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Globalisation, transport and the environment: new perspectives for ecological economics

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Abstract

This article aims to offer an overview of key issues centred around the relationship between globalisation and transport-related environmental decay in the ecological economics literature of the past decade, followed by an exploration of new research endeavours. The scientific contribution of 10 years of *Ecological Economics* to issues of environmental sustainability in relation to international trade and transport is certainly not impressive. Hence, also contributions from other environmental economics journals are considered. Two themes which apparently have received less attention in the ecological economics literature are addressed, namely (1) the influence of global trade on the environment and (2) the environmental effects of international transport induced by trade. The total effect of globalisation and transportation on the environment originates from complex changes in the scale, structural, technological and product effects of our industrial system. Various conflicts between global trade/transportation and the environment are pointed out on the basis of these four effects. The paper argues that the net effects of these changes are still uncertain. Ecological economics, however, should contribute to the challenging task of analysing more thoroughly the effects of global trade and transport on the environment. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

Global change has become a fashionable word in scientific debates on long-range structural transformations in the earth's ecology. *Ecological*

Economics has in the past decade played a major role in the scientific awareness discussion in this area. Nevertheless, several gaps in scientific knowledge can be observed, in particular in regard to the intricate linkages between globalisation, trade and transport, and environmental decay.

Globalisation is at present a 'vogue' word that refers to opening up and increasing internationali-

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sation of markets, worldwide communication and mobility, changing consumption patterns and lifestyles, key positions of multinational firms in world markets, and shifting of industrial activities all over the world. Driving forces of this megatrend are, *inter alia*, the liberalisation of international trade, the rise of new consumer markets, technological developments in the field of telecommunications and a decrease in (generalised) transportation costs. All these structural changes are likely to have an impact on environmental practices and conditions in all regions of the world. It is remarkable, however, that most globalisation studies devote only attention to the economic and social consequences of changing production and consumption patterns (Van Esch, 1994; Van der Zwet, 1995; Castells, 1996) and much less attention to the trade- and transport-related environmental consequences of globalisation.

Clearly, globalisation may have a great variety of environmental impacts, both locally and globally. These changes have been extensively mapped out in numerous global change and climate change studies published also in the ecological economics literature. In the present contribution we will limit ourselves to those environmental consequences that arise mainly as a result of shifts in trade and transportation patterns associated with modern globalisation tendencies. This appears to be a much less explored area. Because transport is largely a 'derived demand', international transportation flows depends mainly on the size of international trade flows and shifts in internationally operating business. Current trends indicate a steady growth in international trade flows and international transport (see OECD, 1992). The emergence of new markets, sectors and new forms of competition results in an increase of trade and foreign direct investment. The general trend in international transport is clearly a growth in volume and distance and a modal shift to less environmentally friendly modes. If these trends continue, CO₂ emissions caused by transport will lead to increasingly unsustainable outcomes. We refer for a wide variety of statistical background data to Nijkamp et al. (1998).

In this article, we focus on two fascinating issues which are most relevant to the discussion of globalisation: transport and the environment. First, what are the environmental effects of globalisation and trade? A conceptual framework developed by the OECD is used, by making a distinction between scale, structural, technological and product effects (Jones, 1997). Second, what are the environmental effects of international transport induced by globalisation? The consequences of globalisation for the transport sector are again described in terms of the previously mentioned scale, structural, technological and product effects.

This paper will address in particular the effects of trade liberalisation on transport volumes and the environment. The implications of environmental policy on trade, transport and the environment form a different and largely neglected issue and will only be touched upon in passing. In our contribution, only the effects of globalisation on freight transport will be considered, though it ought to be recognised that globalisation may also lead to an increase in passenger transport (e.g. international tourism and global business travel).

The outline of our article is as follows. In Section 2, main trends in globalisation, trade and transport, and the environment are summarised. Section 3 deals with the environmental effects of globalisation by using the above-mentioned conceptual framework of the OECD. Subsequently, Sections 4–7 consider successively the scale, structural, technological and product effects of globalisation and transportation in relation to the environment. Finally, in Section 8 various new analytical challenges for ecological economics are raised and discussed.

2. Trends in globalisation, trade and transport

Current industrial economic trends show a persistent growth in trade flows and in transportation, not only locally but also worldwide. The increasing volumes of goods and persons will, without effective counter-measures, lead to severe environmental degradation (for extensive empiri-

cal information, see Nijkamp et al. (1998). In the following, some important megatrends, which offer a broad scope for the globalisation–transportation question, are concisely presented.

2.1. Liberalisation of trade and finance

A main driving force behind the globalisation of the economy is clearly the liberalisation of trade and finance all over the world, instigated also by the World Trade Organisation (WTO). Recent political-economic transformations reflect drastic changes in the world economy. In the past decades, many countries have adopted more market-based and open economic systems, needed for the increasing liberalisation of trade and finance. A wide range of countries has adopted free market principles, which has spurred their economic growth and integration into the global economy (OECD, 1997b). Many countries have lowered their barriers to the import of goods, services and capital. These sharp cuts in both tariffs and in non-tariff barriers have significantly stimulated international trade.

