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Jute, Polypropylene, and the Environment : A Study in International Trade and Market Failure

by

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In recent decades the international market for jute has been hard-hit by competition with polypropylene, a synthetic material produced mainly in the industrialized countries. The production of polypropylene generates considerable pollution; the environmental impacts of jute appear to be modest by comparison. In other words, jute appears to have a *comparative environmental advantage.* If so, the internalization of environmental impacts in market prices–for example, via pollution taxes or tariffs–would improve jute's competitive position vis-a-vis polypropylene. This case contradicts the common assumption that tradable goods produced in developing countries have higher environmental costs than competing products of the industrialized countries.

I. INTRODUCTION

Since the Second World War, renewable natural raw materials, including cotton, jute, wool, sisal, and rubber, have lost international markets to synthetic substitutes. Between 1963 and 1986 substitution by synthetics is estimated to have reduced the developed market-economy countries' consumption of natural raw materials by 48%.[1] While the production and consumption of natural raw materials are by no means free of negative environmental impacts, the environmental costs associated with the production and consumption of synthetics are often considerably larger.

The production of many natural raw materials is concentrated in developing countries (the 'South'), while the production of synthetic

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[1] Based on calculations by Maizels (1992, p. 189; 1995, p. 108), who reports that substitution reduced the developed market-economy countries' consumption of natural raw materials by 2.9%/yr from 1963-65 to 1971-73, 0.9%/yr from 1971-73 to 1978-80, and 1.2%/yr from 1978-80 to 1984-86.

substitutes is concentrated in the industrialized countries (the 'North'). In the competition between natural raw materials and synthetic substitutes, therefore, relatively clean products of the South have lost market shares to relatively dirty products of the North—the opposite of what is often assumed in discussions of North–South trade and the environment.

This paper examines one such case : the competition between jute and polypropylene, jute's main synthetic substitute. Section II traces the competition between jute and polypropylene in the past three decades, during which jute lost much of its share in its main traditional end-use markets. Section III summarizes the available evidence on the environmental impacts of the production and consumption of jute and polypropylene, and section IV presents estimates of the economic costs of several of these impacts. Section V offers some concluding observations.

II. THE COMPETITION BETWEEN JUTE AND POLYPROPYLENE

Jute is the second most important natural fiber in world trade, next to cotton. Its two main end-uses in the postwar period have been burlap cloth (also known as hessian) and carpet backing. As late as the mid-1960s, synthetic substitutes were perceived as a threat to jute markets only in relatively minor uses such as rope and twine (Rabbani 1964, p. 321). In the past three decades, however, jute consumption in the industrialized countries has contracted sharply due to competition from synthetics. Between 1970 and 1992 the annual jute imports of North America and western Europe plummeted from 1.0 million to 52,000 metric tons (Thigpen *et al.*, 1987; IJO 1993). Over this same period the real price of jute fell by roughly 70%.[2]

Bangladesh, with a per capita income of $220/year, accounts for roughly 80% of total world jute exports (FAO 1994, p. 233). Jute cultivation and jute manufacturing affect the livelihoods of about 25 million Bangladeshis–roughly one-quarter of the country's population (World Bank, 1992, p.1). According to the 1983/84 agricultural census, small farmers (cultivating less than 2.5 acres) devote 10.4% of their net sown acreage to jute; among large farmers (cultivating 7.5 acres or more) the corresponding figure is 7.4% (see Table I). Jute cultivation is highly labour-intensive absorbing about 50% more labour

[2] The nominal price of raw jute was $299/ton in 1972 (World Bank, 1992, p. 12) and $277/ton in 1992/93 (IJO, 1993, p. 4). The real price trend is here calculated using the US producer price index as a deflator. There was considerable price instability in intervening years; for example, the nominal price peaked at $583/ton in 1985 and fell to $270/ton in 1986 (World Bank, 1992, p. 12).

per unit land area than rice, the main alternative crop (Hye 1993, p. 294). Hence, as Avramovic (1976, p. 3) observed, the deterioration of jute's position in world markets 'has been felt most strongly by the poorer segments of the rural population—the smallest farmers and hired labourers.'

