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computer-using industries such as finance, insurance and real estate did not witness high TFP growth.

Explaining the disparity between high investment in technology and productivity impact in computer-using industries is not only an important task for analysts but also for market participants. It can be argued that it was only a matter of time before malaise would set in fed by the non-realized gains in productivity, hoped for by those who invested heavily in ICTs in non-high-tech but heavily computer-using industries. Fast growth cannot be sustained – and in the present juncture will not easily pick up again – simply based on productivity gains in high-tech industries and in ICT price decreases.

The debate's essence, as mentioned above, is whether technology's impact on productivity substantially extends beyond the high-tech industry. This makes the need for more accurate measurement of productivity impacts (e.g. taking into account quality improvements across the board) fairly urgent. Providing updated indicators (technology-updated in a sense) is not only a matter of facilitating the work of analysts; it is also a key step in allowing market participants to assess and project the productivity impact of their investments in ICTs, and then see whether the Scylla of dire prospects is as unwarranted and illusory as the Charybdis of exuberant optimism on the all-encompassing and transforming impact of new technologies of the late nineties.

Notes

1. A substance supposed by 18th-century chemists to exist in all combustible bodies and to be released during combustion.
2. Jorgenson, D and Wessner, C., *Measuring and Sustaining the New Economy.* Appendix A. National Academy Press, Washington DC, 2002.

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rence to be treated at home (Friedewald and Pion, 2001). Elderly people appear to be more keen on spending money on technology aids that keep them in their homes and make them less reliant on other people than on spending (usually) more than is absolutely necessary on long-term care in an institutional environment. Also, certain telecare applications can increase the knowledge and awareness patients and their carers have of their particular health condition thereby allowing some involvement in decision making over the treatment or even some degree of self-care.

A third reason is the ageing of the population, which is expected to have a multiplying effect on the demand for such services. With a significant rise in average life expectancy gains and with more citizens passing this critical age threshold the required public finances for covering healthcare costs are expected to continue to grow. The provision of health and social care services to individuals on a mobile basis or at home over electronic networks receives considerable attention among policy-makers and health practitioners as it provides opportunities for independent living, increased security and greater social integration for the people in need.

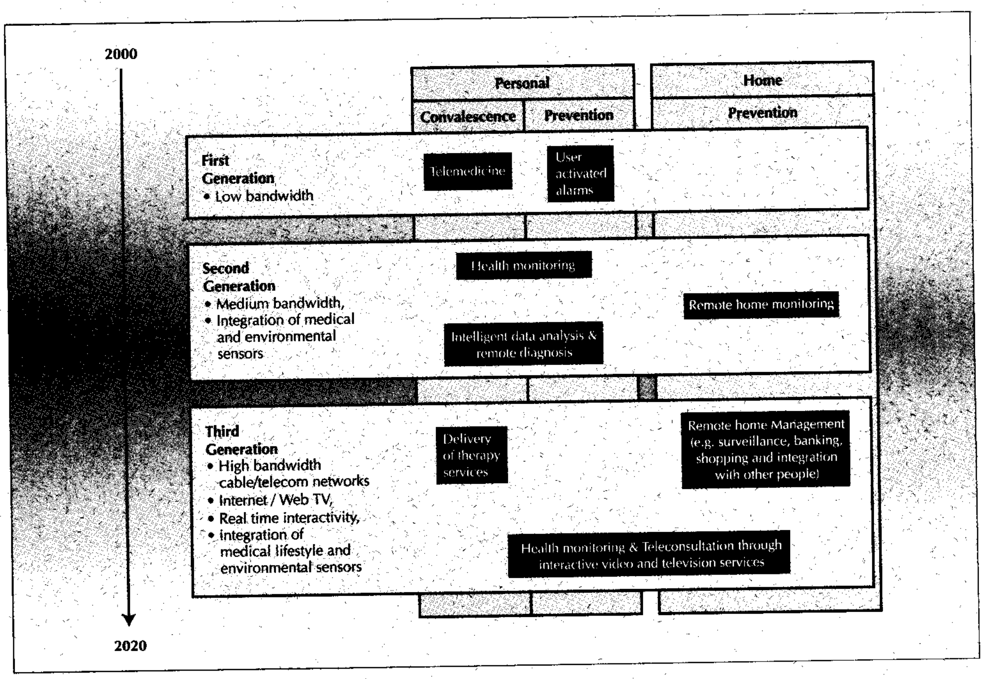
The technological dimension

Three generations of telecare systems can be identified as shown in Figure 1.

The first generation includes user-activated applications with no embedded intelligence and no special requirements in terms of public network infrastructure or home wiring. The second generation is more 'intelligent' and uses environmental and personal sensors for the continuous monitoring of a patient's behavioural and medical condition. The third generation is characterized by real-time interactivity between care providers and recipients that can be possible over broadband networks and digital interactive TV platforms.

From the users' side, there is demand for telecare among the elderly and disabled, as it allows them greater independence and the possibility of remaining in their own home. In the context of an ageing population, this demand is likely to increase yet further

Figure 1. A typology of telecare applications



Source: Based on Doughty et al.(1996) and authors' elaboration.

The first generation of telecare applications includes user-activated devices with no embedded intelligence and no special requirements in terms of public network infrastructure or home wiring nomic question for telecare stakeholders is whether the benefits from investments in telecare can outweigh the high costs incurred in their development.

There is currently a shortage of cost-benefit analyses into the acclaimed economic benefits of telecare. This is partly due to the limited take up of such applications and partly due to the difficulty in measuring and assessing the indirect benefits from their deployment. One example of the constraints entailed in the cost benefit analysis of a telecare service has been the economic analysis of the NHS Direct initiative in the UK[1].

NHS Direct provides medical assistance and advice to recipients over the phone. Teletriage can be performed by the receiver at the control centre, who is normally a nurse trained to prescribe treatment or call in the ambulance service.

The analysts involved in the exercise identified the following drawbacks in their effort to estimate the total economic cost (initial capital investment and operating costs) to the NHS of providing the service. First, although the service has been designed with the aim of reducing demand for other care services, in practice there was some evidence that individuals who might otherwise have provided self-care after contacting NHS Direct contacted their doctor. At the same time, it was found that the new service provides reassurance to callers through disease information, increased opportunity for self-care, and better response time to emergency situations, all of which were indirect benefits which were difficult to quantify and include in a costing exercise. The analysts concluded that the overall impact of the new service is likely to be felt in a time horizon of between five to ten years when real economies of scale are expected to reduce its costs as a result of (a) less need for spare capacity due to increased predictability in the demand patterns; and (b) the operation of 'virtual call centres' which are expected to reduce traffic congestion of incoming calls.

