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Get ready for technoscience: the constant burden of evaluation and domination

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La revolución tecnocientífica
Javier Echeverría
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Madrid, 2003, 282 pp.

At the outset of the book, Echeverría characterizes the "technoscientific revolution" as the unfolding in the twentieth century of two others revolutions that are constitutive of modernity: the scientific revolution of seventeenth century, and the second industrial revolution of the mid-nineteenth century. According to him, however, unlike the scientific revolution, the technoscientific revolution, is neither an epistemological nor a methodological revolution, but what he calls a "*praxiological* revolution": a profound transformation of the structure of scientific practice and of the values that shape science and technology (p. 12).

1 Seven thesis concerning technoscience

Echeverría proposes the following theses, which I state summarily, to articulate the principal aspects and consequences of the "praxiological revolution".

> (1) During the twentieth century, especially from the Second World War on, a new way of practicing science has come into being and developed rapidly, first as "big science" and, more recently, as "technoscience" (p. 15).
> (2) This development – a technoscientific revolution "or better, technoscientific revolutions, because they are produced in almost all scientific disciplines, although in different ways in each one" (p. 15) – is the contemporary analogue of the seventeenth century scientific revolution.
> (3) The technoscientific revolution is one of the main motors of a deeper social and economic change, the "informational revolution" – the analogue

> of the industrial revolution. Just as science was vital for the development of industrial society, so technoscience is a basic component of the emerging informational society, which brings with it the replacement of the modern notion of "industrial, scientific and technological development" by the contemporary one of "technoscientific and informational development".
> (4) Since earlier studies of science and technology (historical, philosophical, sociological, political, cultural, anthropological, economical etc.) are unable to confront the challenge imposed by the technoscientific revolution (p. 15), they need to be replaced by the studies on technoscience that have a trans-disciplinary character.
> (5) Philosophy of science and technology should be concerned with the philosophical analysis (i.e., evaluation) of technoscientific activity, and the changes in this activity. In this way, it becomes aligned with scientific and technological policies, a component of technoscience, that originated in Vannevar Bush's report (1945) to President Roosevelt.
> (6) The traditional questions of philosophy of science, related with justification, objectivity, and rationality of scientific knowledge, are completely inadequate for dealing with "the foundations of technoscience" – a problem that "happens to be more important" needs to be added, "the evaluation of scientific practice" (p. 16).
> (7) "The thesis of axiological pluralism of technoscience" – it "presupposes on-going axiological conflicts in technoscientific activity" (p. 16), and opposes the positivistic thesis of axiological neutrality and the thesis that restricts values in science to epistemic or internal ones; and it is is combined with the claim: "Axiology provides a powerful instrument of analysis that integrates, in a single conceptual system, the various tools used today to evaluate technoscientific actions and its results" (p. 16), where these tools include: (a) "evaluation matrixes", and "quotas or evaluation limits", and (b) the indices of science and technology, statistically determined, that can be used to establish evaluation protocols "that are used in current technoscientific practice".

The bulk of the review will leave aside other issues, and devote itself to discussion and criticism of these seven theses. Before proceeding, however, I will make a brief comment on the third chapter that aims to justify the title of the book by making an analogy with Thomas Kuhn's analysis of scientific revolutions. In order to suggest that technoscience corresponds to a deep "Kuhnian" transformation in scientific practice, Echeverría feels obliged to employ concepts such as "technoscientific paradigm"; to

discuss its components (e.g., symbolic generalizations, models, values, and exemplars); to explore what the counterparts in technoscience of Kuhnian incommensurability might be; and finally to introduce the question (to me, completely wrongheaded) of the existence of technoscientific communities, and of "the conversion of scientific communities into technoscientific enterprises" (p. 193). It is a strained analogy, for Kuhn was never concerned with the financing of scientific research, or with applied science, but these are indispensable for understanding technoscience; and it is not pursued beyond this chapter, suggesting that the author only wants to obtain a rhetorical aura for his argument for a technoscientific revolution from association with Kuhn's widely acclaimed account of scientific revolutions.

