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THE IPTS REPORT

Produced by IPTS and issued in Cooperation with the European S & T Observatories Network

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EUROPEAN COMMISSION
Joint Research Centre

ABOUT THIS REPORT

This Report is addressed to the decision-makers involved in 'managing change', seeking distilled, selective presentation of technoeconomic intelligence and prospective alert on under-discussed facets of a topic, rather than a deluge of data and encyclopaedic reviews.

This Report stands as the most visible indication of the commitment of the IPTS to Technology Watch, its main priority and mandate. In this context, the Report aims to focus on issues of projected pertinence for decision-makers, exploring *prospectively* the socio-economic impact of scientific and technological developments. On the one hand, such exploration implies signalling on issues which are not yet clearly on the policy-makers' agenda, but can be projected to draw attention sooner or later. On the other hand it implies alerting actors about underexplored aspects of an issue on the agenda, aspects which, though under-appreciated today may have substantial consequences tomorrow.

The Report benefits from a validation process, underwritten by networks of renowned experts and Commission services, making this Report a product of not only the IPTS but also of its collaborating networks inside and outside of the Commission. The process of interactive consultation used guarantees the validity of the points highlighted, the relevance of the topics chosen, and the timeliness of their examination.

There are many publications excelling within their discipline. The Report takes the extra step, prospectively exploring interdisciplinary repercussions, often drawing surprising connections. Moreover, sharing the Commission's priorities, the Report is still the product of a research institute, and can be a neutral platform for dialogue on issues of relevance and a nexus for facilitating debate.

ABOUT THIS ISSUE

The present issue is the fourth instalment in a seven-issue introductory series that will last until September 1996. Throughout this period, and with the feedback and comments of its readers, the Report will be shaped and fine-tuned. Here we attempt to help orient the reader and ease navigation through the articles.

The management of change and the role of science and technology therein, is the overarching concern of the Report and of IPTS as a whole. The opening article explores advances in agricultural engineering and their impact on the sustainable management of water resources increasingly under strain from rising urban, industrial, and tourism-related demand. The second article focuses on the failure, contrary to expectations, of productivity growth to keep up with information technology investment in the last twenty years. It suggests that this paradox has recently started to evaporate, and that new (often unduly pessimistic) questions have emerged regarding employment impacts. The next article deals with managing change in the area of management itself, exploring the implications of the increasingly popular model of the 'agile enterprise'. The fourth article revisits the potential of hydrogen for automobile use, in the light of increasing pressure for cleaner cars, and increasing interest in this technology in the US and Japan. The penultimate article examines the repercussions that an increasing reliance on programs 'standing-in' for humans would have for pricing and prioritisation issues, and the consequences for users who may or may not afford the levels to which prices are bid. The last article explores the need for a common framework for dealing with information flows in the Information Society, for which the existing legal and regulatory frameworks may be inadequate (e.g. intellectual property rights).

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The Task Forces

During the ten years since it was first established, the European Union's Framework Programme for research and technological development has become a point of reference for researchers all over Europe. It has been instrumental in creating a truly European research community through the development of networks and consortia which cross national boundaries. Besides the many important scientific and technological results achieved, the Framework Programme has also provided training for thousands of researchers that is particularly well-suited to the international character of modern research.

Nevertheless, European research and technology policy clearly cannot stand still. There are still huge national differences across Europe in science, technology and innovation, and persistent problems remain. The enduring reality is that the EU invests proportionally less in research than its major competitors, the US and Japan, and is less effective than these countries in turning its highly successful science into profitable innovation. The Commission has now taken a major initiative to boost the contribution of research to industry and to society at large, by setting up a series of Task Forces. The role of the Task Forces is to foster a closer and more productive relationship between industry and the research community by coordinating and focusing the Community's research resources on prominent industrial and social needs. By doing this, the Task Forces are also expected to add visibility to EU research and show that it has tangible benefits to citizens at large.

Task Forces are made up of Commission staff who are concerned with research across a wide range of relevant areas. Eight have been set up to date, in the following areas:

- *New-generation Aircraft*
- *Educational Software and Multimedia*
- *The Car of Tomorrow*
- *Intermodal Transport*
- *Environment - Water*
- *Vaccines and Viral Diseases*
- *The Trains and Railway Systems of the Future*
- *Maritime Systems of the Future.*

Task Forces are pilot actions to demonstrate the advantages of new and integrated approaches to research coordination. They help to promote the cross-linkages between various strands of generic technologies involved in concrete applications, and should thus contribute to the diffusion of technological possibilities more widely throughout the European economy. They have three major tasks:

- *to define research priorities and identify technology bottlenecks, in conjunction with industry - including SMEs - and users;*
- *to coordinate relevant research activities around a nucleus of clearly identified objectives, beginning with activities from within the Fourth Framework Programme.*
- *to investigate other options - financial and regulatory - which will contribute to effective implementation by industry.*

A pragmatic approach is being taken, in putting forward options and ideas for coordinating research and diffusion activities and developing funding opportunities, so as to capitalise on national strengths in the interests of the Community as a whole and reach a critical mass. The EU Member States and Parliament are currently examining a Commission proposal to devote ECU 700 million to the Task Force initiative so as to reinforce existing research actions, as well as to improve the focusing and coordination of existing research. For the future, consideration will be given to options such as:

- *Coordinating with other European research initiatives such as COST and EUREKA.*
- *Drawing on the support of other Community actions and funding mechanisms, such as the Structural Funds, international cooperation funds and the resources of the European Investment Bank.*
- *Exploiting so far unused Articles of the EU Treaty which would allow for Community investment in programmes involving certain Member States, investment in existing multinational collaborations established by certain Member States, and investment in joint undertakings.*
- *The use of venture capital to support Task Force activities.*

The Task Forces can be judged a success, even after a relatively short trial period. The Commission is confident that their work can contribute substantially to the next item on the agenda for Community RTD, the preparation of the Fifth Framework Programme.

Crops That Are Kinder To Our Water Supply

Anne Burrill, Yiannis Samaras

Issue: Sustainable water resource management is emerging as a European priority. In northern Europe, concern primarily revolves around improving water quality; further south, the quality issue is inter-linked with supply constraints imposed by the dry climate. Reasons for increasing pressure on our water resources include greater demand from urbanisation and tourism, linked to rising standards of living, and increased industrial usage in growth industries. However, agriculture has a predominant influence on both water quality and availability.

Relevance: Support for development and adoption of water-friendly crop varieties could contribute significantly to sustainable water management. Community research and agriculture policies could be harnessed for this purpose. Among possible instruments for addressing the negative influences of agriculture on water supplies are pricing policy, regulatory instruments, tradable permits, land use change, and improvements in irrigation technology. Frequently forgotten, however, is the potential contribution of crop science, including both conventional breeding and bio-technological research.

The impact of agriculture on water resources

Following recent Directives and action under the European Commission's 5th Environmental Action Plan, many pollution point-sources (particularly industrial outflows) have been controlled, improving the quality of surface waters. However, the quality of our groundwaters, which provide some 65% of the public water supply, continues to deteriorate. Most groundwater contamination comes from diffuse sources; agriculture is believed to contribute 25% of the total phosphorus, 60% of the nitrogen, and a significant proportion of the organic micro-pollutants. Model computations show that the nitrates concentration in ground water at 1 metre depth exceeds the guide level set by the EU (25mg/l) on more than 85% of European agricultural lands. Similarly, the model shows that the 0.5mg/l EU drinking water standard would be exceeded on about 75% of the total arable land. Although it was once mistakenly believed that the soil would adequately filter agro-chemicals, it is now evident that groundwaters do become contaminated. Since clean up is very expensive, and may be technically unfeasible, preventive action is indicated.

Agriculture is also a major infuence on water availability, especially in the Mediterranean regions where increasing surfaces of irrigated agriculture account for more than 80% of the total demand. Furthermore, irrigation is highly seasonal, corresponding to the months when the water supply is lowest for climatic reasons, and when tourist and household demands also peak.

Agriculture accounts for an increasing proportion both of water pollution and total water demand

Development of crops resistant to drought, cold and salt are yielding promising results

Crops requiring less fresh water

Drought-resistant plants need deep roots that can penetrate clay pan, have thick leaf surfaces and the ability to balance salt concentration within cells. Scientists are trying to engineer cereals with these traits but are having greater success using conventional breeding combined with molecular markers to facilitate identification and selection. Through selection and breeding, drought-resistant varieties of several grain crops have been developed.

Development of salt-tolerant varieties can reduce pressure on water resources by allowing irrigation with water from sources such as saline aquifers. Extensive work in this field is underway in India, Pakistan, Japan and North Africa, where genes that can improve plant salt tolerance have been successfully transferred using classical methods to crops including barley, alfalfa, tomatoes and wheat. Similarly, a research group at Purdue University has recently developed salt-tolerant maize plants using traditional breeding.