Naturally, not all telecare services face the same high set up costs. Costs vary according to the sophistication of the service provided, the type of infrastructure required for its operation, the size of operation (local, regional, and national), and the size of labour costs involved. For example, providers of first generation mobile care systems offering telecare services on an individual basis bear relatively low capital costs compared to other first generation services. In the case of a nationally available telephone helpline, such as NHS Direct, the costs of installing and operating the necessary IT infrastructure (software and hardware) are substantial. As the IT infrastructure and databases need continuous monitoring, feedback, and updating in order to provide an acceptable level of service to callers, capital costs rise in line with usage although overall they remain lower than the respective labour costs incurred. Overall, it would be over-optimistic to maintain that the deployment of technology would bring strategic benefits to patients and their carers if it fails to generate and sustain an acceptable level of revenues or cost savings that offset the high costs of service development (Kibbe, 2001). In this respect, economic analysis is a necessary first step that provides a guiding tool to policy-makers regarding the pace and direction that technology-based reforms can be introduced into the health care system.

Another economic aspect relates to the reimbursement of costs for both practitioners and end users. Issues such as what should be the on-line service charges of practitioners; how, and to what extent care recipients can be refunded by public social security organizations, and what should be the role of private insurance coverage demand immediate attention. Given that the development costs of a telecare system are high and do not provide immediate profit to the funding body, it is unlikely for the private sector alone to proceed in providing advanced telecare services. Private organizations and state authorities need to cooperate

The real economic question for telecare stakeholders is whether the benefits from investments in telecare can outweigh the high costs incurred in their development

Measuring the costs and benefits of telecare systems has proved difficult, partly because it is difficult to place an economic value on the indirect benefits such systems deliver

Given that the development costs of a telecare system are high and do not provide immediate profit to the funding body, it is unlikely for the private sector alone to proceed in providing advanced telecare services and resources. The voluntary sector could also become engaged in initiatives of this kind designed to bring care services closer to citizens.

Conclusion

ICTs have the potential to dramatically change the work processes and delivery of health and care services. The promotion of technologies for telecare has been on the top of the policy and research agendas of the European Commission and the Member States as a means to improve healthcare support and amplify inequalities in accessing health-care.

However, in Europe today, the use of ICT systems in the delivery of care services remains rudimentary despite the critical mass of scientific and technological knowledge that has accumulated in this area. Technological factors, including the limited supply of broadband access, the multiplicity of technology platforms and standards used in pilot test beds, and the fragmented nature of national health information infrastructures represent major barriers to the effective development of telecare applications.

This article has argued that efforts to abridge the technological barriers to telecare should in parallel be accompanied by the orchestrated efforts of State authorities to explore the economic, institutional, and organizational aspects of telecare deployment. These efforts should be made on the understanding of national technological, socio-economic, and cultural specificities and on the recognition that telecare practices complement rather than replace traditional methods of health-care delivery. Starting from the most simple telecare applications of the first generation and gradually proceeding to the more complicated ones allows for effective learning processes to take place within the communities of major stakeholders. Policy-makers have a critical role to play in opening up opportunities and creating the appropriate institutional environment for the effective launch of telecare. A clear legal and regulatory framework needs to be established for the development and delivery of these applications and the reimbursement of the key actors involved, including a framework of practice for health and care professionals. This is necessary in order to enhance users and practitioners' confidence in telecare technologies given the concerns about the potential misuse of medical and personal data. Such a framework would also provide for the transformation of the current paper-based medical record into electronic form. Electronic health records can be accessible by health-care providers and patients and contribute to the reduction of administrative costs, prevent duplicate treatments, and reduce medical errors. In this sense, they are an essential component in the delivery of telecare.

In the short term, policy efforts should concentrate on increasing user awareness and understanding of the benefits of telecare. The latter could be achieved through State-organized events, seminars, and open public workshops. The provision of health-care technology devices to specific target groups (e.g. people suffering from kidney deficiency, diabetes, etc.) that can be easily deployed in individuals' homes according to their evolving needs could be another opportunity to raise awareness. Public authorities also need to invest in the training and education of health and care professionals to advance their ICT skills and capabilities and alleviate their mistrust over their use. Such policies are expected to accelerate the process of change and the transformation of health and social care provision into an IT-driven, knowledge-based system.

Biofuel Production Potential of EU-Candidate Countries

Boyan Kavalov and Peder Jensen, *IPTS*

Issue: The European Commission (EC) has set indicative targets for the market penetration of biofuels, but the agriculturally-based biofuel production potential of the current 15 member states of the European Union (EU-15) appears to be insufficient to meet the targets under the prevailing production conditions. It is sometimes assumed that EU-candidate countries (CCs) have a large, presently unexplored potential to produce biofuels which could be tapped as a way of reaching the indicative biofuel targets within an enlarged EU.

Relevance: The EU is heavily dependent on imported energy resources and especially on oil. Transport is one of the main oil-consuming sector in the EU. Therefore, the EC is developing an alternative fuel policy for transport and in particular for road transport. The EC is proposing biofuels as a viable short-term alternative enabling the energy supply for road transport in the EU to be secured and diversified, and a directive on measures to promote the use of biofuels was agreed on by the Council and the Parliament in March/April 2003. The directive sets out the framework conditions, but needs to be filled out by policies in other areas such as agriculture and by initiatives in the member states.

Introduction

The EU is heavily dependent on imported energy resources and especially on oil. If no measures are taken, the EU's dependence on imported oil could increase to 90% by 2020. Transport is one of the main energy-consuming sectors, responsible for about 67% of the final oil demand in EU, and additionally, it is almost entirely dependent on oil-based products (98%) (EC, 2000; EC, 2002). It is forecast that international energy markets will become increasingly volatile over the next 20-30 years, therefore action needs to be taken now to start addressing a shift in demand away from oil (EC, 2002c). Thus, finding alternative energy sources for transport represents a main challenge for the energy policy of the EU.

Liquid biofuels are considered to be a promising short- and medium-term alternative to conventional automotive fossil fuels because they require little or no modification to current fuel and engine technologies (EC, 2001a; IPTS, 2002a; IPTS, 2002b). Thus, promoting biofuels in road transport has become a priority of the EU energy policies for transport. Indicative target market shares of bio-

The EU is heavily dependent on imported energy resources and especially on oil. If no measures are taken, the EU dependence on imported oil could increase to 90% by 2020

The views expressed here are the authors' and do not necessarily reflect those of the European Commission.

those production levels will require significant input from EU-15, among other things, in terms of crop technology to allow for higher yields.

