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The IPTS REPORT

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C O N T E N T S

data samples must be taken into account, wage effects must not be confused with returns to education, etc.

An interesting methodological innovation were the studies conducted in the nineties by Ashenfelet and Krueger (1994), Rouse (1999), and others in which they studied returns to education for twin brothers and sisters. In these studies, and for the US, the overall rate of return to investment in education is still roughly around 10 percent. An area which calls for further analysis and research is the production of convincing and converging estimates of social rates of return, which go beyond private ones (and their summation across the population), including social benefits not appropriable by a single individual - externalities, spillover effects. They are hard to identify and harder to measure. Here more work can be done to help inform policymaking in the area.

Note

1. George Psacharopoulos and Harry Anthony Patrinos, "Returns to Investment in Education: A Further Update", World Bank Policy Research Working Paper 2881, September 2002, JEL codes: C13, J31 (which includes a full bibliography on the issue).

Contact

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[illegible] IPTS Study on the Impact of Technological and Structural Change on Employment

[illegible] study commissioned by the Committee on Employment and Social Affairs of the [illegible] examined the role of technology in the economy of the EU and its impacts on [illegible] "Impact of Technological and Structural Change on Employment: Prospective analysis [illegible] Report" (EUR 20258). The IPTS applied a combination of qualitative and quantitative [illegible] collaboration with the European Science and Technology Observatory (ESTO) network [illegible] guidance of the IPTS High Level Economist Group (HLEG) comprising Nobel prize winner [illegible] and professors William Branson, David Ulph, Jean Jacques Laffont and Christian von [illegible] point of the work in this study was the Technology and Employment Maps of [illegible] project, which identified the main emerging technological developments and their [illegible] employment. The potential impact of these technologies on productivity growth and [illegible] was estimated using theoretical and empirical evidence. These estimates were [illegible] for two established simulation models in order to quantify the impact of these [illegible] developments in terms of economic growth and employment under various alternative [illegible] scenarios.

[illegible] reinforce the argument that technological development stimulates economic growth [illegible] in the EU. Technology policy can be one of the keys for achieving the [illegible] social and environmental policy, and a valuable instrument in achieving the [illegible] Society", as defined at the Lisbon Summit.

[illegible] of the study suggests that a limited increase in R&D spending can lead to a [illegible] GDP and employment levels, provided that certain complementary measures [illegible] new technologies are often accompanied by structural changes, concerted [illegible] necessary in order to exploit the full potential of new technology and ensure that [illegible] share in the benefits. In particular, policy measures in the areas of education [illegible] laws and regulations, and incentives for innovation and investment are of [illegible] The study addressed the following basic questions concerning the impact [illegible] and structural change on employment over a 20 year time-horizon:

- **[illegible] will offer high growth potential and quality jobs?**
- **[illegible] will have a significant impact in those sectors?**
- **[illegible] will be required to match the needs of those sectors and technologies?**
- **[illegible] impact of emerging technologies on the organization of work and job profiles?**
- **[illegible] the impact of selected innovation and technology policy strategies under different [illegible] conditions?**

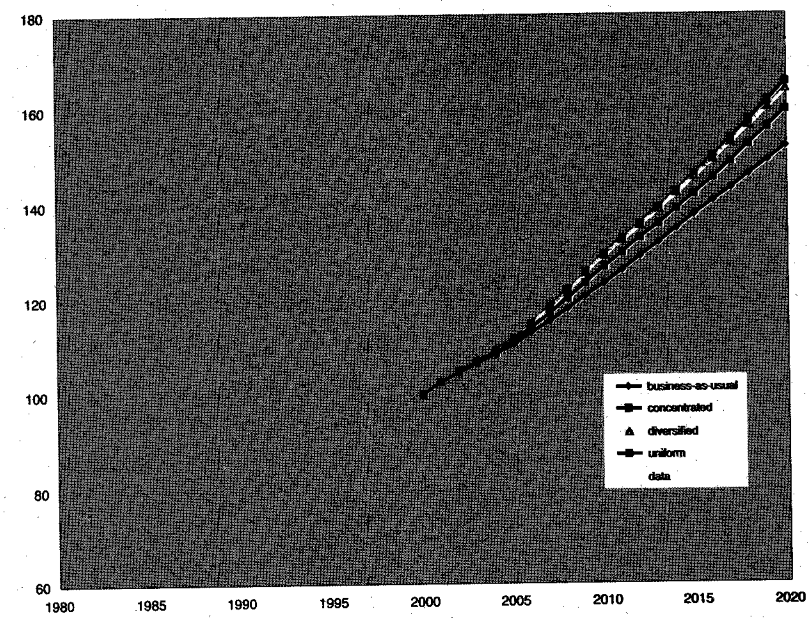
[illegible] technology was analysed under four alternative policy-driven scenarios. Each scenario [illegible] of technology policy that led to different results for economic growth and [illegible] and regional level.

[illegible] the analysis

- ***[illegible]" scenario:*** Innovation and RTD expenditure follows current patterns and [illegible] share of GDP. Productivity growth per sector and region is in line with OECD [illegible]
- ***[illegible] technology policy" scenario:*** The increase in innovation and RTD efforts is [illegible] technologies (electronics, telecommunications, genetic engineering, [illegible] & space applications). The affected sectors that demonstrate [illegible] growth mainly include electronic equipment, services, high-tech [illegible] equipment and chemicals.
- ***[illegible] policy" scenario:*** The increase in innovation and RTD efforts is [illegible] that are currently showing strong performance, taking regional specialization [illegible] Efforts are concentrated on research fields pertinent to advanced materials, [illegible] and ICTs. The affected sectors include chemicals, equipment manufacturing, [illegible] transport and communication services, food industry and services.
- ***[illegible] policy" scenario:*** Innovation and RTD spending increases uniformly [illegible] all technologies and sectors. Each sector increases its productivity [illegible] to its use of emerging technologies.

5
Innovation and Technology Policy

Figure 1. Total GDP, EU-15 (constant prices, year 2000=100)



of the sector. This higher income is transformed into new consumption that generates employment in other sectors. A second, though weaker, compensation mechanism is the increased consumption of a sector's products as a result of the lower prices brought about by higher productivity. The simulations mentioned above show that these are the two main compensation mechanisms for the EU economy as a whole and imply that productivity growth does not, in principle, reduce overall employment levels.

In the business-as-usual scenario, total employment levels are expected to undergo moderate growth over the next 20 years and to increase by 5.6%. This increase corresponds to a (long-term) ratio of employment growth to total GDP growth of about 0.1, comparable to the figure for the EU economy over the period 1980-2000[2]. This relatively low level has been a key characteristic of the EU economy, especially if compared to the much higher one of the US (although at the other end of the spectrum, that of Japan is almost zero).