2.2. Increase in international trade

An indicator for the economic growth effects of globalisation is the fact that international trade has risen at a steady pace in the past decades. World exports as a percentage of GDP have risen from 7% in 1950 to about 14% in 1992 (OECD, 1997b). In particular, the high increase of trade ratios for East Asia and Latin America and the Caribbean during the last decade has been remarkable. Furthermore, the steep increase in foreign direct investment in high-income countries also underscores the fact that these countries, already the most integrated, are continuing to deepen their interaction with the world economy. In the rapidly growing economies in Asia (Southeast Asia and China) an investment boom has occurred in the 1990s (OECD, 1996), although the Asian crisis has recently tempered the accelerated growth in this region.

2.3. Participation of new countries and sectors in the world economy

The world economy has also witnessed structural changes as a result of globalisation. The emergence of new countries and sectors participating in the world economy makes the present globalisation trend different from former internationalisation patterns. An increasing part of the world and a rising number of independent countries are participating in the world economy—e.g. the emerging economies of Asia and Latin America (Courier, 1997). Furthermore, the internationalisation of the industry has evolved from plain export and import strategies to more complex industrial linkages. To compete globally, firms interact on a global scale through a wide range of external alliances such as joint ventures, subcontracting, licensing and interfirm agreements (OECD, 1992). Finally, globalisation has evolved from global competition in labour-intensive sectors to competition in capital-intensive and service sectors. Sectors that are most commonly involved in this global competition include the automotive sector, as well as high technology sectors such as electronics, aerospace, telecommunications and computers. Nowadays globalisation also affects the service sector, including the financial sector, transportation and the media sector (see Van Esch, 1994).

2.4. Reduction in the cost of transportation and telecommunication

International linkages have been reinforced as a consequence of globalisation. New information and transportation technologies have reduced transportation, telecommunication and computation cost (for some illustrations see Table 1).

As a result, economic distances have shrunk and coordination problems have diminished to such an extent that in many cases it has become an efficient industrial organisation strategy for a firm to locate different phases of production in different parts of the world (see also IMF, 1997). These communications technologies are helping to overcome the barriers of physical distance and are therefore both an important driving force and a

consequence of modern globalisation (see also Castells, 1996).

2.5. Rise in environmental problems of international transport

The rise in worldwide trade and the increasing interaction between countries previously separated by trade barriers have spurred a significant increase in transportation flows at all geographical levels. This has caused a wide variety of environmental externalities, ranging from ecological footprint problems to global pollution. Thus, a pressing problem of globalisation is formed by environmental decay caused by the rise in international transportation. Due to an increase in international trade, changes in firm strategies and a global convergence of consumption patterns, the need for international transport is clearly and steadily increasing (see Nijkamp et al., 1998). In general, the transport sector is a significant contributor to local air pollution, noise annoyance, intrusion of landscapes, congestion and high fatality rates. Transport also damages the global environment. It is contributing to two prominent global environmental problems, namely, the greenhouse effect (global warming) and the depletion of the ozone layer. The World Bank (1996b) expects that if current trends continue, CO₂ emissions caused by transport will significantly increase by the year 2010. The increase in CO₂ emissions caused by transport will be the highest for Central and Eastern Europe and the former Soviet Union, China and centrally planned Asia

and other developing countries (although various Asian countries are at present trying to reduce the environmental externalities of transport).

The above trends indicate that international transport induced by globalisation will most likely rise considerably in the next decades, resulting in severe environmental problems. Because the transport sector is interrelated with all aspects of human life as a 'derived demand', it seems that it does not make sense to study transportation issues separately. The transport sector is interrelated with changes in international trade patterns, lifestyles and location choices of multinational firms. The worldwide liberalisation trends have undoubtedly created the political-economic conditions for the globalisation of our economies. These globalisation trends may have large impacts on the international trade and transport system and on the environmental effects of increased international transport. This issue will be further discussed in the next section.

3. Environmental impacts of globalisation

The liberalisation of trade and finance in the post-war period is an important driving force behind globalisation. Since its inception in 1947, the General Agreement on Tariffs and Trade (GATT), has prompted a systematic removal of barriers in pursuit of a system of free trade. By liberalising trade, the GATT promotes open competition between member countries. Although a system of regulation-free trade is not yet a reality,

Table 1

Costs of air transportation, costs of telephone calls and computer price deflator (in 1990 US dollars unless otherwise indicated)^a

Year	Average air transportation revenue per passenger mile	Cost of a 3-min call, New York to London	US Department of Commerce computer price deflator (= 1000 for 1990)
1930	0.68	244.65	–
1940	0.46	188.51	–
1950	0.30	53.20	–
1960	0.24	45.86	125,000
1970	0.16	31.58	19,474
1980	0.10	4.80	3,620
1990	0.11	3.32	1,000

^a Source: IMF (1997).

it is clear that current negotiations are, probably irreversibly, pointing in this direction (De Bellevue et al., 1994).

The current debate on the environmental effects of globalisation is particularly concerned with the question whether a worldwide liberalisation of trade may aggravate environmental degradation. Three major environmental concerns related to trade are: (1) domestic environmental effects caused by the consumption of imported products, (2) foreign environmental effects caused by the production of export goods (e.g. tropical timber), and (3) environmental effects caused by transport movements needed for international trade. Seen from a policy perspective, generally, two ideological viewpoints on the problem can be distinguished, namely, the viewpoints of advocates of free trade and of the environmentalists (Esty, 1994).

