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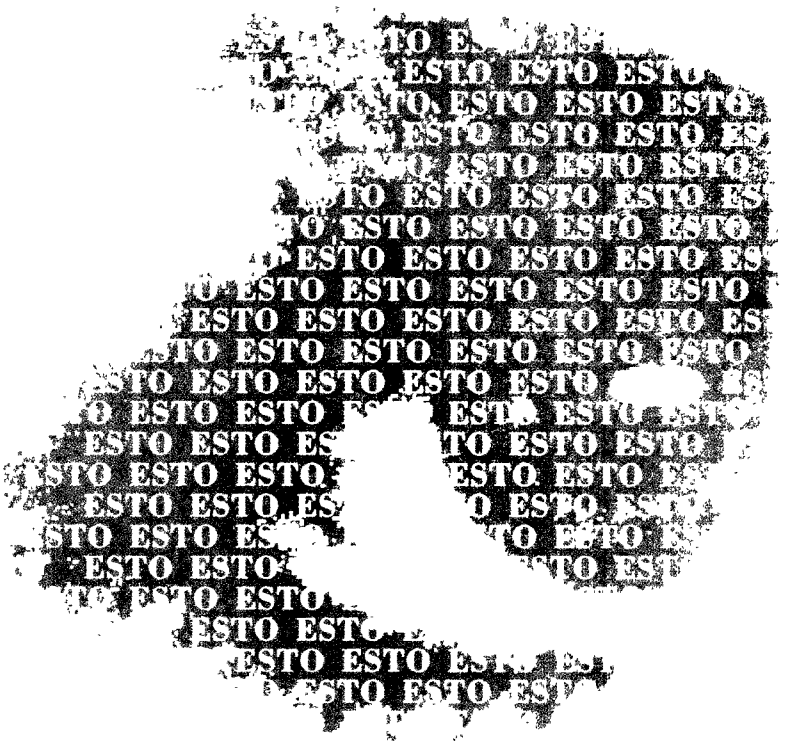

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A farewell in lieu of a prologue...

I was aware of the wisdom of this old Arab proverb even before I joined IPTS, and I am certain of it as I am leaving it. This is partly why I have striven to emphasise in our work at IPTS not predictions, but rather the projection of possible outcomes and their repercussions. The time devoted to carving out a niche for the IPTS, and securing it a voice, most evidently through the IPTS Report, in the context of the European decision-making environment, has been one of the most challenging and rewarding periods in my life. As I leave IPTS, sure of its solid foundations, I would like to express my gratitude to all those in academia, industry, the European parliament, as well as the Commission itself, who have honoured us with their support, patience and - always bona fide - criticism. I would also like to thank all the readers who have embraced the IPTS Report so warmly and helped establish it in such a short time. Finally my deepest gratitude goes to all my staff for their dedication. Einstein reportedly said that success is 98% perspiration and 2% inspiration. My staff has provided both in abundance; working with them has been a privilege.

HE who PREDICTS the FUTURE LIES EVEN if HE TELLS the TRUTH

H. J. Allgeier

After more than two years at the helm of the IPTS, Mr. H. J. Allgeier has assumed the duties of Director of DGXIII-B, running the Advanced Communications Technologies and Services programme (ACTS). He will also be heading the Task Force 'Aeronautics' and the Space Coordination Group. The IPTS Report wishes him best of luck in his new endeavours.

Preface

During the Florence Summit last June, the Council formally requested that a plan of action in the field of innovation be set up as part of the series of measures to be undertaken in the fight against unemployment, which is the top priority of both the European Union as a whole and individual member states.

The Green Paper on Innovation, drafted last year, drew attention to a situation which is worrying for the EU. A number of structural obstacles (a complex legal and administrative framework, financial systems that are not adapted to needs, inadequate transfer of Re²D to firms, etc.) were pointed out as serious handicaps for European companies and so for employment. On the other hand, the EU's potential is clear: excellent scientific researchers, a network of innovating SMEs, inventions which have been successful world-wide, and so on.

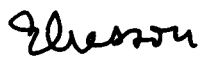
The First Action Plan for Innovation in Europe seeks to improve the level of European innovation with the goal of obtaining a competitive Europe and it arose from the conclusions reached during the public debate following the publication of the Green Paper on Innovation. The main points of the Action Plan laid down by the Commission are that: innovation must be approached globally from its technological, financial, legal and administrative aspects, without, of course, forgetting training; the importance of the international dimension of innovation must be taken into account, as must the diversity given it by different national, regional and even sectorial circumstances; finally, actions at the European level must go hand in hand with those at national, regional or local levels.

The Commission has identified three vectors upon which to concentrate the actions to be developed within the framework of the Action Plan for innovation: promoting an 'innovation culture'; establishing a legal and financial framework that favours innovation; and improving the linkages between research and innovation.

The proposed priority initiatives to be undertaken along these three axes have been deliberately limited in number so as to maximize their efficiency. The services of the DGs concerned are currently working on the details of these different lines of action, including in particular the launch of the Green Paper on the European Patent (September 1997) and the communication on 'tax and innovation' (probably in 1997). The European Science and Technology Observatory (ESTO), set up by the Institute for Prospective Technological Studies, itself part of the European Commission's JRC, is reinforcing technology watch at European level and serves as a reference at national level for both research and its applications. Other measures are to be developed over the coming months. The importance given to innovation in the Fifth Framework Programme for Technological Research and Development also needs to be mentioned.

The Commission must, in this context, concentrate its efforts on drawing up the 'rules of the game', and putting them into practice, in particular in relation to copyright, competition and the internal market. At the same time, it is facilitating the exchange of experience and the effective coordination of policy measures coming from a variety of sources. Finally, the EU aims to set an example by mobilising the financial instruments which are capable of sustaining the measures for which it is responsible, drawing upon the Structural Funds and the Framework Programme for Research and Development.

The Commission is keeping a close watch over the progress of the First Action Plan for Innovation in Europe and will report back regularly to the European Council on its achievements, and make recommendations for adjustments or complementary activities as and when required.



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EDITORIAL

One hundred years ago, in March 1897, J.J. Thompson, whilst working at Cambridge, discovered the electron. It would have been hard to anticipate at that time the revolution that this development, along with others before and after, would unleash. The identification at micro-level of elementary particles has not only facilitated the understanding of electric and electronic processes, it has ultimately paved the way for the convergence, at macro-level, of the handling and exploitation of the opportunities/challenges these processes present.

The first article in this issue is a good example. It identifies the tendency and need of electric utilities to expand their scope of activities from electricity provision to the energy-services, exploiting the opportunities provided by modern electronics and information technologies. This way intelligent management of energy use (in terms of time, quantity, price, source, etc.) can be achieved by and for the use. Appropriate regulatory frameworks can enable the reaping of these benefits by both users as well as the utilities.

The second article presents a recently proposed technology policy scheme to deal with the intermediate neither basic, nor applied areas of research. It would have the government play an enabling role and actually leave the initiative and management to the firms in each industry. Should sufficient interest be expressed by the majority of firms in an industry, the government would set up mechanisms whereby firms would finance the creation of industry investment boards, each dedicated to the specific tasks/research issues concerned. The two novel elements are that results would be made available to all, and that there would be competition among boards for the funds from firms as such boards could be set up to handle the same tasks as existing ones if it is felt that the latter are not performing adequately. The article also examines some of the caveats associated with the proposal including possible international repercussions.

The third article deals with the impact of the TRIPS agreement on intellectual property rights, which was recently signed and has begun to be implemented as part of the Uruguay round trade negotiations. It explores consequences, and possible actions to alleviate the strain upon some developing countries during the transition period before the benefits start to show. It moreover identifies some repercussions for developed countries, and possible complications that may arise for them as well, apart from the evident benefits.

The fourth article provides an introduction to the challenges faced by the world wide web (WWW) Internet platform, as well as ways that are emerging to overcome the limitations of the WWW (in terms of speed, interactivity, etc.). It describes the characteristics of mobile code and the projected trend towards network computing and suggests some of the applications and market structures that could be created/altered or benefit from such developments.

Finally, the fifth article examines the impact of some novel food packaging technologies on health and environmental issues. It presents protective films which promise to reduce food produce loss and deterioration, as well as packaging waste. Such films include but are not limited to, edible films. The introduction of novel food packaging may call for an examination of food safety and quality control regulations, as well as conformity standards, depending on the type of food packed and the packaging used.

Selling Energy Services, not Just Electricity: Towards a Tertiarization of EU Electricity Utilities

P. Moncada Paternò Castello and A. Soria

Issue: Present and future opportunities for EU utilities are related to their ability to provide energy users with customized electricity products and services rather than merely expanding electricity production. Therefore, the electric utility industry may shift its present focus of attention from. power generation transmission/distribution towards energy end-use services.

Relevance: The paradigm shift in the electricity sector towards attention to customers implies new interface mechanisms between, on the one hand, generation and transmission and, on the other, users of electric power. This may also imply a new organizational structure and access to new technologies. An appropriate regulatory framework can play a key role ensuring that all electricity consumers will benefit from the changes in the electricity market, and can create conditions that foster development. In this regard, electric utilities, customers and public bodies must recognize and manage the shaping factors influencing this change.

Analysis

1. Introduction

There is a widely held belief which asserts that services offer more opportunities for growth than manufacturing, product-based industries. The electric power sector -traditionally envisaged as a commodity-delivering industry- has been slower in changing towards a service-based business than other sectors (eg. telecommunications). An interesting fact that may directly affect electric utilities in the near future is that new technologies (in particular non-energy technologies) will catalyse and accelerate this change. Besides this, within the frame of increasingly competitive electricity markets, utilities will need to aim at satisfying customers expectations by improving the trade-off between the economics of generation-transmission/distribution and quality of service of the end-use energy system, regardless of the effect on the economics of central power stations. The expected change will concern especially the ability to differentiate electricity products and to provide customers with a variety of additional services around the core product.

Utilities will need to improve the trade-off between the economics of generation-transmission/distribution and quality of service of the end-use energy system

2. Electricity-centred energy services

To provide in more useful ways an adequate range of services, the main product -electricity- may be differentiated, a new capability which

Electricity can be price-differentiated in terms of time of delivery, quality and source of generation

relates to novel energy services should be created, and the handling of demand should be segmented. Electricity can be price-differentiated in terms of time of delivery, quality and source of generation.

Time of delivery is the one most important differentiation attribute of energy products or services. Electricity costs vary depending on the daily and seasonal time of delivery, depending on the structure of the generation and transmission system. Recent technology developments -such as automated communications systems- allow real-price (based on the system's marginal cost, rather than on an average cost) billing of energy users.

Quality: 'Power quality' may have different meanings for different end-users. The availability of power-sources with restrictive requirements concerning constant voltage and/or frequency may be separately charged, as well as the availability of a reserve maximum power demandable. In the same way, there are customers willing to accept a price cap to receive, in turn, a uninterruptible electricity supply.

The incentive for electricity utilities to provide energy services depend upon the structure of the system, in particular whether the utility operates in a monopoly or an open market

Source of generation: Customers sensitive to environmental concerns may be willing to pay an extra price for consuming power generated from environment-friendly power sources. They could receive information from the utilities about the power-mix used, and accordingly select what kind of electricity they are willing to buy. Recognising that to lower the electricity bill is users' main objective, they can however be able in this way to choose the least polluting electricity source.

