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North-South Trade and the Distribution of Environmental Goods and Burdens: A Biophysical Perspective

STEFAN GILJUM
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In the last 20 years, the implications of international trade for environmental distribution between North and South gained increasing attention in the debate on sustainable development. In this article, the authors take a biophysical perspective to analyze the distribution of environmental goods versus environmental burdens in North-South trade relations. Studies based on physical accounting are particularly suitable to elucidate environmental consequences of economic specialization processes in different world regions, as they clarify implications for both the use of natural resources and the generation of waste and of emissions in a coherent and comprehensive manner. Empirical evidence from biophysical accounting studies suggests that the formation of specific metabolic profiles of societies in the North and in the South, as a consequence of economic specialization, leads to an unequal environmental distribution. The article closes with an evaluation of policy measures and instruments appropriate for reducing negative environmental consequences of North-South trade.

Keywords: *ecologically unequal exchange; environmental distribution; international division of labor; material flow accounting; North-South trade*

The implications of North-South¹ trade for economic development and for the distribution of economic benefits through international trade have been a long-discussed issue in economics. Standard economic theory assumes that free trade leads to a win-win situation for all actors participating in international trade. However, a number of alternative theories have been presented that suggest that trade might lead to a systematic deterioration of one party's development potential through an unequal appropriation of economic surplus by different actors.

1. In this article, the North is equivalent to the group of OECD countries, and the South comprises all other countries. Evidently, the South is not a homogeneous group of nations. Members of this group differ substantially with respect to economic structures, social and environmental problems, and power in the international system. Considering the global perspective taken in this article, however, the general use of the terms *North* and *South* seems justified.

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In the past 20 years, environmental-distribution issues gained increasing attention in the international debate, in particular since the recognition of sustainable development as the guiding principle for future global development (World Commission for Environment and Development, 1987). Sustainability concepts like the concept of *environmental space* explicitly stress the global equity principle, demanding a fair distribution of resource use between the inhabitants of the different world regions and the maintenance of an intact global environment as the base for prospering economic development of future generations (Spangenberg, 1995).

Concerning the interactions between trade, environment and sustainable development, a large number of studies were published in the last few years. Contributions to this debate were made by international institutions (OECD, 1997; United Nations Environmental Programme [UNEP], 1999; World Bank, 2001; World Trade Organization [WTO], 1999), by environmental and by development NGOs (Friends of the Earth Europe, 2001; Oxfam, 2002; World Wildlife Fund [WWF], 1999), and by researchers from the natural and the social sciences (see the literature cited in Jayadevappa & Chhatre, 2000; Muradian & Martinez-Alier, 2001b; and Neumayer, 2001 for recent overviews). Most of these studies take an economic (monetary) approach or focus on specific environmental problems related to international trade activities (e.g., air and water pollution or soil degradation). Very few of them, though, take a systemic perspective of the economy-environment relationship and explain environmental results as a consequence of the biophysical metabolism of societies (for exceptions, see Döppe et al., 2002; and Fischer-Kowalski & Amann, 2001).

In this article, we try to take such a systemic, biophysical perspective to analyze the distribution of environmental goods² versus environmental burdens in North-South trade relations. We focus our arguments on the environmental dimension, being aware that a comprehensive evaluation of North-South trade from the viewpoint of sustainable development also requires a profound analysis of socioeconomic implications of global integration processes.

Studies based on biophysical accounting are particularly suitable to elucidate environmental consequences of international specialization processes for specific countries and for world regions, as they reflect implications for both the use of natural resources and the generation of waste and of emissions in a coherent and comprehensive manner.

2. The term *environmental goods* stands for natural resources (in terms of materials and energy) as necessary inputs for economic activities (see Ayres & Warr, 2002). Note that this definition differs from the use of this term in the OECD and in the World Trade Organization context, in which *environmental goods* mainly refers to pollution-management technologies (e.g., OECD, 2000).

On one hand, it is often emphasized that 20% of the world population (mainly in the North) is appropriating 80% of the world's natural resources (e.g., von Weizsäcker, Lovins, & Lovins, 1995). On the other hand, a process of relative dematerialization³ can be observed for many Northern countries (Adriaanse et al., 1997). Some authors discuss the possibility that this dematerialization is facilitated by a relocation of resource-intensive production from North to South (Rothman, 1998). Physical-accounting studies of international trade can clarify whether relative dematerialization in the North is going along with a deintensification of trade flows or is linked to increased physical inputs of natural resources from the South.

Activities in the primary sectors (such as agriculture, forestry and mining) are the most resource intensive per unit of economic output (Mani & Wheeler, 1998; UNEP, 1999). That means that for relatively little added value, they extract large amounts of materials and generate large amounts of waste in the process of extraction and refinement. Concerning the distribution of negative environmental consequences through specialization in the world economy, physical-accounting studies can investigate whether negative environmental consequences are disproportionately concentrated in particular world regions.

Several physical-accounting concepts and indicators, such as ecological footprints (e.g., Andersson & Lindroth, 2001) and energy-related concepts (e.g., Odum, 1984) have been applied to analyze environmental-distribution issues related to international trade. In this article, we will focus on empirical studies based on material flow accounting and analysis (MFA).

The article will be structured as follows: The second section reviews theories dealing with distribution issues in North-South trade. The third section presents and discusses empirical results from trade-related MFA studies. The fourth section evaluates potential policy measures and instruments with regard to their likely effects on the distribution of environmental goods and burdens between North and South. The fifth section summarizes the results and gives an outlook to future research need.

3. Relative dematerialization arises from a relative decoupling of growth in GDP from growth in natural-resource use. This causes a declining material intensity of GDP. However, absolute levels of resource use still may grow in a situation of relative dematerialization (Hinterberger, Luks, & Schmidt-Bleek, 1997).

Distribution Issues in North-South Trade: Theoretical Aspects

THE DISTRIBUTION OF ECONOMIC BENEFITS

The principles of trade theory were laid by Ricardo (1817) in his theory of comparative advantage. The theory assumes that two countries engaging in international trade both have welfare gains when specializing in the production of goods that they produce with relatively lower costs. Explanations on differences in comparative advantages between nations were later given by Heckscher and Ohlin (H-O theory). Their theory is focused on factor proportions to explain relative efficiencies in production. The H-O theory states that a country will export those goods that use the country's most abundant factor (e.g. labor or capital) of production intensively. The win-win situation for all trade partners would result from two premises. First, every country's comparative advantage is considered unique, and its products would therefore find a ready market. Second, international specialization along the lines of comparative advantage would increase efficiency, lower production costs, and thus maximize world product. Accordingly, free trade would stimulate economic growth through an increased division of labor and intensified export production in all countries participating in international trade (World Bank, 2002). The dominating paradigm in international development policy is still based on this standard framework of trade theory. Positive links between free trade, economic development, and poverty eradication in Southern countries are being reemphasized by the World Bank and the World Trade Organization (WTO), which call for a "trade-for-development" agenda to be centered in a new round of talks on global trade liberalization (World Bank, 2001).

