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"SCIENCE AND GOVERNANCE IN THE

NATIONAL SYSTEMS OF INNOVATION APPROACH"

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Abstract

The aim of this article is to analyse the process of technology regulation as a sub-system in the National System of Innovation approach. Firstly, the article discusses the limits of the evolutionary approach by analysing the conflicts of interest involved in the regulation of technology. Then, by analysing with the experience of regulating biotechnology in countries of the European Union and Brazil the article discusses the practices of managing conflicts of interest through the respective regulation models. This discussion turns to the governance of science and technology as a fundamental element of operationalisation of policies for risk analysis and management.

Key-words: National Innovation System; power; technology; institutions; regulation; gmo

INTRODUCTION

Since the seventies, the concern of industrialised societies over the environmental impacts of technical progress has played a steadily increasing role in political agendas both at national and international levels. The risks associated with nuclear energy, toxic residues, carbon emissions and, more recently, genetic engineering have contributed towards building a social critical vision of the positivist approach to technical progress.

In his book (*The New Industrial State*) Galbraith (1967) makes a critical analysis of an economic system which prioritises and spreads the values of economic growth as an ideology. Through an institutionalist approach, Galbraith highlights the power exerted by a planning system controlled by big industrial corporations and supported by the organised

use of capital and technology. The exertion of power would consist of an increasingly intense symbiosis between the interests of corporations and the State, thereby allowing the socialisation of the risks of capital reproduction. By providing the material basis for capital reproduction, scientific and technological knowledge becomes a fundamental instrument in the strategies of expansion of the techno structure. The (re)production of this knowledge in turn depends on education and research institutions which, according to Galbraith's critical approach, tend to assimilate the preponderant values of the production of goods.

The systemic approach of technical progress has gained strength since the late eighties with the evolutionary theory that analyses technical progress as a phenomenon based on endogenous mechanisms of generation and diffusion of technology. These mechanisms are subsumed in a context of intercapitalist competition. The linear vision of technical progress – from scientific to technical knowledge and afterwards its diffusion on the market – has been replaced by a systemic vision which takes into account the importance of interaction between actors and institutions devoted to the (re)production of knowledge. The National Systems of Innovation approach appeared as an alternative analysis to the comprehension of economic growth in developed countries and also to the technological catching-up process achieved by Japan and Korea (Freeman, 1997; Edquist, 1997). The systemic approach of innovation intends to be holistic and interdisciplinary by recognising the importance of the economic aspects as much as the social and political.

Despite the acknowledgement of the interdisciplinary importance, the National Systems of Innovation approach has prioritised a much more economicist analysis emphasising the determinant factors of innovation linked to competitiveness and economic growth (Nelson, 1995; Smith, 1997). This kind of approach which omits the contradictory or negative aspects of technical progress, finds some favour in the policy-making instances of a number of countries notably concerned with competitiveness gains from S&T investments. In this context favourable to the fast approval of new technologies, the governmental organisms responsible for their regulation seek for legitimacy by supporting their decisions with expert advice in the science-based policy. On the other hand, the growing critical participation of organised society and of part of the scientific community, along with the limits and evaluation mistakes of experts over the adverse effects of technical progress, has generated a legitimacy crisis of the prescriptive uses of science. The

effects of these disputes have provided remarkable impacts on the pace and direction of technical progress in addition to the market structures in the more dynamic industrial branches (Gellman, 1974; Rothwell, 1980; 1981; 1992; Thomas, 1990).

The aim of this article is to discuss the process of technology regulation as a fundamental sub-system analysis in the National System of Innovations approach. The emphasis on the regulatory process of technology is intended to recover the evolutionary analysis of technical progress, considered as a satisfactory allocation of resources and also a result of conflicts of interest on the part of different social actors. The aim, therefore, is to highlight the political dimension of the economic analysis of technical progress, which is central to the approach proposed by Galbraith (1967) and other institutionalist authors such as Dugger (1980) and Samuels (1989).

The article is divided into three sections. The first section recovers the institutionalist analysis of the techno structure proposed by Galbraith, emphasising two aspects: the mechanisms of the exertion of power of the techno structure; and the economic importance of the infra-structure of education and research. The second section discusses the limits of the economic analysis proposed by the evolutionary approach of the National Systems of Innovation concerning the regulatory process of technology and the management of the conflict of interests involved. The third section presents the discussion of the democratisation of the science-based policy from an institutionalist approach. This means, considering the governance of science as a process of social and political learning capable of transforming the regulation of technology into a participating instance of decisions and not merely into the exertion of technocratic power. In this section the European experience concerning the governance of science will be discussed together with the Brazilian experience of attempts to regulate Genetically Modified Organisms (GMOs).

1. THE PLANNING SYSTEM

In his book (The New Industrial State) Galbraith carries out a critical analysis of the post-war capitalist system that prioritises and diffuses the values of economic growth by way of a planning system that transcends the power of the market, traditionally identified by neo-classic economics. Using an institutionalist approach, Galbraith highlights the power of a planning system controlled by large corporations and sustained by the organised use of capital and technology.

Given the ever-rising cost of investments to guarantee the expansion of these corporations, along with the inherent risks of research and development of new technologies, the activity of economic planning at both the macro and microeconomic level is superimposed on the "natural balance of the market". The exercise of power would thus consist of an intense symbiosis between corporations and the State Apparatus in such a way as to guarantee a certain stability of demand and socialise the risks of capital production. By proportioning a material basis for the reproduction of capital, scientific and technological knowledge becomes a fundamental instrument in the expansion strategies of companies. The (re)production of this knowledge depends in its turn upon the learning and research institutions which, according to Galbraith, tend to assimilate the preponderant values of the mode of capitalist production.

