TRADE, FORESTRY, AND THE ENVIRONMENT: A REVIEW

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ABSTRACT

Despite an extensive conceptual literature on trade and environment, empirical work remains limited. Forest products and their distinguishing market characteristics have received little attention within this literature. The theories of comparative advantage and externalities link trade and environmental economics, providing a framework for analyzing the environmental effects of freer trade and the trade effects of environmental restrictions. The review assesses the state of the forest economics literature on these issues, suggesting empirical work to support more informed deliberation of trade and other forest sector policies.

Keywords: Comparative advantage, environment, forest products, international, trade.

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INTRODUCTION

In the last ten years, a growing literature has explored the links between international trade and the environment. To the extent that it has addressed forestry, this literature has focused on the tropical timber trade and on log export policies in the Pacific Northwest of the United States. Yet links between trade, the forest sector, and the environment affect most countries in important ways. The purpose of this paper is to summarize the main developments in the economics literature that addresses the relationship between trade and the environment and to assess the state of knowledge of this relationship, stressing in particular the links between trade and the forest.

Initial interest in the connections between trade and environment was prompted by the fear that environmental regulations enacted in the 1970s would harm firms' competitive position. A number of economic studies followed,

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the general finding of which was that, while in principle domestic environmental regulations might reduce a country's comparative advantage in particular products, in practice the effect is small[1].

More recently the opposite relation, i.e. the impact of trade on resources, has also become the subject of research and policy debate. This debate is the product of a second wave of environmentalism and the accompanying interest in sustainable development. The large increase in the volume of world trade since the 1970s[2] has been a major factor in concern that international trade may be partly to blame for unsustainable patterns of development. In particular, effects on the location of polluting industries and on resource use in primary commodity exporting countries are often cited as adverse effects of freer trade.

Observers of international trade have expressed sharply differing views on whether greater trade among nations is good or bad for the environment. Arguments that trade is harmful hold, for example, that ever greater integration of the international economy reduces local self-reliance, increasing production instability; that it encourages greater consumption of natural resources; that it robs nations of the ability to govern environmental issues within their own borders; and that Northern countries use their historical economic advantage over the South, in effect making them do the dirty work. Some opposing arguments are that trade enhances environmental quality by increasing global wealth, enabling poorer countries to afford environmental protection; that greater wealth increases willingness to pay for environmental quality; and that international trade facilitates the exchange of more environmentally benign technology.

[1] In addition (and in contrast) to this work on the potentially negative effects of environmental regulations on comparative advantage, a counter-literature has emerged arguing that environmental regulations may in fact enhance a country'is competitive position by prompting innovations in production that would both decrease negative externalities and decrease costs or increase output efficiency. See Porter & van der Linde (1995) for a recent exposition.

[2] Paul Krugman (1996) offers an interesting caution against thinking of the global economy as a recent phenomenon, noting for example that "world trade as a share of world production did not return to its 1913 level until about 1970" and that "net international flows of capital made up a considerably larger share of world savings in the years preceding World War I than they have since, even in the 'emerging market' boom of the last few years."

Views on the links between trade and environment often reflect the differing intellectual predilections of economists and ecologists. Economists generally argue that trade itself is environmentally neutral, but that it alters existing environmental problems attributable to market or government failures. To economists, the relevant questions are how the societal costs of trade may be reduced efficiently and whether they outweigh the benefits. Increasing trade affords nations more wealth with which to protect their environments, and reduces the urgency of resource exploitation for short-term gain. Economists have therefore tended to believe that (with certain important caveats) freer trade leads to desirable environmental outcomes (Runge, 1993), and ecologists that it implies greater environmental and resource degradation (Morris, 1990; Shrybman, 1990b). Economic analysis does not, however, unambiguously support the superiority of free trade, and a number of economists have made ecological arguments against it.

Interactions between trade and environment have led to extensive analysis of trade policy as a tool for reaching environmental policy goals (Beghin *et al.*, 1994). However, the diffuse nature of the hypothesized links, and the complexity of the interactions, has limited empirical investigation (Dean, 1992a). While there is a general consensus among economists that policies addressing environmental externalities directly are more efficient than trade policies in achieving environmental ends, few empirical studies of the relative efficiencies of different policy options exist. The literature is clearer on the costs of trade losses due to environmental regulations, which have been shown by several studies to be small.

This imbalance in the environmental economics literature appears in the forest economics literature as well. A number of studies have addressed the impact of domestic forest policies on trade and welfare, but few have explored directly the environmental implications of trade policies. Deforestation, with its implications for human welfare, wildlife, and climate, has been commonly associated with the international timber trade. However, most deforestation is due to conversion of forestlands to other uses, not to forestry sector activities themselves (Burgess, 1993). Other environmental concerns relating to the forestry sector include the chlorine bleaching of paper products, the

recycling or disposal of wastepaper, and the role of the forest in carbon sequestering[3]. Trade in forest products, or in other sectors that affect forests, potentially influence these issues.