Energy services that could be offered to the final user may be grouped along three lines a) efficient energy end-use, b) terms and conditions of delivery, and c) finance. Efficient energy end-use could be implemented via demand side management (DSM), end-use electricity appliances and environmentally sound architectural design. The installation of local generators (or even home generators) may be an efficient alternative. Terms and conditions of delivery could include information-reporting, installations and monitoring, recommendations on appliance. Electric utilities can also offer financial services: buying/leasing service and/or equipment, service guarantee, uninterruptible power supplies, renting/upgrading end-use energy conversion devices, etc.

These energy-related services could also be accompanied by non-energy services (eg. standards/measures to improve indoor environment, comfort, health and safety, water savings, waste minimisation, noise reduction, etc.). The expansion of the traditional utility towards other economic activities may go beyond a mere tertiarization of the energy business. Fibre-optic cable installed in the electricity transmission system may be used only for about 5% of its capacity for energy management, and utilities can exploit (either by directly management or by leasing capacity to other companies) excess capacity to provide other, and very different, information services, fully exploiting the economies of broadened scope.

3. Incentives for electricity utilities to provide energy services

There are many examples to confirm the trend which is driving the electric utilities towards becoming providers of energy services. The most advanced ones are from the United States, where electric utilities, communication industries and computing and software companies are exploiting the competitive advantage of creative pricing and delivery techniques in this new market configuration (see box). In Europe, there are numerous initiatives that represent the first attempts to bring about a shift towards energy services. However, these attempts heavily rely on the structure of the system of incentives.

Differences relate to monopolistic electricity markets (see box), or to liberalised/deregulated electricity markets (see box). In a monopolistic market the utilities may want to (by priority order): 1) exploit all options for improving system efficiency (which can for example make it possible to increase the share of electricity sold during hours of low demand and surplus of generating capacity) also by using new, non-electric (eg. IT) technologies, 2) get new market opportunities by offering additional services and, 3) satisfy the customer. In a free-access electricity market, utilities try to offer their clients the best available option (including nature and variety of services and their quality) at the lowest possible price, while maximising their own profits.

A USA case

The electricity provider structure integrates small generators (eg. from renewable energies, which are typically of small capacity) into the power system. This integration could be made easier by the use of a two-way communication system between the utility and the user through fibre optic cable placed along the main transmission lines. Through it, the utility can monitor and control the power system down to the level of individual home appliances. This allows the utility to increase the overall efficiency of the system by reducing peak power demand and, with it, the need for spare generating capacity. In fact, such an electronic communication system provides the users with 'real time' electricity pricing information and permits on-site optimisation of energy use employing the computer to program their appliances on and off as preferred (mainly, when demand is low and electricity is available at less expansive rates). The success of the first projects (1994) in the USA confirmed the viability of this system. The utilities which fulfilled these pioneer commercial projects estimate that real-time pricing, combined with electronic controls make it possible to avoid, for each household, the installation of an additional 1.5 kilowatts of capacity, saving US$ 350 (as compared with US$ 1,200 for the avoided capacity and US$ 850 for the cost of the telecommunication system). Companies like Energy Corp., Pacific Gas & Electric (electric utilities), TCI (telecommunication), and Microsoft (software) have already entered the business.
[source: Flavin and Lenssen, 1995]

A French case

Since 1994, Electricité de France - EDF (F) has implemented computerized measuring technology - Tempo- which enables households to receive about 12 types of information from the electric utility (eg.: power subscribed, contract type, energy consumed by different tariffs). Tempo makes it possible to obtain good energy and economic efficiencies, especially if coupled with existing home energy management technologies. It also includes programming options for main home appliances and domestic water heating.

EDF (more precisely EDF GDF SERVICES) has a more ambitious project: the ICC (Interface Clientèle Communicante). ICC will allow households to optimize the use of energy from different sources as delivered to the customer (eg.: electricity, gas, and heat), through a complex system for measurement and communication (double-way type) of data (also including tariffs, end-user's habits and needs), for its diagnostic and for consequent actions (energy management). Furthermore,

the ICC can offer additional services as customized pre- and post-selling assistance, and the energy's home appliances remote-management. The ICC system can employ all communication technologies, as telephone, or fibre optic cables and radio-frequency, and will make use of computers both for communication and programming purposes. 2500 ICC modules have already been tested. The experimental phase of this project will end by 1998.
[source: Mathieu et al., 1996]

Two UK cases

In order to maximize economic margins in delivering energy services, many competing electric utilities have started to establish processes to fulfil market requirements in the quickest and cheapest way by exploiting IT to automate processes. Two cases are reported in the following paragraphs.

Since the privatisation of the national electricity industry, Eastern Electricity (UK) has undergone major changes. For example, it has invested over £4 million to install an advanced information technology network to deal with the vast volumes of data involved in handling the company's three million customers. The new network has made services such as call logging, job tracking and engineering resource control much more efficient, ensuring that the customer is guaranteed an adequate service. Other applications covered by the network include customer accounts, engineering, contracting, finance and personnel records.

A new work management system has been recently adopted by Yorkshire Electricity (UK). The system is used to manage the maintenance, installation and special meter reading work carried out by the company to better serve its two million customers. The system assists the operators to meet customer service standards and provides comprehensive management reporting on performance, in addition to general accounting information.
[source: Cray Communications, 1996]

4. The importance of the regulatory environment and the market structure

Opening up the internal market in Europe will favour reorientation in this sector, but the success of restructuring depends upon taking regional differences into account

Regulatory measures should ensure that all types of customers (ranging from large industrial enterprises -which have more bargaining power- down to SMEs and households) can benefit from this new organizational framework. The forthcoming new European directives on deregulation and liberalisation would need to take into consideration any possible skewed distribution of benefits. The liberalisation of the electricity market could stimulate all this, by increasing the degree of competitiveness within the industry. In fact, some of the regulatory reforms include provisions to promote a performance-oriented, rather than a technology-oriented, approach. Furthermore, public authorities could favour a suitable re-orientation of this sector if fair and progressive regulatory frameworks, which allow electric utilities to invest in other sectors (eg. information technology), are set up. The creation of a European internal market for electricity, the shift towards a more competitive power industry, the emergence of trans-European energy networks, the reduction of the external dependency in primary fuels, the decrease of the environmental impact of energy consumption, and market harmonisation, are all priority issues for EU energy policy.

The success of such sectoral restructuring depends on the adaptation of these business schemes to the orientation of the EU policy strategy and on the adaptation to specific characteristics of regional markets. A given model will not work everywhere. Differences between countries (not only in the previous structure of the electric sector in terms of development and regulatory scheme, but also in 'customer-satisfaction' culture, customer-lifestyle and sensitivity, etc.) should be taken into account.

5. New organizational configuration, new actors and technology opportunities

To operate such a radical restructuring, each power utility should organize itself internally and focus all operation upon being customer-driven. Giving increased importance to the planning and control centres, as well as strong capability in using advanced information technologies should be expected. The implementation of marketing practices will be an organizational approach to doing business that will be new for most of the electric sector's players.

It has been already mentioned that the regulatory frame may definitively have an effect on the speed of transformation of traditional utilities onto service-providing firms. Simultaneously, the outcome of the process of massive reorientation towards the tertiary sector may have an effect on market structures (regulatory instruments rewarding defence against predators for small-size organizations may be desirable). Although the effects of this are a priori difficult to predict (ie. whether the position of dominant firms will be reinforced or weakened), it is possible that decentralized (or even dispersed/modular) power-production schemes will emerge (vs. centralized generation as 'the only scheme'). New types of jobs may be created in the industry as a response to new needs: eg. the customer manager and the capability manager may substitute the traditional product manager. Specialized traders and brokers may come on the scene to ensure energy users and utilities to get the best-possible options in the market.

The application of new technologies will determine utilities' ability to compete within the service market. The extensive use of IT may allow utilities to identify and track potential customers and new needs, and therefore provide services specifically tailored to customer requirements. The application of computerized electronic communication technologies (optical fibre, microwave, satellite, etc.) may allow for the introduction of real-time, spot-pricing that will act as an important incentive to demand a flatter load-curve. Energy-service vendors may promote new demand-side technologies, including new, efficient appliances, building-insulation techniques, sensors and lighting technologies with built-in electronic control. These novelties may induce significant reductions in costs of building and operating generation-transmission-distribution systems, thus allowing the integrated power system to run more reliably, and with small reserve margins.

6. Constraints and perspectives for electricity/energy services in Europe

Assuming that optimal regulatory and market environment condition (see above) are in place, market penetration of energy/electricity services will depend on market conditions, such as the general level of economic growth and the customers' valuation of these energy services within their perceptions of the quality of life. It is certain, for example, that not many customers can be found during a recession who are willing to pay extra money for extra energy-services. There is some empirical evidence indicating that, at

Within a restructured frameworks new roles could appear, for instance in customer service or energy broking

Energy service vendors could promote energy-efficient technologies, reducing costs and consumption

Large/industrial customers are likely to be the target group of the first phase of this kind of service, with domestic users following later

present, customers are highly price-sensitive when considering new electricity-services. This indicates that priorities should concentrate on offering better services to the final user with no significant price increases. According to this concept, it may happen that, during the market-transition phase, large/industrial customers are the target group, and that specifically tailored energy-services are offered to households later.

Budgetary and cultural constraints arise for many customers when considering investments in their own new, efficient demand-side-technologies. Alternative financial schemes (eg. leasing programmes) and direct participation by electricity utilities in the implementation and O&M of these technologies/services could overcome these obstacles. Indeed, the prospects for the development of energy services are very promising. The volume and frequency of some investment-operations suggest that there will be in future a larger range of energy services with higher quality.

Some electric-power utilities specialized in the electricity-generation sector are now reinforcing their positions in energy-distribution and vice-versa. Moreover, many electric utilities are investing in information and communication technologies (ICT). This new wave of investments from electricity-based organizations can easily be explained. First, ICT is already a 'familiar' sector for electric utilities; in addition, the application of further ICT know-how in the electricity-sector can be achieved in a way that is beneficial and easy. Finally, for many utilities, ICT represents a good opportunity for a diversification strategy. There are many analyses that confirm the view of an increase in the offer in energy services. For example, an interesting study (IPSEP, 1995) concludes that, in the period 1985-2020 the size of the electricity service market will double on average in 5 countries of the EU: F, I, NL, UK, FRG. In France alone, it is foreseen that systems for energy services, as the ICC (see box), will be installed to 30 million customers in the next 15 years.

7. Conclusion

It can be expected that the modernisation of the electricity business will relate not only to the core-technology or product (ie. technologies related to generation-transmission), but also to many other aspects that entail new market features, customer-characteristics and values, the regulatory environment., etc. The application of advanced technologies from other sectors (notably information and communication technologies) is likely to determine the way in which the final product is re-formulated and provided (selling electricity vs. selling end-use energy services), as well as the organizational transformation and new market strategies of the industry.

Keywords

Electric utilities, end-use energy services, market and regulatory environments, customisation, technologies, organizational transformation, market strategy.

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12 Technology Policy

Technology Policy Strategy: Between Research and Development

D. Kyriakou

Issue: A recent proposal for innovative ways of organizing national technology policy in the US has attracted attention not only overseas but also in Europe. It persuasively presents a scheme for combining the government's effectiveness in jump-starting collective action with the market's efficiency in selecting practical problems that offer the highest rates of return.

Relevance: The proposal is very cogently set out, and it merits attention since it promises to deal with the crucial intermediate 'missing link' area of R&D: ie. that which is neither purely basic nor entirely applied. If this approach to providing the 'missing link' (or strengthening the 'weak link') between pure research and applied results gains following in the US, interest in it can only increase, especially since there may be benefits accruing to the first one to adopt such practices.