In this institutional context, in which planning substitutes the market, the frontiers between private and public organisations tend to become more fluid: "There is no longer a distinct frontier between the public and private sector; the line has become less clearly defined; the line is fluid, even imaginary. Each organisation is important to the other; their members co-mingle in their daily tasks; each adapts the objectives of the other to their own objectives. In consequence, each is the extension of the other." (Galbraith, 1989: 359). And therefore large corporations become "an arm, an extension of public burocracy", exercising more direct political power than the individual businessman (Idem: 366).

Following this line of reasoning, Stanfield[1] (1995: 52) defines the power exercised by corporations as "...the capacity to influence the allocation of society's resources and therefore the quality of existence in society." And this power gains legitimacy in that it

[1] This article was first published in the *Nebraska Journal of Economics and Business* (1974).

becomes an expression of the cultural values of society. “My argument is rather that now our consumptive desires are systematically and purposefully influenced to meet the needs of the corporate system. We live in a corporate culture – a culture which is shaped to a large degree by and for the corporate system.” (Stanfield, 1995: 66). As a result, the economic power of corporations becomes a political power, capable of influencing the legal structure of institutions. “Our principal productive institutions have the means of persuasion, including political power, to clear their products from the market.” (Idem).

Dugger (1980) analysed the hegemony of corporations, identifying four social control mechanisms which would form the superstructure of power: subordination; contamination; emulation and mystification. Subordination is related to the process by which the aims of other institutions correspond to the means of the dominant institution, in this case the corporations. Contamination implies the diffusion of the motivations of corporations along with other institutions. Emulation is the social acceptance, the prestige that the dominant institution (corporation) enjoys in the other institutions. And mystification promotes the construction or distortion of the symbols of society as a form of legitimising the dominant institution. Thus, the power of corporations is exercised not by conspiracy but by the combination of these four mechanisms of control. The basis of power would not therefore be individual, but institutional in that the individuals who exercise it have already been submitted to certain rules and habits of thinking (the institutions).

According to Dugger (1988), the market is therefore not the source of power. The market is merely a reflection of the rules established *ex-ante*, established by the power game, adjudication and legislation. Therefore, Dugger refers to the modern economy as an industrial economy or as a corporate economy, not as a market economy (Dugger, 1988: 984).

Samuels (1989) observes that, irrespective of where power originates, it is exercised within a space that is configured in a nexus that exists between economics and politics. The separation of the two spheres, in which economics would be the space for autonomy and freedom, and politics the space for authority and regulation, it is a false dichotomy. There would also be a legal-economic nexus in which politics and economics are constituted as interdependent activities which are continually (re)formulating.

> The legal-economic nexus is the social location wherein, on the basis of ideology or material interest, private individual and business attempt to influence the social agenda, and

> politicians and courts, through the exercise of government choice, translate pressures and influences into government policy and thereby determine the scope and performance of the market. (Samuels, 1989, p. 1566).

According to Samuels (1989: 1577) governance is the central element in this nexus in which power is exercised, "...in the sense of a process in which important decisions are made, whether by legislatures, courts, or administrative agencies; by giant manufacturing corporations, cartels, trade associations, pension funds, major banks and so on; or by alliances of governmental institutions and private organizations."

2. THE NATIONAL INNOVATION SYSTEM

Unlike the institutionalist analysis that concentrates on demonstrating the exercise of power by large corporations in the economy, the approach of the National System of Innovations is rooted in the search for explanations for the variations in growth rates among industrialized nations. The micro-economic approach adopted by neo-Schumpeterians, identifying the innovative attitude of the firm as the central analysis element of technical progress has become relativised by a systemic vision of innovation, stressing the importance of coordinated action between certain actors (universities, companies, research institutes, financial institutions, public policy-making government organs) for the technological performance of countries. This view, proposed by Freeman (1987) in its most consistent form in the book *Technology and economic performance: lessons from Japan*, allowed for the establishment of an explicative nexus between the differing growth rates of the economy and their association with technological innovation.

2.1. The Institutional Ambient of the Firm

When attributing to the firm the role of highlighting technological innovation, authors such as Lundvall (1988) and Nelson (1993) concentrate on the fact that firms do not innovate in isolation but rather within an institutional context that allows for interaction between producers and users of technology. This innovation is therefore recognised as a process of interactive learning triggered by evolutionary mechanisms of search and selection. "The notion of interaction paves the way for a systemic approach." (Edquist & Hommen, 1999: 67).

The complex relationships established among actors by way of feed-back and reciprocity mechanisms constitute networks whose connections are determined by a specific institutional context involving laws, norms, rules and cultural habits. A national innovation system may therefore be defined as "…a set of institutional and organizational actors and of their interactions, having as their ultimate goal the generation and adoption of innovations." Saviotti (1997: 193). Institutions may be formal (patent laws, standards of technical norms, scientific assessment procedures, peer review) and informal (rules of behaviour, conventions, codes etc.). The organisations that make up an innovation system involve a diverse set of actors, being grouped into three main sectors: the State; universities and research institutes; and industry (Galli & Teubal, 1997).

In this analytical framework the importance of institutions is recovered by fulfilling fundamental functions in the innovation process such as: providing information and knowledge in light of reducing uncertainties; ensuring the appropriation and diffusion of knowledge; and managing conflicts of interest. At the same time, institutions are seen as potential barriers to technical progress in that they can inhibit its pace through cultural barriers or tougher regulatory bodies (Edquist & Johnson, 1997).

2.2. The regulation of technology when dealing with a conflict of interests

Birgitte Gregersen (1992) analyses the role of regulation of technology as an institution of influencing the pace of technical progress in the NIS context. There are basically two types of regulations: those that establish technical and patenting standardisations; and those which are directed towards protecting the environment and health of consumers and workers. The latter tends to be reactive to technological innovations which can impose restrictions on the pace and direction of innovation, and guide them towards determined technological pathways.