The approach of this paper is to present forestry issues against the backdrop of the more general literature on trade and environment, most of which has addressed agricultural trade and manufacturing pollution. The next section relates the trade and environmental economics literatures at the conceptual level, emphasizing the theories of comparative advantage and externalities. This is followed by a review of the empirical literature on links between trade and environment, including work on the forest sector where available. It first addresses the impact of trade on environment, an area in which relatively little work has been done on the forest sector. It then reviews writings on the effect of environmental and resource policies on international trade, a topic addressed by several forest sector studies, and the suitability of trade restrictions for meeting environmental goals. The conclusion assesses the forest economics literature in the context of the broader literature on trade and environment, and offers suggestions for empirical research.[4]

THEORY OF THE TRADE-ENVIRONMENT LINKAGE

Environmental economics has evolved largely in isolation from international economics, with the result that the two literatures address different questions and employ different methods (Sutton, 1988). While environmental and resource economics has dealt primarily with optimal resource use, externalities, and non-market valuation, trade theory has concerned itself with the causes of trade and international specialization. Nevertheless, resource endowments play a central role in trade theory, as the basis of comparative advantage in the Heckscher-Ohlin framework. Similarly, the theory of externalities, one of the fundamental analytical tools of environmental economics, has implications for trade theory.

[3] Good overviews of the environmental aspects of forestry sector activities are available in de Steiguer (1989) and Barbier (1994), while Adamowicz *et al*. (1993) provide a book-length treatment.

[4] Readers may find, as we did, previous surveys helpful, especially those of Sutton (1988), Anderson & Blackhurst (1992), Low (1992), Beghin, Roland-Holst & van der Mensbrugghe (1994), and Jaffe, Peterson & Portney (1995).

Trade Theory and Resources

Comparative advantage drives countries to specialize in goods and services they produce relatively more efficiently than their neighbors. David Ricardo's original conception of comparative advantage based on technology alone has given way to a richer notion of comparative advantage recognizing the importance of resource endowments, input costs, tastes, and market structure (Leamer, 1994). Resource endowments play a critical role in the Heckscher-Ohlin model, the cornerstone of modern trade theory. The Heckscher-Ohlin theorem holds that greater abundance of a factor leads to more intensive use of that factor, i.e. that comparative advantage in the production of some good leads to specialization in that good, hence more intensive use of the resources needed for its production.

While resources have played an integral role in trade theory from its inception, only recently were the characteristics of natural resources (as opposed to manufactured capital) explicitly recognized to explore how specialization and trade patterns might differ from the standard Heckscher-Ohlin model[5]. Early works that examine the effect of resource exhaustibility on specialization are Harris (1981) and Kemp & Long (1980). Abbott & Haley (1988) describe the evolution of models from those that predict complete specialization (until resource exhaustion) to more general models. Kemp & Long (1982) demonstrate, for example, that complete specialization may not occur given exponentially rising resource prices.

In addition to demonstrating the ability of the Heckscher-Ohlin framework to accommodate natural resource characteristics, recent research has shown that two standard theorems of the trade literature hold in the presence of natural resources (Segerson, 1988; Abbott & Haley, 1988). The Stolper-Samuelson theorem states that the price of inputs used in the production of a traded good increases as the price of the traded good rises. The Rybczynski theorem states that, given constant commodity prices, an increase in the supply of a scarce input leads to a shift in

[5] Abbott & Haley (1988) provide a useful study of the relation between trade theory and resource issues, and much of this section is based on their work.

production toward commodities that use that input more intensively. While these are rough statements of the theorems, which rely on rather restrictive technical assumptions, they capture the heart of the framework of Heckscher-Ohlin analysis (Abbott & Haley, 1988). The Stolper-Samuelson theorem suggests that changes in real international forest product prices will change stumpage values, which may have significant impact on forest management. The Rybczynski theorem suggests that, commodity price changes aside, an increase in the supply of stumpage will lead to an increase in wood products output, a potentially important insight in light of the rapid development of plantation forestry.