TABLE I

JUTE CULTIVATION BY SIZE OF HOLDING, 1983/84

Size Class (acres)		Per cent of net Sown Area	Per cent of Jute Area	Jute Share of net Sown Area
Small	(<2.5)	27.7	31.2	10.4
Medium	(2.5–7.49)	46.5	48.0	9.5
Large	(7.5+)	25.8	20.8	7.4
Total		100.0	100.0	9.2

Source: Calculated from Bangladesh Bureau of Statistics (1986, pp. 111-112.)

Polypropylene (hereafter pp) was first produced commercially in 1957. It is primarily derived from petroleum in three stages : first, the refining of crude oil in which naphtha is separated from other products such as gasoline and fuel oil; second, the 'cracking' process, in which naphtha is refined to separate propylene from other chemicals; and finally, the polymerization of propylene to produce pp. Propylene is thus a by-product of the petroleum industry, providing an inexpensive raw material for pp production (FAO 1969, p. 17). By the late 1980s, pp had become the third most important thermoplastic in world production after polyethylene and polyvinylchloride (FAO 1989, p.18).

PP is produced mainly in the OECD countries, although newly industrializing countries including Korea, China, and Brazil have entered the industry in recent years. The United States is the world's top producer, accounting for 29% of global output in 1989, followed by Japan with 16% (see Table II). The firms involved in pp production are very large, as illustrated in Table III. The petrochemical industry, of which polypropylene is a subsector, is characterized by a high degree of industrial concentration : the United Nations Conference on Trade and Development (1981, p. 19) reports that in the late 1970s twelve firms accounted for more than 80 per cent of total world trade in chemical fibres. The competition between jute and pp thus pits some of the world's poorest people—Bangladeshi farmers and agricultural labourers-against some of the world's biggest transnational corporations.

TABLE II

POLYPROPYLENE PRODUCTION BY COUNTRY, 1989

Country	Production (000 metric tons)	Percentage Share
United States	3039	28.9
Japan	1719	16.3
Belgium	736	7.0
France	702	6.7
Germany	540	5.1
Korea	530	5.0
Italy	477	4.5
United Kingdom	353	3.4
Brazil	295	2.8
China	293	2.8
Spain	267	2.5
Russia	208	2.0
All others	1358	12.9
Total	10517	100*

*Total does not add to 100.0% due to rounding.
Source: United Nations (1993, p. 472).

Jute and pp are not perfect substitutes. PP's advantages include lighter weight and moisture resistance; jute's include breatheability, greater resistance to solar degradation, and less propensity to slip or tear. The two products are close enough substitutes, however, that price is a critical determinant of which is chosen by buyers: 'The relative prices of jute and polypropylene fabrics largely determine the market split between the two competing materials' (World Bank, 1973a, p. 13).[3]

[3] In the early 1970s the World Bank (1973a, p. 13) estimated the elasticity of jute demand with respect to the synthetic/jute price ratio at 2.2; in other words, a one per cent decline in this ratio led to a two per cent drop in jute consumption. More recently, Burger and Wansink (1990, p. 5) estimated the elasticity of demand for jute carpet backing cloth (again with respect to the PP/jute price ratio) at 0.35 and 0.9 in Western Europe and Japan, respectively.

TABLE III

LARGEST POLYPROPYLENE CAPACITY EXPANSIONS BY PRODUCER, 1989-1992

Company	Location	Capacity (000 metric tons/yr)
North Sea Petrochemical	Antwerp, Belgium	180
Shell-Indonesian partner	Cilicap, Indonesia	180
Hyundai Petrochemical	Daesan, S. Korea	170
Himont	Bayport, Texas, USA	160
Aristech Chemical	Neal, W. Va., USA	143
Exxon Chemical	Notre-Dame-de-Gravenchon, France	140
DSM	Geleen, the Netherlands	140
Formosa Plastics	Houston, Texas, USA	130
PPH	Triunfo, Brazil	130
Shell Chemical	Carrington, UK	130
Thai Petrochemicals	Rayong, Thailand	130
YCC	Kaohsiung, Taiwan	130
Eastman Chemical	Longview, Texas, USA	120
Beaulieu Chemicals	Dunkirk, France	120
Hoechst	Knapsack, Germany	120
Hoechst	Lillebonne, France	120
Neste Oy	Beringen, Belgium	120
OMV	Buirghausen, Germany	120
Shell Chemical	Wesseling, Germany	120
Soltex	Deer Park, Texas, USA	115

Source: Johnson (1990, p. 36).