Despite the fact that the author recognises that the regulation of technology involves negotiation between specialists in both public and private sectors, her analysis does not take into account the conflicts of interest that arise as a result. She limits herself to discussing the interest of the public sector as a user of technologies and therefore being capable of stimulating innovation through favourable regulation (Idem).

Nelson & Winter (1982: 371) have already indicated in their book *An evolutionary theory of economic change* the importance of laws and regulations for the formation of an environment for the selection of firms. The authors comment, for instance, that the mechanisms for the control of the quality of the air in California in the sixties and seventies, through the *Clean Air Act*, had a resounding impact on technological development in certain industries such as the automobile industry and the energy-producing industries. At the same time, this allowed for the consolidation of a more efficient institutional structure and that of specific organizations such as the Environmental Protection Agency (EPA).

Henderson, Orsenigo & Pisano (1999) analyse the process of co-evolution of technical progress, industrial structure and the institutional context of the pharmaceutical industry, indicating the conflicting aspect of regulation in the incentive to technical progress in this industrial activity. On the one hand, the system of patents in countries where the pharmaceutical industry is more advanced (USA, Germany, Switzerland) has resulted in more encouragement towards R&D, quickening innovation in pharmaceutical products and setting a faster pace than in certain other countries whose systems of intellectual property have been universally regarded as weaker (Italy, Japan). On the other hand, there is the mark of recrudescence of the sixties for the reassessment of toxic effects in pharmaceutical products in several countries, the cause being attributed to the disaster resulting from the commercialisation of thalidomide. This disaster ended up causing a serious impact on the pacing and the cost of introducing new drugs onto the market[2]. In the case of developing drugs through genetic engineering, Henderson, Orsenigo & Pisano (1999) mention the tendency of the large European pharmaceutical companies to set up R&D laboratories in the USA, where regulation and public opinion have proved to be less demanding and less concerned with the possible side effects which could result from this type of technology.

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[2] According to Rigoni *et al* (1985: 51), the average cost of obtaining a new pharmaceutical substance in the USA went from 1.5 to 2 million dollars in the period of 1956-1962, to 20-22 million dollars from 1966-1972. At the end of the eighties, these costs were estimated at somewhere in the range of 150 million dollars (Ballance *et al*, 1992). In the nineties, these costs had soared to as high as US$350 million (Halliday *et al*, 1997, p. 63). The average period for the development of a new product had reportedly risen from 2.7 years in 1966 to 6.6 years by 1973 (Rigoni *et al*, 1992: 74. According to Ballance *et al* (1992), this period had been lengthened to around twenty years as the eighties drew to a close.

A more systematized effort in the analysis of the influence of regulation on technical progress was made by Coombs, Saviotti & Walsh (1987). This influence is expressed through government policies and actions, through pressure groups (trade unions, both of employers and workers) and through the determination of companies in the process of innovation. In their book, the traditional view that the market and firms constitute a self-regulatory system without state intervention and the innovation demonstrates productivist neutrality, is discarded. Conversely, it is assumed that the adoption of new technology by society implies a struggling process in that "All innovations have costs and benefits, but some innovations provide benefits to one group of people and costs to a different group." (1987: 209).

Matters such as environmental pollution, scarcity of natural resources, the health of workers and the public at large have taken on a political as well as a technological connotation, and just as important, one which has led to the adoption of regulatory practices. In this case, resolving conflicts of interest is not restricted to a mere legal battle, but to a tug of war in which access to information, along with scientific and technological knowledge may play a deciding role. As Coombs, Saviotti & Walsh (1987, p. 245) have observed:

> Groups with different interests are likely to conflict, and the outcome may be resolved on the basis of the power of the groups concerned, rather than abstract justice. The development of conflicting interests also influences the status of scientific and technical knowledge. Different interest groups frequently attempt to use experts and scientific information to back up their case, thus undermining the status that such knowledge claims generally.

The arguments put forward against the regulation of technology insist that it would cause serious damage and loss to some businesses, discouraging the innovative process or increasing the cost of their goods beyond tolerance levels. In this case, an exclusively economic approach tends to prevail, leading to extreme statements as in the study of Peltzman[1], cited by Coombs, Saviotti and Walsh (1987: 252). In this study, a cost/benefit analysis of the regulation practices of medicines by the Food and Drug Administration (FDA) in the United States of America, suggested that it was economically more desirable for there to be a disaster like thalidomide than to impede the introduction of new substances which could save the lives of people with other illnesses.

Coombs, Saviotti & Walsh (1987) recall that over 90% of resources marked for R&D in Great Britain and the USA originate from private enterprise and government organs. This leaves these protagonists with a more active role in the determination of the pace and direction of technical progress than the trade unions, consumer associations or non-governmental organizations. Such concentration of power involves economic aspects and decision-making as much as the control of information inherent to analysis of risks from the technical progress being made[2].

Despite the neo-Schumpetarian or evolutionary approach recognizing the importance of regulatory institutions in the pace and direction of technical progress, this current theory has not prioritised the analysis of the regulatory process itself. A co-evolutionary analysis has yet to be made that is capable of establishing an explicative referential of the nexuses that exist between market control strategies and public regulation policies of scientific and technological knowledge. To this end, Nelson (1995) remarks in his study of the evolutionary theory, little research has been carried out into the relationships of cause and effect that exist between regulatory laws, technology and industrial structure. He shares ideas with sociologists such as Tushman & Romanelli (1985), Rosenkopf & Tushman (1994) and Hughes (1983) concerning the importance of the political action of companies in the definition of rules and productive standards which cater to their interests.