While this research shows that trade theory can accommodate dynamic natural resource issues, the patterns of specialization predicted with these dynamic extensions is more varied, making testing and prediction more difficult. For example, countries that are rich in a natural resource may not export that resource if they believe there is a strategic advantage to later exploitation (Segerson, 1988). A related literature explores the implications of market imperfections and market power in resource trade, as when a small group of producers is able to form a cartel. For example, Kemp & Ohyama (1978) develop a model in which resource-poor countries are able to exploit resource-rich countries when the latter lack processing capacity. Recently, many economists have studied the effects of market structure on trade. This work is important to commodity trade, commonly conducted in oligopolistic and oligopsonistic markets[6]. These theoretical links between trade theory and resources raise policy questions. Theory suggests that changes in timber inventory or real price level can affect the level and distribution of resource use. Further, the work on market structure and trade raises questions regarding the creation of comparative advantage and the management of market power. The section on "Trade and the Forest Resource", below, describes the state of the empirical work that might support policy analysis of these issues.

[6] Helpman & Krugman (1989) and Smith (1994) provide useful surveys of the major issues and results in this litterature.

Externalities and Trade

The theory of externalities provides the framework for most of the literature on the environmental effects of trade policies. Runge (1993) and Binswanger (1991) argue that trade affects the environment through externalities due to market and government failures. Trade policies may therefore contribute to environmental degradation or enhancement, depending on how they influence existing externalities."

Segerson (1988) classifies externalities susceptible to the influence of international trade as intratemporal and intertemporal. Short-lived pollution problems are a typical example of the former, while dynamic resource issues such as forest harvest rates are an example of the latter. Each of these may be further categorized as domestic or international, i.e. whether the externality takes place across national boundaries or not. The standard policy prescription related to externalities, based on the work of Pigou, holds that the socially efficient level of pollution (the level which maximizes the sum of producers' and consumers' surplus) is reached by forcing the party generating the externality to pay for its cost. It is efficient for the government to require the polluter to pay because the polluter then maximizes its own welfare subject to the full social cost of pollution. The difficulty with this prescription is that transfers from the polluter to the victim must be determined and then made.

Based on Pigovian theory and her taxonomy of externalities, Segerson assesses the usefulness of trade policy to achieve environmental goals as follows. When the externality is intratemporal and *domestic*, it is efficient for each government to force polluters within their own borders to pay the cost of the pollution. But even when each country implements efficient policies, high pollution assimilative capacity, or low valuation of environmental quality, may lead countries to adopt different standards, conferring a cost advantage to those with lax environmental policy (Perroni & Wigle, 1994; Copeland & Taylor, 1994). When one country adopts this efficient policy and another allows the pollution to continue at greater-than-efficient levels, the refusal to force polluter payment amounts to a subsidy (Shrybman, 1990a; Andersson, Folke & Nystrom, 1995).

When an externality is intratemporal and *international*, achieving the socially optimal level of pollution is even more difficult. In this case policies that achieve the socially efficient level of production in the country generating the externality will not be efficient from an international point of view, since this country does not take into account the costs inflicted on other countries. Copeland & Taylor (1994, 1995) find that the welfare effects of international trade in pollution-intensive goods are indeed very different depending on whether the associated externalities are domestic or international: trade is always welfare-enhancing when the externalities are domestic and the government adopts an appropriate policy, but this need not be the case with international externalities.

If an externality is intertemporal, socially efficient outcomes again depend on internalizing the external costs, in this case the user-cost of resource depletion, i.e. the loss of future income associated with current use of a resource. Segerson (1988) notes that one of the implications of intertemporal externalities is that static and dynamic comparative advantages differ. For example, a country may falsely appear to have a comparative advantage in timber production because its policies or institutions fail to account for the user-cost of current forest exploitation. Segerson also argues that, even if the intertemporal externalities can be fully internalized, the dynamic nature of resource management links the resources to growing international trade in other ways, such as by establishing a stronger connection between capital markets and trade flows[7], or by inducing resource-rich countries to adopt in-country commodity processing requirements in an attempt to capture more value-added.

The Desirability of Free Trade

Ricardian trade theory suggests that free trade is unambiguously welfare-enhancing as long as external costs are internalized to the appropriate party, be it a nation or a firm. Most economists share this congenial view of trade, while

[7] Since interest rates are a key factor in dynamic resource management decisions.

recognizing, as do Perroni & Wigle (1994), that "the lack of internalization distorts the pattern of comparative advantage, resulting in non-optimal levels of trade." Copeland & Taylor (1994) point out that even in the presence of significant negative externalities, the gains from trade may still outweigh the associated external costs. Further, free trade, by increasing national wealth, may create greater demand for environmental services and provide the means to pay for environmental protection and clean-up (GATT, 1992; Sorsa, 1992). Wheeler & Martin (1992)make a more direct argument in favor of free trade by demonstrating that the reduction of trade barriers can enhance environmental quality through the spread of cleaner technologies.

