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International trade and environmental quality: a survey

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Abstract

International trade has been incorporating various aspects of environmental issues since 1970. The extent to which environmental problems might affect many facets of trade, or vice versa, has been the subject of considerable debate over these years. In this article we have attempted to establish some of the links between international trade and environmental quality by performing a comprehensive literature review. We discuss issues such as establishing direct and indirect effects of international trade on environmental quality, effects of trade on economic development, environmental quality, and energy and their relation with each other, and, finally, the role of governments and international organizations in this context. Studies have so far revealed some linkages between trade and environment through conventional trade theory. However, interactions between international trade and types of pollution, their sink and assimilative capacity need to be analyzed using a general equilibrium approach. Currently, very little knowledge and agreement on the nature of interactions between trade theories, development process and environmental quality exist. Existing studies have shown that the structure of environmental regulations should be modified to reflect the existence of trade under imperfect competition. Therefore, further research on the interaction between new trade theory and environmental regulation is needed. Also, theoretical and quantitative analysis regarding the effects of environmental regulations on competitiveness and location decision is needed. The intensity and type of environmental measures vary across issues and countries. Therefore, harmonizing environmental measures creates an inefficient atmosphere, and to assume that trade restrictions will either improve or reverse the environmental damages is a serious mistake. Given the dynamic and intricate nature of the problem, trade and environment debate continues despite vast research and poses a challenge for researchers and policy makers in the foreseeable future.

Keywords: Economic development; Environmental quality; Environmental regulations; Harmonization and competitiveness; Trade

1. Introduction

The issues surrounding trade and environment are multidimensional and intricate. Apart from being formidable competitors for a country's re-

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sources, environmental issues can influence the production costs, trade pattern, industry location, and, finally, gains from trade. Since the 1970s, this fact acquired importance in international trade arenas (Bailey, 1993) as many industrialized countries began introducing significant environmental control programs. Also, globalization of economy was recognized as a sound developmental policy during this period. However, the environmental impacts of trade policy measures and vice versa raised concerns, some of which were voiced at the 1972 United Nations Stockholm Conference on Development and Environment. Such concerns stem from the fact that globalization of economy has both positive and negative effects on environmental quality. Accordingly, an important challenge identified during the Earth Summit (1992) was to ensure that trade and environment are mutually supportive. This led to incorporation of environmental concerns in trade agreements such as General Agreement on Tariffs and Trade (GATT) and North American Free Trade Agreement (NAFTA) (Beghin et al., 1994; DeBellevue et al., 1994; Daly and Goodland, 1994a; Winham, 1994; Costanza et al., 1995; Benton, 1996). However, environmentalists and liberal trade advocates are equally concerned with these propositions. To address these concerns we must understand the intricate links between trade and environmental quality.

In this article we have attempted to establish such links by performing an extensive literature review. So far, five such studies have been conducted in this area (Dean, 1992; OECD, 1993; Beghin et al., 1994; Jaffe et al., 1995; Thompson and Strohm, 1996). The Dean (1992) study was more of an enumeration of literature, addressed no particular problem and encompassed only part of the existing research. The other two studies—OECD (1993) and Jaffe et al. (1995)—addressed trade and environmental regulations with respect to the issues of competitiveness. Beghin et al. (1994) studied the issues of growth, competitiveness and some global environmental problems. Thompson and Strohm (1996) addressed the factors related to economic growth and environmental quality, particularly the environmental Kuznets curve (EKC). Thus, no comprehensive analysis of issues related to trade and environmental quality exists.

This article addresses the following issues of international trade: (1) its direct and indirect effects on environmental quality; (2) its effects on economic growth, environment, energy and their interrelation; (3) its effects on environmental regulations and vice versa, and (4) the role of governments and international organizations in environmental management. Accordingly, the article is arranged into five sections. The second section ascertains theoretical and empirical issues surrounding trade and environmental quality. In the third section, various theoretical and empirical aspects related to economic development, trade, and environmental quality are discussed. The fourth section examines the effects of environmental regulations on trade and vice versa. This section also presents the theoretical and empirical issues of environmental regulations related to competitiveness, industrial location, product standards, harmonization of environmental standards, and role of international organizations. Conclusions and directions for future research are presented in the final section.

Table 1
Pro-environment and pro-trade arguments

Pro-environment group	Pro-trade group
Trade damages natural resources (stocks and services)	Trade enhances economic development
Trade allows environmentally harmful goods and processes to transfer to 'pollution haven countries' in exchange for economic gains	Trade-derived income can fund improved environmental management and disseminate environmentally sound technology
Trade undercuts existing environmental protection laws	Trade provides incentives for environmental policy reform
Trade affects international environmental agreements	Trade enhances environmental harmonization among countries

2. International trade and environment

During the past four decades environmental issues have gained significance on various fronts. The first major wave of public concern for the environment (during the 1960s) focused mainly on the problems of industrial pollution in the advanced economies. In the late 1970s, environmental concerns started appearing in trade analysis. Trans-boundary environmental issues entered the prominent trade negotiations of the 1980s. During the 1990s, it was felt that differential environmental regulations could affect the competitiveness of countries/industries. Accordingly, efficient environmental regulations and their ranking received importance. Also, during this period environmental issues started occupying the global agenda.