Analysis

A large part of economic growth is due to increases in total factor productivity, namely in the accumulation of knowledge and innovations that have allowed us to combine the same basic inputs in ever more efficient forms. The creation of such knowledge is often limited by the following dilemma: on the one hand incentives have to be given to the inventor/discoverer, so that research be undertaken; on the other hand incentives should be limited so that benefits from the invention/discovery accrue to the society as a whole (including other researchers), and are not captured exclusively by an inventor-turned-monopolist.

Although it is recognized that economic growth depends on innovation and the accumulation of knowledge, this process is often limited by the conflict between the interests of inventors and society as a whole

The area of basic science is usually sufficiently removed from market-relevant results to be able to be conducted in academic settings cherishing free exchange of ideas, although often firms undertake basic research themselves (Lufthansa, 1996) which may not necessarily foster free exchange of ideas and the resulting positive spill-overs. At the other end of the spectrum, development work with obvious immediate market impact is usually undertaken, or funded, by individual firms. There is however a large grey area in between, covering problems that have an impact on the industry as a whole and not merely individual firms, where the help of scientists would be welcome (indeed would be often necessary) to deal with certain bottlenecks in translating ideas into marketable results, but where collective action would be welcome by firms in the industry, for the solution of their common problem, ie. for the provision, in other words, of an industry-wide public good. Such action is often not forthcoming, due to free-riding behaviour on the part of firms, or, due to

hopes/efforts by individual firms to appropriate the solution for themselves. Note that even if the size of the task were not overwhelming, it would still be socially desirable to have the solution of an industry-wide problem be available to all, and not only to a prospective monopolist.

A recent proposal by Paul Romer in the US (Lufthansa, 1996) that has attracted attention more recently within the Commission, suggests that government can trigger collective action in such cases by:

a) Passing enabling legislation allowing levying a small specific tax on the consumption of the goods produced by the industry in question, if and only if a sufficiently large majority of firms in it expresses its approval by voting in favour of such a tax;

b) Using the proceeds to fund industry investment boards dedicated to promoting research on specific, industry-selected 'bottlenecks';

c) Since there may be more than one bottleneck, each firm will be able to choose the bottleneck whose research it wants its tax contribution to go to;

d) Crucially there may be competing investment boards created, even for dealing with the same bottleneck, in order to provide competition and keep the boards lean and efficient. If certain firms are not happy with the way a specific board is carrying out its prescribed task, they can withdraw their funding and set-up (and fund) another competing board dealing with the same issue. Equally importantly, the results of the research funded by the boards will be available to all.

Developments in science and technology may be hampered by the difficulty of co-ordinating collective action in such a way as to avoid 'free-riders' and potential monopolists

The frontier of S/T is limited by the difficulty of organizing collective action, when individual effort does not suffice to tackle problems. Policy innovation may enter the scene at this point, attempting to improve collective action. The goal is to organize effective collective action, where needed, in order to take advantage of mutually beneficial co-ordination, while using the pressure of competition and market tests to improve institutional arrangements (AiF, 1992, p.348). Regardless of the merits of Romer's specific proposal there is a need to combine policy innovation with business and R&D innovation (ie. mere calls for more of the latter two will not suffice).

The proposed scheme works as follows: Firms belonging to a certain industry note that industry-wide challenges and opportunities exist that cannot be addressed by individual firms. They (ie. a certain threshold number of them) would petition the government for the creation of Industry Investment Boards (IIBs) to tackle specific industry-wide challenges. The government would then examine whether the application for collective action addresses genuine needs. If they decide they do, firms vote whether to levy a small (eg. 1%) tax on the sales of the good they produce. If a sufficiently large fraction votes in favour, the tax is imposed by the government on the entire industry. The proceeds however do not go to the government; they rather are used to fund the IIBs outlined in the original application to the government, one IIB for each one of the issues to be tackled (eg. one for a design-related bottleneck, another for a safety-testing procedure). The IIBs function as pass-throughs, channelling tax obligations from the firms to R&D projects, pursuant to each IBB's mandate.

Industry Investment Boards (IIBs) could be set up with industry funding, and possibly compete among themselves, with the aim of tackling industry-specific challenges

IIBs would be financed by obligatory targeted contributions proportional to a firm's sales, but the industry could vote for the creation of a competing IIB if a given IIB was unsatisfactory, or for the withdrawal of the tax

In the US examples of this kind of organisation already exist, Bell Labs being the best known

Surprisingly the US pharmaceutical industry asked the FDA to raise the fees it charges pharmaceutical firms, with the aim of reducing time to market

The crucial point is that although the amount each firm is obliged to contribute depends only on its sales and the tax rate, the allocation of each firm's contribution across the various IIBs is up to each firm to decide. For instance a firm with sales of 200 million ECU will have a tax obligation of 2 million ECU for a 1% tax rate. It is its choice how to divide these 2 million ECU between the design-issue IBB, and the safety-testing IBB (or other IBBs that may have been created).

Equally importantly, if firms are not satisfied with the performance of a specific IIB they may start a new IBB, addressing the same issue as the IBB with the unsatisfactory performance and hence competing with it for funding. In the worst case, firms could use periodically-scheduled elections to ask the government to rescind the tax altogether. Note here that this is already a point of possible contention: the enabling legislation for IBBs would need to clearly specify the revocability of IBBs, and the qualified majorities needed for their establishment and dissolution through a vote rescinding the tax which funds them. The results of IBB-funded research should be publicly available, and the equipment built with IBB-funding should be made available on equal terms to the whole industry.

Feasibility and related experiments

Is all this an outlandish theoretical proposal, with no real-life analogue/precedent and too cumbersome to implement? Not really. One of the oldest forerunners exists in the USA as a result of the enactment of the Agricultural Marketing Agreement Act of 1937. This made provision for setting up 'marketing orders', given a two-thirds majority approval and periodic referendums (every 6 years) to gauge continued support. Although marketing orders were also used as vehicles for output restrictions, about three quarters of them collect funds for R&D and market promotion. What they lack compared to the IBB proposal is free entry of new boards and the possibility of competition among them.

The most obvious, and possibly most successful example of this idea is the Bell Labs in the USA, which was supported by paying a small percentage of the revenues of operating companies to AT&T. To the extent that this 'support' was permitted by the regulators to be part of the rate base of operating companies, the government, in effect, sanctioned a tax to be used for industry-wide research. Since AT&T controlled the vast majority of the operators, free-riding behaviour was not a problem.

Perhaps the most recent, and arguably the most striking, example comes from the US pharmaceutical industry. It convinced the US Food and Drug Administration to raise the fees it levies when drugs are submitted for approval, so that more evaluators can be hired with the extra revenue, leading to a reduction in the 'approval-pending' time.

In Europe similar efforts have been undertaken as well. They include cooperative research projects dedicated to industrial sectors, using a bottom-up approach and taking ideas for research projects which reflect the needs of the industry. Industry commonly finances co-operative research, in some cases with the help of public co-sponsorship. Research results are available for all participating companies, and they are supposed to be strictly pre-competitive. In some countries such as Germany, Belgium, France and the UK, there are established structures of co-operative research; in other countries efforts depend on more spontaneous actions. Institutional example include, but are not limited to, the AiF in Germany (The National Body for Industrial Cooperative Research), FEICRO (The European Body for Industrial Cooperative

Research), and the EU Commission's CRAFT (The European Programme for Industrial Cooperative Research) (AiF, 1992).

Other interesting schemes involving option-sharing, have also been proposed in Europe, Japan and the US. In cases of increasing dynamic complexity, options can be used to limit exposure to risk. When the next step is highly risky, actors may come to a halt. To escape this situation some sort of insurance is needed. Options can provide that: the buyer of an option gets a 'worst case' floor secured- which means that the most he can lose is the premium he paid. The vendor of the option gets the premium, and, if the option is tradable, he also gets information about subjective probabilities regarding future events, in spite of high uncertainty. This has applications in analysing/planning companies' R&D efforts, project results, etc. Under the name of 'Real Options' this concept has been applied to the field of material activities, rather than just to the financial field. Along these lines small working groups have been established on the topic of Real Option Management (in Germany and the US, for instance), collaborative projects have been supported or initiated by industry.(Lufthansa, pp. 2-3)

Note however that most efforts to date (in Europe and elsewhere) have not included the competition element among industrial research entities. One entity is usually set-up in the various experiments mentioned above, and it exercises an effective monopoly, when it comes to performing research or channelling resources towards research in each industry, or for each topic. The multidimensional competition (across goals, and across research organizations) allowed by the proposal presented here is absent in most other experiments. Note also that in the European examples results are often (though not always) available only to participants and not to the entire industry.

Applicability and potential impact

The importance of the provision of public goods for growth is unquestionable. Public goods (such as the industry-wide public goods IIBs are supposed to provide) are crucial in the growth process. To facilitate the discussion let us indicate in what sense public goods differ from other goods. Goods can be classified along an 'excludability' axis (corresponding to the ease with which others can be excluded from enjoying the good in question), as well as a 'rivalness' axis (corresponding to the degree to which my consumption of a good reduces everyone else's possibility to consume it). Public goods are both highly non-rival and non-excludable.

The neo-classical growth models already identified the production of nonrival goods (technical progress leading to total factor productivity growth) as key to the growth process. More recent work on endogenous growth has done away with the assumption that nonrival goods are provided exogenously, and has stressed the conflict between the incentives for the production of such goods and the incentives to make the distribution of benefits less skewed. Strong property rights give incentives to producers of such goods, but they may have quite unwelcome repercussions (imagine the effect of a non-expiring patent on the transistor, or on the do-loop in programming!) (Romer, pp. 354-358). The existence of non-rival goods, their importance for growth, and the need to balance the two sets of incentives (regarding production and distribution of non-rival goods) mentioned above, handicaps the applicability of the pure individualistic market-exchange laissez-faire models, and justifies institutions for collective action (one of the most important among them being the limited liability corporation)(Romer, p. 389).

There is then ample theoretical support for the importance of non-rival goods (and public goods as a subset of them). How about empirical

Most European co-ordinated research efforts have not included the possibility of competition, nor are the results necessarily made available to the whole industry rather than just the participants

Neo-classical growth models identify the production of non-rival goods, ie. those which one individual's consumption does not limit others' consumption, as the key to growth

Previous initiatives have tended to be top-down, not responding to the needs perceived by industry itself

A number of administrative issues, as well as international repercussions, need to be looked into

evidence? With R&D used as a proxy, studies consistently compute large social rates of return on investments in non-rival goods (30-50%). It is also much higher than the private rates of return accruing to those financing the investment in the first place. Based on Grilliches' seminal survey (1992) and earlier work (1958), total factor productivity growth at the national level can be explained as a result of measured spending on R&D. These results are consistent with recent cross-country studies by Lichtenberg (1992) and Coe and Helpman (1993) (reported in Romer, p. 354-358).

The IBB proposal however deals with goods that are neither purely public (eg. polio vaccine), in which case government generally provides funding, nor the excludable (though still non-rival) type, which are best dealt with in the context of the private sector (eg. movies). Is the intermediate zone important? Even if it is not, the proposal is designed to do no harm (cf. its free entry/exit, competition, market-driven characteristics). Having said this however, this intermediate area may indeed be quite crucial. It covers what Nelson (1983) calls generic research, and he argues that it may offer large returns on investment in research (Romer p. 361, p.374). This area includes 'goods' such as program design fundamentals, principles of computer interface design, principles of chemical engineering. It may include in the future such projects as the setting-up of a biotechnical engineering school that would do for biotechnology what chemical engineering at MIT did for the US petroleum and chemical industries, or the establishment of a separate software engineering discipline, training professionals for software production. It may include less fancy sub-fields such as single family home construction, an area which seems to have missed technological progress. According to Nelson (1983) part of the problem in previous initiatives in this area was their top-down approach, not necessarily well matched to the needs perceived by participants from industry (op. cit.).