The three alternative scenarios suggest a further increase in the number of jobs with respect to the business-as-usual scenario. Although the impacts on employment at a sectoral level do differ, *the impact on total employment is still relatively low* compared with the employment levels of the year 2000. The total labour supply is to a large extent independent of the technology policy; the labour supply and demand reach an equilibrium that corresponds to the level of real wages. Real wages are expected to increase in 2020 compared to 2000, and are expected to be higher in all the alternative scenarios in comparison with the business-as-usual scenario as a consequence of higher productivity. The extent to which productivity growth will be reflected in real wage growth depends on the labour market structure and regulation, bargaining processes, etc. The "concentrated" and "diversified" scenarios demonstrate this more clearly: they are expected to lead to an increase in employment levels by 2.85 percentage points and 2.77 percentage points, respectively, compared with the business-as-usual scenario.

In the business-as-usual scenario, total employment levels are expected to undergo moderate growth over the next 20 years. The alternative scenarios suggest a greater increase in the number of jobs the labour supply matches the required size and quality. Two critical issues can be identified: the availability of sufficient numbers of employees with the required skills, and the conversion of the skills of employees moving from contracting to expanding sectors (skills mismatch). An issue that deserves further study is the responsiveness (elasticity) of skills conversion to changes in wages.

The demand for skilled workers is expected to increase faster than that for non-skilled workers. Indeed, the *technology-induced skill bias* has caused increasing unemployment rates of unskilled workers in continental European countries and stronger effects on the wage dispersion between the skilled and unskilled in the US and - to a lesser extent - in the UK. *There is already evidence of a growing skill bias in manufacturing, and research suggests that future growth in services will also demonstrate that tendency.* A main impact of the skill-bias that should be taken into account is the worsening social and economic position of the unskilled.

The demand for skilled workers is expected to increase faster than that for non-skilled workers, continuing the already growing skill-bias in manufacturing

Economic sectors and employment growth: summary of results

All the scenarios predict that employment growth will be concentrated in the services sector. Agriculture is expected to continue to lose its share of total employment, while manufacturing seems to be stabilizing, with some sub-sectors even increasing their share of employment. Electronic equipment, often considered a promising sector, is not expected to take on an important role as regards employment levels, since the predicted impact of labour productivity growth in the sector is higher than the predicted impact of growth in consumption of its products.

The sub-sectors where employment growth is expected to be more significant—though the extent of the impacts also depends on the specific scenario—include the following:

- Trade and commerce
- General business services (including data processing, advertising and general technical services)
- Healthcare
- Entertainment (including electronic media and recreational services)
- Catering and other food and drink services (restaurants, cafes, etc.)
- Education
- Transport services, storage, warehousing and logistics
- Construction
- Tourism
- Financial services, insurance and legal services
- Transport equipment
- Communication services
- Social and related community services
- Manufacturing of special industrial machinery
- Specialized manufacturing (fashion items, furniture, jewellery, scientific equipment, etc.)

A summary of the results of the scenario analysis exercise is given below in question-and-answer form:

Q.1 Which economic sectors will offer high growth potential and quality jobs?

The sectors where employment growth is expected to concentrate—though the extent of the impacts also depends on the specific technology policy—include trade and commerce, financial services & general business services, healthcare, entertainment and recreational services, catering & food and drink services, education, transport and logistics services, construction, tourism, transport equipment, communication services, social and related community services, manufacturing of special industrial machinery, and specialized manufacturing (fashion items, furniture, jewellery, scientific equipment, etc.).

All the scenarios predict that employment growth will be concentrated in the services sector, with employment in manufacturing stabilizing somewhat and that agriculture continuing to decline and regional characteristics of the EU economy are taken into account. In addition, technology policy has to be accompanied by suitable supply-side policies in the labour market, as well as measures in the fields of education and training, immigration, fiscal and monetary policies, capital markets and product market regulatory policies, investment incentives and social protection.

Conclusions

Simulation results reinforce the argument that technological progress is a central option for EU firms and, more generally, economic entities, to maintain competitiveness at the international level. Since the potential for the EU to compete in labour intensive sectors is very limited, the most viable option appears to be that of increasing the EU's share in the technology intensive sectors. In addition, technological progress can lead to higher wages and improved quality of work, thus allowing a higher standard of living. Seen in the context of the overall EU policies, technological progress can be the key for achieving the objectives of economic, social and environmental policy, and the main tool to reach the goals of the 'Knowledge-based Society' as defined in the Lisbon Summit. Especially as regards the recent Communication from the European Commission concerning the increase of R&D spending to 3%, the study's results confirm the positive relationship between R&D spending and economic growth.

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Panayotis Christidis is a Civil Engineer and holds a PhD from the University of Thessaloniki (Greece). He is currently a postdoctoral researcher at the IPTS in the Transport and Mobility Group. His research interests include transport economics and transport policy issues, focusing on the interaction between transport infrastructure and economic development.
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Clean Technologies in Europe: Diffusion and Frontiers

Ignacio Calleja, Josefina Lindblom and Oliver Wolf, *IPTS*

Issue: The concept of sustainable development advanced by the World Commission on Environment and Development and popularized at the 1992 Rio Earth Summit stresses the interdependence of the economy and the environment. On the one hand, advances in technology and economic growth are needed to solve environmental problems, but on the other, this economic growth cannot be sustained if the natural resource base is degraded as a result.

Relevance: Clean technologies that lower the costs of environmental protection can play a significant role in achieving sustainability goals. Such technologies can help meet increased demands for a cleaner environment by reducing the environmental impact of economic growth while, at the same time, they reduce the impact of higher environmental standards on GDP growth itself.

Introduction

Clean technologies can play an important role in de-coupling negative environmental impacts from economic growth. Consequently, there are strong and natural links between the European Union Lisbon Strategy for a competitive, dynamic and inclusive Europe and the Göteborg strategy for a sustainable Europe. Fostering technological progress and renewing the EU's capital stock are major objectives in this context. Against this backdrop, this article examines the pace at which newly developed clean technologies are being adopted by industry, whether their potential finally is being exploited to the full, and what barriers and obstacles this process confronts. In this article these issues will be addressed by introducing the main drivers for the adoption/implementation of clean technologies and focussing the analysis on the uptake of clean technologies in the cement and the pulp sectors in Europe.