The existing literature shows no consensus regarding effects of trade on environment. Table 1 summarizes some of the arguments between pro-environment and pro-trade groups (Bhagwati, 1993; Daly, 1993; French, 1993). Interactions between trade and environmental quality can be analyzed using three categories of spatial environmental problems resulting from production and consumption activities: intra-country (local), inter-country (trans-boundary), and global environmental problems. The intra-country environmental problems (example: particulate, lead, biochemical oxygen demand, municipal waste, etc.) are local in character with varying abatement costs. Thus, appropriate control measures must be determined locally. When more than one country is jointly or individually responsible for environmental degradation of their common natural resources (such as rivers, coastal seas, lakes and common air shed), inter-country problems arise. Here a country can affect the welfare of its neighbor(s) and thus the solution often requires cooperation. Global environmental problems are global in nature (depletion of ozone layer, climate change and endangered species). When the environmental damage extends beyond borders and affects the global welfare, the polluting country has less incentive to minimize it. A global environmental problem is an environmental externality of international common property resources. An important difference among the first and the other two categories is that in the first case, environmental problems and trade interact through exchange of goods and services. In the other two cases they are due to physical spillovers. However, in certain cases, these three categories can overlap.

2.1. Environmental externality and comparative advantage

The theories of international trade use natural resources and climate as variables that affect labor productivity, as suggested by the Ricardian model. The factor proportion model frequently included natural resource inputs under the composite heading 'land', and developed the analysis with labor and land as factors of production. Using the comparative advantage model d'Arge and Kneese (1972) showed that there was no rationalization for greater control over trade to protect the environment. Such rationalization was not substantiated based on either long-term comparative advantage and efficiency or short-term impacts on the balance of payments and domestic incomes. Identifying production (extraction and processing) and consumption (primary and secondary) activity is important while analyzing the environmental effects on trade. Ayres and Kneese (1969) showed that pollution (gaseous, liquid or solid) is inherent to the production and consumption activity of an economy and a tradeoff exists between the forms of pollution. The effects of environmental externality on production and consumption were analyzed by Grubel (1975) using a modified Hecksher–Ohlin (HO) model (the HO model states that each country has a comparative advantage in the good which is relatively intensive in the use of the country's relatively abundant factor). If the environmental costs are not reflected in the domestic production of the commodities in the trading countries, it will increase production of commodities normally imported and decrease the production of exports. By relaxing the assumption specified by Grubel, Koo (1979) analyzed the effects of pollution reduction using a three dimensional trade model. He found that trade will increase real income, part of which may be in the form of cleaner environment.

Blackhurst (1977) discussed domestic industrial pollution within the context of a factor proportion model. He suggested several approaches to address the endowment of natural material inputs: (1) combine labor and capital into a composite factor with land as the second factor, (2) expand the model to include more than two factors of production, or (3) include land as a part of capital endowment. He defined environmental assimilative capacity (EAC) as factor endowment, and introduced it into the standard factor proportion model. EAC is defined as the demand for aesthetic and recreational services which considers the endowment of waste absorptive capacity function and the physical endowment (example: land, lakes, rivers, coastlines and airspace). Thus, by providing a flow of productive services, EAC can play a role in factor endowment that could vary among countries. The national environmental endowment is influenced by natural assimilative capacity, demand for assimilative services and value accorded to the environment (Siebert, 1992). Therefore, environmental policy of a country affects the environmental quality in another country through specialization and trade.

2.2. Environmental externality and trade: general equilibrium analysis

Environmental externality can be analyzed by considering a simple, two-product, two-country, general equilibrium model under the assumption that a country eliminates intra-country pollution (arising from production of tradeable goods only) by allocating required resources. This shifts productive capabilities from internationally tradeable goods to goods that cannot be traded. Thus, each country's ability to produce tradeable goods and services is lower than it would otherwise be. The transformation function between imports and exports, in the presence of pollution control, falls below the level it would otherwise be. The question is, if reduced potential output is symmetrical between those goods and services, that country tends to trade.

If the impact of pollution control is relatively neutral, a country's comparative advantage is unchanged, although the volume and gains from trade may decline. Its terms of trade remain the same, while price of goods increases. Consider the case of unsymmetrical impact of environmental controls on trade sectors of a capital intensive country, where the environmental controls are capital intensive. Here its comparative advantage is reduced and the production mix of tradeable goods and services becomes less specialized in export sectors. At the other extreme, if the country specializes in the production of labor intensive goods and services, potential output in the import competing sector is reduced substantially than that of labor intensive exports. The volume and gains of trade may decline, but less than in the earlier case. Indeed, the country may specialize to a greater degree in the production of exports than it did before. Therefore resource diversions into environmental control activities might lead to reduced output and consumption of tradeable goods (real cost of environmental control to society) and overall reduction in trade.

Walter (1974b) analyzed the aspects of trade and pollution in a general equilibrium condition. He treated environmental quality as a factor of production and analyzed the trade impact using a modified HO model with three goods (imports, exports, and environmentally friendlier goods). He showed that because environmental costs (due to increased demand for environmental quality) draw resources away from exports and imports, trade will decline, while production and consumption of environmentally friendlier goods will increase. Using a two-country, two-goods and two-factors (labor and environment) general equilibrium model, Pethig (1976) derived different interpretations of the theorems of comparative advantage with respect to environmental scarcity. He analyzed three specific trade patterns: between developing countries; between developing and developed country; and between developed countries. In case of trade between two developing countries (where supply of environmental service is greater than demand), neither the comparative nor the absolute size of the country's capacity of environmental services (or EAC) has an impact on the pattern of trade.

