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Towards an ecological theory of unequal exchange: articulating world system theory and ecological economics

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Abstract

The focus of this paper is on how an ecological perspective might provide us with an analytically more precise way of defining 'unequal exchange.' It is only by looking at the ecological conditions of human economies that we can adequately conceptualize the mechanisms which generate inequalities in distribution. Considerations of market power aside, neoclassical economic ideology has dispelled all possible criteria for assessing a market transaction as unequal or unfair. One way to assess the occurrence of unequal exchange may be to look at the direction of net flows of energy and materials (concrete, productive potential), but *without* falling into the trap of equating productive potential with economic value. On the contrary, it can be analytically demonstrated that unequal exchange emerges from a kind of inverse relationship between productive potential and economic value. The notion of a reasonable market price conceals the fact that what is being exchanged are intact resources for products representing resources already spent. If we consider, longitudinally along the production process, any given set of fuels and raw materials destined to be transformed into a given product plus waste, its content of available energy will be inversely related to its utility or price. In other words, the more of its original energy that has been dissipated, the higher its price. This means that 'production' (i.e. the dissipation of resources) will continuously be rewarded with ever more resources to dissipate, generating ecological destruction and global, core/periphery inequalities as two sides of the same coin.

Keywords: Unequal exchange; Capital accumulation; Imperialism; World system theory; Value; Energy; Emergy; Exergy; Political ecology; Environmental justice

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1. Introduction

Emerging concepts of 'political ecology' and 'environmental justice' recognize that environmental problems are socially *distributed*. But the problem of how human societies distribute ecological risks should not be separated from the problem of how they distribute resources. The two problems are, so to speak, opposite sides of the same coin. Martinez-Alier and O'Connor (1996) have suggested a distinction between Political Economy, which studies 'economic distribution conflicts,' and Political Ecology, which 'would study ecological distribution conflicts.' Ultimately, however, such a dichotomy needs to be transcended, and ecology recognized as part and parcel of any attempt to understand political economy. It is only by looking at the ecological conditions of human economies that we can adequately conceptualize the mechanisms which generate inequalities in distribution. The focus of this paper, then, is on how an ecological perspective might provide us with an analytically more precise way of defining 'unequal exchange.'

2. Unequal exchange: Problems of conceptualization

Unequal exchange has been a central concern of various strands of Marxist social theory, including early theories of imperialism, the dependency and world system perspectives of Frank (1967, 1978) and Wallerstein (1974–1989), and more orthodox Marxist arguments focused on 'modes of production' and the international appropriation of labour value (for a brief review, cf. Bunker, 1985; pp. 38–48). None of these approaches has been able to convince conventional economists that free market trade may entail such a thing as 'unequal exchange.' Considerations of market power aside, neoclassical economic ideology has dispelled all possible criteria for assessing a market transaction as unequal or unfair. Economists are generally simply not able to see how there could be a standard that would allow one to speak of some participant in market exchange as being undercompensated. This is indeed the conceptual predicament that conventional economics forces upon us.

World system theories and more orthodox Marxist perspectives are vulnerable to criticism in opposite ways. The former are unable to provide adequate definitions of key notions such as 'core/periphery,' 'exploitation' and 'accumulation' as long as they do not relate to factors specified independently of the premises of the model itself. There is an obvious risk of tautology when concepts of core/periphery relationships and accumulation are used reciprocally to define each other, i.e. core as the locus of accumulation and accumulation as what goes on in the core. The more traditional Marxist model, on the other hand, *does* specify exploitation independently, by referring to the quantifiable appropriation of labour value, but is immediately contradicted by the poor, empirical correspondence between the economic value of goods and the quantities of labour time invested in them (cf. Bunker, 1985; pp. 44–45; Adams, 1988; pp. 96–97). To extend this specification to the appropriation of 'energy values' (Bunker, 1985), though intuitively valid, remains conceptually misleading. This paper will argue that energy transfers are indeed crucial to understanding unequal exchange, but that energy and values should not be confused.