A number of objections against the standard trade theory were presented, explaining that trade might not be beneficial for all participating countries, as economic benefits are distributed unequally among the trade partners. Early considerations of economic inequalities caused by unbalanced trade structures can be traced as far back as Adam Smith. He discussed the possibility of exploitation through trade, presenting the example of trade relations between towns and country-side characterized by different levels of wages and of profits (Raffer, 1987). In the late 1940s, representatives of the structuralist school (Prebisch, 1949) presented a theorem on deteriorating terms of trade for primary commodities exporters. On one hand, this deterioration is supposed to result from different income elasticities for Southern versus Northern export products. On the other hand, productivity gains in the North are passed on to workers as higher wages because of the influence of trade unions, whereas in the South, they result in lower prices for exported products.

Thus, the assumption of stable prices for different product groups does not hold. The theory of unequal exchange (Emmanuel, 1972; Raffer, 1987) had considerable influence on the development debate in the 1970s. It is based on Marx's theory of labor value and focuses on differences in wage levels between North and South causing net-losses of surplus value for low-wage countries and thus an unequal distribution of economic benefits in international trade relations.

Other scholars emphasize that the assumption of nonexistent international capital mobility no longer holds in today's world of globalized financial markets (Costanza et al., 1995; Daly, 1993). In such a situation, comparative advantage becomes irrelevant, as capital flows to countries with absolute advantages. Thus, whole world regions might be excluded from international investment flows and dead-locked as absolute losers in the global economic system (Altvater & Mahnkopf, 1996). Another critical perspective holds that standard trade theory of comparative advantages takes a static view on development and assumes constant benefits from specialization. It thus fails to reflect dynamic disadvantages resulting from specialization in economic activities with decreasing marginal returns, low accumulation of human skills, and low spill-over effects from the export sectors to the rest of the economy, which is crucial for achieving balanced economic development (Röpke, 1994). Furthermore, the assumption of a unique comparative advantage of each country participating in international trade is questionable, as many countries in the South simultaneously pushed their specialization in the same primary sectors because of pressures stemming from poverty, debt burden, and standard structural adjustment programs imposed by the International Monetary Fund (IMF) (Raffer & Singer, 2001). Implementation of these adjustment programs led to a situation of oversupply and of general deterioration of prices on primary commodity markets (see also below).

World-systems theorists point out that today's structure of trade relations between different world regions is to a large extent a consequence of the international division of labor, which has developed since the beginning of colonization in the 16th century (Wallerstein, 1974-1989). This international division of labor led to a restructuring of national economies in the South according to the interests of the European colonial powers, transforming them into suppliers of raw materials and of cheap labor and thus creating dependency and underdevelopment for the South (Frank, 1978). According to world-systems theory, this historical process mainly determined the unequal distribution of economic power in today's world system.

Finally, long-term economic development is not automatically achieved by quantitative growth of world market-oriented production but rather determined by successful integration of export-oriented sectors with the other sectors of the domestic economy. Integration allows

exploitation of technological spill-over effects, development of domestic industries for producer goods, and improvement of transport and of communication infrastructure as crucial factors for balanced economic development. (See Senghaas, 1982, for a historical analysis of European development models.)

DISTRIBUTION OF ENVIRONMENTAL GOODS AND BURDENS

Supporters of a policy of further trade liberalization emphasize that free trade would, in addition to economic advantages, also promote environmental sustainability, as economic growth would increase tax revenues that would enable governments to provide more financial resources for environmental protection. These resources could then be used to satisfy the desire for a clean environment, which is supposedly increasing with rising incomes (Bhagwati, 1993). In addition, the institutional capacities to respond to environmental problems in general increase with growth in income per capita (Dasgupta, Mody, Roy, & Wheeler, 1995). Higher environmental pressures stemming from the expansion of economic activities (the "negative scale effect")⁴ would be overcompensated by other effects. First, it is assumed that, especially in so-called underdeveloped countries, rising incomes will reduce the pressures that poverty places on the environment (Adams, 1997). Second, Southern countries would change their economic structures away from activities in the resource-intensive primary sectors toward more environmentally benign services (the "positive structural effect"). Finally, international trade would foster the transfer of clean technologies (waste treatment or water and energy management) from North to South (the "positive technology effect"), which would significantly contribute to the amelioration of environmental quality in so-called underdeveloped regions (OECD, 2000).

However, the functioning of these mechanisms would presuppose effective environmental policies. Such policies would be cost efficient if they included full internalization of external environmental costs⁵ according to the polluter-pays principle and to the definition of property rights for public goods. Given these preconditions, economic growth and liberalization of international trade would improve environmental

4. See, for example, OECD (1994) for a classification of the different environmental effects of trade liberalization.

5. Two concepts dealing with external costs can be distinguished. In theory, the level of levies to be charged can be derived from an estimation of the occurring external costs, and the internalization would guarantee an optimal solution (a so-called external-cost approach). As this optimum is defined in economic terms, it need not represent an environmental optimum as well. Therefore, in practice, policy in general follows a so-called standard-cost approach, in which a given (environmental) standard is to be achieved using economic instruments.

quality: "In short, trade is really not the issue, nor is economic growth. The issue is how to reinvent environmental policies in an ever more integrated world economy so as to ensure that we live within ecological limits" (WTO, 1999, p. 7).

According to this line of arguments, differences in environmental standards across countries are seen as natural, as they reflect different preferences for environmental quality and varying trade-offs between pollution and income, at different levels of income. Therefore, notions that the diversity of pollution standards result in unfair trade or in unfair competition would, *per se*, be illegitimate (Bhagwati, 1997).