Asako (1979) analyzed the interaction between domestic environmental quality and trade using

three approaches: static analysis to demonstrate a relation between trade and pollution, dynamic analysis to study the optimal trade policy under domestic pollution due to production activity, and comparative analysis of the stationary state pollution problems. He showed that a country can and should control international trade activities to deal with pollution problems. Also, a country engaging in trade biases its domestic economic structure toward exportable sectors, thus affecting environmental quality. Siebert (1992) extended the HO theorem to analyze the interaction between national environmental endowment and competitiveness. He argued that a country with fewer environmental attributes will export less pollution-intensive commodities and vice versa. His analysis showed that a small country, lacking environmental measures, will produce more of the pollution-intensive commodities and its environmental quality will decline. However, with environmental measures, the country's comparative advantage in pollution intensive commodities will decline, leading to reduction in exports of pollution intensive commodities and overall trade. In the case of the large country, its comparative advantage will be reduced more with the environmental measures, leading to increased price in the world market.

2.3. Environmental externality and trade: partial equilibrium analysis

Using a partial equilibrium model, Baumol (1971) and Baumol and Oates (1988) analyzed the short- and long-run environmental (air pollution) effects on trade. They argued that less developed countries may specialize in pollution intensive products in anticipation of economic growth. This could increase their exports without adding to their employment or real earnings. Also, the presence of international pollution problems weakens the argument for free trade and suitable tariffs may improve world resource allocation. Siebert (1974) analyzed the effects of environmental policy on the conditions for trade. A country richly endowed with environment (defined as a receptor of pollutants) will export the commodity with a high pollution content. Also, relative price differences between countries depend on environmental scarcity or abundance. Thus, environmental factors can define comparative advantage in terms of environmental endowment.

Anderson and Blackhurst (1992) analyzed the effects of trade liberalization on environmental quality of a small and large country using partial equilibrium analysis. In case of pollution due to both consumption/production and imports/exports, appropriate environmental policy will improve welfare and environmental quality when the small country opens for trade. However, any trade intervention to abate the pollution will reduce welfare. In a large country case, welfare benefits are enhanced with imports of a product whose production is pollution intensive. Suppose that in the small country this product is no more pollution intensive than other products, and social and private marginal cost curves coincide abroad but diverge at home. Here, if the large country adopts optimal environmental policy, welfare unambiguously increases. Morever, there are welfare gains and no extra environmental degradation in the small country following the trade liberalization. Therefore, industrial countries' environmental standards have implications for poorer countries who engage in trade. If the increase of production of import competing goods in industrial economies is relatively pollution intensive, stricter standards will improve the terms of trade for poorer countries. If the pollution standards are raised in industrial countries compared with poorer countries, production of pollution intensive goods will be moved from richer to poorer economies, provided capital is internationally mobile.

Environmental externalities are results of common property resources. Countries with a high degree of private ownership and proper allocation of property rights have more efficient resource allocation, leading to increased income and decreased environmental problems (Cropper and Griffiths, 1994; Torstensson, 1994). Chichilnisky (1994a,b) analyzed the issues of property rights and pattern of trade in a North–South trade model with three propositions: (1) country with ill-defined property rights overuses the environment as a production input and these rights may

lead to trade between two otherwise identical countries; (2) for the country with poorly defined property rights, trade with a country with well-defined property rights increases the overuse of resources and makes the misallocation worse, transmitting it to the entire world economy; and (3) different property rights regimes for environmental resources can account for the pattern of trade between North and South. Using a two-country (a consumer, with no resource management, and a conservationist, with rational resource management) general equilibrium model, Brander and Taylor (1997) analyzed the effects of efficient management of renewable resources (trees) on trade flows and comparative advantage. The study showed that when the 'mild' overuse consumer country opens to trade, it produces this resource more cheaply, exports it and loses from trade. Whereas, the conservationist country gains from trade by importing. In a 'severe' overuse situation, the consumer country becomes an importer of this good as the trade opens, and thus both countries gain from trade.

2.4. Empirical evidence

Most of the existing empirical studies find conflicting evidence regarding effects of trade on environment (Koo, 1974; Walter, 1975b; Leonard, 1988; Tobey, 1990; Dean, 1992; Low and Safadi, 1992; Gale, 1995; Jayadevappa, 1996). World Bank studies on trade and environment (Birdsall and Wheeler, 1992; Lucas et al., 1992; Wheeler and Martin, 1992) found lower growth rates in pollution intensity of production for countries that pursue more open trade policies. However, Rock (1996) contradicted this and showed those open trading policies are more pollution intensive compared with inward trading policies.

The inter-industry materials flow model is a conceptually satisfying and accurate tool for analyzing the environmental externality effects due to production and consumption activity (Ayres and Kneese, 1969). Walter (1973) calculated the direct and indirect pollution content of US trade using 1960 I-O data. He investigated if the environmental control costs are biased toward either exports or imports, and showed that US trade might be affected if other countries adopt different environmental regulations. Koo (1974) used a simple linear (effective constraint) model to study the consequences of trade on five air pollutants (particulate, Sox, HC, CO and Nox) using US I-O data. Results suggested that, besides labor and capital, the trading nations exchange different types and amounts of pollutants through trade. This highlights the direct and indirect effects of trade on the resource base including pollution of trading countries, and strengthens the argument for incorporating environmental factors while analyzing all aspects of trade. Mutti and Richardson (1977) compared several methodologies for estimating the industry displacement caused by unilateral environmental regulations of the USA. They stressed the practicality of adopting a general equilibrium approach in projecting the effects of environmental controls on domestic output and trade. Tobey (1990) used a set of 11 resource endowments to explain net exports of the most polluting industries using the Hecksher–Ohlin–Vanek (HOV) model. The results showed that stringent environmental regulations imposed on industries during the 1960s and 1970s by industrialized countries had little effect on trade patterns in the most polluting industries.