Advocates of free trade tend to argue that, according to standard welfare economics, free trade will avoid the efficiency losses associated with protection; it will reinforce economies of scale, and entrepreneurs are provided with an incentive to seek new ways to export or compete with imports, a situation which offers more opportunities for learning and innovation (Krugman and Obstfeld, 1994). International trade will lead to a Pareto-optimal situation under the assumption of a well-functioning market mechanism. In accordance with these theoretical findings, the general belief is that trade liberalisation will likely have a positive effect on the environment by making the allocation of resources more efficient, promoting economic growth, and increasing general welfare. The debate on the environmental Kuznets curve is an illustration of this view (see, for example, De Bruijn and Opschoor, 1997).

A necessary implication of the above argument is that environmental policies are adopted and implemented. Under a free trade regime, when natural resources are correctly priced, output is produced against the lowest environmental cost globally (Adams, 1997). However, in practice two types of a broad-based failure of environmental policy-making exist. First, there is an economic failure to internalise environmental costs and to make consumers and producers pay the full price

for the environmental harm they cause. Second, we observe a political failure by incorrectly pricing natural resources for which an international market exists. Advocates of free trade believe that trade policy goals and environmental policy needs can be largely compatible by ensuring that natural resources are properly priced. They put emphasis on lowering trade barriers and increase of economic welfare. In their view, freer trade stimulates prosperity and the subsequent opportunity to devote additional resources to environmental protection.

On the other hand, environmentalists would argue that the 'free traders' are too much focused on a welfare-maximising calculus, which incorporates only impacts that can be easily reduced to a monetary value. In contrast to this assumption, ecological problems are often characterised by critical threshold effects such as time lags between emissions and detection; biological, chemical and physical interactions which are not well understood; and sometimes substantial scientific uncertainties on the source, scope and magnitude of public health or habitat damage. These characteristics make the costs of environmental damage and the benefits from environmental policy hard to calculate (Esty, 1994).

Furthermore, the essence of the environmentalists' view relates to the notion that without environmental safeguards, trade may cause environmental harm by promoting economic growth that results in unsustainable consumption of natural resources and waste production. They argue that if trade causes environmental degradation, then either it must be stopped or environmental safeguards must be incorporated in the rules that guide trade relationships (Anderson and Blackhurst, 1992; Esty, 1994).

In general, both the advocates of free trade and the environmentalists agree with the idea that trade liberalisation can, in principle, cause environmental effects of all kinds. Two main differences in argumentation can be distinguished. First, there is the scale effect of international trade: free traders believe that economic growth will generate more opportunities for environmental protection, whereas environmentalists focus on the increasing environmental burden caused by

economic growth. Second, in mitigating the environmental effects of trade, environmentalists focus on trade policy, whereas advocates of free trade tend to focus on environmental policy.

Anderson and Blackhurst (1992) maintain that case studies are necessary to identify the likely effects of trade liberalisation for particular products and to investigate whether or not this development is favourable for the environment. From an analysis of trade liberalisation of the coal and food sector they conclude that trade liberalisation may not only generate large global income gains, but may also likely reduce global environmental damage from coal consumption and farming.

Thus, from a welfare economics viewpoint and seen from a world trade perspective, globalisation should enhance economic efficiency. But there is considerably less consensus among ecological economics researchers on what this means in practice, or on the social costs or benefits of globalisation for society at large. Changes in international trade patterns, markets, technologies and communication patterns affect both the economy and the environment. Although several international trade models have been developed, and although some of them incorporate also environmental effects (e.g. IMAGE, WorldScan), still more rigorous analytical efforts and comparative modelling studies would be necessary to come up with sound conclusions.

The ecological economics literature cannot boast about an impressive record in terms of a thorough analysis of the relationships between globalisation, trade and transport, and the environment. This is probably a result of a lower interest in global equilibrium analyses and a greater emphasis on valuation studies. In any case, there is much scope for a more systematic study of the various forces at hand.

In the sequel of this paper, we will systematically map out the consequences of globalisation on the environment, by using the conceptual framework developed by OECD (1997a). Four effects of globalisation on the economy are distinguished:

1. Scale effects: globalisation will lead to larger world outputs.

2. Structural effects: globalisation will generate shifts in the composition and location of production and consumption activities.
3. Technology effects: different technology paths will be promoted.
4. Product effects: different product mixes will be produced and consumed.

These effects will likely have important consequences for the environment. On the one hand, a straightforward increase of production and consumption (scale effects) will normally lead to more environmental pressure such as the use of natural resources and the emission of polluting matters into the physical environment (e.g. air, water and soil). On the other hand, structural changes and technology effects can offer new possibilities for increasing material and energy productivity. Hence, it appears that eventually the result of globalisation on the environment is dependent on interwoven changes in these four classes of effects.

Furthermore, it should be noted that (economic) globalisation does not necessarily coincide with economic growth. Globalisation contributes to economic growth, but it is not the only contributor. In addition, population growth, natural resource endowments, institutional and political structures each play a role in the complex global growth process. Each of these factors, therefore, is also critical in determining how the scale, structure, technologies, product mixes and regulatory framework of global economic activity are determined (see also Jones, 1997). In the following sections various issues discussed from the side of ecological economics and related to the above mentioned four effects of globalisation will systematically be considered by using a triangular representation of the complex force fields involved (see Fig. 1).