When assessing the OTP potential, the market situation is not considered. Basically it is assumed that a biofuel market will exist. This could for example be created via obligatory minimum requirements on biofuel content in fossil fuels. Thus, this scenario is not constrained by taxation, agricultural or other framework regulations, affecting the area and as such represents a relatively optimistic scenario.

The potential of the CCs to produce a certain amount of biofuel as a share of the enlarged EU automotive fuel supply is presented in the graphs (see Figures 1 and 2). The absolute shares are accompanied by a curve indicating the "fair share" to be expected from the CCs. The "fair share" is defined as "the expected contribution of a region based on the area of that region as a percentage of the total enlarged EU area". In other words a region covering 10% of the EU-25 could be expected to produce 10% of the EU-25 target. If this target is 5% of transport fuels then this region's "fair share" should be 0.5% of the EU-25's fuel consumption. The Utilized Agricultural Area[1] is used as a measurement of the available cultivatable land.

Biofuel production potential of the CC-10 as part of the EU-25

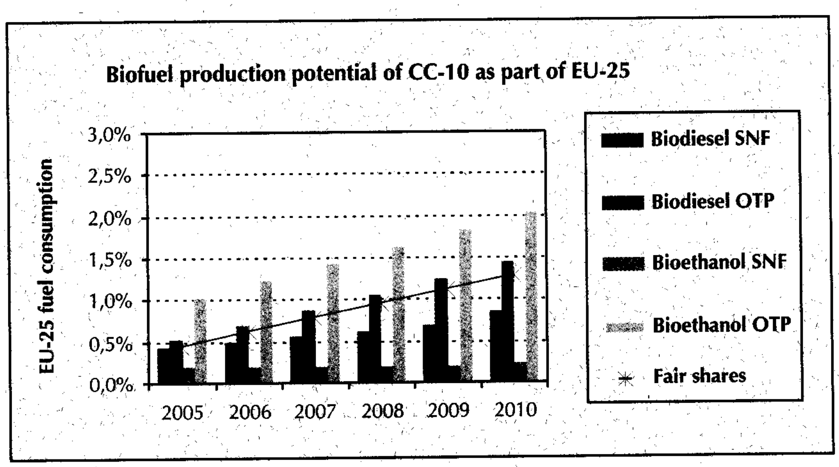
The comparisons of the biofuel potentials of the CC-10[2] with the EU-25's automotive fuel consumption and with the CC-10 fair share in the EU-25's biofuel target are shown in Figure 1.

The following key observations can be made from Figure 1 and the analysis behind it:

- The national forecasts for biofuel production (SNF scenario) are quite modest and well below the fair shares required to meet EU targets – less than 0.9 % for biodiesel and about 0.2% for bioethanol. Modest market expectations certainly play a role here, but another key reason is that the availability of fallow land in the CC-10 is more limited than expected, and because the land which is standing idle, is doing so more due to poor soil quality rather to economic reasons. In addition, six countries from the CC-10 (Cyprus, Estonia, Latvia, Lithuania, Malta and Slovenia) have less favourable climate

The OTP scenario assumes optimal exploitation of all the resources which potentially could be made available for producing biofuels in candidate countries without disturbing their national agricultural balances

Figure 1. Biodiesel and bioethanol production in the CC-10 under the SNF and OTP scenarios, compared to the EU-25 automotive fuel consumption and to the CC-10 fair share in the EU-25 biofuel target, over the period 2005-2010



The national forecasts for biofuel production (SNF scenario) are quite modest and well below the fair shares required to meet EU targets – less than 0.9 % for biodiesel and about 0.2% for bioethanol erate for biodiesel (maximum values of up to around 2%) and relatively promising for bioethanol (up to around 3%) simultaneously.

- As was the case for the CC-10, the national expectations in the CC-12 for the production of biofuels are not sufficient to meet the CC-12's fair shares of the EU-27 biofuel supply. The OTP biofuel output, on the other hand, is generally sufficient to reach the CC-12's fair share of the EU-27 biofuel supply. Compared to the CC-10, the lower biodiesel surplus of the CC-12 is compensated for by a larger bioethanol surplus. Thus, the aggregate "fair share" contribution of the CC-12 to the enlarged EU-27 biofuel supply is larger than the aggregate "fair share" contribution of the CC-10 to the enlarged EU-25 biofuel supply. Thus under optimum conditions agricultural based biofuel production can cover part of the target for the EU-15.

Cost of biofuel production in the Candidate Countries

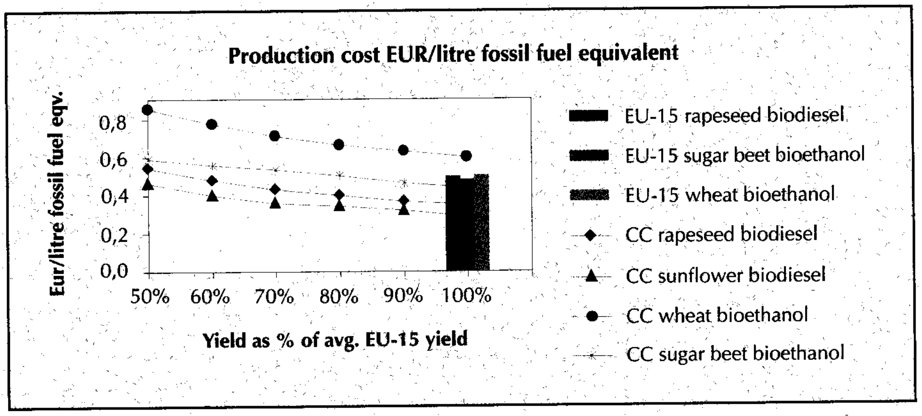
Present production costs –excluding taxes and subsidies– per litre of biofuel in the CCs vary significantly – 0.41-0.75 EUR for biodiesel and 0.36-0.60 EUR for bioethanol. On the other hand, these figures are similar to the average current production costs of biofuels in the EU-15 – 0.56 EUR for biodiesel and 0.36-0.54 EUR for bioethanol. Thus, at present the CCs do not offer cheaper biofuel production compared with the EU-15.

Cultivation costs of the biofuel feedstock constitute around 80% of final production cost of biofuels in the CCs on average. Therefore, the main means of decreasing the overall production costs of biofuels in the CCs are tied to improving cultivation and increasing yields per hectare, rather than to improving post-harvesting processing technologies.

Given the large share of agricultural related costs in the final production cost of biofuel, agricultural parameters plays a significant role for the final price. It is possible to assess the impact of changes in yields on the price. This is illustrated in Figure 3 where production cost as a function of yields of 4 crops compared to the EU-15 average yields (IPTS, 2002a; IPTS, 2002b) are shown.

