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Analysis

Ecological economics, Marxism, and technological progress: Some explorations of the conceptual foundations of theories of ecologically unequal exchange

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ABSTRACT

Almost regardless of ideological persuasion, the seemingly self-evident concept of "technological progress" inherited from early industrialism is resorted to as an article of faith serving to dispel the specter of truncated growth. The increasingly acknowledged threats of peak oil and global warming are thus generally countered with visions of a future civilization based on solar power. I discuss this technological scenario as a utopia that raises serious doubts about mainstream understandings of what "technology" really is. Technological utopianism raises difficult but fundamental analytical questions about the relation between thermodynamics and theories of economic value. While Marxism and some ecological economics share the ambition of grounding notions of economic value in physical parameters, notions of economic value and physical processes should be kept analytically distinct.

1. Introduction

The question that ultimately inspires this inquiry is if it is analytically feasible to posit the existence and polarizing significance of "ecologically unequal exchange" without fully subscribing to the conceptual framework of Marxist economic theory. To pursue this issue, viz. the complex relation between ecological economics and Marxism, necessarily also implies a critical consideration of more conventional Marxian categories such as "use value," the labor theory of value, and notions of technological progress.[1] These considerations problematize how the relation between material, biophysical aspects of production and flows of monetary exchange values, i.e. the relation between physics and economics, is conceptualized in these two paradigms. Marxian and ecological economics share the ambition of integrating natural science and economics in the study of socio-ecological systems, but the discrepancies between their approaches highlight some conceptual problems that need to be disentangled in order to present an analytically coherent theory of ecologically unequal exchange. These deliberations are relevant not only to understanding the role of asymmetric resource transfers in generating and maintaining economic inequalities, but also to the prospects of adopting new, sustainable, and putatively equitable technologies such as photovoltaic energy production. I argue that advanced technologies exist on account of the very discrepancy between flows of money and flows of matter–energy, i.e. between economics and physics, and thus hope to show that the theorization of "ecologically unequal exchange" is inextricably connected to understandings of technological progress (Hornborg, 2013a). However, even heterodox economics such as Marxism and much of ecological economics tend to misrepresent the widely acknowledged discrepancy between flows of money and flows of matter–energy. This paper attempts to address this analytical confusion.

1.1. "Technological Progress" As a Cultural Category, Situated in Global Social Space

Ever since the Industrial Revolution saved Britain from ecological crisis in the early nineteenth century (cf. Pomeranz, 2000), visions of miraculous new technologies have alleviated Euro-American anxieties about the impending doom of the fossil-fuelled capitalism that it inaugurated. Although Malthus's worries about land shortages were transcended by historical events as well as by Ricardo's and Marx's

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[1] I realize, of course, that these issues have generated a vast discussion over the decades (e.g., Benton, 1996; Burkett, 1999, 2005b; Foster, 2000; Martinez-Alier, 1987; O'Connor, 1998; O'Connor, 1994) and that in this paper I am only able to address a specific segment of that discussion, viz. that which pertains to the role of notions of "value" and technological progress in theories of ecologically unequal exchange.

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different versions of technological optimism, they were soon reincarnated in Jevons's warnings about the depletion of coal. Today economists generally dismiss the pessimism not only of Malthus and Jevons, but also of current concerns over peak oil, by expressing faith in human ingenuity, whether in the form of solar panels in the Sahara desert or other forms of putatively "green" production such as biofuels. To retrospectively ridicule pessimists by referring to technological progress that they did not anticipate has become an established pattern of mainstream thought. Almost regardless of ideological persuasion, the seemingly self-evident concept of "technological progress" inherited from early industrialism has been resorted to as an article of faith serving to dispel the specter of truncated growth. The increasingly acknowledged threats of peak oil and global warming are thus generally countered with visions of a future civilization based on solar power. Considering the serious doubts that have been raised regarding the feasibility of solar power as a global solution to future energy crises, it is valid to ask whether this technological scenario should in fact be viewed as unrealistic.[2] The technological utopianism professed, for instance, by some Marxists (e.g., Schwartzman, 1996, 2008) raises difficult but fundamental analytical questions about the relation between thermodynamics and theories of economic value. As I hope to show, the prospect of a global civilization powered by direct solar energy is connected to the debate on how material and semiotic[3] aspects of economic processes are related.

Deliberations about technological futures tend to be founded on considerations of what is feasible to achieve, given current or anticipated knowledge. A common proposition is that a given technical process that has been successfully implemented under laboratory conditions, while still incapable of competing economically with conventional technologies, can soon be expected to be economically viable. Such proposals tend to unite engineers and economists under a common paradigm regarding the nature of technological innovation, even if neither profession is actually prompted to consider technological systems holistically, as simultaneously material and social strategies. To understand the conditions of "technological progress" in such a truly trans-disciplinary way, we need to raise a very diverse set of questions, ranging from thermodynamics and material resource requirements to financial politics and the global distribution of purchasing power. No single business or research specialization is equipped to articulate an understanding of technological progress that takes such diverse factors into serious consideration simultaneously.