Each of the above mentioned four effects will now be mapped out in relation to the force field depicted in Fig. 1.

4. Scale effects

Globalisation means a new way of organising, transporting and distributing goods and services.

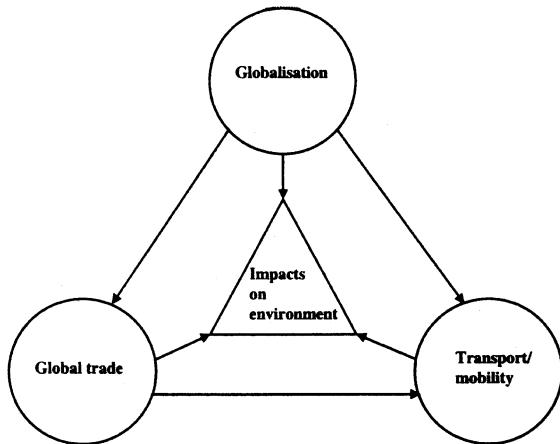


Fig. 1. A triangular force field for environmental impacts in relation to globalisation and transportation.

It is mainly instigated by worldwide competitive forces to produce, transport and distribute goods and services as efficiently as possible. Several environmental effects of trade (liberalisation) are linked to the role of trade in expanding the overall level, or scale, of economic activity. For example, in past decades absolute levels of per capita income have increased very substantially. In this context, Maddison (1989) shows that ‘world’ GDP rose 13-fold between 1900 and 1987, which is equivalent to a compound growth rate of 3% per year.

A large part of the discussions related to global trade and the environment focuses on the relationship between international trade, economic growth and environmental degradation/conservation. Johnstone (1995) argues “those who assert that trade liberalisation is fundamentally benign with respect to environmental effects rest their argument upon the existence of positive relationships between international trade and economic growth on the one hand, and between economic growth and environmental quality on the other hand.” However, the relation between economic growth and the environment has given rise to vivid debates among scientists and decision-makers.

In a special issue of *Ecological Economics* (1995, vol. 15, no. 2), particular attention is given to the relationship between economic growth, car-

rying capacity and the environment. In this special issue, Arrow et al. (1995) claim: “the general proposition that economic growth is good for the environment has been justified by the claim that there exists an empirical relation between per capita income and some measures of environmental quality. It has been observed that as income goes up there is increasing environmental degradation up to a point, after which environmental quality improves” (known as ‘inverted U-curve’ or ‘environmental Kuznets curve’).

To some extent, the existence of this relationship has been defended on the basis of empirical studies. One of the first authors reporting on the inverted U-curve was Jänicke et al. (1989). Focusing on an aggregated proxy for environmentally relevant material input, he observes a tendency of declining levels of throughput beyond certain income levels. Other important contributors to the inverted U-curve are Grossman and Krueger (1995) and Selden and Song (1994) (see De Bruijn and Opschoor, 1997, for an overview). It should be noted that the empirical evidence for the existence of the environmental Kuznets curve is not always conclusive, while the theoretical underpinning is sometimes feeble (see De Groot, 1999, for an interesting recent contribution).

The positive relationship between trade, economic growth and environmental quality is based on two main assumptions. The first assumption involves changes in consumer preferences; growth will change consumer preferences towards environmental quality (Johnstone, 1995). As a result, when a country has attained a sufficiently high standard of living, this leads to a greater demand for environmentally benign products, environmental legislation, effective environmental technology, new institutions for the protection of the environment, etc. Such questions of endogenous growth preference formation still require more solid research. The second assumption is that growth will change the direction of technological change; technological changes are then focused towards the innovation and diffusion of more environmentally friendly products and processes. Here we observe the phenomenon of endogenous technological growth with a particular view to environmental quality. But here the question is in

how far technological trajectories are steered by environmental interests (unless it is beneficial to invest in such technologies).

Despite some (limited) empirical evidence, there are various reasons for caution in interpreting and accepting the inverted U-shaped curves when applying the curve to environmental quality in general. The relation between growth and environmental quality has been shown to be valid only in the case of some selected short-term environmental problems, such as local smoke pollution, SO₂, contaminated water, sulphur or particulates. For long-term environmental problems, such as the accumulation of the stocks of waste and the emission of greenhouse gases, in particular CO₂, the relationships are often increasing functions of income (Arrow et al., 1995; Tucker, 1995).

Second, it is in the context of our paper noteworthy that the analysis of ‘Kuznets curves’ does not take into account the implications of international trade and location choice. Arrow et al. (1995) noticed that the inverted U-curves do not tell anything about the system-wide consequences of emission reduction. Due to outsourcing or firm relocation, it is possible that emission reductions in one country involve emission increases in another country. In that case, the global emissions will be equal or even rise (cf. also the notion of the ecological footprint).

Third, several authors (see, for example, De Bruijn and Opschoor, 1997) argue there are strong reasons to believe that the inverted U-curve is not persistent over time, but that a phase of ‘relinking’ will be entered eventually. They suggest that the levels of consumption of aggregate materials over time may show an ‘N-shape’ rather than an inverted U-curve. An empirical analysis undertaken by these authors even shows that several Western European countries now find their aggregate material consumption again increasing faster than gross domestic product (GDP).

