TECHNOLOGY AND SOCIETY: A VIEW FROM SOCIOLOGY

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During the thirty years that followed the end of the Second World War, the accelerated scientific development of industrialized countries has attracted the interest of many scholars in social sciences and humanities, who have produced a vast literature on the epistemological, social, political, and economic aspects of scientific research. Since about the mid-seventies, however, "technology" has dethroned "science" as the focus of attention. Governments have replaced their "science policies" by "technology policies" and investments in applied and technological research have grown faster than investments in basic research. This shifting of attention from science to technology as the perceived motor of development in industrialized as well as in industrializing countries is linked to major changes that occurred in the world economy over the last quarter of the century.

Since the 1960s we are living a new industrial revolution based on new core technologies like electronics and more recently bio-technology; this new industrial revolution has transformed our way of living more dramatically than the textile and railway revolutions did in the late XVIIIth and early XIXth centuries, or the steel, chemical and electrical revolution did in the late XIXth century. The new technologies have affected skills and machinery in all industries, radically changing communication and transportation, modifying everybody's work and leisure in the developed world. The rise of the South Asian countries in the Post-War period is associated to their appropriation of new process and product technologies. Japan, Korea, Taiwan and the other Newly Industrialized Countries have mastered the most recent technologies, and are now able to spill their high quality products over the developed countries' markets.

It is not surprising, thus, that economists were among the first to think seriously about the role of technology in the economic development (Rosenberg 1982) and that sociologists, political scientists and philosophers have only recently turned their attention to technology in order to study its nature and its process of development.

Given the central place of technology in modern society a Treatise on Basic Philosophy, like the one produced by Mario Bunge, could hardly fail to devote a volume to the philosophy of science and technology, though twenty years ago he could have limited its content only to science without generating a stir among his fellow philosophers. This is not to say however that Mario Bunge is a latecomer jumping on a band-wagon; quite the contrary. In the mid-sixties, he was already among a small number of thinkers who began to insist on the philosophical importance of technology (Mitcham 1980). In a survey of the field of philosophy of technology, Carl Mitcham even notes that Mario Bunge "was the first to use the phrase 'philosophy of technology' as a title in English" (Mitcham 1980, p. 297).

Mario Bunge's scientific epistemology is formulated to be "consistent with contemporary science" and includes the social sciences as an integral part of his system of scientific knowledge. Our paper will thus try to answer his appeal to a dialogue by comparing his conception of science and technology with the one that comes out of recent sociological studies. We use "sociology" in the broad sense of a comprehensive social science that Mario Bunge gives to our discipline.

1. The Nature of Science and Technology

First, a comment about Mario Bunge's definitions of science and technology. From the point of view of sociologists, it is refreshing to see definitions of science and technology that take explicitly into account, though in a formal manner, the social character of the production of knowledge. Hence, Bunge's definitions of science and technology include the existence of a research community composed of "persons who have received specialized training, have information links among them, share certain values and initiate or continue a tradition of research" (Bunge 1985, p. 231). This concise definition adequately summarizes the results of what is now known as the Merton school in the sociology of science which has produced many studies on the dynamic of scientific communities (Crane 1972, Merton 1973, Zuckerman 1988). The realistic epistemology behind this research fits well with Bunge's own research program, but has been the object of much criticism over the last ten years. Seen more as a sociology of scientists than a sociology of science and technology, this paradigm has been replaced by a more relativist one which, taken as a heuristic tool, has raised new questions about the dynamics of the production of knowledge. Instead of starting with an a priori definition of science, this approach observes the manner in which scientists arrive at a consensus about what is collectively accepted as scientific (Knorr-Cetina and Mulkay 1983). It is probably at this point that the roads taken by the sociologist and the philosopher of science and technology diverge. For whereas Mario Bunge only needs to define notions like "basic science", "applied science" and "technology", sociologists of science and technology must, as a rule of method, not only build definitions but study empirically how scientists and engineers arrive (or not) at a consensus on the content of these terms. Hence all empirical studies of technological innovations are faced with the fact, already observed by R.R. Nelson in 1962, in the case of the discovery of the transistor, that "one of the most important things which can be learned from the history of the transistor is that the distinction between basic research and applied research is fuzzy [...] The project was marked by a duality of results and motives. Yet by the standards of the National Science Foundation, the Bell semi-conductor research work most certainly would be considered basic research" (cited by Forman 1987, p. 220).

