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Trade Liberalization, Environment and Poverty

A Developing Country Perspective

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Abstract

This paper revisits the pollution haven hypothesis in the context of Pakistan by offering a systematic analysis of its trade and production patterns. Using bilateral trade statistics from 1975-2003, we test the hypotheses that Pakistan's net exports of pollution-intensive products have increased to the OECD countries. We also investigate if the stringency of environmental governance in the importing countries plays a role in determining Pakistan's exports of pollution-intensive products. The results reveal that there has been a change in the composition of output and exports towards pollution-intensive manufacturing that parallels the opening of the economy. Overall, the findings appear to be in favour of the pollution haven hypothesis and call for effective environmental policy response for poverty alleviation and sustainable development.

Keywords: international trade, industrial pollution, composition effect, gravity model, Pakistan

JEL classification: F18, O13, L60, Q56

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Acronyms

ADB	Asian Development Bank
CAP	social and institutional capacity
CMI	*Census of Manufacturing Industries*
COMTRADE	Commodity Trade Statistics Database of the UN
EEFS	embodied environmental factor services
EPA	Federal Environmental Protection Agency of Pakistan
ESI	Environmental Sustainability Index
GoP	government of Pakistan
HOV	Heckscher-Ohlin-Vanek model of trade in factor services
IPPS	Industrial Pollution Projection System of the World Bank
ISIC	International Standard Industrial Classification System
LAHTI	Linear Acute Human Toxicity Index
NCS	Pakistan's National Conservation Strategy
NEQS	national environmental quality standards
OECD	Organisation for Economic Co-operation and Development
OIC	Organization of Islamic Countries
PEPA	Pakistan Environmental Protection Act
PHH	pollution haven hypothesis
SITC	Standard International Trade Classification system of the UN
SPM	suspended particulate matter
SSHMI	small scale and household manufacturing industries
WTO	World Trade Organization

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1 Introduction

The massive wave of trade liberalization that continues since the last decade has generated an interesting and contentious debate in terms of its impact on the environment. Environmental resources are an important input in all sorts of production.[1] A rapid expansion in the scale of economic activity is considered to cause their overexploitation and misuse, the negative consequences of which are even more pronounced in the absence of appropriate environmental policies because adverse externalities associated with production are not internalized. This is known as the *scale effect* of trade on the environment, which has the potential of encouraging short-run growth at the cost of hampering long-run economic development by causing irreversible damage to the environment.

The fear of environmental degradation associated with trade is expressed especially for developing and poor countries, most of which have weak regulatory infrastructure and lack environmental awareness. Environmentalists argue that due to lax environmental regulations, these countries treat environment as a relatively abundant factor of production and specialize in the production of pollution-intensive products as a result of free trade. This initiates a negative *composition effect* of trade that complements the scale effect, exacerbates natural resource degradation, and causes ecological poverty that accentuates economic poverty and gravely limits prospects for future growth.[2]

The views of the environmentalists are challenged by the proponents of free trade who assert that lowering of barriers to trade and investment facilitates the movement of environmentally friendly technologies, management techniques and information across the countries. Thus, trade gives rise to a positive *technique effect*, which has the potential of outweighing the negative scale effect of increased production. Moreover, they argue that liberalization leads to a *positive* and not *negative* composition effect via income growth. An increase in per capita income induced by greater openness enhances consumers' preference for environmentally friendly products, advances cleaner production techniques and reduces the share of pollution intensive products in total output.

The contradictory predictions of both schools of thought and the mixed empirical evidence suggest that with reference to the environment, liberalization is a double-edged sword presenting both threats and opportunities. The manner in which resources are exploited as a result of free trade poses challenges for the communities. Nonetheless, opportunities are present through clean technology transfer and income growth. To maximize the gains from liberalization, governments must implement appropriate policies that promote both economic growth and environmental protection.

The determination and implementation of optimal policies, however, remain a difficult task for developing countries because of technical and financial constraints, and lack of political will. In general, these countries adopt the 'pollute now, clean up later' approach to fast track growth and achieve economic development. Furthermore, earlier

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1 Environmental resources are factors of production not created by effort, for example, air, water, soil, timber, minerals, oil, etc.

2 Ecological poverty refers to the lack of healthy natural resource base for safeguarding public health and local economies (Aggarwal 2001).

research on the issue, which has largely been confined to cross-country investigations that were sensitive to the choice of pollutants and the countries included in the sample, has been unhelpful in offering guidance and sound policy advice to the developing countries.[3]

In recent years, an increased emphasis is being placed on examining the experience of individual countries so that policy frameworks are suggested according to their unique circumstances and resources. To date, however, few empirical assessments are available especially for developing countries because of lack of data on environmental indicators. This paper aims to fill the gap in literature and attempts to assess the environmental consequences of trade liberalization for a developing country, Pakistan, which makes an interesting case study for various reasons. First, like many other developing countries, Pakistan commenced rapid liberalization from the early 1990s onwards and it is of interest to examine which types of industries, environmentally friendly or hazardous, have prospered under its liberalization policies. Second, Pakistan has experienced severe bio-diversity loss and a rise in pollution during the last two decades. It is therefore important to investigate if increased trade activity has played a role in the deterioration of environmental quality. Finally, environment is an area that has been persistently ignored in Pakistan and environmental concerns have never been adequately addressed. This attitude may have non-trivial consequences due to the prevalence of a strong poverty-environment nexus in the country. As the costs associated with environmental degradation, such as reduced opportunities for earning livelihoods and health costs of being exposed to pollution, hit the poor hardest of all, it is critical to evaluate the environmental consequences of Pakistan's macroeconomic policies for devising appropriate poverty alleviation strategies.