2 Critical exposition of Echeverría's arguments for his seven thesis

I will now examine in some detail Echeverría's theses about technoscience, in order to assess critically his main argument about technoscientific activity.

2.1 Underestimating the experimental dimension of technoscience

Thesis (1) just affirms a general historical fact. Echeverría elaborates it in the first two chapters, based on historical studies of science and technology and their relations with industry in the USA (cf. Price, 1973; Smith, 1990; Dickson, 1988; and especially articles in Galison & Hevly, 1992). He maintains that technoscience originated in USA during the twentieth century; that there are two forms of it: big militarized science, and that practiced by the large private corporations; and that, broadly speaking, it developed in three stages. The first stage, 1940 – 1956, corresponds to the implantation of "big science" generated by US public financing. During it, while the state and the military predominated, as exemplified in the Manhattan Project for the construction of the atomic bomb during Second World War, we also find the growth of new corporations that, for the sake of furthering their private economic interests, instituted their own departments of research and development (R&D), as well as the strengthening of corporations, such as Du Pont, that already functioned in this way. The second stage, 1966 – 1976, was a decade of crises and stagnation produced by Vietnam War, in which there was growing criticism of militarized science. Finally, during the third stage, from 1976 on, the large globalized companies with their activities organized around R&D of goods and services were created, followed by, from 2000 on, enterprises aiming at "innovation" through development of the so called "new technologies".

Although referring to the three stage development of technoscience in this way may seem acceptable, the detail of the exposition has serious limitations. These derive from the way in which, throughout the book, the author underestimates the importance of epistemology, methodology, history, and sociology (and from his predilection for the entrepreneurial dimension of technoscientific activity). By downplaying epistemological and methodological considerations in his characterization of technoscience in favor of "praxiological" ones, he is impeded from evaluating correctly the scientific dimension of technoscience, and the role and function of experimentation, of the experimental method, and of instrumentation in "big science". Echeverría minimizes the role of experimental research that is conducted using the instruments, laboratories and buildings of the institutions that support "big science", and does not consider the strictly scientific importance of the construction of the enormous experimental apparatus (telescopes, microscopes, particles accelerators laboratories and industrial plants) that are capable of generating knowledge at the frontiers of science. The upshot is a distorted perspective that fails to grasp adequately the social place of the institutions connected with experimental science. It also fails to evaluate correctly the place that experimental science and technological instrumentation occupies in the productive system. In this way, Echeverría does not give due attention to instrumental reason and to its actual social functioning; ironically, in so doing he makes the same mistake that he accuses philosophers and historians of making. This illustrates that the author seems to be more interested in developing a discourse about the importance of evaluating technoscientific actions and activities, than in coming to comprehend them.

Echeverría long discussion (over a hundred pages) of both "big science" and technoscience will now be summarized in order to show the preeminence that he gives to evaluative policies and practices for technoscientific activity.

> • Big science = public financing + integration of scientists and engineers + aim to advance knowledge and efficiency of technological instrumentation in order to obtain economic and military power (p. 37-8) + industrialized + militarized + gives rise, first, to public technoscientific policies and projects, and, later, to private ones + juridical agent/subject.
>
> • Technoscience = private financing + integration of scientists and engineers + aim to gain political control of economic and innovation development (p. 77-81), or "the control and domination of nature and societies" (p. 90)[1]

1 Echeverría pays little attention to the question of control: he doesn't seem to consider control as a value, or to perceive its centrality in contemporary scientific and technological activities; and he uses "control" and "domination"

> + entrepreneurial + for the market or war + private scientific and technological policies and projects + plural subject or plurality of agents.