At present biofuel production costs are not significantly lower in the candidate countries than in the EU-15

Figure 3. Projections of the CCs' biofuel production costs for different feedstocks, depending on the yields as a percentage of the corresponding EU-15 average yields, compared to the average production costs of biofuels in the EU-15 (IPTS, 2002a; IPTS, 2002b). All figures in EUR/litre fossil fuel equivalent[4]



Keywords

EU-candidate countries, biofuels, biodiesel, bioethanol, alternative fuels policy

Notes

1. The Utilized Agricultural Area generally comprises all lands, appropriate for cultivation purposes: arable land, permanent grassland, permanent crops, crops under glass and kitchen gardens (Source: "Statistical yearbook on candidate and South-East European countries – data 1996-2000" EUROSTAT, 2000).
2. The candidate countries are divided into groups based on accession date. The CC-10 represents the 10 countries which signed an accession agreement in April 2003 for accession in May 2004: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia. The CC-12 also includes Bulgaria and Romania, which are expected to join EU around 2007.
3. Due to the long crop rotation period of rapeseed – 5 to 8 years.
4. Fuel economy depends on the energy content of fuels, a parameter which differs from fuel to fuel. In rough terms, it takes 1.1 litres of biodiesel to replace 1 litre of fossil diesel and 1.5 litres of bioethanol are needed to replace 1 litre of fossil petrol. The biofuel costs in Figure 3 are presented in fossil fuel equivalents, in order to make possible comparisons with the production costs of the respective fossil fuels replaced.

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business to develop the technological potential of new processes and products and provide quality research for the U.S. Government. By including qualified small businesses in the nation's R&D effort, SBIR grants are intended to stimulate high-tech innovation to help meet the specific research and development needs of the nation. Under the Act, Federal agencies with extramural research and development budgets over $100 million are required to administer schemes under SBIR by allocating a percentage of their external R&D for awards to small companies to conduct innovative research or research and development that has potential for commercialization and public benefit.

The Small Business Research and Development Enhancement Act of 1992 reauthorized SBIR and raised the percent of their R&D budget agencies are obliged to earmark for grants to small firms from 1.25 percent to 2.5 percent. This increase was consistent with a recommendation from the National Academy of Sciences to increase SBIR funding as a means to improve the U.S. economy's ability to adopt and commercialize new technologies. Most recently, the Small Business Reauthorization Act of 2000 extended the programme again until September 30, 2008. This act also calls for an assessment of the programme's effectiveness by the National Research Council.

Operational Goals of SBIR

The 1982 SBIR legislation set out two broad goals. According to the report language accompanying the legislation[4] (U.S. Senate, 1981) these were "to more effectively meet R&D needs brought on by the utilization of small innovative firms (which have been consistently shown to be the most prolific sources of new technologies) and to attract private capital to commercialize the results of Federal Research." More specifically, the 1982 act creating SBIR listed four programme objectives:

- To stimulate technological innovation
- To use small business to meet Federal research and development needs
- To increase private sector commercialization of innovations derived from federal research and development.
- To foster and encourage participation by minority and disadvantaged persons in technological innovation.

Ten agencies and departments grant SBIR awards totalling some $1.3 billion annually to support a wide variety of federal missions. While large, overall, SBIR is decentralized in terms of the agencies responsible for its implementation. This decentralization reflects the diversity of programme goals and the variety of award recipients covered under SBIR. For example, SBIR awards by the National Institutes of Health (NIH) are often directed towards initiating long-term drug development. Those awarded by the Department of Defense (DoD) by comparison, are often directed towards shorter-term product acquisition and commercial applications. It is important to note that there is important variation across and within agencies. For example, sub-units of large agencies such as NIH and DoD pursue their own distinctive organizational goals. Within DoD alone, these vary from outfitting Special Forces, to supply management, to the development of vaccines to protect troops in battle. Reflecting this mission diversity, each agency typically also has its own manner of initiating solicitations, choosing awardees, and screening for applicants.

Policy Goals of the Programme

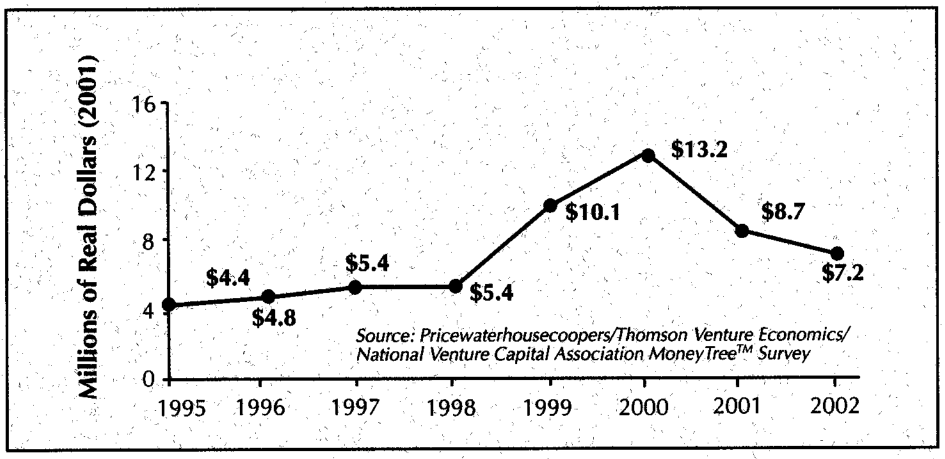
Beyond these operational considerations, SBIR serves the larger policy goal of fostering innovation in the United States. U.S. venture capital markets are often considered broad and deep compared with similar markets around the world. They are nonetheless, subject to asymmetries, and

The SBIR Program was established to encourage small business to develop the technological potential of new processes and products and provide quality research for the U.S. Government

Under the programme, Federal agencies funding research and development are required to set aside a percentage of their R&D budget to provide finance to small companies conducting innovative research and development

Ten agencies and departments grant SBIR awards. Each agency typically also has its own manner of initiating solicitations, choosing awardees, and screening for applicants

Figure 2. Average Real Deal Size (2001 constant dollars)