Today's significant uptake of clean technologies is driven by a confluence of environmental, technological, economic and social forces. Firstly, the globalization of markets is both increasing overall demand and bringing new

The adoption of clean technologies is driven by various forces, including changes in markets, technological developments and social pressures

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

75% of production is based on dry processes due to the availability of dry raw material in most countries, with the exception of Denmark, Belgium, and to some extent, the UK.

The cement industry is an energy intensive sector with energy typically accounting for 30-40% of production costs (excluding capital costs)[2]. Therefore, there are strong economic and environmental reasons for using energy efficiently and to reduce energy costs. The optimization of energy use in existing plants has been largely utilized[3]. The typical fuels used by this sector are: petcoke, coal, fuel oil, lignite, gas and various types of waste.

Most general primary measures trigger reductions both in production costs and atmospheric emissions (see Table 1). In many cases there is scope for offsetting increased investment costs through savings from better process efficiency in terms of use of energy, raw materials, labour as well as improved product quality, higher value added products, better product consistency and reduced waste disposal requirements.

Another option for reducing the environmental impact of the cement industry would be the reduction of the clinker portion, which can be replaced with industrial by-products such as coal fly ash (a residue from coal burning), blast furnace slag (a residue from iron making) or other pozzolanic (e.g. volcanic) material[4].

Cement plants situated in European countries that have rigorous national environmental regulations have to implement primary and/or secondary measures to achieve the required emission levels and these measures have to be implemented irrespective of size, ownership and cost situation. Firms operating under stricter environmental regulations

The cement industry is an energy intensive sector with energy typically accounting for 30-40% of production costs. There are therefore strong economic and environmental reasons for using energy efficiently

Table 1. Primary measures in the cement industry

Primary measures	Unit production costs	Air emissions	Clinker quality
Process control optimization	Decreased	decreased	improved
Modern, gravimetric solid fuel feed system	Decreased	decreased	improved
Preheating and precalcination to the extent possible	Decreased	decreased	improved
Modern clinker coolers	Decreased	decreased	improved
Heat recovery from waste gases	Decreased	decreased	improved
Power management systems	Decreased	decreased	improved
High energy efficiency of electrical equipment	Decreased	decreased	improved
Use of raw materials and fuels with low pollutant contents	Mostly increased	decreased	Mostly improved

Source: Cement BREF Document 2001. The impact of BAT (best available technologies) on the competitiveness of the European cement Industry. Wagner K. Triebswetter U. 2001 the study on best available technologies (BAT) and the impact on competitiveness for the European industry conducted at the IPTS[6].

A number of important measures to reduce emissions have been introduced in recent years and examples of relatively new and more widely spread clean technologies on the water side include modified cooking, oxygen delignification, ECF (elemental chlorine free) bleaching, purification and reuse of condensates and secondary (biological) waste water treatment. All except the last one are process integrated technologies.

Most process-integrated measures can also have a positive impact on the quality of the final product, process efficiency and profitability and in addition to regulation and environmental reasons, quality and cost also drive investments. These measures often result in better usage of energy and raw materials, which of course has a positive effect on both costs and the environment. Table 2 summarizes the findings for modified cooking when interviewing 21 kraft pulp producers in the EU (11), Canada (7) and Brazil (3).

Table 2 shows how cost and quality play an important role in the decision to invest in modified cooking. With reduced or unchanged operating and production costs, significant environmental improvements could be achieved without losses in competitiveness, market share or profitability. In the case of an end-of-pipe measure such as secondary treatment, the result is naturally different but often enough for competitiveness to be kept unchanged (see Table 3). The companies visited are all actors on the global market and face competition from all around the world.

Diffusion of Clean Technologies

The extent to which the different Clean Technologies are implemented varies from one technology to another. While dry debarking,

Paper and board are used for a variety of applications. Demand growth is expected to continue and may accelerate as certain types of paper and board products are used to replace other packaging materials

Pulp is produced from a variety of materials using a range of processes, all of which have their own particular pros and cons from the environmental point of view

Most process integrated measures in the pulp and paper industry can also have a positive impact on the quality of the final product, process efficiency and profitability

Table 2. Main drivers for, and effects of, modified cooking for kraft pulp producers

	Europe	Canada	Brazil
Main drivers	cost, regulation, quality	cost, environment, quality	market, quality, cost
Capital cost	5 million euros		21 million euros, together with oxygen delignification
Operating cost	unchanged/reduced	unchanged/reduced	reduced
Process efficiency	increased/unchanged	increased	increased
Capacity	increased/unchanged	unchanged	increased/unchanged
Product cost	reduced/unchanged	reduced/unchanged	reduced
Competitiveness	unchanged (1 increased)	unchanged (1 increased)	increased
Market share	unchanged (1 increased)	unchanged (1 increased)	increased
Profitability	unchanged (1 increased)	unchanged or increased	increased

at least neutral) impact on profitability for most investments. On the other hand, the poorer performers reported very few clean technologies as having a positive effect and, actually, four of the technologies had a positive impact on business for the good environmental performers while the very same four ones caused a negative impact among the poorer performers.

Interestingly, the study also revealed that the best environmental performers claimed that their main driver is not regulation but reducing costs through environmental efficiency. Although this could be motivated by these companies' taking a long-term view so as to avoid future costs in terms of taxes, fines or having to invest in other, more expensive, clean technologies to follow regulation, it is interesting that these companies do not look at themselves as regulatory driven and they have a positive attitude to investments of this kind.

Trends

Because of the fact that a kraft pulp mill should be a net producer of energy and a paper mill is an energy consumer (with all the energy needed for separating the water from the product), integrated mills (where pulp and paper are being produced at the same site) will in many cases support sustainable production. This is an on-going trend and not only for energy reasons but also due to the fluctuation in pulp price which can create problems for non-integrated paper mills.

Other trends are pointing in the direction of increased system closure combined with the use of

Clean technologies in the pulp and paper industry are particularly expensive and levels of adoption vary widely

The case studies revealed that firms whose environmental performance is good stated other reasons for adopting clean technologies than regulation much more often while, on the other hand, regulation is still the most common driver for firms with a poorer environmental profile

Table 4. Summary of drivers and impacts on profitability for the EU and Canada (kraft pulp producers)

	Good env. performers Regulatory driven investment	Good env. performers Non-regulatory driven investment	Not good env. performers Regulatory driven investment	Not good env. performers Non-regulatory driven investment
Positive impact on profitability		Modified cooking, Oxygen delignification, Mitigation of TRS, Reduction of SO2 from the RB, Dry debarking, Brown stock washing, Evaporation	Brown stock washing, Evaporation	Dry debarking
Neutral impact on profitability	Control of NOx from RB	Reuse of condensates, Spill monitoring, Reuse of cooling waters, Electrostatic precipitators	[illegible], Spill monitoring, Control of NOx from RB, Electrostatic precipitators	Reuse of cooling water
Negative impact on profitability	Primary treatment, Secondary treatment, Concentrated malodorous gases		Primary treatment, Secondary treatment, Concentrated malodorous gases, Modified cooking, Oxygen delignification, Mitigation of TRS, Reduction of SO2 from the RB	

- *Ability to tackle adverse events.* The progress and success of an innovation project is inevitably threatened by adverse events, such as scientific or technical problems, difficulties in project management, insufficient resources for the innovation project, lack of support for the innovation project, critical economic situation of the company, changes in market situation etc. Therefore, the ability to prevent, manage and "survive" such difficult phases is important to the successful completion of an innovation project.