2.2 The ubiquity of revolutions and the systematic illusion

Theses (2) and (3) form a unity and have to do with the supposedly revolutionary character of technoscience. Echeverría's argument, however, is marred by a conceptual confusion: he does not clearly distinguish the technological medium from the technologies that produce it, and from those that could come to be developed in virtue of the configuration of this medium. Since, for him, technoscience corresponds "to a great transformation in the structure of scientific activity", it can be interpreted as "a revolution in the practice of science that is neither an epistemological, nor a methodological revolution" (p. 149). Yet, in order to show the effective functioning of such a transformation in scientific practice, the author invariably has to come back to considerations about scientific methodology, for this transformation consists basically in the introduction of informatics and of the method of simulation. In Echeverría's own formulation:

> the two main methodological axes of modern science were mathematics and the experimental method. Informatics and simulations constitute the two great methodological novelties of the twentieth century, whose irruption, development, and consolidation mark the passage from science to technoscience from the point of view of formal languages and methodology (p. 106)

From this perspective, technoscience is characterized by the use of technologies of information (cf. p. 125), and by the production of models and simulations, that represent new forms of experimentation. Furthermore, informatics is accompanied by a corresponding growth in control (control of nature, and also social control) by means of automation in the functioning of the machines. Then, the author concludes that since all the sciences employ informatics and conduct their researches in networks, and all disciplines uses informational equipment and languages, "we may claim that in all sciences there has been the emergence of technoscience" (p. 146-7). For Echeverría:

> In the twenty first century, it will be necessary to distinguish between traditional disciplines and their corresponding technosciences: techno-mathematics,

as synonymous. Moreover, he has an ambiguous attitude toward control: on the one hand, he affirms, "technoscience continues to show itself highly efficient at the moment of transforming the world or of dominating nature" (p. 99); but, on the other hand, "technoscience does not intend to dominate or to transform nature, but society" (p. 209).

> techno-logic, techno-astronomy, techno-physics, techno-chemistry, techno-biology, techno-medicine, techno-geology, techno-economy, techno-sociology, techno-psychology etc. (p. 160).

Following the argument where it appears to lead him, Echeverría goes on to affirm that, because "Greenpeace uses some of the new information and communication technologies (television, internet etc.) ... from our point of view, [it] is another technoscientific agent, although it intervenes from outside of the science and technology system" (p. 85). On this way of looking at things, even this review is technoscientific, because it was written on a computer using a specific informational software, and it will be assessable on the internet, and it intervenes from outside of the system criticizing one of its ideologues.

Informatics is, indeed, an invariant component of all the systems of activities in contemporary society and culture; it is the technical/technological medium in which these activities are developed. But, it is important not to confound (or create an ambiguity between) two senses of the term "technoscience": (i) a general sense, technoscience as the informational and cybernetics medium in which we live, a medium that expands the dominion of machines by means of informatics, automation, feedback systems, regulation, control of objects and processes; and (ii) a narrower sense, technoscience as the "technoscientific enterprise". Echeverría confounds these senses, and consequently he falls victim to an illusion – seeing technoscience where it is not.

Then, consistent with (ii), the author claims that "technosciences are not made by the scientific communities, but by entities far more complex, the technoscientific enterprises" (p. 156). In this sense, "technoscience" refers to the set of private enterprises, which aim to gain economic and (in some cases) even military power, and which put R&D&I at the center of their entrepreneurial strategies. But, in this sense, this review is not a technoscientific product, and Greenpeace is not a technoscientific agent – recognizing this the illusion vanishes. Echeverría, however, because of his downplaying of the sociological perspective, is effectively impeded from recognizing this and, more generally, from dealing systematically with the view that technoscientific activities are new forms of institutional organization that explore the productive and services opportunities, which are made possible by the actual technological infrastructure. Fortunately the medium is less deterministic than Echeverría supposes it to be. Not recognizing this, passing from illusion to delirium, he considers as revolutionary the introduction of each technical object, "such as the railroad, the automobile, the electrical domestics etc." (p. 179). The cost of maintaining the ambiguity is high.