Caveats

As well as its many merits the proposal has certain vulnerabilities that need to be identified and discussed. For instance the role and treatment of foreign firms may not be easy to resolve. Romer argues for their inclusion on an equal footing in every stage of the process (voting, tax allocation, sharing of benefits, etc.), although one could envisage objections to this, however, if foreign firms exploit the skills and know-how, newly acquired through IBBs, in third countries in which they may already have market share, and in which other firms (eg. the firms of the country setting up the IBBs) will not have time to penetrate.

Moreover one can raise the question of what will the effect of IBBs on future potential entrants in the market (both domestic and foreign). Benefits from IBB-funded research (including new equipment developed) must be made available to them too and on the same terms, as for the incumbents, in order not to bias the market in favour of the latter.

The ease with which IIBs can be created may lead to a thinning of the resources available for funding, reducing their possible impact. Moreover if different boards compete for employing the services of the same scientists the price of these services may be bid up quite suddenly, to the detriment of other projects requiring their attention, ie. projects which do not enjoy IIB support. Care should also be taken when labelling research 'basic' and so assuming it will not be carried out by firms (SPRU comment, J. Molas).

The whole process begins with an application, which is evaluated by the government on its weight and the extent to which it identifies real

needs. This may deteriorate into the government being only too eager to accept, since this will imply some, albeit minimal, extra amount of bureaucracy build-up. This in turn may make difficult for a tax to be rescinded once it is on the books. It will imply not only less funding for certain R&D projects; it may also diminish the justification for the bureaucracy build-up.

Clearly, funds should not be permitted to go to lobbying, public relations or other related activities. Penalties in the form of rescission or suspension of the scheme by the government could be imposed for this kind of abuse. Note however -and this applies even in case where the industry itself votes in favour of rescinding the tax - that once the scheme is well established (and interests have grown up around it) it will not be easy to revoke. Note also that the proposed tax is on sales, and not on production. This is in order to avoid penalising exports and promoting imports.

If the market is not competitive enough the tax may simply be passed on to consumers (which is what happened with Bell Labs, in other words), moreover the very mechanism of IIBs may foster collusive attitudes in general. In addition, foreign consumers will reap the benefits of the higher quality/lower prices which have been paid for by the taxes shouldered by home consumers. This could only be alleviated if international co-ordination promotes the adoption of such mechanisms internationally.

Care should be taken in the implementation phase. On the other hand firms have been dealing with much more difficult issues related to accounting, logistics, etc. in the course of their work; and since this is an initiative that they themselves start or terminate they should be more willing to undertake whatever measures are necessary to deal with implementation issues.

Finally the location of the R&D centres that will be funded by IIBs is an important issue. Governments are not likely to be indifferent to where Bell labs look-alikes are situated. Furthermore even if foreign firms participate in the IIB approval and funding, chances are that funds will most readily flow towards domestic research centres rather than foreign ones. For this reason there is a first-mover advantage for the country that adopts IIBs. Its research activities will be financed (even by foreign firms, who would not want to be left out), bidding resources away from research centres in other countries. It is quite likely therefore that if this scheme catches on it will spread quite quickly.

Conclusion

Overall, and notwithstanding the unquestionable merits of other efforts (from the less fluid research organizations to the quite malleable option-sharing schemes) the proposal deserves attention. It provides a way to empower firms to solve collective action problems, bound to emerge in providing industry-specific public goods. The proposed scheme combines both government aspects (mandatory taxes to eliminate 'free-riding' behaviour) and market mechanisms (free entry, competing industry investment boards, etc.). Moreover it provides a way to reinforce the relevance of science, by placing it in contact with practical challenges, without sacrificing the free exchange of ideas and the positive spill-overs arising from them. Offering firms proprietary control over the results, which is the common solution against science drifting into apparent irrelevance and hence diminishing funding, undermines this essential freedom of disseminating ideas. Finally industry investment boards could be a vehicle by which firms can influence the larger context in which they operate (vocational training, university curricula, interactions between industry and university researchers, etc.).

If the idea of IIBs takes off there is likely to be competition for hosting them; there is likely to be an advantage to the first country to adopt the scheme

About the author

Dimitris Kyriakou holds a BSc in Electrical Engineering and Computer Science and a Ph D in International Economics from Princeton University Before coming to the IPTS, where he is a scientific officer and is responsible for advising on economics issues and the editing of the IPTS Report, he worked as an economist at the World Bank. His main research interests include information technologies, employment, regional development and sustainability

Keywords

R&D, investment, innovation, public goods, collective action

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Policy implications of the TRIPs Agreement

G. Di Pietro

Issue: One of the most important results achieved by the Uruguay Round of trade negotiations is the extension of multilateral rules to new areas such as services (General Agreement on Trade in Services -GATS) and intellectual property (Agreement on Trade-Related aspects of Intellectual Property Rights - TRIPs).

Relevance: The implementation of the TRIPs Agreement requires substantial changes in the national law of most developing countries and could change international trade flow patterns, and could also have an impact (possibly negative) on both the economies of developing countries and (less directly) on those of developed countries. In this context, in addition to the measures that developing countries governments' will have to adopt in order to facilitate adjustment, a key role could be played by developed countries, international organizations and the European Union.

Introduction

The Final Act of the Uruguay Round was signed in Marrakech in April 1994 and it embodied all the results achieved by the countries which took part in the negotiations. The Uruguay Round transformed the GATT into the World Trade Organization (WTO) establishing a set of multilateral rules liberalizing trade in goods and services. Some of the major commitments undertaken by the WTO members concern both areas such as textile/clothing and agriculture where the market access was obstructed by high tariff barriers and by a wide range of non-tariff barriers and fields such as intellectual property and investment where the pre-existing international laws, mainly Conventions, are signed by a small number of countries and they do not contain provision for any enforcement procedure.

Laying down a minimum standard of protection for each category of rights, the agreement on intellectual property basically meets the needs of the countries which are producers of technological knowledge, whether in the form of new ideas, products or processes. By prohibiting piracy and counterfeiting these new regulations will allow technologically advanced countries to appropriate some of the benefits deriving from their investments in research and development. The TRIPs Agreement is a clear demonstration that intellectual property matters have moved to the centre stage of international economic relations. The strengthening of competition has pushed countries which invest a significant part of their resources in R&D to create an international regime which legally protects most of the results of these activities.

The signing of the TRIPs agreement on intellectual property at the end of the Uruguay Round is a clear indication of the extent to which intellectual property has come to be a key element of international economic relations

Depending on their circumstances governments have been given differing periods in which to comply with the agreement's provisions

The improved protection offered may induce patent holders to move into new markets, but will adversely affect companies in formerly less well-protected countries which lived by imitating and copying technologies from abroad

Main features of TRIPS

The TRIPs Agreement covers the following seven categories of intellectual property: copyright and related marks, trademarks, geographical indications, industrial designs, patents, lay-out designs of integrated circuits and undisclosed information including trade secrets. The Agreement requires WTO members to adapt their national law to the substantive obligations of the main conventions of the World Intellectual Property Organization (WIPO), the Paris Convention for the Protection of Industrial Property and the Bern Convention for the Protection of Literary and Artistic Works. In addition it adds a substantial number of obligations regarding matters not covered or inadequately covered by these conventions. The TRIPs Agreement also establishes mechanisms for the enforcement of intellectual property rights and for dispute settlement among WTO Members. The majority of the Agreement's provisions will be implemented by governments only after a transitional period, the length of which depends upon the circumstances of the country in question:

- one year for developed countries
- five years for developing countries
- eleven years for those countries on the UN list of least developed countries
- five years for countries which are in transition from a centrally-planned economy to a market one and which are still engaged in structural reform of their intellectual property systems and have special difficulties in so doing.

Moreover, in order to stress the credibility of the commitments contained in the Agreement it is fundamental to consider that countries which are members of WTO or which wish to be members of this organization have already accepted or will have to accept (respectively) all the main WTO Agreements including TRIPs. The implementation of the TRIPs Agreement is inseparable from that of WTO.

The economic impact of TRIPs

The TRIPs Agreement could have an adverse effect on several developing countries in particular which, being net importers of information, whether in the form of technical know-how or products, would be forced to pay hefty royalties or face fines. Domestic enterprises in these countries, particularly the smaller ones, which already in the present circumstances have difficulties keeping pace with the latest productive methods and technologies, could see their situation worsening. Up until now a lot of them were able to survive in the market both by imitating and copying the technologies produced mainly by large companies from advanced countries and by acquiring fundamental knowledge and skill through methods such as the process of 'learning by using'. Within a period of ten or fifteen years the situation could change and, because of the higher cost of the using technology, a considerable number of local enterprises would be obliged to increase the price of their products thereby losing an important part of their market share without any redeeming benefit for domestic consumers. These consequences do not apply to technologies which are more difficult to 'imitate' (through reverse engineering and other means) or which are effectively protected by trade secrets. In this situation the impact of the TRIPs Agreement and of an effective system granting legal protection could both reduce transaction costs and stimulate patent owners to enter new markets. In this case social welfare would increase due to the fact that consumers could benefit respectively from a lower price level and a wider range of products.

Nevertheless this case seems to be less widespread than the first one where there is a lot of evidence that the increase of counterfeiting is due to the relative ease of copying as a spin-off from new technologies (eg. software). In any case

the legal and administrative changes are likely to be costly in budgetary terms. Developing countries will have the obligation to substantially improve and enlarge their judicial, administrative and enforcement framework, including the setting up of customs control machinery and to mobilize and develop the necessary human resources. The picture could be particularly dramatic for enterprises in developing countries operating in high technology sectors such as the pharmaceutical, chemical and information technology industries where patent, trade secrets, copyright, and computer 'chip' protection have a more decisive impact on market outcomes.

Given this scenario, both policy makers and enterprises in technologically less developed countries should take some measures, before the TRIPs Agreement is fully implemented by all the WTO Members, in order to smooth the way towards this change. A future priority for developing countries' governments should be to alleviate the shocks which may follow a rapid adaptation of their national law to TRIPs. It is possible to identify three main broad areas of intervention:

- technology diffusion policies
- macroeconomic policies
- cooperation policies.

Technology diffusion policies

The aim of the provisions included in this area is gradually to reduce and to rationalize the information flow from technologically-advanced countries to the ones which are net importers of technology . This can be summarized in two points.

Firstly, stronger patent protection will stimulate the promotion of indigenous R&D efforts. However this process may not be automatic as the higher cost of technology may reduce firms' profits, making further investments in R&D difficult to finance. Moreover firms will benefit from these activities only in the long term and in the meantime they could be tempted reduce them.

Secondly, firms should use their current technologies more efficiently making small improvements and adaptations to them, not radical changes. Empirical studies on the role of technological change (Rosenberg, 1976) have shown that inventive activity is a continuous and incremental process of accretion and this is the reason why technology often makes the major improvements a long time after its introduction. In his work Rosenberg also stresses the slowness characterizing the phenomenon of diffusion of new technology, an effect caused by bottle-necks. Technologies are often not easily transferable because they embody a non-codifiable, tacit part. In this case training courses and long practical experience are required for effective technology transfer. In addition, some technologies could be specific to certain people or institutions (Pavitt, 1984), in the sense that they perform well only within a given context which cannot be imitated.

