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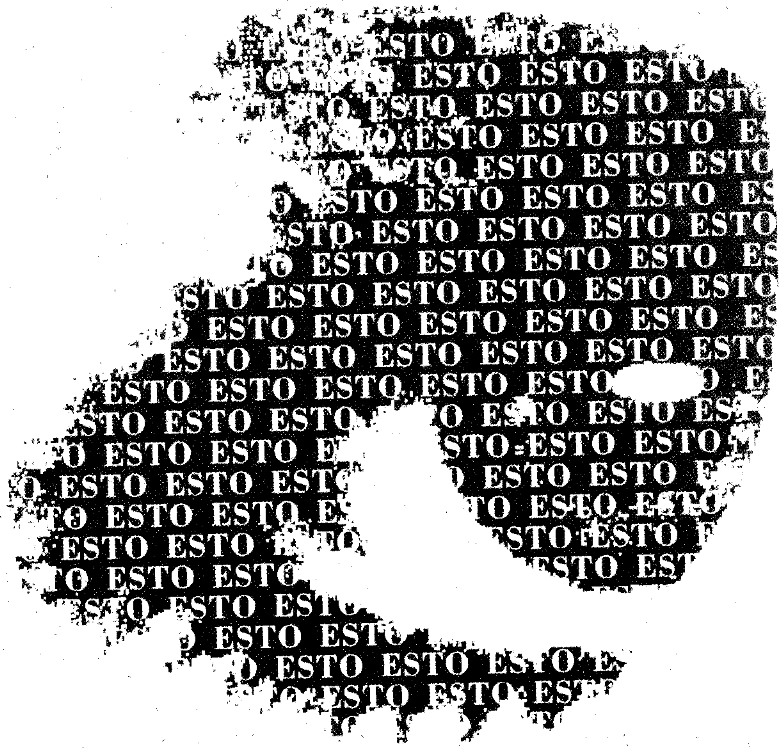
The IPTS REPORT

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



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publication in the popular press may ride the coat-tails of other debates heating up in parallel. It then may compound and exponentially widen the scope of any problems the academic publication of the same material could conceivably cause. In the case at hand, apparently, the ad in the NYT coincided with and exacerbated a politically charged regional debate on the teaching of science.

To be fair to academic journals, they are charged with two functions that are not always easy to reconcile: to disseminate research results as well as to filter out patently wrong or insignificant results.

Nevertheless, in retrospect it might have been more appropriate and less troublesome to publish the iconoclastic views/criticism in question (which Ohio State University Astronomy Professor Andrew Gould deemed harmlessly incorrect) in the academic journals, instead of unwittingly channelling them towards a wider, more easily impressionable audience, and having them complicate further, other unrelated debates with wider social impacts. It would also have been simpler in an academic journal context to evaluate Prof. Robitaille's criticisms of the gaseous model of the sun, and any alternative models of the sun's nature. Note that such alternative models may be easier to refute than the criticisms to the gaseous model itself, which is presumably why he devotes most of the NYT ad to the latter.

More generally, and borrowing a page from game theory and the work of John Nash (to whom we devoted last month's editorial), it is not a good idea for anyone to drive a rival/competitor to desperation. For instance it may be counterproductive for the academic community to drive those (e.g. by shunning them), who would like to put forth and subject to scientific (not theological) debate their harmless, if unorthodox, views, to view their situation in extreme, desperate ways. The strategies of those shunned may change as a result, they may seek unlikely, even unsaviory, bedfellows, and the academic community may end up in an undesirable 'equilibrium' as the outcome of this confrontation.

Another paradoxical effect of academic journals' overdoing their filtering role – if indeed they overdo it - and driving scientists to alternative publication venues, is that the journals may be undermining indirectly their own predominance. If an unforeseen side effect of bypassing academic journals, drawing the public's attention, and perhaps becoming a *cause célèbre* in the process, is to open doors (e.g. for research funding or well rewarded careers) for the authors spurned by academic journals, then more may start considering it. One wonders what the future may hold for communicating scientific work – TV commercials?

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with implementing advanced technologies. That is, education-based measures could give a misleading picture especially for countries with a workforce trained in a very different set of technologies, such as the workforce of formerly socialist countries, which dominate the present group of candidate countries.

At face value, the available educational statistics on quantity, quality, and resources point to most PACs-accession countries having a fairly good record relative to the EU average.[1] For instance:

- all the PACs except Slovenia and Turkey achieve a higher score than the EU average in terms of average years of education;
- in all PACs, net primary enrolment is close to the average EU level of 100 percent;
- net secondary enrolment is lagging behind the EU average (94 percent) in most PACs countries, but not by more than 20 percent, except for Turkey;
- the quality of education as measured by test scores in international comparisons of student performance (IEA 1998) does not seem to differ substantially between EU countries and PACs;
- the variation of class size in the PACs vary considerably, but do not generally differ much from those in the EU. That is, Latvia has an average class size which is comparable to that of Austria or Belgium, whereas Poland has an average class size which is larger but still comparable to that of Spain (Turkey appears to be an outlier with a class size about twice as large as the EU average).

The problem is that a good record on recent educational statistics may only slowly translate into a high stock of human capital once the workforce gains experience with new technologies. A good record on educational measures that were accumulated under socialism may not have contributed to a stock of human capital that is economically relevant today. The disturbing fact remains that given the conventional measures of human capital discussed, the formerly socialist countries in particular display a rather low level of productivity as measured by their GDP per capita.

Overall, the education measures certainly allow for alternative interpretations and are always subject to possible statistical ambiguities. But if anything, there seems to be a negative correlation between per capita output and average years of education across the formerly socialist PACs (Figure 1). When Cyprus and Turkey are included in the sample, there appears to be no statistically significant relationship at all. By contrast, the correlation between per capita output and average years of education is generally found to be statistically significantly positive in cross-country studies (Hall and Jones 1999, Gundlach et al. forthcoming). This seems to suggest that for most formerly socialist countries, the reported conventional measures of education should not be taken as a reliable proxy for the economically relevant stock of human capital. In this respect, East Germany's experience with EU membership provides some additional evidence.

