Resistance to new technology and its effects on nuclear power, information technology and biotechnology

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Basic questions

The word 'resistance' has become unsuitable for use in the context of new technology. The allegation is that it serves mainly to blame those who resist; talking about resistance implies a managerial and technocratic bias. However, in developing the idea for this conference, I was confident that 'resistance' would prove ambiguous in meaning and rich in connotations, particularly in the European context.[1]

Historians of technology recently rediscovered 'resistance' as a 'force' that shapes technology which requires an adequate analysis (Mokyr 1990, 1992). For the economist resistance is basically the vested interests of old capital in ideas, skills and machinery. In addition, in the light of the critique of the 'Whiggish' historiography of technology (Staudenmaier 1985), it seems reasonable to lift 'resistance' from the dustbin of history.

Artefacts such as machines, power stations, computers, telephones, broadcasts and genetically engineered tomatoes, and the practice of their production, handling, marketing and use – in other words, technological innovations – are not the only factors of historical change. Technological determinism seems an inadequate account of our history. Various social activities give form to processes and products, facilitate their diffusion and mitigate their consequences. However, technology is not neutral. It creates opportunities and simultaneously constrains human activity. We experience the latter as being paced by 'machines' rather than controlling them. The selection of options is not neutral; it is likely to be contested and in need of legitimation. The control of technology by those affected by it remains a desirable agenda. From here the disagreement begins: who should be accountable to whom, and which procedures ensure this accountability?

In this context it constitutes a challenge to reflect on the concepts of resistance, and to review historical events, in order to rehabilitate the notion. In my view this may be achieved by analysing resistance in terms of its various consequences. This means starting with a functional hypothesis, instead of assuming *a priori* dysfunctional consequences of resistance for the 'progress' of society. Here we are less interested in the causes of resistance than in its effects. Resistance as the 'enemy of progress' is only a part of the story, as we will see, both historically and for more recent events.

Methodologically resistance to new technology is as much an independent as it is a dependent variable: the public reaction to technology influences new technology in a circular process. The study of resistance is located halfway between traditional impact analysis and the recent focus on socio-technical networking of humans and artefacts (Latour 1988; in German, *Technikgenese*: e.g. Joerges 1989).

The term 'resistance' elicits contradictory connotations. It seems necessary to justify an academic contribution on 'resistance' because the term is loaded with a managerial and modernisation bias and is not suitable for an impartial analysis of social events.[2] A participant at the conference put it bluntly: resistance implies a 'whitewash of big industry' in technological controversies. The term 'resistance' elicits quite different connotations. Traditions of philosophical thinking give resistance a moral dignity; and events of the twentieth century impute 'resistance' (*Widerstand, resistence, resistenza*) with an aura of 'heroism' in the struggle against totalitarianism. In South America 500 years of colonialism give it the 'heroic' meaning of fighting a lost cause that may finally prevail. We may deal with a real cultural difference in semantics.

The managerial and technocratic discourse stipulates resistance as a structural or a personal deficit. Resistance is irrational, morally bad, or at best understandable but futile. In contrast, the German discussion of new technology since the 1970s has been conducted under the term 'acceptance crisis'; the debate carefully avoids the term 'resistance', which is reserved for the respectable part of the national identity for which post-war historians, not only in Germany, have fought (Schmädeke & Steinbach 1985).

Because of these semantic confusions authors have argued that the term be dropped. I disagree, and suggest that we keep the term and stress the intended meaning. The ambiguity of the term 'resistance' allows us to ask different questions about an old problem of social change. This volume provides a review of the notions of resistance in technological controversies. The nineteen contributions compare forms and effects of resistance across time, space and technology: from machine breaking and technology transfer in the nineteenth century, Fordism in the early twentieth century, to three base technologies after 1945: civil nuclear power, information technology, and new biotechnology.

The comparison is done, naturally, using different approaches. The scope of material is limited geographically. The technological processes in countries of the Far East, in China, Taiwan and Japan are excluded; equally excluded are countries of the Third World and of Eastern Europe, where the problem of resistance to new technology may have a different angle altogether. These chapters mark the ambitious beginnings of an attempt to map intellectual territory: to study the contributions of resistance to the 'progress' of technology.

In the following I elaborate the rationale that brought contributors together to address the following key questions:

What are the forms of resistance?
What is being resisted?
Who are the resistant actors?
What are the effects of resistance?
What are the (dis)analogies between technologies?
The concept of 'resistance': towards a functional analysis?