Against this background, we address three key concerns pertinent to the trade-environment debate. First, we explore the environmental impacts of trade liberalization in terms of the industrial composition effect and test the hypotheses that the exports of pollution-intensive products have increased, whereas the imports of pollution-intensive products have decreased after the reform process. Second, we examine the impact of environmental regulations in the importing countries on the exports of Pakistan's pollution-intensive products. Third, we review the implications of our findings for the poor and suggest appropriate policy responses.

We use disaggregated manufacturing and bilateral trade data for our investigation. To our knowledge, this is the first study identifying compositional changes associated with liberalization using a bilateral trade flow framework. Also, unlike earlier literature, which assesses the pollution intensity of industries based on a single pollutant, we use a risk weighted toxicity measure to classify industries as pollution-intensive. As industrial pollution intensities tend to vary across different types of pollutants, a risk weighted toxicity index is a superior indicator of the overall hazardousness of a sector to individual intensities.

The rest of the paper is organized as follows. Section 2 presents a brief overview of Pakistan's economic and environmental profiles. Section 3 discusses the conceptual framework and methodologies adopted in the paper. Section 4 reviews the data issues

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3 See Vincent (1997) and Stern, Common and Barbier (1997) for a critique of cross-country investigations of economic growth-pollution relationships.

and presents the results. Section 5 investigates the effect of environmental regulations in the importing countries on Pakistan's exports of dirty products. Section 6 discusses the policy implications of our findings with reference to the poor. Section 7 concludes.

2 Economy and the environment in Pakistan

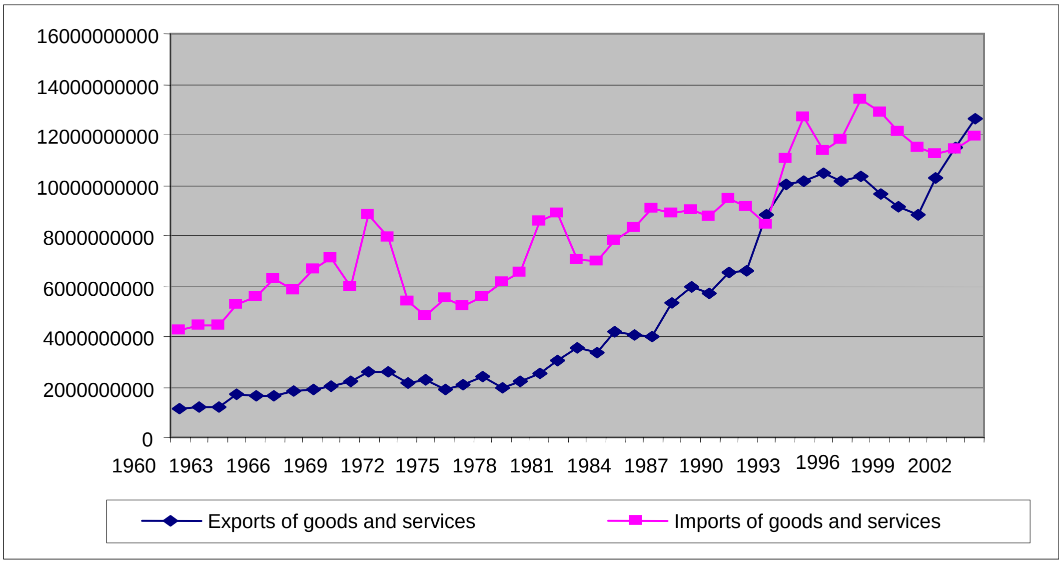
2.1 Corporate performance and trade liberalization: background and present scenario

Pakistan has recorded a mixed industrial performance since its establishment 55 years ago. Its transition from a high tariff, import substitution strategy in the 1960s and 1970s to an open economy began from the mid-1980s onwards when liberalization reforms were undertaken that included measures to reduce export controls, encourage imports of industrial raw material and machinery and increase foreign investment (Figure 1).

Overall, industrial performance was remarkable during the decade of the 1960s when the manufacturing sector thrived and achieved high growth rates. Industrial growth, however, dampened during the 1970s due to the nationalization of industrial and financial sectors in 1972 (Table 1). The reason behind the slowdown was the high extent of protection provided to domestic firms without proper performance checks. Operating within a highly sheltered environment with no export obligation and no exposure to international competition, the domestic industries had low productivity and remained technologically backward.