The productivity of human capital after EU accession: the case of east Germany

East Germany's average number of years of education among the population aged 15 and above was estimated to be about 10 percent above that of West Germany in 1990 (Barro and Lee 1996). Hence it is no surprise that German unification (and hence East Germany's EU membership) in 1990 immediately raised high expectations of "blossoming landscapes" in the eastern Länder within less than a decade. Physical capital rather than human capital was seen as the most serious bottleneck for growth and development, and that bottleneck was thought to be addressed by substantial net

On standard measures such as average years of education, test scores, class sizes, etc. most pre-accession countries have a similar score to EU Member States

The problem is that a good record in terms of recent educational statistics may only slowly translate into a high stock of human capital once the workforce gains experience with new technologies

In the case of most formerly socialist countries, the reported conventional measures of education a perhaps not a reliable proxy for the economically relevant stock of human capital

and the West German workforce. The available measures of formal schooling and training may only allow for a partial picture of the economically relevant stock of human capital as long as there are important unobserved abilities such as, say, familiarity with advanced technologies or basic differences in behaviour in response to the incentives offered by a given set of work contracts. The brain drain that occurred in the early years after unification also seems to indicate that probably some of the most motivated (young) and most productive (skilled) workers have left the East German labour force. So differences in the average quality of the work force are likely to exist but cannot be quantified on the basis of formal measures of education.

One possible way of identifying an East German human capital deficit is to simulate the recent productivity record with the help of a simple growth model (for details, see Gundlach (2001)). Starting with a level of labour productivity of 50 percent of the West German level (as in 1993) and given that investment as a share of GDP is about twice as high as in West Germany (as is observed) and also given that human capital per worker does not differ from the West German level (as conventional measures of education suggest), the model in fact predicts an average annual growth rate of output per worker of 4.6 percent for the period 1993-2000. But East German output per worker actually grew only by 2.6 percent in 1993-2000.

Assuming a lower stock of human capital in East Germany appears to be the most obvious possibility to reconcile the predicted and the actual growth rates of productivity. For an otherwise unchanged parameterization, the simulation model predicts a growth rate close to the observed growth rate of 2.6 percent for 1993-2000 if the East German stock of human capital is arbitrarily set to 30 percent of the West German level. Future research will have to prove whether such simulations bear any empirical significance. But for the time being, these simulations may be considered as a reminder not to confuse the average level of formal schooling and training of the workforce with a measure of the economically relevant stock of human capital.

This possibility should dampen overly optimistic growth expectations of EU membership in the present group of accession countries. Central European countries in particular, like East Germany before them, display measures of average years of schooling which tend to exceed the EU average. However, if East Germany's stock of effective human capital per worker is only about 30 percent of the West German level, then conventional measures of education may grossly overestimate the effective stock of human capital in Central European accession countries as well. If so, the question arises how such presumed human capital deficiencies in Central European accession countries could be eliminated.

Worker Retraining Programmes as a Short Run Investment in Human Capital

In principle, retraining measures can improve and enhance the human capital of workers and thereby raise their reemployment chances and their future wages. Retraining measures can also help to adjust the quality of the existing labour supply to structural changes in labour demand caused by new technologies, increased competition on world markets or, as in the case of the PACs, by EU membership. However, publicly funded retraining measures can have unintended side effects. Future employers may interpret participation in a retraining programme as a signal of low worker productivity, or retraining may actually downgrade the qualification of workers as compared to their previous level of human capital, or alternatively reemployment of trained workers

To obtain the actual growth rate using the model, human capital would have to be just 30 percent of that in West Germany, rather than the 50 implied by standard measures. The model therefore points to the risks of using average schooling as a measure of economically relevant human capital

When East German productivity increases are simulated using a growth model the expected annual growth rate of output per worker is 4.6 percent for the period 1993-2000. The actual figure was just 2.6 percent

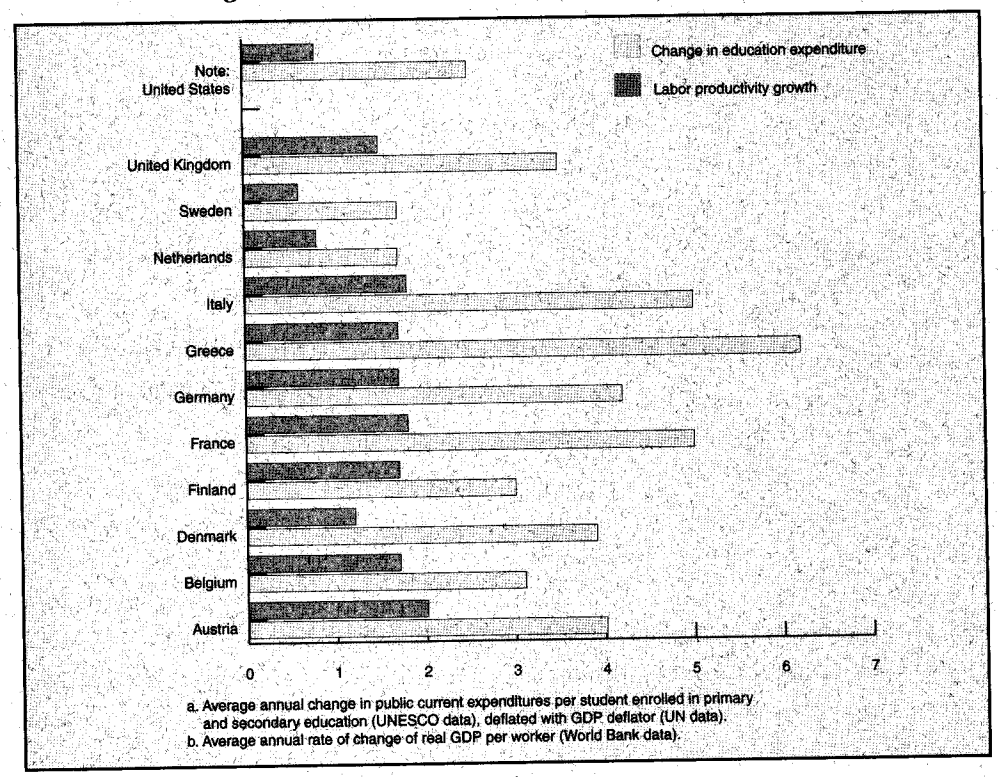
For a start, one would expect that educational expenditure per student should rise over time. This is because schooling is likely to face an increase in the relative price of each unit of output. The reason is that services like schooling face an inherently slower productivity increase relative to other sectors like manufacturing. Sectors with relatively low (or zero) productivity growth will necessarily face increasing costs. As a benchmark, theoretical considerations suggest that inflation-adjusted educational expenditure per student should rise in line with average labour productivity growth if the same amount of schooling resources per student always produces the same amount of schooling quality in the form of student performance (Gundlach et al. 2001).

