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THE SOCIAL STUDY OF TECHNOLOGY: THE CASE FOR PUBLIC PERCEPTION AND BIOTECHNOLOGY*

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Abstract

Studies concerned with the development of technologies have lately undergone a great impulse. Many of them have been approached from diverse academic perspectives with long-standing traditions and a great number of them have also benefited from the assumption of new conceptual perspectives. In this respect, history, sociology, and philosophy of technology constitute paradigmatic examples. An analysis of the evolution of these various academic paradigms in recent years is carried out, although succinctly, in the first part of this Working Paper.

The second part of the Working Paper deals with the issue of social research on public perception with the particular case of the development of biotechnology. Research on the public perception of technologies is a useful tool of a prospective and pre-formative nature which plays an important role as a *via media* between descriptive analyses (sociology and economy of technical change) and value-oriented studies (technology assessment and science and technology policy analysis).

In recent times, the citizens have registered a growing concern over the regulation, management and elaboration of technological policies. This development demands a comprehensive knowledge of the interaction between society and technology. Studies on public perception are highly important not only for the analysis and interpretation of future scenarios in the development of technologies, but also for the task of identifying the kind of public policies required to avoid unwanted effects and for the orientation of technological advancement towards ends considered as beneficial by society as a whole.

Introduction

Studies on the public perception of technologies derive from social analyses and opinion research of a wider scope. In advanced Western democracies this type of social inquiries are carried out for purposes which range from, say, assessing the commercial interest of a new product to identifying social expectations with relation to political change. Social indicators have gained special relevance as tools for research interpretation and their use has greatly expanded in recent times. This is reflected in the proliferation of private companies and public agencies engaged in this type of opinion research and marketing ([1]). Given this context, it is useful to

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[1]. On the issue concerned with the use of social indicators in the process of technology management, see the critical work by Wynne (1975).

identify the reasons behind the growing concern shown by public, private bodies and NGOs (Non Governmental Organizations) with respect to the design, development and eventual implementation of technologies.

As happened with other related issues, the 1960s represented a turning point for social research concerned with the development of technologies. It was precisely in those years when public opinion in the industrially advanced democracies became aware of the importance of the citizens' role in the process of shaping technological innovation: design, assessment, implementation and evaluation (Cutcliffe, 1989; Brown, 1989; Winner, 1986). Debates on nuclear energy and environment decay, as well as issues related to the implementation of technologies which fell outside democratic control, came to the forefront of public concern. At present, the need for the institutions to undertake studies on public perception in order to legitimate the use of new technologies is beyond any contention.

In 1972, the OTA (*Office of Technology Assessment*) was established in the USA and was commissioned to study, among other priorities, the public perception of technologies. This institutional initiative was followed by other practices related to the assessment, management, and policy analysis of technologies in the USA and other Western countries. New Parliamentary Offices and Committees on Ethics were created to this end.

A special mention should be made of genetic engineering and the new technologies of assisted human reproduction. These are technologies of important social effects due to their direct implications for citizens' expectations and vital beliefs. Therefore, it comes as no surprise that the OTA, the European Parliament, the European Commission and other national legislatures have commissioned a great number of social surveys with relation to the public perception of technologies ([2]). The main aim pursued by this type of social research is the analysis of the different opinions expressed by the general public and their understanding of technology development. Data provided by these social studies are essential inputs to incorporate in the subsequent processes of legislation and regulation of technologies.

Studies concerned with the development of technologies have lately undergone a great impulse. Many of them have been approached from diverse academic perspectives with long-standing traditions and a great number of them have also benefited from the assumption of new conceptual approaches. In this respect, history, sociology, and philosophy of technology constitute paradigmatic examples.

Research related to technology assessment, science and development policies, and to the economy of technological change has also expanded the academic interest in these issues since WWII. Within this ensemble composed of studies formulated from diverse disciplinary orientations we can observe, however, a main division between those of a descriptive nature and those which are value-oriented and more inclined to prospect considerations (Luján, 1992).

The main thesis expressed in this Working Paper is that studies on public perception of technologies constitute a useful link between both descriptive and prospective research lines. As a first step, it is therefore necessary to analyse the evolution of these various academic paradigms in recent years. This we carry out, although succinctly, in the first part of this paper. The second part is devoted to a reviewing of the case of public perception on biotechnology.

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[2]. Cf., Cantley (1987), OTA (1987), Eurobarometer 35.1, Durant (1992), and Moreno, Lemkow & Lizón (1992).

I. The social study of technology.

'Traditional' approaches.

Quite a number of premises and findings are common to the 'traditional approaches' assumed by the sociology and economy of technology and the assessment of technology as first formulated by the OTA. Although socio-economic studies of technology have dealt with a diversity of issues and questions, a general and latent perspective can be traced in all of them.

Broadly regarded, technology is conceptualised as an autonomous activity which produces a social impact. A set of main tasks undertaken by sociologists and economists has been precisely that related to the observation, measurement and interpretation of the impact of technology development. Traditionally, a majority of the economic and sociological studies have tended to assume that society is related to technological products but not with the process of technology construction, something which rests solely upon the dynamics of human knowledge. According to this view, society is mainly considered as an aggregate of consumers whose ideas and decisions are moulded by the effects produced by those technologies available in the market. This aspect of technological change has traditionally been at the centre of the main interests of social scientists.

Neo-classical economy was rooted in several premises: consumers' rationality, maximization of profit, self-balancing and 'perfect equilibrium' of industrial relations, open market and complete information (Bijker, 1993). From this perspective, technological change is regarded as a result of the maximizing behaviour of industrialists and firms favouring 'cheaper' techniques per unit of production (e.g. by reducing workforce or using less costly raw materials). For Marxist theory, technological change depends also on decisions taken by employers in the light of the socio-economic impacts involved. According to this view, it is not so much profit maximization that is at stake as the maintenance of a position of dominance in the process of the class struggle (i.e. the criteria is, thus, related to social power in its broader sense and on a long term basis) (Elster, 1983; Mackenzie, 1984).

The primary consideration of impacts in the social analysis of technology is also evident in the early projects related to technology assessment -it becomes apparent in the description of its operational procedure. According to Jones (1971), this procedure for technology assessment is committed to the following tasks:

(i) Defining the scope of the assessment.

(ii) Describing the relevant technological aspects which imply an identification of the most probable future developments.

(iii) Studying the non-technological elements which would intervene in the technology development.

(iv) Identifying the areas of impact (social, economic, political, institutional, technological, legal, environmental).

(v) Analysing preliminary impacts.

(vi) Identifying possible options for action.

(vii) Analysing and measuring the technological impact (reviewing the estimates in -v- in the light of the possible options -vi)

Except for (iii) there is no reference to the process of technology development. However, an absolute emphasis is placed on all aspects related with the impact and effects of the technological products ([3]). In the 'classical' orientation of the studies of technological assessment the frequent use of cost-benefit analysis is to be underlined.

As regards the studies and analyses of science and technology (S&T) policies much can be argued along the same lines. According to Schienstock (1993), a similar restricted concept related to the application of techniques for the main purpose of improving industrial machinery or/and maximizing production is also present in this type of research. Within this perspective, progress is functionally shaped by the technological impacts on economic competition. Thus, the *osmosis model* is referred to as that by which basic research conditions in a decisive manner the ways and means of technological innovation outcomes. These, in turn, determine either increases or reversals in human well-being. Consequently, public authorities should take the initiative in the implementation of science and technology (S&T) policies simply because the market economy on its own does not secure the promotion of basic research. In this respect, both applied research and industrial innovation are dependent on this promotion of basic research. The market economy is regarded, then, as incapable of regulating available resources and securing the continuous development of technology which is required for economic growth. In the end it is the state and the public sector that must finance and promote basic research.

A general idea of a lineal progress ([4]) and one-dimensional causality ([5]) is thus latent in this amalgamation of 'traditional' social studies engaged mainly in establishing relationships between science, technology, industry and society.