Macroeconomic policies

Policy-makers should help firms to enhance their investment capacity in R&D both directly by launching new financial aid programmes and indirectly by contributing to establishment of an atmosphere which would attract foreign capital and which would promote the transformation of national savings into domestic investments. This objective could be achieved through the adoption of prudent macroeconomic policies including bringing down interest rates. The latter task will be particularly difficult for those countries which already have to face high ratio of public debt/GDP per year both because their borrowing would tend to keep real interest rates high and because they can be tempted to 'inflate away' some part of their debt.

Measures will need to be taken at both government and enterprise level to lessen the shock of rapid adoption of TRIPs

Strong patent protection may not give an immediate boost to domestic R&D, as it depends on the availability of funding and the way the cumulative nature of technological change tends to root it in particular contexts

According to the TRIPs agreement, governments of developed countries are obliged to give technical and financial support to developing countries

TRIPs could give an important boost to foreign direct investment, a crucial part of any country's technology development programme

Other important provisions which could stimulate the channels through which national saving are transformed into investments are the improvement of the efficiency of the banking system and an alleviation of the 'thinness' of the stock/bond markets.

Cooperation policies

Cooperation in favour of developing countries should be induced by the TRIPs Agreement at two different levels: government level and enterprise level.

Firstly the TRIPs Agreement contains one article which explicitly requires the governments of developed countries to give technical and financial support to developing countries. Relevant international organizations could also play a fundamental role in assisting developing countries in their effort to implement the Agreement. An important step has already been taken with the coming into force of arrangements on cooperation between the WIPO and the WTO.

Secondly a statutory intellectual property rights system will constitute an important component of an environment conducive to international voluntary transfer of technology. The strengthening of intellectual property protection could positively influence firms' decisions to transfer technology to, or invest in, host countries. Among the different forms of technology transfer a fundamental role could be played by foreign direct investment (FDI). The impact of TRIPs on FDI could be of paramount importance because FDI generally embodies new technology, the acquisition of which is a key component of any country's technology development programme. The enforcement of IPRs will guarantee firms avoid the risk of losing proprietary information by expanding production in host countries. Other important elements on which enterprises' decisions concerning the expansion and profitability of FDI are normally based are: the size of the domestic market, the structure of factor supply, productive infrastructure and the degree of stability of the macroeconomic environment. The increase of public investments in infrastructure and the gradual dismantling of trade barriers could help create an environment conducive to FDI.

Moreover the trade-related investment measures (TRIMs) Agreement, which also belongs to the WTO Agreements, could represent a further strong incentive for FDI and licensing agreements between the owner of technology and subsidiaries, joint venture and unrelated firms abroad. By prohibiting the use of local content requirements and by precluding trade and foreign exchange balancing requirements the TRIMs will limit the ability of countries to impose operating requirements and to issue compulsory licenses; TRIMs will thus encourage multinational corporations to start business in other countries.

There are numerous studies (eg. Ari Koko, 1994 on the Mexican manufacturing industry 1970) which shows that technology spill-overs from FDI may provide important benefits for the host countries of multinational corporations. The technology and productivity of local firms may improve as foreign firms enter the market and they use new technologies, provide technical assistance to their local suppliers and customers, and train local employees Foreign enterprises could be discouraged, despite low wages, by the high cost of technology transfer. Moreover, as a result of stronger patent and trademark protection, technology-supplier firms could demand higher license charges and royalty fees. It is important that the governments of developed countries take measures to prevent this situation by applying the provisions which provide for limitations and exceptions to the Agreement when and where they are necessary.

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The possible repercussions of TRIPs on the economies of developed countries

The immediate effect deriving from the implementation of the TRIPs could be positive for developed countries' firms. Since developing countries companies have already a low profit margin due to international competition they could not let the profit margin shoulder the higher cost of technology. In this case they would be forced to increase their prices. This situation could produce adverse consequences for firms based in developing countries both in foreign markets and in their domestic markets. On the one hand the price rise could cause a reduction in exports. On the other hand developing countries' enterprises could have also to deal with a stiffening of competition in their domestic markets due to the fact that the price of domestic products will rise relative to foreign competitors.

Nevertheless, more indirectly, the coming into force of the TRIPs Agreement could have negative repercussions on the economies of developed countries. The increased attractiveness of products from developed countries could activate two forces pushing in the same direction and leading to a shift in exchange rates favouring the currencies of developed countries. Firstly as far as the goods market is concerned, the rise in the demand of developed countries' exports could lead to an increase in the value of developed countries' currencies. Secondly the increased demand for developed countries' products could cause a speculative capital movement from developing countries to developed countries due to the expected upward shift in the exchange rate of developed countries' currencies. Because of high mobility of capital and within highly integrated financial markets, this flight of capital will accelerate this appreciation. In addition, a drop in exports to developed countries will produce export earnings for developed countries and it will damage the capability of developing countries governments' for paying off the high debts they accumulated in the past with public and private financial institutions. The debt crisis which took place in the beginning of the 80's was in fact caused by the inability of developing countries to pay back their debts.

Considering the previous arguments, it could happen that at least in the short run, assuming the price level to be rigid, the appreciation of the exchange rate of developed countries' currencies could overshoot its longer run equilibrium. The reason for the overshooting lies in the fact that capital markets adjust more rapidly than goods markets. The flight of capital toward developed countries will push up the exchange rate at least temporarily, achieving a value which could be higher than one which will allow the balance of payments to return to equilibrium. The eventual correction will have to come through a depreciation of the exchange rate so that equilibrium can be obtained. In goods markets this appreciation could make developed countries' exports less attractive, leading to a depreciation of the exchange rate of their currencies. However the process of depreciation is slow and the final adjustment to the long run equilibrium value of the exchange rate could take some time. Until the exchange rate reaches its long run level, developed countries' enterprises could lose significant market shares both in foreign markets and in their domestic markets (besides a decline in exports from developed countries' the appreciation will also make the price of the imported goods to developed countries' relatively lower than the one of domestic products).

During the overshoot time the rise in exports from developing countries towards developed countries' markets could be considerable. In order to prevent this situation the public authorities of

Spill-overs from foreign direct investment provide important benefits for local firms in the host country

Enterprises in developing countries may have to face stiffening competition as their products may be made more expensive relative to imports. However, this may be offset by adjustments in exchange rates also brought about by the changing scenario

The short-term overshoot and instability in exchange rates could have repercussions in the developed world

developed countries could be tempted to adopt protectionist measures. That could have serious repercussions on developing countries' economies as well as on the developed ones and the decrease in trade would constitute an obstacle for GDP growth world wide.

Conclusions

It is in developed countries' own interest to assist developing countries in designing an efficient system of intellectual property rights which complies with the TRIPs Agreement. A provisional strong appreciation of the exchange rate of developed countries' currencies could in fact be produced by a considerable loss of market share of developing countries' products coming after TRIPs comes into force. In order to prevent this situation, the governments of developed countries could help developing countries to link the gradual changes in their national law to policies aiming at promoting appropriate legal incentives for information/knowledge diffusion and local innovation. By co-ordinating stronger IPRs with broader modernisation programmes for technology development, including human resources and skill development, developing countries' firms will be capable of benefiting in the long term from additional technology transfer, FDI and joint ventures.

Keywords

TRIPs Agreement, patents, technology transfer, developing countries, R&D, investment

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Notes

1- Article 67 of TRIPs speaks about "...technical and cooperation in favour of developing and least-developed country Members.

2- From the 1st of January 1996

3- When a firm must ensure that local inputs are used for a specified amount or share of production

4- A firm must ensure that imports are not greater than a specified proportion of exports

5- For example article 13

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26 Communications Technology

Internet: From Hyper-links to Interactive-Multimedia

J. Perdigao

Issue: In just a couple of years the World Wide Web (WWW) has turned the Internet into an immeasurable source of information to the general public. Despite its tremendous success, current Web technology suffers from a number of deficiencies which render the on-line distribution of truly multimedia-based services impracticable. A new technical approach has recently emerged to cope with these shortcomings: mobile-code.

Relevance: Mobile code -the second wave of the 'information technology revolution' is about to reach us and its implications on our society's communication and information channels may be quite fundamental. Its impact on SMEs in the hardware and software markets, as well as those firms which are users of information services, are easy to imagine; other facets of socio-economic activity however, such as education, are also likely to be affected.

Background

Before the Web

It was only with the release of Web browsers that the huge potential of the Internet became available to a non-expert public

Just few years ago the Internet was far from being a data-dissemination medium available to a broad cross-section of the public. The arcane nature of its interfaces — mainly reliant on FTP and Telnet sessions — as well as its being unavailable to most people, made it off-limits to the general public. A new tool to provide user-friendly and intuitive access to Internet services, simple enough for use even by computer illiterates, was still lacking. Typing in line-mode commands was a task requiring a certain amount of technical training and thus inappropriate for the casual user.

The Web: The new information paradigm

This situation was radically changed by the World Wide Web (WWW) initiative — the first true global hypermedia network. In 1993, the release of the Mosaic Web browser gave the casual user a simple and user-friendly front end onto the Internet. The result was astonishing. It turned the Internet into an enormous, distributed and freely available information store.

The rapid take off of the Web and the exponential growth in its use -particularly when compared with other network information systems such as gopher or Hyper-G- is mainly due to the following factors:

- public domain code and protocol specifications
- large heterogeneous installation base, providing users with the ability to browse data independently of the computing equipment used
- ease of use — instead of learning complicated index-based systems and difficult commands, the user just clicks on hyper-links to jump from one document to another
- good browsing capability — by cross-referencing electronic documents, the Web

Box 1.

Some Internet Terms

FTP (File Transfer Protocol)	A client-server protocol which allows a user on one computer to transfer files to and from another computer over the network
Telnet	The Internet standard protocol for remote terminal sessions
Gopher	A once popular distributed document retrieval system which started at the University of Minnesota.
Browser	A program for accessing and viewing Web pages. The best known browsers are Mosaic, which was originally designed and programmed by Marc Andreessen and Eric Bina at NCSA, and Netscape.
Hyper-G	A competitor of the Web system developed at the University of Grass.
Hypertext	A mixture of text, images and links. The standard format used on the Web is HTML (Hypertext Mark-up Language).
Script	In the Web context, script is a piece of code triggered by an external request.
Image file formats	There are a variety of formats for storing and transmitting images, among these are TIFF (Tagged Image File Format) GIF (Graphics Interchange Format) and JPEG (Joint Photographic Experts Group format).
Stream	An abstraction referring to any flow of data from a source (or sender, producer) to a single sink (or receiver, consumer).
Intranet	A private network using Internet protocols and software.

has proven particularly efficient at handling large amounts of distributed information.

- availability of inter-protocol gateways — making it compatible with other existing protocols, such as Gopher, FTP and Telnet.

Hyper-links: The basic document-retrieval Web-mechanism

Hypertext, hyper-links, and hypermedia are at the heart of the Web. Hypertext is basically text containing anchors — called hyper-links — to other text or services. Following these links with the use of a Web browser, allows the reader to 'navigate' in information space, 'virtually' jumping from one document or service to another.

The term hypermedia actually refers to hyper-text-based documents containing in-line multimedia objects: images, graphics, videos, animation, and sound. This is the way documents are usually presented on the Web.