Furthermore, the Northern fear that diversity of standards will lead to a race to the bottom as firms migrate toward Southern pollution havens with lax environmental standards, would be unjustified (Wheeler, 2001). Differences in national environmental regulations would have small or negligible effects on transnational companies' (TNCs) decisions on where to locate a production plant, as pollution abatement costs are no more than 1% of production costs for the average industry (WTO, 1999). TNCs would in many cases be forced to comply with international standards by shareholders in the Northern home countries. Finally, TNCs would incur no higher costs when using the same technology as in their home countries as they export standardized technology as a "clean package" to the South (Sprenger, 1997).

However, the WTO also admits that structural changes in the industrial composition could lead to a redistribution of local pollution problems toward countries that have a comparative advantage in industries that are inherently more polluting. The WTO considers it likely that the major share of these countries will be located in the global South. Nevertheless, gains from trade could pay for the necessary abatement costs and still leave a net economic surplus. Thus, "by combining trade and environment reforms one should be able to find ways to raise incomes without compromising the natural environment" (WTO, 1999, p. 34).

Ecological economists tend to be particularly critical of theories concerning the trade-and-environment relationship pursued by supporters of free trade. Some authors argue that free trade provides incentives for increasing externalization of environmental costs to gain competitiveness on the world markets. This would result in a global race to the bottom of environmental (and social) standards (Daly, 1993). However, other authors suggest that free trade would, rather, lead to a polarization of environmental standards between North and South, as the North would increasingly shift pollution-intensive production stages to the South, while maintaining high environmental quality within its own borders (Muradian & Martinez-Alier, 2001b). Furthermore, there is general criticism concerning the assumption of free-trade supporters that welfare gains from trade could pay for all necessary abatement costs to compensate environmental destruction. This view is seen to neglect the

fact of possibly irreversible environmental destruction through economic activities.

Supporters of world-system theory focusing on a historical perspective to analyze international development processes increasingly include the environmental dimension in their observations. As Bunker and Ciccantell (1999) emphasize, the secured and stable access to inexpensive raw materials (be it within or outside the territory) was one central precondition for the ascent of hegemonic powers (be it the Netherlands, Great Britain, or the United States) since the very beginning of capitalist development. The distinctive feature of the capitalist world economy of the last 500 years thus was the systematic expansion of the exploitation of nature via a division of labor on an increasingly global scale. As direct military conquest and defense of resource-rich regions in the periphery became increasingly expensive and insecure, the hegemonic powers sought to establish and to control a trade system that continued the secured access to natural resources but that shifted large shares of the costs, for example, for building up transport infrastructure, to the Southern regions (Bunker & Ciccantell, 1999). Because of the strategic importance of natural resources (especially fossil-energy carriers and metallic raw materials) for the maintenance of industrial processes, their appropriations through international trade could not be, and were not, left only to market forces, but had to be additionally secured through institutional arrangements and backed up by military interventions, if found necessary. Some scholars identify the Bretton Woods institutions (the International Monetary Fund [IMF] and the World Bank) and the WTO as the main institutions that determine the rules of international trade and development according to Northern interests (Altvater, 1992).

Increasing empirical evidence of global environmental problems (climate change, destruction of the ozone layer, desertification, species extinction, etc.) suggests that the present level of resource use does not comply with requirements of environmental sustainability (e.g., WWF, UNEP, Redefining Progress, & the Centre for Sustainability Studies, 2002). Resource flows were identified as one major driving force behind these environmental problems (e.g., Spangenberg, Femia, Hinterberger, & Schütz, 1998). However, the effects of this driving force are parallel but not necessarily proportional to the environmental damages caused, as qualitative characteristics of different materials vary considerably.

The current level of resource use (in terms of material flows, energy consumption, and land appropriation) predominant in the Northern, industrialized countries cannot be generalized to the global level. From this perspective, the traditional development model for the South, which projects that today's still underdeveloped countries will catch up in their industrialization process with the level of Northern countries, completely neglects global environmental constraints. Furthermore, it

conceals the need of Northern countries to develop alternative models of production and consumption, characterized by significantly lower levels of resource use (Schmidt-Bleek, 1994).

Industrialization, in its current form, therefore can be considered a positional good that not all nations and world regions on this planet can get hold of at the same time. Some scholars (e.g., Altvater & Mahnkopf, 1996) emphasize that the development path of catching up in industrial development would be doomed to failure because of the dynamics of the international trade regime. To trigger the process of industrialization, Southern countries would need to import technology from the North, which could either be financed by debt loans or by the export of natural resources. In such a system, the North would obtain from the Southern extracting economies cheap material and energy resources required to maintain their already industrialized systems.

From such a perspective, accumulation processes and economic development have always been closely connected to the appropriation of natural resources from regions outside the accumulation center. As Hornborg (1998a) puts it, "Ecological conditions are implicated in all processes of accumulation ... [and] it would be impossible to understand the global polarization of rich and poor without reference to ecological factors" (p. 170).

In the modern trade system, market prices provide the key to understanding how market institutions organize the net transfer of natural resources to world centers, as they are, to a large extent, the outcome of power and distribution conflicts (Hornborg, 1998b). Low prices for primary commodities allow industrialized countries of the capitalist core to appropriate high amounts of biophysical resources from the peripheral economies in the South while maintaining external trade relations balanced in monetary terms. Thus, what within the system of prices appears as reciprocal and fair exchange masks a biophysical inequality of exchange in which one of the partners has little choice but to exploit and to possibly exhaust his natural resources and to use his environment as a waste dump, whereas the other partner may maintain high environmental quality within its own borders.

Resource Flows in the Global Trade System: Empirical Evidence

In the last 15 years, several approaches have been developed that provide comprehensive information on the relations between socioeconomic activities and resulting environmental pressures in biophysical terms (see Daniels & Moore, 2002, for a recent overview). These methods of physical accounting, in particular MFA (EUROSTAT, 2001), proved to

be appropriate tools to quantify “societal metabolism” (Fischer-Kowalski, 1998). Presently, material flows resulting from international trade are mainly accounted for as direct import and export flows in terms of their weight. In addition to that, some studies also account for material flows, which are not physically imported but were generated abroad to enable the production of the imported goods (so-called indirect flows associated to imports). Also, flows of waste and of emissions can be considered as indirect material flows related to the production of goods (Muradian, O’Connor, & Martinez-Alier, 2002).

Direct physical trade flows inform mainly about the global redistribution of natural resources as direct physical inputs to the socioeconomic systems of countries and world regions. Unequal distribution of natural resources between different world regions in the direct sense occurs when some regions are characterized by a physical import surplus while others face a physical trade deficit (Andersson & Lindroth, 2001). Even if direct physical imports and exports are balanced between trading partners, distribution can still be unequal with regard to indirect flows embodied in traded goods (see below for empirical studies).