An alternative approach would be to ground notions of underpayment and unequal exchange not in some (contestable) theory of value (whether based on bullion, land, labour, or energy), but in the proportion of a manufacturer's or manufacturing centre's total, finished product that is continuously returned to the suppliers of energy and raw materials in the context of various institutional arrangements. This proportion defines how much of the productive potential of energy and materials is permanently being transferred to the manufacturing centre and likely to be accumulated in its own, expanding infrastructure. The only adequate way to assess the occurrence of unequal exchange may be to look at the direction of net flows of energy and materials (concrete, productive potential), but *without* falling into the trap of equating productive potential with economic value. On the contrary, it can be analytically demonstrated that unequal exchange

emerges from a kind of inverse relationship between productive potential and value. Logically, in accordance with the Second Law of Thermodynamics (cf. Georgescu-Roegen, 1971), the productive potential of a given set of resources *diminishes* as it is being converted into a product, i.e. as its value or utility *increases*. Thus, since Bunker (1985; p. 45) observes that 'additional value is created when extracted materials are transformed by labor,' it becomes confusing when he elsewhere states that energy is a value. We cannot have it both ways. To pursue the implications of this paradox means building bridges between world system theory and ecological economics.

3. The material and the social

One of the most sophisticated statements of ecological economics to date is Martinez-Alier's (1987) book with that title. His point of departure seems to have been to find a meeting-point between Marxism and ecology. In his research, he discovered that a Ukrainian *narodnik* by the name of Serhii Podolinsky (1850–1891) had tried to convince Marx and Engels to bring natural science into their theories on surplus value, but that they would not listen. More than 100 years later, we are still struggling with the same problems of transdisciplinary communication. Although basically sympathetic to the world systems perspectives of Frank and Wallerstein, specifically mentioning Frank's (1959) work on the correlation between the growth of capital stocks and energy consumption in the US and UK, and observing that dependency theory helped 'prepare the terrain' for ecological critique, Martinez-Alier twice reproaches them for paying too little attention to ecology (Martinez-Alier, 1987; pp. 15, 238).

Theories of labour value, like energy theories of value (Bunker, 1985; Odum, 1988; Costanza, 1980), belong to a tradition of ideas that goes back to Aristotle's distinction between 'real' economics (*oikonomia*), concerned with the management of concrete use values, on the one hand, and *chrematistics*, or the art of making money, on the other (cf. Daly and Cobb, 1989; Ch. 7). The operation of human economies, however, can only be understood in terms of the *interfusion* of objective, material conditions and subjective, cultural constructions. The history of economic thought reflects a systematic incapacity to deal with this mutual interpenetration of the material and the social. Its two recurrent pitfalls are either: (1) to attempt to specify objective criteria of value (such as labour or energy); or inversely, (2) to more or less ignore, like the neoclassicists, the objective substratum of the human economy.

The recent discourse on ecological economics, although increasingly explicit about its aspiration to overcome such difficulties, still has to find a way of adequately handling the recursive (positive feedback) links between material conditions and cultural constructions. A recurrent problem is an inability to deal with cultural valuation, social institutions, and thermodynamic laws as separate levels of reality. There is a concern with calculating 'correct' prices and even establishing energy theories of value, endeavours which, it will be argued, represent a confusion of what Bertrand Russell called logical types. A meeting of world system theory and ecological economics, however, could be a very productive one, because each could contribute something that the other is missing. World systems theorists have generally been as unconscious about thermodynamics as ecological economists have been naive about imperialism.

The perspective of anthropology, finally, might provide an ideal setting for such a meeting. No other science has a tradition of handling the comparative, cross-cultural study of human economies, technologies, and ecologies. Nor has any other science proceeded as far in conceptualizing the recursive interfusion of cultural categories and material circumstances. One of the central ambitions of anthropology is to 'defamiliarize' aspects of Western civilization by means of 'cross-cultural juxtaposition' (Marcus and Fischer, 1986; p. 138). If we are ever to escape from the cultural categories that continue to govern our rapacious industrial economy, this may be a strategy that we shall have to pursue (cf. Sahlins, 1976; Godelier, 1986; Gudeman, 1986).