3. SCIENCE AND GOVERNANCE

As scientific knowledge gains importance as a productive force to be internalised in policies for the creation of innovation systems, governance of science is increasingly in the limelight in the political agendas of countries. The problem of governance in this case is twofold: the generation of knowledge through the definition of lines of research along with financial policies; and the regulation of the laboratorial and commercial use of scientific and technological knowledge. In the latter instance, the commercialisation of products which directly affect human health, such as medicine and industrialised food, depends on a regulatory mark which, in a general way, tends to be more rigorous, especially due to four aspects which complement one another: the development of new analysis techniques which allow a for closer estimate of the adverse effects of technology; the largest organisation of society in the sense of winning greater participation in the decision-making that affects

general well-being; greater availability of information to the public; and greater consumer demands in terms of the quality of products.

In the regulatory institutions, science has a highlighted role in two ways: aiding in decision making in that it foresees and assesses the risks generated by new technologies; and by arbitrating disputes caused by the questioning of such decisions in that a status of neutrality is attributed to it vis-à-vis political and economic interests. Science therefore has a power of decision-making that legitimises the actions of governmental agencies to find a balance between the profits of a company and the security of citizens. Even so, the room for this harmonizing effect is simultaneously occupied by conflicts of interest in which governance, as a collective action resulting from the interaction of a number of governmental and non-governmental actors, tends to substitute the monopoly of power in the hands of the government (Stoker, 1988).

3.1. European Union: towards a new governance model

As science and technology references and competitiveness grow at both the micro and macroeconomic levels, their governance tends to be determined according to market imperatives. Levidow & Marris (2001) highlight this concern in the European Union in relation to their main competitors (USA & Japan) by quoting a communiqué from the Social and Economic Committee:

> "More than ever, investing in research and technological development offers the most promise for the future. In Europe, however, the situation is worrying. Without concerted action to rectify this, the current trend could lead to a loss of growth and competitiveness in an increasingly global economy. The leeway to be made up on the other technological powers in the world will grow still further. And Europe might not successfully achieve the transition to a knowledge-based economy." (CEC, 2000:4)

In this atmosphere of competition, determined by the so-called knowledge-base economies, regulatory institutions tend to stress the positive character of technologies in detriment of discussions into the associated environmental risks. (De Marchi, 2001; Levidow & Marris, 2001). In this way, the science-based legitimising discourse increasingly reveals a character of partiality in favour of short-term economic interests.

Callon, Lascoumes & Barthe (2001) illustrate the role played by specialists in minimising risks and impacts associated with leaks in nuclear power plants, nuclear waste deposits or in the radioactive cloud of the Chernobyl accident, all the while attempting to

play down the suspicions and knowledge of the local populations who were most affected by the environmental impact of these events that marked the eighties. In the nineties, the BSE case in the United Kingdom was emblematic in that it revealed that the actions of the government sought above all to protect the interests of farmers and the food industry by minimising the risks of passing the disease on to humans. All of this was supported by committees of specialists and scientific evidence, and the results were, in some cases, manipulated or kept secret to reduce negative repercussions among consumers (Miller, 1999; Millstone & Zwanenberg, 2001).

Another emblematic case involved the regulation process of genetically modified organisms (GMOs) which became a source of intense controversy, especially among the national and European Union regulating agencies and the entities representing environmentalist groups and consumer defence associations. At the centre of the controversy were two fundamental and interdependent criticisms. One involved uncertainty over the environmental impact of GMOs. This uncertainty, however, was not limited to a simple lack of knowledge of the possible risks of the technology. Knowledge in itself may be interpreted in a number of ways due to the differing results of the different methods and theoretical models utilised, leading to controversy between specialists (Levidow & Marris, 2001; De Marchi, 2003). As Christoforou (2003: 208) notes:

> The basic legal definition of scientific uncertainty reflects the potential for error inherent in science and scientific information. In law, uncertainty indicates evidence showing credible scientific disagreement among experts, which prevents the judge from rendering an informed decision on the scientific basis of the dispute. Legal systems and courts should, therefore, acknowledge scientific uncertainty in the presence of incomplete, inconclusive or contradictory evidence coming from credible and reliable sources (even if they are minority scientific views).

The other criticism of the process of regulating GMOs emphasises the way in which the problems associated to biotechnological agricultural risk are formulated. According to Levidow (1988), the risk analysis proposed by the majority of regulatory bodies tends to simplify the problems of transgenic agricultural diffusion, restricting it to a strictly technological ambient. Even in this ambient, transgenesis is dealt with in a very simplified manner, formulating agronomical problems in terms of genetic deficiency. As Levidow (1998: 215) observes:

> The strategy of biotechnological control is often expressed through social metaphors codes, combat and commodities. In a computer metaphor, biotechnology precisely alters the genetic "code" to enhance the predictable control of nature. With surgical precision, biotechnology redesigns nature to

> protect crops or to attack pests, and through "value-added" genetics, is searches for genetic changes which can enhance the market value of agricultural products. (...) Through these kinds of metaphors, design choices take the reified form of natural properties to be enhanced, thereby recasting nature in the image of biotechnology. (...) In these ways, R&D priorities take the form of external imperatives and opportunities discovered in nature. The undemocratic character of biotechnology arises from its self-perpetuating problem definition, which biotechnologizes both nature and agriculture.

The technology assessment proposed by specialists and by the majority of regulating agencies, based on an analysis of the type of risk-benefit, limits the discussion to a quantitative and probabilist control analysis of previously established risks. The socio-economic impacts of adopting the new technology – as the loss of autonomy of farmers in the reproduction of their vegetal material – are discarded as it is presumed that the assessment of risk should be politically neutral[3].

Levidow (2001) identifies the divergent visions which predominate in the EU around the diffusion of GMOs, classifying them in three fundamental approaches: the neo-liberal vision, linked to the bio-technological companies; the vision of environmental management associated with the regulating bodies; and the environmentalist vision, linked to the NGOs.