In addition to being difficult to distinguish in practice, the notions of "pure" and "applied" science are also the object of debate between groups having different or opposing interests. The history of the projects Hindsight and Traces offers a good example of the social use of categories like "pure" and "applied" science. Sponsored by the U.S. Department of Defense, the Hindsight report, issued in 1966, concluded that most recent innovations were not linked to pure research but to prior applied research. This conclusion clearly jeopardized the then current dictum that applied science flows from pure research, an idea frequently used to convince governments to invest in pure science. In order to counteract the possible use of this conclusion, the NSF sponsored a new study (Traces), published in 1968, showing that, contrary to DOD's conclusions, many recent technological innovations could be traced to pure research if one went sufficiently backward in time (Kreilkamp 1970). This episode clearly shows that the classification of knowledge is an object of contention among groups and that if they want to be able to see these phenomena, sociologists must not impose their own definitions of the terms.

From this point of view, we cannot but notice that Bunge's argument against what he called "sociologism" is circular, for the argument that "scientists indulge in nonscientific activities" presupposes a modern definition of science whereas the sociologist finds that "mindless data collection" – which by the way was typical of many activities *called* "baconian" in the 18th century – and even "pseudo-science" are problematic notions with variable content (Bunge 1983, p. 202). In short, the practice of sociology naturally intends to socialize epistemology and put the various conceptions of "science" within their proper historical context (Hesse 1988).

2. *Technology and Economics*

Among the "descriptive social sciences of knowledge", envisaged by Mario Bunge, economics is probably the most developed. Technical innovation is one of the most important economic issues. It refers to a new or improved product, process or production system that is commercially used and/or produced (Freeman 1974). Technological innovation is based upon technical change and their diffusion among economic units. Technological change may lead to increased productivity, improved goods and services and/or economic growth. In the history of economics, K. Marx and J. Schumpeter were the most important thinkers of technological innovation and technical change (Rosenberg 1982, Elster 1983). Today's themes have changed somewhat from those that originally interested the founding fathers.

One of the main issues in recent debates has been the explanation of technical innovation. Some authors, led by J. Schmookler (1966), explained both innovation and technical progress by demand side factors: innovation would depend upon the size of the market for new goods and services. Against this "demand-pull" approach, A. Philips (1972) and N. Rosenberg (1974), among others, put forward a "science-push" explanation: innovative activity is influenced, according to them, more by the availability of scientific knowledge than by market considerations.

Another key issue is the identification of the main performer of innovation. For Schumpeter (1911), the entrepreneur was the heroic character who seized the opportunities arising from simple inventions (key idea, model or scheme forming the basis of innovation), translating them into new or improved products, processes or productive systems. In C. Freeman's view (1974, 1988), the rise of the modern corporation in the late XIXth century in Germany and the United States, with its Research and Development department, has bureaucratized and routinized innovation, which has become a familiar dimension of the business strategy of large industrial firms.

Other determinants of innovation analyzed by economists are the size of the industrial enterprise and market structures. Again, Schumpeter thought that large industrial firms and oligopolistic market structures were the more conducive to innovation and technical progress. Only large firms had the resources necessary to conduct R & D and to produce a continuous flow of innovations. Several authors produced evidence confirming Schumpeter's hypothesis, including Philips (1956) and Villard (1958). Others (Shrieves 1978) arrive at the opposite conclusion: small firms that are involved in R & D expend a higher percentage of sales on Research and Development activities. A more blended picture is now emerging, where R & D is often located in large entreprises, but small firms with R & D activities are usually more research intensive (measured by R & D expenditures divided by sales) than large ones; also, R & D intensity and the participation of small firms depends on the industry considered; finally it is more and more accepted that innovation depends not only on formal R & D activities, but also on the daily problem-solving technical endeavours of the firms.

A third major theme that appears in the literature is technological diffusion between firms, industries and nations. Competition forces less innovative firms to follow the leader. The factors favoring and retarding the diffusion of innovations, its channels and time lags are among the most frequently studied issues in the economic literature. In the international arena, the role of multinational corporations (MNCs) as appropriate vehicles for the transfer of technology is the object of a widespread debate. Some economists (Williams 1973, Emmanuel 1981) consider MNCs the least expensive and the fastest vehicle for technology transfer, while another group of economists emphasises the internalisation of technology by MNCs (Hymer 1960, Buckley and Casson 1976, Chesnais 1988) and the weak diffusion effects of the transnational corporation.