The pp industry received a boost in the late 1960s from the huge demand for sandbags for the Vietnam war, which led to major investments in productive capacity. The disruption of jute deliveries during Bangladesh's 1971 independence war gave pp manufacturers a further opening. Shortly thereafter the World Bank (1973a. p. iv) observed that 'synthetics producers' strategy and expectations have shifted from those of penetration into jute end-markets to that of elimination of jute in all major markets.' The chemical industry invested tens of millions of dollars in research and development of synthetics at a time when jute research was virtually stagnant (*ibid.*, p. xi). Polypropylene's triumph was further abetted by protectionist measures: tariffs and quantitative restrictions of jute imports 'provided an umbrella under which... the domestic industries of many European countries could carry out a comfortable transition from jute to the manufacture of synthetic substitutes' (*ibid.*, p. iv).[4]

In the face of market losses in the industrialized countries, the main focus of world jute consumption shifted to the developing countries, particularly in Asia, where demand for jute bags has remained strong. Between 1966 and 1988, during which jute consumption in the industrialized countries slid from 1.6 million to 725,000 metric tons, consumption in developing countries rose from 1.8 million to 2.6 million metric tons (Burger and Wansink, 1990, p. 9). PP is now making inroads into developing country markets too, however, with price again a key advantage (FAO 1989). Moreover, although trade barriers against jute have been largely dismantled in the industrialized countries, tariff policies in many developing countries discriminate against jute in favour of pp.[5]

The price advantage which has permitted pp to capture and retain the erstwhile markets for jute in the industrialized countries has been fairly modest. In 1990 the wholesale price ratio of jute to synthetic cloth in New York was 1.35; its average over the preceding decade was 1.42 (World Bank 1992, p. 12).[6] As discussed in the next section, the incorporation of environmental costs into the prices of pp and jute could substantially lower this ratio.

III. ENVIRONMENTAL IMPACTS OF JUTE AND POLYPROPYLENE

The environmental impacts of jute production appear to be rather small compared to those of polypropylene. Jute growers use some chemical fertilizer, but not very intensively, and most apply no pesticides at all to the crop.[7] The flooded fields in which the jute plants mature support diverse fish populations, which play a crucial role in the Bangladeshi diet (and especially in the diets of the poor).[8]

[4] Grilli and Morrison (1974, pp. 31-34) provide details.

[5] Thigpen *et al.* (1987, p. 177) state that 'many developing countries have encouraged the growth of inefficient domestic synthetic fiber industries' by means of trade barriers. See also Burger and Wansink (1990).

[6] PP's price advantage dates from 1970: the jute/synthetic cloth price ratio rose from 0.63 in 1967-69 to 1.48 in 1970-75 (Avramovic, 1976, Annex IV).

[7] Cost-of-production studies conducted by the Ministry of Agriculture in the mid-1970s found that the average jute producer used no pesticides, less than 50 kg/acre of chemical fertilizers, and almost one ton/acre of organic manures (Government of Bangladesh, 1977).

[8] Fish provide approximately 80% of the animal protein in the Bangladeshi diet (World Bank, 1990, p. 4). For discussion of the role of open-water capture fisheries in the diet of the poor, see Minkin *et al.* (1993).

Hence the fact that jute can be grown without reliance on pesticides is an important feature.[9]

Like all plants, jute absorbs carbon dioxide (CO_2) from the atmosphere as it grows, and releases it when it decays. Atmospheric CO_2 is the most important of the greenhouse gases believed to be responsible for global warming. In this respect jute thus provides a temporary environmental benefit : it sequesters carbon while in use. The transport and milling of jute, and the production and transport of inputs for the jute crop, generate some CO_2 emissions; depending on their magnitude, the net short-run effect of jute production is estimated to range from zero to the net absorption of 1.2 tons of CO_2 per ton of fiber (Braungart *et al.*, 1992, pp. 89-90).

The most important negative environmental impacts of jute production probably arise in the process known as retting, when the jute stalks are submerged for 3-4 weeks in ponds where anaerobic microbial decomposition loosens the fibre in the inner bark. Retting causes transitory deterioration in water quality, including oxygen depletion, which can harm gill-breathing fish. The decomposition products are non-toxic, however, and enhance soil fertility (Alam 1993, p. 362). Retting releases methane, a potent greenhouse gas, in quantities which have not been measured; technologies to capture this for use as biogas fuel are still at the experimental stage (Alam 1993, p. 365).