In several EU countries the policy of development of bio-technology is based on a liberal vision of the concept of sustainable agriculture, eco-efficiency. Products which originate from this source would allow for a reduction in the use of agro-chemicals and an increase in agricultural productivity, generating greater competition as a result. On being submitted to pressures in favour of and against GMOs, the tactic of environmental managers would be to accommodate the liberal vision of sustainable agriculture. The potential risks of GMOs would be mitigated by the real risks of the intensive use of chemical raw materials. Thus, regulating bodies in Europe concluded in the mid 1990s that GMOs would not cause any more environmental damage than the traditional methods of intensive agriculture (Levidow, 2001).

Resistance from activists in several European countries has made governments recoil at the adoption of GMOs. The harmonising policy which was adopted between 1992 and 1995 in the EU ended up being destabilised by the initiative of some in declaring a moratorium of the adoption of GMOs within their borders (Morris & Adley, 2000). The policy of harmonisation, seeking the commercial liberation of GMOs, began to be re-established in 2000 when the EU demanded that foodstuffs containing a level of GMO over

1% should be labelled as such (Regulation 49/2000) and in April, 2004, this level was reduced to 0.9% (Regulations EC 1829/2003; 1830/2003).

The fact that the public has questioned the analysis procedures of technological risks adopted by the regulating bodies has become a source of concern for some governments that have faced a legitimacy crisis by adopting a governance model which is supposedly neutral scientifically. In the view of those agents interested in maintaining this model, the resistance of consumers to the new technologies is based in irrational arguments and the ignorance of the lay man. By this token, the proposed solution has been the need to provide better information concerning the risk of these technologies, which would lead to better understanding and acceptance on the part of consumers (Mayer, 2003; De Marchi, 2003; Levidow & Marris, 2001).

This view that resistance on the part of the consumer public is based in ignorance of biotechnology was questioned in a survey carried out between 1998 and 1999 (*Public Acceptance of Agricultural Biotechnologies*). The results of this survey showed that scepticism by the public concerning the legitimacy of the process of regulating biotechnology has much deeper roots in a critical assessment of the lack transparency and the exemption of the regulatory bodies which the public associates with past experiences like pesticide, asbestos and BSE (Marris, 2001).

Following this critical view of the consumer public, some within the EU have had more in depth debates on the new governance models for science and technology, as happened at the *Science and Governance in a Knowledge Society* Conference in 2000 at which a discussion was begun into the perfection and democratisation of regulating bodies. Among the conclusion reached at the event, the following may be highlighted:

> Public inputs to policy debates are not merely "opinions", but may be relevant knowledge, values or questions which scientists have neglected. There needs to be a long-term process of mutual learning between the public and science, which will necessarily involve new institutional relationships and forms. This will require deliberate experiments in the design of new hybrid institutions and roles. Tools should be explored to bring the public closer to debates on science and technology and its repercussions (e.g. consensus conferences, focus groups, etc.). The general diversification of knowledge sources and actors in modern society should be accepted and used as a platform for further development of democratic knowledge cultures, also including innovation cultures. (underlined in the original) (DG-JCR, 2000)

In the report *White Paper on Governance*, which was written following this conference, the need to democratise institutions at an EU level is reaffirmed:

> While such expert-based regulatory policy of the European Union can be seen as a guarantee of efficiency, it is often perceived as technocratic and need of review. This may be because may issues once dealt with at national level are now dealt at the European level, and have as a result become more visible. For example, the transboundary nature of BSE ('mad cow disease') requires decision at European as well as national levels. The criticism of 'technocracy' can also be seen as a part of the broader quest for more accountable institutions at all levels, and for more transparent and participatory procedures. (Liberatore, 2001: 4)

In this new governance model conceived by the EU, the most active participation of the public consumer in decisions relating to the adoption of new technologies is now evaluated through the experiences of hybrid discussion forums (citizen's juries, consensus conferences, focus groups and public hearings) in countries such as Denmark, France, Germany, Norway, the Netherlands and the United Kingdom (Liberatore, 2001)[4].

3.2. Brazil: in search of a governance model

In Brazil, the disputes surrounding the liberation of GMOs which led to a judicial ban on the planting of these crops (most notably transgenic soy) since 1988, became relevant both politically and economically because of the country's position as the second largest producer and exporter of soy in the world. Since 1996, there has been an intense ongoing debate concerning the environmental effects and the effects on human health caused by GMOs that was initially restricted to the academic community. The controversy concerning the issue intensified further in June, 1998 when Monsanto requested authorisation from CTNBio for the right to commercialise Roundup Ready (RR), the herbicide resistant soybean. At that time, several organisations such as the Brazilian Society for the Progress of Science, Greenpeace and the Institution for the Defence of the Consumer (IDEC), came out against the approval of the seed, basing their arguments on the lack of studies into environmental impact to confirm the alleged harmlessness of the product. To follow up this argument, IDEC and Greenpeace filed a public civil lawsuit questioning the assessment procedures proposed by CTNBio[5].

At this point, a long legal battle was begun in which Monsanto and the Federal Union, defending the position of CTNBio, which is directly subordinated to the Ministry of Science and Technology, presented appeals contesting the judicial decision. In June, 2000, the Federal Courts extended the ban on the cultivation and commercialisation of RR soy to include all genetically modified organisms in answer to another law suit filed by the same

NGOs. The appeal of the Union and Monsanto was not heard until February, 2002 by a collegiate of three judges. The final ruling was given in June, 2004. By two votes to one, Monsanto and the Union won the cause as it was considered that CTNBio has the autonomy to decide on the demands of the studies into environmental impact. Nevertheless, as the ruling was not unanimously decided, there is still the possibility of an appeal by IDEC and Greenpeace in the higher courts, prolonging the case even further.