Finally, in the context of international trade and transport, it may appear that the environmental intensity of global production will continue to rise in the next decade, since the developing countries—with a huge critical mass

of population—have not yet reached the ‘turning-point’ of the inverted U-curve. Moreover, it might also be possible that the economic process generates irreversible environmental degradation before the economic process brings about a fall in the environment-intensity of production beyond the ‘turning-point’ (Johnstone, 1995). Furthermore, even a negative scale effect may be identified if trade-driven growth would worsen environmental problems, for example, when expansion of global production and consumption coincides with market and intervention failures (Adams, 1997). Increases in the scale of production and consumption induced by trade may lead to more degradation and faster depletion of natural resources when there are failures to internalise environmental costs, to value ecosystems properly and to clearly define and assign property rights.

It is thus evident that, given the complexity of the globalisation phenomenon, it is as yet uncertain whether the scale effects of globalisation will unambiguously lead to positive or negative environmental effects. This will—apart from the implementation of environmental policies and the internalisation of environmental costs—largely depend on the locational behaviour of multinational firms and resulting trade patterns. Seen from this perspective, international transport and mobility plays a critical role in sustainability trends.

The demand for freight transport originates from an underlying basic demand, which is a location-specific demand for a product that results in a need to ship the product to a particular location. As a derived demand, a critical factor in total freight demand is the volume of products produced and consumed at different locations. The demand for freight transport has shown a considerable rise in the last decade (see Corsi and Grimm, 1995, for empirical evidence). The general trend over the past centuries of international goods transport has shown a continued growth. The question whether this expanding world output is caused by a higher share of services or by production and consumption of more products with a high value but a low volume has been given different answers. In case of a worldwide trend towards deindustrialisation, this could have

a positive effect on the environment. In addition, it is also possible that changes in modal split result in a decrease in environmental pressure. For instance, if global trade is mainly based on the use of less environmentally damaging transport modes (such as rail or inland waterways rather than road or air transport), a fall of emissions per unit transported might be expected. Unfortunately, recent trends show opposite patterns: a shift from the use of slower modes to the use of faster and hence less environmentally friendly modes. Clearly, the nature of goods has important influences on the modal choice. Low value commodities are commonly transported by the slower, less costly modes (pipeline, barge and rail), whereas higher value and perishable products are usually transported by truck and sometimes by air (see Nijkamp et al., 1998, for details). The above pattern can be exemplified by referring to the modal split of freight transport of 12 European countries, which has shifted towards less environmentally friendly modes. Road transport expanded from 47.8% in 1975 to 69.0% in 1992, principally to the detriment of rail whose contribution declined from 44.4% in 1975 to 25.2% 1992 (ECMT, 1997). It is expected that the continued increase in the demand for freight transport in the future will largely be met by the fast and less environmentally friendly modes (road and air).

In conclusion, we may argue that, although the scale effects of globalisation in relation to trade and transport are not necessarily detrimental to environmental quality, in practice current trends show an adverse pattern. Clearly, more insight would be needed into the success conditions of a compatibility of scale effects with sustainable transport by investigating more thoroughly concentration and distribution patterns in modern industry.

5. Structural effects

The structural effects of globalisation refer to changes in the composition and location of production and consumption activities. According to the classical theory of international trade, the

composition and location of production and consumption is explained by differences in production functions and factor endowments among countries. In the Ricardian model, countries will export goods that their labour produces relatively efficiently and will import goods that their labour produces relatively inefficiently. Therefore, in Ricardo's model, trade patterns are explained by differences in labour productivity, and not by differences in technology or physical geography. If labour is the only factor of production—as the Ricardian model assumes—comparative advantage could arise only because of international differences in labour productivity. However, in the real world, trade can also be explained by differences in the countries' resources (capital, labour, land, mineral resources, etc.). The Heckscher–Ohlin theory of trade assumes that countries tend to export goods that are intensive in the factors with which they are abundantly endowed. A country that has a large supply of one resource relative to its supply of other resources is abundant in that resource. In this theory, differences in resources are the main determinant of explanations for trade patterns (Krugman and Obstfeld, 1994). In the latter publication, we also witness an integration of trade, transport and location theory by a clear emphasis on agglomeration advantages under monopolistic competition.

Therefore, to the extent that trade promotes allocative efficiency and geographical specialisation among nations, trade liberalisation can have positive structural effects in allocating economic activity in accordance with the environmental capacities and conditions of different countries. If environmental assets are properly valued and measured, if their value is taken into account in international markets and if their use is not distorted by policy interventions, then trade will certainly generate sustainable development. In the absence of these ideal conditions, trade may instead have negative structural effects, causing increased specialisation in ecologically unsustainable activities (see Adams, 1997, for convincing arguments).

From an ecological economics perspective a major problem is that environmental costs are often not internalised, while large differences in

environmental policy between different countries do exist. It can be argued that national differences in the degree of internalisation of the environmental effects of production may induce unfavourable environmental effects (Daly and Goodland, 1994; De Bellevue et al., 1994; Johnstone, 1995). These differences are largely influenced by the tightness of domestic environmental policy, which in turn is affected by domestic fiscal policies often imposed from outside.