A fourth major theme is the influence of technology on international trade. Up to 1954 the Ricardian theory of international trade reigned supreme, in its modern version, based on the Heckscher-Ohlin-Samuelson theorem. With the publication of the Leontief's paradox, technology made its entrance in this field, and its importance has continued to grow. Technology is increasingly considered not only a factor of production, along with capital and unskilled labour, but appears as the most important element in modern international competitiveness (Dosi and Soete 1988). And technology can be produced by State intervention in economic activity, through the skilling of labour force, the nurturing of technically-intensive industries, government-sponsored R & D, government laboratories, *etc.*

Finally, another major issue is the impact of technological change on employment. Technological change may create structural unemployment, mainly by the adoption of labour-saving technologies without increases in output. But also the slow adoption of new technologies by industry can channel demand towards foreign-made goods, and create insufficient demand for domestic goods; the lack of specific technical skills in the labour force can have the same effect (Freeman *et al.* 1982). Most neo-classical economists, however, believe that technological unemployment is only a frictional, short term phenomenon.

As a result of these studies, the relations between technological innovation and the R&D activities of firms cannot be realistically portrayed in a chart flow which naturally suggests, despite the presence of feedback loops, a movement from pure science to technology and innovation. Studies in the economic theory of innovation show that innovations do not neccessary come from the conscious, planned R & D activities of the firm, but from its daily problem-solving activities. In fact, not only most enterprises do not have R & D facilities but most innovations do not come from R & D activities. Besides, government (and in particular defense laboratories) are important producers of innovations (Freeman 1974). Students of the dynamics of science and technology would not agree that "the most common pattern is nowadays: scientific paper – applied science report – technological blueprint." (Bunge 1983, p. 211) Far from admitting that "since about 1800 on the whole, technological breakhroughs have followed scientific discoveries" (Bunge 1983, p. 211), economists of technological change like Nathan Rosenberg affirm that "the normal situation in the past, and to a considerable degree in the present, is that technological knowledge has preceded scientific knowledge" (Rosenberg 1982, p. 144). In fact, we think it rather sterile to decide which comes first, technology or science, for the answer depends on the definition of technology as Bunge (1983, p. 244) observes. It is more fruitful, from a sociological and historical point of view, to observe that these relations are changing and that the fact that research activities have diffused in many places (firm, government lab, military lab, in addition to the usual university lab) has modified the content of terms like "science". Nowadays, the complex relationship between science and technology is essentially the result of the development of new relations of production between institutions that were not previously linked, and the creation of new ones (like the industrial research laboratory in the middle of the 19th century). Thus, Bunge's observation that basic research is still carried out "mainly by universities", hardly corresponds to the present situation though it was true before 1945. A less formal approach to the problem of the production of knowledge helps to see the crucial role of the military in scientific and technological change. Modern aircraft and aerospace technologies, as those of telecommunications and computing, came originally from state (military) orders, and are the products of research which are not easily classified as "pure" or "applied". As we have already mentioned, it is the essence (so to speak) of military as well as industrial research to blend practices that in the past could be more easily labelled as "pure" and "applied" partly because of their institutional separation. Once created, however, technological products such as satellites, computers or radar, can be appropriated for scientific purposes (Smith 1985, Forman 1987).

The fundamental problem of a flow chart is that it freezes in time the changing relation between the terms. There is no doubt that the relations between the many activities forming the spectrum between the ideal-type of "technology" and the ideal-type of "pure science", are more complex today than in the 17th century and that the mid-nineteenth century can be pointed to as the period were technology and science began to amalgamate one another in such a way as to become hardly distinguishable. Though this fact does not preclude the construction of definitions, it implies that in practice such a priori definitions function more as performative distinctions than descriptive ones, and can usefully be applied only to a particular historical period.

3. Sociotechnology

This observation about performative versus descriptive definitions bring us to Bunge's conception of "sociotechnology", which some sociologists may find too rigid. Bunge's analysis concludes with sociotechnology, conceived as the creation, adjustement and maintenance of social systems (Bunge 1985, p. 274). This branch of technology is divided by the author into *management science*, concerned with small scale social systems (firms, government units, cultural organizations), and *social engineering*, or large scale public management, including macro-economic policy, civilian, cultural and military policy.