Environmental impacts in the manufacturing stage of jute production arise primarily from energy consumption, the production of fibre wastes, and pollution from dyes. Energy use in jute production is estimated at up to 14 gigajoules/ton (Braungart *et al.*, 1992, p. 89). Jute dust waste produced during processing amounts to roughly two per cent of the fibre : some of this is burnt for energy (*ibid.*, p. 35). Only a small fraction of jute fabrics around 1-2 per cent—is dyed, but effluent samples from jute dyeing processes reveal significant releases of heavy metals (*ibid.*, pp. 34, 39).

Jute is biodegradable: at the end of the product life-cycle it simply decomposes in the soil. Mineral oil residues from the softening process may persist; conversion to the use of vegetable oils for this purpose would ensure rapid and complete biodegradation (Braungart *et al.* 1992, p. 38).

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[9]For this reason, the World Bank (1973b, p. 51) criticized government plans to distribute pesticides free of cost to jute growers, describing the scheme as 'at best wasteful and at worst highly dangerous.'

Several additional side-benefits of jute deserve mention. The leaves of the jute plant are edible, and the stalks provide a renewable source of cooking fuel and building material.[10] The high labour intensity of jute cultivation can be counted as a further social benefit in a setting where agricultural labourers are among the poorest of the poor.

The manufacture of polypropylene has important environmental impacts via air pollution and energy consumption. Air pollutants generated in pp production include particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and volatile organic compounds, all of which are hazardous to human health. Total emissions of these pollutants are estimated at 127 kg per ton of pp (see Table IV). In addition, pp production emits smaller amounts of various other toxic air pollutants, including ammonia, benzene, biphenyl, ethylbenzene, lead, methane, toluene, and xylene (Tellus Institute, 1992, p. 9 Table-6).

Energy use in the production of pp cloth is estimated at 84 gigajoules/ton, at least six times the energy requirement for production of jute cloth (Braungart *et al.*, 1992, p. 89). Carbon dioxide emissions in the pp production process are estimated at 3.7 tons per ton of fiber (ibid., p. 91). The long-term environmental effects of such additions to atmospheric CO_2, derived from fossil carbon, remain uncertain and a matter of controversy; they include impacts on agriculture, forestry, biodiversity and a rise in the sea level.[11] By virtue of its deltaic terrain, Bangladesh is among the countries which stands to be most seriously affected by the latter (Pearce *et al.* 1995).

PP is not biodegradable. Its potential for recycling is limited by the use of additives in the production process, and by mixture with other plastics in the collection process (which leads to 'downcycling', or re-use in products of inferior quality). At the end of the product life-cycle, therefore, pp disposal entails the costs of landfill storage, incineration, or litter. As much as six per cent of PP cloth, by weight, is comprised of chemical additives, including stabilizers, colouring pigments, and flame retardants (Braungart *et al.* 1992, pp. 66-75). Some of these contain heavy metals : Laboratory analysis of random samples of pp fabrics have detected chromium, copper, lead, nickel, and zinc (*ibid.* p. 66). These too ultimately enter the waste stream.

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[10]In the Bangladesh village where I lived in the mid-1970s, many of the poorest people subsisted largely on jute leaves during the lean season before the spring rice harvest. The yield of stalks ranges from 2.1 to 3.4 times the production of fibre depending on varietal characteristics and cultural practices; roughly 80% is used as cooking fuel, and the remainder for construction (Alam 1993, p. 364).

[11] OECD (1992) and Pearce *et al.* (1995) provide overviews.

More than two decades ago, a World Bank study remarked upon this aspect of jute's comparative environmental advantage:

> Increasing use of synthetics of variety of products will, at some point, become a serious burden to the environment unless appropriate disposal techniques are developed. It is possible, and would be economically efficient, to require synthetics manufacturers to bear this burden. The implied increase in the financial cost of synthetics to reflect economic costs would improve the competitive position of jute. (World Bank 1973a, p. 47.)

The same logic can be applied to environmental impacts earlier in the product life-cycle.