Despite the legal ruling which banned the commercial planting of RR soy in Brazil, in September, 1998, many farmers went against the decision and illegally planted the seeds and this practice was widely expanded, especially in the southern state of Rio Grande do Sul. The agricultural ministry estimates that around six million tons of soy, over 10% of national soy production (expectations were around forty-nine million tons in the 2002/03 harvest), are transgenic (Salvador, 2003). This caused a serious judicial, political and economic impasse for the country in that the destruction of this illegal production would correspond to an estimated loss of between 1 and 1.3 billion dollars in exports (Zero Hora, 2003).

For as long as the judicial decision remains undefined, the juridical way out of this impasse has been for the federal government to resort to what has been termed "conduct adjustment", through which lawbreakers have been forgiven as long as they promise to cease production of GMOs from the 2003 harvest onwards. Nevertheless, this commitment has not been adhered to and the Federal Government has extended the pardon to next year while attempting to pass a new Bio-security law, which is less restrictive to GMOs, in Congress.

In this new edition of the Bio-security Law, the central controversy between those in favour of the rapid liberation of GMOs and those against it concerns the attribution of decision-making power to CTNBio concerning the commercial liberation of GMOs. While those against the liberation of GMOs support a merely consultative role in the decisions of CTNBio., leaving the decision on commercial liberation to an inter-ministerial committee, those in favour defend a deliberative role for the Committee. In this case, other ministries, such as the Environment, would lose their legal attribution to demand environmental impact studies in the case of GMOs, leaving the final decision making power to CTNBio, which is traditionally made up of a large majority in favour of GMO liberation.

The resistance movement to GMOs in Brazil is part of a network of NGOs that are traditionally linked to the social and economic development of the small farming community. These NGOs are in networks that, among other things, aim to diffuse farming techniques at a nationwide level as the preservation and improvement of vegetal genetic material. Among these NGOs, AS-PTA[6] stands out from the crowd. This is a network of NGOs which aim to develop alternative technologies in rural districts and currently coordinate the campaign against the rapid liberation of GMOs, organising seminars, debates and by lobbying Congress. AS-PTA was especially involved during the discussion process and approval of the intellectual property law for seeds (Law on Plant Variety Protection) in 1997, supporting the interests of small farmers in their right to access genetic material. Mobilisation and political disputes involving legislative power provided AS-PTA with an important learning experience which was later used in the disputes against the liberation of GMOs in Brazil (Pelaez & Schmidt, 2002).

The lobbying done by NGOs has demanded more transparency of the criteria for assessing GMOs adopted by CTNbio as well as the tightening of federal legislation to guarantee this transparency and avoid the approval of any transgenic products without a prior investigation into their environmental impact. The demand for a stricter regulatory framework when it comes to setting up commercial barriers is done in order to minimise the risk of small farmers losing control of the reproduction control of genetic material (Pelaez & Schimdt, 2002).

The mobilisation of NGOs pressuring the legislative body of the National Congress and several State Assemblies as well as entities in various states in the country has led to the establishment of discussion forums, contributing to the dissemination and politicising of the debate concerning the socio-economic and environmental risks involved in GMOs. The experience of mobilising the Brazilian public at large when it comes to regulation of GMOs caused quite an impact in the pace of diffusion of this type of technology by impeding the legal commercialisation of the product for seven consecutive years[7].

The impasse of the judicial decision on the demand for studies into the environmental impact of the liberation of GMOs in Brazil indicates a weak side in the established regulatory framework while the State is shown to be inoperative when it comes to enforcing a legal decision that prohibits the commercial dissemination of these products. On the other

hand, such an impasse reflects the democratic side of the dispute through which NGOs have accumulated experience of disputes and lobbying Congress.

While official institutions in the EU seem to evolve towards a more participative governance model, the technocratic model is still predominant in Brazil and the predominant discourse of competitiveness is aligned with the political agenda of the current government which is chiefly aimed at increasing exports[8].

3.3. The Regulation of Technology as a NIS sub-system

Regulation of technology is much more than an institution that establishes control mechanisms on the innovation process. It also constitutes a NIS sub-system involving the interaction of representatives of governmental agencies and specialists in the productive and academic sectors – the elements usually considered by the NIS neo-Schumpeterian approach. At the same time that they generate scientific and technological knowledge, these actors are articulated in that they establish the analysis procedures for management and communication of the inherent risks of this knowledge, thereby indicating the possible technological pathways and the alternatives of public and private investment.

In the technocratic governance model, illustrated in Figure 1, decisions concerning possible technological pathways, based on a positivist vision of science and technology, exclude the possibility of participation of the lay public. A dichotomous vision is established: on the one side, specialists with a supposedly objective and impartial view of the risks associated with technology; on the other side, the lay public whose aversion to risks is based on subjective arguments (values) and their ignorance of the procedures adopted by the specialists.

This technocratic model of governance is the very picture of the techno-structure described by Galbraith (1967), by which the capture of the public sector by the private sector is reflected in the mechanisms of social control described by Dugger (1980) and labelled as subordination, contamination, emulation and mystification.

According to Callon (2003: 30), the technocratic model corresponds to the model of representative democracy that was configured and consolidated in the wake of World War II, leading to two forms of polarization: “a neat division of roles between experts (or specialists) and political authorities, with the former producing reliable and ‘consensible’

knowledge (what is possible) on which the latter base their decisions (what is desirable); and the constitution of an ignorant public, incapable of entering into the abstract formalism of scientific knowledge... and whose support for science and technology requires constant education." Such polarisation corresponds to a dual delegation in which citizens delegate the power of decision making to their elected representatives and these in turn delegate decision of a scientific nature to specialists.