Pest-resistant varieties of crops offer increased yields, while reducing the need for potentially-harmful pesticides

Manipulation of genes affecting the synthesis of osmolytes - proline, betaine, trehalose, polyols - is also promising. Over-production of osmolytes confers salinity tolerance and drought resistance in tobacco, enhances biomass production and facilitates flower development under stress conditions. However, these osmolytes may cause negative side effects, as they tend to attract insects. Further research is needed to identify alternative metabolites which are not attractive to the plant's predators.

Self-fertilising cereals offer both environmental and economic benefits

Development of cold-resistant or earlier crops may also reduce irrigation by allowing the crops to use precipitation in the earlier months of the year. Research has focussed on genes in *Arabidopsis*.

Crops requiring fewer chemical inputs

Nearly a third of all cereal production is lost to weeds, insects and pathogens whose impact is increased in modern agricultural practice with its heavy reliance on monoculture. This has led to the widespread use of chemical protection with its attendant environmental concerns such as contamination of water resources. Furthermore, complex mixes of chemicals have been introduced to combat resistant pests. Although the business of developing insecticides (mostly chemical, some biological) is worth in excess of US$7.5 billion worldwide, the loss of production due to insects is still about 13%.

Farmers are hesitant to abandon pesticides without a secure alternative. Crop breeding research is beginning to provide such alternatives in the form of naturally pest-resistant varieties. Genetic improvement of crops is likely to be less environmentally hazardous and more socially acceptable than the manufacturing and spraying of chemical pesticides. During the course of this century, conventional breeding programmes have had some success in generating highly productive, pest-resistance crops. However, few modern varieties retain the same degree of resistance exhibited by their wild relatives. Biotechnology is increasingly being used to develop more stable resistance against a variety of pests (Figure 1).

Research is also underway in the Netherlands and the US to develop field and forage crops requiring less fertiliser. A particularly promising but still futuristic example is self-nitrogen-fertilising cereals. An international team led by the University of Nottingham (UK) has found strains of nitrogen-fixing bacteria that enter cereal roots and convert atmospheric nitrogen into a form that the plants can use. The potential benefits are outstanding: as well as decreasing groundwater nitrate pollution, this product could eliminate

Figure 1: Transgenic Plants with Pest Resistance

Resistance	Status	Examples
Insects & Nematodes	32% of GMO trials Full scale commercialization expected by mid-1996.	Insertion of genes encoding intra-crystalline proteins from *Bacillus thuringiensis*. Resistance confirmed in over 50 plants against pests incl. Colorado potato beetle, cotton bollworm, tobacco bud-worm, pink bollworm, European corn borer and other moth pests. (Mixed cropping with susceptible varieties combats resistance noted in some field populations of the vegetable pest *Plutella xylostella.)* Use of pea lectin gene and cowpea trypsin inhibitor protein appears promising. Ciba, Mycogen and Monsanto to plant 200,000 acres of engineered corn, potato and cotton.
Viruses	18% of USDA-approved field tests advanced field-testing	Transgenic plants with coat-protein genes
Fungi & Bacteria	lagging behind viral & insect protection due to complexity and diversity of the systems	Resistance against *Phytoptera infestans* in potato Resistance to bacterial wilt (*Erwinia)* in potato

The EU lags behind North America in crop breeding research.. ..

the US$20+ billion annual cost for synthetic nitrogen fertiliser, and decrease greenhouse gases by replacing fossil fuel-based fertilisers. There is a reasonable chance of success within the next fifteen years in developing these plants if the required investment is made now.

It is important to note that worldwide, herbicide tolerance is the trait most commonly tested - in over 28% of field trials - in transgenic crops. Herbicide-resistant crops may have beneficial effects on the environment when, for instance, a single broad-spectrum herbicide, that breaks down relatively rapidly, can be used to replace persistent herbicides like alchlor and atrazine. The primary interest of agricultural corporations in developing herbicide-tolerant varieties, however, are clearly commercial, and in most cases total herbicide use is increased as farmers try to maximise weed destruction knowing that crops will not be damaged (even with doses well above those recommended by the manufacturer). Repeated use of a single herbicide also greatly increases the chances that weeds will develop resistance and require larger herbicide doses.

. .partly because of over-strict legislation

Bottlenecks in research and development

On-going research and development in breeding and biotechnology is producing new varieties which could contribute towards the sustainable

In view of the social benefits, there is a clear case for greater public sector involvement

Farmers hold the key to the introduction of new crop varieties

management of European water resources. New transformation techniques have led to the production of forty different species of transgenic plants. About four thousand field trials had been conducted by the end of 1995. Although in 1991, the number of field trials was approximately the same in North America and the EU/EFTA, since 1992 North America has taken the lead with far more than half of all trials conducted to date. In the next 6 years more than 3000 products are expected to be diffused in the US.

Under the EU directives on deliberate release of genetically modified organisms (GMOs), new varieties of GMO must undergo an approval process, including risk assessment to show that they do not pose significant threats to the environment or human health. The particular concerns about transgenic crop varieties are that they might invade other habitats as weeds, and that their resistant characteristics might transfer to undesirable plants. A recent IPTS study suggests that the EU directives may be unnecessarily strict, in view of the impossibility of disproving all significant risk.

Japanese and American legislation regarding GMO release is less restrictive, focusing on the product rather than the process. Since 1987, the US has had a well-defined system for review and approval of transgenic plant trials, which was greatly simplified in March 1993. The EU has enacted changes in the GMO directive (90/220/EC) to introduce simplified procedures for certain plant releases, but these will take full effect only this year; so far only the UK, France and the Netherlands have streamlined their procedures. Furthermore, the patent process for transgenic plants is an area of considerable uncertainty.

According to industry officials, each GMO costs about US$10 million to develop (including US$1 million for regulatory expenses) and requires at least 6 years from laboratory to commercial product. Although there is significant private investment from sources including farmers' cooperatives, those seed vendors whose primary business is selling agrochemicals have only limited interest in developing varieties which would reduce these sales. It is, therefore, unlikely that the necessary research will be undertaken without increased public support.

Public sector participation in crop trials is higher in North America (28% of all trials) than in Europe (17%), perhaps as a result of greater support for plant biotechnology, more university research in gene identification and isolation, and better links between public and private sectors. In the Pacific Rim, the public sector is responsible for 79% of the trials. As benefits in terms of water management accrue to society as a whole, the public sector should contribute to this research. Investment in crop science should be seen as a cost-effective contribution towards integrated water resource management - certainly less expensive than development of alternative water resources, and/or decontamination of groundwater.

Impediments to adoption of new varieties

Introduction of new varieties of crops, whether produced through biotechnology or traditional breeding techniques, might have negative ecological repercussions but direct additional costs to farmers should be minimal. However, farmers will be hesitant to change varieties without a clear reason. Although farmers are dependent on reliable water supplies, these supplies are part of the public "commons" and individual farmers have little incentive to reduce their individual impact on this shared resource. Furthermore, in the case of GMOs, regardless of their actual risk, as long as the public perceives danger and there is doubt about their marketability, farmers will hesitate to adopt them. Farmers may also be reluctant to switch to patented varieties. In the case of drought-resistant and saline-tolerant varieties, farmers may benefit from greater crop selection flexibility and higher yields. Farmers might also be convinced that they would expend less on agro-chemicals with certain new varieties.

While individual's attitudes are important, the major factor presently influencing most European farming decisions is EU agricultural policies. Agricultural policy, however, is beginning to evolve to reflect environmental concerns. A fundamental tenet of new policies would be the sustainable use of the soil and water resources which support agriculture. In order to encourage less intensive land use, subsidies are now paid on the basis of surface, not production. At present, however, there are no subsidies linked directly to either the water requirements of crops, and/or to the quantity of agrochemicals used in their production. The introduction of such linkages could directly encourage the use of more water-friendly crops, and would be a step towards the development of a truly integrated European water policy.

Agricultural policy also has a part to play

Keywords

Water, agriculture, transgenic plants, crop breeding, resistance

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Returns on IT investment:

the end of the productivity paradox?

Cecilia Cabello

Issue: Recent studies seem to indicate that the large returns promised on investments in information technology (IT) are finally beginning to materialise. This fact has important employment and industrial competitiveness implications for Europe.

Relevance: The question posed here is whether or not improvements in productivity imply a period of "belt tightening" and restructuring, or the generation of more capital and profits to invest in further economic and employment growth. In industrial competitiveness terms, the key question is whether EU firms are keeping up with their competitors (particularly those in the US) or lagging behind in reaping the benefits of IT investments.

The slowdown in productivity growth, especially in services has coincided with adoption of IT

A great deal of discussion has focused on the relationship between productivity slowdown and high investments in IT; the association has become known as the "productivity paradox". Many explanations have been proposed, such as problems with the measurement of productivity, and time lags in the necessary re-organisation within firms to accommodate new technologies. Recent studies indicate, however, that this "productivity paradox" is gradually being resolved as substantial returns are beginning to materialise. Nonetheless, it is more important to consider the possible employment and competitiveness implications this might have within the EU.

Industry productivity and IT

Before 1973, **total factor productivity** in all the OECD countries grew at an annual rate of nearly **3%** (OECD, 1996). Between 1974 and 1979, the rate dropped to 0.5%, and although it rebounded slightly to just over 1% in the early 80s, it declined again to 0.8% between 1986 and 1993. This slowdown contrasts with the 'great expectations' for productivity increases promised by the extensive introduction of IT throughout OECD economies during this same period.