However, several economists have made arguments, based on environmental or other concerns, that are in varying degrees opposed to free trade. Ekins, Folke & Costanza (1994) offer a four-point argument that the gains to free trade are exaggerated. First, because a shift in developing countries from subsistence to export-oriented agriculture is counted entirely as a gain in GDP, the gains from trade in these countries are systematically overstated. Second, consumption is not the same as welfare, and to base the desirability of trade on consumption criteria alone is misleading. Third, the Pigovian transfers that play a central role in the argument for the welfare-enhancing nature of trade are seldom if ever realized. And finally, specialization induced by trade "represents a serious risk inherent in deep involvement in the world trading system." They also cite several renowned economists on the virtue of trade regulation to make the point that conventional trade theory, contrary to the general perception, recognizes that at times free trade is worse than no trade (Pethig, 1976).

Daly & Goodland (1994) hold that greater economic activity implies greater externalities in production and consumption. They further argue that the assumptions underpinning the standard trade models, in particular those of perfect markets and immobile capital, are not credible. That markets are not perfect makes it impossible to internalize all costs; that capital is highly mobile undermines the theory of comparative advantage, because mobile capital will flow to the use that has absolute rather than relative

advantage[8]. Daly and Goodland conclude that because the assumptions underlying the case for free trade on social welfare grounds are so clearly invalid, the presumption should be in favor of domestic production for domestic consumption whenever practicable. Ekins, Folke & Costanza (1994) note in a similar vein that the conventional trade theory rests on the assumption that firms are price takers, whereas in practice international commodity markets are often dominated by either small groups of producers or small groups of nations.

In sum, the conceptual links between trade and environment imply a range of empirical questions and policy issues, including the role of natural resources in determining trade flows, the impact of trade on the environment, and the role of market structure in influencing this impact. Regarding this last point, Helpman & Krugman (1989) suggest that "the odds may be that external economies are a more important distortion of real-world economies than monopoly power." However, empirical research in the area, and in particular the research related to forestry, is thin, and opinions are strongly divided on some points. Below, we consider the empirical literature first on the effects of trade on the environment, and then on the role of environmental and resource policies in international trade.

TRADE AND THE FOREST RESOURCE

The preceding section has suggested three major issues relating trade and the forest: the connection between trade and forest degradation; the impact of environmental and resource policies on domestic forest industries; and the suitability of trade measures for achieving environmental objectives. This section assesses the applied literature on these links within the context of the more general applied literature on trade-environment links. We consider the major effects trade may have on the forest via timber production, competing land uses, and economic growth, then

[8] Comparative advantage is defined in relative terms, i.e. production in which a country is more efficient relative to other goods. Absolute advantage is defined simply as greater efficiency vis-a-vis another producer. A country may have absolute advantage in every good, but cannot have comparative advantage in every good by definition. Capital mobility in effect makes the idea of comparative advantage moot.

turn to the effect of environmental regulations on trade and the suitability of trade regulations for environmental policy purposes.

Trade and Timber Production

Because timber markets in almost all countries are driven by domestic demand, the link between timber trade and forest degradation is arguably weak. FAO (1995), citing the relatively low proportion of timber harvests traded internationally, concludes that "Trade is not a major cause of deforestation." However, trade in downstream forest products is substantial and could be a significant driver of resource depletion. Applications of forest sector models to international trade have been numerous, particularly in recent years, as interest in the effects of regional trade agreements has grown. Boyd, Doroodian & Abdul-Latif (1993) investigate the impact of US tariffs on timber imports from Canada, concluding that removing the tariffs would result in a 4.5% increase in Canadian softwood exports to the US. Prestemon and Buongiorno (1996) use partial equilibrium trade models to examine the effects of NAFTA on forest product trade in North America, while Boyd & Krutilla (1992) explore the same issue in a general equilibrium framework. These studies demonstrate that changes in trade regulation are likely to have significant effects in the volume of trade and production of at least some forest products, with the potential for concomitant environmental impacts.

A number of studies have addressed the impact of trade liberalization and structural adjustment policies on the tropical forest. Wisdom (1996) presents a stylized model of the welfare gains of liberalizing lumber imports into the Philippines, showing how the elimination of lumber import tariffs can contribute to forest preservation there. Thiele & Wiebelt (1994) contrast the effects on the forest of economy-wide trade liberalization versus agricultural trade liberalization in Cameroon, concluding that the former can enhance both economic performance and reduce deforestation, provided the policy change induces a shift of labor from agriculture to manufacturing. Several researchers have argued that log export restrictions in Indonesia have been economically inefficient and have exacerbated environmen-

tal degradation there by encouraging wasteful resource use (Braga, 1992; Gillis & Repetto, 1988; Manurung & Buongiorno, 1997). Deacon (1995) disputes this conclusion, arguing that employment policy and not log export policy itself is the key element in the link between timber trade policy and the forest.