However, in most EU countries educational expenditure per student rose much faster than average labour productivity growth, with Sweden and the Netherlands as possible exceptions (Figure 2). Inflation-adjusted education expenditure per student increased by almost 200 percent in Germany and by more than 200 percent in France and Italy. By contrast, the average productivity record of these countries suggests that for a given quality of schooling output, educational expenditure should have increased by only about 50 percent. Hence either there was a large increase in the average performance of students or the additional expenditure just did not work. If anything, the available empirical evidence suggests that the performance of students in Germany, France and Italy has remained at best constant at best over the period 1979-1994 (Gundlach et al. 2001). What is more, the only countries with a slight improvement in measured student performance, namely Sweden and the

Although devoting more resources to public education tends to be considered a good strategy for meeting the challenges of the "knowledge-based" economy, experience in Europe has not been straightforward

The lack of hard evidence of a positive link between increased educational expenditure and improved schooling outcomes may mean more attention needs to be focused on the efficiency with which the resources are used

Figure 2. Changes in Education Expenditure per Student[a] and Average Labour Productivity Growth[b], 1970-1994



Source: Gundlach and Wößmann (2001)

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mainly for the sake of the food producers, with little apparent benefit to consumers. Such innovations are seen by consumers as being approved by scientists and regulators, but later found to have unanticipated long-term health effects. The recent food scares have reinforced this perception.

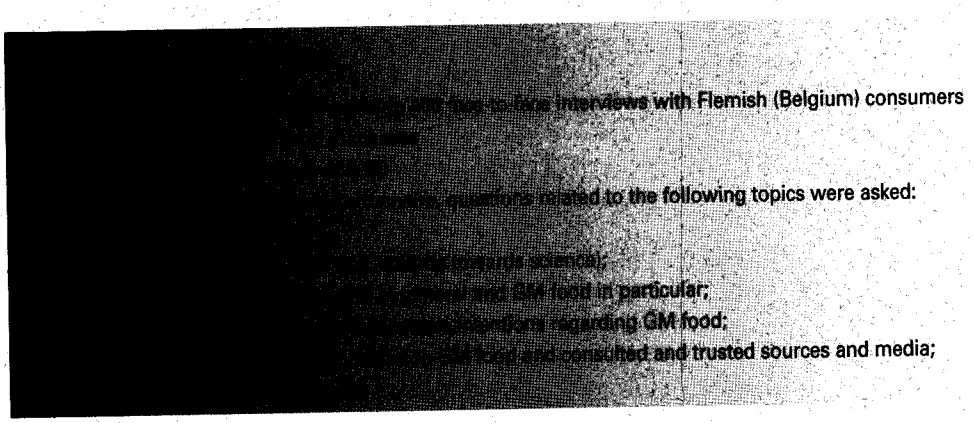
Faced with consumers' growing concerns over (GM) food safety, food safety has become a key issue in the decision-making regarding the types of food products offered on the market (Burton, James, Rigby and Young, 2001). For GM food, this is illustrated by the decision of several farmers, food producers and retailers to ban GM food products, even if the application of GM technology in food production provides cost-efficient ways to produce a range of novel, value-added food products (Finch, 1999; Spetsidis and Schamel, 2001).

To properly address consumers' safety concerns related to GM food it is essential to get to know the audience and gain insight into the formation and nature of the perceptions of GM food safety. This knowledge will provide the necessary input for effective communication with consumers about the use of GM technology in food production. Therefore, the aim of this research is threefold. The first aim is to identify consumer segments based on beliefs, in particular consumers' perception of GM food safety, and attitudes towards GM food. The second aim involves profiling the identified consumer segments. This places the emphasis on socio-demographics, knowledge, general attitudes and purchasing intentions in relation to consumers' perceptions of GM food safety. Finally, the third aim is to infer recommendations for a targeted communication policy regarding GM food. The research methodology to reach these aims is indicated in Box 1.

Results

Consumer perceptions regarding GM food consists of four factors, which each contribute to consumers' attitude formation vis-à-vis GM foods:

- Perceived safety of GM food, which corresponds to the perceived health risks;
- Perceived environmental risks related to GM food;
- Perceived benefits of GM food, which include personal, social and environmental benefits. The perception of major health benefits may compensate for a low perceived safety of GM food;
- Perceived credibility of the government and the food industry's claims to be able to guarantee safe (GM) food as well as a free choice between GM and GM-free food. A high level of trust in the government and the food industry could mitigate high perceived health risks.



Source: Verdurme, Gellynck and Viaene, 2001

Recent food scares have heightened consumers' awareness of the extent to which modern food production is characterized by the use of technology and the industrialization of farming

Consumers' growing concerns over food safety have made it a key issue in decision-making regarding the types of food products offered on the market. This has particular implications for genetically modified (GM) foods

GM food is unlikely to result in consumer acceptance on its own. However, this should not be the goal of communication. Instead, policy-makers, scientists, consumer organizations and other stakeholders such as the food industry should direct their communication efforts towards dispelling any fallacies about GM food and, by doing so enable consumers to make informed choices about it.

The aim of communication with the "Food Neophobics" and the "Balancers" is to address their concerns about health risks related to GM food. Given their limited knowledge and relatively low level of educational attainment, a simple, non-technical picture of the actual scale and seriousness of the health risks related to GM food should be drawn, thus presenting actual GM food products and, in the case of the "Food Neophobics", also indicating the potential benefits. The less abstract the information that is provided, the greater are the chances that consumers will understand it. Besides their different perceptions of the benefits, the differences in age and in general attitudes towards trying out new food products between these two consumer segments should also be taken into account during communication. For example, since the "Balancers" comprise a higher percentage of older respondents, providing information through media, which allow internal pacing (i.e. the receiver processes the information at his/her own pace; e.g. print media), is recommendable.