The 1980s witnessed a move away from the inward-looking import substitution policy to an outward-oriented strategy through liberalization of trade and financial markets. In the early 1980s, exports were typically half or less than half of the import bill. By late the 1990s, however, processed commodities became more competitive internationally, and exports rose to around 90 per cent of imports (Table 2). During 1985-91, tariffs

Figure 1
Pakistan's exports and imports of goods and services (constant US$)



Source: Compiled by the author from World Bank (2004).

were reduced on 1134 items, approximately 700 items were removed from the negative list of imports and the maximum tariff rate was decreased from 225 per cent to 100 per cent.[4]

The reform process combined with political stability paid a dividend and the economy recovered considerably in 1980s. The manufacturing sector grew on average at 8 per cent per annum and annual GDP at 6.5 per cent. Total exports in real terms increased by 9 per cent per annum and the share of manufactured goods in total exports increased to 49 per cent in 1986 as compared to 38 per cent in 1976 (Table 3).[5]

Table 1
Annual average growth performance of various sectors (per cent)

Sector	1960s	1970s	1980s	1990s
GDP growth rate	6.8	4.8	6.5	4.6
Agriculture	5.1	2.4	5.4	4.2
Manufacturing	9.9	5.5	8.2	4.8
Services sector	6.7	6.3	6.7	4.6

Source: GoP (*Economic Survey* 2001-02).

Table 2
Pakistan's external trade

Year	Exports (US$ million)	Imports (US$ million)	% share of GDP: Exports	% share of GDP: Imports
1980-85	2,675	5,596	9.0	18.7
1985-90	4,167	6,275	11.3	17.1
1990-95	6,958	9,154	13.5	17.8
1995-00	8,707	11,805	13.7	17.4
2000-01	9,202	10,729	15.7	18.4

Source: GoP *Economic Survey* (2001-02).

Table 3
Economic classification of exports and imports (percentage share)

	Exports			Imports		
Years	Primary	Semi-manufactured	Manufactured	Capital	Consumer	Industrial raw material
1975-76	44	18	38	35	21	34
1980-81	44	11	45	28	15	58
1985-86	35	16	49	37	18	45
1990-91	19	24	57	33	51	16
1995-96	16	22	62	35	14	51
2000-01	13	15	72	25	14	61

Source: GoP (*Economic Survey* various issues).

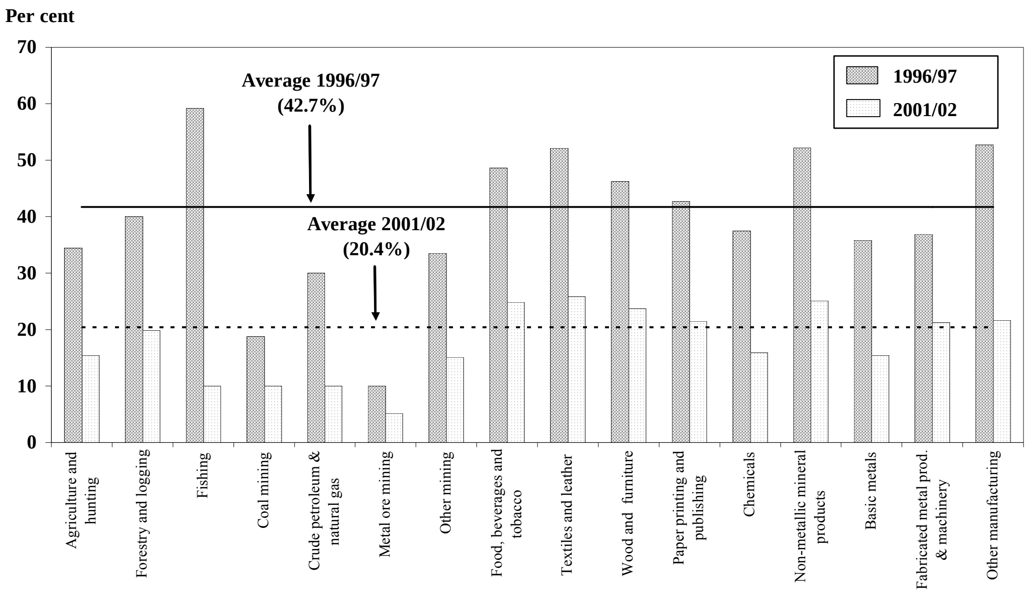
4 Negative list consists of items that are not allowed on the grounds of public health, environmental concerns, morality or national security.

5 Khan (1999) shows that the emergence of manufacturing sector as Pakistan's primary export is a consequence of trade liberalization reforms

The momentum of economic growth was lost again in 1990s due to political instability caused by frequent changes of governments and the deteriorating law and order situation in major cities. Industrial and trade performance remained depressed and the average annual GDP growth rate fell to 4.6 per cent and that of the manufacturing sector to 4.8 per cent. The share of manufactured products in total exports, however, continued to rise and jumped from 45 per cent in 1980 to 62 per cent in 1995-96.