An important point of debate has been whether international trade creates environmental problems or merely exacerbates existing ones. On this question the majority view among economists is the latter. Anderson & Blackhurst (1992), for example, emphasize the fundamental role of government and market failures as the cause of environmental degradation, while Dean (1992b) states categorically that trade does not cause pollution. Taking the opposite position, Røpke (1994) argues that trade is inherently detrimental to the environment. Within the forestry literature, similarly disparate views are represented by Vincent (1992), who argues that trade can potentially protect the forest by enhancing its market value, and Nectoux & Kuroda (1989), who claim that Japanese demand for tropical timber is responsible for significant forest destruction in Southeast Asia.

The most direct influence of international trade on the forest is through supply and management decisions made by private and public landowners. Landowners may respond to production incentives by bringing new lands into forestry production or by stepping up their efforts to produce on lands already in production. In contrast to the general downward trend in commodity prices, real forest product prices have tended to fluctuate around a stable or somewhat increasing average (Lyon & Sedjo, 1992; Klemperer, 1996; Zhang *et al.*, 1996). In the short run, the effect of higher stumpage values on forest conservation is ambiguous: while higher prices are an incentive to exploit and market forest resources, they also provide an incentive not to convert forestland to other uses. Over a longer time horizon, timber prices affect investment in afforestation and plantation development. In the United States, pension funds are investing heavily in timber production, suggesting that fund managers are willing to sacrifice some liquidity for the combination of steady value growth and low risk available in timber investments (Binkley *et al.*, 1996).

While much timber plantation development is driven by government policies, the dramatic increases in private-sector plantation activity in New Zealand and Chile suggest the expectation of significant profits from wood production. Lyon & Sedjo (1992) argue that while in earlier times harvest and transport costs were the key to comparative advantage in timber production, in recent decades the ecological and cost considerations of artificial regeneration have become more important. They conclude that long-term real price increases have made artificial regeneration economically profitable, reducing the comparative advantage of remote natural stands in the long run. As more readily available natural stands are drawn down, comparative advantage shifts to those areas that can support intensively managed forestry, such as Chile, New Zealand, and some developing countries.

Such changes in trade and production patterns have direct implications for the distribution of environmental costs and benefits associated with the forest resource. New Zealand has reduced timber production from the natural forest to less than 1% of its total production (Brown, 1997), effectively eliminating timber harvest as a source of forest degradation. At the same time, the prospect of plantation timber playing an ever-larger role in global timber supply has implications for the value of natural forest stumpage and the rate of forestland conversion to other uses. Thus, opportunities for international trade link production decisions and associated environmental impacts across countries.

While sector models provide a framework for linking changes in trade and production, predicting the effects of changes in production on the environment is more difficult[9]. Important factors conditioning the degree and distribution of forest impacts are the market-responsiveness of landowners, source of production (primary, secondary, or production forest), domestic policies and institutions, and market structure[10]. The only attempt we are aware of to explicitly link trade-induced changes in production to en-

[9] A good overview of forest sector models is provided in Binkley (1987). Several papers on this issue are in Adams *et al*. (1992).

[10] Angelsen & Kaiminowitz (1998) provide a useful review of the empirical literature on the causes of and factors influencing deforestation in particular.

vironmental change is that of Perez-Garcia (1995), who uses a coefficient to relate timber harvest levels to land use change. While such a conversion factor is useful as a rough estimate of one important environmental consideration, it cannot account for the distribution of production across wood sources, which may be a more important determinant of environmental impact than simply the amount of harvest. Furthermore, as noted by Barbier *et al*. (1995), management technique is at least as important a determinant of forest degradation as the level of production.

The possibility that domestic forest sector policies might transfer environmental impacts to other countries via international market forces has been examined with regard to log export restrictions in the United States. Brooks (1995) argues that the global environmental effects of log export restrictions in the US Pacific Northwest are unlikely to be large, due to the region's relatively small contribution to world timber supply and the availability of substitutes in many end uses. Perez-Garcia (1993, 1995), using a global trade model, suggests instead that the international impact of domestic restrictions on production or export may be substantial. Sedjo (1996) demonstrates with a different model that reductions in US timber production could have substantial international environmental effect, and compares the environmental impacts of increased production in various world regions.