IV. VALUATION OF ENVIRONMENTAL IMPACTS

A comprehensive valuation of the social costs of these environmental impacts is beyond the scope of the present paper. Instead I limit my attention to three impacts: air pollution, carbon dioxide emissions, and solid waste disposal. Given data limitations and the inherent difficulties of monetary valuation of environmental impacts, the results should not be regarded as definitive. Rather the following is intended as an exploratory exercise, and a stimulus to further research.

A large literature has emerged in recent years on the valuation of environmental costs. One general approach is to assess damages (or equivalently, the benefits of environmental improvements). The techniques developed for this purpose include hedonic methods in which willingness to pay for environmental improvements is inferred from market data, such as property values and wage differentials, and contingent valuation methods in which hypothetical values are derived from sample surveys.[12]

A second general approach is to examine the costs of pollution prevention, and to use the observed levels of these costs as a surrogate for damage costs. This approach is based on the assumption that pollution-control decisions reflect the 'revealed preferences' of regulators who attempt to equate marginal control costs to the marginal benefits of pollution reduction. A weakness of this approach, of course, is that such revealed preferences may understate (or overstate) actual damage costs, due to faulty information or to failures and biases in the decision-making process.

[12] Winpenny (1991), Munasinghe (1992), and Pethig (1994) survey these and other standard valuation techniques.

But an attraction of this approach is that it measures what societies actually do—and what value they implicitly place on environmental impacts—rather than what they *should do*. The policy recommendations derived from such an analysis are, therefore, more likely to be consistent with other existing policies.

The latter approach was used to obtain the monetary valuations of air pollution damages reported in Table IV. These pollutants covered here include only the five categories generated in the largest volume in pp production; the many toxic air pollutants emitted in smaller quantities are not included. The calculations are based on the average valuations used in policy making by government agencies in the United States as a whole. In densely populated and highly polluted regions, such as southern California, the implicit valuations on these pollutants are up to 40 times larger.[13] The total costs amount to $594 per ton of pp.[14]

TABLE IV

AIR POLLUTION COSTS OF POLYPROPYLENE PRODUCTION

Air Pollutant	Emissions	Damages	
	(Kg/ton PP)	($/Kg)	($/ton PP)
Particulates	5	4.40	22
Sulfur oxides	18	1.65	30
Nitrogen oxides	38	7.70	293
Carbon monoxide	28	0.95	27
Volatile organic compounds	38	5.83	222
Total	–	–	594

Sources: Calculated on the basis of emissions estimates from Tellus Institute (1992, p. 9T-6), and damage estimates from Bernow and Marron (1990, p. 33).

Recent research on the environmental impacts of CO_2 emissions has produced a variety of monetary valuations. Dixon and Mason (1994) summarize a number of damage cost estimates, ranging from $5.3-$50/ton of carbon in the decade 1991-2000 and rising to $6.8-

[13]Bernow and Marron (1990, p. 33) report that in southern California nitrogen oxide valuations are 40 times higher; suspended particulate valuations are 11 times higher; sulfur oxide valuations are 50 times higher; and volatile organic compound valuations are 5 times higher.

[14]All prices are here quoted in U.S. dollars.

$120/ton in the following decade.[15] These variations are attributable not only to scientific uncertainties as to impacts of greenhouse gases, but also to differences in valuation methodologies. On the prevention-cost side, economists have used values ranging from $3/ton to more than $600/ton to assess the potential impacts of carbon taxes (Pearce 1991, p. 38).

Table V reports calculations of CO_2 costs based on valuations of $5, $50, and $500 per ton of carbon. The production of one ton of pp is estimated to release 3.7 tons CO_2 (that is, 1 ton of carbon), as noted above. Jute production is here assumed to release 0.6 ton CO_2 (0.16 ton of carbon) per ton of fiber.[16] No account is taken here of the positive benefit provided by carbon sequestration in jute, on the grounds that in the long run this carbon returns to the atmosphere via biodegradation.

TABLE V

COSTS OF CO_2 EMISSIONS OF POLYPROPYLENE AND JUTE PRODUCTION

	Emissions (tc/ton fibre)	Damages Costs ($/ton fibre) @ $5/tc	@$50/tc	@$500/tc
Polypropylene	1.0	5	50	500
Jute	0.16	1	8	80

Source : Emissions based on data in Braungart *et al.* (1992, pp. 89-91).
Note : tC=tons of carbon.