Runge (1993) synthesized the analytical studies on trade and environmental quality in agriculture sectors. He argued that environmental problems of agriculture sectors were due to inappropriate policy measures such as subsidies, taxes, and agricultural trade barriers. Wyckoff and Roop (1994) used I-O and energy consumption data from six OECD countries (Canada, France, Germany, Japan, UK and USA) to estimate the amount of carbon embodied in manufactured goods. The percentage of carbon embodied in each country's imports varies from 8% (Japan) to 40% (France), with an average of 13%. Gale (1995) used an I-O model to study the effects of NAFTA on CO_2 emissions in Mexico. The results showed that Mexico's economy will grow due to NAFTA, leading to an increase in CO_2 emission. However, structure of production and final consumption will shift away from sectors that are the most CO_2 intensive. Perroni and Wigle (1994) developed a general equilibrium model with local and global

environmental externalites, and showed that trade had little impact on environmental quality. Further, the magnitudes of the welfare effects on environmental policies were not significantly affected by changes in trade policies. Also, the size and distribution of the gains from trade liberalization may be little affected by changes in environmental policies. The effects of trade protection on chemical production were studied using data from less developed countries (LDC) (Hettige et al., 1992). They suggested that the toxic intensity of LDC manufacturing output rises with both higher tariff and non-tariff barriers on chemical imports. Also, outward oriented, high growth LDCs had slow-growing or even declining toxic intensity of manufacturing, while it increased more rapidly in inward oriented economies. Lee and Roland-Holst (1997) used data for the period 1965–1990 for Japan and Indonesia and analyzed the interaction between trade and industrial pollutants (particulate, SO_2, NO_2, lead, VOC, CO, BOD, suspended solids, toxic release, bio-accumulative metals) using a two-country, applied general equilibrium model. Results indicated that export oriented growth would harm the economy when the country has comparative advantage in dirty industries. Also, trade liberalization may lead to an increase in real income of Indonesia, and may increase emission from all major industrial pollutants. Therefore, a combination of trade liberalization and cost-effective tax policy could improve the country's welfare and environmental quality.

3. Trade, environment and development

The perplexing interactions between economic development, trade and environment address issues such as: economic development and its environmental consequences; effects of pattern, composition and terms of trade on economic development and related environmental impact; and impacts of environmental regulations on economic development and terms of trade. Economic development, trade and environmental systems can be analyzed effectively through resource allocation. The following aspects are crucial in such analysis: the extent to which allocation principles are derived from trade and development theory; different approaches for measuring optimal resource allocation, applicability and environmental effects, and their related political and policy implications. A country's income level and social and political structure play an important role in the public's concern for environment. Trade policies are crucial for sound economic development, industrialization and efficient resource allocation (Chenery, 1961; Evans, 1989; Office of Technology Assessment, 1992; Repetto, 1995; Krueger, 1997). Also, national and international economic policies and national environmental issues are not separable (d'Arge, 1971a).

3.1. Environmental Kuznets curve

During the past few years, attempts have been made to link trade and environmental quality through developmental parameters. The environmental Kuznets curve (EKC), or inverted U-shape relation between environment and income, suggests that environmental damage increases at lower income levels, reaches a maximum level and declines thereafter. This maximum level varies with sources and types of pollution. EKC is based on the Kuznets curve, introduced by Kuznets (1955) to predict income inequality during a country's economic growth and influencing factors. However, this notion was eventually revealed to be deceptive (Beghin et al., 1994). Park and Brat (1995) analyzed the global Kuznets curve and showed that global inequality among nations has worsened over the period 1960–1988, despite rising income. Also, it is not clear if every country will follow the sequence of stages implied by Kuznets curve.

Radetzki (1992) proposed the intensity use hypothesis that high per capita income correlating with technological progress will often reduce the environmental damage per unit of output. He constructed an inverted U-shape curve by plotting intensity of environmental wear against per capita gross domestic product (GDP). The peak of environmental wear was hypothesized at an income of about \$5000–\$6000 per capita. Grossman and Krueger (1991) and Grossman and Krueger (1995) used global environmental monitoring sys-

tem (GEMS) data to address the relation between per capita income and various environmental indicators, and validated EKC empirically. The peak was $5500 for SO_2 and smoke. Later using much reliable data, they revised the peak to $8000. Selden and Song (1994) obtained the EKC relation using the same GEMS data set, but at a much higher income level. The simulation results of this study raised concerns since it showed an overall increase in air pollution (particulate, SO_2, NOx, CO) level for the next several decades.

Lopez (1994) and John and Pecchenino (1994) showed theoretically that under certain conditions the EKC relation between pollution and income can be obtained. Stern et al. (1996) and Thompson and Strohm (1996) expressed valid limitations of EKC with respect to theory and methodology in estimating such a relation. Stern et al. (1996) carried out simulations based on earlier estimations of EKC to show that emissions of SO_2 will continue to increase globally up to 2025. Hilton and Levinson (1998) identified the EKC relation between automotive lead emissions and national income (peak around $7000), using data from 48 countries for 20 years. They showed that income growth is not solely responsible for environmental patterns. Other factors such as government policies and technology are equally important. Lucas et al. (1992) examined changes in the international distribution of pollution intensity arising from the sectoral composition of industry. They analyzed the EKC with respect to pollution intensity of manufacturing sectors. The results indicated an inverse U relation between GDP per capita and toxic emissions from manufacturing relative to GDP, but not for high income. Hettige et al. (1992) showed that industrial toxic pollution intensity per unit of GDP has an inverted relation with per capita income, but not for intensity per unit of industrial output. Thus they concluded that the GDP-based intensity result is due solely to a broad shift from industrial sectors toward lower polluting service sectors as development proceeds. Shafik (1994) investigated the relationship between various indicators of environmental quality and income (measured as purchasing power parity) using data from 149 countries for the period 1960–1990. He showed that environmental indicators such as water and sanitation improve with income, others (particulate and sulfur oxides) worsen and then improve, while some others (carbon emissions, municipal wastes and dissolved oxygen) deteriorate steadily.