Aggregate studies have been conducted focusing on information (white-collar) workers in a variety of industries (Roach, 1991). While in the past, office work was not very capital intensive, recently the level of IT capital per information worker has begun approaching that of production capital per production (blue-collar) worker. Roach cites statistics indicating that, in the US, output per production worker grew by 16.9% between the mid 1970s and 1986, while output per information worker decreased by 6.6%.

Many firm-level studies have been conducted which report manufacturing and service industry's productivity levels and returns on IT investments. Most of these have further illustrated the paradox by only attributing slight, if any, gains in productivity to IT. However, it has been widely reported that most of the productivity slowdown has been concentrated in the service sector, which at the same time has dramatically increased its total share of employment. This issue has been widely debated and explanations have been offered to this dilemma.

Explanations of the Productivity Paradox

In general, explanations of the apparent paradox between IT investment and productivity can be grouped into two categories: (1) **mis-measurement** of outputs and inputs; (2) **time lags** due to the time taken to learn, and adapt to, firm re-organisation and management inertia.

The first explanation points to shortcomings in research, not practice, as the root of the problem. There is a possibility that IT investment benefits have been quite large, but the proper index of its true impact has not yet been determined. Traditional measures of the relationship between inputs and outputs fail to account for non-traditional sources of value. Increases in quality, consumer satisfaction, timeliness, etc. are not captured by the statistics, thus making it difficult to measure the perceived benefit. This fact is especially significant for the service industries.

The second explanation relates to the fact that 'information' is actually an organisational issue. That is, re-organisation of information management, work re-engineering and an adaptation process is needed before firms can fully take advantage of the benefits IT offers. Firms, mistakenly, have been incorporating new technologies using old operating practices and information structures. If the business structure was highly ineffective initially then the introduction of IT only increases the exchange of information, not its usefulness. Thus, structural change in the organisation of information needs to accompany the introduction of IT.

Along these same lines, a Stanford economist (David, 1991) draws a parallel between the adoption of electricity and IT. He states that it was only after completion of the transition from an industrial fabric based on steam to one based on electricity, a process that took almost 40 years, that industrial countries began to experience any productivity gains. This may be the case for IT, which, according to an MIT study (Brynolfsson and Hits, 1993), is going to be one of the big contributors to growth from 1994 on.

This ties in directly with the concept of 'humanware' (OECD, 1991). Humanware is the source of productivity resulting from the quality of the relationships and interactions between human resources and other elements in the firm, such as machines, tools and software. The role of humanware, which refers directly to organisational methods, training, skill, etc. is no longer perceived as simply a social issue, but rather at the core of the competitive process. Thus, industries and governments must give high priority to the human resources aspect when adopting new technologies, especially IT.

The MIT study (referred to above) claims to identify as much as 50 and 60% returns on IT investment in both manufacturing and service industries, respectively. The authors attribute the statistical significance of such findings not only to the more recent time period of their data, but also to the large data set which enabled them to estimate returns for all factors with greater accuracy.

Therefore, while mis-measurement is an important factor to consider, there is evidence of significant delay in firms carrying out the necessary restructuring process. While productivity relates to many factors in the economic system, it is clear that firms which accompany the adoption of new technologies with organisational changes have a much higher productivity than those who simply adopt new technologies. Successful firms are those which not only use advanced technologies, but at the same time innovate and invest in worker

The paradox of high investment in IT and low productivity growth may be due to.

..mis-measurement of output and inputs.

..and time lags in carrying out the necessary managerial reorganisations that would allow productivity impacts to materialise

There may be a comparison with the productivity gains associated with the transition to electricity

Successful firms innovate not only technologically but also organisationally

Although pessimists raise the spectre of net job losses in the future ?

training. These broad results are consistent among many studies performed in different countries.

Employment and Competitiveness implications for Europe: Manufacturing

The decline in manufacturing employment began in the 70s, and by the early 90s jobs were being lost at the rate of 3% p.a.. Through the 70s and 80s, over 20% of all jobs were lost in European manufacturing industry (OECD, 1994). Moreover, before 1973, manufacturing labour productivity grew at an annual rate of 4.3%, but growth decreased to 3.5% during the 80s (OECD, 1996).

However, the overall decline in manufacturing employment has not been uniform. Low technology, low skill and low wage employment has dropped, while high technology, high skill and high wage employment has expanded proportionally. Recent studies have found that technologically advanced firms have had above average performance, while low productivity plants were actually reducing employment by 'downsizing'. Industries with the fastest growth in productivity have also gained the most jobs where as past technical process innovations generally caused labour displacement (illustrating the changing relationship between technology and employment in the manufacturing sector). It has also become evident that firms experiencing productivity increases have in fact undergone the necessary re-organisation and learning processes. More and more firms are claiming that organisational innovations are not only necessary for the effective use of IT, but are also the key to competitiveness (L.A. Andreasen et al. 1995).

Services

Services employment growth in Europe has risen slowly but steadily since the 60s. In 1994, service employment was 20% higher than in 1980, although growth in the early 90s was much slower than in the 80s. At the same time, the service sector accounts for over 80% of the IT capital investment in the US. In fact, services' employment growth has been faster for those that have invested most in the application of new technologies (OECD, 1996). However, before 1973 annual growth in productivity for the service industry was 2.5%, while during the 80s it was almost stagnant, with an annual growth rate of 0.8% (OECD, 1991).

During the 80s, high investment in IT was associated with an increase in services employment and was considered a 'complement' to the labour force (though not accompanied by productivity increases). However, there has been a recent decline in services' employment growth from almost 2% in the 80s to about 0.5% between 1990 and 1993 (which in any case must be taken lightly considering the recession during the early 90s, as opposed to the growth that took place in the late 80s). Nevertheless, there is a 'pessimistic' view that, with the recent increases in productivity, there is concern that the services sector may have begun a labour-displacing restructuring process under pressure of international competition, similar to that of the manufacturing sector. Others, however, support the 'optimistic' view which contends that IT - labour-saving technologies - are positively related to employment growth in the service sector. The optimists claim that services are entering a stage of growth caused by IT investments, which have a great potential for increasing demand either by enhancing convenience and the variety of existing services, or by creating entirely new services.

The evidence suggests that as IT diffuses and productivity increases, new demand is generated, creating more jobs than are displaced. However, there is an inevitable period of adjustment and transition. This adjustment period involves an adaptation which is broader than the simple introduction of new techniques or the creation of new products. Technological change must be accompanied by organisational and institutional changes in order for it to be absorbed efficiently, and to realise its job creating potential. In particular, adequately focused education and training strategies are essential. The importance of 'worker skill' is stressed by the fact that while there has been a direct positive relationship between IT and annual growth rate in employment, a structural change has also occurred, with a shift from low skilled to higher skilled workers both in manufacturing and services industries (OECD, 1996).

In conclusion, the 'productivity paradox' points out that as technologies, such as IT, diffuse they raise the importance of intangible factors which eventually become main determinants in generating added value, wealth, growth, etc. Thus, there is an increasing need to better understand the causal links between technology and the changing economic system. It is clear that for industry and government, strategies must combine structural and social policy actions in order to respond to the increasingly knowledge-based world economy, arising from the diffusion of IT.

analysis indicates that such pessimism is unwarranted

Keywords

productivity paradox, information technology, information society, competitiveness, manufacturing and services industries, employment

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Agile Enterprises

Martin T Harvey & James P Gavigan

Issue: During this century, the basis of manufacturing has progressed from Craftsmanship, through Mass Production, to Lean and Flexible Manufacturing, and presently continues to evolve at an ever increasing rate. The only certainty is change, and pressure is building for that to be a step change. The newly emerging paradigm may turn out to be the so-called "Agile (Manufacturing) Enterprise"

Relevance: The Agility drive is inextricably linked to science and technology, both in the way it builds on existing technological capabilities and in helping to drive new technological trajectories. It predicts a total re-invention of the organisation of manufacturing, through realignment of business processes, relationships, and contractual arrangements. It conjures up notions of "virtual companies", raising fundamental socio-economic issues around employment, skills, and lifetime finances, which are important for individuals, families, industry, and society at large.

Agility fundamentally calls for fast response to changing demands, and a focus on providing solutions to customers, not merely products

What is meant by agility?

In a global economy with almost instant communications, competing on a world scale means satisfying ever more sophisticated and demanding customers, in increasingly fragmenting markets. These market drivers will require a manufacturing response where mass customisation, short lead times, short product life cycles, production to order (not forecasts), on-time delivery, as well as price, quality, and service will all be essential. Agile Manufacturing could well come to define that response.

The fundamental feature of Agility, therefore, is an absolute customer and market orientation, characterised by the rapid provision of solutions to customer needs (rather than 'products'), and the capacity to survive and thrive on unpredictable changes and events (changing customer needs, new market opportunities, etc.).

Not just a passing fad?