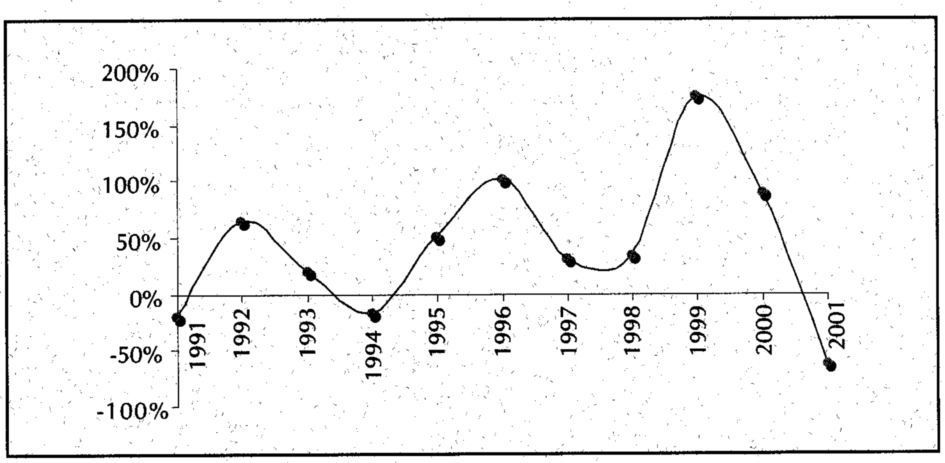
Finally, the cyclical nature of the venture capital market, represented in figure 3, means that funds availability is highly variable. This is even more pronounced in areas that are not seen as offering the same prospects for return in the same time frame as others.

Young companies today are finding themselves increasingly trapped in an innovation system characterized by very slow flow-through and high-risk aversion. At the front end of the system, small innovative firms with promising business models face difficulties in gaining customers and generating revenues due to recent declines in technology spending. At the back end, financial markets have been characterized by sobering valuations and growing lack of liquidity. Venture capital investing has continued to decline from its peak in 2000. Venture capital investing totalled $21.2 billion in 2002, approximately half of the $41.3 of 2001. The inability to move firms to the Initial Public Offering phase on acceptable terms is placing higher demands on funds to sustain existing investments while depriving them of the resources and incentives to invest anew.[6]

In such circumstances, public awards may play an increased role in funding new ideas and new

Given the difficulties innovative start-ups have in raising finance, public awards may play an increased role in funding new ideas and new companies

Figure 3. The Venture Capital Cycle-Year over Year Growth Rates of Venture Capital



SBIR funds the commercialization objectives resulting from the Phase I & II R&D activities. In some Federal agencies, Phase III may involve follow-on non-SBIR funded R&D or production contracts for products, processes, or services intended for use by the U.S. Government.

Programme Effectiveness and Trends

The effectiveness of the SBIR Program rests on its dependability, its competitiveness, the rigor and perceived fairness of the screening process, and the flexibility with which it is administered across the different participating agencies of the government. The programme's design generates positive incentives that enhance its operations and the generation and flow information within and about the programme. (See Table 1.)

Ensuring an environment conducive to innovation among programme managers can contribute to the operational effectiveness of SBIR. For example, on-line proposal submission and proposal management, which agencies such as NASA have adopted, help to reduce paper use, speed the processing of applications, and facilitate tracking of proposals and their evaluation. Electronic management, furthermore, can help make the programme's operations more transparent, thus increasing accountability and the perception of fairness.

Programme effectiveness could also be enhanced through more evaluation of the programme's operation and impact. With some notable exceptions, evaluation has not been a strong point of the SBIR Program's first twenty years. A model in this respect is assessment programme of the US Advanced Technology Program (ATP) where a rigorous competitive selection process is combined with an independent evaluation of the technical and commercial merit of each proposal.[8]

Reaching outside the agency to potential candidates is important. Outreach programmes, where programme managers travel across the country to contact potential grant beneficiaries, are often an important source of awareness about the opportunities of the programme and a source of programme feedback. Information flows within the broader SBIR system also include those conveyed through small business advocacy groups to Congress.

Programme operations are also enhanced when the policies guiding programme operations are—and are seen to be—fair, consistent and reliable. To be perceived as *fair,* SBIR should not be seen a

The effectiveness of the SBIR Program rests on its dependability, its competitiveness, the rigor and perceived fairness of the screening process, and the flexibility with which it is administered

The operation of a programme of this kind is enhanced when the policies guiding it are seen to be fair, consistent and reliable, above all so as to avoid its being construed as a form of political patronage

Table 1. Conditions for SBIR Program Effectiveness

	Improving Motivation	Improving Information
Operational Level	• "Guaranteed" funding for programme • Entrepreneur encouraged to seek award • Agency incentives to obtain mission enhancing technologies • Bottom-up proposals by industry [illegible]	• Outreach to potential applicants • Transparency of decision process • Ongoing project assessment • Certification effect of award to attract private finance
Policy Level	• Public returns on R&D investments • Public support and awareness for benefits of innovation • Public acceptance of rewards to entrepreneurs	• Parliamentary or Congressional interest in and support for programme is enhanced by assessment of programme outcomes and objective selection process • Avoiding "friends of the minister" problem

whether firm failure is indicative of a complete loss on public investment, or if knowledge generated by the SBIR grant is transmitted through other more indirect ways, with benefit to society.

A fourth set of criticisms relate to the issue of selection bias—that SBIR may award firms that already have the characteristics needed for a higher growth rate and likelihood of survival. In relation to this, it has been suggested that a number of SBIR recipients would have followed the same commercialization process even without the award. Recent economic research finds that this criticism is flawed.[10] Moreover, the selection bias issue overlooks two important functions of SBIR. First, by developing and signalling information about hitherto hidden firm characteristics, the programme improves the potential of private capital markets to work better. Second, SBIR awards can serve to motivate a decision to start a firm. As Audretsch *et al.* observe, SBIR "may encourage entrepreneurship by some scientists and engineers who otherwise never would have tried to commercialize their knowledge."[11] The authors also find that "successful science-based entrepreneurs who received SBIR support influence the behaviour of their colleagues by inducing subsequent commercialization." These incentive effects are a result of the programme and do not exist in its absence.

Finally, some analysts take an ideological stance, objecting to the SBIR Program as an unwarranted and unnecessary intervention into capital markets.[12] This assumes levels of information that do not exist in reality. Capital markets, like all real-world markets, are imperfect. Venture capital firms tend to focus on later stages of technology development rather than on early stage firms, and are prone to herding tendencies, as illustrated by the dot-com boom and bust. Further, the attention of institutional private investors also does not penetrate to all nodes of innovation; SBIR increasingly serves as a mechanism to help bring university research to market.[13] SBIR has also been alleged to "crowd out" or replace private capital. This view is fashionable in some economics circles, even though no positive evidence of crowding out exists.[14] To the contrary, there is some evidence that programmes like SBIR can prompt "crowding in" as when these awards serve as a certification—a government endorsement of technical quality—for private investors.[15]

While the standard US criticisms of SBIR may lack traction, one caveat is in order. An SBIR-like mechanism, however useful, does not operate in an institutional and regulatory vacuum. A policy framework conducive to entrepreneurial activity is necessary to maximize the return to this type of programme. Confiscatory taxation, slow-moving bureaucratic decision processes, restrictive regulations, cultural biases against businesses, and negative incentives in universities can all have the unintentional consequence of reducing entrepreneurial activity. By contrast, an entrepreneur-friendly environment can contribute a great deal to firm creation in general, and to the effectiveness of an SBIR-like programme in particular.