4. Emergy and value

Theories of value should be of a different logical type than valuation itself, that is, the assigning of values to things by market actors. They should be descriptive, that is, they should tell us why people value things the way they do. This is, in fact, what neoclassical economic theory does. Even if the argument is tautological ('people find things useful because of their utility'), it is logically coherent. Labour or energy theories of value, however, are not primarily descriptive but normative. They propose to establish the 'real', objective value of goods and services. In effect, what such theories are doing is not telling us how people actually value things but how their authors would value them. In other words, they insert themselves on the same logical level as the phenomena they are to explain. This is what qualifies them as confusions of logical types. Valuation must be recognized as a subjective, cultural, and contextual phenomenon (Sahlins, 1976), not to be conflated with the material aspects of production. It is only by keeping these levels analytically separate that we can develop a scientific, non-normative theory of unequal exchange. Instead of trying to reduce economics to thermodynamics, we should show how the two are connected.

Probably the most famous theory of unequal exchange based on thermodynamics is that of Howard T. Odum (Odum, 1988; Odum and Arding, 1991). His point of departure is the concept of 'emergy' (with an m), which originally was meant to stand for 'embodied energy.' Formally, it is similar to Marx's concept of labour value in that it denotes the amount of energy that has been invested in a product. Odum is an ecologist, and the idea of embodied energy ultimately derives from studies of ecological food chains. In other words, he uses a food chain metaphor to understand production processes. Top predators such as eagles, wolves or humans represent the embodied energy of all the lower trophic levels all the way down to the plants.

The problem for Odum was that it was simply incorrect to speak of all the energy consumed as remaining, as it were, 'embodied' in the top predators or, by extension, finished industrial products (cf. Adams, 1988; p. 96). Most of the energy, of course, would have been dissipated on the way. So in 1984, he decided to keep holding on to the concept of emergy, but to give it a new definition (Odum, 1988; p. 1139, note 11). Henceforth, it would not stand for 'embodied energy' but 'energy memory.' Eagles and electric tooth brushes would thus carry within themselves the memory, so to speak, of all the energy spent to produce them. But the concept is obviously a metaphysical one. Let us only mention two problematic implications. One is that two identical craft objects should have different emergy values depending on the efficiency of the craftsman. Another is that the emergy value of a junk car, having been subjected to years of maintenance, should be higher than that of a brand new one. If the early definition of emergy was downright mistaken, the latter is metaphysical. Emergy is not a property of the items exchanged. The notion that the dissipated energy is somehow still there in the object only confuses things.

Odum (1988) (p. 1136) has explicitly argued that emergy provides us with a theory of value. He and his associates have demonstrated correlations between the amounts of energy expended in production and the price of the product (Costanza, 1980). It remains unclear, however, whether an emergy theory of value proposes to be: (a) descriptive; (b) normative; or (c) both? In other words, does it propose to explain how people actually do evaluate things (as reflected in prices) or how they *ought* to evaluate things? The emergy/price correlations suggest that it is descriptive, but Odum clearly also considers it normative. He undoubtedly feels that energy memory *should* be a measure of value. But if it is *both* descriptive *and* normative, it would seem to amount to nothing less than a way to legitimate, by and large, world market prices as they are. Industrial products, of course, have a higher emergy value than the fuels and raw materials from which they were produced.

On the other hand, Odum is very much concerned with exposing the unequal exchange of emergy between nations and regions. He suggests that there are differences in the emergy/dollar ratio in different parts of the world system, and

discusses trade between different countries in terms of their 'emergy exchange ratio' (Odum and Arding, 1991). Odum believes that the periphery is being underpaid for the emergy content of its natural resources because these are free gifts of nature and thus not properly evaluated on the market. In this part of his argument, the emergy theory of value is presented as normative, but *not* descriptive. Global trade policies, he concludes, should be directed at achieving 'emergy equity.' From a world systems perspective, however, this concept suggests no less of an oxymoron than does 'sustainable growth.' If a major rationale of international trade is precisely the transfer of energy and other resources from peripheries to centers of accumulation, the commendable principle of 'emergy equity' would amount to nothing less than to deprive world trade of its *raison d'être*.

5. Exergy, prices, and the social foundations of technology

It has been suggested that 'emergy' is a metaphysical concept. There is, however, another concept, building on thermodynamics, that is useful for our purposes because it does say something about the properties of the items exchanged. This is the concept of 'exergy' (with an x), which is the *quality* of energy in a particular substance or context, or, in other words, that part of the energy which is available for mechanical work (Wall, 1986; Kåberger, 1991; Månsson and McGlade, 1993). Strictly speaking, there is no consumption of energy anywhere, only of its quality and accessibility (that is, exergy.) Exergy is closely related to the concept of negative entropy. A non-mathematical interpretation might describe it as the potential for work that is inherent in any physically manifest information, order, structure or contrast. When such material structures or contrasts are neutralized, e.g. in combustion, some of the energy that once generated them can be unleashed as work.