The most obvious changes to be precipitated by the drive for Agility are generally expected to be most visible at the level of business organisation and management. However, the potential depth and breadth of these changes (outlined below), implies that a broader **socio-economic impact** would be felt beyond the purely business sphere.

In sectors of the economy where Agility seems poised to make a major impact, the underlying concept would appear to have important dimensions above the realm of fashionable managerial and business process development trends, in which it is often classified.

Managerial and organisational implications

- An agile response will require the re-organisation of **management accounting** procedures used to measure and cost the production process, moving away from product-cost-driven prices, towards activity-and-project based costing, with price being based upon comprehensive market intelligence. Similar re-consideration will have to be given to legal matters such as product, and public liability, insurance, and ownership of intellectual property.

- Above all, Agility has major implications for the **organisation** of manufacturing, and the role of the work force. Successful companies will require visionary and innovative management and knowledgeable, empowered people, in flatter organisations, using state-of-the-art production processes. Contractual arrangements between companies and workers will have to be rethought. Workers will become "project stakeholders" rather than simply employees. Supply chain relationships become "added value chain, shared reward partnerships", and customer loyalty will depend upon an enduring, open-ended relationship of continuing service. Natural resistance to such a radical change of organisation, especially from middle management and workers, is probably the greatest **barrier** to the creation of Agile enterprises.

Many of the **business processes**, and the **tools** required to facilitate this change, have already been defined and, to a certain extent, are already in place. Rapid developments in information technology and communications will enhance their use. The key to the successful adoption of Agility by any suited business segment, is to create the **organisational framework,** and more importantly the **culture,** in which the latest business processes and tools are fully accepted and implemented. This invariably implies breaking the current mould of hierarchical, departmentalised organisation, and encouraging the emergence of a new flexible, flatter, cross-functional style of organisation in which individual enterprise can flourish.

S&T implications of agility

If markets are the driver then **technology is the main enabler**, especially communications, IT and knowledge-based systems, which provide the basis for market analysis, technology transfer, product design, process integration, supply chain management, and customer awareness. The whole gambit of "electronic commerce", everything from Electronic Data Interchange, INTERNET & WWW through E-mail, to CAD/CAM and 'open systems', will need to be applied, understood and used throughout the organisation. And this knowledge base will have to be backed by flexible, intelligent production systems and an innovative logistic response.

Tools to facilitate agility have been defined and some are in place, but the organisational framework is crucial

In addition to relying and building on existing technological capabilities, the adoption of Agility as an operational mode for business will also have very important consequences for the directions taken by new technological development and innovation activities. Beyond the higher performance hardware and software technologies that agile operation will require for the various aspects of goods and services production, the **ways** in which R&D is conducted and technology developed and deployed will also undergo important changes.

As far as tacit knowledge or "know-how" is concerned, the whole knowledge accumulation process stands to benefit from Agility via an improved scope for **interactive learning** in the economy, and an automatic stimulus for **continuous learning** by individual firms and workers.

The agility model is not limited to manufacturing

Agile enterprises & Virtual enterprises?

In light of all the above, it is easy to contemplate **every facet of doing business becoming agile**. This invokes the concept of the complete **Agile Enterprise**, rather than the narrower focus on agile manufacturing alone.

The need for flexibility and re-configurability of, and within organisations, to meet rapidly changing market demands, also raises the notion of **"virtual organisations"** as **one** likely mode of agile operation. This would entail people coming together to create an endeavour, re-con-

Flexibility and reconfiguration taken to their logical conclusion lead to the 'virtual organisation' figuring to deliver the product, re-configuring again to meet changing demands, or moving on their [separate] way to new challenges. The implied social and socio-economic issues such as continuity of employment, maintenance of skills, motivation and reward, lifetime finances, have considerable implications for individuals, families, and industry, as well as society at large.

> The construction industry demonstrates some of the attributes of Agility. In large civil engineering projects, for example, the architect conceives the idea, engineers and designers plan the execution, and experts in materials, logistics, contracts etc., come together with subcontractors and workers for the time necessary to complete the project - all supervised by a small and lean overseeing contractor or management group.
>
> The construction industry also demonstrates some of the problems around employment, maintenance and upgrading of skills, responsibility for health and safety, quality, contractual arrangements and finance.
>
> Construction is not a perfect analogy for Agility, as projects tend to be one-off, organised on a linear basis, involving relatively low technology applied on a craft basis, with much of the subcontracting being of a self-employed, labour-only nature. By contrast, manufacturing is a more dynamic, relatively continuous, iterative process requiring higher tech skills, and significant networking, with people contributing on a group basis rather than as individuals.
>
> Other fast-changing industries which, in a similar sense, are forerunners of Agility include fashion, toy manufacture and publishing. Here, agility takes the form of a highly flexible Dynamic Network organisation (Miles & Snow, 1986) where a core firm acts as broker, pulling together other specialised, independent firms into short-term contract-based partnerships.

The Origins of Agility

Conceived in the USA, "Agile Manufacturing" (AM) activity was inspired by the Department of Defence, concerned for the competitiveness of US manufacturing in the global market. They commissioned a report "21st Century Manufacturing Enterprise" (Iacocca Institute) in 1991. The authors Goldman & Preiss of Lehigh University went on to establish the Agility Forum (AF) with funding of $4.5M pa. from the Advanced Research Projects Agency (APRA - part of the DoD), the US National Science Foundation and the US Department of Energy. Matched by funds from US industry, they have a $9M budget with 35 staff and consultants.

However, this is only the central administration and dissemination activity. Federal, State and industrial funds amounting to $100M+ pa. support a wide range of collaborative projects under the "Agility" umbrella.

A core group of 12 major US companies is keenly involved, with a further 300 "piggy-backing" on their activity. Key to the process has been the secondment of very senior, upwardly mobile managers from industry to the AF - several of whom have returned to implement agility in their companies.

The AF is organised on a business process basis (e.g. Technology, Personnel, Accounting, Logistics, Customer Focus, Manufacturing etc.) across industry sectors to identify and transfer best practice between sectors. This is managed through 11 "Focus Groups" that call upon the best resources available, from industry, academy and consultants.

Agility also seems to take a long-term perspective, looking beyond current best practice towards "new practice"; hence its extension into the concept of **"virtual companies"** and all the social and organisational implications this has. In fact the social and cultural issues have been highlighted as both significant drivers and obstacles to adoption. We have already seen companies "out-sourcing" a lot of their professional and support services such as legal, IT, transport, canteen and security. The virtual company takes this a stage further, but at the same time closely integrates all the "added value chain" **partners** through enhanced communication systems, and **mutual interest values.** This fragmentation of industry into smaller, leaner, more flexible groups of specialists facilitates the ability to re-configure on demand to meet market needs and global competitive challenges.

At the same time, however, many see the disappearance of the benevolent large industrial employer as a threat and a challenge to the individual, especially in terms of job security, continuity of employment, and occupational pensions, but also in terms of training, maintenance of skills and career progression. Current "down-sizing" has been cushioned by generous redundancy, early retirement and retraining. Who will match these benefits in the smaller, leaner groups of the virtual company? The new paradigm will undoubtedly bring more frequent job changes and place more responsibility on the individual for training and lifetime personal and family finance.

Like any new paradigm, a few organisations are already exhibiting some of the features, allowing inferences to be drawn, and to provide a "peep over the horizon". The AF "Knowledge Base" has collected a wide range of case studies that provide much anecdotal evidence, though a well defined formula for Agility has yet to emerge.

The Agility Forum has been running for 4 years and a considerable amount of work has already been done, and reports published - all in the public domain. An extensive programme of dissemination and collaborative adoption is underway and there are plans for monitoring the ultimate benefits.

By using the most advanced communications systems and allowing their suppliers to have real time access to their CAD/CAM/CIM facility, Motorola were able to speed product development, reducing time-to-market for new lines by 40%. An added, unexpected benefit came from a reduction in the time designers and engineers spent travelling to, and visiting suppliers, and in associated expenses.

So far little of this activity has diffused out of the USA, although there is a move to establish a European Agility Forum[1], and CEST Centre for the Exploitation of Science and Technology, London in the UK are providing a focus to learn from US activity. Other organisations are working on parallel paths: the Fraunhofer "Fractal Company" (Warnecke, 1993), and IMD's "Manufacturing 2000" have many features in common with Agility, and some individual companies are looking at similar concepts - Ford's "Project 2000 - nimble manufacturing" for instance. However, the European approach to date has been fragmented and uncoordinated.

The US Government funded "Agile Manufacturing" initiative (AM) has some parallels in Europe such as the UK's "Innovative Manufacturing Initiative" (IMI)[2] and Germany's "Production 2000" [3] project, similar to AM in their genesis and objectives. There are also some obvious differences, particularly in the approach being adopted. In the AF the focus is on cross-sectoral business functions, with an emphasis on business processes, whilst the IMI is organised on an industry sector basis. Both require integration of output to provide holistic messages for dissemination.