From a descriptive point of view, the sole relationship between technology and society has been considered as the paramount nexus for the characterization of the resulting social impacts. From an axiological or value-oriented viewpoint, such a relationship has been regarded as being the principal tool for the interpretation of social progress. In line with the well-known *dictum* established by the principles of Illustrated Despotism, both approaches have sustained the preview that technology is beneficial for society as long as the latter does not interfere in the development of the former.

'New' approaches: evolutionists and constructivists.

During the 1980s a deep theoretical transformation took place as regards social studies of technology. The so-called evolutionist approaches and social constructivism -in the fields of the economy and sociology, respectively- can be mentioned in this respect (Bijker, 1993; Luján, 1992).

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[3]. Cf. Coates (1976) and Porter, Rossini & Carpenter (1980).

[4]. This labelling is also applicable to certain evolutionist authors, e.g. Ogburn & Usher.

[5]. Cf. Pinch & Bijker (1984), and Sanmartín & Ortí (1992). See also Bury (1920), Basalla (1988), and Staudenmaier (1989).

More than a process of rational choice, evolutionist economists regard technical change as a process of 'trial and error' (variation and selection). Richard Nelson and Sidney Winter, first theoreticians of this school of thought, rejected concepts such as 'maximizing rationality' and 'equilibrium' ([6]), and proposed alternatively the ideas of 'search' and 'selection'. The goal to be accomplished is not so much pre-determined by 'maximization' as such, but by a type of satisfaction compatible with industrialists' behaviour and expectations in broad terms. Thus, companies and industries in a better position to research and obtain better techniques and technologies would also be in better conditions for expansion. Nelson and Winter refer, consequently, to both 'technological trajectories' and 'environment selection'.

Giovanni Dosi has also introduced the concept of 'technological paradigm'. One of the expressions of the paradigm is the technological 'trajectory', which is also conditioned by a specific milieu. A technological paradigm defines, moreover, the needs to be satisfied, the scientific principles and the technological materials to be used. In other words, a paradigm is a pattern for sorting out the techno-economic problems by applying principles established in the natural sciences (Dosi, 1982).

A technological paradigm is characterised by a collection of exemplars ([7]) (a car, an integrated circuit, for example, together with their techno-economic qualities) and by a collection of heuristic principles: Which position can we move towards from where we stand now?; what can we search for?; what kind of knowledge can be useful for us?. A paradigm defines future options for innovation and some of the basic procedures to carry them out. In other words, paradigms concentrate innovative efforts in a chosen direction. Nevertheless, 'paradigm' and 'trajectory' are concepts used in different terminological variations: technological guide-posts or focusing devices, for example. Christopher Freeman and Carlota Pérez make use of a concept broader than the technological paradigm: the techno-economic paradigm. They refer to both common and complementary qualities and the inter-relationships between various technological paradigms ([8]).

By using these concepts, the evolutionist economists underline the fact that the technological 'mutations' offered in the market are not produced at random. The systematic selection made by the market provides the process of technological change with a direction. This is, in fact, the result of an interaction between cognitive and socio-economic elements. In recent times, and in reference to this interaction, theorists of this school of thought have used expressions such as 'co-evolution of technologies and institutions' (Nelson, 1993). This will be analysed further on in this paper.

Concerning social constructivism the first aspect to be underlined is that under its umbrella there co-exist research programmes with different stresses. In particular, the SCOST programme (*Social Construction of Science and Technology*) is the result of the merging of EPOR (*Empirical Programme of Relativism*) and SCOT (*Social Construction of Technology*). EPOR is a programme within the field of the sociology of scientific knowledge. This can be considered an orientation in the social studies on science and technology (S&T) -more than an academic

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[6]. These are common to the neo-classical approach reviewed earlier.

[7]. On the concepts of paradigm and, cf. Kuhn (1962, 1974). See also Shapere (1966), Lakatos & Musgrave (1970), Barnes (1982), and Luján (1993).

[8] Cf., for example, the contributions reproduced in Dosi et al (1988).

discipline in itself- which aims at explaining the structure of scientific knowledge from a social viewpoint (Collins, 1983). SCOT, in turn, is a programme of the sociology of technology in which the development of a technology is regarded as a process of variation and selection. Contrary to other approaches in the sociology of technology, the shaping of a successful technology cannot be perceived as the only one possible. Its success is to be considered rather as the *explanandum* than the *explanans* (Pinch & Bijker, 1984). Consequently, the construction of multi-directional models are set to explain why some variants survive and some do not. This exercise is carried out taking into account which problems are solved by each variant in order to determine, later on, the relevant social groups affected. The selection process of technological variants surfaces as a distinctly social process.

In the SCOST methodology, as expressed by Trevor Pinch and Wiebe Bijker (1984), scientific or technological controversies are examined to determine the variability in data interpretation (in the case of science), or in the interpretation of technological designs or products (in the case of technologies). We subsequently analyse the closure mechanisms by which such a variability is reduced and why certain designs or interpretations (closing mechanisms of the controversy) are imposed. Finally these closure mechanisms are related with the social context (relevant social groups, professional, class or corporate interests, for instance)([9]).

Michel Callon has elaborated another approach within the constructivist camp of the sociology of technology which is known as the *actor-network theory*. According to this approach, both scientific and technological developments can be analysed in terms of struggles between different actors who seek to impose their respective definition of the problem to be solved. Michel Callon and Bruno Latour refer either to human or non-human actors (chips, batteries, circuits or any other technological component or physical object). Consequently, human actors have to take into account not only the behaviour of other fellow human beings but also the dynamics of the objects involved in the development of any given technology (Latour, 1987; Callon, 1987).

Some of the aspects present in Callon's approach have been developed further by Philip Vergragt (1988). For this author the choices made between different R+D (Research and Development) options reflect interests and power relations of the various actors involved in the technological process. Thus, a research line is the result of a succession of decisions taken with relation to such a collection of options. In the periods when no decisions on the different options are taken, the research aims and the definitions of the problems remain unaltered. In these periods, scientists and technologists work to increase their level of knowledge and to solve irregularities related to the dominant definition of the problem. As a result of a decision taken among different options, a 'niche' is created in which scientists and technologists carry out their activities in accordance with standardized scientific rules and procedures. The concept of 'niche' is similar to that of 'normal science' in Kuhnian perspective. However, apart from dealing with 'puzzles', niches are also related to the findings of possible technological applications, as well as to the study of the perception of potential markets and corporate and industrialists' strategies. Actors are not only the scientists and technologists, but also company directors, managers and heads of the research departments, as well as engineers and staff responsible for commercial and marketing activities. A research line is, then, the result of a process of negotiation among actors, each of whom seeks to incorporate support from other actors. Once a dominant definition

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[9]. A number of case studies can be found in Bijker, Hughes & Pinch (1987), Bijker & Law (1992) and Jasanoff et al (1993).

is established, the research line stabilizes and a 'niche' of scientists and technologists is finally created.

Vergragt's approach shows resemblance with the evolutionist theories of technological change, for which the outside environment to the scientific activity -as perceived by its own actors- can lead to critical periods when negotiations on the different options for the definition of the problem re-open. Such an exogenous environment is subject to government regulations, market needs or, for instance, competitors' strategies ([10]). Re-negotiation can also be determined by the failure (or a perception of failure) of a research line or by corporate changes within the organization which the research centre is dependent on: staff substitutions, re-formulations of commercial strategies, deviations of budget resources or simply reduction of the research personnel. According to Vergragt himself, his approach avoids both technological determinism (choices are taken between the possible and available options) and economicist determinism (economic constraints and possibilities are perceived, assumed and negotiated by each of the various actors intervening in the technological process).