The potential of SBIR-like programmes elsewhere

European research is incontestably of high quality. There are many centres of excellence and many prosperous, specialized regions with the ability to capitalize on scientific advances. To bring this research to the market through dynamic new firms, with all the associated social benefits that entails, is a central challenge for European policy-makers. An SBIR-type programme is potentially a valuable policy tool to grow the knowledge economy and to bring the fruits of European innovation and research to market. In the European context, SBIR-like programmes appear to have many advantages:

- SBIR addresses problems in early stage finance—an area poorly understood by policy-makers in many countries, e.g., the United

Another issue is that of selection bias—i.e. that SBIR may award firms that already have the characteristics needed for a higher growth rate and likelihood of survival

Keywords
innovation, small business, government-funded research

Notes

1. The views expressed here are the author's and do not necessarily reflect those of the National Research Council, the operating arm of The National Academies. The author wishes to recognize the important contributions of Dr. Sujai Shivakumar to the preparation of this article.
2. See EURAB Advice 2001-2002, Chapter 5, "Improving Innovation." See also Charles W. Wessner and Sujai J. Shivakumar, "The Role of Macro Targets and Micro Incentives in Europe's R&D Policy," *IPTS* No. 69, November 2002.
3. See National Research Council, *Government-Industry Partnerships for the Development of New Technologies—Summary Report,* C. Wessner, ed., Washington DC: National Academies Press, 2003.
4. U.S. Senate, Committee on Small Business (1981), Senate Report 97-194, Small Business Research Act of 1981, September 25, 1981.
5. See Joshua Lerner, "'Public Venture Capital: Rationales and Evaluation", in C. Wessner, ed. *The SBIR Program: Challenges and Opportunities op sit,* pp. 115-128.
6. See PriceWaterhouseCoopers/Venture Economics/National Venture Capital Association Money Tree Survey", at **http://www.pwcmoneytree.com/moneytree/index.jsp**
7. See Paul A. David & Bronwyn H. Hall & Andrew A. Toole. "Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence," No 7373, NBER Working Papers, 1999.
8. See National Research Council, *The Advanced Technology Program, Assessing Outcomes,* C. Wessner, ed., Washington DC: National Academy Press, 2001.
9. See, for example, Scott Wallsten, "Rethinking the Small Business Innovation Research Program," in Branscomb and Keller, eds., Investing in Innovation. Cambridge, MA: The MIT Press, 1998, pp. 194-220.
10. See Adam Jaffe, "Building Program Evaluation into the Design of Public Research Support Programs," *Oxford Review of Economic Policy,* forthcoming.
11. See David Audretsch, Jeurgen Weigand and Claudia Weigand, "The Impact of the SBIR on creating entrepreneurial behavior," *Economic Development Quarterly* Vol. 16, No. 1, February 2002, pp. 32-38.
12. See, for example, Scott Wallsten, "Rethinking the Small Business Innovation Research Program," op. cit.
13. See National Research Council, *The Small Business Innovation Research Program: An Assessment of DoD's Fast Track Initiative.* C. Wessner, ed., 2000. op. cit.
14. See Paul A. David & Bronwyn H. Hall & Andrew A. Toole. Op cit.
15. See Maryann P. Feldman and Maryellen R. Kelley, 2001, op. cit.
See Magnus Henrekson and Nathan Rosenberg, "Incentives for Academic Entrepreneurship and Economic Performance: Sweden and the United States," Stockholm School of Economics, SSE/EFI Working Paper Series in Economics and Finance No 362, March 7, 2000.
16. See David Audretsch, Jeurgen Weigand and Claudia Weigand, "Does the Small Business Innovation Program Foster Entrepreneurial Behavior? Evidence from Indiana," in National Research Council, *The Small Business Innovation Research Program, An Assessment of the Department of Defense Fast Track Initiative,* 2000, op. cit. See also David Audretsch, Jeurgen Weigand and Claudia Weigand, 2002, op. cit. Finally see David Audretsch, *Innovation and Industry Evolution,* Cambridge: MIT Press, 1995.

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ditional resources to satisfy future peak system capacity and long-term Power Purchase Agreements (Kaslow and Pindyck, 1994).

- *(ii) Fossil Fuel Price Uncertainty*

Conventional electricity production incurs high variable costs and is exposed to oil-price shocks. The result is extended operating cost volatility, which is directly reflected in electricity prices. The use of renewable energy sources (RES) for electricity generation can provide price stability against the risk of fuel price volatility (Venetsanos et al., 2002).

- *(iii) Environmental Regulations Uncertainty*

The uncertainty of conventional production methods has increased, due to the inclusion of externalities (e.g. stringent emission standards) in electricity prices, whereas environmentally friendly production methods, such as use of RES, do not face such an uncertainty.

- *(iv) Initial Capital Cost and Technological Uncertainty*

The initial capital cost uncertainty refers to the initial investment cost, as well as the additions to the installed capacity. Energy projects have to deal with the risk of cost overruns during construction and with increased costs due to project delays.

The technological uncertainty relates to the risk that the installed resources can become economically obsolete, due to technological changes, before capital costs are fully recovered or the investment provides positive cumulative cash flow.

- *(v) Market structure uncertainty*

In a competitive market it may be difficult for producers to pass on to consumers any increase in their production costs unless they affect the industry as a whole rather than a specific production method. The decision to build, operate and own an renewable-energy (RE) generating facility will be influenced by economic parameters relating to the technology and/or to the market structure.

Interaction between Uncertainties and Resource Attributes

Modularity gives the investor the opportunity to assess, after the completion of a segment, the existing situation and decide whether to proceed with the project's next steps immediately or wait. Moreover investors are given the option of stopping construction without incurring a total capital loss, unlike non-modular projects (e.g. natural gas plants), which can only operate upon total completion. During the construction period, therefore, project developers definitely benefit by modularity, as they are required to engage fewer capital resources. Once a segment has been completed, it can start to operate and produce cash flows, which in turn can be used to finance the subsequent segments. Furthermore modular RES installations have greater flexibility in operating and maintaining units and an improved ability to match acquisitions to load growth.