The so-called "Green Opponents" group considers GM food to be a threat to food safety and perceive high environmental risks despite being quite knowledgeable about the topic. Therefore, the communication objective for this segment is to hand them two-sided, factual information about all the potential risks and benefits of GM foods, thus focusing on the possible consequences for the environment. This information offers the "Green Opponents" the possibility of critically testing the foundations of their negative beliefs and, if necessary, rectify any fallacies. Environmental groups and third world organizations are appropriate information sources for the "Green Opponents", as these consumers consult and trust them. Governmental and industrial information sources are not trusted and consequently, unsuitable for addressing this segment.

In the case of the "Enthusiasts", communication is intended to make sure they are in favour of GM food for the right reasons. Indeed, consumers' positive feelings about GM food may be based on excessively positive beliefs about the benefits offered by GM food and/or a limited insight in the potential risks of GM foods. This aim can be fulfilled by providing varied and accurate information about GM foods. Given the high level of knowledge and educational attainment of the "Enthusiasts" and their confidence in the government and the food industry, scientists and policy-makers as well as the food industry (if open and honest) may act as an information source. Building confidence in government and the food industry is the main goal of communicating with the so-called "Cautious" group. To improve trust, policy-makers could meet consumers' information demands, cooperate with more trusted sources such as scientists and consumer organizations and be consistent and transparent in their communication. The food industry should try to be more proactive and straightforward in their communications with consumers.

Conclusions

Not all consumers perceive the use of GM technology in food production to be a threat to food safety and of those who do, not all do so for the same reasons or to the same extent. Nevertheless, the perception of GM safety has a significant impact on consumer attitudes towards GM foods. The safer GM foods are perceived to be the less negative attitudes towards GM foods become. General attitudes towards technology,

The existence of a group characterized by both in-depth knowledge of, and strong opposition to, GM foods indicates that simply providing more information is not guaranteed to enhance consumer acceptance

More concrete and self-paced information may be more suitable for some groups of consumers, particularly older ones or those with lower levels of educational attainment

Consumers who oppose GM foods for environmental reasons tend to trust information from environmental groups more than that from government sources

Ethical Aspects of Biotechnological Patenting Revisited

Dolores Ibarreta and Nikolaus Thumm, *IPTS*

Issue: The regulation of the patenting of biotechnological inventions together with the rapid development of genomics and cloning techniques are driving a debate on the ethics of the technologies involved. Voices have been raised arguing that permitting the grant of patents for isolated parts of the human body undermines the inallenable nature of living human matter, an inallenability which is considered to be a component of the fundamental right to human dignity and integrity.

Relevance: The transposition of Directive 98/44/EC of 6 July 1998 on the legal protection of biotechnological inventions, which sets out which inventions involving plants, animals or the human body may or may not be patented, has not yet been completed. The directive requires the Member States to allow the patenting, under certain conditions, of inventions which may have an industrial application making it possible to produce, process or use biological material.

Introduction

The provision of Patents for biotechnological inventions, such as patents on breeds of animals, plant varieties, the patenting of nucleotide sequences or on material derived from human tissue, has already been the subject of public debate for more than a decade and the controversy is still ongoing[1]. In particular, ethical concerns are raised by the patenting of biotechnological material. The importance of the issue becomes clear when looking at the importance of biotechnology for the new millennium and considering the heavy future responsibility of biotechnological research, development and its economic exploitation. On the one hand the biotechnology industry is calling urgently for the legal clarification of many issues regarding patentability and types of inventions –and as a result of the legal uncertainties a large number of patent applications have yet to be processed. On the other hand, human rights and the dignity of the human being with regard to the application of biotechnology and medicine seem to be more and more in crisis[2]. The whole debate on the patentability of biotechnological material often boils down to a conflict between entrepreneurial reasoning on the one side and social and ethical arguments on the other. This becomes particularly clear in the case of patents deriving from human stem cell research.

A debate has been underway for over a decade on the ethics of patenting nucleotide sequences or material derived from human tissue

function, for example the treatment of a disease. However, the issue of the patentability of gene sequences is first of all a technical problem regarding the definition of patentability, it does not directly involve ethical questions. Some may argue that this is not the case, in view of the Myriad case (BRCA1 and BRCA2 genes). Gene patents came to the fore when the first diagnostic test for breast cancer was commercialized by the US company Myriad Genetics, Inc. (Salt Lake City, UT), which enjoyed a patent-buttressed monopoly position. These patents were not well-received by public sector bodies because, among other things, they felt it was not in the public's interest to pay such high royalties to access the material. In Europe, clinicians from France, Belgium, Denmark, Germany, the Netherlands, and the United Kingdom filed an Opposition request against Myriad's EPO patents. In October 2001, the European Parliament adopted a resolution opposing the Myriad patent, repeating its call on the EPO to ensure that all patent applications in Europe do not violate the principle of non-patentability of humans, their genes or cells in their natural environment[9].

'Patenting of life'

'"Life' cannot be patented but living organisms can be patented if they differ significantly from organisms as naturally-occurring"[10].

In the United States the first transgenic animal patent was issued in 1988 with the 'onco-mouse', a genetically manipulated mouse which is highly susceptible to cancer. The same patent application led to controversy at the European Patent Office. Patents on animal varieties already have a long tradition in Germany.

In the history of the European patent office several objections were made against the patentability of plant varieties. Until 1995 Article 53 (b) European Patent Convention was not applied to plants which did not meet the profile of a variety and belonged to a classification unit taxonomically higher than that of a variety. In 1995, the board of appeal of the European Patent Office decided in the Plant Genetic Systems (PGS) (Technical Board of Appeal, 1995, (T 356/93)) case that plants *per se* were no longer considered to be patentable. In the Novartis decision (T 1054/96 (OJ 1997, 551) Novartis 1998), the court of appeal reaffirmed this decision. Advocates from both industry and academia, continue to call for the abolition of Article 53 (b) European Patent Convention[11].