Liberalization efforts gained further momentum in the late 1990s with the introduction of wide ranging structural reforms. Successive trade policies attempted to diversify the export base and to improve the export infrastructure to increase exports. On imports, almost all type of quantitative restrictions, except for customs duty were removed. The customs duty itself was lowered substantially from 80 per cent in 1996 to 30 per cent in 2001 and to 25 per cent in 2002.[6] The average applied tariff rate fell from 42.7 per cent in 1996-97 to 20.4 per cent in 2001-02 (Figure 2). Further, in 2002, only 57 items constituted the negative list of imports and 192 items remained on the restricted list due to health and safety concerns. The accelerated pace of liberalization improved the trade balance significantly and Pakistan's trade deficit reduced from US$3.12 billion in 1995 to US$0.83 billion in 2003.

Figure 2
Applied tariff averages by 2-digit ISIC category, 1996-97 and 2001-02



Source: WTO (2001).

2.3 Environmental profile

A population size of approximately 145 million, coupled with a population growth rate of 3 per cent per annum, an average GDP growth rate of 4.5 per cent per annum and rapid urbanization, has put immense pressure on Pakistan's natural resource base and environmental absorptive capacity. Pakistan's main environmental problems include industrial and vehicular emissions, domestic wastewater pollution, deforestation,

6 This excludes certain types of automobiles and alcoholic beverages.

rangeland degradation and water logging and salinity. No comprehensive database on environmental degradation exists, however, according to the World Bank estimates, environmental damage exceeds 5 per cent of GDP in 1992 values (Brandon and Ramankutty 1993).

Although data on industrial pollution are fragmentary and cannot be compared over time, the industrial sector is considered to be a major contributor to overall pollution. Almost 80 per cent of the industrial growth in Pakistan has occurred in major urban cities where firms indiscriminately release carcinogens and manufacturing waste matter into the water and air. Most industrial clusters have been established without planning and a majority of firms do not have end-of-pipe treatment facilities. The untreated wastewater is disposed in drains, canals, rivers and agricultural fields, which has brought the existing water resources under severe threat.[7]

In Karachi, which is the largest city of Pakistan with a population size of 10 million, more than 6000 industrial units are established along the coastal belt. With the exception of a handful, most of them discharge the untreated effluent containing heavy metals, detergents, lubricating oils, chlorine and various organic and inorganic toxic compounds into the sewers or rivers and the adjacent creeks leading to the Arabian Sea, which is having adverse effects on the fishing and shrimp industry.

The situation is no different in other parts of the country. According to the Punjab Environmental Protection Department estimates, approximately 9000 million gallons of wastewater having 20,000 tons of biological oxygen demand (BOD) are discharged daily into water bodies by firms in the main industrial cities of the Punjab province. The water available in most of these areas is unfit for human consumption and it is therefore hardly surprising that approximately 40-50 per cent of total deaths in Pakistan are the result of water borne diseases (GoP-IUNC 1992).[8]

Table 4
Estimated air pollutants from various economic sectors ('000 ton)

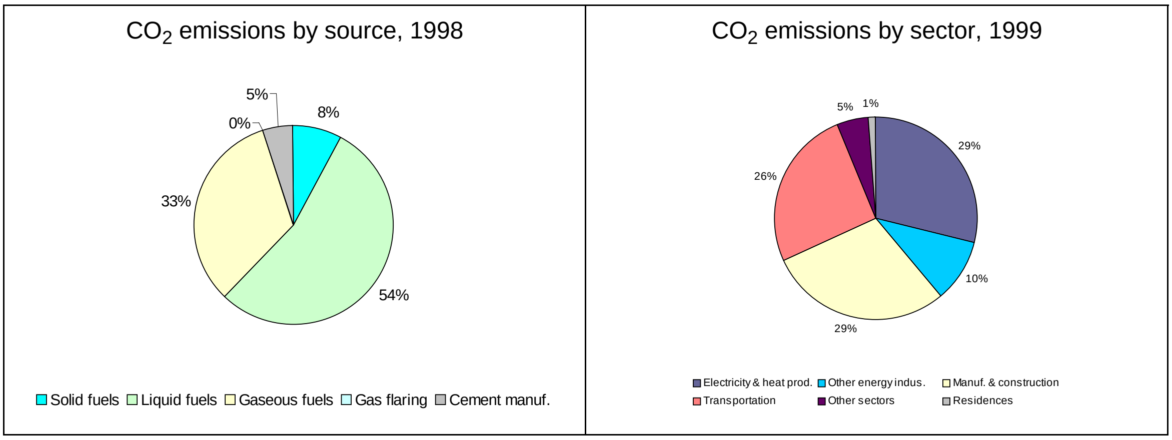
	1977-78		1987-88		1997-98	
Sector	CO_2	SO_2	CO_2	SO_2	CO_2	SO_2
Industry	12,300	19	26,700	423	53,400	982
Transport	7,100	52	10,300	57	19,000	105
Power	3,600	4	11,200	95	53,100	996
Domestic	16,600	5	24,100	16	40,000	40
Agriculture	850	5	4,500	28	6,400	40
Commercial	1,700	11	2,600	13	4,300	25
Total	42,150	96	79,400	632	176,200	2,188

Source: GoP (*Economic Survey* 2000-01).