To our point of view, physical accounting can serve as a suitable framework for the analysis of environmental distribution issues in international trade relations. However, some important methodological shortcomings should be kept in mind. Despite the large number of existing MFA studies on the national level, data availability concerning resource flows (especially indirect flows) of international trade activities is still very limited. Some trade-related indicators have been proposed, and studies applying them will be presented in the following section. Most MFA indicators on the economy-wide level are highly aggregated and do not allow assessments disaggregated by economic sectors or by products. Another important point is that, in aggregated MFA indicators, qualitative aspects (like the potential for environmental harm) of different types of material flows remains unconsidered. MFA indicators thus can reflect environmental pressures stemming from human activities but do not provide information on specific environmental impacts.

REVIEW OF TRADE-RELATED PHYSICAL ACCOUNTING STUDIES

In MFA studies on the national level, direct physical trade flows between the country under consideration and the rest of the world are assessed. Figure 1 shows empirical examples for selected industrialized and for two Latin American countries.

The four examples of industrialized countries illustrate that in these countries physical imports exceed physical exports, resulting in a physi-

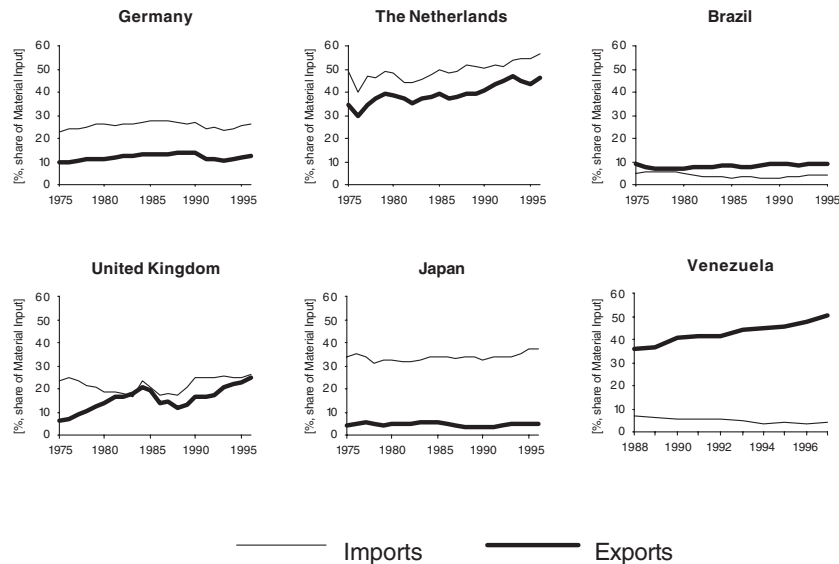


Figure 1: Imports and exports as shares of direct material input for selected industrialized and Southern countries, 1975 to 1995 (Venezuela 1988 to 1997).

Source: Fischer-Kowalski and Amann (2001).

cal trade surplus.⁶ Densely populated countries with a scarce endowment of natural resources are, in particular, dependent on resource imports from abroad. In the case of Japan, most resources are consumed domestically by the Japanese socioeconomic system. In the case of the Netherlands, a large fraction of its high physical imports is reexported to other European Union countries (which can be explained by the importance of Rotterdam, the Netherlands, as the biggest harbor of the European Union). Several years with negative economic growth rates between 1976 and 1984 caused the significant decline of the United Kingdom's physical imports and (with a time lag of several years) of its physical exports, before an economic upturn was observed toward the end of the 1980s.

The examples of Brazil and of Venezuela illustrate that these countries are net exporters of natural resources. Because of its high exports of fossil fuels, the difference between physical imports and exports is particularly remarkable for Venezuela.

6. Note that the calculation of physical trade balances is done by subtracting exports from imports, in reverse to monetary trade balances. Deficit in this context refers to the net loss of biophysical resources.

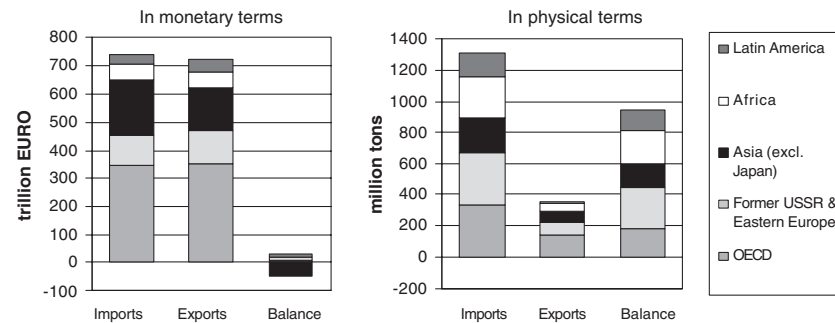


Figure 2: External trade relations of the EU-15 in monetary and physical units, 1999.
Source: Giljum and Hubacek (2001).

A more detailed picture concerning the international distribution of resource flows can be obtained when physical trade data is disaggregated by world regions. Taking the example of an industrialized region, Figure 2 presents the external trade relations of the European Union (EU-15) in monetary (left) and physical (right) units in 1999.

The figure clearly illustrates the significant structural differences of the external trade relations in monetary and in physical terms, respectively. Whereas the monetary trade is more or less balanced (apart from a small deficit with Asian countries), the physical trade is characterized by a large trade unbalance (imports in tons exceeding four times exports in tons) with all other world regions, including the non-EU OECD countries. This is mainly because of the high import of fossil fuels (around 60% of all imports in terms of weight) and because of nonrenewable raw materials and of semimanufactured products (together around 20% of all imports). The EU serves as a net exporter of crops and of animal products to Africa, Asia, and the former USSR and Eastern Europe. However, as physical amounts of exports are much smaller than imports in the two categories mentioned above, they do not compensate for the physical surplus. More than two thirds of physical imports originate in countries outside the OECD region, whereas OECD countries are, to a larger share, the destination of EU exports. On the average, EU-15 exports have a money value of 4 times that of imports. With regard to trade relations with Southern regions such as Africa and Latin America, one ton of EU exports embodies a money value 10 times higher than one ton of EU imports (Giljum & Hubacek, 2001).

So far, only a few physical trade balances have been calculated from MFA data for Southern countries. For Latin American countries, there seems to be a general tendency toward a growing physical trade deficit, as Figure 3 illustrates.