In contrast, when we attend to the distinction between the technoscientific medium and the technoscientific enterprise, we see that there is no revolution, no rupture or sudden transformation, but the gradual and cumulative, albeit rapid, expansion and consolidation of the electronic medium over the electrical one, which remains in place as the base on which the dynamics of the changing medium unfold. What Echeverría considers to be a technoscientific revolution in information is part of the social process of consolidation of the machinist medium, based on information and automatic processing, in which new possibilities for social, economic, political, and cultural relations arise, as do new forms of exploitation of the productive sector of society. Putting the ambiguity aside, we can see – without illusion – that the very existence of large globalized corporations, Echeverría's "technoscientific enterprises", is made possible by the gradual development of the technological medium. One may use the computers and software of technoscientific companies, and "be in the network", without engaging in technoscience; but it has become close to a necessity to be an employee in a technoscientific enterprise.

2.3 The importance of evaluation to the administration of technoscience

Thesis (4)-(6) also compose a unity. Their role in Echeverría's argument, we will see, is to legitimate the activity of evaluation, given its supposed importance to the entrepreneurial policies and projects of science and technology, and to enable him to appropriate the term, "philosophy of technoscience", for use connected with the merely statistic task of establishing Science & Technology indexes and indicators.

Thesis (4) has two parts: first, none of the traditional disciplines and specialties that make up "studies on science and technology" are able to grasp the new phenomenon of technoscience, supposedly brought about by a "technoscientific revolution", so that now they have to give way to the "studies on technoscience"; second, these studies have a trans-disciplinary character. Thesis (5) particularizes thesis (4) to the case of philosophy, so that philosophy can be transformed into an instrument of the politics of science. Thesis (6) completes the reduction of "the philosophical analysis of scientific activity" to a mere technical activity (non-critical) of constantly evaluating "scientific practice".

Remember that the author's thesis concerning technoscientific revolutions, and their ubiquity, was based on considering technoscience ambiguously: sometimes as the technological medium, sometimes as an activity developed by private enterprises of the productive sector of society. This ambiguity is also used for the purpose of insinuating the centrality of the evaluative and entrepreneurial activity in technoscientific practice.

From the premise that technoscientific enterprises can be characterized as those that put R&D&I at the center of their entrepreneurial strategies, and a hypothesis that rigidly associates epistemic values to research, technical values to development, and economic values to innovation, Echeverría concludes that "the axiology of technoscience *always* has to take into account, minimally, three systems of values: epistemic, technical, and economic (p. 70, author's italics). For him, innovation has economic import; "innovation" means a "technological development designed to be launched into the market" (p. 211). Echeverría affirms the primacy of economic values in technoscience: "economic and entrepreneurial values penetrate technoscientific activity through and through and integrate the axiological nucleus of technoscience's investigation and application ... technoscience is always guided by economic values" (p. 70). Then, maintaining that D&I are "the entrepreneurial components of technoscientific activity", he emphasizes the importance of axiology, "which guides technoscientific actions and their evaluations *ex ante* and *ex post*".

There are several problems with Echeverría's argument. The first has to do with the use of the term "system", and his failure to address the issue of relations among the three "systems" of values systematically. The author does not even raise the question about the import of the primacy of economic values to the relations between the three systems of values, much less show what it is. It is hard to figure out what role the term "system" is intended to play – the treatment is not systematic; the term is vaguely employed; no functional, structural or formal relations among the three "systems" are displayed. The language used gives the impression that the argument makes use of the theory of systems and that it is aligned with this authoritative scientific trend. That is misleading rhetoric.