Though these studies have discussed the hypothesis of EKC, none have addressed the causes of such a relation and the influencing parameters. Trade has broad implications for real income, output, employment and economic growth, which in turn have bearings on structural change and adjustment. Kaufmann et al. (1998) suggested that the spatial intensity of economic activity, rather than income, provides a better measure of policies and technology for SO_2 reduction. Torras and Boyce (1998) showed that literacy, political rights, and civil liberties strongly affect air and water quality in some low income countries. Rothman (1998) showed that for consumption-based pollution (CO_2 and municipal waste) the EKC characteristic is invalid. Hettige et al. (1997) used country level data to show that the EKC hypothesis is rejected for industrial water pollution. De Bruyn et al. (1998) showed that decline in emission in some developed countries is due to technology and structural changes of the economy. They argued that since the process of development differs among countries, the generalization of the EKC pattern as ascertained by previous studies is inappropriate. The problems associated with concept and empirical implementation of the EKC are such that its usefulness is limited to the role of a descriptive statistic (Stern et al., 1996). Linking environmental quality through developmental parameters will be inappropriate since they differ among countries (Holtz-Eakin and Selden, 1995; de Bruyn et al., 1998; Unruh and Moomaw, 1998). Though intuitively important, the EKC relation offers no information about the actual chemistry of the interactions between development and environment that is crucial for policy measures. A complex combination of technical change, market structure, income effects, public demand for environmental quality and political systems has significant impact on pollution intensity (Barbera and McConnell, 1990; Bailey, 1993; Beghin et al., 1994). Also, the assumption behind EKC that

environmental damages are reversible is not true for all types of pollution (Dasgupta, 1995).

3.2. Income, trade, energy and environment

Using a static, two-country (differentiated by income) general equilibrium model, Copeland and Taylor (1994) analyzed the linkage between national income, pollution, and trade. They showed that income gains from trade can affect pollution in a different way than those from economic growth. Free trade, like growth, raises real incomes, but it also changes the composition of national output and therefore alters the incidence and level of pollution. If the pattern of trade-induced specialization is driven only by differences in pollution policy, then aggregate world pollution may rise with trade. If income level differs between countries, then a movement from autarky to free trade will increase world pollution (Copeland and Taylor, 1995b). Also, the effects of economic growth and relative price changes on environment depend on the nature of the resource stock effects on the production and/or whether individual producers internalize such stock effects (Lopez, 1994). Stephens (1976) used neoclassical growth model to show that when firms are subjected to adequate pollution control measures, income will grow exponentially with constant (or improving) environmental quality. The trading system has contributed to the environmental problems in many ways, especially in developing countries (Røpke, 1994). However, income effect of trade does not dominate the pollution effect (Thompson and Strohm, 1996). With a dynamic, two-sector trade model, Copeland and Taylor (1997) showed that free trade under certain circumstances will increase pollution while reducing environmental quality and real income, thereby proving the trade-induced environmental degradation hypotheses.

So far, the most poorly discussed issue regarding trade and environment is their link to energy. Energy is the backbone of economic development; it plays a pivotal role in trade and contributes to national and global pollution. The direct and indirect energy inputs have a profound effect on the economy and should be included in the trade analysis (Office of Technology Assessment, 1990). Eliminating trade barriers in energy sectors has significant economic and environmental impact. Trade enhances the role of markets and causes structural changes, which in turn alter the resource allocation, reduce market distortions, increase energy efficiency and decrease pollution (Lucas et al., 1992; Plourde, 1993; Jayadevappa, 1996). Some of these issues were discussed in case studies of NAFTA and it was concluded that the energy sectors will benefit in terms of efficiency and access to larger markets due to NAFTA (Lemco, 1989; Foss et al., 1993; Gordon, 1993; Hogan, 1993; Kaufmann et al., 1993; Kessel and Kim, 1993; Plourde, 1993; Randall, 1993; Rubio, 1993; Verleger, 1993; Watkins and Waverman, 1993; Rubin and Dean, 1996). Bustani and Cobas (1993) analyzed the effects of natural gas imports on air pollutants in Mexico. They argued that access to cleaner energy markets, such as natural gas, may reduce emissions from industrial and power sectors in Mexico. Suri and Chapman (1998) investigated the relation of EKC with energy consumption and showed that for industrialized countries imports and exports play a crucial role in the pattern of EKC.

4. Environmental regulations and trade

Judicious policy design is central to the study of externalities (Hahn and Stavins, 1992; Hahn, 1994). Regulatory responses to environmental concerns have important implications for trade (Pethig, 1976; Dasgupta et al., 1978; Rubin and Graham, 1982; Baumol and Oates, 1988; Krutilla, 1991; Bhagwati and Hudec, 1996). Evidence shows that there are fewer future inexpensive measures to improve environmental quality (Jorgenson and Wilcoxen, 1990). Many have addressed policy interventions and their ranking for safeguarding the environment, and this remains an important topic in the trade arena (Markusen, 1975a; Krutilla, 1991; Copeland, 1994; Copeland and Taylor, 1995a, 1997).