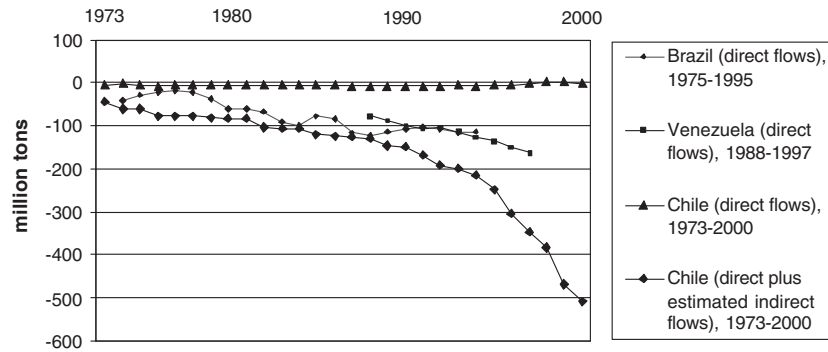


Figure 3: Physical trade deficits for Brazil, Venezuela, and Chile.

Source: Machado (2001), for Brazil; Castellano (2001), for Venezuela; Giljum (in press), for Chile.

The physical trade deficit of direct import and export flows significantly increased for Venezuela, mainly because of rapidly growing exports of petroleum. The same general trend is observed for Brazil, which is exporting both biomass products and minerals (particularly iron and steel). The physical-trade deficit of direct material flows is much smaller for Chile, as imports (mainly fossil fuels) also significantly increased over the last 30 years. However, a first estimation of indirect flows associated with imported and exported products of Chile revealed that a large physical deficit with regard to these “hidden” resource flows can be observed, which mainly reflects the high material requirements of copper mining and refining (Giljum, in press).⁷ This calculation shows that, for evaluating environmental consequences of international trade activities, it is not sufficient to consider only direct import and export flows. An assessment of indirect material inputs, which end as wastes and emissions of the refining process in the country of extraction, provides important additional information, especially for extracting economies in the South.⁸

Other studies on the level of single materials or of material groups investigated the physical trade balances of the three industrialized regions (the United States, the EU, and Japan) with regard to the most important ores and semiprocessed metals. Results show that for almost all metallic raw materials a trade deficit can be observed, most notably

7. In the case of copper production, these flows are huge amounts of waste material, which had been treated with acid solvents and with other environmentally harmful substances in the course of the refining process.

8. It must be stated, however, that data quality concerning indirect material flows so far still is very low and cannot be compared with the quality regarding direct material flows.

Table 1
Change in South-North Trade Flows of
Nonrenewable Resources in Weight Units and in Prices Between
1971 and 1976 and Between 1991 and 1996 (5-year average numbers)

<i>Item</i>	<i>Change in Weight (%)</i>	<i>Change in Price (%)</i> <i>(constant U.S. \$ 1987)^a</i>
Aluminum	660	-12
Pig iron	306	-26
Iron and steel shapes	238	-31
Petroleum products	230	-21
Nickel	196	-22
Gas (natural and manufactured)	128	10
Zinc	87	-35
Copper ores	70	-52
Copper alloys	32	-35
Bauxite	30	71
Tin	12	-63
Lead	9	-46
Zinc	8	-45
Nickel	-3	-46
Iron	-10	-32
Lead	10	-34
Crude petroleum	-12	-10

Source: Muradian and Martinez-Alier (2001b).

a. Numbers are deflated to eliminate changes caused by inflation.

for iron, aluminum, and bauxite (Muradian & Martinez-Alier, 2001a). Moreover, the North, in general, increased its imports of most metallic resources from the South during the last 30 years, as Table 1 illustrates.

For 14 of the 18 analyzed resources, physical exports from South to North increased for some raw materials of strategic importance for economic performance, such as fossil fuels, iron, and aluminum, with growth rates of more than 200%. At the same time, prices decreased for 16 of the 18 materials in the range of 10% to 63%. This implies that, compared to the 1970s, the South had to export higher quantities of these nonrenewable resources to generate one unit of export revenue in the 1990s.

Also, with regard to energy use, global inequalities significantly increased in the last 50 years, as Podobnik (2002) showed in a comparative study on the production and consumption of fossil energy in the North and the South for the past 150 years (see Figure 4).

At the end of World War II, the industrialized countries were almost totally self-sufficient in fossil energy supply. From the 1950s on, the South has increasingly served as supplier of fossil fuels for the North.

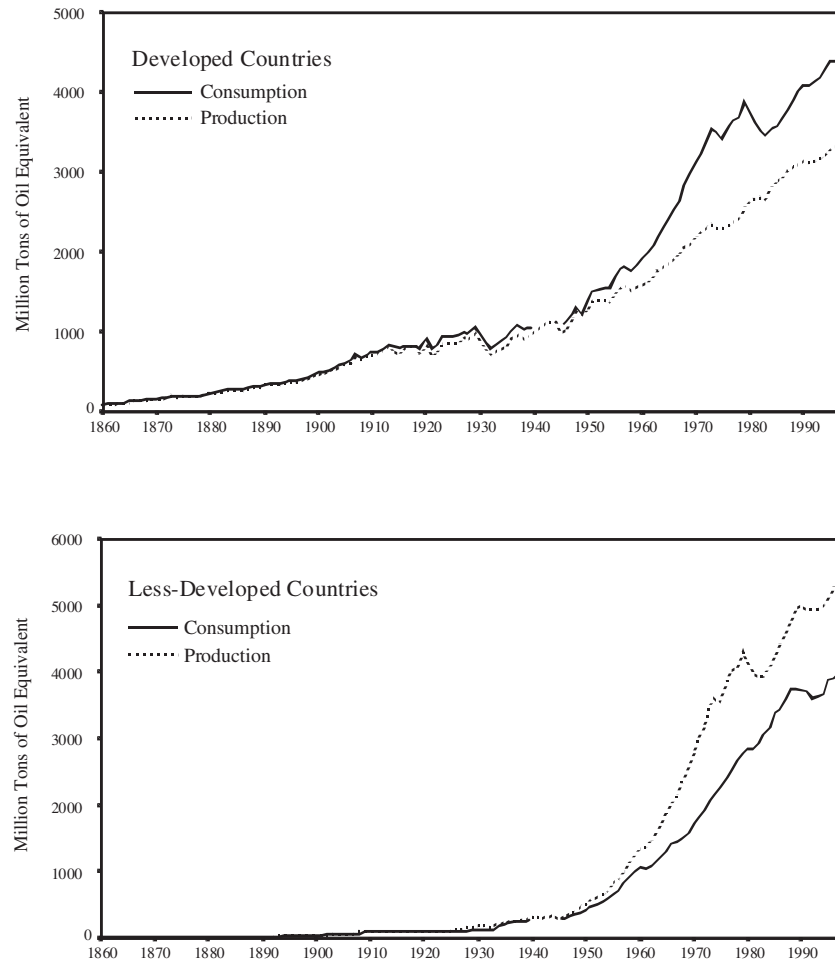


Figure 4: Commercial production and consumption of fossil energy in developed and in less developed countries, 1860-1998.