In the traditional environment–competition debate, the usual argument is that environmental regulation raises production costs and that this may reduce the market share of domestic companies in global markets. Under a system of free trade, industries confronted with a strict environmental policy are then less competitive than industries which do not require environmental cost internalisation. The industries in the non-internalising country will increase their share of world output at the expense of the industries in the internalising country. Furthermore, the introduction of national environmental policies may cause pollution-intensive production processes to gradually relocate from richer and/or more densely populated countries to poorer and/or more sparsely populated countries (Anderson, 1993). From a global perspective, it may then be concluded that international trade will increase the environmental burden when domestic differences in environmental policies exist. From an ecological economics viewpoint, a first task would then be to get the prices right.

The above argumentation needs however, some critical consideration, as the endogeneity of environmental technology in response to environmental policy is neglected. In this context, Porter and van der Linde (1995) claim that firms or industries can benefit from environmental regulations that are more stringent than those faced by their competitors in other countries. Their argument rests upon the idea that properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them. These so-called ‘innovation offsets’ may not only lower the net cost of meeting environmental regulations, but can even lead to an absolute advantage over firms in foreign

countries not subject to similar regulations. In short, by stimulating innovation, strict environmental regulations can actually enhance competitiveness. This means that, on a global level, differences in domestic environmental policy may lead to an improvement of the environmental implications of production and trade. Clearly, the endogeneity argument has also met some criticism and has prompted a debate in the *Journal of Economic Perspectives*. For example, Palmer et al. (1995) argue that Porter and van der Linde (1995) neglect the costs of environmental regulation and that only a cost–benefit analysis can offer a good assessment of the effects of environmental regulation. But even if this argument may be valid, it does not imply that positive technological spin-offs in the private sector do not occur. The structural effects of globalisation may show up in both the country of origin and destination of goods. If global trade implies more long-distance transport, it is normally argued that the effects on the environment are negative. There are however, also countervailing powers. In the last decade, the introduction of new logistic concepts such as ‘just-in-time’ has led to a reduction in order cycle times, which is leading firms to seek suppliers who can offer faster delivery times, even though they are located further away. The net environmental balance of this development is difficult to assess. Partly due to changes in the balance between the relative costs of sea and road transport costs, a growth in international sourcing can be noticed. For instance, over the last 15 years the real price of sea transport has fallen by approximately 24–30% and container vessels have increased, whereas local journey times have often become longer and less predictable because of road congestion (EuroCASE, 1996). The increase of international sourcing may lead to an increase in average distance travelled. For further empirical evidence on the environmental consequences of just-in-time systems we refer to Rovers (1999).

In the above structural change scenario the environmental impacts of global trade may be negative, but there may be also other scenarios that are consistent with the globalisation phenomenon. Various authors argue that regionalisation instead of an internationalisation of world

trade will take place (Ruigrok and van Tulde, 1995; Kleinknecht and ter Wengel, 1996; Mensink and van Bergeijk, 1996). Regionalisation involves the increasing international dependency on economies in a certain region; the Third Italy is a good example, and in a more general sense we may refer to the so-called 'Europeanisation'. Kleinknecht and ter Wengel (1996) suggest that patterns of commodity and foreign direct investment are not consistent with the proposition that European economies are experiencing a process of increasing globalisation. For example, intra-regional trade in Europe climbed from around 55% in the mid-1960s to 70% in 1989 (OECD, 1997b). This may imply that international transport flows have a regional instead of a intercontinental character. Under such conditions the environmental consequences of trade would be far less devastating.

However, Mensink and van Bergeijk (1996) remark that the main limitation of the approach of Kleinknecht and ter Wengel is the use of a bilateral scope. They maintain that the mutual dependency between economies can only be demonstrated by a multilateral approach. For example, import and export rates of the Netherlands only explain the degree of internationalisation of the Netherlands, and do not explain the mutual dependency of other nations. Moreover, the World Bank (1996a) argued that contrary to popular belief, the regional concentration of trade has not grown much in the second half of the twentieth century, except within the European Union, which is the principal example of deep integration (involving harmonisation of standards, policies and institutions).

It seems as though both patterns—increasing global trade and increasing regional trade—are showing up in parallel, although with different intensity in various countries. This is confirmed by a study carried out by the World Trade Organisation Secretariat, which concludes that trade with partners in the same region and with partners in other regions have both become increasingly important in national economies throughout the post-war period. The growth of trade between countries in regional agreements and their trade with other regions does not support the conclu-

sion of an increasing regionalisation of world trade, nor does it confirm the notion of the emergence of trading blocs centred in North America, Western Europe and the Asia-Pacific region. In fact, the legal foundations for more open trade have been laid by the multilateral trading system—global in its coverage—with regional integration agreements serving to deepen relations with neighbouring countries (see Focus, 1995, for details). According to this, global as well as regional integration of economies takes place; trade figures show an increase in regional imports and exports as well as global imports and exports. This may likely mean that the average transport distance has increased, so that the environmental effects of such structural changes are still negative, unless they are offset by new developments in transport technology and logistics.

6. Technology effects

The technology effects of globalisation refer to the innovation and dissemination of new technology regimes on a global scale (see also Koski, 1998). The introduction of new technologies has contributed to expanding production possibilities and opportunities for economic growth; in particular, information and communication technology, biotechnology, new materials and environmental and energy-linked technologies have provided new technological opportunities. These 'key or base technologies' result in the innovation and adoption of many new products, they influence production processes and are applicable in many sectors in the economy (Tuininga, 1989). Liberalisation of trade may encourage the rapid diffusion and adoption of more advanced technologies—e.g. through multinational corporations as vehicles of technology transfer.