Previous decisions regarding the ethical dimensions of patents

'Patenting, as such is in itself neither wrong nor right, but could be classed as ethically neutral'[12].

According to Article 53 (a) European Patent Convention it is prohibited to grant European patents for inventions which are contrary to *'ordre public'* or *morality*. Only a few cases of patents where ethical issues have been taken into consideration have been decided so far:

In the case of the human protein H2-relaxin the opposition division of the European Patent Office had to decide on a patent on DNA fragments of the protein taken from the tissue of pregnant women. The European Patent Office decided that the patenting of a single human gene has nothing to do with the patenting of human life and that there is nothing immoral about the patenting of genes.

In a well-known case in the United States, a doctor managed to obtain a patent on a cell line he retrieved from the spleen cells of a patient he had operated on. After the patent had been licensed, the patient sued the doctor for having taken his property. In this case the California Supreme court decided that patient had no property rights over cells that were once taken from his body. The

Although patents are recognized to be a facilitator of innovation and the spread of knowledge, there are signs that excessive patenting can stifle innovation

The issue of the patentability of gene sequences is primarily a technical problem regarding the definition of patentability and does not directly involve ethical questions

The European Patent Office decided that the patenting of a single human gene has nothing to do with the patenting of human life and that there is nothing immoral about the patenting of genes

Stem Cells and Patenting

In Europe, procedures for human reproductive cloning are explicitly excluded from patentability (Directive 98/44/EEC, Art 6,2). This includes the prohibition of some processes deriving from stem cell research. In this respect it is important to differentiate research on embryonic stem cells from research on adult stem cells. The patenting of adult stem cells does not, in principle, infringe the law. Given that the differentiation potential of stem cells in tissues of the adult is less limited than previously thought, this could open the way for the use of cells of this type in therapeutic applications in the future as an alternative to the use of embryo-derived cells.

Any ban on human cloning methods should be careful to avoid restricting research on human body cells in general. The Human Genome Organisation (HUGO) argues in favour of the research on embryonic stem cells due to their potentially beneficial medical applications[17]. According to HUGO, it would make sense to treat techniques for 'therapeutic' and 'reproductive' cloning differently. However, fundamental steps of both techniques are the same. A literal interpretation of the definition of human cloning in Directive 98/44/EEC would also include the initial step of the so-called somatic cell nuclear transfer technique (SCNT). Patenting of the initial steps to develop stem cells using SCNT is therefore not contemplated in the current Directive 98/44/EEC. SCNT offers the development of autologous[18] human pluripotent[19] stem cells[20] for cell-based gene and tissue therapies with the possibility of developing human tissues for auto-transplantation with a reduced risk of rejection. Transplantation of embryonic stem (ES) cells derived from SCNT could restore function to diseased or damaged tissues, or be genetically altered before transplantation to deliver gene therapy. However, research has a long way to go before it is actually possible through SCNT to generate replacement cells or tissues from an adult human for transplantation back to the original donor. The development of SCNT has the important ethical connotation of unavoidably sharing part of its technical pathway with human reproductive cloning. Thus, the different treatment of 'therapeutic' and 'reproductive' cloning methods, if not carefully handled, could open the door for misinterpretations and carries the danger of opening the door to techniques to implement human reproductive cloning.

Things are, however, moving along driven by the potential financial gains to companies that can secure for themselves a niche in the market for the biotechnologies used to manipulate genetic material. For instance, Geron Corp, which owns the technology used to produce Dolly, the cloned sheep, through its purchase of Roslin (the company that originally developed the technology) has already been granted a patent on aspects of nuclear transfer technology used in the cloning of animals (non-human) by the European Patent Office. Geron is currently in a patent battle with Advanced Cell Technology (ACT) over an animal cloning patent licensed by the U.S. Patent and Trade Office.[21]

Although ACT has been denied a patent on cloned embryos, it was granted one on cells taken from cloned embryos. Britain gave Roslin a patent covering cloned human embryos up to 14 days old — but only in the United Kingdom, the only country in Europe to have passed a law approving research into human therapeutic cloning.

Canada has issued patents for plant, animal and human DNA sequences, genes, proteins and cells, but has drawn the line claiming that "ownership concepts cannot be extended to human beings."[22]

Conclusions

There is a need for dealing with ethical standards for granting biotechnology patents. In many

Procedures for human reproductive cloning are explicitly excluded from patentability in Europe, and while this affects embryonic stem cell research, adult stem cells can, in principle, be patented

The different treatment of 'therapeutic' and 'reproductive' cloning methods has to be monitored carefully in order to prevent reproductive cloning from masquerading as therapeutic cloning

6. The Human Genome Organisation (HUGO), **http://www.hugo-international.org/hugo/patent2000.html**)

7. A submarine patent is one that hides in the patent office for years, emerging after a particular technique has come into common practice. This can result in considerable economic benefit to the holder of the patent, making it often desirable to delay the journey of the patent application through the patent office.

8. Atkins, R., Krägenow, T., Germany ponders extra gene patent limits Financial Times, Friday August 11, 2000.

9. European Parliament, Motions for resolutions on patenting of human genes, B5-0633/2001, B5-0641/2001, B5-0651/2001, B5-0663/2001, 4 October 2001.

10. Crespi, S., Intellectual Property in Biotechnology, conference paper, Biotechnology in public: DNA & the quality of life. 2-4 December, Vienna, 1998, page 3.

11. Van Overwalle, Geertrui, Patent Protection for Plants: A comparison for American and European Approaches. IDEA – The Journal of Law and Technology; Vol 39 No 2, 1999 pp. 143-194.

12. Crespi, S., Intellectual Property in Biotechnology, conference paper, Biotechnology in public: DNA & the quality of life. 2-4 December, Vienna, 1998.

13. On this and other patenting related harmonisation issues in Europe, see, Thumm 2000, in particular chapter 5.2, Thumm, Nikolaus: Intellectual Property Rights. National Systems and Harmonisation in Europe, Physica-Verlag (Springer), Contributions to Economics, New York, Heidelberg, 2000.

14. See Judgement: Federal Court of Canada Docket A-334-98, President and Fellows of Harvard College and Commissioner of Patents et al. August 2000.