Competing Land Uses

Changes in trade policy can also affect the forest by altering production in sectors that compete with forests for land. Agriculture is by far the most important competitor for forestland, followed by urbanization. A substantial portion of deforestation for agriculture can be attributed to export commodity production. In the United States, virtually all forested land east of the Mississippi was cleared for agriculture prior to this century, but increases in agricultural productivity have made it possible for much of this land to revert to forestland since World War II (MacCleery, 1992). Similarly, in South America a large proportion of deforestation is due to agricultural conversion (Puttock and Sabourin 1992). Johnson (1991) estimates that 64% of deforestation in the tropics is due to agriculture, 18% to commercial log-

ging, 10% to fuelwood gathering, and 8% to cattle ranching. Marchak (1995) asserts that logging has a greater impact than such figures suggest because it sets the stage for much agricultural clearing of forestland, while Braga (1992) similarly argues that such a breakdown of deforestation by activities ignores their interconnection.

Much empirical work has been done on land use competition and forestland conversion. Barbier & Burgess (1997) estimate demand for agricultural conversion of tropical forestland, concluding that such conversion has been greater than socially optimal. El Nagheeb & Bromley (1994) trace deforestation in the Sudan to the collapse of the international gum arabic trade. Coxhead & Jayasuriya (1993) find that employment effects in other sectors are a crucial determinant of land clearing in the upland Philippines, as do Thiele & Wiebelt (1994) in the case of Cameroon. Vincent & Hadi (1991) analyze the effect of a boom in the world market for rubber and palm oil on deforestation in Malaysia, concluding that the long-term yields of these tree crops enables them to move into forested areas where other agricultural endeavors could not be profitable. This literature suggests that the effects of trade on sectors that compete with forests for land can be significant, though accurate quantification is difficult.

Trade, Growth, and Demand for Forest Services

To the extent that trade encourages overall economic growth, downstream forest product industries may experience a trade-induced boom that puts added pressure on the forest. At the same time, increasing incomes may generate greater demand for environmental services supplied by the forest. Kitabatake (1992), for example, discusses the role of Japanese economic growth in timber resource use, both in providing money to preserve forests and in increasing demand for forest services at home. A more quantitative investigation of the relation between economic growth and environmental quality has been undertaken in the literature on the "Environmental Kuznets curve," the hypothesis that environmental degradation increases with income at low income levels but decreases with income at higher levels. Grossman & Krueger (1992) find in a study of 42 countries that pollution levels of sulfur dioxide and smoke

increase up to GNP per capita of $4000-$5000, as greater economic activity causes more pollution, and decrease above that level, as wealthier populations demand environmental regulation and less-polluting production techniques.

Stern, Common & Barbier (1996) compare three different studies that examine whether changes in forest area conform to a similar pattern, i.e. whether deforestation increases with income at low income levels and decreases with income at high income levels. They identify analytical problems in this line of work, and highlight the inadequacy of available data on forest area change. Miller & Rose (1985) assess the effect of urban and suburban expansion on the forest resource in the US, concluding that the increasing popularity of housing in forested rural areas provides a high-value alternative to commercial forestry, suggesting a link between high income levels and forest retention. A somewhat different approach is taken by Patel *et al*. (1995), who find that increasing population density and land subdivision in Kenya may be associated with increasing tree cover, as higher population density increases the payoff to investing in fuelwood trees. Angelsen & Kaimowitz (1998) suggest in their review of the deforestation literature that at least at low income levels, increasing income is associated with more deforestation. However, no robust conclusions have emerged regarding the relation between income levels and forest cover.

The results of Grossman and Krueger on income as a factor in environmental degradation suggest that the relationship between growth and environment is of particular concern in developing countries. Chichilnisky (1993) shows that developing countries' property rights problems make them more vulnerable to environmental degradation as a result of trade with industrialized countries. Ritchie (1992) argues that property rights problems in developing countries may themselves be worsened by trade, as the incentive to own land for export crop production causes small holders to be further marginalized by more powerful interests. Experience in developed and developing countries suggests that other factors, notably land tenure and public land management decisions, are equally important, but that low income levels are generally associated with resource degradation (Angelsen & Kaimowitz, 1998).

Regulations, Trade, and Environmental Protection

In the 1970s the potentially adverse effects of environmental legislation in the United States and Europe on trade competitiveness were researched in some detail (examples include d'Arge & Kneese (1972) and Walter (1975)). Less demanding environmental regulations in effect confer a cost advantage, leading to more production in pollution-intensive industries in countries with more lax environmental regimes (Srinivasan & Bhagwati, 1995). By changing the cost structure of production, or by otherwise regulating trade-related activities, environmental regulations can shift comparative advantage and change the structure of resource use between countries. Jaffe *et al.* (1995) report in a recent review of this subject that about 2% of US gross domestic product goes to complying with environmental regulations.[11] They therefore conclude, "International differences in environmental regulatory stringency pose insufficient threats to US industrial competitiveness to justify substantial cutbacks in domestic environmental regulations."