The concept of exergy can give us a completely different perspective on the relationship between energy and trade than can Odum's concept of emergy. Briefly, if emergy and price are positively correlated, exergy and price are not. In fact, there is a specific sense in which they are *negatively* correlated: Up to the point where the final product is sold, there is a negative correlation between price and the proportion of the original exergy that is left in a set of processed substances. The more of the original exergy that has been dissipated, the higher the price. We shall return to this matter shortly.

Another perspective that needs to be introduced at this point is Ilya Prigogine's concept of 'dissipative structures' (Prigogine and Stenger, 1984; cf. also Adams, 1982, 1988). Dissipative structures are systems which stay far from thermodynamic equilibrium by continually drawing in exergy (negative entropy) from the outside and exporting the entropy, or disorder, they produce in the process. Erwin Schrödinger (1967) suggested that all living systems can maintain their internal order only by sucking order from their environments, and discharging the disorder generated by their own metabolism. This interpretation can be extended from biological to social systems (Adams, 1982, 1988). Societies also maintain their internal structure by drawing order from their environments. For hunter-gatherers this is generally a matter of exploiting other species in a fairly local, ecological context. For cities or world system centres, however, the maintenance of structure relies on exchange with other, peripheral social sectors more directly involved in the extraction of exergy from nature. This social dimension of exergy appropriation has proven very difficult to conceptualize in terms which can be integrated with the perspectives of thermodynamics. Bunker (1985; p. 33) observes, for instance, that Adams (1982) has 'not fully realized the sociological implications of his essentially physical formulation.'

The question we must address is: If organisms draw order into their systems by eating, and export disorder by discharging waste materials, heat, etc. how do cities go about doing it? How do world system centres do it? The answer must be all around us, like water to fish. It is just a matter of getting our eyes on it, and permitting ourselves the naivety of a first encounter. The reader will have anticipated that *market prices* are

the specific mechanism by which world system centres extract exergy from, and export entropy to, their peripheries. It would be impossible to understand accumulation, 'development', or modern technology itself without referring to the way in which exchange values relate to thermodynamics, that is the way in which market institutions organize the net transfer of energy and materials to world system centres.

For a century and a half, ecologists and economists have been trapped on opposite sides of a dualistic cosmology. Ecologists have looked for objective foundations for subjective, cultural phenomena, as when the Technocrats of the 1930s and later H.T. Odum offered their different versions of an energy theory of value. Economists, on the other hand, continue to assume that objective phenomena should be reckoned with in terms of subjectively founded criteria such as 'willingness to pay.' In the former case, there is an attempt by natural science to subsume the economy by suggesting that prices should reflect energy flows. In the latter case, there is an attempt by economics to subsume nature by suggesting that ecology can be evaluated in terms of prices. Neither position, it seems, properly accounts for the way in which ecology and economics — nature and society — are actually interfused.

The conundrum for ecological economics boils down to two, seemingly contradictory and irreconcilable observations. The first is that prices are cultural constructions that do not measure or reflect real material flows. This observation was emphasized by pioneers such as Geddes (1854–1932), Lotka (1880–1949) and Soddy (1877–1956), and continues to be a point of departure for ecological economics (Martinez-Alier, 1987; pp. 13, 90–91, 128–143). The second, which should have become evident during the so-called oil crises of the 1970s, is that prices are real determinants of local material conditions for production. When politically engineered shortages caused a dramatic rise in oil prices, the very foundations of oil-importing industrial economies seemed to be at stake. In the first sense, prices are not coupled to real material conditions; in the second sense, they are. They thus seem to be unreal and real at the same time.