Using standard trade models, studies have shown that in countries with stringent environmental regulations, environmental control costs

encouraged reduced specialization in the production of polluting outputs (Siebert, 1974; Pethig, 1976; Asako, 1979; McGuire, 1982; Baumol and Oates, 1988; Rauscher, 1994). Magee and Ford (1972) used partial equilibrium trade models to study the effects of various pollution taxes on terms of trade and trade balance. They showed that production pollution taxes are less ambiguous than consumption pollution abatement. Chapman (1991) analyzed the need for an environmentally related import tariff on pollution intensive industries such as copper and automobiles. He argued that such tariff measures are valuable, lacking uniform global environmental regulations. The economic impacts of selected environmental policies were analyzed by Merrifield (1988) and impact of environmental tax/subsidy policy on the terms of trade by Krutilla (1991). Copeland (1994) analyzed the welfare effects of trade and environmental policy reforms using a standard model of a perfectly competitive, small, open economy. He compared the reforms in tax regimes and mixed regimes, where some pollutants are regulated with taxes and others with quotas. Low and Safadi (1992) showed that an economically efficient hierarchy of interventions can be established to internalize environmental externalities.

Most of these studies have assumed constant returns to scale and/or a perfectly competitive market structure, thus eliminating the strategic element. It is well known since the work of Brander and Spencer (1985) and Dixit (1988) that the optimal trade policy for oligopolistic industries is not necessarily laissez faire. Also, an emission tax rate that is appropriate for the pure competitor may not induce behavior that is consistent with optimality in the second-best world inhabited by a monopolist (Baumol and Oates, 1988). Conrad (1993) used an oligopoly model with negative externalities in production to analyze the effects of emission tax and subsidy in an imperfectly competitive international market. He showed that the structure of environmental regulations should be modified to reflect the existence of trade under imperfect competition and this has incentives to introduce subsidies in environmental policy. Kennedy (1994) examined the strategic incentives to distort pollution taxes in a free trading economy with imperfect (oligopoly) market condition. He argued that an imperfect competition in global markets creates strategic interaction between governments with potential for inefficient distortion of pollution taxes. Barbier and Rauscher (1994) argued that if importing nations want the exporting countries to conserve more of their forests, trade interventions are a second-best way of achieving it. However, increased market power by a large exporter may actually lead to greater forest conservation. If the domestic industry is a monopoly and the foreign industry is imperfectly competitive, then the domestic government has an incentive to set a weak environmental standard (Barrett, 1994). Therefore, differential environmental regulations can alter the competitiveness of a country in an imperfectly competitive market environment. In non-competitive markets, one must look beyond simple analysis of how environmental policy affects production costs, and consider its effects on the strategic behavior of producers (Ulph, 1996).

4.1. Environmental regulations and competitiveness

Siebert (1974), Pethig (1976), McGuire (1982) and Krutilla (1991) found that strict environmental standards weaken a country's competitive position in pollution intensive industries and diminish its exports. McGuire (1982) extended the HO model to incorporate environment as a factor of production and analyzed the effects of environmental regulations in regional and global context. He concluded that for local environmental damage, relocation of industry is desirable from an efficiency standpoint. Differential regulations will transfer polluting production processes to regions of low utility cost. Also, for inter-country pollution, unilateral regulation is inefficient and ineffective. However, these theoretical predictions have little empirical support. For example, Tobey (1990) tested the hypothesis that environmental regulations have altered the pattern of trade in goods produced by 'dirty' industries. He found that a qualitative variable describing the stringency of environmental controls in 23 countries

fails to contribute to net exports of the five most pollution intensive commodities. Similarly, Walter (1974a) and Leonard (1988) found no empirical evidence for the claim that pollution costs have influenced the location decisions of multinational firms. Also, few studies have found the differences in environmental regulations and control costs explaining the pattern of trade between countries (Jaffe et al., 1995).

Markusen et al. (1993) demonstrated that plant location and market structure can be a function of environmental policy, by considering the resulting non-cooperative equilibria of a game between the regions. They looked at environmental quality and government competition, given that two regional governments can compete with environmental policies when plant locations are endogenous. Ulph (1994) extended this model and showed that the impact of environmental policy was much greater than the earlier estimates of competitive models. Competition between the two governments to restrict pollution and exploit monopoly power will result in highly restrictive policies and very low levels of pollution and trade. Using an oligopoly trade model between two similar economies, Markusen (1997) showed that stringent environmental regulations give the multinational companies little incentive either to increase production or to relocate. However, Ulph and Valentini (1997) used a game theory model with inter-sectoral linkages to analyze the impact of environmental regulations on location of imperfectly competitive firms. They showed that under certain circumstances, environmental regulations might affect relocation of industries between countries.

Competitive impacts of environmental regulation on US manufacturing have been assessed since the early 1970s. The majority of these studies concluded that environmental regulations lead to relatively small cost increases for producers. Some studies failed to find any relation between environmental regulation, trade and investment. Robison (1988) showed that a 1% increase in environmental cost would reduce the US balance of trade by $6.5 billion during 1982. The economy-wide effects of environmental control regulations are generally small or non-existent, though some studies have suggested significant sectoral effects. For example, the Commerce Department found no relation between environmental control costs and overall trade patterns. However, the report argued that 16% (1974–1987) of the increase of US copper imports was attributed to additional environmental controls on the US copper industry (Office of Technology Assessment, 1992).

4.2. Migration of 'dirty' industries

The change in comparative price advantage suggests variations in potential trade flows and location advantage (Siebert, 1992). The question is how differences in environmental regulations influence the in-migration of dirty industries. Copeland and Taylor (1995b) argued that under certain circumstances the pollution intensive industries migrated to countries with weaker environmental regulations. However, empirical results are unable to support this claim. Birdsall and Wheeler (1992) found that dirty industries developed faster in relatively closed Latin American economies than in the open ones. Low and Yeats (1992) used revealed comparative advantage (RCA) technique to determine the magnitude of location pull of dirty industries toward developing countries. They showed that developing countries have a stronger tendency to develop RCA in polluting, as opposed to non-polluting industries. Low (1992) identified a list of 123 dirty industries in the USA and Mexico, and showed that their pollution abatement and control expenditures (PACE) and export earnings are small compared with their total output. He analyzed if PACE equalization tax can correct the effects of increased imports of pollution intensive products and concluded that this would be a bad environmental and trade policy.