Conclusion

Looking at the two sectors discussed in this article, it can be stated that the uptake of clean technologies depends on a broad range of different factors. The basic and overriding requirements are the economic viability and/or support through the regulatory framework. In other words, a new technology not only has to be cleaner, but also to make a product cheaper and better. Environmental friendliness is almost seen as an extra. However, environmental management guidelines, as well as social pressure, make it virtually impossible to replace any given technology with a dirtier one. Probably it is for this reason that new technologies coming on to the market are almost a priori cleaner than comparable existing ones.

It is widely accepted that regulatory incentives and economic feasibility exert the strongest influence as "triggers" for the uptake of clean technologies. However, a range of "softer" factors also exists which have a more indirect, but nevertheless strong impact on the decision for or against clean technologies. These include the awareness of a new technology, the skills available within a company, the company's attitude towards innovation, its size, and the perception of the expected cost/benefit ratio. A good example of indirect and more general causes (more active in R&D) and effects (environmentally friendly producers fare better in other, non-environmental respects) is the pulp case. However, results of this kind could differ greatly between sectors.

As a general finding for policy-makers it can be said, that there is a need to address the soft factors described above in order to achieve the greater adoption of clean technologies within industry. In particular it will be helpful to foster education in the area of new technologies at an early stage, so as to ensure a suitably skilled workforce is available to companies. Additionally, the realization of pilot and demonstration projects with new technologies would make it easier to calculate the cost/benefit ratio for potential technology-users.

Finally, specially designed technology subsidies or credits would make it easier for companies (especially SMEs) to cope with emerging technical/scientific problems when setting up a cleaner production process.

The adoption of a clean technology can be influenced by how aware managers are of the technology, the perceptions of its costs and benefits, the availability of suitable skills and expertise, and the company's ability to tackle adverse events

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Ignacio Calleja is a Environmental Chemist and holds two MSc in Environmental Management and Technology from the University of the Basque Country (Spain) and Environmental Chemistry from the University of Edinburgh (Great Britain). He is currently a post-doctoral researcher at the IPTS in the Environment group and also collaborates with the Energy and Climate Change group. His research interests include industrial clean technologies focusing on its diffusion and implementation process and its techno-socio-economic impact.

The role of Macro Targets and Micro Incentives in Europe's R&D Policy

Charles W. Wessner and Sujai J. Shivakumar, *National Research Council*, USA*

Issue: At the March 2002 meeting of The European Council in Barcelona, the Council set an ambitious objective of increasing the Union's global research expenditure to approach three percent of Gross Domestic Product by 2010.[1] Achieving this three percent target is intended to place the European Union on par with the United States and Japan in terms of overall R&D expenditure. This policy is expected to promote a more robust knowledge economy and to boost European competitiveness in high technology industries.

Relevance: The Presidency Conclusion notes that "in order to close the gap between the EU and its major competitors, there must be a significant boost of the overall R&D and innovation effort in the Union, with particular emphasis on frontier technologies."[2] US experience underscores the importance of micro-level incentives in boosting the effectiveness of setting targets for overall R&D expenditure.

Introduction

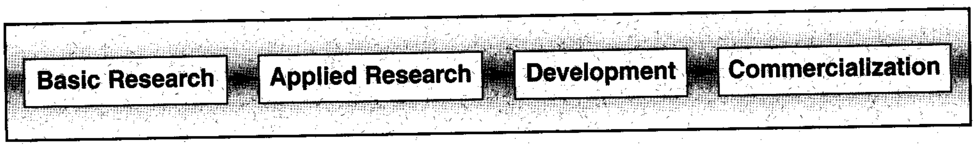
This article looks at the issue of setting targets and creating incentives for R&D expenditure from two perspectives. First, we examine some of the standard underlying assumptions about innovation and market behaviour. Second, since it is explicitly cited as a comparison, we look at recent U.S. experience to see what, if any, U.S. policy lessons might apply to Europe. In general, we suggest that these considerations reveal that, drawing on the US experience, it is very important that numerical targets be accompanied by policies and action focused on the incentives and intermediating institutions designed to facilitate innovation.

Europe's 3% Target for R&D

Recent benchmark indicators, published by the European Commission, find that European public and private expenditure levels (taken as an average) are lower than those in the United States and Japan.[3] While recent data show that the share

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

Figure 1. The Linear Model of Innovation



The linear model creates the impression that increasing public and private investments in research will result in greater commercialization, strengthening, in turn, competitiveness in global markets. While useful in general discourse and elegant in exposition, it is easy to forget that this simple model severely understates the complex interactions that actually take place within the innovation process.[7] In the real world, distinctions between basic and applied research are rarely clear cut; often it may simply depend on the researcher's intent. Many discoveries have a serendipitous element. Much learning occurs by trial and error. Many good ideas simply do not make it to the market place. The process from discovery to innovation to commercialization involves consecutive challenges and market signals that can often be indistinct or even absent.[8]

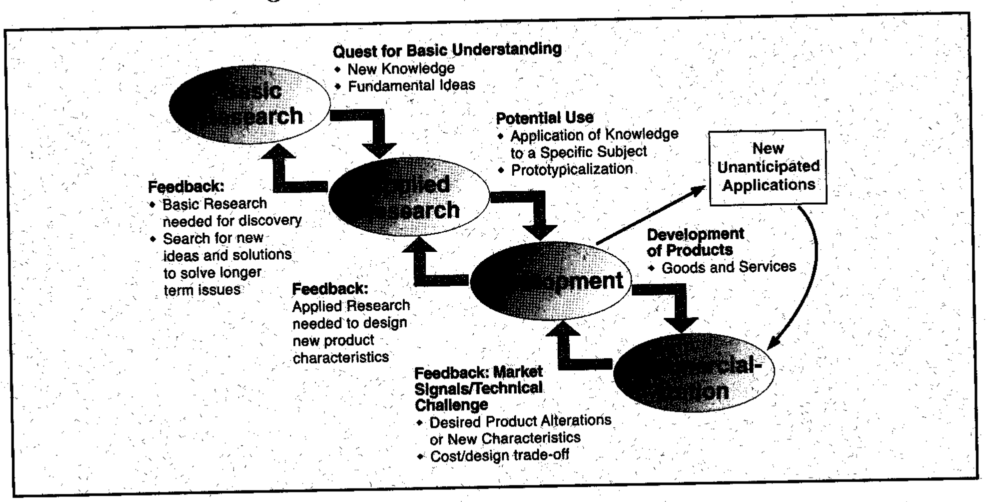
A Feedback Model

A more sophisticated representation of the innovation process includes feedback loops through which learning occurs. These loops—portrayed in Figure 2—suggest that technological breakthroughs may precede, as well as stem from, basic research.[9]