The second problem has to do with the way in which the author uses concepts such as "transdisciplinarity", "interdisciplinarity", and "multidisciplinarity" vaguely, without precision and without attention to the context of application of the concepts. He constantly confuses two levels: "studies on science and technology"; and science and technology itself. This is a consequence of Echeverría's unjustified downplaying of the sociological dimension that makes it difficult for him to make distinctions that are important for comprehending the social functioning of technoscientific activity. In particular, he cannot make use of the more adequate characterization of trans, inter, or multidisciplinarity that derives from the sociology and history of institutions, where they are considered as regimes of production and diffusion of science and technology that have certain institutional aspects. These aspects make it indispensable that the question of the interaction between the scientific disciplines and specialties be dealt with on the institutional level, at which there occur relations among universities,

private companies, financial agencies, government officials, etc. The prevailing institutional regime makes possible the relations among individual agents that are needed for collaborative activity to unfold. It may favor, induce, and sustain, for example, transversal collaborative relations that are established by individuals, who come from different disciplines and specialties, so as to constitute a temporary research team to work on some problem or application at the frontiers between them (cf. Shinn, 2008; Marcovich & Shinn, 2012). Hence, the constitution of these teams does not depend only on the interactions of the individual agents involved, but relations among them are modulated, and in some cases, even regulated, by the institutions involved.

A final problem is that nowhere does Echeverría present the basics of what he calls "studies on technoscience". This, together with his failure to give clear content to inter, multi or transdisciplinarity, only confirms the rhetorical tone of his discourse.

2.4 An interactionist theory of technoscientific action

Echeverría's argument is based on the very simple idea that the subject – in the sense of agent – of technoscience is a plural subject that has constantly conflicting values. This is why we need to be guided by an axiology that will serve to evaluate technoscientific activity. The argument is based on a broad analogy: "the structural complexity of scientific activity reflects itself instantaneously as complexity of the technoscientific agent" (p. 219). The agent of technoscience is not the Cartesian or Kantian individual subject, but a plural subject, i.e., one composed by a plurality of agents. Now, since the plural subject is not "autonomous and coherent" as the individual subject may be considered to be, it is more prone to conflicts of values. Such conflicts are considered to be inherent to plural subjects, because, in the final analysis, agents act following their own values, and these conflict with those of others agents. It is necessary, then, to construct an axiology that can serve as an instrument to regulate the conflicts in order to render the plural subject coherent. The thesis that conflicts of values are a structural component of technoscience – and hence the importance of axiology (a theory of values) to technoscientific activity – depends, therefore, both on the idea of plural agent and on the characterization of value. I will now discuss the basic notions of "agent" and "value".

First, consider the notion of "agent" that Echeverría uses to make sense of his notion of "plural subject". The system of science and technology, for example, is composed of sectors that Echeverría identifies as "the political, the financial, the scientific-technological [aren't they two separate sectors?], the entrepreneurial, the military, the juridical, the market, and society [!]". In the system of technoscience, "pri-

vate enterprises and financial bodies" are the predominant agents; however, since "in other sectors [of society] there may be different agents relevant to technoscience (...)", also "it would be necessary to analyze the structure of these agents in each country, in each discipline (...)". So far, leaving aside its dependence on tacit suppositions, the argument is acceptable. But, the author goes on to conclude: "from our point of view, it is fundamental to include society among the technoscientific agents, not only because (...) the great majority of the actions are directed toward society, but also because society is not passive with respect to technoscience" (p. 215). But are not the sectors social? Is not technoscience made possible by material conditions and socially provided organization?

We can then enumerate the agents: enterprises, public and private financial institutions, military, and government agencies and officials; and we must, in order to consider society as a technoscientific agent, charitably interpret "society" – a term used by Echeverría in the general sense – to refer to civil organizations, such as NGOs, workers unions, consumer associations etc. However, the agents he refers to as "integrated" into the nucleus of technoscience, turn out not to be institutions, organizations or enterprises, but individuals: "financiers, entrepreneurs, managers, lawyers, scientists and engineers" (p. 219) – so that the plural subject is composed of a plurality of individual agents that act motivated (egoistically) by their own interests and values. Technoscientific action is, then, conceived as being produced by the interaction (synergy) established among individual agents, independently of the hierarchical relations required for them to develop a project inside of a private enterprise. The fact that individual agents engage in their activities inside of an agent of higher order, then, has no repercussion in their actions, which are considered as resulting from the deliberative evaluations of individuals motivated by their own values. Remember that Echeverría never indicates functional, structural or formal relations between systems and subsystems or their component parts.