It seems that not all countries are able to benefit fully from the technological advantages of globalisation, despite closer economic interdependence. Due to national differences in factor endowments, the cost associated also differs as a consequence, and firms face different incentives in terms of the generation and diffusion of particular technological innovations. Differences in relative

factor cost can explain differences in diffusion rates between the developed and developing countries (Johnstone, 1997).

Is this drive towards new technological paradigms favourable to the environment? It should be recognised that technological change is only partially driven by efforts to save on environmental costs. As a consequence, many of the resulting environmental benefits (and costs) arise almost incidentally out of efforts to save on the use of other factors of production. Thus, there is no *a priori* reason to believe that from a global perspective technological progress will tend to bring about resource-saving and pollution reduction. Of course, an exception is formed by environmental innovations, as here policy instruments may have a significant effect on the environmental intensity of an economy's technological trajectory (Johnstone, 1997). Nevertheless, the competitive forces in a global economy may stimulate firms to economise on all costs, including energy and resource costs, so that as an unintended effect some environmental benefits may be expected.

In our era of global trade, we observe also significant changes in transportation technology and related environmental effects. Clearly, a positive environmental effect can be expected if new and more efficient transport technologies substitute more polluting alternatives. In general, four categories of technologies can be distinguished, namely, an improvement of existing transport modes, the development of new transport modes, improvement in the management of transport (such as logistics and route planning systems) and the development of alternative fuels. It should be added, however, that the implementation of new transport technologies may lead to additional transport rather than to substitution of polluting alternatives. This argument has been put forward by Gwilliam and Geerlings (1994) who claim that increased fuel efficiency reduces fuel costs, and hence results in longer trips; the same amount of fuel expenditure will then increase the total distance travelled by vehicles. Furthermore, economic and institutional barriers can obstruct the development toward less environmental friendly transport modes (see Nijkamp et al., 1998, for many examples). In conclusion, technological de-

velopment will lead to more energy efficient transport modes, and hence have positive environmental effects, but there may be various indirect transport needs prompted by this development, so that the net environmental effects are as yet uncertain. It goes without saying that there would be a great research perspective for ecological economics in mapping out the force field of technological innovation in relation to trade, transport and the environment.

7. Product effects

Finally, we will pay attention to changes in the market demand for products which may have impact on international trade flows. The focus of the conventional international trade theory is primarily on production, while almost entirely neglecting consumption. Many models assume that consumers have identical and homothetic utility functions, regardless of where they are located. Linder (1961) is one of the main authors emphasising the importance of demand factors for explaining international trade. Linder argues that the principles governing trade in manufactured goods are not the same as those governing trade in primary products. He supports the idea that trade in primary products is determined by factor endowments, but he argues against the notion that differences in factor endowments are the major determinants of trade in manufacturing products. He observes a large volume of trade between the developed countries. These countries have very similar factor endowments and thus, according to the Heckscher–Ohlin theory, we might not expect a large volume of trade between them, unless we address also the demand side.

A newly manufactured good is created by an entrepreneur in response to a perceived demand. It is this perception of potential demand that triggers production rather than considerations of factor endowments. The second step in the argument is that entrepreneurs are most familiar with their home market. Therefore, for a manufactured product to be produced in (and exported from) a country, there must exist a significant home demand for the product. The best export opportuni-

ties will be found in countries that have very similar demand patterns to the entrepreneurs' home country. This final step implies that the countries with the most similar demand patterns for manufactured goods will tend to be those with more or less equal per capita income. Thus the volume of trade in manufactured goods will be the highest between countries of equal per capita income. It is thus the demand side that determines the pattern of trade in manufactured goods (Markusen and Melvin, 1988).

It is noteworthy that an increasing environmental awareness among consumers is also reflected in their purchase patterns of consumption goods. Seen from this perspective, trade can have positive product effects by facilitating the diffusion of environmentally beneficial goods and services (Adams, 1997). One of the convincing environmental arguments of the GATT for free trade is that free trade gives the consumers the greatest opportunity to choose 'green' products (Ropke, 1994). Following the argument of Linder, trade of environmentally beneficial goods and services will then primarily take place between countries with similar levels of welfare.

Negative environmental product effects resulting from trade occur in cases such as the insufficiently controlled trade in toxic chemicals, hazardous waste, disease-bearing pests, and endangered species (Adams, 1997). A country's environment may suffer if products are imported which cause particular environmental damage or risks; for example, trade in hazardous wastes. Clearly, environmental agreements would be necessary to cope with such negative externalities of environmental trade.

Does the change in the product mix also affect environmental consequences of the related transport flows? The composition of the product mix determines, to a large extent, not only the volume of the transported goods but also the transport mode that will be used. For instance, a change in the product mix towards products with a high value but a low volume may result in a decline in the volume of the commodity flows (scale effects). The trends toward deindustrialisation may imply that less agricultural and industrial goods and more services are traded. However, the transport

of more high value products may also lead to the use of more environmentally damaging modes. As mentioned before, a trend towards the use of less environmentally friendly modes can be observed. Therefore, positive volume effects of changes in the product mix can be counterbalanced by negative changes of the modal split, and vice versa.

It is thus clear that the shift in consumer preferences offers interesting perspectives for more environmentally benign globalisation developments. Only if this is offset by a rise in volume of goods or by a shift to less unsustainable transport modes would this development have a negative environmental impact. This assertion provokes at the same time an interesting research challenge for ecological economics.