7 A study by Punjab Environmental Protection Department estimates biological oxygen demand in Pakistan's main river Ravi to be as high as 300 mg/l as compared to the acceptable WHO limit of 9 mg/l.

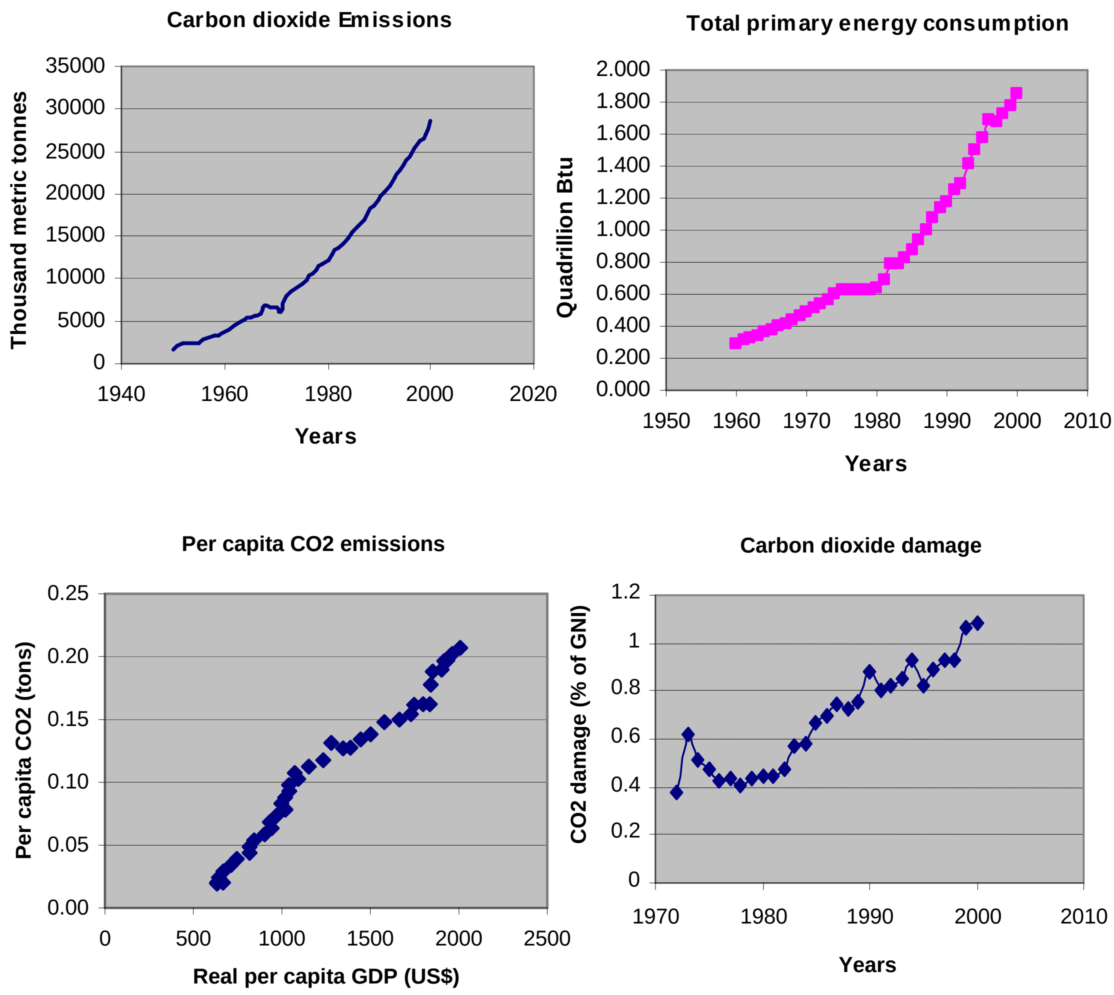
8 Cases of waterborne diseases caused by industrial pollution in Pakistan have gained international attention. Two notable examples are the industrial fluoride poisoning case where hundreds of villagers in eastern Punjab were diagnosed to suffer with bone deformities caused by bone fluorosis, and the Kasur tannery case where thousands of people in Kasur, which is the hub of leather industry, suffered from cancer, eye disorders and skin diseases due to soil and water pollution caused by the tanneries.

Figure 3
CO_2 emissions by source and sector in Pakistan



Source: GoP (*Economic Survey* 2000-01).

Figure 4
Indicators of environmental quality



Source: Compiled by the author from World Bank (2004).