This concise review of 'new' theories and concepts is illustrative of the important conceptual renewal of the social studies on technology. As a consequence of this, a common tuning between evolutionists and constructivists is also observable, even though both descriptive perspectives share similarities and differences at an equal level. However, a characteristic which is common to both schools of thought is the consideration that the social (economic, political and cultural aspects alike) is a decisive element in the emergence, development and consolidation of technologies. Further, the evolution of technologies is regarded as the result of two processes: one of variation and the another of selection, and the social factor intervenes in both. The main difference between both approaches is that, while the former distinguishes in an explicit manner between processes of variation and selection, the latter emphasizes the relationship between them (Schot, 1992) ([11]).

Prospective approaches: Assessment and policy analysis.

A process of conceptual renovation is also noticeable as regards technology assessment and scientific and technological policy analysis. In the case of technology assessment such a revitalisation is reflected in the proceedings of the successive conferences of the ISTA (*International Society for Technology Assessment*). Early modifications on the concept of technology assessment emerged in 1976 on the occasion of the II ISTA Conference and consolidated during the III Conference held in 1982 (Smits, 1990). Table 1 reproduces the main variations.

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[10]. See also Irwin & Vergragt (1989).

[11]. On this issue cf. the 'sociologization' of the proposals of the evolutionist economists made by Belt & Rip (1987) and Rip & Belt (1988). See also, Bijker (1993).

Table 1: Variations in the concept of technology assessment

Embracing context	Initial Paradigm	Emerging Paradigm
1. Philosophical	Evaluative	Futures-creative
	Elitist assessment	Public participation
	Incremental policy orientation	Metapolicy orientation
	Product and result operation	Process/ balance orientation
	Holism (bottom-up)	Holism (top-down)
2. Epistemological	Value-free	Value-sensitive
	Restricted to empirical inquiry	Accepting inquiry systems
	Restricted to scientific knowledge	Admitting intuitive judgement
	Projective (forward-time) causality	Anticipatory (time-reversed) causality
	Empirical verification of truth	Dynamic growth of valid knowledge via falsification and error-feedback
3. Methodological	Technology as independent variable	Technology and society as interdependent variables
	Quantitative analysis based on data	Combination of qualitative analysis
	Convergent thinking	Successive divergent/convergent thinking
	Theoretical integration	Systemic integration
	Single *ad hoc* project/model	Multiple complementary projects/models
4. Procedural	Emphasis on intellectual process	Emphasis on social learning process
	Bounding by project staff	Unbounding and bounding jointly by interested parties and project staff
	Aggregated cost-benefit analysis by project staff	Disaggregated cost-benefit analysis jointly by interested parties and project staff
	Policy options suggested for a limited number of political actors	Alternative policy packages analysed by value-oriented procedures for interested parties
	TA as an independent evaluative	TA embedded in a futures-creative activity system for society

Source: Boroush, Chen & Christakis (1980).

In 1987, a new concept was formulated on the occasion of the I European Conference on Technology Assessment held in Amsterdam under the auspices of the Department of Scientific Policy of the Dutch Ministry for Education and Science, the NOTA (*Netherlands Organization of*

Technology Assessment) and the FAST Programme (*Forecasting and Assessment of Science and Technology*) of the Directorate General XII of the European Commission (Smits & Leyten, 1988). The main differences between 'traditional' and 'new' concepts of technology assessment are reproduced in Table 2.

Table 2: Main differences between 'traditional' and 'new' concepts of technology assessment

Traditional concept	**New concept**
Dominant role of science	Equal role for researchers and users
High expectations as regards the potential of research	Modest expectations as regards the potential of research
TA output = study report	TA output = study report + discussions ensuing from study results
Little attention given to problem Definition	Much attention given to the formulation of the problem definition
One TA research organization	Multiform TA research capacity
Instrumental use of information in a rational decision-making process	Conceptual use of information in decision-making processes dominated by political considerations
TA results are automatically incorporated in the decision-making process	Much attention given to the tuning of the TA process to decision-making
Technology is an autonomous process	Technology is the work of man

Source: Smits & Leiten (1988).

In the Amsterdam Conference the concept of constructive technology assessment was also outlined (Rip & Belt, 1988; Smits, 1990). According to this new conceptual elaboration, technology assessment should not be devoted exclusively to factors external to the technology such as impacts and effects but should basically be related to its internal development as an on-going process in which emerging choices are conditioned by social, economic, technical, scientific or political factors (Schot, 1992). Basically, technology assessment serves the purpose of facilitating decision-making regarding new techno-industrial possibilities. The latent idea is that contemporary societies can control, in some degree, the pace and direction of technological change. On this very point, both evolutionists and constructivists maintain a close relationship with the new concept of technology assessment.

Constructivist sociologists and evolutionist economists have replaced the traditional one-directional models with the multi-directional ones. Prior to that, models of technological change could refer to the increase of technical efficiency, to the increase of the economic efficiency or any other 'maximizing' criteria. The pursued result was always a history of -more or less- technological success. Multi-lineal models, in turn, show that the evolution of any given technology could have been different had other economic, technical, cultural or political factors taken place. With the use of technology assessment and the development of S&T policies the whole process is 're-addressed' in order to secure the incorporation of certain social, moral and political values. Under this perspective, the regulation of research and technology (R & T) appears as a task of orientation and incentive for innovation rather than one of sheer normative limitation (Rip & Belt, 1988; Irwin & Vergragt, 1989; Jelsma 1991, Schot, 1992).

Recent analyses on S&T policies question the main premises on which the above-mentioned *osmosis model* is based. At present, there are few experts on S&T policy who sustain the view that an increase in the scientific knowledge is a sufficient condition for both industrial innovation and economic growth. The nexus between the various stages of innovation, which in the past was regarded as 'natural', is now considered to be a crucial relationship. In fact, such a connection is the main object of the policy action deployed by the state, namely the transfer of the results procured by basic research to applied research, and from this to industrial innovation. A last -but not least important- question is to determine which are the most competitive sectors at the national level. This exercise implies not only the need to carry out comparative cross-national analysis on the level of technological development reached by other countries, but also to assess our own state's organisational, economic, cultural or socio-political peculiarities. Differences between traditional and modern research and development (R+D) are compared in Table 3.

Table 3: Characteristics of the traditional and modern technology policies

	Traditional R & T policy	Modern R & T policy
Object	Material aspects (substantive technology)	In addition, organisational, institutional and cultural aspects (technological practices)
Objective	Economic growth	In addition, social and ecological compatibility
Stage of Technological Innovation process	Stages of little bearing on the market (primarily fundamental research)	Also stages closer to the market (technology transfer)
Policy Integration	Part of economic policy (largely implicit R & T policy)	Independent policy field closely interlinked with other policy areas (increasingly explicit technology policy)
Role of the state	Central actor of technological innovation process	Facilitator and coordinator of the self-regulation of the innovation process
Instrument	Support, regulation	Provision of infrastructure
Policy type	Direct control	Context control

Source: Schienstock (1993).

The new perspectives brought about by the various social studies on technology are synthesized in the modification of the very concept of technology itself. Traditionally, technology has been substantively and instrumentally conceived. Cars, microwaves, high-speed trains, computers or laser printers have been considered the products of technology In other words, technology was defined as the result of the technological activity. At present, the emphasis is on the technological practice or the process geared to the production of results. This, we sustain, is a common feature to the main disciplinary approaches concerned with the social study of technology.