The AF has been running for several years longer than the European initiatives and some lessons have already been learned about the organisa-

The agility paradigm places greater responsibility and pressure on the individual rather than the firm

Although agility related activities have found strongest support in the US, interest in other countries is also growing

1 Initiative by Lufthansa Cargo, USW Cologne, Technical Uni of Berlin, Fraunhofer Institute and CEST
2 UK Government Research Council £3 million funding over 3 years for academia & industry
3 "Production 2000" - a 5 year German Government project

tion and administration of the programme itself, from the results of work completed to date, and from the dissemination and follow-on activities. The annual three-day Agility Conference organised by the AF (this year in Boston 5,6,7 March 1996), and attended by several hundred delegates, has proved a major factor in dissemination and raising the profile of agility on a national basis.

These lessons, and **their interpretation in a European context,** could well improve the effectiveness of European business process development, and reinforce or modify its output. In any event, they provide a sanity check and add to the overall database of experience. An analysis of AM will provide a useful benchmark against which to measure the progress, output, benefits and impact of European developments.

Figure 1 - Market Segmentation

UNCERTAINTY	COMPLEXITY: High	COMPLEXITY: Low
High	**Super Value Goods** Aerospace Defence Shipbuilding Professional Electronics Process Plant Major Construction Heavy Electrical	**Fashion Goods** Aerospace Defence Shipbuilding Professional Electronics Process Plant Major Construction Heavy Electrical
Low	**Consumer Goods** Automotive Consumer Durables White Goods Brown Goods Machine Tools Pharmaceuticals	**Commodities** Primary Materials Chemicals Glass Paper Building Materials Commodity Tools Simple Components

Figure 2 - Differentiators and Critical Competencies

UNCERTAINTY	COMPLEXITY: High	COMPLEXITY: Low	
High	**Super Value Goods** FITNESS FOR PURPOSE	**Fashion Goods** TIMELINES	⇦ DIFFERENTIATION
	Product Design Product Development Information Technology	Market Vision Time to Market	⇦ Critical Competence
Low	**Consumer Goods** VALUE FOR MONEY	**Commodities** PRICE	⇦ DIFFERENTIATION
	Time to Market Flexible Manufacturing	Productivity Logistics	⇦ Critical Competence

4 Intelligent Manufacturing Systems - 1990 MITI co-operative program with EU &USA

5 EUREKA EU 1005 "Factory for the Future" DTI Jan '95 - study of 107 companies

The Competitive Position

There is no lack of other philosophies being promoted. In Japan the concepts of "Intelligent Manufacturing Systems" (IMS) [4] and "Bionic Manufacturing Systems" are being studied, and it should be remembered that their Toyota Production System (TPS) and Kawasaki Production System (KPS) had a significant effect upon competitiveness. Agility Fora are also being established in Brazil and the Philippines.

The total world effort addressing manufacturing competitiveness is considerable. Is Agility just a passing phenomenon, or the framework that will define the "Next Generation Manufacturing Enterprise"? Paradigm changes do not occur over night and those who lead tend to accelerate away from the followers. **An *understanding* of this activity, and its implications is essential to maintaining and improving Europe's competitive position.**

The three country EUREKA project EU 1005 [5]- "Factory for the Future" - highlights aspects of agility and virtual companies, and underlines areas for future study to understand these, and other features of competing in tomorrow's global marketplace. Agility will undoubtedly have a different meaning for each company, and there is probably no such thing as an all-encompassing Agility model. However, the Market Segmentation and associated Differentiators and Critical Competencies defined in EU 1005 (figures 1 & 2) may provide a useful basis for defining four principal Agility models that can be tailored to individual company circumstances.

Others, notably America & the Far East, are already looking over the horizon, raising questions about Europe's ability to coordinate its fragmented approach, learn from others, set the research agenda appropriately, and make its cultural characteristics help rather than hinder such efforts.

Keywords

agility, manufacturing, virtual companies, management and organisation, US Agility Forum,

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Alternative Fuels for Automobiles:

Hydrogen potential and its implications

Hector Hernández

Issue: The main concerns over automobile fuels include emission effects on health and environment, and, for the longer term, energy security. Hydrogen, as an alternative vehicle fuel, presents particular characteristics that have to be carefully examined in order to evaluate its potential and implications. Recent advances within transport technology demonstration programmes have prompted renewed interest in hydrogen which, in Japan and the US, is being followed by significant policy steps.

Relevance: The market for alternative automobile fuels is expected to grow rapidly as they pass successfully through research, test and demonstration stages. This has serious repercussions for the automotive and related industries, assuming that the main barriers are overcome, i.e. price, refuelling infrastructure, safety and on-board-storage concerns and public acceptance. Given the renewed interest and promising technical developments, the harmonisation of European policies and regulations appears evermore important.

Hydrogen is claimed to be one of the cleanest transport fuels

Introduction

At present, there is no alternative fuel in the mass market that minimises the negative effects of, and competes with, conventional fossil fuels, i.e. gasoline and diesel. No fuel meets all the requirements of energy content, local/global emissions, cost, public acceptance, safety, sustainable supply, and maturity of technologies and infrastructure for fuel production, transportation and distribution.

It is claimed that hydrogen (H_2) is a suitable fuel for transport applications, and one of the cleanest. Hydrogen presents advantages from both environment and energy security viewpoints, yet it also has serious drawbacks, especially for automobile applications where tighter safety and on-board storage requirements have to be met.

Hydrogen issues specific to automobiles

Hydrogen can be used to fuel slightly modified internal combustion engines (ICEs) or to feed fuel cells that generate electricity for electric vehicles (EVs). It can also be blended with natural gas (15-30% H_2) to power ICEs (Pohl, 1995). The main issues, specific to automobiles, concern on-board storage and, perhaps most sensitively, safety.

Hydrogen has been used for a long time, as a feedstock for many industrial applications and in space-programmes to fuel rockets, with a relatively good safety record. Its use as an automotive fuel has also been tried during the past two decades without major safety problems, but on a very small scale and therefore, the overall safety of hydrogen in powering vehicles on a broad scale remains to be demonstrated.

In fact, hydrogen has particular characteristics that require careful examination. Some of its physical properties make it more hazardous than other fuels when it is released into confined or poorly vented areas. On the other hand, hydrogen is non-toxic and can be less dangerous than other fuels when adequate venting is in place (see Box 1). Therefore the design of hydrogen systems for automobiles should emphasise the prevention, detection and mitigation of leaks and the avoidance of confined spaces.

Safety is a major concern

Box 1. Safety-related aspects of hydrogen as a vehicle fuel

Embrittlement. Can provoke metal embrittlement and induce reduction of fracture toughness even when stored at low pressures. The choice of materials for storage and transportation is therefore very important.
Venting. A critical aspect of storage and manipulation of hydrogen. Safety measures should assure clean supply lines, avoidance of close ignition sources, elimination of possible confinement and all materials employed should be compatible with hydrogen.
Refuelling. Safe systems should also prevent air from entering the filling lines and vessels, and avoid major fuel leakage. Thorough measures for intrinsic safety and interlocked functions should be implemented.
Crashworthiness. The storage vessel and fuel lines should be carefully placed and protected against crashes. In addition, in case of leakage, hydrogen confinement should be avoided.

Hydrogen could offer zero pollution emissions

By far the main advantage of hydrogen is its low or zero emission of pollutants. In fact, hydrogen-powered ICEs produce only water and some nitrogen oxides that can be avoided by upgraded combustion (and some unburned hydrocarbons from lubricating oil). More significantly, its use in fuel cells involves no harmful emissions. However, in terms of the global emission problem related to greenhouse gases (mainly CO_2), hydrogen's impact depends largely on the way it is produced, and more generally on the full energy cycle.

Regarding its energy characteristics, hydrogen's energy content per kilogramme is about three times higher than for gasoline, but its energy content per litre is only a quarter (though somewhat different when including vessel characteristics, see Table 1). In theory, the performance of liquid hydrogen is comparable to gasoline, when considering vehicle range, but the energy density of the compressed fuel is significantly lower. Thus, the characteristics of the on-board energy storage system required presents a major problem. Many options for such systems are under study, but this remains a major technical challenge for automobile applications (see Box 2). Hence, the importance of research in this area (e.g. on advanced materials, nanomaterials, etc.).

The challenge of on-board storage is being addressed through materials research

The comparison of hydrogen with other fuels should also include the efficiency of energy conversion throughout the overall cycle. Regarding its use in conventional spark-ignition engines, reported results indicate that hydrogen engines could be 15-25% more efficient than gasoline ones. In addition, fuel cells, that offer a much higher efficiency than conventional engines, could further improve hydrogen conversion to 20-30% (SAE, 1994).

Another interesting comparison is with natural gas (NG), a competitor to hydrogen and, at present, its main feedstock. In fuel cells, use of liquid hydrogen produced via the NG route is reported to have a small efficiency advantage over the direct use of NG. By contrast, in ICEs use of liquid hydrogen is less efficient than direct use of NG.

Box 2. Hydrogen on-board storage technologies

Conventional systems include compressed storage, liquid storage and metal hydrides, all of which are, to some extent, limited by either excess weight, volume, refuelling time, cost or safety. These problems are being addressed through R&D e.g. use of new light-weight materials. Promising systems, still at research level, comprise:

Carbon adsorption: Hydrogen can be adsorbed on to activated carbon at cryogenic temperatures (about -115 °C) and also within the porous carbon structure under pressure, thus achieving concentrations similar to that of liquid hydrogen. This system could combine the advantages of compressed and liquid hydrogen storage.