The deterioration of air quality is another serious issue. Recently, a joint study done by the Environment Protection Agency and the Japan International Co-operation Agency revealed that the average suspended particulate matter (SPM) in the ambient air of Lahore, Islamabad and Rawalpindi is 6.4 times higher than World Health Organisation's guidelines and 3.8 times higher than Japanese standards. From 1963 to 1990, it is estimated that the levels of six types of industrial pollutants—toxics, heavy metals, BOD, suspended solid water pollutants, SPM, and sulphur dioxide (SO_2)—increased from six to ten times whereas the average GDP growth rate was 3 per cent only (ADB 1998). Table 4 shows that the average increase in SO_2 was twenty-three fold and that in carbon dioxide (CO_2) emissions was fourfold from 1977-78 to 1997-98. The major contributors to this increase are the manufacturing and power-generating sectors (Figure 3).

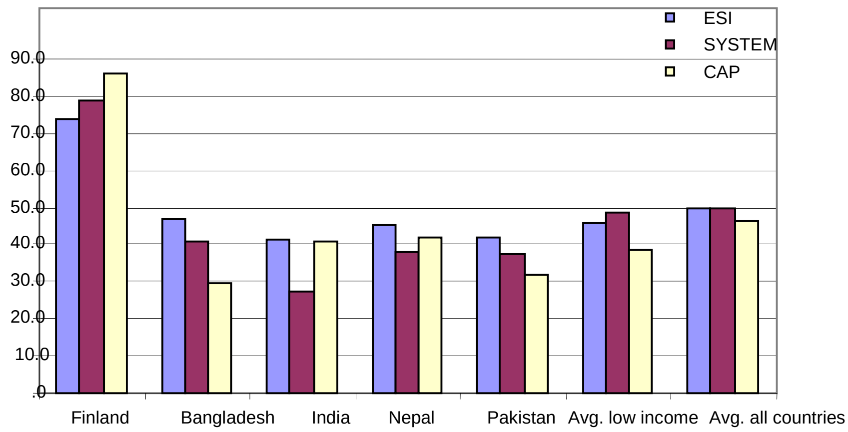
Figure 4 shows that total primary energy consumption and CO_2 emissions have been increasing exponentially over time, whereas the damage incurred by CO_2 emissions as a percentage of gross national income exhibits a positive linear trend. Table 5 presents the

Table 5
CO_2 emissions in Pakistan

Carbon dioxide (CO_2) emissions	Pakistan	World
Total emissions in 1000 metric tons, 1998	97,109	24,215,376
% change in total emissions since 1990	43 %	8 %
Emissions as a % of global CO_2 production	0.4 %	
Per capita CO_2 emissions in 1000 metric tons, 1998	1	4
% change in per capita emissions since 1990	12 %	-2 %
CO_2 emissions (metric tons) per million dollars GDP, 1998	1445	773
% change in CO_2 intensity since 1990	3 %	-10 %
Cumulative CO_2 emissions, 1900-99 (in billion metric tons)	1,771	933,686

Source: World Resources Institute (2003).

Figure 5
ESI comparison—Pakistan and other countries, 2002



Source: Compiled by the author from the ESI database.

performance of Pakistan vis-à-vis the rest of the world. The most striking observation is the rapid increase in CO_2 emissions—whereas the percentage increase in world emissions during 1990-98 was 8 per cent, it was 43 per cent in Pakistan. Another noticeable feature is its high emission intensity (emissions per unit of output), which is almost double the average world intensity.

The Environmental Sustainability Index (ESI) compiled by the Yale Centre for Environmental Law and Policy and the Centre for International Earth Science Information Network, ranked Pakistan as 137 out of 146 countries in 2005. The highest ranking country was Finland that scored almost double than Pakistan. Pakistan recorded poor environmental performance as compared to its neighbouring countries as well as to its counterparts in the low-income group (Figure 5).

2.4 Environmental regulation in Pakistan

The response to environmental pollution in Pakistan began in the early 1990s. In 1992, as part of its preparations for participating in the Rio Earth Summit, the government of Pakistan prepared the National Conservation Strategy (NCS), which outlined an environmental agenda for the country and set forth goals for natural resource conservation. In 1993 environmental concerns were brought to the fore and National Environmental Quality Standards (NEQS) were approved to set limits on major industrial and vehicular emissions, municipal effluents and noise. The NEQS were, however, rejected by the industrial sector and deemed as unrealistic. They were revised in 1996 and made compatible with the standards of other developing countries with a similar industrial base.

After several years of deliberations, the Pakistan Environmental Protection Act (PEPA) was enacted in 1997, which led to the establishment of four provincial environmental protection agencies to facilitate monitoring of compliance in the provinces. However, the regulatory authorities face numerous financial, technical and political constraints and the enforcement of NEQS to date remains extremely weak.[9]

3 Conceptual framework

The impact of trade liberalization on the environment has been the subject of many theoretical and empirical investigations. The trade-environment literature is closely linked to the growth-environment studies which, following the pioneering contribution of Grossman and Krueger (1993), examine the effect of economic growth on the environment by decomposing emissions into *scale, composition* and *technique effects*. The decomposition of the total emissions released during production of a commodity X is expressed as:[10]

$$Z = eX = e\xi S \tag{1}$$

9 The government is now actively encouraging self-monitoring and reporting of effluents and emissions, but this initiative has received a lukewarm response from the industry so far.