8. Retrospective and future research

Our review has tried to map out systematically the force field of environmental damage in relation to international trade. Apparently, the total effects of globalisation on the environment are the net result of the complex changes in the scale, structural, technological and product effects. Based on a broad literature search, it cannot conclusively be stated whether these four effects are positive or negative for the environment because many feedback effects between globalisation and the environment can be distinguished. In Table 2 the main conflicts between global trade and transport on the one hand and the environment on the other hand are depicted. Several items on an ecological economics research agenda emerge from this list.

In regard to the scale effects of globalisation, the main issue is the debate on economic growth versus the environment. Some authors argue that liberalisation will lead to an increase in the scale of the production and consumption, which will lead to an increase of environmental quality caused by changes in consumer preferences and technology change. Others maintain that market and intervention failures will lead to more degradation and faster depletion of natural resources. These conflicting views also show up in the transport sector. An increase in the scale of production

and consumption will in principle lead to an increase in international transport. However, when this increase is caused by an increase in the production and consumption of products with a high value and a low volume (e.g. services), then the environmental pressure will decrease. Furthermore, modal shift towards less environment damaging modes can also decrease environmental problems. More empirical ecological economics research is necessary to arrive at conclusive answers.

Next, the main issue of the structural effects of globalisation concerns the dilemma of environmental regulation versus competition. Trade liberalisation can have positive environmental effects in allocating economic activity in accordance with the environmental capacities of different countries, under the assumption that environmental costs are internalised. However, large differences in environmental policies between nations all over the world do exist. Some authors argue that differences in environmental policies will lead to an increase of environmental problems, because the industries in non-internalising countries will increase their share in world output at the expense of the industries in the internalising countries. However, others claim that strict environmental policies trigger innovations and enhance competitiveness, which will lead at the global level to an improvement of environmental quality. A related issue is the globalisation–regionalisation debate. Again some authors argue that globalisation will lead to transportation of goods and passengers over a longer distance, which will have negative environmental effects. But others observe a re-

gionalisation of international trade which may imply that transport has a regional rather than an intercontinental character and hence a less devastating impact on the environment.

In regard to the technology effects of globalisation, the main conflict concerns the question whether technological development results in expanding production possibilities (with accompanying scale effects) or whether technological development may generate resource saving products and processes and hence also pollution reduction. Concomitantly, in the transport sector, positive environmental effects may be expected from new and more efficient transport technologies, while negative environmental effects occur from additional transportation rather than substitution away from physical transport.

And finally, positive environmental product effects can be expected from trade by facilitating the diffusion of environmentally friendly goods and services. Negative environmental effects result from trade in hazardous wastes and toxic chemicals. The product-mix largely determines the mode for transportation. A larger share of services in the product-mix may lead to less transport, which implies a positive environmental effect. Clearly, products and services with high values are often transported by fast and environmentally damaging transport modes.

In retrospect, the analysis of the above-mentioned four globalisation effects has demonstrated that net environmental changes are not unambiguous. By no means may it be concluded that a trend to global trade developments is by definition negative for environmental quality. There are cer-

Table 2
Conflicts between globalisation/transportation and the environment

Effects of globalisation	Main conflicts related to global trade	Main conflicts related to transportation
Scale effects	Economic growth versus environment	Increase of the transport volume versus increase in the share of services and/or modal shift
Structural effects	Environmental regulation versus competition	Increase of distance versus regionalisation
Technology effects	Expanding production possibilities versus resource saving and pollution reduction	More efficient transport technologies versus additional transport
Product effects	Trade in hazardous wastes versus 'green products'	Low volume goods versus use of faster modes

tainly interesting perspectives for tracing a development path that supports sustainable environmental development. It is also interesting to observe that various contributions published in *Ecological Economics* do not offer a conclusive perspective. This is also confirmed by taking into consideration scientific publications in other channels. Ecological Economics could contribute to the challenging task of analysing more thoroughly the effects of globalisation on the environment in various ways. New research activities are needed for investigating the linkages between globalisation, transport and the environment. The key research themes for the next 10 years of *Ecological Economics* may focus on:

- Examining the structuring role of international institutions (e.g. WTO) in achieving a worldwide system of sustainable transport.
- Analysing the regulatory possibilities of national and international policy for steering cross-border transport flows (e.g. taxation schemes for international transport).
- Building up a monitoring system and database for trade, transport and the environment in order to stimulate international comparative research on sustainable transport.
- Modelling and measuring the environmental effects of international transport (e.g. on the basis of a computable general equilibrium (CGE) model in relation to both global and transport systems scenarios).
- Undertaking multidisciplinary research on the impact of new transportation technologies, including the use of information and communication technology (telematics research).
- Analysing the influence of globalisation on global mobility and international passenger transport (e.g. international commuting, international tourism).

In conclusion, the field of international trade, transport and environment offers a formidable research challenge for the economic analysis of environmental sustainability. So far, only a fragmented subset of issues has been investigated in the ecological economics literature. The present contribution has tried to critically evaluate the achievements made thus far and to suggest new departures for promising research in a still largely

unexplored area. It seems to be a plausible expectation that in the next decade the ecological economics literature will place trade and environment in the center of its attention.

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