My own theoretical inclination is towards a functional analysis of resistance by its consequences in a wider context. We do better to study functions of a process first, and to study dysfunctions afterwards as a dynamic aberration of normal processes. To date we have assumed the dysfunctions and neglected the functions of resistance to new technology. My framework draws upon recent developments in the theory of autonomous systems and elaborates a functional analogy between resistance and acute pain with reference to processes of self-monitoring. Metaphorically speaking, resistance is the 'acute pain' of the innovation process. I cannot assume that contributors subscribe to this framework, so I put it at the end of the book in an attempt to summarize. I develop this framework which both stimulated the idea of the book, and, I dare to hope, embraces many of the issues in a coherent manner. The core thesis states:

> Resistance affects socio-technical activity like acute pain affects individual processes: it is a signal that something is going wrong; it reallocates attention and enhances self-awareness; it evaluates ongoing activity; and it alters this activity in various ways to secure a sustainable future.

Three base technologies after 1945

Someone interested in contemporary history might ask: why compare nuclear power, information technology, and biotechnology? The automobile and space technology are equally major technological innovations of the twentieth century.[3] There are several reasons for the focus on these three technologies. The choice depends on the frame of comparison or '*tertium comparationis*'.

Table 1.1 *Invention, innovations and Organisation for Economic Co-operation and Development (OECD) attention*

Technology	Invention	Innovation	OECD attention
Nuclear	1942 first nuclear chain reaction	1955–6 first nuclear power stations (USSR, UK)	**1956 first report**
Information technology	1943 ENIAC		**1960 micro**
	1947 transistor	1954 commercial	1965 office automat
	1959 integrated circuit	1961 commercial	1971 IT policy series
	1959 micro processor	1965 micro computer	1979 new IT series
		1975 home computer	
		1981 IBM PC	
Biotechnology	1944 DNA		**1982 first report**
	1947 double helix		
	1973 rDNA	1975 CETUS US	
		1977 BIOGEN (Europe)	
		companies founded	

Sources: OECD publications catalogue; Wright, 1986; Rüdig, 1990.

Similarities

Five similarities of nuclear power, information technology, and biotechnology suggest a viable comparison. I am using these technologies generically as clusters of innovations that are distinct objects of R & D policy, planning and public perceptions.

First, economic historians suggest a periodization of time since about 1780 in cycles of roughly 50 years, commonly known as 'long waves' or 'Kondratieff cycles' of the world economy. Each upswing is based on the scientific and technical ideas developed during the previous downswing for which capital becomes available in the new upswing. Evidence indicates that the fourth wave turned into the downswing in the early 1970s, and a fifth long cycle may have taken off since.[4] The technologies commonly associated with this hypothetical fifth upswing are **civil nuclear power**, the new source of energy; **microelectronics**, with its ramifications into computer and communication technology, the new form of communication (Freeman 1985; DeGreene 1988; Ayers 1990); and **biotechnology and genetic engineering**, the new forms of food production, animal breeding and medical care. Resistance to new technology can take the form of social movements. Hobsbawm (1976) suggested that the size and intensity of social movements, in his case nineteenth century labour movements, relate to long waves of economic development. Screpanti (1984) showed that strike activity intensified during long economic upswings between 1860 and 1970 to reach peaks at the upper turning points of the long cycles; long periods of depressions showed the lowest level of strike activity. More recent observers see the decoupling of social protest movements from the economic system as characteristic of the post-war period (Pakulski 1993), suggesting that the link between economic cycles and popular unrest is historically contingent.

Secondly, nuclear power, information technology and biotechnology reach the attention of planners, forecasters and policy makers in a time series. Table 1.1 compares basic inventions, first-time commercial innovations, and the first related OECD policy reports for the three technologies.[5] This indicator shows that civil nuclear power gained policy focus as early as 1956; information technology after 1971, when the OECD starting a series of reports on information technology policies;[6] biotechnology came into the international policy focus not earlier than 1982. In terms of government policy nuclear power is older than information technology; and information technology is older than biotechnology.