10 This approach concentrates on industrial emissions and does take into account pollution caused by the transportation of products due to trade liberalization (Jenkins 1998).

where Z is the total emissions released, e is the pollution intensity of X, ξ is the share of output X in total output of the economy and S is the scale of total output. Taking logs and totally differentiating, we obtain:

$$\hat{Z} = \hat{S} + \hat{\xi} + \hat{e}, \tag{2}$$

where ^ denotes percentage change. The first term on the right-hand side is the *scale effect*, which implies that, all else remaining constant, an expansion of economic activity increases environmental damage because more emissions are created as a by-product. The second term is the *composition effect*, which refers to any changes in emissions solely as a result of the structural changes in the economy, that is, ceteris paribus, a move towards pollution-intensive production would generate more pollution and vice versa. Finally, the last term in (2) represents the *technological effect*, which indicates changes in pollution as a result of changes in the production processes while holding the scale and composition of economic activity constant.

In the context of trade liberalization, the scale, composition and technique effects reflect the environmental consequences of the increase in production as a result of increased market access opportunities, the changes in the industrial structure brought about by changes in the relative prices of goods, and the technological progress as a result of technology transfer, respectively. In general, the scale and technique effects are considered negative and positive, respectively, but the direction of the composition effect is most controversial. The latter has therefore been a subject of much controversy and research in the past few years, which has given rise to two competing points of view on the issue: the *factor endowment hypothesis* and the *pollution haven hypothesis* (PHH).

The *factor endowment hypothesis* predicts that factor endowments rather than environmental policy are the prime determinants of trade patterns. Under this view, developed countries that have a comparative advantage in capital-intensive products are more likely to specialize in capital-intensive and, hence, more pollution-intensive products regardless of the environmental regulations in place. Among others, the findings of Tobey (1990), Grossman and Krueger (1993), Jaffe *et al.* (1995), and Mani and Wheeler (1999) lend support to this argument and they report no relationship between environmental regulations and trade patterns.

The PHH, however, asserts that environmental policy plays an important role in determining the comparative advantage of a country. Firms in countries with weak or no environmental regulations consider environment as a relatively abundant factor of production and pollute freely. The production and export of environmentally hazardous products therefore increase under trade in these countries. A number of studies find evidence in support of this argument, for example, Low and Yeats (1992); Lucas, Wheeler and Hettige (1992); Heil and Selden (2001); Jha and Gamper-Rabindran (2004); Mani and Jha (2005).

In order to investigate the PHH, traditionally two approaches have been used: the factor content of trade approach and the trade-in-goods approach. The factor content approach studies the effect of trade on the environment indirectly by tracking changes in the pattern of environmental factor services embodied in traded commodities in the form of pollution emitted domestically (Walter 1973; Robison 1988; Xu and Song 2000). If environmental regulations differ across countries, then countries with low (high) environmental standards are expected to export (import) goods with relatively higher embodied environmental services and import (export) goods with relatively low embodied environmental services. In contrast, the trade-in-goods approach examines the changes in trade patterns directly in a bilateral or multilateral framework (Grossman and Krueger 1993; Cole and Elliott 2003; Ederington, Levinson and Minier 2003). We assess the changes in Pakistan's trade pattern pre- and post-liberalization in a comprehensive manner by employing both approaches in this paper.

3.1 Factor content of trade

We study the embodied environmental factor content of Pakistan's trade by building our framework on the standard multi-factor, multi-commodity, and multi-country Heckscher-Ohlin-Vanek (HOV) model of trade in factor services, developed by Vanek (1968). The HOV model, an extension of the traditional two-good two-factor Heckscher-Ohlin (HO) model, interprets trade in goods as an international exchange of factor services embodied in the traded goods and shows that under balanced trade, countries will have an embodied net export and net import of relatively abundant and scarce factors, respectively.

Following Coase (1960), and treating environment as a factor of production, we use the HOV model to estimate environmental services embodied in trade.[11] Thus, if f countries produce j types of goods with i factors of production, then under the standard HOV model assumptions of identical and constant returns to scale technologies across countries, homothetic consumer preferences, different cross-country factor endowments, international mobility of goods and immobility of factors, no possibility of joint production and no factor intensity reversals, the vector of net exports for country f is given by:

$$T^f = X^f - M^f , \tag{3}$$

where X^f and M^f denote the vectors of exported and imported goods, respectively.