This process of excluding the average citizen from decisions relative to analysis and risk management tends to lose legitimacy in that organised groups within society begin to question the supposed neutrality of the technocratic process of regulation of technology. As uncertainty towards the negative impacts of technical process grows, conflicts of interest between producers and consumers of technology tend to increase. In this context, regulation of technology transcends the conventionally adopted approach, in the neo-Schumpeterian theory, of an institution capable of limiting or encouraging technical progress, to acquire a more political dimension in that it reveals room for a conflict of interests.

There now surface the possibilities of a new model of governance no longer based on a representative participative democracy in which room for negotiation tends to limit the *subordination* of regulatory institutions to private interests. In the same way, the diffusion of the motivations of private corporations together with other institutions (contamination), their social acceptance (emulation) as well as their values (mystification) become more visible, revealing the economic and legal nexus built up by the technocratic model of governance.

In this new model of governance, which is labelled as pluralist, the sub-system of innovation, aimed at regulation of technology, incorporates the lay public, mainly through the action of an organised society, allowing for the inclusion of the citizen in the process of deciding which technological paths will be adopted and the evaluation of technological risks (figure 2). This inclusion of society as an institutional element of the NIS concerns organisations of people - at collective level - and also the notion of citizenship - at individual level - by which the citizen claims its inclusion into the process of taking technical decisions as a generator and consumer of knowledge (Jasanoff, 2004). In this new institutional context, the practice of confrontation and management of conflicts generate a

process of interactive learning through the constitution of hybrid discussion forums that incorporate technical and dimensions along with technology policies, eliminating the dichotomous view adopted in the technocratic model.

The process of regulating technology through the correlated institutions and organisations is thus characterised as a sub-system in the systemic analysis of national economies when it comes to innovation policies and the technical pathways that are adopted. Furthermore, the possibilities for democratisation of technocratic decisions constitute important institutional innovations that, according to Callon (2003: 61) involve: "(a) explicit recognition of the existence of constantly emerging concerned groups; (b) the existence of procedures intended to facilitate the expression, discussion and collective negotiation of these groups' identities; (c) the establishment of incentives and structures aimed at encouraging, developing and funding collaborative research in all its forms; and (d) the construction of public spaces in which identities and research are discussed simultaneously."

Figure 1. Technocratic Governance Model

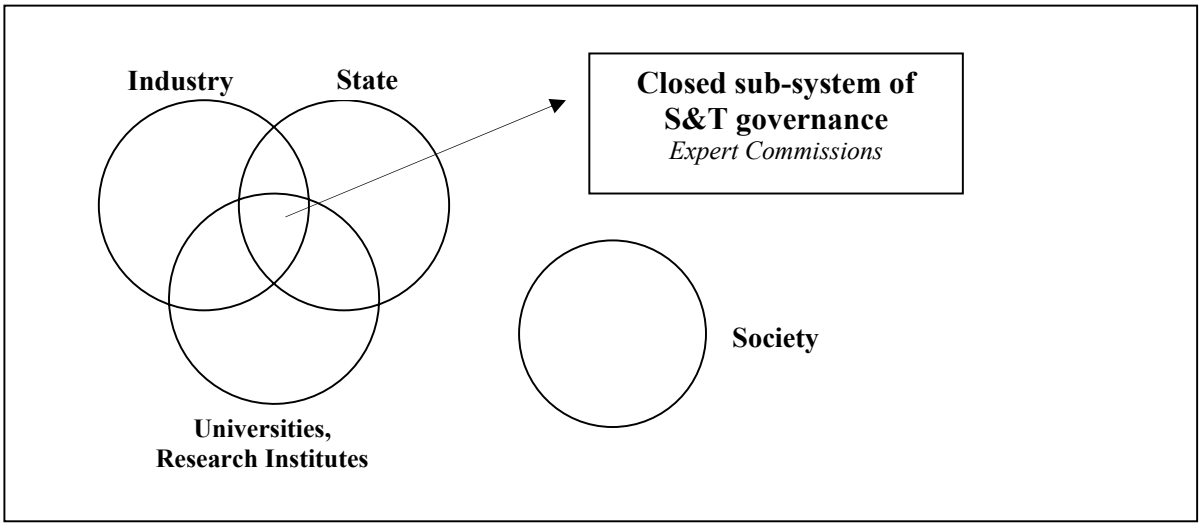
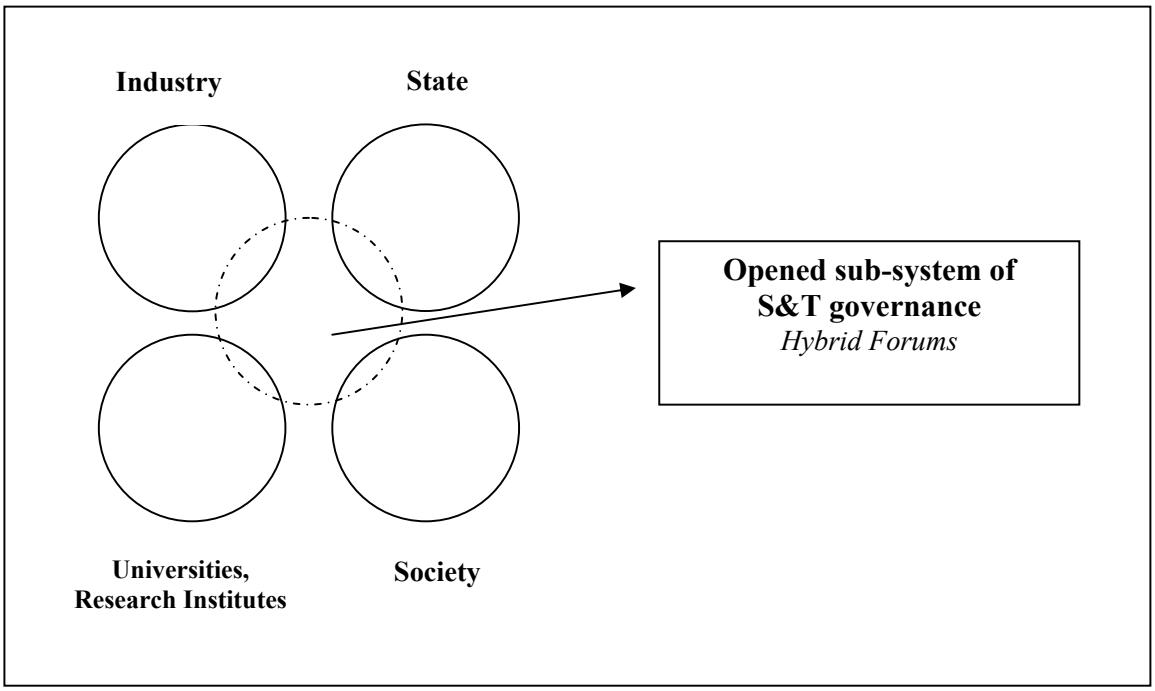