15. Claes, T., *Cultural backgrounds of the ethical and social debate on biotechnology*, in: Biomedical Research and Patenting: Ethical, Social and Legal Aspects, European Platform for Patients' Organisations, Science and Industry, 1996.

16. "Are EPO examiners to have courses in moral philosophy or theology? And if so, of what variety?" Grupp [1999], Patents for chemicals, pharmaceuticals and biotechnology, Fundamentals of global law, practice and strategy. Clarendon Press Oxford, 1999, page 258.

17. '... processes involving the culture and study of embryonic stem cells, genetically modified or not and aimed at investigating a wide variety of diseases, ageing, cancer and other health problems, are not affected by those exclusionary provisions' **http://www.hugo-international.org/hugo/patent2000.html**

18. i.e. originating from the patient/subject's own tissue.

19. i.e. capable of giving rise to most tissues of an organism.

20. i.e. cells that have the ability to divide for indefinite periods in culture and to give rise to specialized cells.

21. Deena Beasley, *Geron challenges ACT's animal cloning patents*, Reuters, Los Angeles, 31 January 2002.

22. The Canadian Biotechnology Advisory Committee, in a draft report to the Government, November 2001.

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reduce their impact on workers' health. The anticipation of probable risks therefore becomes a strategic tool, insofar as it allows us to face the changing situation of the labour market, raising a debate on the measures that have to be taken in order to reduce the potential negative impacts of the changes currently underway.

Following the prospective approach to the evolution of occupational health and safety risks, this article looks at the evolution of trends in stress factors brought about by the incorporation of robotic and automated systems at work. Robotics technology is spreading rapidly, with a spectacular increase in the use of robots in the European Union. Over the last five years, robot sales have increased by more than 15% a year. During the year 2000 manufacturing-robot sales increased by 20% in the countries of the EU compared with the number of units sold in 1999 (IFR, 2001). In Sweden, for instance, sales increased by 56%; and, in Spain, 39%. The impacts of robotics on management and on working conditions will have an effect both on manufacturing and on services over the coming years (López and Krux, 2000). This trend will therefore influence the evolution of rates of accidents at work. In fact, one reason for investing in robots is to automate jobs that imply serious risks for human health. Advanced automation reduces physical risks and reduces the number of accidents at work. However, it creates new working conditions that have an effect on the psychological and social factors that affect stress. In this respect, this article reports on some of the results of prospective research based on the Delphi Method, which allows us to approach the experts foresights about the evolution of these risk factors, and to propose –in relation to this probable evolution– a set of measures to improve occupational health and safety conditions in this changing context.

Working conditions and new risk factors in the European Union

The evolution of working conditions in the European Union over the last ten years reveals a transformation of the working environment to one which is characterized by a greater presence of new technologies, a more rapid pace of work (which is increasing in all the member states: workers work faster and against shorter deadlines), a greater autonomy at work, and an increase of the number of tasks implies a greater strain on workers (i.e., the tasks tend to produce greater stress). The European Foundation For The Improvement Of Living And Working Conditions has carried out three surveys on working conditions in the European Union (1990, 1995, 2000). In the survey carried out in the year 2000 the following results were obtained (Table 1):

Robotics and automation are spreading rapidly in the European Union, and while automation generally reduces workers' exposure to direct hazards, it creates new working conditions that can increase factors such as stress

Table 1. Main Conclusions About Working Conditions In The European Union

- There is a direct relationship between health problems and adverse working conditions; in particular deriving from intensive, repetitive tasks.
- Exposure to physical risk factors (noise, vibration, dangerous substances, heath, cold, etc.) is still frequent, as is working at badly designed posts (manual handling of heavy loads and incorrect postures).
- Work is becoming more and more intensive: more than 50% of workers working at a rapid pace and within tight deadlines for, at least, the 25% of their working hours.
- The number of people working with computers has increased: from 39% in 1995, to 41% in 2000.
- Flexible working has spread: working hours (shift work, and part-time jobs), work scheduling (versatility, team work, empowerment) and employment instability (18% of employees have temporary contracts).
- Temporary jobs: more workers are hired on temporary contracts or through temporary employment agencies and consequently feel they are more exposed to risks than those that have permanent jobs.

Source: Foundation For The Improvement Of Living And Working Conditions (2001): Third European Survey On Working Conditions, Dublin.

new technologies). Improving working conditions requires the consolidation of risk prevention by combining prospective research with other political instruments such as legislation, social dialogue, instances of best practices, companies' social responsibility and economic incentives. It also requires collaborative efforts involving all the agents concerned in the field of health and safety (COM (2002) 118 end, 03/11/02). Among the various objectives concerning the promotion of constant improvement in the labour market, we find –precisely- the analysis of new risks, in particular those related to the interaction of chemical, physical, or biological agents and those related to working conditions (economical, psychological, and social risks). (see Table 3).

In this sense, research in the field of occupational safety and health could fruitfully focus on: Firstly, the constant monitoring of risks. Secondly, coordinating the various centres of research so as to be able to make progress towards practical measures enabling problems to be solved and new risks to be anticipated (by means of implementing training strategies and adapting regulations with a view to raising safety levels and reducing risks at work). Thirdly, the transfer of relevant research results to companies.

Concrete proposals emerging from research can help anticipate specific risks brought by the spread of robotics and automated. This happens both in industry and in public utility companies, but particularly in the fields of initial and continuing training, and in the regulation of rest breaks appropriate to the greater intensity of work. As regards household robots, the risks posed by their power supply and by their mobility should be addressed by framing legislation that takes their characteristics into account and that defines standards for all such robots. This approach would enable any potential problems entailed by the more widespread use of domestic robots to be foreseen and avoid the somewhat *ad hoc* approach that has characterized the uptake of certain other technologies.