An important implication of this more complex representation of the innovation process is that key elements often occur spontaneously within local clusters of innovation. Knowledge is not generated solely through explicit basic and applied research efforts but often iteratively though processes of evaluation and feedback. This means that pushing in more funds at one end of the system—i.e., through increased funding for research—will not necessarily result in more innovation (as output) at the other end. A more comprehensive and more integrated policy is needed to take into account the different clusters of activity and the need for appropriate incentives at each phase of an innovation system. It is important to recognize and develop appropriate policies for each stage to help ensure increased R&D expenditure leads to the desired outcome.

The linear model of innovation assumes that innovation is a one-way process, beginning with basic research supplying a steady stream of fresh and new ideas, some of which are later turned into marketable products

Figure 2. The Spin-off Process



A more sophisticated representation of the innovation process includes feedback loops through which learning occurs. These loops suggest technological breakthroughs may precede, as well as stem from, basic research progress in information technologies—particularly since these two frontier technologies are increasingly interdependent and interrelated.[17]

In sum, the R&D effort in the United States is not as large as it may appear, once Department of Defense (DoD) expenditures are better understood, and the allocation of the U.S. research portfolio is open to question, particularly insofar as it under-spends on IT-related disciplines, the source of much U.S. growth and competitiveness for U.S. firms.

Notwithstanding concern about the allocation of U.S. R&D investment, the United States does have a high rate of innovation and a high rate of technology-based new firm formation. As noted above, this is in part because the United States adopted a series of policy measures in the 1980s to encourage the growth of small firms and to facilitate the commercialization of federally funded research, policy innovations driven in large part by the poor economic performance of the 1970s and 1980s.[18]

Early Stage Finance

In the post-Cold War period, the evolution of the US economy continues to be profoundly marked by the interaction between government-funded research and innovative entrepreneurs. Government supported research—as opposed to commercial products—in areas such as microelectronics, robotics, biotechnology, the human genome, and in the development of ARPANET (the forerunner of today's Internet) has created the foundation of a new economy.[19] In this new economy, individual entrepreneurs and researchers often play leading roles in developing new approaches and new businesses to exploit these research investments.[20] Small firms create jobs and contribute to growth through their ability to focus on new technologies.[21]

Studies of early stage funding in the U.S. reveal that funds are not spread out evenly over the course of the innovation process.[22] In fact, despite the presence of well developed "angel" networks and relatively broad venture capital markets in the United States, small and new innovative firms in the U.S. often face difficulties in obtaining "early-stage" funding.[23] In many instances, entrepreneurs with innovative ideas may lack financial resources to undertake the R&D necessary to commercialize their innovation, whereas investors with funds available may, in many cases, be uninformed about such opportunities.[24] Similarly, R&D funding in Europe is likely not to be evenly distributed across the various stages of innovation.

U.S. experience in R&D allocation and analysis of early-stage finance help draw the lesson that enhanced success in fostering a knowledge economy requires attention not only to the overall level of investment but also to how it is distributed over the innovation process.[25]

Policy Experiments in Partnering

During the 1970s and 1980s, the United States recorded slow economic growth relative to post-war norms, accompanied by a loss of global market share, notably to East-Asian competition. Technological leadership in key U.S. industries such as steel, automobiles, consumer electronics, and semiconductors was lost.[26] These events spurred a variety of policy measures.

One major element in the U.S. policy response took the form of a flurry of legislation aimed at modifying the rules that govern incentives present at various stages in the innovation process (See Box 1). Among these, the Bayh-Dole University and Small Business Patent Act of 1980 permitted government grantees and contractors to retain title to federally funded inventions and encouraged universities to license inventions to industry.

In the post-Cold War period, the evolution of the US economy continues to be profoundly marked by the interaction between government-funded research and innovative entrepreneurs

One major element in the U.S. policy response to relatively slow rates of economic growth in the 1970s and 1980s took the form of a flurry of legislation aimed at modifying the rules that govern incentives present at various stages in the innovation process industry initiation and leadership, industry cost share, public funding that is limited in time and amount, clear objectives, and feedback learning through regular evaluations of achievements.

Two prominent examples of "generic" government-industry partnerships are the Small Business Innovation Research (SBIR) Program and the Advanced Technology Program (ATP). The Small Business Innovation Development Act of 1982 established the SBIR Program within major federal agencies to increase government funding of research and its commercialization by small firms. This programme is intended to help small firms bring their innovative ideas to market by providing small, highly competitive awards to the embryonic and seed stages of the business development cycle—stages that private investors often find too risky to support.

Bayh-Dole and the change in culture it induced in universities combines effectively with the SBIR Program. The small SBIR grants encourage innovation by small, highly focused firms, and the awards themselves have a certification effect *vis-à-vis* private capital. The ATP Program, which began in 1988, gives large awards to small companies and also encourages partnering between large and small companies on products with broad-based spillovers. Its goal is to stimulate development, through single firms or joint ventures, of high-risk, potentially high-payoff technologies with economy-wide benefits.

These legislative initiatives are noteworthy because they address several different points in the innovation process. They are an effort to encourage innovation through highly focused, agile, small firms, sometimes in cooperation with large firms, by providing small awards for a limited term. By bringing together universities and companies, or in the case of SBIR, providing incentive awards to specific researchers, they stimulate research and encourage innovation for national missions in health, the environment, or national security. By focusing on incentives for different partners, they represent a more integrated approach than the "one-item fix" presented by the three percent R&D target. Moreover, as ongoing policy experiments, the performance of these initiatives is increasingly subject to regular review, providing an opportunity for further learning and feedback, both within the partnerships and at the policy level of the U.S. innovation system. [30]

Conclusions

The three percent target focuses on aggregate expenditure on R&D and economic growth. The connection is valuable insofar as it underscores the importance of science-based growth for Europe. Yet there is no doubting the quality of Europe's research, for instance European R&D in leading sectors such as biotechnology is already world class. The issue has more to do with the region's ability to capitalize on its research. The problem facing many European countries is how to capitalize on the *existing* R&D investments. The challenge is to move the ideas from the university to companies that can develop innovations that become promising products. This involves policies and programmes to bridge critical gaps in innovation funding –known in the US as the "valley of death" – that many new ideas and new firms fail to cross. Focusing on a single input in a complex process of innovation may not be enough if it is not accompanied by support for the commercialization of research results.