Dean (1992a) provides a survey of evidence on the importance of environmental regulations to trade within the framework of the following questions: 1) How much have trade patterns shifted as a result of regulation? 2) How much have industries changed location to move from one regulatory regime to another? The first question has been addressed by a number of researchers in both partial and general equilibrium settings, with findings indicating the effects on trade patterns range from small but significant (Robison, 1988) to no clear impact (Tobey, 1990; Leonard, 1988). More recent work cited in Jaffe *et al*. (1995) reaches similar conclusions.

Regarding the extent to which whole industries have shifted locations in response to regulation, Dean (1992a) notes that industries might move because of comparative advantage in environmental services (e.g. a greater capacity for assimilating pollution) or due to the undervalua-

[11] In addition to the aggregate effects on the economy, important distributional considerations attend this issue, since many of the more pollution- and resource-intensive industries employ a high proportion of less-educated workers. We are not aware of studies that have addressed the distributional consequences of environmental regulation in a trade framework.

tion of environmental services in some locations. Jaffe *et al*. (1995) make two points regarding strong evidence of a shift of dirty industries to developing countries. First, industrialized countries have historically exported most of the pollution-intensive goods on the world market, though the share of developing countries has grown. Second, demand for polluting industries is largely domestic, as developing economies themselves consume more resource-intensive products.

In terms of the questions raised by Dean (1992a), forest sector environmental regulations could contribute either to industry relocation or to changes in trade patterns. However, research on the competitive effects of forest sector regulation is much less developed than the environmental economics literature surveyed by Jaffe *et al.* (1995). While we are not aware of studies that explicitly link location decisions of forest products industries to environmental regulations, there is evidence of an overall shift in the share of world forest industry output to developing countries. ITTO (1996) offers anecdotal evidence of a recent move by Asian logging firms into forest-rich areas in Africa and South America. FAO (1996) indicates that from 1983 to 1994, developing countries' share of chemical pulp production rose from 7.5% to 11.7%, while for paper and paperboard production it increased from 12.6% to 21.0%.

More easily identifiable are changes in forest products trade flows caused by environmental and other resource regulations, including trade restrictions imposed for environmental reasons. Protection of endangered species, watershed protection, fiber recycling, and other environmental policy goals may have implications for trade patterns. For example, German exports of waste paper rose dramatically in the wake of recycling regulations implemented in recent years. Van Beers & van den Bergh (1997) include wood panels, pulp, and paper as 3 of 14 sectors in their analysis of the effect of environmental policies on location and trade of dirty industries. Their results indicate that the impact of environmental policies on forest products trade flows is likely to be muted because of the dependence of the industries on the resource. Nevertheless, Prins (1992) suggests that in Canada, a country rich in forest resources, effluent regulations are likely to reduce exports of pulp. A further issue, which does not seem to have been explored

so far, is the effect that changes in regulations relating to downstream industries have on forest value and management.

Another environmental policy that has a potentially important impact on trade patterns is the certification that forest products are produced in sustainable fashion (Varangis *et al*., 1993). The intent of such certification is to provide consumers with the opportunity to encourage sustainable forest management by purchasing from producers whose practices are certified to meet some standard of sustainability (Upton & Bass, 1996). Barbier *et al*. (1994, pp. 151–4) compare product, producer, and country certification. They conclude that country certification will be the cheapest and most effective option, and point out the danger that any certification scheme might be used as a non-tariff barrier instead of as a means to promote sustainable forest production.

The policies that have been studied most closely in this context, however, relate to the use of trade policies themselves to achieve environmental goals, in particular the protection of tropical forests. Opinion is strongly divided on the suitability of trade interventions to achieve environmental ends. In addressing domestic externalities, Perroni & Wigle (1994) conclude that trade restrictions are a poor substitute for direct interventions. Runge (1994) and Subramanian (1992) concur with this position, but Baumol (1971) and Srinivasan & Bhagwati (1995) argue that trade sanctions against international polluters may in certain situations improve global welfare. Barbier & Rauscher (1994) analyze a variety of domestic and international policies intended to promote sustainable forest management in the tropics. In addition to providing a general model for the analysis of such policies, they derive conditions under which trade interventions support or hinder conservation policies, and demonstrate the superiority of international transfers to trade restrictions as a way to conserve the forests. Barbier *et al*. (1995) conclude that "there seems little scope for the use of trade policy interventions as a means to reducing tropical deforestation in Indonesia." Kohn (1995) addresses the equity of tropical timber marketing restrictions, which have been criticized as a form of neocolonialism. He finds that when a Heckscher-Ohlin model is constrained such that both industrialized and develop-

ing countries must maintain equal shares of old growth forest, the Salvatore constraint (each party must be as well off after a trade as before) is satisfied.