In general, two definitions of technology can be identified as being generally accepted (Pacey, 1986). The former, of a restrictive nature, refers principally to technical aspects (knowledge, skills and techniques, tools, machines and resources); the latter, of more general scope, also incorporates organisational aspects (economic and industrial activities, professional commitments, users' and consumers' concerns), as well as cultural factors (aims, values, ethics, and behaviourial codes). Technical changes can produce cultural and organisational adjustments in the same way as organisational innovations can lead to technical and cultural changes. Pacey invites us to study, analyze, asses and manage technology in a comprehensive manner and making explicit the underlying cultural values. According to the conventional conception of technology, solutions to problems arisen within human society are exclusively technical. Pacey states that the kind of solutions which are more in line with citizens' wishes and hopes often depend to a greater degree on the implementation of changes in the organisational sphere of life. In a broader sense, each relevant area of technical/functional organisation in modern society can be regarded as an *instrumentation regime* (Winner, 1986). Thus, a task which is as crucial as analyzing the impact produced by the technological development, or even more so, is to assess the social and material infrastructures which are responsible for the establishment of specific technologies required by the daily social activity of human beings.

Public perception and political environment

In the context of the new academic approaches which are the object of our analysis, the studies on public perception of technologies constitute a type of social research of crucial importance. Doubtless, the final configuration of a technology, its subsequent evolution, and the selection of alternative designs depend on a great number of factors. Among them, the meanings assigned by the different social groups on the implementation of technologies and their correlation with the promotion of their own interests are of paramount importance. In this respect, the studies on public perception contribute with useful insights to studies of technology assessment and R & D policies, as well as for the regulation of the technological activity.

Public perception analyses often refer to the political environment or milieu within which the technological process takes place. Linda Pifer has studied the case of the genetic testing of schizophrenia in order to illustrate, in general, the social conformation of technologies, and, in particular, the shaping of a concrete political milieu related to this disease. According to Pifer's observations, the main influential actors of social conformation are the general public, the mass media, the public administration, the biotechnological industries, and the associations of the persons affected by the disease (Pifer, 1989).

After a thorough review of the related literature, Pifer concludes that USA citizens have a very limited knowledge of biotechnology/genetic engineering, as a whole, and of the symptoms, prognosis and causes of schizophrenia, in particular. Only 14 per cent of the survey answers given by young middle-class respondents with high-school degrees showed some familiarity with the main applications of human genetic engineering. 55 per cent of all USA citizens were of the opinion that such a mental disease did not exist. Other studies reveal that a majority of people sustain the view that schizophrenia is incurable and usually inherited (NB. This contrasts with the fact that up to 50 per cent of schizophrenic persons improve notably or even recover completely ten years after catching the disease). Despite the fact that most USA citizens do not have a good level of knowledge concerning genetic engineering and schizophrenia, it is somewhat striking that up to 50 per cent of the women in the United States expressed their willingness to take a genetic test in the eventuality of becoming pregnant.

In Pifer's study, the media tended to present schizophrenics as violent individuals, very different in their behaviour from everybody else. Most citizens are convinced that becoming affected by heart diseases or even cancer tumours is something that may well happen in modern life. However, hardly anybody has the same kind of 'expectations' of suffering schizophrenia. These type of public images or conventions which are induced in many cases by the media eventually become powerful factors conditioning the level of institutional support for the preservation of research programmes aimed at the eradication of the disease (NB. Compared with schizophrenia, the case of AIDS would illustrate the reverse process in attracting a growing level of popular compassion).

In the United States, this kind of research on diseases related to mental disorder is very limited and highly dependent on public funds. Note that while up to 50 per cent of all bio-medical research is funded by the private sector, around 85 per cent of the research on mental diseases is financed by the government.

It seems more than plausible to believe that the pharmaceutical industry will have great interests in everything related to the development of genetic tests on schizophrenia. At present, the medicines and drugs available on the market can only alleviate the symptoms of schizophrenia but cannot cure it. Thus, genetic testing has emerged as a fundamental instrument for the identification of this disease. It comes as no surprise that this type of testing, which is also applicable to the diagnostics of other diseases, has become one of the main objectives of industrial strategies deployed by both the 'traditional' pharmaceutical sector and the 'genuine' biotechnology companies that have had a rapid development in recent times. Moreover, psychiatrists are looking closely at all these developments with deep and sizeable economic repercussions.

It is, therefore, no exaggeration to foresee a modification in the public perception of schizophrenia which will be eventually induced by the action of other concerned actors in the political milieu (the industrial and the medical sector, principally). This 'probable' outcome would, nevertheless, be subject to the pressure of advocacy groups in support of the schizophrenic which would seek as 'desirable' in the future a greater involvement of the government. This, in turn, is just a 'possible' scenario which would be very much influenced by changes in the public image of the disease ([12]). Obviously, the action of the media would play an important role in helping to create 'new' public insights into the nature of schizophrenia. The commercial and economic interests of the industries would no doubt lie behind the 'tuning' of the media with the fortunes of the schizophrenic and, in conclusion, the whole circular process of interaction would be 'closed' in an interactive process.

Studies on public perception are highly important not only for the analysis and interpretation of future scenarios in the development of technologies, but also for the task of identifying the kind of public policies required to avoid unwanted effects and for the orientation of technological advancement towards ends considered as beneficial by society as a whole.

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[12]. The future is both multiple and indeterminate. For the 'project building approach', based on both empiricist knowledge of 'possibles' and 'probables' and on a vision of 'desirables', cf. Masini (1981, 1982).

The social perception of technological risks

Closely related to the issues raised in the preceding section lies the theme of the public perception of the risks produced by technologies. Let us remind that one of the main commitments assumed by the OTA after its creation was precisely that concerned with risk management (Medina, 1992). Before it, this issue had normally rested on the consideration that risks involved in any technological activity could be determined in an univocal way: decisions were simply taken following the release of 'technical' recommendations (Brown, 1989). This model of management is known as 'objective assessment of risks' ([13]).

However, the lack of agreement among experts, the varying assessment of risks made by diverse interest groups involved in the technological process, the difficulty of calculating social impact -just to name a few factors to be taken into account-, encouraged the emergence of a new model of risk management characterised as 'decision analysis'. According to this model, the objective measurement of technological risks is not as important as the analysis of the various possibilities of action with relation to individual and institutional preferences. Perhaps the most relevant problem faced by this type of approaches is the proclivity to 'monetarise' individual and social choices.

In recent times, studies of the public perception of risks have experienced a great impulse. A feature shared by all of them is their concern for a close analysis of the ways in which individuals learn through experience about their own social milieu (Brown, 1989). Four distinctive methodologies can be distinguished in this respect: the cognitive approach, the psycho-social, the cultural and the sociological (Turner & Wynne, 1992) ([14]).

The cognitive approach seeks to determine the level of risk that society should be prepared to accept and the elements that citizens would take into account when assessing technological risks. Psycho-social methodology on risk perception is mainly focused on the study of public attitudes with respect to the social environment. This perspective puts the emphasis on the nexus established between risk perception and axiological systems of values and beliefs.

From a cultural viewpoint human beliefs regarding nature and risk are considered to be social constructions. Mary Douglas has analyzed many of the environmentalist controversies and has reached the conclusion that the various social groups involved in these social debates do not diverge much on the factors to be introduced in risk assessment but rather on the identification of the different kinds of risks associated with the development of any given technology. Risk selection is made according to the type of group organization and the mode in which the group interacts with the broader political context. While environmentalist groups mainly concentrate on risks of a catastrophic magnitude and on its long-term consequences, the shortage of energy sources is the paramount concern for industrialists. Bureaucrats, in turn, mainly devote themselves to the task of risk measurement and management (Turner & Wynne 1992).

From the sociological perspective, technological risk is related to its potential threat to social life

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[13] A good deal of contributions devoted to technology risks and social perception are reproduced in Chalk (1988). See also the monographic issue edited by *Daedalus* (1990, vol. 119, no. 4).

[14]. Wildavsky & Dake (1990) use a not too different classification: 'knowledge theory', 'personality theory', 'economic theory', and 'cultural theory'.

(eg. family structures and processes of socialization) rather than to the calculation of numerical estimates of the possible physical damage produced by the technologies under scrutiny. Public perception of technological risk is closely intertwined with socio-cultural identity, moral values and socio-economic relationships. Disagreements on risk perceptions between the general public and the experts depend, thus, on the various elements and premises to be accounted for when carrying out the technology assessment.