Improvements health and safety through advanced automation: trends for year 2010

One of the main contributions made by robots in industrial manufacturing is their ability to perform tasks in dangerous conditions and hostile environments. Satisfying occupational safety rules at work and reducing the risks inherent in certain jobs (such as welding or painting during the car-manufacturing process) are two of the main objectives when investing in industrial robots. For instance, robots painting with spray guns make it possible to avoid exposing workers to hazardous substances, the surfaces they paint are smoother,

One of the main contributions made by robots in industrial manufacturing is their ability to perform tasks in dangerous conditions and hostile environments. Satisfying occupational safety rules at work is often an important factor behind the decision to install robots

Table 3. Objectives of European Union Policy For The Improvement Of Occupational Safety And Health

- Reducing the number of work-related accidents and illnesses.
- Introducing the notion of equality between men and women, with regards to [illegible] and compensation.
- Preventing social risks.
- Reinforcing prevention of labour illnesses.
- Taking into account demographic evolution and its incidence [illegible]
- Considering transformations of employment, methods of work organisation, and working [illegible]
- Taking company size into account.
- Analysing new emerging risks.

Source: 'Cómo adaptarse a los cambios en la sociedad y en el mundo del trabajo: una nueva estrategia comunitaria de salud y seguridad (2002-2006)'; COM (2202), 118 end of 03/11/02.

ducted, social relationships at work, and the development of a professional career at the company; and, finally, organizational structures, and the environment where the activity is carried out. The experts involved in the study highlighted that robotics and automation will have an effect on all three groups of stress factors, and will create a new context that will need to be taken into account in order to develop strategies for coping with stress-related occupational risks. On this point, the experts envisaged work becoming more varied and fulfilling, and a reduction of labour disputes; two features that, in principle, can reduce stress factors (Table 5). However, as we can see in table 6, other impacts produced by the spread of robotics and advanced automation place us into a context where stress levels are likely to rise as a result of the stress factors inherent in automation.

The experts involved in the study pointed out that we need to take specific steps on two levels to reduce the negative impacts of robotics: in relation to companies that install these systems, and in the global context of a technologically advanced society where there are ever higher levels of automation.

- As for the issue of employment status and the companies that install robots and automated work systems, it will be necessary to increase workers' levels of capability, responsibility, and technical training; and, at the same time, programmes for continuing training and retraining need to be put in place. Training requirements will increase, and a process of continuous adaptation to the system and to the new working conditions needs to be established. The aim of this process is the

Steps to mitigate the potential impacts of the spread of robotics need to focus both on the companies that install these systems and on the global context of a technologically advanced society where there are ever higher levels of automation

Table 4. Impacts Of Robotics: Organizational Context; Characteristics of new types of employment; Occupational health and safety: Improvements and risks

[illegible]	Job Characteristics	[illegible]	New risks brought about by the implementation of automated systems
More flexible working-hours (both shift-work and flexitime). Higher levels of training of workers More temporary employment contracts (up to 40% of industrial employment in 2015 and 50% of service employment in 2010) More labour instability. Salaries will remain as at present Reduction of career/promotion opportunities.	Higher number of tasks and functions performed by the operators of automated systems and robots. [illegible] [illegible] [illegible] and automated systems. More varied and fulfilling work in highly automated companies.	Lower numbers of occupational accidents in highly automated companies. From a physical viewpoint, automation improves and optimizes working conditions by eliminating occupational risks produced by hostile environments and toxic substances. Elimination of routine, tiring jobs.	Higher levels of stress, produced by the greater intensity of work and by the increase of workload. More psychological pressure, [illegible] [illegible] produced by mobile plants and the use of electric power. In non-industrial sectors (such as construction, cleaning and maintenance, or hospital care), risks produced by the misuse of the robot or faults related to its mobile capability, to its strength when moving objects, or to its power requirements.

Source: López Peláez, A. (2001): Nuevas Tecnologías y Sociedad Actual: El Impacto de la Robótica, Doctoral Thesis, Madrid, UNED

- In the context of a global society we have to take into account the fact that the foreseeable impacts of robotics and advanced automation will produce an increase in the global productivity of the economic system and an improvement in the quality and price of goods and services, favouring a transition towards a leisure society. However, in parallel with these positive impacts, automation of an increasing number of tasks in an ever broader range of areas of business will lead to significant changes in the situation of large swathes of the workforce. There will clearly be increased unemployment in fields where robots and automated work systems are introduced. And new skills requirements may make it harder for people with less marketable skills to find a job. Thus, together with the organizational strategies directed toward improving working conditions at highly automated companies, policy decisions need to be made in order to mitigate the negative impacts of automation. These could include pensions for excluded groups, improvement of welfare state provision for those made unemployed by the changing context, or financing technical training programmes to increase the employability of those displaced by automation.

Conclusion

The changing trends in working conditions in the context of a technological revolution and widespread organizational change are creating a challenge that public authorities and social partners will have to face in order to avoid the fragmentation of the labour market, something that experts foresee as probable if adequate measures are not taken (Tezanos, 2001b). In the specific area of work-related accidents and illness, a strategy directed toward improving health and safety at work must take into account both the new risks and the opportunities brought by the introduction of robotics and advanced automation. Forecasts regarding the spread of manufacturing robots and service robots in the near future also need to be taken into account, and the experience accumulated over 30 years with regard to the implementation and use of industrial robots.

The analysis of stress factors highlights the importance of exploring coordinated Europe-wide

safety, working conditions in a context characterized
and public utility companies

specifically in the field of automation and robotics.
towards the knowledge of new technologies but also
to take on more tasks and functions, adapting to
training must be directed to increase workers' ability to
systems and stress levels.
activity, taking into account the greater intensity of
due to the use of robots and automated work
to substitute for informal rest strategies (these tend to
environments where the operator is obliged keep up

of robots in new branches of economic activity (building
construction, agriculture, life-saving, and
standardized products to minimize the risks possibly
mobile capability and to their power source.
and empowerment addressed to operators in those activity
beyond the sectors that have traditionally been users

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Renewable energy technologies as a new techno-economic system

A system is a *holon*[2], where each element evolves in tandem with the rest. Hughes (1987) argues that there is no deterministic relationship between technical form and management structure, rather co-evolution of both within a wider context. He goes on to stress that: "over time, technological systems manage increasingly to incorporate environment into the system, thereby eliminating sources of uncertainty, such as a once free market" (p. 53). Change within the system occurs through the identification of critical problems and the underlying 'reverse salients' or weak points that prevent any substantial improvement from resulting from other elements due to the interacting nature of the system (Hughes, 1987; Rosenberg, 1976).