Current Web technological-shortcomings

Despite its enormous success, the current Web technology suffers from a number of pitfalls. Some of these are described below.

With the current Web technology local user-interaction i is just an illusion

Despite its fancy presentation features, the Web is too static to be considered a distributed interactive-multimedia system. The only mechanism providing a certain degree of interaction is the so called Common Gateway Interface (CGI). Through this mechanism, the Web server, upon reception of a request from the client, can execute a script that returns a dynamically generated HTML-formatted page. Because this process is done in a completely transparent way,

it gives the user a certain feeling of local interactivity. This is of course an illusion given that all the processing is done on the server-side. Consequently, the round-trip time for each single user-action makes it virtually impossible to provide interfaces that can be manipulated directly, including pop-up menus, drag-and-drop mechanism and so on.

The Web is too static to be considered an interactive multimedia system, all processing is done at the server end, thus response times are slow

The large number of return trips between client and server — ie. a request message followed by a reply — required by the Web protocol is particularly restrictive for a network with significant latency periods, which is the case of most current Internet services, based on low capacity lines not designed to handle the demands of this bandwidth consuming mechanism.

Thus, the HTML language associated with the CGI mechanism are only able to provide a limited subset of the desirable user-interface functionality. It goes along the lines of 'fill the form and press the submit button'. Ironically, this is a reminder of the old-days of mainframe-terminal type operation.

As well as there being a variety of image formats other interoperability problems can arise as different add-on features are adopted

Fake multimedia support

Current Web browsers are limited in that they still need to use external viewers in order to handle non-textual data. This restriction presents users with several obstacles:

- platform-dependent viewers must be installed locally on the user's machine;
- some configuration work must be done on the user's browser;
- the interaction between the browser and the external viewer is virtually null.

Current Web technology still follows the traditional client/server paradigm of the now outdated mainframes

There are only a few exceptions concerning the display of in-line images. Even so, image display in the same window as the main hypertext document is limited to one or two formats. The problem is that for each media type there are many different encoding formats - an image, for example, can be encoded as TIFF, GIF or JPEG, to name but a few.

Furthermore, real multimedia means more than just a collection of different visual or audio effects: it also means their synchronized delivery. The obvious case is the synchronization of audio and video tracks arriving separately via two independent streams. This lack of integration is in sharp contrast with typical stand-alone multimedia applications where the presentation of related information in different media formats is integrated coherently.

The Web's limited multimedia-data handling capability has been partially overcome by embedding special mechanisms inside browsers – see for example the 'plug-in' approach of the Netscape browser. Here the problem is that given the rapid growth of the market this kind of uncoordinated approach may well lead to interoperability problems — which may be caused by the adoption of mutually incompatible add-on features. To guard against this trend, the handling of a variety of formats and protocols must be done independently of the specific browser being used.

Server-side centred model

In the old days of the computing era, mainframe terminals used to request services from remote servers on behalf of users. Then, after performing some computations, results were sent back to the user terminal for display. Curiously this server-centric model is still used by current Web technology.

Given the diversity of bandwidth and response time at different Internet nodes, such a model

presents unacceptable performance for modern-day user-interfaces. As a result, the presentation, interaction and update cycles become too slow, severely affecting the desirable direct-manipulation 'feel' of the user.

Mobile-code: bringing local multimedia-interaction to the Web.

To overcome these severe restrictions of current Web technology a solution has recently emerged: mobile-code. This approach ships code resident on a server-computer over the network so it can be executed transparently on a remote computer. Thus, the idea is to download from the server not only a static piece of data but also the code to process it locally.

An analogy with the object-oriented approach can be drawn. The Web browser is made able to download 'network - objects'. These objects encapsulate not only data, but also the set of actions which may be applied to it. In other words: the new browsers present the users with documents which have 'intelligent content' embedded in them, instead of being simple static hypertext pages. In this way the Internet comes to behave as a web of distributed objets.

Java: the Internet's common language

The commonly understood form of mobile code is typified by Sun's Java language. Not surprisingly, this mobile-code language has been developed by a company that has always promoted the key-thought behind this technology, stating that 'the network is the computer'. According to Sun, Java is an object-oriented language which is portable, architecturally neutral, distributed, multi-threaded, robust, dynamic... It has the potential to revolutionize not only how applications are developed, but also the way they are distributed, and so represents a significant breakthrough in the history of the Web's development.

Full interactive Graphical-User-Interfaces.

Front-ends that can be used intuitively and productively require a rich Graphical-User-Interface (GUI) tool-kit. This tool-kit allows developers to provide the user with several interface-controls (menus, buttons, edit texts and so on). Furthermore, the user-interface should be dynamically re-configurable to permit an optimal presentation according to user needs and preferences.

The solution here is to have a generic tool-kit written in mobile-code. The challenge is to develop a framework for specifying user-interfaces generically, while dealing with the differences between the various platforms' environments. The 'lowest common denominator' approach, supporting only those facilities common to all graphical environments, was the solution.

Full multimedia support

The Web browser should not be constrained by the type of data format/encoding used by the information supplier. It should be able to handle, automatically and transparently, the encoded information and display it on the user's screen. This kind, of openness can be given by mobile-code, which makes it possible to dynamically download 'handlers' that implement and support viewing of such a variety of format-encoded objects.

Network-centric model

Mobile-code could bring about a new model of computing: the network-centric model. Given its unique capability of offering 'write once and

Mobile code, using languages such as Java, brings about the possibility of downloading the program from the server to the client, where it may be run interactively

run anywhere' programming, the end user will be able to access any application or service from anywhere on the network and then run it locally. Note that this model is more like a transformation of the usual client-server model than a replacement of it. In fact, most probably the freshly loaded application will still need some services from a remote server, such as for example access to a certain database. What makes this new model unique is the partitioning of the application into presentation functions and invocation services, both being downloaded on-line and on-demand via the network.

An Example: interactive weather-maps

Let us illustrate both the limitation of current Web presentation and the potential of mobile code by looking at a popular Web application: a weather-map.

There are now a significant number of Web sites offering a variety of up-to-date observational and forecast weather maps. They have introduced an unprecedented availability of meteorological information to the casual consumer. Before the Web this kind of data was only available to the professional public by means of expensive dedicated hardware.

Although this was an impressive achievement, very soon people realized that the process of browsing weather-data was largely a passive activity consisting of the following steps:

1) select a map from a list;
2) view it;
3) dismiss it;
4) repeat the process for other images.

The process was then somewhat improved by the introduction of the so called IsMap mechanism: specific regions of the map (rectangles, circles, etc.) can be invisibly hyper-linked to additional data. This means that the user can select a point or a pre-defined region from the original map for further exploration — for example, selecting a certain continent from a globe representation of the earth.

But what if the user wants to select a specific region of the map instead of a predefined-one? A typical operation is to select a user-chosen rectangle for zooming purposes. Since the user can only select one point at a time, the standard interactive click-and-drag operation is not possible. Here is the entire cycle:

1) the user clicks in the north-west corner of the user-chosen rectangle;
2) the pixel co-ordinates are transmitted to the Web-server;
3) a new dynamically-generated page containing the map with the spot corresponding to the first rectangle's corner is transmitted back to the user's browser;
4) the user clicks in the south-east corner to fix the limits of the rectangle-region;
5) the new pair of co-ordinates is transmitted;
6) finally the new zoomed-image is displayed on the user's browser.

In summary: an operation that would normally require a simple click-and-drag operation results in a round-trip of the full image. The whole process becomes cumbersome, slow, non user friendly, and bandwidth consuming.

From this example we conclude that the hyper-text mark-up language and its associated mechanisms (forms, CGI, IsMap) is a simple way of formatting and presenting distributed information, but a rather unsatisfactory mechanism for developing real interactive applications.

On the other hand, with a genuinely interactive image system the user could perform a variety of local operations such as: changing the layout of the

map (colours, size); overlay extra-data to the current image (wind vectors or temperature contours, for example); getting additional information on an unfamiliar weather symbol just by moving the cursor into it; and so on. All these kinds of 'events' should be handled locally instead of remotely by the Web-server. Mobile-code can allow this fundamental change in approach.

Industrial Impact

Software industry: momentum for small-and-medium-size enterprises (SMEs)

Mobile-code is likely to introduce significant changes in the way people write and distribute software. Currently, the effort required to write and maintain different software-versions for each type of supported platform is well beyond the capacity of most small-and-medium sized software-houses. Consequently, it is difficult for them to support more than a couple of platforms. As a result, the software produced is almost always confined to fulfilling niche-market gaps, never becoming broadly accepted products. Mobile-code, due to its platform-independent characteristics, will eliminate the burden of supporting such a variety of versions. SMEs will be able to narrow their focus on adding functionality to a piece of code instead of investing significant human resources in software portability operations.

Another major problem SMEs face arises from the way software is distributed and licensed. The process is such that software is treated like any other commercial good, basically using physical distribution by local retailers. Wide availability of a software-product requires a world-wide commercial network — certainly, not an easy achievement for a SME.

On the other hand, mobile-code will introduce a new way of doing business in the software arena. Users will be able to download the software they need directly from the network, on the fly and as they want it; thus, with no more intermediate agents; no more customisation requiring platform experts; no more time-consuming software upgrades; no more purchase/installation cycle.

Furthermore, the process of licensing and payment will also radically change — new alternatives, such as pay-per-item and pay-per-duration, will become possible. The 'global-village' nature of Internet will finally eliminate the distance-to-market physical handicap — geographic location will be no longer relevant. This will give rise to a new opportunity for those SMEs from periphery regions to enter this market.

Nowadays everyday desktop applications – text processors, spreadsheets, and so on – are growing into huge monolithic pieces of software, with a myriad of functions that the casual-user rarely needs. The enormous investment required to bring about such big applications makes it very difficult for SMEs to develop and market alternative-products. Mobile-code's distributed object-oriented characteristic will break down this model of monolithic applications, making it become possible for SMEs to produce small pieces of code ('mobile-objects' of sorts), that the user will load, on-demand, in order to supplement a certain core-application with a specific add-on feature. For example, a spell-checker for the Estonian language could be written by a specialized software-house somewhere in the Baltic region and dynamically incorporated into the user's text processor. As always occurs in open markets, the bigger the number of providers the better for the consumer: lower prices, better quality and broader choices.

The hardware industry:

It is still very unclear the way mobile-code technology will affect the computer-hardware industry. What seems to be certain is the arrival of

The software industry has come to be dominated by a few large actors selling complex programs requiring a level of investment SMEs cannot match. Mobile code may reverse this trend, offering automatic distribution networks and a plethora of niche markets

A number of manufacturers already seem to be moving in the direction of supplying network PCs supporting mobile code

The greater degree of interactivity offered by mobile code makes it ideal for educational and publications purposes

a new market player: the Internet PC. The chief idea here is that Internet PCs will be very inexpensive devices, with the ability to download programs from the network. Industry leaders, such as IBM, Oracle and Sun, seem already to be moving into this direction.

Potentially, the Internet PC will ensure significant cuts in administration and maintenance costs — reduced and very light operating systems and the elimination of upgrade cycles. Most probably, due to the constraints of network bandwidth, these devices will be equipped with some advanced caching mechanism. In this way it should be possible to gain 'virtual bandwidth' in the sense that the mobile-code would often be returned from the local cache rather than from a remote server.

In some ways, the concept of Internet PC extends what many Intra-nets are doing right now. In these cases user's computer-drive houses the operating system and everything else is remotely provided by various servers on the Intra-net.