What does this mean in policy terms?

- Beyond aggregate R&D numbers it is also important to consider the allocation and effectiveness of R&D expenditures. In order to achieve higher growth, the underlying incentives that govern each national innovation system must be taken into account. Focusing

Legislative initiatives to enhance competitiveness in the U.S. address several different points in the innovation process. They are an effort to encourage innovation through highly focused, agile, small firms, sometimes in cooperation with large firms, by providing small awards for a limited term resources are directed towards industry needs, and tend to be focused on applied and development research more clearly linked to the market than public research. In addition to public funding of R&D, R&D financed by industry provides the basis for future industrial competitiveness.

6. Despite this high percentage, the ability of the Swedish economy to generate new, internationally competitive companies is a source of concern.

7. Any model captures only a small window on reality. Models are useful devices in highlighting those aspects of the real world relevant to a given problem-solving exercise, but it is important not to confuse this representation with reality.

8. For an excellent discussion of the consecutive challenges, see L.M. Branscomb, K. P. Morse, and M. J. Roberts. 2000. *Managing Technical Risk: Understanding Private Sector Decision Making on Early Stage Technology-based Projects.* NIST GCR 00787. April.

9. The feedback model depicted in Figure 2 was developed by our colleague Adam K. Korobow, a National Research Council staff member.

10. For example, a key factor shaping market incentives are the rules of intellectual property and their enforcement. Social perceptions of wealth are also important motivating factors. In societies with an egalitarian ethos, excessive wealth accumulation is often frowned on. In still others, wealth can be associated with ill-gotten gain.

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14. See National Research Council, *Allocating Federal Funds for Science and Technology,* Washington, D.C.: National Academy Press, 1995.

15. See Dale W. Jorgenson and Kevin J. Stiroh, "Raising the Speed Limit: U.S. Growth in the Information Age," in National Research Council, *Measuring and Sustaining the New Economy*: Report of a Workshop, D. Jorgenson and C. Wessner, eds., Washington, D.C.: National Academy Press, 2002. The "6.3" accounts in the DoD budget are more focused on product development than research.

16. See National Research Council, *Capitalizing on New Needs and New Opportunities in Biotechnology and Information Technology,* C. Wessner, ed., Washington D.C.: National Academy Press, 2002; and Stephen A. Merrill and Michael McGeary, "Who's Balancing the Federal Research Portfolio and How?" *Science,* 272:942-944, 1999.

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Global Experience in Long-Term Water Assessments: Lessons for the New European Water Policy

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Issue: In Europe today, general studies of the long-term dynamics of water and its management, in particular studies applying the concepts outlined in the newly adopted Water Framework Directive (WFD) are scarce.

Relevance: The experience that has been acquired at the global level or for very large river basins has evolved from "pure" hydrological mathematical models to models with socio-economic components, from global to regional and river basin level and from in-house hydrology to participatory assessment. However, concepts, causalities and data pertinent to the global scale may not necessarily be valid at a river basin scale, and tailor-made long-term assessments may be needed for a specific river basin.

Introduction

The recently adopted Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, referred to here as the WFD) introduces challenging goals, new means and trend-breaking concepts for the management of water resources in Europe. These include river basin management (river basin management plans), a combined approach to pollution control (agriculture, energy production, transport and land planning), systematic monitoring, full-cost recovery (recovery of environmental and resource costs) and public participation and consultation. The implementation of such an all-inclusive directive will only be feasible if socio-economic parameters are linked to hydrological ones. Hence, the internalization of socio-hydrological dynamics for the long-term in the management of river basins requires methods and tools to do this in a structured and comprehensive way.

The recently adopted Water Framework Directive introduces challenging goals, new means and trend-breaking concepts for the management of water resources in Europe

Water supply and demand dynamics have been central to hydrological thinking for many years. With the simultaneous rise of systematic long-term assessments (futures studies, scenario building, *prospective*, foresights, forecasts, and environ-

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purchase at a given price (or charge for water). The water needs or requirements are based on some notion of physical and/or technical relationship between economic/social activity and quantity of water.' (p. 170). We need to realize that socio-economic demand and supply do not necessarily equate with physical withdrawal (or consumption) and availability (see also Margat, 1998).

Thirdly, trends, uncertainties and conjectures in demand and supply rely heavily on the priorities we give to water, of course in interaction with its availability. Hence, the critical issue is not one of focusing on quantities, but rather *'what we want to do with the water and how we do it, taking into account the dynamics of its availability'*. This question is neither purely physical (although it relies on sufficiently accurate hydrological forecasts), nor purely socio-economic. It is, in essence, a question that requires thorough investigation of the nature and dynamics of both natural and socio-economic factors.

Water projections at the global level: from the traditional approach towards new water-demand approaches

During the 20th century, water planning focused on making projections of variables such as future populations, per-capita water demand, agricultural production, levels of economic productivity etc. These projections were used to forecast future water demand and evaluate how to meet it. However, these water demand projections typically ignored any analysis of human needs, water required for ecosystems, or actual regional water availability. The next step on this approach was to identify projects able to bridge the gap between the projected water demand and the estimated available water supply. The basic assumption behind this so-called water-supply management was that building more physical infrastructures (e.g., reservoirs, aqueducts, pipelines for inter-basin transfer) could meet the projected shortfalls (Gleick et al. 2001). Therefore, environmental, ecological, social and economic constraints were rarely considered.

Today, the debate lies between those who believe that the problem is primarily technical (i.e. having more efficient technology, better cost-benefit analyses to satisfy the needs of all interested parties) and those who believe that reorganization and coordination of the water policy process will rationalize decisions toward water-demand planning. Although traditional water supply planning continues to dominate water management measures, it has been questioned over the last 30 years. A number of international agreements, declarations, new strategies and policy documents were produced by international and national agencies, setting the stage for new approaches (most recently the Ministerial Declaration of The Hague on Water Security in 2000). Resource efficiency, water supply alternatives not requiring new structures to be built, wastewater reuse, demand management, intergenerational distribution issues, ecosystem protection and public participation are but some of the new elements explored in the new approaches to water management.