Beghin and Potier (1997) used empirical findings to argue that trade liberalization will not cause the developing countries to specialize in dirty industries. Lucas et al. (1992) showed that the pollution intensity (of toxic emissions) and number of 'dirty' industries grew rapidly in developing countries between 1960 and 1988. The drop in industrial emissions at higher income levels is

due to a declining share of the manufacturing sector in GDP rather than a shift toward cleaner technology. Also, stricter environmental regulations did not discourage investment given their insignificant contribution to the production cost. Other studies have used input–output and multisector macro-econometric models to assess the magnitude of effects of environmental control on trade (d'Arge, 1971b; Robison, 1988; OECD, 1993). These studies used costs of pollution control programs on an industry basis and found small but measurable effects. An OECD (1993) report found that pollution control measures in France, Netherlands, and the USA may have reduced the level of total exports by one-half to 1%. Industrial location studies (Walter, 1975a; Pearson, 1985, 1987; Leonard, 1988) found little evidence that pollution-control measures exerted an impact on trade and investment.

4.3. Trans-boundary environmental issues

Trans-boundary or inter-country pollution represents an externality between countries and implies a distortion in sharing of common resources. Copeland and Taylor (1995a) examined how welfare and pollution levels are affected by free trade, international income transfers and trans-boundary environmental agreements. They showed that with differential income levels between countries, free trade will increase world pollution. Siebert (1992) analyzed cooperative and non-cooperative solutions for trans-boundary pollution problems and showed that an optimal solution can be reached through cooperation with side payments. In case of trans-boundary, non-cooperative pollution problems, a tariff on imports of the good produced by the offending country will be nationally optimal policy (Markusen, 1975a). Copeland (1996) presented a two-country, trans-boundary pollution model where governments have incentives to use trade policy to control foreign pollution. Since the country suffering from foreign pollution cares about its level and intensity, a tariff alone cannot adequately address this problem. Therefore, pollution content tariffs or process standards applied to imports may be an optimal solution.

Bilateral agreements by the USA and Canada are necessary to solve the common air shed environmental problems facing North America (Munoz and Rosenberg, 1993). Ludema and Wooton (1994) used a two-country, non-cooperative game model in a commodity whose production creates a negative externality for the importing country and analyzed the nations' strategic policy choices. They proved that in Nash equilibrium both countries impose tariffs in an attempt to exploit their monopoly power in trade, and as a result the externality is always overcorrected. Accordingly, multilateral trade liberalization may be an inappropriate goal for international negotiations. Therefore, new policy instruments directed at the externality are needed to guarantee welfare gains from trade (Sanchez, 1990; Mumme, 1994; Mumme and Duncan, 1996).

4.4. Harmonizations of environmental standards and international organizations

Although evidence for harmonization of environmental measures does not exist (Krugman, 1997), there is a strong political urge to do so. If all countries adopt uniform environmental regulations, then only by chance are the resulting trade patterns efficient (d'Arge and Kneese, 1972). Such adoption would decrease the global social welfare. Countries are not identical and need not base their environmental policies on multilateral approval (Charnovitz, 1992a,b). A cooperative imposition of national production taxes will not guarantee Pareto efficiency. However, transfer payments in connection with cooperative tax adjustments will produce such a solution for international common property resources (Markusen, 1975b). Ulph (1996) ascertained no theoretical justifications for harmonizing environmental regulations between countries. International cooperation is necessary to control global pollution (Barrett, 1990), but this cannot justify uniform environmental standards that might reduce welfare and distort trade (Majocchi, 1972). It is very difficult to set a uniform standard that will be optimal to all countries (England, 1986; Mäler, 1990; Pearce et al., 1992). However, Steininger

(1994) argued strongly for international harmonization of environmental regulations, especially to deal with competitiveness caused by transnational and global environmental problems. Also, there is a need for an international environmental regime to alleviate the market failure and the corresponding political failure (Esty, 1994).

International institutions dealing with trade and environment have acted in isolation until recently. The growing conflicts between trade and environment suggest that this isolation is no longer desirable (Arden-Clarke, 1992; Uimonen, 1992, 1995; Zaelke et al., 1993; French, 1994; Eglin, 1995; Beghin and Potier, 1997; Ferrantino, 1997). Sorsa (1992), Young (1994) and DeBellevue et al. (1994) proposed several institutional mechanisms for incorporation in GATT and NAFTA to achieve complementarities between trade and environmental quality. Husted and Logsdon (1997) studied the impact of NAFTA on Mexico's environmental policy and concluded that it had a positive and indelible effect. Lee (1994) analyzed the relation between environmental protection and trade through process and product standards and called for GATT to take initiative in identifying these linkages. Distinguishing between product and process standards is important and the emphasis on the product in trade law is suited for creating trade and environmental policy (OECD, 1994).