Social Impact

Mobile-code technology will potentially influence every aspect of modern society: education, entertainment, business, public services and so on. Below we present a couple of examples from what could be an endless list.

Multimedia Distance Learning

Due to the rapid technological changes in our society, workers require new knowledge through frequent short-term training as the skills demanded change. Multimedia distance-learning seems to meet this requirement particularly well.

As discussed above, the lack of effective local-interactivity in current Web protocols do not facilitate the publishing of multimedia educational information. Mobile-code, instead, will allow multimedia data to be shipped to the client with the subsequent possibility of processing it locally, in much the same way as today's off-line CD-ROM's.

With mobile-code the student will no longer be a passive reader of course documentation. Instead, he or she will learn 'hands-on' under the control of 'courseware' running locally. It will be also possible for the 'remote' teacher to have control over the flow of information to the student (for example, denying access to new information before the student has successfully completed a prerequisite test).

Scientific Publishing

There are already a number of electronic scientific magazines accessible through the Internet. Electronic journals present several advantages when compared to their hard-copy equivalents. Access is given to material earlier and more conveniently as well as in conjunction with improved search capabilities.

In fact, the reason why CERN set up the Web system in the first place was to distribute scientific data among colleagues. Static scientific documents, still images and video, as well as sound files can nowadays be located and downloaded through the Web. However, scientific information is dynamic by its nature and the current Web technology handles this characteristic unsatisfactorily. Let us present a few examples on how mobile-code could improve the current situation:

- Images — instead of computing the image on the server side and sending it back to the client, the image data is transmitted with the code to locally compute the view. The same image can be viewed by the user from different angles, formats, colour and so on. Rotating a 3D model of a molecule is a typical example.

- Tabular data — the reader will be able to extract tabular data, or a sub-set of it, from the document and further process it and view it in a number of different ways.
- Information-specific protocol — the reader will be able to interact with specific data types, such as mathematical expressions. For these cases a specific protocol is implemented by the mobile-code in order to communicate with specific-data applications.

Final Remark

'The degree of acceptance of new information services by users is one of the determining factors for an effective development of the information society.' European Council of Ministers Resolution, 7th November 1995. Doubtless, mobile-code technology with its additional presentation capabilities can help pave the way.

Keywords

Mobile-code, interactive-multimedia, distributed information-services

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Notes

1- An operating-system dependent mechanism, locally installed, to render possible the display or interpretation of a particular file format.

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Health and Environment Improvements through Novel Food-Packaging Technologies

M. Demicheli

Issue: The acquisition and use of knowledge about fundamental biological mechanisms affecting human life, especially with regard to health and food was put forward in last July's discussion paper of the Fifth Framework Programme. Half-way between the plastics and food industry, new innovative films and coatings may render both fresh and processed food safer for consumers while reducing environmental costs.

Relevance: Simultaneous growth in demand for fresh produce and 'easy-to-use' foods combined with consumers' desire for less, and more readily biodegradable, packaging material, make that both methods and materials used to package food will have to change in consequence. This would make the introduction of additional food safety measures and quality control procedures necessary. Novel protective films have the potential to reduce fresh produce losses and packaging waste with a minimum use of resources. In particular, the introduction of edible films and coatings may call for conformity standards to be designed in relation with the food packed.

Analysis

Introduction

Consumers in industrialized countries are increasingly concerned by health and environmental protection issues

Consumers in industrialized countries are increasingly concerned about health and environmental protection issues. And as our lifestyles have changed, so too has our demand for food products. Today, first priority is given to safety and taste, combined with ease of consumption. A huge demand for take-away food and snacks has also emerged in recent years.

The anxiety for a better quality of life has been translated, within the food sector, into the search for a more balanced diet (the 'Mediterranean' diet is a good example) and of food with supplements of vitamins, minerals, etc., which is often referred to as 'healthy' or 'functional' food. The 'green' consumer wants also less packaging (change from the monopack to the multipack concept) and a type of packaging which is biodegradable or can be recovered.

These trends create new challenges in light of the pressure to continually redefine the optimal trade-off between a minimum of processing and the maintaining of product's hygiene and safety standards.

Food packaging must meet the expectations of all actors (consumers, retailers, distributors, food producers, packaging manufacturers and suppliers of raw material). It must be durable, hygienic and safe, lightweight, environmentally sound, versatile, transparent and cost-effective. It must also inform and promote. These demands are often in conflict. However, acquaintance of food processing companies with the consumer's emphasis on safe

and healthy food would sometimes spare them expensive marketing and advertising campaigns (Maitland, 1996). The food processing industry in developed countries already transforms 75-80% of agricultural produce. Plastics pack about 50% of packed food in Europe, competing mainly with glass, paper and metal.

Plastics with high barrier properties are necessary to adequately protect food either from external influences (oxygen, water vapour) or from loss of flavours. Meeting these complex requirements is not easy and many different approaches have been proposed (thicker films, further processing, composite films), which often go against the main aims of the current Packaging Directive (avoidance of unnecessary packaging, maximum recycling), without being entirely satisfactory.

Safe packed food: a delicate compromise

Packaging keeps food fresher for longer and protects it from contamination. It also prevents 'odour escape'. However, a number of factors all along the food chain threat the quality and safety of food.

Migration of additives

Migration of functional additives from plastics into foodstuffs is a phenomenon of prime importance. It can result in a loss of food quality (eg. off-flavour) and/or food safety problems. In order to be preserved, meat and fish are sometimes pre-packaged in plastic films and then irradiated to avoid microbial recontamination. Low doses of irradiation (λ- and β- radiation) do not present a toxicological risk or affect the nutritional value of food. Furthermore, irradiation kills all types of pathogens and could with time replace chemical treatments (often with ozone-depleting methyl bromide). However, depending on the nature of the film used and the specific conditions of irradiation, the packaging material can change, and plastics components (plasticizers, monomers, stabilizers, etc.), some of which are known to have adverse effects on humans, can get into the food. Moreover, the formation of new toxic radiolytic products cannot be ruled out. Last year, researchers from the UK Ministry of Agriculture found levels of phthalate plasticizers in baby formula milk high enough to potentially trigger oestrogenic effects. These findings have heightened concerns about phthalates in food (ENDS, 1996).

Novel preservation methods are being considered. Treatment of food by high hydrostatic pressure inactivates micro-organisms and enzymes, while nutritional and organoleptic values are not affected. Moreover, the layer used to separate the food from the pressure medium (eg. water) may also be the food package. In particular, this method has shown not to alter the diffusion barrier properties of polymer films (Kubel, 1996).

Under the terms of Council Directive 89/397/EEC on the official control of foodstuffs, the European Commission is responsible for co-ordinating the 15 Member States' national food inspection programmes at Community level. A study into the migration of plasticizers into food was among this year's priority food control areas. National food inspection authorities are asked to examine the behaviour of plasticizers (eg. phosphoric esters, phthalic esters, stearic and adipic esters), used to enhance the suppleness of plastic materials including those in contact with food, within the limits laid down in the Commission Directive 90/128/EEC (Agri-industry europe, 1996).

Food packaging must meet the expectations of all food-chain stakeholders. This may often impose conflicting demands

Migration of additives into foodstuffs has caused concern about the safety of certain packaging materials

A factor limiting expansion in the use of radiation techniques is the possibility of formation of new radiolytic products

The possibilities of novel techniques, such as hydrostatic pressure, are being explored

The behaviour of packaging materials when exposed to heat or placed in close contact with fats have to be taken into account

The immobilization of antimicrobial enzymes in food packages is a novel and interesting approach

The production of plasticizers from renewable, biological sources is possibly the key to innovation in biodegradable plastics

Migration phenomena can also take place when heating foodstuffs both during industrial processing and at home. Film packaging additives have a particularly high affinity for fatty foodstuffs with which they are in direct contact. In the US, more than 90% of homes own at least one microwave oven. The corresponding figure for Europe is now about 30% and increasing. Among the advantages of microwaving are speed of operation, energy savings, and precise process control. These trends create new challenges for packaging manufacturers, who have to produce suitable films and additives, and perhaps also for food processors in the conditioning of the food to be packed.

Food preservation

Surface microbial growth is often the main cause of spoilage for refrigerated food products. Consequently, antimicrobial agents are often added to films and coatings in contact with foodstuffs. However, the effectiveness of the preservative over time is limited because the preservative diffuses into the food. A lot of work has gone into attempting to solve this problem. Recent investigations have shown that diffusion of sorbic acid, a commonly used preservative, into intermediate moisture food models could be decreased 150- to 300-fold by coating the substrate with zein (corn prolamine) films. Good results have also been achieved by the addition of fatty acids to polysaccharide-based films and of acetylated monoglycerides to gluten-based films (Redl, et. al, 1996).

The immobilization of antimicrobial enzymes in food packages is a different approach that could reduce or eliminate microbial growth without addition of the antimicrobial agent. For example, it was recently found that lysozyme immobilized in cellulose acetate has a high, long-lasting activity against some bacteria. (Appendini and Hotchkiss, 1996). Whatever the antimicrobial factor used, its action must be durable. The challenge appears to be finding the optimum film formulation that, with a minimum use of other functional additives, can endure the increase of critical variables such as temperature and water activity. Synergistic effects between antimicrobial agents and antioxidants could be highly beneficial. The risk of creating anaerobic conditions that favour the growth of Clostridium botulinum must also be evaluated. More research is clearly needed to fully define the impact of antimicrobial films on food safety.

Biological or synthetic plasticizers?

More than often, plasticizers are added to polymer films to obtain suitable properties, such as flexibility. In particular for food, pharmaceutical and biomedical applications, extractability in water or lipids, migration and toxicity of plasticizers must be kept at the lowest levels. Furthermore, the use of PVC films is increasing in these sectors. Therefore, the development of low-toxicity plasticizers that can provide these films with the desired mechanical properties while avoiding unsafe additives is a challenge. (Guiot, 1992).

The production of plasticizers from renewable resources or biological waste is of key interest. Indeed, some actors would view this sector as the gateway to further innovation in biodegradable plastics. Suitable plasticizers can be modified plant oils, such as epoxidized linseed or soybean oils. In 1985, 15% of the 777,000 tons of plasticizer produced in the US were provided by plants. By modification of the composition of oilseed lipids, biodegradable plasticizers with better properties might be developed (Demicheli, 1996). For example, vernolic acid a major fatty acid in seeds of Euphorbia and other plants, is used as a plasticizer and stabilizer in PVC and

could potentially be produced in crop plants (Nawrath, 1995). It must be pointed out, however, that plant-derived materials may be as toxic or even more toxic than synthetic products.

Edible films and coatings to protect food

Many modern agricultural practices adversely alter the natural protection of fruit and vegetables. For instance, the application of pesticides necessitates washing the produce before it can be distributed. At least 20% of a fruit crop is lost between harvest and consumption because of damage in transit or over-ripening. The equivalent figure for developing countries may be as high as 80%. To protect fresh fruit and vegetable produce, the beneficial effects of controlled atmosphere storage (CA) are usually coupled with refrigeration. However, both techniques are relatively expensive.