Implementing renewable energy plants in a modular way gives investors the opportunity to assess the situation after completing a segment and decide whether to proceed with the project's next steps immediately or wait

As concerns the *Lead-time*, the time lag between the moment when demand is recognized, the investment decision is made, and the time when the facility is finally brought into operation is usually considerable. RES installations require short construction lead-times that enable developers to make investments in a timely way and constitutes sound protection against both cost overruns and lost revenues due to plant delays. Electricity demand grows at a fairly predictable rate in the long run and a certain period of time is required between demand level identification and the decision-making concerning the installation of new capacity (Hoff and Parsons, 1996).

The *Modularity* and *Lead-time* attributes allow retrospective consideration of the various stages in

The importance of option-strategic thinking in the investment appraisal process lies in extending ROs as a tool for assessing investments to show that future investment opportunities should be viewed as analogous to ordinary call options on securities. So, a discretionary opportunity to invest capital in productive assets (e.g. plant, equipment, etc.) some time in the future is like a call option on a real asset, or a "growth option" (Kester, 1984).

The RO-based approach deals with three components of relevance to decision-makers (Amram and Kulatilaka, 1999):

- Options are an instrument used where decisions are made in the face of uncertainty (i.e. they give the opportunity to decide after incoming information resolves at least part of the uncertainty)
- Option valuations are aligned with financial market valuations, i.e. the RO approach uses financial market inputs and concepts to value complex payoffs across all types of real assets
- Options thinking can be used to design and manage strategic investments proactively in identifying and valuing the options in a strategic investment, in redesigning the investment to make better use of the options and in managing the investment proactively through the options created.

There has been extensive work concerning the determination of the RO value (e.g. Dixit and Pindyck, 1995), which addresses the uncertainty of an investment decision issue and provides the theoretical background for using ROs as a strategic, decision-making and valuation tool. Decision-makers are particularly interested in the range of possible outcomes that the uncertain variable might have when the decision date arrives. The uncertainty of the future outcomes is measured by the volatility, which is calculated as the standard deviation of the expected growth rate (Amram and Kulatilaka, 1999).

A financial call option is the right, but not the obligation, to buy an asset at a fixed price in the future. If the holder of the option chooses to buy the asset- often termed the underlying asset- we say that he exercises the option, paying the fixed exercise price to receive the underlying asset. This would happen only if the market price of the asset is higher than the exercise price on the maturity-exercise date.

An RO is similarly defined but is more general. An investment opportunity (e.g. building a plant) is like a call option where the management has the right, but not the obligation, to acquire the assets of an operational project. The irreversible investment cost that is committed at the outset of the investment project plays the role of the exercise price and the real asset is the project once this starts producing cash flows. Although this cost keeps the investor in the game, because it gives him the option to benefit from future upward movements in underling asset prices, and to make additional investment decisions, it keeps significant cash flows frozen, the opportunity cost of which should be paid, e.g. in the form of loan rates and/or loss of other alternative investment prospects.

The RO approach treats an investment opportunity as being like a call option where the management has the right, but not the obligation, to acquire the assets of an operational project

The value of a call option can be calculated using the "Black-Scholes Option Pricing Model" (Hull, 1989). The decision whether to implement the project immediately or wait depends on the incoming information. When we give up the option to wait, we can no longer take advantage of the future value volatility of the project, since volatility is the attribute that generates the upside potential. During the period when NPV is positive, we are eager to exercise the option if we consider that the cash flows produced are high enough.

- *(ii) ROs inherent within RES projects*

The static DCF methods fail to capture the dynamic aspects of investment assessment. The principal uncertainties that influence the forecasted Cash provide optimal solutions. RES projects are endowed with certain attributes (modularity and short lead-time) that enhance their flexibility.

The evaluation of the benefit of this flexibility requires capturing the dynamic nature of demand growth. Given that lead-time of the RES facility is only one year, developers have ample time to recognize whether demand changes over time represent a permanent trend and then decide to install new capacity. A typical static approach is to make forecasts and build scenarios with high, average and low demand levels. The weakness of this approach is the lack of recognition that demand can grow or not. At each point in time we have the following decisions to make:

- Recognizing whether the demand growth pattern is the actual trend. Invoking probabilities, we get as a result a binomial distribution of how demand may grow. If we consider that demand might grow, we decide to proceed with the new capacity installation. Short lead-time allows forecasts for the near future, which is rather safe.
- Having decided the capacity installation, the next step is to determine the size of the new investment. The modularity and short lead-time allow adding new capacity when the trend of demand growth has been established and the

[illegible] generation project
[illegible] horizon, with initial outlay in the first three years and income [illegible]

[illegible]	[illegible]	10
[illegible]	[illegible]	
[illegible]	[illegible]	1400
[illegible]	[illegible]	-600
[illegible]	[illegible]	800

[illegible] each stage.

[illegible]	[illegible]	10
[illegible]	[illegible]	400
[illegible]	[illegible]	
[illegible]	[illegible]	400

[illegible] is discounted at the risk free rate since part of the initial [illegible]

[illegible]	[illegible]	10
[illegible]	[illegible]	400
[illegible]	[illegible]	
[illegible]	[illegible]	400

[illegible] the option to defer.
[illegible] = 2428
[illegible] = 1721
[illegible] = 5.89%
[illegible] = 3

[illegible] = -405
[illegible] *NPV*
[illegible] *NPV = 683 + (-405)= 278*
[illegible] of the project is greater than the Value of option to wait"
[illegible] Option Value = 683

Keywords

renewable energy technologies, call options, uncertainty, real options

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organizing and processing all the information necessary to assess the current status of the environment in order to plan its future sustainable development.

It is interesting to think of a GIS as an observatory of territorial transformations: a sort of *dynamic container* for very different kinds of data and information with which to develop applications for the planner's needs. With the philosophy that 'better information leads to better decisions', a GIS can contain several levels of knowledge to assist decision-makers in devising solutions to the problems they face, it can be equipped with user-friendly interfaces, it can be used as a communication medium to share information, and it can give public access to digital data archives.

These features of a GIS make it accessible to decision-makers in a way that allows them greater interaction with spatial analysis tools (cf. examples in cases of integrated coastal zone management, soil strategy or the environment).

A Geographic Information System (GIS) is a computer-based tool that enables users to perform spatial analyses through digital representations of a geographic area, combined with other geographically referenced information existing on the same area. Different data on such features as coastal areas, river basins, etc., plus social and statistical information, are loaded into the GIS, manipulated, and modelled for data mapping and analysis.