Social research on public awareness of technological risk can also be divided according to the manner in which it interconnects the perception of the experts and that of other social groups. Some approaches hold the assumption that the 'objective' calculation of risks associated with technology implementation is not possible. They also look carefully at the factors that influence public opinion. On the other hand, other approaches consider that both kinds of perception are related to social and cultural elements, so that technical risk assessment or experts' statements should be privileged.

Recent research on public perception has come to the conclusion that the historical and social contexts in which risk emerges, is identified, and develops are of greater importance than they have traditionally considered to be (Turner & Wynne, 1992). Above all, this finding has a practical repercussion. The regulation and management of risk associated with technology implementation can greatly benefit from public perception studies which must take into account the referred-to historical and social contexts. Often, as is the case of biotechnology, technology development is regarded by the public with a considerable degree of uncertainty. In this respect, two goals should be accomplished in any study of risk assessment: (a) the analysis of the nature of the social context, and (b) the direct incorporation of the experiences of all relevant social groups involved.

Regulation and innovation management

The idea of recognising and setting limits to the development and implementation of certain technologies has greatly extended in recent times. This growing social consensus is based upon the following criteria (Winner, 1986):

(1) When technological applications threaten public security or health.

(2) When their use could result in the exhaustion of sources of anything which is vital sources for the well-being of citizens as a whole.

(3) When their implementation would have negative effects on the environment (air, land or water).

(4) When protected areas and natural species would be jeopardised by technology practices.

(5) When their implementation would provoke social unrest or disproportionate effects among the citizenship.

In advanced Western democracies, a general social consensus seems to indicate that the majority of citizens are not prepared to renounce their high levels of consumption, much of which are the commercial expression of numerous technological applications. Nevertheless, a growing feeling of dissatisfaction is also observable in connection with the effects produced by many technological applications affecting the quality of life and the preservation of the environment, both necessary elements for achieving individual and social stability.

In conclusion, the citizens have registered a growing concern over the regulation, management and the elaboration of technological policies. This demands a comprehensive knowledge of the interaction between society and technology. Research on the public perception of technologies is a useful tool of a prospective and pre-formative nature which plays an important role as a *via media* between descriptive analyses (sociology and economy of technical change) and value-oriented studies (technology assessment and science and technology policy analysis).

Furthermore, controversy between technological and sociological determinism has been induced by an extreme conceptual dichotomy: technological versus sociological determinism. Despite their opposite entrenched positions they share somewhat common practical considerations. Despite the fact that these determinist viewpoints regard research on technological assessment and S&T policy analysis as aimless, they assume that any effective human action is highly dependent on a correct understanding of the interaction between technology and society (Pavitt, 1987).

There are there scopes of analysis to be reviewed when studying the interaction between technology and society: (a) Research and development (R+D); (b) innovation; and (c) technical change or diffusion of the innovation. One aspect of the controversy between technological and sociological determinism concerns precisely the scope of study (Luján, 1992). Social research on R+D or on technological innovation is mainly focused on social factors which influence the process of technology construction. On the other hand, in a great deal of the studies on technical change the very existence of technologies is taken for granted and their influence is merely analyzed within an economic context (NB. In most of the approaches this context is seen as being responsible for making the technology selection on its own). The possibility of overcoming the dichotomy of the determinisms -sociological and economic- lies in a synthesis capable of addressing both processes of invention innovation.

At present, it seems beyond dispute that a common conception of the relationship between technology and society is underlying most of the research carried out in this respect. Technology cannot be simply regarded as technological. It is also social. But the social dimension of technology is never completely social; it is also technological (Law & Bijker, 1992). Given these premises, studies on public perception contribute greatly not only to the understanding of technological development but also to the orientation of it.

II. Biotechnology and the public

When dealing in a broad sense with the relationship between society and technology the fact that the latter has been the subject of both public scrutiny and political debate in the last decades must be emphasized. In the 1960s, technological development became the focus of diverse social movements. The reasons for such an interest lay in: (a) The persistence of major technological accidents; (b) The attention given to them by the media; (c) An increasing lack of public confidence in the experts' advice and in the government's ability to cope with these events; and (d) a growing politicization of the issues related to the protection of public health and the physical environment (Brown 1989). Also, the emergence of the 'Big Science', the academic concern for the divorce between the scientific-technical and social-humanistic cultures, as well as the harsh criticisms of technological development made by the contra-cultural movements were other causes which explained such an interest (Cutcliffe, 1990; Durbin, 1990).

The issues of nuclear energy and chemical pollution deserve a special mention. Undoubtedly, one of the contributions which stimulated the developing of a critical social conscience towards technological development was the book by Rachel Carson, *Silent Spring* (1958). Synthetic pesticides or heavy metals were seen as material for the gradual poisoning of human beings and the planet as a whole. Carson brought these issues to the forefront of public interest in a very powerful manner. Moreover, the building of nuclear plants was another crucial conflict which spurred the quest of the ecological groups and the extension of a general environmentalist creed.

Social actors and their action

The great development of biotechnology has been taking place in a socio-political context of technological hyper-sensibility ([15]). This circumstance has helped to make a special case of the development of biotechnology which, furthermore, has potential effects on most human and social activities due to its horizontal repercussions (eg. medicine and health, agriculture, environment protection, chemical and pharmaceutical industries, and social insurance or labour relations). Further, biotechnology development incorporates a powerful symbolic dimension, precisely because it deals with the very concept of life. It affects the very understanding of humans as living beings (Hottois, 1990). Biotechnology is also related to issues of great social debate at the present time: biodiversity, technological transfers, rights of industrial property, and North/South relations, to name a few. Finally, past experiences on the nuclear power controversy have made social groups and actors approach the issue raised by the development of biotechnology in a substantially different manner. Let us review briefly the main features of their expectations and action.

Scientists and technologists are aware of the public concern for biotechnology R+D. In the Conference of Asilomar, held in 1975, a moratorium resolution was approved in relation to all experiments of recombinant DNA. Later on, the moratorium was raised. Since then, a great deal of the research on biotechnology, and in particular as regards recombinant DNA, has been focused in the establishment of safety measures for both experimentation and the liberation of genetically modified organisms (GMOs) (Jelsma, 1991).

Public institutions have played an important role concerning three aspects of the development of biotechnology/genetic engineering: (a) Support for carrying out studies on public perception; (b) Incentives for research on biotechnology; and (c) Regulation of biotechnological practices. Most of the industrially advanced countries have implemented specific R+D programmes on biotechnology, and in particular the USA, Japan, France, the United Kingdom, Germany and Denmark. The European Community have been very active with programmes such as BRIDGE (1990-93) or BIOTECH (1992-94).

While giving support to biotechnology research and innovation, public institutions have also taken initiatives in order to let the general public be aware of the applications related to the development of this 'new technology'. In 1982, a European Report promoted by FAST under the title, *Education: for human resources and public understanding* stated that,

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[15]. Implementation of new technologies has always provoked social mobilization. The case of the Luddites and the controversies on railway expansion can be cited as well-known examples.

"The strategic projects to be pursued through the key centres should respond to (or anticipate) the needs expressed, through marketplace or political decision, by a democratic society, and must in that context be capable of winning the political, financial and social support necessary for their implementation. Such support depends on a degree of public acceptability and comprehension. Obtaining such support can be more difficult than solving the technical problem, and the consequences of failing to do so can be more costly than the development of the technology itself" (Cantley, 1992:19).

This general concern towards public opinion has materialised in a good deal of sociological studies. The OTA report (1987) in the United States and the Eurobarometer 35.1 in the case of the European Community must be referred to. As well, a number of studies are also available at state level: eg. Denmark (Borre, 1989); Ireland (Landsdowne, 1989), the Netherlands (Hamstra, 1991), Spain (Moreno, Lemkow & Lizón, 1992) and the United Kingdom (Martin & Tait, 1992), as well as for the EC countries as a whole (Cantley, 1987) ([16]).