On a global scale, water projections made over the last 30 years or so took a similar approach and reached similar conclusions, leading to worries about ensuring an adequate water supply (Gleick, 2001). Most prominent examples of attempts to evaluate global water resources and predict future water use was done on a per sector and per region basis[4].

Early global water projections greatly overestimated water demand compared to what has actually materialized. In the 1990s, actual global water withdrawals were only half of what they was expected 30 years ago. This is partly

Water planning traditionally focused on making projections of variables such as future population, economic activity, etc. These projections would then be used to forecast future water demand and evaluate how to meet it

Today the emphasis in water management has shifted from solely relying on managing supply to new approaches that incorporate resource efficiency, wastewater reuse, and demand management, etc.

Early global water predictions greatly overestimated water demand. In the 1990s, actual global water withdrawals were only half of what was expected 30 years ago

Dealing with the long term

Besides linking hydrology and socio-economic factors, the cases discussed here also set out to understand the **future dynamics** of the socio-ecological water system. This requires a different style of reasoning, which we introduced earlier as the *prospective* approach. Its basic premise is that the future is by default uncertain and therefore may unfold in (many) different ways. In that respect, the best we can get is an understanding of the range of different futures, a detailed analysis of the dynamics that lead to these futures, and an assessment of the impact of different strategies on the state and dynamics of the system. In the above-mentioned cases, this is either done by mathematical simulation (as is the case with *WaterGAP*), mathematical simulation enriched with human interaction (as is the case with *Globesight*) and/or through human interaction enriched with scenarios and simulations (the World Water Vision).

Dealing with the long-term is a common issue for environmental research and policy-making. In fact, the impacts of environmental policy as well as environmental threats are usually long-term. Furthermore, the environmental debate has gradually moved from local and visible issues (point pollution and local degradation) to global, long-term and intangible concerns (like climate, integrated water resources management, etc.) (Hajer, 1995). Acting on the environment (which is the main objective of the WFD) is therefore almost naturally linked to theory and methods for long-term thinking (see Mermet, 2003 forthcoming). However, accepting the relevance of the long-term does not immediately lead to a better understanding of the future dynamics of a system. Methodological and practical concerns have to be taken into account to make long-term assessment useful.

A first remark is that there are different ways of dealing with the dynamics. Both *Globesight* and *WaterGAP* (see Box 1) rely on arithmetical simulation. *WaterGAP* is the more rigorous of the two, since its detailed model is calibrated on past time-series to understand future behaviour. It interacts with its model-environment through a so-called 'Story and Simulation' approach (European Environmental Agency, 2001). The stories are based on a scenario approach, and comprise a consistent exploration of possible future developments in a broad perspective. These scenarios are translated into a consistent set of model-assumptions. After having run the model, the results are fed back into the stories, which continuously evolve in an iterative process. As such, the model provides mathematical reflections on logical but discursive deliberations.

This logic of 'story and simulation' has been part of one of the other cases presented here (see Box 1), namely the World Water Vision programme. In this programme, however, the scope was much larger and many other approaches were integrated. In the programme the Story-and-Simulation was initially launched to initiate visioning exercises in different water sectors (such as environment, drinking water, irrigation, etc.) and global regions (like Southeast Asia, the Rhine river basin or the Arab States). Visioning is a normative way of dealing with future dynamics, in the sense that actors are invited to express what they think should be improved in the long-term. Coupling scenario analysis and simulation with visioning provided a very large platform for normative debate on what has to be done combined with rigorous understanding of the dynamics through scenario analysis and simulation modelling.

The case of *Globesight* is more intermediate. Its process is based on mathematical simulation and it places the focus on the dynamics of the system. As we have seen, parts of the dynamics of the system are influenced by actors' reflective behaviour. These so-called 'human-models' can

Dealing with the long-term is a common issue for environmental research and policy-making. Moreover, the environmental debate has gradually moved from local and visible issues to global, long-term and intangible concerns

Visioning is a normative way to deal with future dynamics, since actors are invited to express what they think should be improved in the long-term. This technique is a useful addition to scenario analysis and simulation deserve more attention from both researchers and managers. But, again, there is a balance between the modelling of the system, and the qualitative scenarios that interact to try to understand the evolution of the system. Unfortunately, different scenarios will always come up with different answers. Since the number of possible scenarios is infinite, it will not be sufficient to prepare one single set of scenarios and rely on them. Rather, it is through their evolution that they become valuable tools. A recurrent revision of the *prospective* employed is therefore very useful for the implementation of the new water policy in Europe.

Keywords
global experiences, water, European policy, supply, demand

Notes

1. We have used the French word *prospective*, which broadly equates with futures studies or foresight, although differences between approaches do exist. *Prospective theorie* assumes that the future cannot be known other than through a set of conjectures, which together cover a large range of possible future developments. As such, the theory emphasises the existence of (critical) uncertainties and tries to explore them. Its aim is not to develop a model that can decide what conjecture is going to be realized (which is a critical difference with concepts like prediction).
2. Although we need to realize that, in spite of the huge amount of work that has been done so far, data sets are still incomplete, especially where it comes down to seasonal fluctuations, or more localized effects. Today, climate variability demands another layer to be added to the models. Therefore, gauging and modelling of the natural regime for river basins is a necessity for understanding a large part of the resource availability.
3. For example, the WaterGAP model presented in this paper explicitly mentions that *water use* equals *water withdrawal* in their research (Alcamo et al. , 2000, p. 11). In their case the lack of data makes a serious distinction difficult, since non-consumptive use of water leads often to serious degradation, the return flows of used water is not very well localized in space and time, and consumption data is scarcer than withdrawal data.
4. Gleick (2001) made a historical review of the works from Nikitopoulos (1962, 1967), L'vovich (1974), Kalinin and Shiklomanov (1974), De Mare (1976), Falkenmark and Lindh (1974), Shiklomanov (1993, 1998), Gleick (1997), Raskin et al. (1997), Alcamo et al. (1997) and Seckler et al. (1998). For a discussion of water prospective in Tunisia, see Treyer (2002).
5. Case Western Reserve University.
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Applying ICTs to Public Participation in Enhancing the Urban Environment

Giovanna Anselmi, *ENEA* and Ugo Mocci, *ICT*

Issue: The possibility of combining active public participation with the interactive communications that is enabled by the Internet can be exploited to create a city monitoring system enabling public feedback on services and participation in monitoring urban areas, thus integrating the existing monitoring mechanisms and improving the efficiency of the city's public services.

Relevance: The implementation of web-based interactive systems can complement a range of strategies and enable better knowledge to be obtained of the city's problems, improve the efficiency of public services, inculcate greater public respect for the environment, stimulate wider participation in local democracy and foster social cohesion.