Source: Podobnik (2002).

Although exploiting and exporting fossil-fuel resources has brought exceptional economic growth for some countries, the implications for the environment are very different among the group of oil extractors. Environmental impacts differ substantially depending on the ecosystem conditions of extraction activities (i.e., if extraction takes place in the deserts of Saudi Arabia or Libya or in the wetlands of Nigeria and Venezuela).

Recently, a number of empirical studies have dedicated attention to the so-called pollution haven hypothesis. This hypothesis assumes a migration of pollution-intensive industries from North to South because of more stringent environmental regulations in the industrialized countries (Mani & Wheeler, 1998). Only a small number of investigations based their analyses on physical trade-flow data. Most notably, Muradian et al. (2002) investigated the emissions embodied in physical imports and exports between the three industrialized core regions (the United States, Western Europe, and Japan) and Southern countries between 1976 and 1994. They found that embodied emissions in products imported by Northern countries from the South were generally higher than in products sold by the North. This gives evidence for a displacement of environmental load from North to South through international trade activities. The authors also calculated "environmental terms of trade (ETT)" between North and South, defined as environmental pressures associated with Northern exports in relation to environmental pressures associated with imports from the South (p. 56). ETT were deteriorating for the United States, meaning that embodied pollution of U.S. products traded with the South increased over time for almost all pollutants. In the same time period, ETT improved slightly for Western Europe and significantly for Japan, reflecting structural changes of the Japanese export economy within the last 25 years away from pollution-intensive activities (Mani & Wheeler, 1998).

Other authors applied input-output analyses based on hybrid input-output tables, containing information in both monetary and physical units, for the analysis of emissions generated by export-related production. Machado, Schaeffer, and Worrell (2001) used such a model to calculate energy and carbon embodied in the international trade of Brazil. Results revealed that Brazil (in parallel to direct material flows, [see Figure 3]) is also a net exporter of energy and of carbon embodied in internationally traded products. In 1995, each dollar earned with exports embodied 40% more energy and 56% more carbon than each dollar spent on imports.

DISCUSSION OF EMPIRICAL STUDIES

Empirical studies in material flow accounting presented above portend a tendency toward an unequal distribution of environmental goods and burdens between the different world regions through international trade. Although a number of studies exist that investigated direct resource flows in North-South trade, data availability concerning indirect flows, embodied resource requirements, and emissions based on biophysical assessments is still very limited.

In the international trade system, industrialized countries are, in general, physical net importers of natural resources from other world

regions. For some material categories (like fossil fuels and basic metal products), a clear tendency toward an increasing physical trade surplus (imports higher than exports) can be observed. Although in many industrialized countries a process of relative dematerialization is taking place (Adriaanse et al., 1997), South-North resource flows maintain or even increase their importance. The fact that not all nations can be net importers of natural resources at the same time is completely missed by the argumentation of free-trade supporters (Daly, 2000). But rising net imports of the North are only possible if the South serves as a supplier of biophysical resources. First analyses of physical trade flows for Southern countries revealed that, in these world regions, physical trade deficits (exports higher than imports) because of increased exports of resource-intensive products were growing in the past decades. In contrast to the situation in industrialized countries, resource extraction is growing faster than GDP in countries such as Brazil, Venezuela, and Chile (Fischer-Kowalski & Amann, 2001; Giljum, in press). These findings seem to support the hypothesis of world-systems theory that economies of the capitalist core ensure access to natural resources from regions in the global periphery through international trade. However, data is available only for a very limited number of Southern countries, and thus, much more empirical evidence is needed to derive general trends.

From the perspective of environmental sustainability, a specialization of some regions on primary activities cannot be disapproved in principle, as some regions produce some goods (e.g., agricultural products) with lower energy, material, or land input than do other regions. To some extent, therefore, a specialization makes sense also from an environmental perspective.⁹ However, economic activities in the primary sector are in many cases characterized by higher environmental loads as compared to other sectors (e.g., Mani & Wheeler, 1998; UNEP, 1999). An international division of labor, in which primary activities are increasingly concentrated in the South, thus leads to an unequal distribution of environmental burdens, such as high material, energy, and land intensities in primary sectors and the accumulation of hazardous wastes or emissions in countries specialized in metal mining and processing.

Furthermore, according to some authors, many primary commodities (such as minerals or agricultural products) are traded on the world markets at prices that do not fully reflect the amount of environmental and social costs occurring in the course of mining and producing (Cabeza-Gutés & Martinez-Alier, 2001). Occurrence of external environmental costs is closely linked to physical transformation processes, which can be depicted, for example, through MFA. In particular, so-called unused

9. A major environmental problem resulting from economic specialization is increasing transportation of goods (OECD, 2002). However, in this article, we do not deal with this aspect of international trade.

domestic extraction causes environmental costs, which are not reflected in market prices and which can therefore be addressed as physical externalities (Hinterberger, Renn, & Schütz, 1999).

The tendency to not internalize costs is put forward as a strong argument against the theory of free-trade supporters, who assume an optimization of resource allocation through international specialization. If production prices do not reflect the actual costs, less restricted trade may lead to a more inefficient allocation of resources when countries or whole world regions specialize in activities, which, in fact, decrease welfare, as total costs of production exceed export revenues (Costanza et al, 1995; Neumayer, 2001). The exchange of goods between different world regions, therefore, can be unequal considering not only the direct and the indirect physical flows, but also with respect to environmental and social costs (Cabeza-Gutés & Martinez-Alier, 2001).

International trade opens the possibility for industrialized countries to maintain or even increase the regional or national environmental quality without changes in the resource intensity of the population's increasing consumption. The fact that negative environmental impacts of the production of goods can be shifted to other world regions and that so-called "clean" final products are imported instead of being produced within the home territory highlights the necessity to fully include trade aspects in the evaluation of so-called environmental Kuznets curves¹⁰ in the North (Tisdell, 2001).