As far as the regulation of biotechnological practices is concerned, the consolidation of a climate of public confidence has been a goal of paramount importance ([17]). In this respect the states and public institutions have implemented diverse norms and pieces of legislation to secure the active acceptance of the general public ([18]). The European Commission has approved several directives on several biosafety aspects. Directive 219/90 regulates the use of genetically modified micro-organisms in confinement (R+D and industrial laboratories), and Directive 220/91 urges the European member states to implement legislation related to the liberation of GMOs. Finally, Directive 679/90 concerns the protection of workers under exposure to biological agents (Luján & Moreno, 1993). Regarding regulation matters, a particularly conflictive issue is patenting. In fact, a proposal made by the European Commission (Directive Draft 89/C10/3) has not yet been approved.

In the United States, the RAC (*Recombinant DNA Advisory Committee*), which is dependent on the EPA (*Environmental Protection Agency*), the FDA (*Food and Drug Administration*), and the USDA (*US Department of Agriculture*), has set down rules to control the liberation of GMOs, as well as for the regulation of biotechnological products. In this respect, the coordinating body is the BSCC (*Biotechnology Science Coordinating Committee*).

A Report on Biotechnology prepared in 1991 by the Presidential Commission on Competitiveness recommended that the United States should not create new normative structures and proposed a better coordination among the existing institutions in order to speed up the process of authorization and risk assessment. The stated aim was to preserve safety without imposing restrictions.

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[16]. Other qualitative studies have also been carried out in France, Germany, Spain and the United Kingdom. Cf. Moreno, Lemkow & Lizón, 1992.

[17]. In a Symposium held by the US National Academy of Science in 1986, Bill Ruckelshaus, Director of the Environmental Protection Agency, stated that, "the possibility for biotechnology to develop is directly dependent on the inception of a regulating system capable of securing and maintaining the trust of the public".

[18]. Directives and recommendations have been implemented to preserve health and environment with relation to biotechnology activities: OECD, European Commission, US National Institutes of Health, and the European Science Foundation's Liaison Committee on Recombinant DNA Research have been some of the main institutions involved.

With the development of biotechnology the economic interests of diverse social groups are at stake. The most obvious conflict is between the agriculturalists and the chemical industry, on one hand, and the biotechnological sector, on the other. Biotechnological products can substitute a number of agricultural and chemical goods. It is precisely for this reason that biotechnology development has aroused uncertainty and anxiety in the traditional economic sectors. This conflict becomes evident in the issue of extending property rights and patents.

A considerable number of biotechnological industries are interested in the possibility of patenting living beings or biological material. In the opposite camp, a majority of agrarian organisations regard this possibility as a serious threat to their interests. The European Parliament voted for the maintenance of the so-called 'privilege of the agriculturalist'. This meant for the agricultural producers the granting of the rights to use seeds produced on their own land, even though these seeds were obtained from patented seeds. Note that the European Commission has opposed this decision of the Parliament (Beguer, 1992). In any case, the greatest fear expressed by the agriculturalists is their concern that this process of land 'technologization' could result in their losing the control of their own farming exploitations and in their becoming mere subsidiaries of the biotechnology sector.

The advocates for the protection of the environment constitute the last social actor of our brief analysis. These environmentalist groups can be divided into the following categories: mono-thematic organisations, related to aspects of biotechnological development and dealing especially with genetic engineering applications; ecological associations in which biotechnology is just another issue of concern; consumers' associations which relate with biotechnology in an indirect manner; and advocacy groups for the protection of animals which are particularly sensitive to research experimentation and testing. Moreover there are other groups which have put the issue of biotechnology on their agendas: feminists, critical scientists, alternative agriculturalists, advocates for the development and solidarity with the Third World, and religious organisations (Moreno, Lemkow & Lizón, 1992).

In the last twenty years social actors have been interacting among themselves in different ways. Contrary to what could be assumed, this process of interaction has been a constructive one because all of them have modified their starting positions to some degree. This is illustrated in Table 4, which refers to the situation in the United States.

Table 4: Social actors in the development of biotechnological policies in the USA

Period	Scientists & technologists	Industries	Activists	Public Administration
1970s	Voluntary restrictions: Elaboration of guidelines for the NIH (*)	Passive attitude	Total refusal	Passive attitude Support for the NIH guidelines
Beginning of 1980s	Deregulation: bargaining	Voluntary use of NIH guidelines	Protests against liberation of GMOs (**)	Defensive mood. Reluctancy towards liberation of GMOs (**)
Late 1980s	Opposition to 'excessive regulation'	Opposition to regulation: bargaining	Support for negotiating a restrictive regulation	Creation of administrative procedures on the base of existing norms
Beginning of 1990s	Support for regulation and for research on risk evaluation	Worries about safety and its influence on public opinion	Partial refusal. Support for informative campaigns	Support for biotechnology in conflict with biosafety. Support for informative campaigns

* NIH: *National Institutes of Health*.
** GMOs: Genetically Modified Organisms

Source: Adapted from Baark (1991)

Public perception of biotechnology in the USA and the European Community.

In this section we will comment on some of the main findings of relevant studies carried out in recent times on public perception of biotechnology. In the OTA survey (see Table 5) two thirds of the respondents were of the opinion that genetic engineering would improve the quality of life, while 92 per cent felt the same about solar energy and 51 per cent about nuclear energy. Modification of the genetic information of human beings was questioned on moral grounds by 42 per cent, while one quarter of the total was against the application of genetic engineering techniques to animals and plants. A NIMBY attitude ('Not in my backyard') was evident when risks for human health and the environment were mentioned. This relates to the willingness to assume risks provided that their effects are located away from one's place of residence.

Table 5. Scores of public acceptance of genetic engineering in the USA (1987)

	In human Cells	In animal cells	In bacteria	In plants
Total	4.5	5.3	5.6	6.6
Scientific knowledge				
Very good	5.2	6.1	5.9	6.6
Sufficient	4.5	5.3	5.6	6.6
Limited	4.1	4.9	5.4	6.2
Has heard about genetic engineering				
A lot/quite a lot	4.9	5.9	6.0	7.2
Little	4.3	5.2	5.4	6.3
Hardly anything	4.3	4.7	5.2	6.0
Effects of genetic engineering				
Better	5.1	5.8	6.1	6.8
Worse	2.9	4.1	4.3	5.9

10 = Maximum score of acceptance
1 = Minimum score of acceptance

Source: OTA (1987)

Table 6: Attitudes to biotechnology in the European Community (9 countries)

Country	Total	G	B	DK	F	I	IR	L	NL	UK
Attitudes to genetic engineering research										
Positive	33	22	38	13	29	49	41	37	36	32
Indifferent	19	16	20	10	22	19	20	31	17	21
Risks										
Unacceptable	35	45	22	61	37	22	22	18	41	36
Don't know	13	17	20	16	12	10	17	14	6	11

G=Germany; B=Belgium; DK=Denmark; F=France; I=Italy; IR=Ireland; L=Luxembourg; NH=Netherlands; UK=United Kingdom

Source: Cantley (1987)

In 1979, the European Commission commissioned a survey along similar lines to the OTA's (Cantley, 1987). Data show great disparity of opinions throughout EC countries. In Italy, for example, half of the population had a positive view of genetic engineering, which contrasted sharply with a figure of 13 per cent in Denmark (Table 6).

The Eurobarometer 35.1, carried out during the first semester of 1991, is one of the most recent sources of information about the public opinion of Europeans on biotechnology/genetic engineering. As was the case with Cantley's study, this survey also shows stark differences as regards both the knowledge and the attitudes of the citizens in the various EC countries. In particular, the degree of difference between knowledge of biotechnology and knowledge of genetic engineering is remarkable. The number of 'don't know' answers is high in the less developed EC countries (Greece, Ireland, Portugal and Spain) (Table 7).