Introduction

Applications at local level of ICTs such as the Internet mainly focus on to providing solutions to citizens' individual needs, for instance to provide access to general and specific information, administrative applications, newsletter services, etc. However, their use can readily be extended to provide local authorities with incident reports about inefficiencies and other difficulties occurring in urban areas. Various sorts of Web-based systems and applications are being developed to facilitate interaction between citizens, local government and public services. These are mostly aimed at making general interest information and administrative applications available on the Web at all times, send local alerts to registered groups, managing citizens' complaints, etc. A number of European Projects (e.g. TELECITIES: **http://www.telecities.org/**; MAJORCITIES: **http://www.majorcities.org**) are actively developing systems to improve interaction between the local authorities and consumers and citizens and to encourage the provision of innovative services to citizens.

In addition to addressing citizens' *individual* needs, local authorities are also concerned with the difficulty of maintaining or improving the quality of the *environment* and of *collective* public services. These difficulties are often exacerbated by factors

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take an educational approach towards the citizens, relegating them to a secondary role;

- quite a few programmes are dedicated to developing and deploying advanced technological systems able to promote the active participation of citizens in monitoring their towns and cities, and accordingly provide an effective channel for this participation.

Many of the limitations described above could be overcome by the web-based interactive systems in various areas of city life.

The implementation of web-based interactive systems for city monitoring

The implementation of "digital cities" is creating a new opportunity to give citizens a central role in city life. The presence of hundreds of thousands of citizens and the diffusion of public Internet access points and privately owned PCs or other devices suitable for network operations distributed all over the city constitute a solid basis for developing powerful integrated web-based systems which may be used to monitor towns and cities effectively.

The traditional means of communication used by citizens (phone calls, faxes, letters and e-mails), which require human interaction and interpretation, do not allow automatic delivery and processing of the messages, highlighting the kind of barrier that needs to be overcome. Even following a simple and effective approach the most relevant events occurring in the towns can be classified and described in appropriate forms made available on the web.

Currently, sending letters to newspapers or to the authorities is the main channel by which members of the public can contribute to monitoring their town or city. However, this traditional approach has a number of drawbacks

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[illegible] participation in urban government and city monitoring

[illegible] in encouraging public participation in the information, consul- [illegible] processes concerning city development (proposals for the Public Adminis- [illegible] negotiation and resolution of conflicts, dissemination of information [illegible] environmental quality, etc.) is far from widespread. Nevertheless, useful [illegible] trials based on a variety of different approaches. A range of pilot [illegible] in USA and "Architectural Centres" in UK, an initiative by the [illegible] **http://www.wien.gv.at/**; traffic, priority of public transportation, urban [illegible], the "Participation Project" involving more than 50 municipalities [illegible] of "Interactive Information", in which the information is given in a [illegible] feedback is already envisaged (information desks, websites, activity [illegible] Oregon Model in the USA and other trials in Canada, New Zealand, [illegible] of a more comprehensive approach. In this approach the aim is to [illegible] i.e. a system of objectives strategies and actions able to steer [illegible] Planning for real (NIF, England), European Awareness Scenario Workshop [illegible] Plan (Arun, UK) are some examples of "Urban Scale Design", in [illegible] is applied to building restoration, popular housing and use of public

[illegible] various different groups of people are involved (the population as [illegible] private and public institutions) and sometimes permanent structures [illegible] Newcastle (Community Planning and Democratic Renewal [illegible] **default.htm**;) and in Rome (USPEL- Special Office for Citizens' [illegible] **http://www.comune.roma.it/uspel/**).

[illegible] participation cover different phases of the consultation and deci- [illegible] limited are the cases of citizen participation in monitoring and [illegible] public service activities such as cleaning rivers or parks, removing [illegible] Greater stimulus and efforts are required in this area to [illegible] and develop new supporting tools (e.g. ***CitySensor*** systems —

powerful tool for local democratic participation. Additionally, the same framework can be used for different public services, allowing management costs to be optimized and enabling maximum scalability.

The indirect benefits of this kind of system include they way it gives citizens a greater sense of their role in the city life (monitoring, event signalling, service and environmental control) and thus help overcome sense of there being a powerful group of individuals whose complaints are listened to. Making residents feel more closely identified with the city in which they live could lead to improvements in certain aspects of public behaviour. In practical terms, the implementation of feedback systems of this kind introduces a control loop, external to both the service supply chain and the actual environmental control processes, thus potentially enabling useful cooperation between citizens and public service enterprises. The information gathered by the system could allow focused monitoring and the drawing up of priority lists for maintenance activities introducing citizens in the public service delivery process thus enhancing efficiency and improving the overall quality of service.

Although trials with systems enabling public feedback on services and participation in monitoring urban areas are still in the early stages, a number of factors can already be identified as being important to the success of schemes of this type. Firstly, although the system is designed to handle messages automatically, in addition to the development effort, adequate resources need to be set aside for website management, updating of forms, extension of processing procedures and development of back office interfaces. Secondly, although citizen participation in city monitoring allows both the handling of individual complaints and statistical monitoring to be implemented in the same framework, for convenience the two areas of functionality can be set up at different development stages and assessed separately. Thirdly, adequate promotion is needed (using both advertising and the educational system) in order to ensure the citizens' trust and overcome the possible reservations of both local authorities and public service companies. To ease the process of introduction, this could be limited to selected groups of people. Finally, adequate security needs to be put in place to protect the system against malicious intent (although it is worth noting that as the same incident will probably be notified by many citizens a certain degree of intrinsic message redundancy is assured). Thus, above all the website supporting the system needs to be accessible, efficient, effective and reliable, and advanced website technology should be used for this purpose (including user-friendly multilingual interfaces, access control, dynamic forms handling, on line database management, expert systems and decision-support systems, etc.). The example of the ***CitySensor*** system currently under development in Rome is described in Box 2.

Conclusions

Demographic analysis indicates that as much as 80% of humanity may live in just a few dozen large conurbations by 2030-2050 and even Western countries will have to cope with continuous changes in environmental and social conditions in the large cities that can weaken the relationship between citizens and the town or city in which they live.

In this context, local policy-makers need better environmental and social monitoring systems in order to acquire a fuller knowledge of their city's problems, contribute to a more effective and economic provision of collective public services, improve public behaviour in terms of respect for the environment, stimulate wider participation in local democracy and greater social cohesion.

The information gathered by the system could allow focused monitoring and the drawing up of priority lists for maintenance activities introducing citizens in the public service delivery process thus enhancing efficiency and improving the overall quality of service

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