Another way of approaching this conundrum is by juxtaposing certain conclusions of ecological economics into a logical syllogism, the pursuit or spelling-out of which seems to have been effectively blocked by the Cartesian matrix. On the one hand, it has long been observed that technology ('productivity' or 'productive forces') is a matter of energy availability (Martinez-Alier, 1987; pp. 226–227). On the other hand, it is equally evident that energy availability is a matter of prices (Martinez-Alier, 1987; pp. 4, 187, 210). To complete the syllogism, then, we would have to conclude that *technology is a matter of prices*. Systematic ratios of exchange and energy appropriation are at the very foundation of our industrial infrastructure. Unequal exchange in the world system is what reproduces machines, and machines are what reproduce unequal exchange. But does this agree with our everyday conception of technology as an application of inventive genius to natural resources? In some important sense it seems as if we have not yet grasped what technology really *is*. Not even the Marxist understanding of 'capital' or 'productive forces' seems to have pursued the syllogism to its distinctly post-Cartesian conclusion.

6. Capital accumulation and the appropriation of energy

Technology has always represented a junction of the subjective and the objective (the mental and the material), but capital refers to those specific kinds of technologies that are dependent not only on human knowledge, but on human *evaluations* regarding the social exchange of labour time and other energy resources. The recursive relationship between technology and economy is well exemplified by modern transport technology (railways, steamboats, etc.), which neutralized the ancient distinction between distantly traded luxuries and locally traded bulk goods. In suddenly rendering long-distance transports of bulk goods rational, nineteenth-century technology thus also reinforced the accumulative process of which it itself was a manifestation.

All infrastructure founded on an asymmetric exchange of energy between different social categories represents an *appropriation* of productive potential (Borgström, 1965; Rees and Wackernagel, 1994). Our intuitive, everyday understanding of modern technology, however, is generally not that it is inherently exploitative. We are aware that it consumes energy (or exergy, to be precise), but what seems to escape us is the social logic by which it inexorably *provides itself* with ever increasing amounts of this energy. Yet this is crucial to an understanding of the very nature of modern technology. Industrial technology does not simply represent the application of inventive genius to nature, but is equally dependent on a continuous and accelerating social transfer of energy organized by the very logic of market exchange.

It may seem trivial to point out that New York and Tokyo are net importers of energy. Yet we rarely reflect on why this must be the case. From a purely thermodynamic perspective, cities 'must' be net importers of energy because, like all other dissipative structures (such as biomass), their techno-industrial infrastructures require continuous inputs of energy in order to maintain their structure. But this explanation is only one side of the story: a retrospective account in which the presence of urban technomass is taken as a self-evident point of departure. From another perspective, we can turn the question around and observe that the import of energy to industrial sectors is *an inexorable consequence of market exchange*. If industrial processes necessarily entail a degradation of energy (Georgescu-Roegen, 1971), the sum of products exported from an industrial center must contain less energy than the sum of its imports. But in order to stay in business, of course, every industrialist will have to be paid more money for his products than he spends on fuels and raw materials. At an aggregated level, then, this means that the more energy that has been dissipated by industry today, the more new resources it will be able to purchase tomorrow.

If we consider, longitudinally along the production process, any given set of fuels and raw materials destined to be transformed into a given product plus waste, its content of available energy will be inversely related to its price, i.e. the more of its original energy that has been dissipated, the higher its price. The significance of this correlation is that it defines the logic of an expanding cycle of past, present and future exchanges. We can completely disregard the subjective 'utility' of the products, which is more or less arbitrary and ephemeral anyway — arbitrary because it is culturally defined (Sahlins, 1976) and ephemeral because it diminishes rapidly with use — and observe that if a finished product is priced higher than the resources required to produce it, this means that 'production' (i.e. the dissipation of resources) will continuously be rewarded with even more resources to dissipate.

In the past few centuries, this logic has given the industrial sectors access to accelerating quantities of energy of various kinds. So blinded are we by the miraculous 'discoveries' and 'achievements' of technology, that we generally fail to appreciate the extent to which the development of new technologies in itself is a manifestation of this increasingly intensive, social appropriation of energy. It has become everyday knowledge that a minority of the world's population consumes an increasing proportion of its energy resources, but because technology and economy tend to be conceived as separate domains (Hornborg, 1993), this unequal distribution of resources is attributed to the 'requirements' of industrial technology (i.e. an advanced level of 'development') rather than to the accumulative tendencies which are inherent in market exchange, and *which made industrial technology possible to begin with*.