Thirdly, each of these technologies gave rise to sociological imaginings of the 'coming new era', sometimes optimistic and enthusiastic in terms of revolutions, pessimistic in the light of doom, but often ambiguous. We find an abundance of books and articles with titles ranging from the 'atomic age', 'nuclear state' (Jungk 1979), the 'micro-electronic revolution', the 'computer age', the 'information society', the 'electronic society' (Dertouzos & Moses 1979; Lyon 1988), to the dawning of 'biosociety', the 'age of biology' or 'biotechnics' (see Bud 1993).[7]

Fourthly, all three technologies gained considerable media attention at different times. although in a controversial manner mainly after the 'Oil Crisis' of 1973. The cycle of press coverage for nuclear power, information technology and biotechnology confirms the time series in which these three technologies have entered the public arena. Figure 1.1 shows the shifting of media attention between these technologies, based on several European sources.[8] The peak of the coverage is indexed with the value 100 in each case. In Germany nuclear power reached a peak of press attention in 1979 (Kepplinger 1988, p. 665) coinciding with large scale anti-nuclear demonstrations.[9] The coverage of information technology peaks in 1984 (Sensales 1990, p. 66), the year ominously associated

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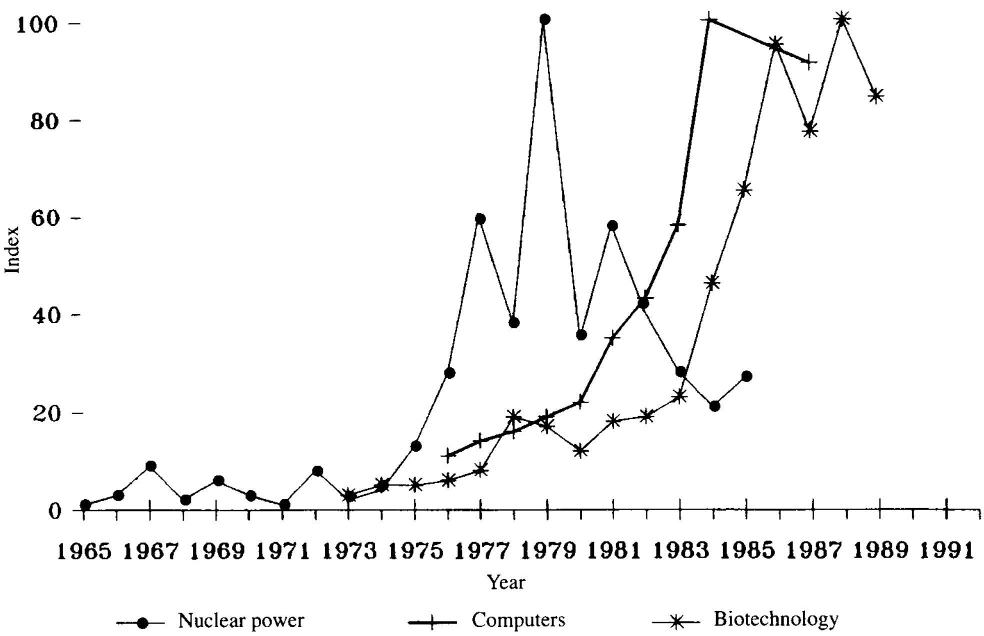

Figure 1.1. Press coverage of nuclear power, information technology and biotechnology in Europe 1965–90. The graph shows the development of press coverage on three technologies. The coverage is indexed with the peak = 100. Data on nuclear power and biotechnology from Germany; data on information technology from Italy.

with George Orwell's dystopian novel. This peak was probably reached earlier in Germany, during the public debate on the Population Census in 1983 (Mathes & Pfetsch 1991). The coverage of biotechnology, genome analysis and new genetics peaks in Germany in 1989 (Kepplinger, Ehmig & Ahlheim 1991; Brodde 1992; Ruhrmann 1992), coinciding with the publication of the parliamentary enquiry, the Catenhusen report, into the dangers and benefits of biotechnology (see Bud, Chapter 14, or Radkau, Chapter 16). In Britain, to date, press coverage on biotechnology peaked in 1992, and it is likely to rise in the coming years as the public debate intensifies (Durant, Hansen & Bauer 1996). The evidence shows that the Asilomar conference in February 1975 (Wright, 1986), where a group of US geneticists put a moratorium on their own research in order to explore the social consequences first, was an event with limited impact on the European public. Nuclear energy, information technology, and biotechnology form a series of policy and media attention. Media attention lags behind policy attention but the gap is decreasing (compare Table 1.1), an indication that public sensitivity to technological issues is increasing. The 'reaction time' from first innovations to public controversy in Europe is about 20 years for nuclear energy, 12–15 years for information technology, and about 8–10 years for biotechnology. Public opinion expressed in media coverage seems to function as feedback information for a process that is already under way.

