new technological products and process into classical teaching models and designing new didactic architectures with new teaching/learning patterns.

At the same time initiatives should be aimed to validate usability and quality of teaching/learning tools especially the quality related to the informative contents and to the teaching methods used.

Planning a course based on new learning technologies naturally involves new professional skills and new methods involving teachers; domain specialists; teaching and education experts; librarians; software designers; and evaluation experts.

A new distance learning system is a complex-system involving: heterogeneous objects (libraries, databases, interface users, expert systems); different kinds of communication (sounds, texts, images, animation); different types of networks (local nets, national nets, internet, intranet); open areas with a high degree of interactivity (e-mail, teleconferences, learning circles, scientific laboratories).

A resulting course is then an open modular system, made up of independent learning components. Each didactic module is organized with a core that accomplishes a specific function (with defined targets, contents, didactic materials), and some interfaces that connect it —intelligently— to other didactic modules or to external accesses. All of these create a personal, flexible, dynamic learning path inspired by the user's needs.

One of the most significant aspects in modular-design methodologies is the possibility of reusing the didactic modules and importing/exporting them from/to different learning contexts. Classrooms, campuses, workplaces, homes will become virtual learning realities in a learning network providing access to common knowledge resources and service areas.

Within this context libraries can play a new role. They can provide not only real time access to the different types of documentation, but they can also represent an intelligent repository of standard, high quality, reusable integrated learning modules.

In this scenario a cooperative effort seems necessary to "organize" learning, involving not only schools, universities and companies, teachers and librarians, but also research organizations, software and hardware producers, service suppliers, telecommunication operators, and policy-makers.

The development of common experiences improves not only the quality and reliability but also the transportability of learning products between different places of the same context (school to school or industry to industry). It increases the transferability of learning applications and learning contents to different areas and stimulates the search for standards in the field of learning technologies and educational multimedia software.

Standards are, in fact, a crucial point for the success of educational material, as they affect the widespread utilization of this material and the consequent reduction in production costs (SRI, 1998).

The EU is already going in this direction with a mandate granted by the European Commission and SOGIST (Senior Officials Group for Information Technologies Standardization) to CEN (European Committee for Standardization), and a

Using new learning technologies requires the involvement of a variety of professional skills and brings together a heterogeneous set of objects and tools

Courses are designed to have a modular structure, which also makes it possible for teaching modules to be reused and exported and imported to and from different learning contexts

For course modules to be transportable standards are crucial. A partnership has been set up at European level to find a common approach to the production and delivery of learning technologies

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Antonio Sanò graduated in physics in 1960 at "La Sapienza" University of Rome. Since 1961 he has been working for ENEA, where he is currently Head of the Documentation Unit of the Funzione Centrale Studi. Since 1980 he has been involved in research activities concerning the acquisition, processing and the dissemination of information. From 1962 to 1980 he was an assistant and then professor of Applied Electronics at "La Sapienza" University of Rome.

nuous growth in consumption cannot but place increasing burdens on the planet. The Kyoto World Conference (1-10 December 1997) was not only a call for the survival of the Earth, it was a sign that the limits of growth in industrialized countries may have already been reached. The impact of our present way of life has huge repercussions for the planet and it is no longer possible to reproduce and to perpetuate it indefinitely.

Many people therefore consider "Science" to hold the key to the solution. However, the word "Science" in relation to biological diversity does not refer only to work conducted inside universities and other research centres. It also includes the body of knowledge produced by local/indigenous people and the acquired expertise of professionals.

Globally speaking biological diversity means the variety of life on earth. The concept was consecrated at the UNCED Rio world Conference (UN, 1992b), where its importance was universally recognized through the approval of a specific Convention on Biodiversity (CBD). The concept of biodiversity is a "cosmogonic" concept. Its importance resides in its capacity to concentrate the attention of all parties concerned on the risk of its loss. At the same time it obliges States, Governments and in general all decision makers and the public to try to protect it through the global effort towards what is called "Sustainable Development".

Thus the Convention on Biological Diversity (UN, 1992a) provides a recognized framework in which to incorporate the efforts of individuals, groups, governments, and international organizations so as to safeguard biodiversity for future generations. This context of participation should allow modification of our present ways of life and should be the new challenge for all, but especially for researchers studying biological diversity.

This new challenge is well described in another international document: the Global Biodiversity Assessment (UNEP, 1995). Written with the contribution of more than 400 experts, this document is a first attempt at a world analysis of the state-of-the-art of knowledge and understanding of biodiversity and the nature of human interactions with it. Of course, the assessment could not be exhaustive given the huge dimensions and complexity of global biodiversity, but estimates suggest that, on a global level, biodiversity is currently decreasing very rapidly. The "Convention on Biological Diversity" came into force in December 1993. European governments were among the first supporters and they have been actively sustaining this international agreement.