An evaluation of North-South trade from the viewpoint of sustainable development also requires a profound analysis of the implications of global integration processes for socioeconomic development. Integrated quantitative trade assessments linking MFA data with social and economic indicators have not been carried out so far. However, comparative data on monetary versus biophysical flows in North-South trade presented above suggest that Southern exports have a significantly lower and, concerning at least some raw-material groups, declining value per physical unit than Northern exports. The general downward trend of prices for primary commodities is also expected to continue in the long run (World Bank, 2001). Considering the limited power of Southern countries on world markets and considering the falling prices for primary commodities, revenues in many cases can be maintained only through an increase of physical export volumes, a well-documented dynamic for Latin American countries (Muradian & Martinez-Alier, 2001a). The low price levels of natural resources allow the maintenance of high levels of resource consumption in the North and

10. The environmental-Kuznets-curve hypothesis postulates a correlation in the shape of an inverted U between economic affluence and negative environmental consequences.

lead to environmental destruction and the maintenance of unsustainable exploitation patterns in the South (Arden-Clarke, 1992).

Policy Options

A large number of policy measures and instruments for reforming the international trade system toward (environmental) sustainability have been suggested by researchers, politicians, and NGOs. The most prominent measures are presented in this section, and their likely effects on environmental distribution are discussed.

From a material-flow perspective, the central goal for a reform of world trade toward (environmental) sustainability is a reduction of international physical trade flows as part of a more comprehensive strategy toward absolute dematerialization¹¹ of all economic activities (Hinterberger, Luks, & Schmidt-Bleek, 1997). Under this goal, the Northern countries, especially, are challenged to drastically reduce their share in the use of global natural resources. However, decreasing Northern demand for natural resources will show negative economic implications for extracting economies in the South if no additional policy measures are taken to compensate for these negative effects. Therefore, dematerialization should be implemented as a global strategy, combining resource-use reductions in the North with structural change toward production of exports with higher value in the South (see below). Along with other measures to redistribute financial resources from North to South (such as debt-relief programs), this strategy could open up new development perspectives for Southern countries and enable the construction of diversified and more stable economies there (Sachs & Agarwal, 2002).

So far, the South has been very skeptical about integrating environmental issues into trade negotiations, most of all because Southern governments fear that environmental standards might be used as new trade barriers by the North (so-called "green" protectionism) and that environmental concerns might distract from more pressing developmental needs. However, according to some Southern scholars, these countries would be better advised to take a positive and proactive attitude toward linking trade and environment issues and to not leave this debate subject to Northern interests only. They also should aim at integrating the trade-and-environment debate into the broader discourse on sustainable development, focusing on the links between trade and poverty alleviation and social and environmental justice (Najam, 2000).

11. Absolute dematerialization is achieved when the use of natural resources, and thus the generation of waste and of emissions, is reduced in absolute terms.

COMPENSATION OF UNACCOUNTED-FOR COSTS

Both free-trade supporters and supporters of a reform of the current trade regime emphasize the importance of considering environmental (and social) costs, which are not included in the price of traded goods. As explained above, this issue is especially relevant for Southern extracting economies. Tariffs to be levied in the North and repaid to the South are suggested as one possible approach of how to compensate for these external costs (Arden-Clarke, 1992). Another suggestion is to implement a so-called "natural capital depletion tax" at the point of extraction to compensate for natural capital losses to increase export prices and to fulfill the conditions of weak sustainability¹² (Costanza, Cumberland, Daly, Goodland, & Norgaard, 1997; Muradian & Martinez-Alier, 2001b). Fair-trade and alternative-trade initiatives directly link Northern consumers to Southern producers. As they offer products at prices that are higher than world market averages, they also include a compensation for incurred external environmental (and social) costs (LeClair, 2002).

From a biophysical perspective, these approaches are likely to have environmentally positive effects in the North, as higher prices for natural resources would stimulate technological change toward a more efficient use of natural resources. However, in the Southern extracting economies, higher prices could set incentives for increased exploitation of natural resources. These incentives could be reduced if the redistribution of higher tax revenues would be directed toward investments in education, health, and infrastructure, instead of supporting intensification of natural-resource extracting activities.

Negative environmental consequences could also be balanced by raising extraction costs (see above), by implementing social and environmental standards, or by imposing regeneration costs (e.g., for landscapes destroyed by mining) on the operators.

The implementation of a strategy of absolute dematerialization would lead to radical changes of economic structures in both North and South and to price changes on international commodity markets. It would have to be reevaluated under these new framework conditions which instrument (or set of instruments) would be best suited to provide an effective compensation of unaccounted-for costs.

REMOVAL OF SO-CALLED PERVERSE SUBSIDIES

The removal of subsidies, which are at the same time economically distorting and environmentally destructive (therefore *perverse* subsidies), is another central point in the reform of the world trade system

12. Weak sustainability assumes substitutability between natural and man-made capital. According to this concept, sustainability is achieved if the aggregated capital stock of natural and of man-made capital is not decreasing.

(Neumayer, 2001). The most commonly cited examples are export subsidies for large-scale agricultural production (mainly in the United States and in the EU), forestry and fishery activities, and subsidies in the energy and transport sectors. All of these subsidies have a tremendous impact on the dynamics of the trade system (van Beers & van den Bergh, 2001). Subsidies on fossil fuels, in particular, have a stimulating effect on the intensity of world trade and contribute to the maintenance of unsustainable consumption levels of natural resources (von Weizsäcker et al., 1995). If the transport sector would actually bear all costs (including health casualties, noise pollution, and environmental damage caused by intensive use of resources, energy, and land), air freight transport would likely be radically reduced and road transport limited, whereas other transport modes, such as marine shipping and railway transport, would gain in competitiveness.

Removal of these subsidies should trigger structural changes according to social and to environmental criteria (Spangenberg, Omann, & Hinterberger, 2002) and should support current marginalized activities, such as alternative-energy use, clean and small-scale production, and sustainable agriculture (Sachs & Agarwal, 2002).