This is an interactionist theory of action that considers all agents as individuals independently of their position in the enterprise hierarchy, and holds that action results from a process of constant deliberative evaluation, realized by these individuals agents, considered as evaluators, each guided by its characteristic set of values. Furthermore, they are stereotyped agents. Each agent is taken to hold a delimited and coherent system of values: the scientist only has scientific values, the engineer technical values, the lawyer legal values, and the entrepreneur economic values. Echeverría does not take into account that the agents live in society and, therefore, hold confused mixtures of values; that they are individuals who belong to a particular social environment, who have acquired particular habits, who work in particular institutions or companies, who inevitably adopt political and religious positions, who have particular aes-

thetic tastes, and who may adhere to a particular scientific or professional ethos;[2] and that they act following a set of habits and attitudes (not necessarily consciously) that operate even when they are called upon to produce specialized judgments.

What are values for Echeverría; and how are they related with actions? According to him, "values are functions (in the Fregean sense) applied by evaluating agents to the systems of scientific, technological and technoscientific actions" (p. 237). This means, first, that values are conceived as exterior to the activity itself, because they are applied from outside in the evaluation of action. Moreover, to each action, there are only two possible attributions of value to an action, positive or negative value, as there are two attributions of truth, true or false, to propositional functions; and Echeverría adds: "it is important to keep in mind that values have contraries, negative values, and that evaluative or axiological rationality is based on the rule of incrementing the degree of satisfaction of positive values and of diminishing that of the negative values" (p. 233-4).

There are many passages (e.g., p. 240, 248) that show that Echeverría does not entertain, and apparently opposes, the idea that values are qualities that practices (actions) have in virtue of their aims, directions, consequences, and risks, and that may manifest themselves in practices (actions) in greater or lesser degrees. He opposes the idea that values come to be embodied in individual agents because of habits acquired by socialization, in the family, school, community etc. But if agents themselves do not embody values (many of them tacitly acquired), and if their actions do not manifest certain values in greater or lesser degrees, how are values connected with actions? He answers this question by transforming every agent into an evaluating agent "a scientist, an engineer, an entrepreneur, a business person, a general, a politician, a lawyer, an ecologist, or a common man" (p. 248). Each one acts by attributing a positive or negative value to certain actions or set of actions. According to this conception, the consensual values must be intensively constructed from the interactions between different individual evaluative acts of scientists, engineers, entrepreneurs etc. involved. Echeverría does not entertain that there may be preexisting consensus on values, which modulates technoscientific actions, that are not the product of evaluative deliberation, but are tacitly incorporated into the goals and regulations of the institutions or corporations in which the action unfolds.

2 Echeverría's discussion of values in technoscientific activity omits any reference to the scientific ethos, discussed by Robert K. Merton (1973 [1942]), and the recent sociological discussion motived by John Ziman (1994, 2000) on the contemporary transformations of that ethos. I will not discuss the implications of this omission in this review. See also Oliveira, 2011.

All of this confirms what has already been said, that Echeverría is not much concerned with understanding technoscience. Rather, based on his conviction that one of the main consequences of technoscience has been the creation of "assessors and experts for the management of scientific policies as well as for evaluating science and technology" (p. 204), he proposes the managerial hegemony of evaluation, which he claims can provide the ground for upholding the pragmatic principle of strategic action that considers that "technoscience is the source of economic, political and military power" (p. 266). Echeverría is convinced that "the struggle for power" is the motor of contemporary technoscience, whether it be for military power to which big science contributes, or for economic power to which the R&D&I departments of big corporations of the globalized economy contribute.

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