The European Union and the Biodiversity Context

The role, presence and activity of the European Union (EU) in the field of Biodiversity is not only due to the growing awareness of European citizens but also to its particular position and responsibility within the industrialized world. The EU has worked carefully to wed economic and productive growth to a safe environment for present and future generations. A number of EU initiatives are being watched and followed with attention worldwide. For example the principle of "subsidiarity" permits the EU to incorporate specific actions at local, regional, national and European level allowing European Union structures to support and intervene where those levels need to be complemented, especially to respect Community or international commitments. Moreover this principle is accepted voluntarily by the EU Member States and avoids conflicts of competencies, supporting the principle of solidarity in a pragmatic way.

To implement its international engagements the EU has created several legal instruments.

The UN Convention on Biological Diversity provides a recognized framework in which to incorporate the efforts of individuals, groups, governments, and international organizations so as to safeguard biodiversity for future generations

The principle of "subsidiarity" permits the EU to incorporate specific actions at local, regional, national and European level allowing European Union structures to support and intervene where those levels need to be complemented

that for the design of research strategies and for the definition of scientific protocols, the research activity on biodiversity needs a multi-disciplinary approach involving actors of several different sectors. In this context the need for enhanced communication among different actors is also addressed.

The two documents recommend that the research activity should concentrate, among other things, on a better understanding of the threats to biodiversity (e.g. consequences of introduced species and GMOs, effects of bioprospecting, pollution of terrestrial, freshwater and marine environments, agricultural practices and land use change, etc.) At the same time researchers and the other actors involved have to be able to put values on biodiversity (incorporating ethical, cultural and other values, improving economic evaluation) and to develop specific indicators (particularly 'indicator sets' to measure the role and mechanisms of biodiversity for the functioning of ecosystems and their production capacity and at different scales). Last but not least, the constant theme in all activities is the need to resolve "conflicts" that may have a negative impact on biodiversity. As a result, research is called for to identify and help solve the factors that lead to conflicts (such as analysis of the attitudes of various groups to biodiversity) and to identify the most critical conflicts affecting biodiversity from local (e.g. reserve conflicts) to national and international scales.

In parallel with the debate on the new research challenge, the EU launched a specific action to define an EU Biodiversity Strategy finalized and officially approved by the Council of Ministers the 4th of February 1998 and endorsed by the EU Parliament in November 1998. The Community Biodiversity Strategy (CEC, 1998) aims to anticipate, prevent and combat the causes of significant reduction or loss of biological diversity at source. It defines a framework for the actions necessary to fulfil the European Community's legal obligations under the Convention on Biological Diversity and requires development and implementation of specific Action Plans, that have to be built on and complement existing policies and planned initiatives by Member States. This is to ensure real added value, consistency and complementarity.

Research is officially given a front line role. Moreover it becomes relevant for all policy areas identified in the aforementioned strategy document and defined as: the Conservation of natural Resources, Agriculture, Fisheries, Regional Policies and Spatial Planning, Forests, Energy and Transport, Tourism, Development and economic co-operation. It has to be underlined that the EU Strategy recognizes the role of the EWGRB and incorporates many of its recommendations as valid for the overall Strategy.

It could be claimed that the attempt to link research and policy has a chance of success in this new context. For its position as an interface between scientists, end-users and national/ international organizations, biological research may establish deeper links between the actors involved (including science, politics, ethics as well as economic actors) and between the various sectors concerned. It could operate on the interactions between different concerned levels starting from individual, local, regional right up to European and International levels. It could also help implement concepts such as synergy and subsidiarity, making it easier for all actors, organizations, institutions, and sectors to be aware of them.

The Fifth Framework Programme: The New Challenge

Clearly the new EU research programme (1998-2002) cannot be absent from the context of growing consensus which has emerged in recent

In the Fifth Framework Programme of the European Commission, Biological Diversity appears as a strategic block of principles, concepts and elementsforming the basis for the sustainable use and development of European agriculture, forestry, fishery, tourism and related industrial sectors

interactions with the other ecosystem factors including the human element?

Conclusion

Special attention should be provided to solve the human resistance to dialogue between "different" communities. Groups within the scientific community are more used to facing "internal" confrontation with their own community rather than with a wider one. There are a number of reasons for this. On the one hand, researchers tend to defend their own research field from intrusions by other disciplines and overall by non-scientists. In some way they are primarily responsible for their own isolation. On the other hand, planners and decision-makers prefer to get rapid solutions to solve present problems rather than complicated longer-term analyses. To create the conditions for a real dialogue we could concentrate efforts on demonstration projects to be defined jointly by the actors and the researchers.