ABOLISHING SOUTHERN DISCRIMINATION THROUGH TARIFFS AND THROUGH OTHER TRADE BARRIERS

Despite its free-trade rhetoric, the North still maintains a strategy of double standards toward the South. Although requirements of structural adjustment programs force Southern countries to rapidly open their economies, sectors of key interest for the North (such as textiles and agriculture) are still heavily protected by high tariff barriers (Raffer & Singer, 2001). On average, import tariffs on Southern products are four times those of exports from North to South (Oxfam, 2002). According to estimates from the World Bank, Southern countries lose incomes of more than U.S. \$100 billion annually because of these protective measures (World Bank, 2002).¹³

If the industrialized countries in fact would intend to pursue a trade-driven strategy of development and of poverty alleviation, the primary measure would have to be the abolishment of discrimination of Southern export products in market access and the establishment of a fair and internationally balanced tariff system.

Although the positive economic consequences of such a reform for Southern countries could hardly be questioned, the environmental (and social) implications are less clear. In the short run, free access to North-

13. However, these economic gains could be fully realized in Southern countries only if multinational enterprises would be obliged to reinvest in the domestic economy instead of retransferring profits to their headquarters in the North.

ern markets would probably set incentives for specialization in primary sectors if no additional measures as part of a long-term development strategy (see below) are taken. This could increase export volumes, especially for agricultural products, and South-North resource flows. Thus, further losses of natural resources in the South and an increased inequality in terms of resource consumption could be the unintended consequence.

A removal of trade barriers in Northern agricultural sectors could further support an exports-first policy in the South. This policy stands at odds with a food-first policy, as it favors large farmers and transnational companies producing for export demand over small-scale farmers, which mainly deliver to local markets. Therefore, not unconditional market access should be the overall goal, with the institution of a whole range of fair-trade arrangements, including preferential treatment for small producers and sustainable products at cost-covering prices (Sachs & Agarwal, 2002).

STRUCTURAL CHANGE TOWARD MANUFACTURING AND SERVICES

According to many scholars, the crucial goal for Southern countries is the reduction of dependence on primary commodity exports and the diversification of economic structures. This would provide more production links to other economic sectors, support the accumulation of technological capacities and of human skills, and reduce negative environmental impacts (Economic Commission for Latin American and the Caribbean, 2002). Furthermore, structural change would significantly diminish economic vulnerability resulting from specialization in a small portfolio of export products.

Encouraging processing of natural resources in the South (so-called vertical diversification) would at the same time increase the added value of exports and reduce the negative impacts of price fluctuations on world markets for primary commodities. This would enable Southern economies to reduce extraction rates of natural resources and thus decrease pressures on the domestic environment. Simultaneously, so-called horizontal diversification should be initiated to build up other, less resource-intensive sectors. Active investment in education and in training to foster the acquisition of skills in the labor force is one central measure to shift comparative advantages away from unprocessed to processed primary production and, later on, from primary production to manufacturing, which, on average, is more skill intensive than activities in the primary sectors (Wood, 1999). Supporting structural change would also be a proactive strategy to avoid economic crisis in case of falling demand for natural resources, which could emerge as a consequence of Northern dematerialization efforts.

However important such a development vision might be, a number of obstacles toward its realization can be identified. First of all, severe financial restraints for investing in education and skill acquisition to trigger structural change can be observed. The international debt regime, discriminative trade measures, and declining prices for primary commodity exports all contribute to this situation. Another factor impeding diversification of export sectors is that extraction activities very often are controlled by Northern-based multinationals operating according to interests of owners and stakeholders of industrialized countries (Altwater & Mahnkopf, 1996). Transfer pricing in intrafirm trade is a common practice to repatriate profits to Northern headquarters, a practice that further diminishes Southern incomes from extraction activities. Finally, it has to be emphasized that efficient political institutions in the South are also of crucial importance for the success of a strategy of structural change. Often, politicians pursue their own interests through rent seeking and luxury consumption instead of investing in infrastructure and in human capital (Murshed, 2002).

Two alternative strategies to the standard export-oriented development model as promoted by the IMF, World Bank, and WTO could support Southern efforts toward structural change. First, a selective and temporary dissociation from world markets, along with active governmental support of young national industries through protection tariffs and the concession of tax abatements and of export subsidies should be attempted. This strategy was successfully implemented by the so-called "tiger" economies in East and Southeast Asia and significantly augmented the share of manufactured products in total exports (Raffer & Singer, 2001). A second alternative would be the promotion of regional trade agreements in the South. Integration of countries with small differences in productivities and economic power would likely facilitate more balanced exchange relations between the trading partners than are currently in place on global commodity markets.

Conclusions and Outlook to Further Research

The objective of this article was to analyze the distribution of environmental goods and burdens through North-South trade from a biophysical perspective. Physical accounting methods have a strong potential to highlight consequences for societal metabolism and thus for the environment, resulting from specialization processes through the international division of labor and liberalization of world trade.

The free-trade paradigm neither assumes nor explains the emergence of unequal distribution patterns of environmental costs and benefits

from world trade. However, physical accounting studies reviewed in this article suggest that increased global trade tends to cause redistribution between North and South with respect to the consumption of natural resources on one hand and negative environmental impacts of resource extraction and production processes on the other. Although North-South trade might account for only a small fraction of world trade from a monetary perspective, the physical perspective reveals that the North is a substantial and (at least for some material groups) increasing net importer of natural resources from the South. Especially for the South, specialization patterns with economic activities concentrating on resource-intensive primary sectors cause severe environmental problems and a substantial loss of natural capital while creating a limited number of jobs and contributing little to the development of a diversified economy.

However, because of the small number of empirical studies carried out so far, comprehensive conclusions cannot be taken at this stage. They require substantial future research efforts, which should be directed toward three main areas.

First, research should focus on the improvement of the data situation. More empirical physical accounting studies assessing resource flows in international trade and resource requirements in export-related production in both the North and the South are needed to identify general patterns and trends.

Second, the elaboration of more specific trade-related material flow-based indicators is one of the central challenges for the MFA community. In particular, biophysical indicators should be disaggregated by products and by economic sectors to reflect structural changes; they should assess the environmental performance of export sectors and estimate the environmental implications of sectoral shifts. Also, more detailed information on the links between environmental pressures (expressed as material-flow data) and actual local or regional environmental impacts is needed.

From the viewpoint of sustainable development, the most important research task for the future is the carrying out of integrated environmental-economic-social analyses to assess the links between specific metabolic profiles of countries and world regions and their socioeconomic performances and their potentials for development. In particular, assessments of structural changes and of accumulation processes in the North and South, both in physical and in monetary terms, could demonstrate development implications of specialization in the global economic system.

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