The best way to achieve a sufficiently distanced view of modern, techno-industrial growth is to compare it with earlier modes of accumulation (Hornborg, 1995). This complies with the method which Marcus and Fischer (1986; p. 138) refer to as 'defamiliarization by cross-cultural juxtaposition.' Such a comparison will need to consider three factors which enter into any process of accumulation: (a) the social institutions which regulate exchange, (b) the symbolic systems which ultimately define exchange values and exchange rates, and (c) the thermodynamic and other physical circumstances which allow us to determine the direction of net flows of energy and materials.

In order to support themselves, notes Norman Yoffee (1988), centers of civilization must be able to *disembed* from their peripheral sectors those goods and services which they require for their metabolism. A pervasive aspect of such appropriation is that it is *represented as a reciprocal exchange* (Godelier, 1986). The Inca emperor, for instance, engaged local populations to work in his maize fields by offering them *chicha* (maize beer) and mimicking traditional labour exchange. We can assess the exploitative nature of such arrangements by observing that the *chicha* with which he appeased his labourers could only have represented a fraction of the harvest he gained from their labour. It is from the same perspective that we must view modern market exchange. Increasingly with modern technology, however, the productive input that is being underpaid is resources rather than labour. We can observe that the resources imported to industrial centers are transformed into quantities of products vastly greater than the fraction which is returned to their peripheries. And we must ask by what ideological means this unequal exchange is represented as reciprocal exchange. The answer, as we have seen, is the very notion of 'market price.'

The concept of capital conjures two images, one relating to abstract wealth, or purchasing power, the other to a technological infrastructure of some sort. *Because* capital is both symbolic and material in constitution, economists and ecologists are equally handicapped in their struggle to account for it. In a very general, cross-cultural, world-historical sense, capital accumulation is a recursive (positive feedback) relationship between technological infrastructure and the symbolic capacity to make claims on other people's resources. Such a general understanding of capital accumulation would be as applicable to agricultural terraces in ancient Peru as to the textile factories of eighteenth-century England. In both cases, *the infrastructure is used to produce an output that is culturally transformed into more infrastructure*. The important thing is not whether this transformation is conducted by means of maize beer parties hosted by the Inca emperor or by the sale of British textiles on the world market. The important thing is that, in both cases, the material operation of a technological system presupposes specific rates of exchange that ultimately rest on human evaluations and that guarantee a minimum net transfer of energy from one social sector to another. Whether this energy is in the form of labour, food, fodder, draught animals or fuels is also secondary to the essential logic of unequal exchange underlying capital accumulation itself.

7. Conclusions

The notion of a market price conceals the fact that what is being exchanged are intact resources for products representing resources already spent. This argument is not to be confused with an energy theory of value. It would be nonsensical to offer an 'exergy theory of value,' since it would systematically contradict the valuations which people actually make. Most attempts at achieving a dialogue between ecology and economics are deeply entrenched in the ambition to envisage principles for ecologically correct pricing that will guarantee long-term sustainability, and thus ultimately in the faith that such principles can be devised. But to pursue the logical implications of such a policy must lead to the discovery that it runs counter to those structural imperatives on which the very viability of industrialism is founded. The industrial sectors of world society subsist precisely on that discrepancy between the material and the symbolic which ecological economics is in the process of exposing. It is no coincidence that the emergence of modern industrialism, for which the discrepancy between price and productive potential is so crucial, was accompanied by an ideology (neoclassical economics) which rendered this very discrepancy invisible (Hornborg, 1992).

Since valuation is an altogether cultural phenomenon, a discussion of the objective aspects of industrial resource management that does not examine the assumption that finished products have a higher value than the raw materials for which they are exchanged remains imprisoned by the very cosmology that it should try to account for. A thorough analysis must struggle to distance itself from the cultural categories through which

the system operates. As 'prices' are socially negotiated exchange relationships between human beings, it is useless to search for their correlates in the material world. Only when we stop looking for a real measure of value, which should correlate with price, and recognize the impossibility of such a congruity, can we appreciate the profundity of the problem and perhaps begin to envisage ways of transcending it.

The ideology of prices and money fetishism continues to confuse us in many ways, not least in the contemporary debate on ecology and sustainable development. In the Brundtland Report, even the adverse effects of economic growth are marshalled to reinforce our faith in it. But in representing exchange relationships, money cannot repair damages to the biosphere, only redistribute them in the world system. Ecological issues and distributional issues are truly inseparable.

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