GIS technology integrates common database operations, such as queries and statistical analysis, with the unique visualization and geographic analysis benefits offered by dynamic maps. Moreover, with GIS technologies it is possible to link to the geographic data, to place the data online, and to analyse a remarkable number of statistical indicators, with the possibility of ascertaining the types and amount of human activities in the area under evaluation (Caiaffa,1999).

The *concept of using geographical presentation* for social data analysis (Salvemini, 1999) is beginning to play an important role in the decision-making process. Policy-makers have come to understand that in planning sustainable development, the introduction of geographic information can help reveal important features and patterns of certain key social aspects that would remain hidden in a conventional data representation. In the last few decades, more efforts have been made to improve the potential of GIS tools, bringing them to the stage where GIS can be defined as 'a decision support system that integrates spatially referenced data in a problem-solving environment.'

Geographic Information: A common language for a knowledge-based society

To decide which tools can best supply the answers that policy-makers need, we can see the GIS as a tool for producing dynamic information conducive to an integrated understanding of a knowledge-based society. To assess European phenomena, studying current social phenomena to forecast their possible socio-economic consequences it is necessary to have the relevant data on hand. If such data are geo-referenced, they take on the value of territorial information, with all the implicit advantages of a vision tied to the territory. In this sense, GIS can furnish a support tool for the priority thematic research areas established in the 2002-2006 FP6 programme, in which, besides the thematic areas regarding "Sustainable Development and Global Change," a clear sign of innovation can be seen in the newly-included theme "Citizens and Governance in the European Knowledge Society."

A GIS created at the regional or European level with specific appropriate characteristics could therefore be an innovative tool capable of:

- improving the generation, distribution and use of knowledge and its impact on economic and social development;

A Geographic Information System (GIS) is a computer-based tool that enables users to perform spatial analyses through digital representations of a geographic area, combined with other geographically referenced information existing on the same area

Policy-makers have come to understand that in planning sustainable development, the introduction of geographic information can help reveal important features and patterns of certain key social aspects that would remain hidden in a conventional data representation

Such an approach to setting up a new knowledge-based society implies that it is linked to a territorial view of socio-economic problems. To this end, remote sensing technologies can be combined with GIS facilities. Since satellite data for different areas are collected at regular intervals, processed by identical methods, integrated and correlated with conventional geographic information in a GIS, multi-temporal and comparative analysis can be performed on the same areas at different times.

Remote sensing has already become an important source of geographic information used to monitor land cover transformations and use. Such information is essential for the sound development and sustainable management of agricultural and forestry resources and for environmental protection. Remote sensing technologies offer the possibility of collecting large amounts of data over wide areas, and the advantage that the costs of such operations can be shared by different countries for both their regional research and their participation in European programmes.

Remote sensing data can be used for clearer and more detailed area characterization in which satellite images furnish an immediate and updated view of human activities, changes in land use, real-time identification of the origin and extension of natural disasters, industrial pollution, oil spills at sea, etc. The linkage of such remote-sensing information with population data, road maps, hospital locations and similar relevant data in a GIS can furnish a unique tool to help manage emergencies, organize all kinds of actions, and solve future planning problems.

Future research

Using a geographic tool in the process of designing policies to solve social problems has at last become an established idea because GIS technologies have narrowed the distance between scientists and policy-makers. They offer a realistic way to identify and understand the different environmental and socio-economic mechanisms in play and how they intersect with each other, and to evaluate multiple scenarios depending on such processes.

With contributions from multiple disciplines and skills integrated and entered in a GIS, it is possible to set up specific studies to achieve the following results:

- identify a set of new social indicators to characterize the rapid changes in European society;
- collect, distribute and use this new type of geographic knowledge in a single standardized format;
- enable assessments and comparative studies of multiple socio-economic aspects that influence the quality of life in the European Union.
- monitor a large number of social indicators/ variables in order to better understand socio-economic changes and quality-of-life changes/ losses in European cities and fast-changing areas;
- create a reliable instrument that, based on the mass of data collected, processed, interpolated and interlinked in a territorial context, can indicate the conditions that European populations can expect to materialize;
- lead to the formulation, at the EU level, of precise rules for geographical data/knowledge acquisition, maintenance, use and dissemination.

Conclusions

Building knowledge in a knowledge-based society requires large quantities of data. These data may be heterogeneous and thus appear fragmentary and difficult to interpret. Exploiting the geographic component embedded in any type of data could be a good way to integrate, correlate, understand and disseminate knowledge. Integrating, intersecting and aggregating different types of information according to their common geographic reference could be a new way to transform available information into knowledge (cf. the European

Linking remote-sensing information provided by satellites with population data, road maps, hospital locations and similar relevant data in a GIS will furnish a unique tool that can help manage emergencies

Keywords

knowledge-based society, assessment, Geographic Information Science, GIS technologies, mapping rapid changes in European society

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The mission of the Institute is to provide techno-economic analysis support to European decision-makers, by monitoring and analysing Science & Technology related developments, their cross-sectoral impact, their inter-relationship in the socio-economic context and future policy implications and to present this information in a timely and integrated way.

The IPTS is a unique public advisory body, independent from special national or commercial interests, closely associated with the EU policy-making process. In fact, most of the work undertaken by the IPTS is in response to direct requests from (or takes the form of long-term policy support on behalf of) the European Commission Directorate Generals, or European Parliament Committees. The IPTS also does work for Member States' governmental, academic or industrial organizations, though this represents a minor share of its total activities.

Although particular emphasis is placed on key Science and Technology fields, especially those that have a driving role and even the potential to reshape our society, important efforts are devoted to improving the understanding of the complex interactions between technology, economy and society. Indeed, the impact of technology on society and, conversely, the way technological development is driven by societal changes, are highly relevant themes within the European decision-making context.

The inter-disciplinary prospective approach adopted by the Institute is intended to provide European decision-makers with a deeper understanding of the emerging S/T issues, and it complements the activities undertaken by other Joint Research Centres institutes.

The IPTS collects information about technological developments and their application in Europe and the world, analyses this information and transmits it in an accessible form to European decision-makers. This is implemented in three sectors of activity:

- Technologies for Sustainable Development
- Life Sciences / Information and Communication Technologies
- Technology, Employment, Competitiveness and Society

In order to implement its mission, the Institute develops appropriate contacts, awareness and skills for anticipating and following the agenda of the policy decision-makers. In addition to its own resources, the IPTS makes use of external Advisory Groups and operates a Network of European Institutes working in similar areas. These networking activities enable the IPTS to draw on a large pool of available expertise, while allowing a continuous process of external peer-review of the in-house activities.