Controlled atmosphere storage and refrigeration are both relatively expensive techniques

Lightly processed produce present the 'worst-case scenario' for degradative changes and therefore offers a great challenge to food technologists. Recently, the specific permeability properties required for fresh food storage have been improved by individually packing the food item with microperforated synthetic films. This method, known as modified atmosphere packaging (MAP), has shown to reduce shrinkage and weight loss while increasing the life of the product. In the future, however, edible films (eg. based on gluten) offering a natural selectivity could advantageously replace these films. Depending on further progress mainly in the combined action of storage conditions and film and food properties, application of edible films and coatings could be extended towards more processed foods, like dried, intermediate moisture and frozen foods. This is likely to revolutionize the people's perception and habits regarding food. For example, acceptable potato chip quality can already be maintained up to 43 days at 50% relative humidity using laminated, modified methylcellulose/corn zein edible films (Park, 1996).

The introduction of this simple preservation technique may help reduce food losses. If well adapted to the foodstuff, it can easily improve its appearance. In combination with antimicrobials, it can contribute to retarding microbial growth. Consequently, edible films and coatings are seen as an additional factor for both quality and safety, though hardly as substitutes for classic food preservation techniques –at least in industrialized countries. Future standards will thus have to cover quite different aspects such as the type of film packaging, the presence of chemical preservatives in the film, and allowable storage periods of the packaged food. Labelling regulations (eg. shipping containers) might also be needed.

Edible films and coatings are seen as additional factors for quality and safety, not as substitutes for classic food preservations techniques

Biodegradable films to fill niche markets

Regenerated cellulose film (RCF) might be a strong competitor of edible coatings in such niches as confectionery. The world market for RCF now holds steady at around 150,000 tonnes per year. RCF is still the only naturally permeable flexible material which allows packaged goods to breathe while excluding microbiological contamination. A material like RCF, which will biodegrade naturally within 6 weeks of composting appears very promising for curbing packaging waste. Some European companies are now working on the compostability of RCF. The outcome should lead to the material being placed in the paper rather than in the plastic stream, with significant cost savings.

Regenerated cellulose film, used for packaging confectionery, is a naturally permeable flexible material which allows package foods to breathe whilst excluding microbial contamination

Films composed of macromolecules of agricultural origin could also be used with fully processed food, and even non-food sectors like drug-delivery or microsurgery. Recently, the firm

The absence of water barrier properties is still the main drawback of biodegradable plastics

Polymer Films has applied for patents on a thermosensitive film which behaves like plastic, but is made from wheat. It disappears during cooking and can be tinted and flavoured. This gluten film does not break down when in contact with moisture at normal temperature, opening up opportunities for use with hundreds of processed foods. Its main drawback is high cost.

At MIT, researchers are close to the development of a whole range of cheap and versatile biodegradable plastic by combining polyvinyl alcohol and ethylene with starch. This could provide a cost-effective solution for manufacturers seeking biodegradable packaging (Luesby, 1996).

Multilayer films

Multilayer films are able to meet apparently incompatible requirements simultaneously

Multilayer films were developed in order to meet simultaneously, apparently incompatible requirements. In fact, each layer has a specific function, thus constituting a tailored solution. Multilayer films usually include an internal barrier layer (ethylene/vinylalcohol or polyamide) against eg. flavour or oxygen diffusion. They are already used for packaging of liquid or powdered products but their applications are tremendously increasing at the present time. In Europe, about 9% of plastics food packaging is multilayer (Williams, 1995).

Coating materials with special barrier functions, based on inorganic-organic hybrid polymers (Ormocers), are currently being developed by ISC, Würzburg. These novel materials may contribute to the avoidance of packaging and may also improve the degree of material reutilization. They have already proven useful in improving the water barrier properties of a RCF substrate and in reducing its oxygen and flavour permeability.

Nevertheless, in an age of high-tech composite materials, the innovator EarthShell Corp. of Santa Barbara (California), may have succeeded in developing an 'environmentally-friendly, cost-competitive package alternative to paper, plastic and polystyrene foams–ironically made of natural limestone, potato starch and a small amount of cellulose fibre. Containers made of the material dissolve completely in water after they are broken, and can be composted and used as soil amendment (C&EN, 1996).

The absence of water barrier properties is still the main drawback of biodegradable plastics. The development of coatings with a high water barrier could enable the use of starch as a biomaterial for food containers. In particular, zein is a water-insoluble protein which could be safely used to protect starch-made objects from moisture. The research on protein films from zein is paramount to develop water-resistant starch vessels in the future.

Policy implications

The recently recorded food poisoning outbreaks in Japan, Scotland, etc., have created intense public concern about microbial contamination in meat and fish. This may result in a higher level of consumer acceptance of food treated by irradiation. Microwave heating, like irradiation, has the advantage that most foodstuffs can be processed together with the packaging material. These trends are alerting decision-makers about the possibility of the timely proposal new regulations, based, for example, on risk-benefit analyses, that facilitate the implementation and diffusion of these methods, mainly through the food processing and food service sectors.

As regards the preservation of fresh or lightly processed food, edible films and coatings appear as probable substitutes for synthetic films. A trade-off is to be found in terms of the additional cost of this technology and the shelf life extension and marketing value it provides.

The resource efficiency of plastic packaging has already improved and is expected to improve further through a policy of reduction at source. Typically, plastics films allow for the lowest ratio of packaging to packaged product, which reduces transportation costs and minimizes both packaging and food waste (Williams, 1995). The environmental impact of non-biodegradable multilayer films for food should be assessed by comparison with other alternatives (eg. collect, sort, clean and recycle the items). The main drawbacks of multilayer films would be their final disposal (recycling is troublesome and incineration entails the hazard of air pollution). Consequently, the challenge is in minimizing the ratio of packaging to packaged good. The evolution of packaging from fossil to renewable sources remains a challenge for the future. There is hope that a material which comes from a renewable source will, if handled correctly, contribute to a more sustainable energy balance.

Keywords

Plastic films, food safety, packaging, health, consumer trends, waste management, edible films, multilayer films

About the author

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At the IPTS he is currently performing technology watch and foresight on agri-food technologies, biotechnology and environmental technologies in general. He also participates in the co-operation activities and studies between the EU and Third Mediterranean countries.

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BRIEF NOTE

The First International Conference on "Technology Policy and Innovation" will be held in Macao in the summer of 1997. It is intended to discuss aspects related to science and technology systems and their impact on economic and social development, examining issues of management, assessment, commercialisation, application and organisation of science and technology. Three main perspectives will be addressed, namely aspects of business, public policy, and academia, with emphasis on topics related to emerging Asian markets. An integrated approach, joining views from these different perspectives, will be sought.

Science and Technology(S/T) commercialisation is acquiring increasing importance in the development of contemporary societies. Governments, firms, universities and research laboratories all take part in the process of building up what has been conceptualised as national science and technology systems. The actions of these key players and the interactions between them determine the impact of S/T activities on social welfare. One of the most important challenges in optimising this impact is to understand and manage the complex processes that underlie world-class S/T research, commercialisation and management, including informed education policies, the protection of intellectual property and the funding of science, technology and innovation. Knowledge integration in key subjects is required to enhance economic wealth, shared prosperity and cultural enrichment. The Macao '97 Conference will also address information networking and policy, integrated design, process technology and intensification, and strategies for global sustainable development.

The organising, advisory and conference committees are composed representatives from universities and organisations worldwide, including the EU Commission Directors A. Garcia Arroyo (DGXIIC) and H.J. Allgeier (JRC, IPTS).

More information can be obtained through the organisers at e-mail: macao97@termcomb.ist.utl.pt. fax: +351 1 849 6156

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BRIEF NOTE

42 Brief Note

Scrap tyres in the EU

With an estimated 2 million tonnes per year, scrap tyres is clearly not a mass waste stream in the EU. Problems for the disposal of tyres arise from the danger of ignition and uncontrolled burning, which results in considerable emissions. Landfilling is restricted by the tendency of the whole tyre to resurface due to its shape and elasticity.

The working group set up by the European Commission on used tyres within the Priority Waste Stream Project suggested the following goals for the year 2000:

- an increase of the average life span of a tyre by 5%;
- an increase of the share of re-treated tyres to 25%;
- an increase of the share of recovered tyres to 65%; and
- a close-to-100% collection rate.

Moreover, reuse and recycling should be given a preference over energy recovery.

The main actors in the tyre and used tyre business are tyre manufacturers, tyre dealers, garages, tyre centres (including supermarkets), re-treaders, operators of cement kilns and tyre incineration plants, operators of shredders, and a few recyclers (e.g. for road pavement). Tyre centres appear to be the largest source of used tyres.

Tyres contain more energy than coal but contain less sulphur, nitrogen and ash. After shredding, the so-called "inch chips" can be use in cement kilns as a coal substitute to up to 25%. This is a proven and profitable technology. The steel contained in tyres can even improve the quality of the clinker. Monocombustion is another alternative. However, the profitability of energy recovery depends closely on alternative waste management options, such as landfilling, and the price of energy. Rubber granulate is another material produced by shredding tyres: it is used as base material in other industries, and with other materials to be incinerated, preferably with energy recovery.

In Spain, scrap tyres are generated at a rate of 270,000 t/y. Early this year, under the auspices of the Andalusian government, a company specialized on bitumen-rubber technology ventured with a building company to carry out field tests to evaluate the possibility of using granulated rubber from recycled tyres in roadbeds. This product can, after elimination of metals, canvas, etc., be used as bitumen modifier or as inert load, added directly to the asphalt pavement. Furthermore, the incorporation in road pavement is the shortest, best defined 'cradle-to-grave' cycle for tyres.

The inclusion of rubber in the asphalt notably improved its resistance to deformation, flexibility at low temperatures, and resistance to thermal stresses and fractures. In all tests, the direct addition of the rubber granulate led to a substantial improvement of the characteristics of the asphalt mixture. A higher resistance of the rubber-added mixtures has been corroborated by immersion-compression laboratory tests.

In summary, re-treating requires improved tyre technology for enduring high speed safely and, maybe, European quality standards. Energy recovery in cement kilns could be a very good option provided that investment in modification of the feed system is lowered, and that there is more flexibility in the granting of permits. In the case of granulates, more R&D is needed to cut production costs.

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ABOUT THE IPTS

The **IPTS** is one of the seven institutes of the Joint Research Centre of the Commission of the European Communities. 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 co-ordinates research to improve our understanding of the impact of new technologies, and their relationship to their socio-economic 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 the IPTS enjoys a dual advantage: being a part of the Commission, the IPTS shares EU goals and priorities; on the other hand it cherishes its research institute neutrality and distance from the intricacies of actual policy-making. This combination allows the IPTS to build bridges across EU undertakings, contributing to and co-ordinating the creation of common knowledge bases at the disposal of all stake-holders. Though the work of the 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 the decision-maker 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 nationally based organisations. The IPTS is the central node of ESTO, co-ordinating technology watch joint ventures with the aim of better 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 the driving force behind all IPTS activities, focusing analysis on the potential of promising technologies for job creation, economic growth and social welfare. Such analyses may be linked to specific technologies, technological sectors, or cross-sectorial issues and themes.

3. Support for policy-making. The IPTS also undertakes work to supports both Commission services and other EU institutions in response to specific requests, usually as a direct contribution to decision-making and/or policy implementation. These tasks are fully integrated with, and take full advantage of, on-going Technology Watch activities.

As well as collaborating directly with policy-makers in order to obtain first-hand understanding of their concerns, the IPTS draws upon sector actors knowledge and promotes dialogue between them, whilst working in close co-operation with the scientific community so as to ensure technical accuracy. In addition to its flagship The IPTS Report , the work of the IPTS is also presented in occasional prospective notes, a series of dossiers, synthesis reports and working papers.

The IPTS Report is published in the first week of every month, except for the months of January and August It is edited in English and is currently available free of charge in four languages. English, French, German and Spanish.

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