Other hydrogen storage systems: On-going research on bonded-hydrogen storage systems includes liquid hydrides and an iron/water system. In these, hydrogen is chemically bound to other compounds and released through a reversible reaction. Although, these systems could present some advantages, they involve complex chemical processes, still not well understood.

Hydrogen has advantages over many conventional technologies in terms of overall efficiency

Compared with electrical energy storage systems, hydrogen presents considerable advantages over electrochemical batteries, which, presently and for the foreseeable future, strongly limit the range of pure electric vehicles.

Hydrogen in a broader context

Hydrogen can be produced from virtually any energy source. Many new methods are currently being explored, with special emphasis on those based on renewable energies (Table 2). The main issue is high production costs, particularly for renewable energies which are, for the foreseeble future, also limited by supply capacity. Today, the cheapest and most efficient method of producing hydrogen is through reformation of natural gas. However, NG is a cheaper vehicle fuel than hydrogen.

Table 1. Comparative characteristics of hydrogen and other fuels (IEA 1, 1993)

Fuel	Energy density [a] (MJ/kg)	Energy density [a] (MJ/l)	Fuel requirements for 400 km (kg)	Fuel requirements for 400 km (l)	Life-cycle emission [b] CO_2 eq. (g/km)
Gasoline	33.4	25.3	27.5	36.4	260
Methanol	17.3	13.2	46.2	60.6	250
Comp. Natural gas	9.9	3.5	87.3	246.9	231
Elec. Vehicle (av.)	< 1	< 1	~700	~700	47 - 341 [c]
Liq. hydrogen	20.8	5.1	35.8	145.9	~(53 - 400) [c]

[a] Includes container's weight
[b] Includes fuel production, transportation, distribution and car emissions
[c] Depending on the basic energy source best - renewable resource, worst - coal-fired plants (indicative only)

Regarding distribution, the present, low levels of demand for hydrogen are only covered by expensive truck or rail transportation. To meet larger scale demand, pipeline distribution will be required. In principle this does not present major technical obstacles because similar technology already exists, e.g. for natural gas transportation. Yet here, too, safety has still to be demonstrated. The cost of the required infrastructure, both for transportation and distribution is also a main limiting factor to hydrogen's market introduction. In this respect, the success of on-going demonstration projects on H_2-powered ships, trucks and buses could ease the way for automobile applications.

Finally, public acceptance of hydrogen is an important issue. Certainly, long and extensive demonstration programmes would be required to achieve substantial market penetration.

Outlook of national hydrogen programmes

Hydrogen is considered a promising long-term solution for transport applications. This is witnessed by the significance of national research programmes in the major industrialised countries (Table 2). The overall investment includes funding from industry and other local or regional bodies (not shown in Table 2), which in many countries is substantial.

Over recent years, a shift in policy has been observed, the new priorities being more practical and near term applications (IEA 2, 1994). This can be explained by certain shortcomings of renewable energies, a substantial contribution from which seems, at least, to be postponed. Nevertheless, future support for hydrogen technologies is expected to be maintained worldwide, and even enhanced in countries such as Japan and the US, where large programmes are under discussion.

In Europe, even if the overall data show substantial activity, hydrogen programmes are concentrated in a few countries and clearly lack co-ordination and co-operation. In particular, hydrogen is not addressed through any specific action under the EC's RTD programmes, and the funding of the Euro-Quebec project, the largest on-going hydrogen project, has been interrupted. Moreover, the lack of harmonised regulations and integrated infrastructure is hindering activities in this field, so delaying the clarification of the H_2-option for Europe.

Conclusion

The implications of hydrogen as an automotive fuel are manifold. Hydrogen presents potentially large environmental benefits, and will certainly play a vital role if significant production is achieved from nuclear or renewable resources. Yet, at present and for the medium term, its significant production is still likely to be from fossil fuels, in which case there is little or no benefit in terms of global emissions and energy security issues. Some benefits could arise from the technical similarities between hydrogen and natural gas, which could be an incentive for the development of dual technologies. Moreover, the success of on-going demonstration projects on other means of transportation could yield spin-offs for automobile applications. In this respect, along with the improvement of utilisation technologies, the overall issues of hydrogen production, transportation and distribution have to be addressed. And, in order to achieve public acceptance, key safety and cost issues will need to be overcome.

On the other hand, as far as local emissions are concerned, hydrogen could play an important role, but major technical challenges regarding safety and on-board storage remain. In this context, important technical developments, that could substantially change the outlook for hydrogen are taking place. Moreover, it could be a major competitor to batteries for powering zero (or near zero) emission vehicles.

In any case, hydrogen is likely to remain a strategic issue of energy policy, as demonstrated by research programmes throughout the world. In Europe, where hydrogen technology is at the fore-

Barriers to the take-up of hydrogen technologies include high production costs. .

. and distribution and refuelling infrastructure

There is considerable interest in hydrogen research at national level....

....but little European-level activity

front, there seems to be a need to reinforce co-ordination and co-operation, especially in terms of EU policies, and harmonising regulations and standards.

Recognition of hydrogen as a strategic issue in energy policy calls for greater co-ordination and co-operation across Europe

Table 2. National hydrogen programmes of some IEA countries

Funds[a] (million US$) and main research, development and demonstration areas[b]

Country	1995 Funds	Production	Storage and Transport	Utilisation and Systems	Fuel cells
United States	10	2, 5, 6, 9, 10	1, 3, 4, 5, 6,7	1, 2, 4, 5	
Japan	22.8	1, 3, 4, 5	1, 2	3, 5	1, 2, 3
Germany	12	1, 2, 4, 5		4, 5	1, 3, 4
other Europeans[c]	11				

Source: IEA 2, 1994

[a] Only national government funds

[b] Main areas

Production: 1=advanced electrolysis techniques, 2=from PV electricity; 3=from biomass, 4=photochemical & photoelectrochemical; 5=photobiology, 6=from conc. solar energy, 7=from municipal solid waste

Storage and Tranport 1=metal hydrides; 2=hydrogen liquefaction; 3=bulk storage; 4=other storage options, 5=liquid organic hydrides, 6=pipeline evaluation; 7=glass microspheres technology

Utilization and Systems 1=hydrogen fueled engine, 2= H_2 sensor; 3=embrittlement, 4=H_2 fueled vehicles,

5=H_2 combustion turbine

Fuel Cells. 1=solid oxide, 2=phosporic acid, 3=proton exchange membrane, 4=molten carbonate

[c] France although significantly working on this field is not included

Keywords

Alternative fuels, vehicle emissions, hydrogen technology, energy security, internal combustion engine, fuel cell, hydrogen safety, hydrogen production cost

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Prioritisation in the Information Society:

Efficiency and exclusion

Dimitrios Kyriakou

Issue: Intelligent agent programs ('stand-ins' for humans) have been touted recently as a great advance which, thanks to the emergence of networked environments, can facilitate tasks for which human time and effort are still required. One of the simplest forms of intelligent agents is the software used for 'program trading' in financial markets, where pricing and prioritisation issues addressed here can be seen in embryonic form. Prioritisation between such 'stand-ins', all competing for bandwidth in the fastest execution of certain tasks, may be an issue with unforeseen repercussions in the longer term.

Relevance: The pervasive nature of the emerging Information Society makes some of its less innocuous - though still distant and seemingly esoteric - aspects worthy of attention, and raises questions about the emerging order of knowledge. The use of simple 'intelligent agent' programs is one such case. Specifically, the availability of 'stand-ins' will both automate and commercialise many of those activities which, to date, have been without a price-tag. While systems based on ability-to-pay will increase efficiency, they also raise the prospect of further social exclusion.

The multimedia information society (MIS) is an all-encompassing concept that attempts to capture a wide-ranging transformation. It reflects a series of developments on both the demand and the supply sides of the telecommunications market, centered around the increasing facility, speed and affordability in manipulating data in various forms, as a result of technological as well as (de)regulatory drivers. The concept encompasses the increasingly interactive services and the applications riding on these developments and providing the added value that justifies the launching of the underlying infrastructure; it encompasses the work of the builders of this infrastructure and of the interacting users, producing and consuming information. Last, but not least, the Information Society concept refers to the socio-economic impact of these pervasive techno-economic developments. Information and communication technologies not only change form continually, they also reshape the social context which gives rise to them.

This article focuses on the repercussions of pricing mechanisms and prioritisation of decisions in the MIS. It is not concerned with technical aspects of 'intelligent agents' or 'program trading', nor with sociological analysis of the complex social relationships to which they can give rise. As with most other MIS-related questions, the underlying issue is not new, express letters have always been more expensive than regular mail for example. The **MIS however increases the incidence and the scope of the issue dramatically by, for the first time, putting a price-tag on areas of human activity that**

Pricing and prioritisation are crucial issues in the MIS

Information packets can be assigned priority labels, but competition for bandwidth raises the issue of exclusion

have hitherto been exempt from market disciplines. Although this would in principle raise efficiency, it may also lead to social exclusion. To put it in stronger terms: clearly the MIS will not erase the distinction between rich and poor; it may help bridge the gap in some cases (for example through facilitating teletraining and teleworking), and it may magnify the gap and expand its scope in others, such as the pricing and prioritisation issue examined here.