Table 7: Average number of 'Don't know' by countries (out of 7 points)

Denmark	1.21
Germany	1.31
Netherlands	1.45
Luxembourg	1.56
United Kingdom	1.61
France	1.67
Belgium	1.88
Italy	2.00
Ireland	2.58
Spain	3.10
Greece	3.53
Portugal	3.79

Source: Marlier (1992)

In general, these data are consistent with the scoring assigned to the answers regarding the level of objective knowledge on biotechnology and genetic engineering (Table 8).

Table 8: Objective knowledge (national breakdown of means) (out of 7 points)

Germany	4.83
Denmark	4.58
Netherlands	4.45
United Kingdom	4.20
France	4.17
Belgium	4.15
Luxembourg	3.90
Italy	3.75
Ireland	3.56
Spain	3.22
Greece	2.83
Portugal	2.67

Source: Marlier (1992).

Table 9: Types of biotechnology/genetic engineering research that are 'worthwhile and should be encouraged' (national breakdown of means.

	G	B	DK	E	F	GR	I	IR	L	P	NH	UK
Plants	+0.97	+1.08	+0.98	+1.11	+0.88	+0.65	+0.87	+1.10	+0.44	+1.36	+1.02	+1.12
Micro (1)	+1.07	+1.17	+1.33	+1.19	+1.26	+0.98	+1.11	+1.36	+0.78	+1.49	+1.29	+1.23
Micro (2)	+1.53	+1.56	+1,65	+1.47	+1.60	+1.63	+1.54	+1.55	+1.19	+1.70	+1.73	+1.63
Farm animals	-0.20	-0.03	-0.16	+0.22	-0.27	+0.33	+0.04	+0.21	-0.71	+0.71	-0.63	-0.20
Food	+0.27	+0.86	+0.37	+0.68	+0.52	+0.62	+0.43	+0.81	+0.04	+1.18	+0.74	+0.38
Medicin./vaccin.	+1.47	+1.52	+1.70	+1.60	+1.62	+1.77	+1.60	+1.64	+1.30	+1.77	+1.68	+1.61
Human beings	+0.59	+1.11	+1.06	+1.29	+1.30	+1.44	+1.08	+1.30	+0.47	+1.57	+1.08	+1.04

Note: These means are calculated by applying the coefficients +2, +1, -1, and -2 to the responses 'definitely agree', 'tend to agree', 'tend to disagree' and 'definitely disagree' respectively.

Micro (1): micro-organisms such as yeast to make bread, beer or yoghurt
Micro (2): micro-organisms used to break down sewage and other waste products

G=Germany; B=Belgium; DK=Denmark; E=Spain; F=France; GR=Greece; I=Italy; IR=Ireland; L=Luxembourg; P=Portugal; NH= Netherlands; UK=United Kingdom

Source: Marlier (1992).

Another of the themes addressed by the Eurobarometer was related to concrete biotechnological developments. Three questions were asked on the subject: about increasing the support of research activities; about risks; and about government control. Given the high level of accordance among the answers to these questions, only the most relevant findings are reproduced in Table 9.

At the level of the European Community as a whole, the degree of agreement for supporting research on biotechnology/genetic engineering was in accordance with the level of studies of the respondents (Table 10).

Table 10: Types of biotechnology/genetic engineering research that are 'worthwhile and should be encouraged' (breakdown of EC12 means by education level)

	Age at end of studies			
	-16	**16-17**	**18-19**	**20+**
Plants	+0.86	+0.96	+1.02	+1.15
Micro (1)	+1.10	+1.16	+1.21	+1.28
Micro (2)	+1.48	+1.56	+1,63	+1.66
Farm animals	-0.12	-0.23	-0.12	-0.03
Foods	+0.38	+0.46	+0.51	+0.53
Medicines/vaccines	+1.56	+1.58	+1.56	+1.64
Human beings	+1.08	+0.98	+1.02	+1.06

These means are calculated by applying the coefficients +2, +1, -1, and -2 to the responses 'definitely agree', tend to agree, tend to disagree and definitely disagree' respectively.

Micro (1): microorganisms such as yeast to make bread, beer or yoghurt
Micro (2): microorganisms used to break down sewage and other waste products

Source: Marlier (1992)

It is also interesting to note to the degree of agreement between increasing the support for research and the public perception of risk for the public health and the environment. Although it was considered more appropriate to potentiate research related to human beings than plants, this latter activity was regarded as potentially less harmful than the former (Table 11).

Table 11:Types of biotechnology/genetic engineering research (EC12 means).

	Support for Research	**Public perception of risks**
Medicines/vaccines	1.59	0.21
Micro (2)	1.57	0.24
Micro (1)	1.17	0.45
Human beings	1.04	0.61
Plants	0.98	0.50
Food	0.47	0.67
Farm animals	-0.10	0.91

These means are calculated by applying the coefficients +2, +1, -1, and -2 to the responses 'definitely agree', tend to agree, tend to disagree and definitely disagree' respectively.

Micro (1): microorganisms such as yeast to make bread, beer or yoghurt
Micro (2): microorganisms used to break down sewage and other waste products

Source: Marlier (1992)

Risks were also perceived in different ways. North European countries saw more disadvantageous effects in biotechnology development than countries in the South of the EC. The most homogeneous data referred to the topic of government control over research activities: the citizens of the country which demanded the highest control were the Dutch while those of Luxembourg (+1,74) were in the lowest position on the scale. Among other findings, the following can also be underlined:

-TV and newspapers were considered the most important sources of information on issues related to 'new technologies'.

-Concerning civic associations and NGOs (Non Governmental Organisations), Europeans have a high degree of confidence in the activities carried out by consumers' associations, groups advocating the protection of animals, environmentalist organisations and universities and schools.

-Half of all EC citizens were of the opinion that biotechnology/genetic engineering would improve the quality of life in the next 20 years (NB. One of every ten respondents held opposite view).

Biotechnology and the Spaniards

In this section some of the main findings contributed by the public perception study carried out in 1990 by the Spanish *Instituto de Estudios Sociales Avanzados* are briefly commented upon (Moreno, Lemkow & Lizón, 1992). On the same lines as the result of the Eurobarometer, the Spanish survey pointed out the limited knowledge of the public regarding the development of biotechnology. There are several behind this fact. However, the lack of a public debate on these issues can be identified as the main explanation for it. While in northern European countries biotechnology and genetic engineering have in recent years become a focus of prominent social and political interest, there has not been anything analogous as far as the situation in Spain is concerned. In fact, a common tendency of the public has been to confuse biotechnology applications with techniques such as artificial insemination, human assisted reproduction or *in vitro* fecundation. Although it seems that the situation is beginning to change, the lack of interest and 'awareness' of the media has not helped to stimulate public debate and to improve public information in this field.

The degree of support of the Spaniards for the development of biotechnology and genetic engineering is high and it increases in direct proportion to citizens' educational level. In general, a less favourable attitude towards biotechnology and, in particular, to genetic engineering in human cells corresponded to a lower level of education. On the other hand, a greater propensity towards these 'life-technologies' matched a higher level of education in the respondents (Table 12). In any case, these data could lead to misinterpretations or equivocal explanations. It should not be forgotten, for instance, that ecologists and environmentalists are individuals with a level of education higher than average population figures.

Table 12: Beneficial and damaging effects of biotechnology (in per cent)

"*According to what you have read, biotechnology...*"

Will improve our way of life	74
Will have no effect	23
Will make things worse	3

Source. Moreno, Lemkow, Lizón (1992).