Fifthly, all three technologies have been the subject of public controversy and social mobilization. Nuclear power has been contested by mass movements since the 1960s; local protests merged into anti-nuclear movements all over Europe and gained significant influence in energy policy (see Rucht, Chapter 13). The debate on information technology has been more of a concern for intellectuals; it rarely mobilized large resistance beyond local actions (Kling & Iacono 1988; Martin, Chapter 9, or Miles & Thomas, Chapter 12).[10] Issues of unemployment, social control, privacy, and security of information resulted in a cluster of opinion surveys in the mid-1980s (Jaufmann & Kistler 1986; Bauer 1993).[11] Biotechnology is the current issue: public opinion is forming on genome analysis, gene therapy, and genetically engineered plants and animals, to date without having mobilized mass actions. On the whole one could say that nuclear power has a long history of debate and has mobilized large-scale resistance which moved from local to trans-national activity. Information technology did not result in large collective resistance; resistance is local on the level of particular industries, work-place actions or consumer behaviour. Biotechnology is the great unknown. Local resistance has occurred against field testing of genetically altered plants, and public opinion has been gauged in recent years (Marlier 1992; European Commission 1993). Jeremy Rifkin and his associates campaign worldwide against new biotechnology and its ramifications.

In summary, nuclear energy, information technology and biotechnology have in turn been viewed as leading technologies with long-term impacts; each of them stimulated dreams of a 'new era', from the atomic age, to the information society, to the dawn of the biosociety. Policy concern and public debate about these technologies came in a sequence. One can assume that the resistance against nuclear power conditioned the resistance and its effects for later developments (see Radkau, Chapter 16). It is likely that we are dealing with an example of institutional learning, the building of new procedures and fora of debates at the interfaces of science, technology and society.

Together with similarities, we need to identify differences between these technologies. Such differences may be candidate variables for explaining the variance in resistance that accompanied these developments.

Dissimilarities

Analogies are useful, but may also be misleading (see Radkau, Chapter 16). In substance the three technologies contribute to different functions of human life. Nuclear power is a source of energy; information technology deals with ways of storing and processing information; biotechnology deals with enhanced production of food (fermentation, plant and animal biotechnology), and with new forms of medical care (pharmaceutical and genetic screening and therapy). These developments build on each other. Computers are to a large extent involved in the development of new biotechnology for process automation, modelling and information storage; and computers and biotechnology rely on available energy.

The three technologies differ in the choices they offer to the public. Buying a computer is different from buying a nuclear power plant. Choices offer points of resistance. Many different choices diffuse user resistance, and may prevent it from becoming a social movement. Nuclear energy is mainly a question of binary choice – yes or no – with some leeway on how large the percentage of the total energy production of a country should be in the form of atomic energy. In contrast, information technology and biotechnology offer wider choices. People have some choice over the extent of computerization they want for their lives: they may restrict the computer to assisting in a few tasks at home or at work, or conduct all their lives with 'computer assistance', from driving a car, to cooking a meal, to making coffee in the morning, to finding a partner. These choices are not free from constraints, as Dorothy Nelkin (Chapter 18) will argue on the issue of penetration of privacy. Biotechnology is similar to information technology in terms of choice among various food products; however, when dealing with the problem of production processes, the experimental release of genetically altered organisms, and the issue of patenting life forms, we may be confronted with binary choices of yes or no (see Jasanoff, Chapter 15, or Bud, Chapter 14).

Risk is both a unifying and a distinctive feature of these three technologies. The capital limits of insuring the potential damage of a large technological project marks a crisis point of modern societies and the transition into 'risk societies'. According to this view it is the success of institutions, not their failure, that undermines their basis and creates space for new political processes to emerge. The quest for technological control leads paradoxically to increased uncertainty, and undermines the capability for action. The distribution of unintended consequences of technological progress becomes a conflict area that cuts across traditional party political lines (Beck 1993).

Nuclear power is 'technically' a low risk area, with large dangers but small probability. Incidences such as Three Mile Island or disasters such as Chernobyl have low probabilities, but, as we all know, have happened – in 1979 and 1986, respectively. In contrast information technology poses small dangers with high probability. Computer addiction (Shotton 1989), exposure to VDU (visual display unit) radiation, and posture pains such as repetitive strain injury (RSI) are widespread, but are not regarded as alarming.[12] The empirical risk of suffering from RSI is probably larger than being contaminated by nuclear fallout. However, risk comparison is notoriously controversial (Covello 1991). Jasanoff (Chapter

15) will show that German, British and US expert proceedings attribute different kinds and sizes of risks to biotechnology. Comparisons are furthermore complicated by the fact that public risk perception is not cumulative; it does not add up many small risks to give one large risk. Risk perception feeds on the size and controllability of danger, and less on its probability. The magnitude of potential damage differs for nuclear power, information technology, and biotechnology. Nuclear power and biotechnology share the possibility, in the former case real, in the latter hypothetical, of large scale, unlimited in time and space, social and physical damage – a problem that is to a lesser extent associated with information technology. This difference may explain the presence or absence of large-scale organized resistance.