The sociologist with some interest in history would again find matters to discuss in this conception of sociotechnology. The very concept of sociotechnology is not necessarily one that makes many adepts. But even if we accept it, it is still difficult to believe that social and economic policy creates (or "designs") social systems. Large social systems evolve, at least partially, by themselves, and not only by design; economic and social policy, based on fragmentary knowledge and shaky theories, induces adjustements that often backfire or have perverse effects. Examples are abundant: anti-inflationnary policies in Latin-America that fuel inflation and induce recessions by restricting supply; welfare programs in the United States that create dependence and induce the recipients' families to increase the number of their children in order to maximise allocations; progressive taxation on income in Sweden, that induces massive fiscal evasion; corporate tax exemptions in Canada that are a major factor in the rise of conglomerates, etc.

Even corporations and government departments (and thus micro-management) are not exempt from perverse effects and unexpected loops. The imposition of the so-called "scientific management" in American enterprises since the beginning of the century is now seen as a major factor of the decline of the United States' industrial system, having induced excessive fragmentation and deskilling of the labour force, and fuelled workers' dissatisfaction (Reich 1983, Piore and Sabel 1984).

Besides, there is an abundant literature in political science and political economy that deals with the relationship between the State and technological change. This literature starts from the fact that science and technology are, if only partially, public or collective goods: their use by some actors (be it individuals or organizations) does not preclude its use by others. As public goods, their production may be sub-optimal if the government does not nurture their development: entreprises may be, at least partially, uninterested in their production because they may be unable to capture all the rents stemming from scientific and technological innovations. Government, thus, must favour the development of science and technology through a variety of policies: the creation of public laboratories, university R & D, public funding of privately executed R & D, tax rebates for private R & D, legal monopolies (patents) given to inventors and innovators, *etc*. Political scientists and political economists do not agree on the efficiency of these policies. A strong opposition exists between neo-classical economists of the Public Choice school, who are sceptical about most of these policies (see R. Landry 1987), and political economists of the SPRU school definitely arguing in favour of them (Freeman 1987).

These debates leave us somewhat unconvinced about the usefulness of the social engineering approach suggested by Mario Bunge. At the very heart of government intervention, in the only area in which it is widely agreed that the government has to intervene (the production of public goods in the science and technology area), the debate is still going on and empirical policy evaluations studies must still continue to deepen our understanding of the complex phenomena of State intervention.

4. Conclusion

Mario Bunge has been among the pioneers in the philosophical study of technology and its integration into social science. In this sense, his *Treatise* is a welcome and systematic attempt at introducing technology into philosophy. It also deserves attention for its many contributions in the field of definition and initial formalisation. It finally provides a unifying picture that can be used as a basis for future developments.

However, from the sociologist point of view, his philosophy of technology is somewhat too "rationalistic": technology is seen as deriving ultimately from science, both in actual history and through theoretical and methodological borrowings; technical change is produced by the planned R & D activities of the industrial firm; social systems are designed and redesigned by social engineers and managers, and so on.

In the real world, industrial and military organizations have nurtured technology, and thus "pushed" science, by providing it with new equipment, new objects and (last but not least) new funds. Technology is a major determinant of scientific development though the interactions of science and technology are today more intermingled than in the past.

In our view, Mario Bunge understates the role of governmental military activities in the shaping of modern technology, especially in countries like United Kingdom and United States and, between the wars, Japan and Germany. Modern technical history shows, however, that when most public R & D funds are used for defense-related activities, technical change and innovation are linked to military endeavours. Many of them had important civilian spin-offs, but their origin is military, not commercially-oriented industrial R & D.

We also believe that sociotechnical systems are less obedient and orderly than depicted in Bunge's philosophy. As a system, society evolves at least partially of its own, in the midst of much inevitable disorder. The management of sociotechnical systems, as Bunge conceives it, is still embryonic and we think it dubious that any kind of social engineering (either at the macro or micro levels) can put an end to this situation. In fact, it may be the case that too much faith in the scientific management of society could only bring us closer to Orwell's 1984, a situation that Mario Bunge would surely disapprove.

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