Fortunately, at European Union level "resistance" to biodiversity research has largely been overcome. This is at least partly due to actions conducted by the European Commission in recent years. Moreover the research activities at EU level have been integrated. EU legal instruments have been created. Different activities at Community level (LIFE, TEN, EIONET, LEADER II, PHARE, TACIS) exist and have their logical framework in a unique EU Strategy. New and complementary financial mechanisms have been defined. In theory no further major obstacles should impede action for implementing the objectives identified through the Convention on Biological Diversity. However, the challenge of bringing all actors on board should not be underestimated. To reiterate, in the words of the former European Commissioner, Dr. R. Bjerregaard, at the third conference of the parties to the Convention on Biological Diversity (Buenos Aires, 14 November 1996): "while national and sectoral strategies are the starting points, we will ultimately achieve little unless special steps are taken to make all of those involved aware of the problem, and draw them into partnership (at all levels)".

Motivating SMEs Towards Improved Environmental Performance

Diana Bradford, *CEST*

Issue: The number of small companies that help make up Europe's economy is significant and still growing. Their contribution towards environmental issues is, therefore, of growing importance yet remains elusive (on a scale compatible with larger businesses), despite a number of schemes designed to assist SMEs.

Relevance: Engaging SMEs in environmental improvements, whilst recognizing the financial implications of this for their business, can promote environmental sustainability. Mechanisms for achieving this engagement need to be cost-effective to implement, and need to demonstrate tangible results in order to enable the effectiveness of such approaches to be analysed and replicated as appropriate.

Introduction

The two issues of environmental performance and helping SMEs have been much discussed in recent times, yet there has been little analysis of where and how these relate to each other. At the same time the importance of this issue is growing because of the expanding number of SMEs in Europe. According to the Franco-British Taskforce on Small Firms, for example, there are about 1 million SMEs in the UK, employing an average of 8 people. This constitutes about 57% of the private sector and represents a major source of growth in employment through new business start-ups. Thus the SME sector is an important target for competitiveness, innovation and environmental policies and practices; collectively it can deliver significant economic, social and environmental benefits.

How 'Green' are SMEs?

There is a tendency to talk about SMEs as if they were one uniform kind of organization, but there is clearly a difference between say, a manufacturing company with 240 staff and an IT consultancy employing 2 staff. Thus it is difficult to make sweeping statements about the 'greenness' or otherwise of SME companies. Opinions on this range between comments of the type: "SMEs tightly manage their resources and waste because they can see everything in their backyard... They have to manage their finances more carefully because they cannot take big risks" and "It is difficult for most SMEs to get involved in environmental issues because they are too busy looking after the business in other ways."

It is likely that in different circumstances, both statements are true, but there are some results from other studies in this area that are also useful to

The SME sector is an important target for competitiveness, innovation and environmental policies and practices, as its size means that collectively it can deliver significant economic, social and environmental benefits

These methods are best used when they have a proven success rate in a particular area or sector, are linked with other issues that the SME is likely to be interested in, and show the benefits that can be gained from taking action together with a clear route for taking the matter forward. Most marketing will fail unless it recognizes that SMEs will only be interested in benefits they can perceive and it has to be taken into account that these perceived benefits may often differ from, or be less important than, the actual benefits that the particular course of action may bring overall.

Tools that may be most useful in recruiting SMEs and raising their environmental awareness according to the ADAPT programme study include:

- Newsletters
- On-site visits
- Face-to-face advice
- Help-lines offering regular guidance
- Environmental reviews
- Best practice visits

Future methods suggested, however, would be more business-oriented, reflecting the fact that a good record on the environment was increasingly viewed by analysts as a sign of a well-managed company.

The review further noted that SMEs see environmental regulations as a source of guidance, and this gives the various different regulators a role in exerting an influence on SMEs. However, whereas an environmental regulator will look for environmental improvements, another dealing with health and safety will look for low numbers of accidents – and such approaches may either be complimentary or conflicting in terms of the procedures the company should adopt.

Persuading SMEs to Act

Having attracted SMEs' attention of, there is still a need to decide what should be done and how, taking care to ensure that SMEs maintain their enthusiasm and commitment to the work. Questions that need to be asked include:

- Where is the greatest need to achieve environmental benefits?
- What is the quickest way to achieving early financial benefits?
- Where do the greatest financial rewards lie?
- Is there any external pressure (e.g. regulatory, customer, shareholder) to satisfy quickly?

In the ADAPT programme on raising awareness in SMEs, organizations most effective in persuading SMEs to change their environmental practices were found to be:

- Regulators
- Environmental Agencies
- Insurers
- Customers
- Financial bodies

The list reflects another conclusion from the work so far in that tighter regulation was seen as the greatest stimulus to environmental improvement for SMEs in the current climate. The whole approach is one that is related to the SME's perception of risk.

Nevertheless what is becoming more important in the future relates to market pull issues and the importance of the supply chain. In particular, there is increasing pressure to adopt environmental management systems, to label products and to pay attention to the concerns of stakeholders.