Let us begin by suggesting that a successful technical experiment does not provide sufficient evidence that a new technological system is "feasible" or "within reach." Yet, it is noteworthy that such conclusions are very frequently drawn in both academic and public debates. But if we are agreed that technical and societal feasibility are not synonymous – that technical ingenuity is a necessary but not sufficient condition for adoption – we need to ask what kind of obstacles might obstruct the emergence and expansion of a new technology, once its purely technical feasibility has been proven? On the one hand, there may be material constraints such as unreliability, natural limits on resource availability, or locally perceived inefficiencies in energy conversion. On the other hand, there may be various kinds of social constraints. First, there may be cultural constraints such as conservatism or the relative esthetic virtues of competing designs. Second, there may be economic constraints such as high costs, low profitability, and lack of competitiveness. Third, there may be political constraints deriving from ethical considerations, legislation, policy, or trade restrictions. More generally, we must consider how such various social constraints may simply be expressions of the fact that the expansion of a given technology is ubiquitously limited to that fraction of the world's population which has a sufficient purchasing power to adopt it. In other words, modern technology is always and everywhere a matter of uneven distribution in global society. This means that the extent to which a given technology is adopted hinges on the distribution of money in the world-system, and that the technology itself represents an unequal exchange of resources between different economic segments of world society. The "exchange" orchestrated by a technological system, I have argued (Hornborg, 2001, 2006, 2013a), is in fact an asymmetric flow of embodied human time and embodied natural space between sectors where these assets are differently priced. "Technological progress," in other words, is largely an index of capital accumulation and unequal exchange.

The conventional scientific and popular understanding of technological innovation is that it increases efficiency in a cumulative development that progresses over time. In the well-known IPAT equation (Ehrlich and Holdren, 1971), for instance, technology (T) is assumed to mitigate the environmental impacts (I) of growing population (P) and affluence (A). Counter to this understanding are glaring inefficiencies and unsustainable practices that paradoxically also seem to increase over time, such as waste of resources, environmental degradation, and economic inequalities. These inefficiencies are often referred to as externalities, which might be mitigated by modifying prices. On the other hand, it has been suggested that the very rationale of capitalism is to keep such externalities external. It has been argued, for instance, that growth-based "dematerialization" and the so-called environmental Kuznets curve is a local illusion, ignoring the displacement of growing environmental loads to world-system sectors with less purchasing power (cf. Fischer-Kowalski and Amann, 2001).

Does technological development generally increase efficiency, or does it increase inefficiencies? In order to address this issue, two questions should be posed: 1. By which parameters is efficiency defined? Whereas efficiency is generally assessed in terms of inputs and output of exchange values (money), there is a widespread neglect of other resource metrics such as (embodied/expended) energy, materials, human time, and natural space, and of impacts of production and transports on e.g. biodiversity, environmental quality, or human health. 2. How are the boundaries defined for the social units assessed? Whereas efficiency may appear to be increasing within a given social unit A, it may be decreasing within a wider social system of which A is a subsystem.

I have proposed that increased technological efficiency may be largely illusory, due to an inadequate consideration of all parameters (1), and to an inadequate definition of the boundaries of the social unit under consideration (2). A case study chosen to empirically illustrate such conditions is the adoption of steam technology in British textile production in the nineteenth century (Hornborg, 2006, 2013a). The argument is founded (1) on a consideration of international transfers of embodied human labor time and embodied natural space, rather than exchange value/money, and (2) on the total implications of this technology within a global system of nations engaged in trade, rather than only within Great Britain. A conclusion of this case study is that it is valid to propose a thorough rethinking of technology as a global social phenomenon and cultural category. Rather than a product of local or national innovation generating an increase in overall efficiency, a global perspective on technological development reveals that, to a considerable extent, it may represent an increasingly unequal redistribution of resources among different sectors of world society. To argue that "technological progress" in this sense is inextricably connected to unequal exchange requires a fundamental reconceptualization of the relation between physics and economics, even in schools of economic thought that are currently perceived as challenges to mainstream views.

[2] We should recall that already fifty years ago, the cover of Farrington Daniels's (1964) book *Direct Use of the Sun's Energy* proclaimed that the "most plentiful and cheapest energy is ours for the taking." Already at that time, Daniels referred to a steady progress in the direct use of the sun's energy "during the past decade," asserting that "technologically it could be used to replace the energy now being supplied by fuels and electricity" and that, given more expensive fossil fuels and future development of solar equipment, it will eventually be able to "compete economically with fossil fuels" (Daniels, 1964, 253, 260). Half a century later, it still only accounts for much less than 1% of global energy use, while its low EROI (Energy Return On Energy Investment) and high material requirements raise serious doubts about its feasibility (Andersen, 2013; Prieto and Hall, 2013).

[3] By "semiotic" aspects of the economy I mean those which hinge on the human communication of signs such as cultural values and, importantly, money.