Buongiorno & Manurung (1992) find that European importers of tropical timber would bear the burden of import tariffs intended to diminish forest exploitation, while tropical exporters would be able to sell to other markets. This finding illustrates the potential importance of market power in the welfare analysis of environmentally oriented trade policy. Perroni & Wigle (1994), in arguing that trade and environment links are in fact quite weak, note that the links would have been stronger had they not assumed perfect competition in their model. While the existence of significant economies of scale or market power in trade might suggest the opportunity for welfare-enhancing trade interventions, research into the conditions under which such opportunities exist has not produced generalizable results. Barbier & Rauscher (1994) argue that market power, by enabling a country to extract greater unit revenues, may contribute to conservation. Karp (1996) finds that market power can actually reduce profits for a monopoly producer of a non-renewable resource,but does not address the implications for resource conservation.

Evidence on the existence of market power in forest product exports is mixed. Vincent (1987) and Vincent *et al*. (1991) conclude that while Indonesia was able after banning log exports to exercise market power for some time, the ban led to later substitution by Japanese importers of temperate timbers, with possibly permanent damage to Indonesia's export potential. In the US, Johnson, Rucker & Lippke (1995) find that Washington state has significant market power in log exports and does not suffer revenue losses from the restrictions on log exports. A better understanding of the market structure of international trade in forest products is needed to evaluate the effects of trade and environmental policy on the forest sector.

SUMMARY AND CONCLUSION

Because of a readily available framework for analysis, the effect of environmental and natural resource regulations on trade has been more thoroughly researched than the effect of trade regime on the environment. The general economic literature suggests that the loss of international com-

petitiveness due to environmental regulation is small, at least at the aggregate level. The forest economics literature on this point is less extensive and less definitive. A number of market equilibrium models show that harvesting restrictions can have a significant negative impact on the timber economy, but the econometric work of van Beers & van den Bergh (1997) suggests that trade flows in some forest products are relatively insensitive to environmental regulation. Evidence suggesting substantial international shifts of both timber production and downstream manufacturing exists but is not clearly tied to environmental regulation. The role of this regulation in prompting changes in trade flows and industry location therefore warrants further investigation. A related issue is the effect of market structure on the relation between environmental regulation and international competitiveness. Environmental and trade regulations enacted in the Europe, North America, and Southeast Asia in the last ten years provide material for empirical analysis of these issues.

Opinion is divided concerning the effects of trade on the environment, and empirical work in this area is scant. Most economists believe that on balance trade enhances environmental quality by providing nations the wealth to protect their resources and by increasing their willingness to pay for this protection. Thus, while there may be some increase in environmental degradation associated with greater economic activity, the longer-term positive effects on the environment, together with the non-environmental benefits of trade, are presumed to outweigh the cost of this degradation. Opposing arguments are based on ecological considerations or rejection of the assumptions of trade-theoretical defenses of free trade.

Empirical analysis of the impact of expanding international trade on forests has just begun. To the extent that trade, via comparative advantage, encourages specialization of forest products production in certain areas, it raises questions regarding the associated redistribution of both market and non-market forest values. Technological change, tastes and preferences, policies outside the forest sector, and level of country development all influence this redistribution. The effect of international market incentives on forest sector production is not well understood, yet the cases of New Zealand and Chile make it clear that there

has been a response to these incentives. Research on the international effects of restrictions on timber production in the United States, for example, has not come to a consensus. The suitability of sector and trade policy for forest protection must be assessed in light of price incentives, general equilibrium effects, and equity objectives. Several researchers argue that restrictions on the timber trade, even when they do successfully reduce resource exploitation, have greater societal costs than benefits, particularly when viewed at the global level.

Effective analysis of the impact of trade on the forest environment depends on progress in modeling timber supply and land use decisions, taking into account factors such as market structure and price-responsiveness of landowners. From an environmental point of view, questions of particular relevance are the conditions under which increasing timber value protects the forest or encourages exploitation; the determinants of the distribution of production across primary, secondary, and plantation forest in different regions; and the degree to which plantation production is likely to substitute for production from other sources. The influence of international capital flows on the location, nature, and intensity of forest production is another issue worthy of further research, especially in light of increasing institutional investment in forestry.

The immediate difficulty in pursuing this line of research is the inadequacy of data on timber production, land ownership, and forest area, type, and stocking. Ongoing efforts by international organizations to improve data collection and dissemination should improve the data quality somewhat, but forest sector analysis will be plagued by weak data for the foreseeable future. The ability of forest sector models to address environmental questions meaningfully depends on significant improvements in data and in the modeling of land use change and timber supply.

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