Conclusions and Recommendations

There are a number of issues to consider when looking at how SMEs are motivated to engage in environmentally-friendly production. These include: training; use of IT; networking; assistance already available to SMEs; overcoming the barriers to innovation and organizational issues; and learning from past good and bad experiences.

A number of information and advisory tools can be used to raise the environmental awareness of SMEs. In the future, a more business-oriented approach may be taken, reflecting the fact that a good record on the environment is increasingly viewed by analysts as a sign of a well-managed company

In the current climate tighter regulation is seen as the greatest stimulus to environmental improvement for SMEs, reflecting the fact that it is related to the SME's perception of risk

Keywords

SMEs, environmental protection, sustainable development

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department and plant levels. The adoption of NICTs can make it possible to modify the organizational relationship between phases of the productive process, so that market relations can be strengthened by systems of electronic communications and bureaucratic coordination can be replaced by a mix of cooperative relationship implemented by on-line communication systems (Antonelli, 1988).

When organizational changes of this type take place, the adoption of new networking technologies can have important economic effects on the firm. These effects can include:

- reduced stocks of inputs
- reduced paperwork
- better control of quality standards
- increased access to multi-sourcing
- reduction of minimum efficient size of production lots
- 'footloose' plant location
- reduced negotiation costs
- increased scope for cooperation between different firms
- increased coordination between R&D, production and marketing
- reduced stock of final products
- reduced waste and pollution
- reduced environmental impact of the production process
- shorter delivery times
- quicker invoicing
- greater production differentiation and customization
- greater ease of recycling, etc.

Potential impact of NICTs on the environment

Previous analysis suggests that the adoption and implementation of NICTs in production processes can result in both an increase in total factor-productivity and better organization of the production process. These in turn can lead to a reduction in energy usage and so environmentally-cleaner production processes.

Specific examples of how this may occur include:

- The increased use of telecommunications service reduces the need for people and for documents to move.

- Overseeing work using information technologies helps organize it better and make it more efficient (including in terms of energy usage): stocks of goods can be managed better, there will be less movement of semi-finished and finished products between different areas.

- Intra- and inter-company information networks can link remote plants and offices, even when they are located in different countries. This makes it possible to reduce the need for movement of people and materials, for example, by shifting internal communications from memos to e-mail.

- Computer technology has facilitated the development of environmentally-focused design, for instance through the development of electronic equipment that allows better control of the combustion processes. Data processing has also made it possible to exploit alternative energy sources which, although known, were under-exploited because the available methods were inefficient or ineffective (for example the manufacture of wind generators or the exploitation of biomass energy).

- Transmitting data over long distances reduces the need for much routine travel. An example of this is the way equipment on power lines can position faults remotely, avoiding the need for maintenance crews to travel the whole length of the line to locate them.

NICTs can affect the impact production processes have on the environment in a great many ways, ranging from reducing the need for physical mobility to optimizing designs of products and processes

Policy implications

Because of the relationship between NICTs and productivity, reductions in the prices of telecommunications services delivered to the business sector are likely to induce a significant increase in the overall levels of output and total factor productivity. Hence, the reduction in prices for telecommunication services becomes an issue that is relevant not only in specialized debates on the "appropriate" market structure and industrial organization of the telecommunications industry, but for a much broader set of issues concerning the overall productivity of the entire economic system.

The adoption of new information and communication technologies is far from saturation levels. The diffusion process of new information and communication technologies is still very much on-going, and even more so in the case of the new networking technologies based on enhanced complementarity between computer science and telecommunications. Moreover their diffusion is being delayed by a variety of factors, among which the effect of the price of complementary services such as telecommunications is by no means negligible.

In conclusion then, one could underscore the environmentally-friendly potential of NICTs and the need to take this potential into account in environmental and industrial policies. Much environmental policy has been directed towards the objective of reducing the environmental impact of production processes by imposing new constraints on firms and by raising the relative costs of natural resource use without addressing the positive implications of new technologies. A new approach to environmental policy could take advantage of the potential offered by the adoption of new information and communication technologies.

Such a policy could promote:

- Investment in NICTs in "mature" industries and small firms;
- Infrastructure that facilitates access by the less dynamic components of the industrial structure to networks that provide information and communication services at low average costs;
- Training to supply firms with skilled manpower to speed up the adoption of NICTs within small and medium size firms;
- Diffusion of specialized industrial communication standards that makes it possible to generalize the advantages of enhanced division of labour among firms and more timely coordination between production and distribution processes (see also Antonelli 1994).

Finally, elaborate empirical analysis, beyond the scope of this article, is needed to take into account the multifaceted character of NICTs and their uses, and to come up with more meaningful results, difficult as this may be.

Environmental policy has tended to seek to reduce environmental impact by imposing constraints and raising relative costs of natural resources rather than addressing the positive implications of new technologies

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