Daly and Goodland (1994a), Daly and Goodland (1994b) and Daly and Goodland (1994c) discussed various implications of free trade for the environment and economy. They stressed government intervention to achieve equity, efficiency and environmental quality through trade and called for GATT reforms to address these concerns (Moltke, 1994). Costanza et al. (1995) argued for transparency in international trade and the need for institutionalizing these problems at the international level. Cole et al. (1998) analyzed the effects of Uruguay Round on five air pollutants and concluded that because of pollution intensive output in developing and transition countries, air pollution may increase due to this trade agreement. Using a global general equilibrium model, Whalley (1991) showed that global carbon limitation measures will have profound implications for the international economy. The problem arises when environmental and trade policies compete to enhance the welfare of the society. The environmental problems diffuse easily, skip the political boundaries and assume global scope. However, trade measures are the result of political willingness or agreed cooperation between the trading partners in the hope of enhanced social welfare. Making trade organizations aware of environmental problems, while retaining their ability to prevent nations from erecting trade barriers in the name of environment, is a challenge for policy makers. Also, coordination of environmental policy is necessary to achieve 'socially efficient' trade (Ekins et al., 1994; OECD, 1996; Beghin and Potier, 1997). Brack (1996) in his report examined the interaction between trade and environmental protection with respect to the Montreal Protocol. He argued that the trade provision of the Protocol, which requires trade restrictions between parties and non-parties, is a crucial element for its success in terms of its global agreement and preventing industrial migration to non-parties. Using an intra-industry trade model, Barrett (1997) showed that trade sanctions will reduce welfare (globally) and unilateral trade sanctions should not be the first preference tool to solve global/local environmental problems or practices (Charnovitz, 1994). Therefore, while dealing with global environmental problems the multilateral trading system should not allow signatories to impose sanctions simply because it serves their own interest in a particular instance. Sanctions should be permitted only if they satisfy certain general principles leading to reduction of global environmental pollution. Therefore, before a country imposes trade sanctions on the pretext of multilateral protocol, it is important to analyze and judge the protocol itself (Bhagwati, 1993, 1995; Charnovitz, 1996).

5. Conclusions and discussion

The trade and environment debate continues despite vast research. The dynamic and intricate nature of the problem and its complex interactions pose a challenge. The existing studies have

revealed some linkages between trade and environment, especially in the context of conventional trade theory:

(1) Several studies point to the reinforcing character of trade that has positive implications for welfare and environmental quality. Correspondence between environmental costs and export prices is not simple (d'Arge and Kneese, 1972) because of other influencing factors such as scale of economy, technology and politics. Many interactions between different types of pollution, their sink and assimilative capacity need to be analyzed using the general equilibrium approach.

Does free trade cause environmental degradation? Is there a link between environmental degradation and trade barriers? What is EAC and how is it measured? Does EAC vary with country and income? What is the impact of EAC and property rights on the pattern of trade? These evaluations need a stronger trade-based foundation. Whether market failure or government policy is the cause of environmental problems remains unaddressed. Further research on using new trade theory to address environmental consequences is needed. The existing research emphasizes the importance of interactions between trade reforms and environment and their relation to property rights. However, these interactions need further research.

(2) Trade is an important means for development, whereas bad developmental policies lead to environmental problems. Currently, very little knowledge and agreement on the nature of interactions between trade theories, development process and environmental quality exist. Some elements of environment appear to improve with trade and growth, while others deteriorate. Though simple in nature, EKC offers no help in understanding the chemistry between the process of economic development and environmental quality. Gray areas surround trade and development theory, such as the role of trade in the process of development, effects of different development objectives and instruments on trade and desired trade patterns. All these issues have profound impacts on environmental quality.

(3) Environmental regulations in the context of trade in an increasingly globalized world economy are complicated and necessitate environmental policy reforms. Existing studies have shown that the structure of environmental regulations should be modified to reflect the existence of trade under imperfect competition. Trade policies with imperfect competition provide an input to the design of environmental policy (Carraro et al., 1996). Therefore, further research on the interaction between new trade theory and environmental regulation is needed. Also, how the environmental regulations will affect competitiveness and location decisions in these conditions needs theoretical and quantitative analysis. Awareness of the trade off among the second best policies and their significance for environment will facilitate efficient policy implementation. Under what circumstances are environmental goals legitimate grounds for suspending the trade rules? Should trade considerations over ride environmental ones in any case? Who should make these decisions (importing/exporting countries, or international organizations)? These questions are appearing frequently in trade arenas and need detailed assessment.

(4) The GATT report on trade and environment rejects concern for competitiveness as a basis for environmental trade measures. Interest in competitiveness distracts attention from the real economic problems, particularly low productivity growth (Krugman, 1994). Many studies have concluded that differences in environmental compliance costs are rarely a serious competitiveness factor (Leonard, 1988; Kalt, 1989; OECD, 1993; Jayadevappa, 1996). Environmental quality and productivity are positively correlated (Jayadevappa, 1996), and bad resource management may cause over exploitation, hamper productivity and result in a loss in competitiveness (Brander and Taylor, 1997). The issues of competitiveness and relation between productivity and environmental quality need further research.

(5) Policy coordination between developing and developed countries is vital to minimize environmental costs. However, the challenges differ: the developing countries face the challenge of minimizing pollution level while the developed countries that of reducing it. Both activities require coordination among the countries. The reason for North–South trade and environmental disputes is the reliance on political rather than economic/

technological solutions. The intensity and type of environmental measures vary across issues and countries. Therefore, harmonizing environmental measures creates an inefficient atmosphere. To assume that trade restrictions will either improve or reverse the environmental damage is a serious mistake (Eglin, 1995). Trade and environmental programs must continue without hindrance by unjustified unilateral decisions that could result in production and consumption inefficiencies of international scope (d'Arge and Kneese, 1972; Subramanian, 1992; Bhagwati, 1993). Making countries concerned about the environment, while preventing them from erecting new trade barriers under its pretext, is an important challenge. Global environmental measures that affect the issues of trade between countries require more scrutiny. Countries must have the leeway to set their own policy goals and levels of protection. Also, usage of trade policies as instruments to enforce global environmental objectives needs assessment. How these issues interact is an important puzzle to be solved in years to come.

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