Finally, the tipping fees charged at landfills provide a proxy for non-biodegrdable waste disposal costs at the end of the pp product life-cycle. In the United States, tipping fees range from less than $10/ton in sparsely populated states to more than $60/ton in densely populated states; the 50-state average in 1991 was $26/ton (U.S. Data on Demand, Inc. and State Policy Research, Inc., 1993, Table 0-9). The average will be used here as our proxy measure. This can be regarded as a lower-bound estimate insofar as (i) landfill costs are higher in more densely populated countries; (ii) landfills are publicly subsidized; (iii) landfills generate negative externalities; and/or (iv) the improper disposal of pp is common and this generates higher environmental costs than disposal in landfills.[17]

15. Pearce *et al.* (1995, p. 68) report similar estimates.

16. This is based on data presented by Braungart et al. (1992, p. 89) which indicate that jute production uses up to one-sixth as much energy per ton as polypropylene production.

17. One example is the deliberate or inadvertent disposal of plastic debris in the world's oceans. 'Ghost fisheries' created by lost or discarded synthetic fishing nets pose a particularly serious threat to marine life; for discussion, see Conner and O' Dell (1988).

Table VI summarizes the effects which internalization of these environmental costs would have on the relative price of jute and polypropylene. The environmental costs are here converted to an equivalent-service basis on the assumption that jute fabric weighs 3.2 times more than polypropylene fabric.[18] Three points stand out. First, the environmental costs of pp arising from air pollution in the production process appear to outweigh by far the costs of disposal at the end of the product life-cycle. This finding may diverge from popular perceptions—as reflected in the World Bank (1973a, p. 47) comment, cited above, as to the importance of disposal costs—but it is consistent with the findings of other recent studies of the packaging industry (Ackerman 1993). Second, the costs of CO_2 emissions substantially affect the jute/pp price ratio only at the upper end of the range of carbon costs used here. Finally, the internalization of these environmental costs would substantially reduce, or perhaps eliminate, the market price advantage pp currently wields over jute.

TABLE VI

EFFECT OF INTERNALIZATION OF AIR POLLUTION, CO_2 EMISSIONS, AND DISPOSAL COSTS ON RELATIVE PRICES OF JUTE AND POLYPROPYLENE

	Prices ($/000 yd^2)		Price Ratio
	Jute	PP	(Jute/PP)
Market prices, 1990	240	178	1.35
Prices internalizing PP air pollution costs only :			
	240	224	1.07
Prices internalizing CO_2 costs only:			
@ $5/ton of carbon	240	178	1.35
@ $50/ton of carbon	242	182	1.33
@ $500/ton of carbon	260	218	1.19
Prices internalizing non-biodegradable disposal costs only :			
	240	180	1.33
Prices internalizing all of the above :			
CO_2 @ $5/ton of carbon	240	226	1.06
CO_2 @ $50/ton of carbon	242	230	1.05
CO_2 @ $500/ton of carbon	260	266	0.98

Sources: Market prices from World Bank (1992 p. 12). Jute yardage/weight ratio=4,000 yd^2/metric ton; PP yardage/weight ratio=12,800 yd^2/metric ton. See text for details.

18. The ratio varies somewhat among end-use fabrics: 1.84-ounce PP cloth replaces 6.75-ounce jute hessian; 2.56-ounce PP cloth replaces 9-ounce jute hessian; and 3.5-ounce PP primary carpet backing cloth (c.b.c.) replaces 9-ounce jute c.b.c. (World Bank, 1974, Annex II, pp. 14, 16, 21). The ratio used here is calculated on the assumption that hessian accounts for 60% of end-use and c.b.c. for 40%, their respective shares in industrialized country markets in the early years of competition between jute and PP (*ibid.*, p. 6). Differences in the duration of service of jute and PP fabrics would alter the service/weight ratio. In the case of sacks, Braungart *et al.* (1992, p. 94) suggest that on average a PP sack is used 5 times whereas a jute sack is used 8-15 times, but the basis for these figures is not specified. In the case of carpet backing cloth, re-use is probably rare, but there may be differences in the time of service. In the absence of data, no adjustments for these are attempted here.