The type of risk makes a difference for public perception. The health risks of the three technologies vary. Radiation touches the problem of physical well-being of individuals and society. Leukaemia, cancer and malformations at birth are issues central to people's life concerns. By contrast the problems of information technology are more abstract: it seems to alter the way we think and make decisions; 'artificial intelligence' seems to bother mainly people with expertise in the field of 'thinking', such as intellectuals and academics. Information technology has not lent itself to mass mobilization of resistance that goes beyond local issues except in Germany in 1983 and 1987 where a computer readable identity card and the population census became a major issue (Mathes & Pfetsch 1991). Radiation fallout from accidents like Chernobyl poses **risks without limits**; the event had consequences in Northern Scandinavia within days. Power stations may pose geographically concentrated risks of leukaemia and cancer in the vicinity. The problematic impacts of information technology are more widely scattered and mostly transitory; and impacts such as enhanced social control and penetration of privacy are more symbolic and difficult to recognize (see Nelkin, Chapter 18). In new areas of biotechnology and genetic engineering health risks are an open question, and more of a diffuse but widespread concern than well defined.

The three technologies differ in capital intensity and geographical concentration. Nuclear power is the most expensive technology per investment unit. It may have once been part of the expert imagination that each household would have a nuclear power generator in the back garden, in the basement or in the automobile;[13] but nuclear energy production became concentrated in large plant sites – 423 sites in 24 countries by 1990. Information technology is radically different. Computing units have become increasingly smaller and cheaper and are widely distributed in business and in households as mainframes, micros, PCs (personal computers), laptops or notebooks, or as integrated parts of an increasing number of artefacts. Similarly, biotechnology does not require the large-scale investments of nuclear energy with all that it implies for the disposal or re-processing of nuclear waste. The human genome project is a small investment compared to the nuclear programmes over the last 40 years. The biotechnology industry started up in small businesses linked to university departments (Wright 1986), and turned into a venture of established chemical industries in recent years. Within one country nuclear power is centralized technology, while information technology and biotechnology tend to be distributed technologies.

Whether the enterprise is private or public makes a difference. Nuclear power and computers were initially a state enterprise from research and development to production, a matter of national security linked to the capacity to produce 'the Bomb' and to make large-scale calculations in missile technology. Private companies take over later: nuclear power remains a state enterprise in many countries until the present time while the diffusion of information technology and biotechnology is predominantly a matter of private business. Public control is limited to setting legal boundaries and incentives for investment. The involvement of the state makes nuclear power a direct political issue. Nuclear power is public technology; information technology and biotechnology are primarily private technologies. This leads to a different culture of industry. The nuclear power industry inherited a tradition of secrecy from its military roots. Research and development was conducted behind closed doors, dictated by national security during the Cold War years. The chemical, computer and communications industries are more open. Their processes and products are more visible in everyday use. Public enterprise does not mean an open culture, and private developments do not imply a culture of secrecy.

The public discourse of technology varies across and within technology over time. The geographical concentration of nuclear power makes it visible in the landscape as an icon of 'progress', 'doom', or 'a devil's bargain' (Gamson & Modigliani 1989). The Cold War favoured images of secrecy and national security in relation to nuclear power, while the 1980s favoured the imperative of international economic competition. Neither information technology nor biotechnology is a major issue of national security, but does impact on national competitiveness. Confronted with the threat of terrorism nuclear power implied intensified social control, perhaps even a police state within the 'nuclear state' (Jungk 1979): it has similarities with information technology in terms of political risk. Another variable of discourse is the 'newness' of technology. Jasanoff (Chapter 15) shows that for biotechnology the context dictates the rhetoric: for purposes of fund raising and innovation policy 'novelty' and 'revolution' are appealing arguments. However, to prevent legislation and judicial activity, 'novelty' is an undesirable argument as existing regulations are supposed to suffice; new biotechnologies 'become' forms of brewing and breeding, or 'old