Pricing Issues

Pricing is a hard problem in the MIS, with not only business but also broader repercussions. Efficient pricing would have particularly vexing implications for businesses but most importantly, for the purposes of this article, at the level of users. The Internet, for instance, presents pricing problems in an extreme form. By being owned by everyone and no-one at the same time, the Internet resembles 'the commons' (air, oceans, etc.) and shares some of their misfortune as public goods: readily enjoyed by users who, however, are keen to 'free ride' rather than contribute to its upkeep.

More specifically, when service providers charge a flat fee per month subscribers have an incentive to overuse their connection, possibly leading occasionally to congestion. It would be more efficient for service providers to charge on the basis of actual usage which might alleviate congestion at peak hours. This, however, would take away some of the attractiveness of certain services. Billing experiments in Chile and New Zealand, for example, have shown that pay-as-you-use schemes actually reduce usage and inhibit browsing. It would also be thoroughly impractical: counting the information packets requires significantly more work for the computer than merely transmitting them.

The problem becomes more acute when simple intelligent agent programs enter the scene, defined as programs similar to the buy-and-sell routines used in program-trading in stock markets, fed with simple scenarios and rules of reaction. Such programs place the problem in relief, making incessant bids for concluding a transaction, without being subject to human constraints (tiredness, boredom, multiple concerns, etc.).

Prioritisation issues

Broader repercussions start entering the picture when we contemplate another solution to the problem - the use of priority levels ('priority tags') purchased by the user or subscriber either *a priori* on a monthly basis, or on the spot. Indeed, multiple priority switches have already been built by telecoms companies (e.g. Northern Telecom), allowing multiple tariffing and customised service grades. In such systems, high priority packets flow through the mail without delay whereas lower priority ones have to wait in line. Actually the situation is more complicated because it is conceivable that many high priority packets will arrive at the same time. Then, if traffic congestion calls for it, there would have to be a way to prioritise among the packets with the same 'high' priority. One way would be to use an auction mechanism to grant highest priorities to the highest bidders, presumably those who value speed more, and, crucially, who can afford the levels bid. **Thus, auctions could solve the problem of congestion at the cost of raising new ones.** A bank, for example, can probably afford to pay more to raise its priority rating during such auctions than an individual whose doctor is receiving information and guidance during an operation.

Obviously these issues transcend the Internet, and ushers us into the most problematic aspects of pricing and prioritisation in the MIS. Depending on the narrowness of the available bandwidth, any network or sub-network of the MIS infrastructure may be faced with congestion and prioritisation problems. A solution such as : 'penalise the more bandwidth-demanding packets by putting them at the end of the line' may impede the development of some of the most attractive applications, such as tele-medicine or tele-training.

In other words, new issues will arise regarding **prioritisation** and order of processing at times of **congestion** (i.e. **'traffic controllers'** may be needed). Traditional methods ('first-in-first-out', 'Round Robin' etc.) may have serious ramifications when speed is of the essence for competing 'vehicles' on the highway. If a prioritisation reflecting a regulator's or the government's preferences is put in place, preventing the purchasing of highest priority by those who value it AND can afford it, then it is quite likely that **wealthy private actors** (e.g. large corporations) will partly opt out of this arrangement, and stay with their own speedier networks. This will lead to 'cherry-picking', leaving the more egalitarian, possibly publicly-run networks with the customers least able to pay.

Furthermore, it would be hard for governments to impose priority hierarchies on all networks, since there are uncertainties regarding the jurisdictions for the type of information networks concerned: is the appropriate jurisdiction for the hierarchy the sender's? the recipient's? the intermediary's?, etc. Legislating on Internet-related issues is an indication of how difficult the process is - the Internet can be taken for the purposes of our analysis as a slow, primitive, insecure, embryonic form of the projected MIS infrastructure.

Aspects of optimal and sub-optimal pricing

The issue of prioritisation and auctions points to another repercussion of the MIS. The MIS will bring down barriers to achieving the economically optimal outcome by bidding the price up to levels where demand meets supply (market-clearing levels). In this sense it would provide a strong boost to competition and efficiency, by providing information about demand, supply and prices to the interested parties, and by minimising extraneous costs (associated with waiting-in-line etc). The problem, however, is that such a development may put a price tag on more than society is willing to accept, as the earlier example on tele-medicine indicated.

As a further example, imagine that users have the ability to run applications which will act as their **stand-ins**, waiting-in-line at 'virtual' ticket counters. (This is neither as far-fetched nor as trivial as it may sound at first - it is related to an example used by Microsoft's chairman Bill Gates recently). As soon as tickets become available they are supposed to immediately buy for their masters. How could conflict be resolved if there are 1000 such 'stand-ins' and only 100 tickets? Auctions could do the trick; however they would also essentially prohibit poorer users from ever getting to see any popular performance, as the price will rise to bring equilibrium between supply and demand. In general, monetarisation through auctions may wreak havoc in those cases where society has opted to fix prices at **non-market-clearing** levels (e.g by relying on **rationing** and determination to wait-in-line to filter those who will enjoy a service from those who will not).

Conclusion

This analysis presents potential exclusion problems that may arise in the MIS in their purest form. The assignment (through purchase, decree etc.) of priority tags, the running of auctions etc. are crucial issues in the emerging order of knowledge in the MIS (a topic which will be the subject of a separate article). The increased efficiency afforded by technology may allow competition and ability-to-pay to determine the allocation of goods and services in a way hitherto unforeseen, subjecting even 'untouchable' aspects of human life to the price mechanism, as in the case of the high-bandwidth medical operation mentioned earlier. As is often the case, technology does not cause the problem, it simply magnifies already existing tensions due to social choices and practices to the point where they can no longer be ignored.

If the price mechanism is not allowed to function, wealthier actors will be attracted to separate, speedier networks

Efficiency is boosted when supply and demand meet, driving prices to market-clearing levels...

..but there may be unwelcome side effects, where society has opted for fixing prices at sub-optimal levels

Keywords
information society, market mechanisms, pricing, auctions, prioritisation, intelligent agents

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A Common Framework of Knowledge for the Information Society

Gerhard Grau, Helmut Spinner, Marcus Nicolai

Issue: The image of a world where everyone can find any information, anywhere and anytime is guiding the development of global mobile communications. This vision of an Information Society (IS) brings with it high expectations for a globalised democratic and well-informed society, enjoying full employment and a high quality of life through the use of high-technology. However, this ideal may not evolve by itself, but may be helped by an EU framework conducive to its favourable development.

Relevance: Information technologies are expanding fast and penetrating all areas of society. A common framework for the management of information is needed to support the decision-maker. The current legislative and economic framework used for the trade of goods is not, apparently, capable of managing the exchange, protection and tracing of information. A *Common Framework of Knowledge* may be an important prerequisite for the management of change towards IS.

Why We Need a Framework for IS

Information as a digital commodity is a product, and as such it has its price. If protection for this product is too strict, IS will not evolve; if it is too lax, there is no incentive to create useful information. Present copyrights and patent laws are hardly able to cope with the instantaneous and global availability of information. New forms of commercialising digital data may be rental or sale. However, it is not clear how to measure and price information, and how to control all the partners (possibly many) involved in an electronic transaction.

Intellectual property rights present a dilemma.

To discuss possibilities in establishing such a framework, the European Academy of Sciences and Arts (Salzburg, Austria) initiated an interdisciplinary working group constituted by representatives of the Centre of Technology Assessment of Baden-Württemberg, the Universities of Amsterdam, Barcelona, Karlsruhe, Limburg/Maastricht, Vienna and the CEPS Luxembourg. On November 13/14 1995, the IPTS invited this working group to Seville to meet for a first exchange of opinions.

Traditional forms of company management have to adapt to the influence of IT. Functional hierarchy (the strategy of removing complexity from lower levels and passing it onto higher management ranks) becomes obsolete with IS. Now both the infinite detail and the overall picture are available at all levels (i.e. state, organisation, firm) and consequently more decisions should be left to lower levels, increasing the speed and flexibility of responses to practical customer needs. Many of the current problems of large

Lean network structures and subsidiarity are required in the IS.

A Common Framework requires a multidisciplinary approach

A framework should contain Weight, Distribution and Protection fields

firms stem from the difficulties of adjusting to a flatter and more flexible organisation. These changes will, of course, also have important impacts on social structures which will need to be addressed by both senior executives and other decision-makers.

Depending on our choices, we will move either toward a prospering viable IS and information economy (where the goal is the transformation of information into public wealth and improved quality of life) or simply evolve technically advanced islands in a vast underdeveloped sea with the concomitant social problems.