A comprehensive economic analysis of the environmental costs of jute and PP would incorporate valuations of other impacts, including the effects of fertilizer runoff and retting on water quality in the case of jute; the impact of methane emissions during jute retting; the impacts of the heavy metals and other chemical additives used in the manufacturing processes of both jute and PP; and the impact of other toxic air pollutants emitted in PP production. If, as seems plausible, the most economically important of these are the costs of toxic pollutants due to the use of chemical additives (the quantity of which is greater in PP) and air pollutant released in PP production, then internalization of these missing costs would further reduce the jute/PP price ratio. In any event, the evidence reviewed here lends at least tentative support to the hypothesis that PP's competitive edge over jute rests, in no small measure, on the failure of market prices to internalize environmental costs.

V. CONCLUDING REMARKS

The expansion of markets via international trade extends not only the reach of the celebrated invisible hand, but also the scope for market failures. Among the latter are negative externalities arising from environmental degradation, the social costs of which are not captured in market prices. The nature and severity of environmental externalities, and the extent of remedial government action, vary from country to country. In the case of North—South trade, it is often assumed that with free trade, weak environmental protection in the South will lead to 'environmental dumping'—the sale of commodities below their full cost of production, including environmental costs–at the expense of producers in the more regulated North.[19] The competition between jute and polypropylene illustrates the reverse possibility: relatively clean production in the South can be displaced by relatively dirty production in the North.

Faced with the challenge from synthetic substitutes, the jute industry initially reacted slowly, with what Grilli and Morrison (1974, p. 16) termed 'a curious mixture of incredulity and stubbornness.' The defensive strategy which ultimately emerged had two main planks: (i) price stabilization, in response to the belief that instability was an important factor in jute's declining market share (Anderson *et al.* 1980), and (ii) diversification into new end-use markets, such as geotextiles for erosion control, paper, jute-reinforced plastics, decorative fabrics, and handicrafts (see, for example, FAO, 1991).

19. See, for example, Dean (1992) and Chichilnisky (1994).

These worthy initiatives have proven insufficient, however, to offset the enormous impact on demand for jute of the competition from polypropylene in traditional end-use markets.

The analysis presented here suggests the possibility of a powerful third element in the market strategy for jute: the reassertion of jute's position in traditional end-use markets on the basis of its *comparative environmental advantage.* Further research on the environmental impacts of jute and polypropylene, and their economic valuation, is needed to establish convincingly the full dimensions of this advantage. But the evidence reviewed above suggests that there are solid grounds for such an initiative.

Unilateral policy measure offer some scope for correcting the market failures which inflate the competitiveness of polypropylene vis-a-vis jute. Individual governments could impose environmental taxes on polypropylene, subsidize the use of jute, or otherwise protect jute in specific end-use markets.[20] At a minimum, governments can remove the environmentally perverse trade barriers which today discriminate against jute in favour of polypropylene.

Multilateral initiatives, undertaken in negotiations at the United Nations Conference on Trade and Development, the World Trade Organization, and future rounds of the General Agreement on Tariffs and Trade (GATT), offer further possibilities. As environmental issues become increasingly important in international trade negotiations—as witnessed by talk of the 'greening of GATT'—the time is becoming ripe for such efforts.[21] If the case for jute were framed in the broader context of the displacement of natural raw materials by synthetic substitutes, the number of the parties with an interest in addressing the issue would be multiplied.

By adopting this strategy, Southern governments would move beyond a defensive posture in trade negotiations—in which they are cast as international laggards in safeguarding the natural environment—to a positive stance founded on the comparative environment advantages of their natural raw materials. In this effort, they would have potential allies in the international environmental movement and in particular, among those people in the North who bear the environmental costs of pollution-intensive production.

The case of jute and polypropylene illustrates a more general point: the industrialized countries do not have a monopoly on

[20]. In India, for example, legislation protects jute's market share in the packaging of cement, fertilizer, and agricultural commodities (FAO, 1989, pp. 22-23).

[21] For discussions, see Anderson and Blackhurst (1992) and Esty (1994).

environmental virtue. Indeed it could be argued that the main direction of environmental dumping in the history of international commerce has been from North to South. As trade negotiations confront environmental issues, there is a danger that these concerns will be hijacked by Northern producer interests. Yet this need not be the case. Instead the 'greening of world trade' could not only protect the natural environment, but also benefit some of the world's poorest people, among them the jute growers and agricultural labourers of Bangladesh.

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