The search heuristics that drive technical change include expectations (van den Belt and Rip, 1987), which are influenced from the socio-political structure of the system and by the blinding effect of the paradigm, with respect to alternative avenues of enquiry (Dosi, 1982). Change occurs in the context of interaction between the technological paradigm and the selection environment, which together form the broader system. Kemp et al. (1998) have attempted to capture this interaction by extending the concept of technological regime in order to capture this systemic interaction, a notion that is near Hughes' view of the tendency of technological systems to expand and absorb their environment.

The interaction of technological, social and organizational elements requires a policy that will embrace supply and demand. However the mode of diffusion of the new paradigm still eludes policy makers and analysts. In the framework outlined above, the development and diffusion of RETs constitutes a transition to a new technological paradigm, which raises the question of compatibility with the existing technological regime: Which elements of the technological system, the technological paradigm and the selection environment stand out as the most critical in this context?

RETs' diffusion involves change of a systemic nature, demanding a holistic view of the entire technology system involved (Serchuk and Singh, 1998). The most obvious non-technical changes may be indicated in the deregulation of the energy market and in environmental pressures. In view of global experience RETs integrate concern on the critical challenges that environmental and economic restrictions present to contemporary society.

Although the economic performance of RETs is constantly improving, policy measures are still necessary as counterweights to the support which conventional energy technologies enjoy and the fact that their external costs (i.e. the costs their use imposes on actors not directly involved in their use) are not taken into account. RETs' underlying economic rationale focuses on rational use and energy saving in contrast to the emphasis on consumption scaling that characterizes the existing system. The multiplying effects of RETs' development are also significant: potential for high domestic added value, opportunities for the growth of capital goods and engineering services industries.

As concerns their social particularities: on the demand side their deployment depends to a large extent on the motivation of the public and eventually a shift in values regarding the appreciation of the environment as well as issues of daily convenience; on the supply side new skill specialities are required and employment is created, as existing knowledge capital is devalued.

One may identify new players such as local authorities and local collaborative schemes, within new institutional and regulatory arran-

Techno-economic systems encompass many interacting facets. Technical change may be driven by identification of critical problems and weaknesses which are holding overall progress back

The interaction of technological, social and organizational elements requires a policy approach embracing both the will embrace supply and demand sides of the technological system

Although the economic performance of RETs is constantly improving, policy measures are still necessary to rival the support which conventional energy technologies enjoy and the fact that their external costs are not taken into account

mechanisms are based on the networking of suppliers and users and the exploitation of economies of scope. The development of applied solutions accelerates learning and places it closer to the end of the development process, integrating elements that technology development initiatives tend to ignore (such as system integration and construction capabilities, robustness in diverse physical and institutional conditions). So policy should focus on three aims:

(i) Development of focused learning mechanisms

The experience of information technology has shown that the development of solutions takes place close to the end user (Hobday, 1994; Kautz and Larsen, 2000). Disengagement of design from initial technology development and its connection with use requires the growth of an intermediary sector that will design and install complete (integrated) solutions in collaboration with the user ('system integrators'). The need to open the "black box" of technology is critical in order to develop domestic know-how. The aim would be to initiate learning processes right along the value chain from initial equipment manufacturers down to the end users. This should increase added value and, more importantly, it should constitute an important step on the road towards the long-term competitiveness of the European RET industry.

(ii) Encouragement of new types of players

Within the new deregulated framework RETs require a new socio-economic landscape. This would involve new players as well as a set of new relationships and structural elements such as pricing regulation, linking between diverse energy producers and distributors and restructuring of barriers to entry. The role of public environmental awareness is also critical (Tsoutsos, 2002). Local collaborative enterprises set up to manufacture wind generators or run geothermal applications have already had significant success (Denmark, USA), while at the same time they contribute to the mobilization of public opinion and of local resources (Tennis et al., 1998). Small and medium-sized self-producers may constitute an important new market niche against competing technologies.

(iii) Flexible financing mechanisms, adapted to the characteristics of individual applications, and environmentally consistent economic evaluation

The revision of costing of all forms of energy production is a necessary condition for indirect forms of subsidy and the environmental/social costs/benefits to be accounted for. Provisional motives should encourage efficient projects, ensuring that the marginal life-cycle cost is well founded under reviewed costing. Regulation of competition should be exploited for the promotion of cost reduction in technology, installation and operational efficiency considering economic conditions in the industry (Piscitello and Bogash, 1997).

The Strategic Niche Management approach

A promotion strategy in market segments (Strategic Niche Management) is proposed for the transition to a new technological regime (Kemp et al., 1998; Weber and Dorda, 1998), based on the creation of "protected spaces", for the development and use of new technologies. This approach has a number of interesting advantages:

- It creates conditions for interactive learning that extend beyond individual technologies. In the case of wind energy, improvement has occurred in equipment performance and cost as well as operational performance of wind farms (Street and Miles, 1996). Experience with solar thermal collectors in Greece and wind generators in Denmark has shown that the successful

The experience of information technology industry has shown that new solutions tend to be developed close to the user end of the technology

incrementally within mainstream energy systems. Niches offer a framework of intensive interaction between equipment users and producers, where solutions and improvements can be sought along new design trajectories which are benign to environmental criteria. This would provide a competitive advantage both to equipment suppliers and energy producers, while raising structural and institutional disincentives to continuing with established non-sustainable technologies.

Keywords

renewable energy technologies, innovation, diffusion, energy policy, strategic niche management

Notes

1. For instance the demand for solar thermal installations is growing continuously in Europe, but it is still not enough to reach the target of 100 million m² installed collectors by 2010, set in the EC's White Paper (European Commission, 1997).
2. holon: from the Greek 'ὅλον', means a whole entity.
3. "The Sailing ship effect" refers to the fact that the advent of a new technology can stimulate the incumbent technology to improve its performance well beyond its existing limits. Its name derives from the fact that this was particularly apparent in the case of the sailing ship, which reputedly underwent more improvements in the 50 years after the introduction of the steam ship than in the previous 300 years.
4. The case of organic farming (an energy related field) shows how regime transition may be triggered in the social space and forces the regulators to take action.

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- 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.