Figure 2. Pluralist Governance Model



CONCLUSION

The NIS approach aims to study the causes of economic efficiency in industrialised countries, with an emphasis on the phenomena associated with the process of technological innovation. In this analysis referential, the role attributed to institutions corresponds to the incentives or barriers imposed on interaction between organisations whose aim is to generate and diffuse technology. By giving preference to a theoretical analysis based on the satisfactory allocation of resources under limited conditions of rationality, the evolutionist focus of the NIS ceases to discuss technical progress as a result of conflicts of interest and power struggles between the various actors involved.

The institutionalist approach put forward by Galbraith and other institutionalist authors has in turn contributed to revealing the exercise of power which proceeds within a productive system in which the economic, political and social variables are combined to make the expansion of large corporations viable. The institutionalist approach of the practices of power and conflicts of interest contribute in a most consistent way to understanding the process of regulation of technology in which privileged knowledge of specialists becomes the object of governance on the part of those actors directly linked to innovation (companies). In this process, the revelation of conflicts of interest allows us to identify the main mechanisms of negotiation as well as the strategies of the actors who are either interested in maintaining the status quo of technocratic knowledge or in questioning the decisions adopted by specialists. Therefore, the institutionalist approach of Galbraith allows us to identify important institutional innovations that proceed in society and which exert considerable influence on the determination of the pace and direction of technical progress.

[1] Peltzman, S. *Regulation of pharmaceutical innovation*. American Enterprise Institute, 1974.

[2] One example which illustrates this institutional control of regulation was the allegation made by USA Today (2000) claiming that 54% of the experts hired by the FDA to evaluate the approval of medications had a direct financial interest in the substance or in that area of research. These interests included financial help for research or being hired as a consultant by the pharmaceutical companies involved in the development of these substances. Despite federal legislation to stop the FDA hiring people who had any financial involvement with the topic, the ban has been violated 800 times since 1998 .

[3] The demands of NGOs in the EU countries to extend the technological risk analysis, including discussions of a socio-economic character have most notably been met in Denmark. In this country, the evaluation of the impacts of technology is conducted by a wide-ranging discussion in public forums. The problem was then formulated not only by specialists in a neutral and irreversible vision of the technologies to be adopted, but by taking into consideration the adoption of technological trajectories and social alternatives (Levidow, 1998). This far-reaching and participatory process of evaluation of the technology installed in Denmark is highlighted by Kaas (2000: 323) who observes "In Denmark, democracy is seen as the institutionalisation of debate, deliberation and consensus; in the UK (and many other places) it is the institutionalisation of the rule of the majority subject to checks and balances".

[4] In light of this new model of organisation of hybrid-forum discussions, the experience of the Contact Group deserves to be mentioned. This group was organised by Unilever and the Green Alliance between 1994 and 2001. NGOs which represented environmentalists and consumers were invited to discuss questions related to the development and regulation of GMOs. Unilever's strategy was to encourage more intense dialogue with consumers and was based on the assessment that controversy surrounding GMOs could not be adequately assessed by the company through traditional market research models, public relations and product development. Throughout these dialogues, the company adopted a new concept, that of consumer-citizen, through which they sought to discover the attitudes of the public towards GMOs, not in terms of preferences of the consumers but rather as a process of negotiating citizens' rights. For an evaluation of this experience, see Doubleday (2003).

[5] The use of biotechnology in Brazil was regulated with the approval of the National Congress, in 1995, of the Biosafety Law which set the basis for the control of genetic engineering and GMOs commercial release, in order to protect environment, bio-diversity and public health. Following this law, the Bio-safety National Technical Commission (CTNBio) was set up with the purpose of: certifying and monitoring the quality of infrastructure and technical capacity of those institutions working on teaching, research, and on technological development in the field of GMOs in Brazil; analysing the requests for the release of GMOs, and issuing conclusive technical assessment. CTNBio is made up of 18 members including: academic experts; representatives from the Ministries of Science and Technology, Agriculture, Health, Environment, Education and Foreign Relations; representatives from bio-technology companies; representatives from groups for the defence of consumer rights and workers' health. The president of the commission is appointed by the Minister of Science and Technology, from a short-list of three names put forward by a committee.

[6] Advisory Project on Alternative Agriculture.

[7] Clandestine cultivation of GMOs are currently estimated at around 8% of national soy production according to estimates by the Agricultural Ministry (Folha Online, June 25, 2004).

[8] Pelaez & Albergoni (2004) present a brief discussion on the power struggles among the main ministries involved in the regulation of GMOs.

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