Table 13: Public acceptance of genetic engineering on ethical grounds (in per cent)

(a) Plants	
Acceptable	81
Unacceptable	19
(b) Animals	
Acceptable	61
Unacceptable	39
(c) Bacteria	
Acceptable	78
Unacceptable	22
(d) Human somatic cells	
Acceptable	51
Unacceptable	49
(e) Embryos	
Acceptable	36
Unacceptable	64

Source: Moreno, Lemkow & Lizón (1992)

Attitudes towards biotechnology vary, at least partially, depending on the kind of application or practice under consideration: 49 per cent stated that genetic engineering on human cells was unacceptable, a percentage which rose to 64 per cent in the case of human embryos. In turn, the attitude towards its application on plants, animals and bacteria was favourable: 81, 61, 78 per cent, respectively (Table 13).

The figures reproduced above are, nevertheless, subject to comparison with respect to products or techniques which are the result of genetic engineering applications on animals and plants (see Table 14). Somewhat paradoxically, 76 and 72 per cent of the respondents were opposed, for example, to the use of these technologies for the maximization of cattle-raising or the production of larger fish (NB. As above mentioned, a great majority of the public accepted scientific research on both plants and animals).

Table 14: Applications of genetic engineering (in per cent)

"*Do you agree with genetic engineering practices as regards...?*".

(a) Plants resistant to herbicides		
	YES	69
	NO	31
(b) Fattening up of cattle		
	YES	24
	NO	76
(c) Production of larger fish		
	YES	28
	NO	72
(d) New genetic therapies		
	YES	67
	NO	33
(e) Diagnosis of hereditary diseases		
	YES	96
	NO	4

Source: Moreno, Lemkow & Lizón (1992)

Such differences of opinion can be explained by the social effects of cases like the 'colza poisoning', which had a great impact on Spanish public opinion (NB. Hundreds of citizens died in the early 1980s after using this type of oil for domestic consumption). The illegal use of hormones for fattening up cattle is another episode which has in recent times been responsible for a general reluctancy among the Spanish population as regards the technological manipulation of food products.

Another finding to point out is the great diversity in extent to which Spaniards accept either therapeutic or diagnostic genetic engineering applications. Use of the latter attained a higher level of agreement from the respondents than that of the former. This is also somewhat paradoxical considering the potentially conflictive use of diagnostics not directly associated with therapeutic practices (eg. the 'unwanted' impact of this type of uses seems evident with respect to areas such as personnel selection or contracting insurance polices). Thus, it could be concluded that in Spain these controversial issues related to genetic testing applications have not reached the same level of popular debate as in other EC countries.

As far as the control of the development of biotechnology is concerned, Spaniards showed a high degree of confidence in work carried out by scientists and by a certain type of international and national institutions (see Table 15). However, it is important to emphasize the fact that so far the general question of the citizens' role in the process of technological decision-making has not emerged in the arena of public debate in Spain. The scrutiny of this issue in the years to come will prove to be crucial in the case of Spain.

Table 15: Control of scientific and technological development of biotechnology

(a) International institutions	38
(b) Committee on Ethics	15
(c) Government and public authorities	23
(d) Multinational companies of the biotechnological sector	3
(e) Scientists	61
(f) Others	3

Source: Moreno, Lemkow & Lizón (1992)

Conclusion

This paper has dealt, in general, with issues concerned with social studies of technology and, in particular, with the research on public perception with particular reference to biotechnology development and the case of Spain. Thus, it has been divided into two main parts.

In the first part of the paper, we emphasized the fact that in recent times public opinion in the industrially advanced democracies has become aware of the importance of the citizens' role in the process of shaping technological innovation. As a consequence. research related to technology assessment, science and development policies, and to the economy of technological change has greatly expanded in the last decades.

The 'traditional' studies on technology have been formulated from various disciplinary perspectives. It is possible to observe, however, a main division between those of a descriptive nature and those which are value-oriented and more inclined to prospective considerations. From a descriptive point of view, the sole relationship between technology and society has been considered as the paramount nexus for the characterization of the resulting social impacts. From an axiological or value-oriented viewpoint, such a relationship has been regarded as being the principal tool for the interpretation of social progress. Both approaches have sustained the preview that technology is beneficial for society as long as the latter does not interfere in the development of the former.

During the 1980s a deep theoretical transformation took place as regards social studies of technology. The so-called evolutionist approaches and social constructivism came to the forefront of the academic interest in this field. More than a process of rational choice, evolutionist economists regard technical change as a process of 'trial and error' (variation and selection). Social constructivism, in turn, aims at explaining the structure of scientific knowledge from a social viewpoint. A characteristic which is common to both schools of thought is the consideration that the social element (economic, political and cultural aspects alike) is a decisive one in the emergence, development and consolidation of technologies. The main difference between both approaches is that, while the former distinguishes in an explicit manner between processes of variation and selection, the latter emphasizes the relationship between them.

A process of conceptual renovation is also noticeable as regards technology assessment and scientific and technological policy analysis. Multi-directional models of explanation have replaced the previous unilineal paradigm which established that technological change could refer on its own to the increasing of technical efficiency, to the increase of economic efficiency or any other 'maximizing' criteria. On the contrary, the evolution of any given technology is regarded from different perspectives taking into account the varying nature of economic, technical, cultural or political factors. With the use of technology assessment and the development of S&T policies the whole process is now 're-addressed' in order to secure the incorporation of certain social, moral and political values.

Studies on public perception of technologies constitute a type of social research of crucial importance. The main aim pursued by this social research is the analysis of the different opinions expressed by the general public and their understanding of technology development. Data provided by these social studies are essential inputs to incorporate in the subsequent processes of legislation and regulation of technologies. Indeed, the final configuration of a technology, its subsequent evolution, and the selection of alternative designs depend decisively on the meanings assigned by the different social groups to technologies and the promotion of their related interests. Studies on public perception contribute useful insights to studies of technology assessment and R & D policies, as well as for the regulation of technological activity.

Studies on public perception are highly important not only in the analysis and interpretation of future scenarios in the development of technologies, but also in the task of identifying the kind of public policies required to orientate technological advancement towards ends which are considered beneficial by society as a whole. Thus, public perception analyses often need to be referred to the political environment or milieu within which the technological process takes place and to the task of measuring and interpreting the risks involved in technology implementation.

A feature shared by most of the studies of public perception of technological risks is their concern for a close analysis of the ways in which individuals learn from experience about their own social milieu. A growing feeling of dissatisfaction is observable as regards the effects produced by many technological applications affecting the quality of life and the preservation of the environment, both necessary elements for achieving individual and social stability.

The citizens' concern for the regulation, management and elaboration of technological polices has grown. This development demands a comprehensive knowledge of the interaction between society and technology. Research on the public perception of technologies is a useful tool of a prospective and pre-formative nature which plays an important role as a *via media* between descriptive studies (sociology and economy of technical change) and the value-oriented analyses (technology assessment and science and technology policy analysis).

The second part of this papers has dealt with social research on public perception with the particular case of the development of biotechnology. This has concluded with a brief review of the main findings of a study carried out in the case of Spain.

The great development of biotechnology has been taking place in a socio-political context of technological hyper-sensibility. This circumstance has helped to make a special case of the development of biotechnology which, furthermore, has potential effects on most human and social activities due to its horizontal repercussions (eg. medicine and health, agriculture, the protection of the environment, chemical and pharmaceutical industries, and social insurance or labour relations). Further, biotechnology development incorporates a powerful symbolic dimension, precisely because it deals with the very concept of life. It affects the very understanding of humans as living beings.

Biotechnology is closely linked to issues of great social debate at the present time: biodiversity, technological transfers, rights of industrial property or North/South relations. The very changing nature and ambivalence of the findings produced by those social surveys carried out in the USA, the EC and Spain make the aim of measuring and interpreting public opinion of these issues even more important. Otherwise, the 'unwanted' social impacts of the biotechnological innovation would become a counterproductive element which would question even further the whole idea of technical progress at the turn of the millennium.

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