A Common Framework of Knowledge for the EU: Challenges and Responses

Given that the existing legal and economic framework is not applicable to all kinds of knowledge and information, the following challenges are fundamental for setting up a framework for the IS:-

- Under what conditions is knowledge produced, applied, used, exchanged? Should it be done with or without property rights, with free access or exclusions, as private commodity or public good, within monopolistic structures or with free flow of information at the national and transborder level?
- What structure of IS is advisable to allow the introduction of differentiated technical and non-technical conditions for promoting scientific innovations, societal information and civil rights?
- Is it possible to implement all these issues within the same framework?

A possible answer to these challenges constitutes a Common Framework of Knowledge. This framework should contain: Weight Fields for the steady improvement of high intellectual weight information (in science, technology, industry), Distribution Fields for the free flow of mostly low intellectual weight information (mass media, individual telecommunication), and Protection Fields for sensitive information (privacy, secrecy). The architecture of an advanced IS should also comprise a Legal Framework and an Economic Framework for a fully commercial market of ideas, in accordance with a Common Framework of Knowledge.

This framework for science and technology, and also for the wider society, should be realised on a European level, in order to complement European integration. It should open the door for an innovative interplay of technical innovations and non-technical conditions of IS.

The Interdisciplinary Working Group

In order to develop an approach for such a Framework of Knowledge an interdisciplinary working group was established by the participants of the Salzburg Seminar. Its key issue is: How to shape a Common Framework of Knowledge for a well-balanced interplay between technical innovations and adequate non-technical conditions for a sustainable development of the IS?

This is both a technical and social vision for the information age. The details are the focus of discussions between scientists, decisions makers and representatives of social groups, involving both technical (communications-, hardware- and software engineering) and non-technical disciplines (philosophy of science and technology and most of the social sciences, especially law, economics sociology).

Working Hypotheses

Confronted with this vision, it is sensible to find out what really makes up the system architecture and the system functionality of an IS, to define a range of capabilities supported by it. Then, within the Framework of an Order of Knowledge, let the social and market forces decide what, when, where and how to implement. The following working hypotheses will help to launch the discussion:

(1) We already have the technical means to establish a global IS.
(2) Beyond technical efficiency, we must realise non-technical conditions for the proper use of information and communication technologies. A permanent interplay of technical and non-technical innovations in mutual adjustment can take us from repeating catchphrases on the IS, to realising the ambitious vision of an informed society.
(3) Therefore, the shaping of the framework for the IS must keep pace with the technical developments. This refers, first of all, to the legal and economic non-technical framework conducive to all kinds of innovative work.
(4) To create a positive climate for knowledge-activities of all sorts, from scientific research and public informational services to worldwide, free flow of information, appropriate regulations may be necessary.

In closing, due to rapid globalisation of I&C, including the diffusion of the non-technical conditions (positive or not), the shaping of a Common Framework of Knowledge for the EU is an urgent task, for science as well as for the decision-maker. Such a framework would need to handle issues that often escape the confines of one sector, or even one jurisdiction. Given the problem's multifaceted character, a broadly multidisciplinary effort is needed for the design of such a framework.

Realisation of the well-informed society requires interplay between technical and non-technical innovations

Keywords

Global communication, information economy, information society, Legal Order, Economic Order, Common Framework of Knowledge

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B R I E F N O T E S

The Commission to define a European strategy for the rational management of water

Formerly of good quality and plentiful, water is becoming a scarce resource under the combined effects of waste, pollution, increasing population and drought phenomena which do not spare Europe. Accelerating the design and development of techniques for the rational management of water is therefore an urgent task. This is why Edith CRESSON, European Commissioner in charge of research, has decided to launch an exercise with the goal of building a concrete European strategy in this area. To this end, a "task force" has been set up which associates the different Commission services concerned. In close consultation with the main interested parties, its mission will primarily consist of supporting the competitiveness of European enterprises in this domain, on both the European and world markets.

Four directions for the strategy

The European strategy should follow four directions:

- The **fight against pollution** - improvement of indispensable basic knowledge; pollution prevention by rehabilitation of contaminated soils, sediments and aquifers, "on-site" treatment of effluents and development of agricultural techniques which limit the risks of diffusion of pesticide and fertilizer residues; improvement of wastewater treatment technologies.
- The **rational use of water** - promotion of re-use and recycling in different branches of agriculture and industry; perfecting irrigation methods; development of equipment and management methods saving water for industry; minimise losses in distribution networks, develop economic instruments likely to encourage users to save water.
- The **fight against chronic water shortages** in certain regions, notably in the south of Europe - installation of water infrastructures and development of resources; planning and management of water supply and demand and diversification of supply sources.
- **Prevention and management of crisis situations** - such as floods, sudden and large scale pollution or severe droughts - improvement in the understanding of the causes and effects of these phenomena; development of tools for forecasting, warning and management, the development of security systems for threatened populations.

The strategy will be **concerted** by involving the various European actors concerned: water distribution and treatment operators, specialised research centres, users, regional and national infrastructure and planning authorities, etc. The objective will be to define the **priority actions** within the four proposed directions. The selection will take existing activities into account, the importance and urgency of the problems, the prospects offered by science and technology, market opportunities, the competitive position of Europe and the potential for the implementation of research results.

Various **types of action** will be considered: coordination between programs or research projects within the 4th framework program for R&D and/or other European or national programs, setting up new industrial partnerships, promotion of new research in key areas and start up of pilot and demonstration projects. The Task Force will be placed under the authority of Mr. J. M. Martin, Director of the Environment Institute of the Joint Research Centre in Ispra, assisted by Mr. B. Schmitz, Head of Unit in Directorate General XII "Science, Research and Development".

Water, a major challenge for the 21st century

Water has become a coveted economic good. Its management will be one of the major challenges of the 21st century. The mismatch between water resources and needs is becoming more and more frequent, resulting in overexploitation, degradation of reserves, even tensions between competing users, states,... Even when water is not in short supply, pollution and wasteful behaviour threaten supply in the long term.

Water pollution in the European Union is worrying: 20% of the surface waters are threatened; the causes of pollution of the deep aquifers are diverse and poorly controlled; the coastal zones are being weakened; more than 60% of the agricultural lands contain concentrations of fertilizers and pesticides deemed alarming for the quality of the surrounding waters; the losses in the water distribution amount to 15-30% of the water uptake... The situation is even more worrying for our partners outside of the Union. North Africa and the Middle East are the regions of the World which are the worst off: 53% of their population must live with a supply of less than 1000 m^3 per capita per year, a threshold below which food production is threatened. This is without mentioning the drought that struck Southern Europe severely in the last few years.

Consequently, the human challenge is matched by a **major economic challenge**. The European market is strongly expanding: the expenses for equipment and services in the Union (EUR-12) increased from 12 billion ECU in 1990 to 20 billion in 1995, and are expected to reach 30 billion in the year 2000. The world market should more than double within the next 15 years. Therefore, water rightly takes a prominent position in the international cooperation initiatives managed by the European Union (e.g. Avicenne, Tacis, and more recently Euro-Med).

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My suggestion for a name for the IPTS Report is:

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ABOUT IPTS

The IPTS is one of the seven institutes of the Joint Research Centre of the European Commission. Its remit is the observation and follow-up of technological change in its broadest sense, in order to understand better its links with economic and social change. The Institute carries out and coordinates research to improve our understanding of the impact of new technologies, and their relationship to their socioeconomic context.

The purpose of this work is to support the decision-maker in the management of change, pivotally anchored on S/T developments. In this endeavour IPTS enjoys a dual advantage: being a part of the Commission, IPTS shares EU goals and priorities; on the other hand it cherishes its research institute neutrality and distance from the intricacies of actual policymaking. This combination allows the IPTS to build bridges across EU undertakings, contributing to and coordinating the creation of common knowledge bases at the disposal of all stakeholders. Though the work of IPTS is mainly addressed to the Commission, it also works with decision-makers in the European Parliament, and agencies and institutions in the Member States.

The Institute's main activities, defined in close cooperation with decision-makers, are:

1. **Technology Watch**. This activity aims to alert European decision-makers to the social, economic and political consequences of major technological issues and trends. This is achieved through the European Science and Technology Observatory (ESTO), a European-wide network of similar organisations operating at the national level. IPTS is the central node of ESTO, coordinating 'joint ventures' in technology watch towards understanding technological change.

2. **Technology, employment & competitiveness.** Given the significance of these issues for Europe and the EU institutions, the technology-employment-competitiveness relationship is a driving force for all IPTS activities, entailing analysis of the potential of promising technologies in terms of job creation, economic growth and social welfare. Such analyses may relate to specific technologies, technological sectors, or cross-sectoral issues and themes.

3. Support **for policymaking**. IPTS works in support of the Commission services and other EU institutions in response to specific requests, usually as a direct input to their decision-making and/or implementation processes. Such activities are fully integrated with, and take full advantage of Technology Watch activities.

IPTS works with the policy-makers to understand their concerns, benefits from the knowledge of actors, and promotes dialogue that involves them, and collaborates with the scientific community to assure accuracy. In addition to its flagship IPTS Report, the work of IPTS is also presented in occasional prospective notes, a series of dossiers, synthesis reports and working papers.

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