If $A = [a_{ij}]$ denotes the input-output coefficient matrix for country f, where a_{ij} represents the per unit input requirement, then the factors embodied in X^f are given by V^X such as:

$$V^{X^f} = AX^f . \tag{4}$$

Similarly, the factors embodied in M^f are given by:

$$V^{M^f} = A^* M^f , \tag{5}$$

11 The factor content of trade approach is commonly applied to test the validity of the HOV model for labour and capital (Leontief 1953; Deardorff 1982; Leamer 1984). When environment is taken as an input, variations in national environmental regulations imply that the endowment of environment differs across countries and, therefore, the pattern of environmental service flows may also vary among them.

where A^* denotes the input-output coefficient matrix of the foreign country from where the imports of country f originate.[12] Thus, the net factor content of trade, as specified by Deardorff (1982), is expressed as:

$$V^{T^f} = V^{X^f} - V^{M^f} = AX^f - A^*M^f, \tag{6}$$

where V^T is the vector of net factor trade. With identical technologies across countries and factor price equalization, we have $A=A^*$ and equation (6) may be simplified.

Equation (6) is a straightforward and convenient tool to compare the factor content of exports and imports over time and across countries. A positive (negative) value of an element in V^T indicates that the factor is net exported (imported). When considering only one factor of production, (6) can be written as:

$$V_i^{T^f} = \sum_j a_{ij} X_j^f - \sum_j a_{ij} M_j^f = \sum_j X_j^f \sum_j \left[\frac{a_{ij} X_j^f}{\sum_j X_j^f} \right] - \sum_j M_j^f \sum_j \left[\frac{a_{ij} M_j^f}{\sum_j M_j^f} \right] \tag{7}$$

where V_i^T is the net export of the ith factor, and, X_j and M_j are the exports and imports of the jth good, respectively.

3.2 The trade-in-goods approach

The trade-in-goods approach followed here differs from earlier studies since we analyse bilateral trade flows by employing the gravity model to examine the effect of trade liberalization on the composition of exports and imports. van Beers and van den Bergh (2000) argue that useful information is lost in a multilateral framework because of aggregation; hence, a bilateral approach is preferable to a multilateral analysis. Further, previous studies, for example, Ederington and Minier 2003; Ederington, Levinson and Minier 2003; Jha and Gamper-Rabindran 2004, follow Grossman and Krueger's (1993) HOV framework and express net exports of each sector as a function of the labour, capital and pollution intensity of that sector. For Pakistan, however, the available industrial statistics are limited and unreliable, which makes it difficult to adopt the HOV model for regression analysis.

The gravity model, which follows the law of universal gravitation from physics, is a popular tool to predict trade flows. It models trade as being proportional to the economic size and proximity of trading partners, and inversely proportional to distance and other obstacles to trade. Although simply specified, gravity models have performed extremely well empirically, and have therefore been used extensively for both *inter* and *intra*-national trade flow analysis. In recent years, the models have been augmented to examine determinants of trade other than distance and size and, most commonly, dummy variables are included to capture the influence of various political, cultural and historical factors on trade flows.

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12 Deardorff (1982) suggests that the input-output matrix A should measure the total factor demand, i.e., direct plus indirect use of input factors when the model has more goods than factors. The total factor demand may be expressed as $A=F(I-B)^{-1}$, where F is the direct factor input requirement matrix and $(I-B)^{-1}$ is the Leontief-inverse matrix, which represents the amount of output required as intermediary.

In its most general form, a gravity model is specified as:

$$F = X\beta + D\lambda + \varepsilon\ ,\ \varepsilon \sim N(0,\sigma^2) \quad (8)$$

where F is a vector of (logs of) bilateral trade flows, X is a matrix of (logs of) explanatory variables, D is a matrix representing the dummy variables and ε is the vector of normally distributed error terms.

To test the hypothesis that trade liberalization is associated with an increase in the exports of dirty products relative to clean products in Pakistan, we introduce an interaction term of sectoral pollution intensities with a measure for trade liberalization, T, alongside the traditional variables of gravity model. Hence (8) may be expressed as:

$$\begin{aligned}\ln(F_{ijkt}) = b_0 + b_1 \ln(Y_{it} Y_{jt}) + b_2 \ln(POP_{it} POP_{jt}) + b_3 \ln(Area_{it} Area_{jt}) + b_4 \ln(DIST_{ij}) \\ + b_5 P_k T + b_6 D_{LANDLOCK} + b_7 D_{COL} + b_8 D_{LANG} + \mu_{ijk} + \lambda_t + \varepsilon_{ijkt}\end{aligned} \quad (9)$$

where F_{ijkt} denotes the export or import of a four-digit SITC industry k from country i to country j in time period t.[13] Y_i and Y_j denote real per capita income, POP_i and POP_j represent total population and $Area_i$ and $Area_j$ are the geographical land areas for countries i and j, respectively. $DIST$ is the distance between the trading partners, and $D_{LANDLOCK}$, D_{COL} and D_{LANG} are dummy variables that equal one if the importing country is landlocked, if the trading partners share colonial ties and if the two countries have a similar language, respectively, and are equal to zero otherwise.[14]

The variable of interest in (9) is the interaction term between the pollution intensity (P) of sector k and the trade liberalization measure (T). We use a dummy variable as a measure of trade liberalization, such that T is equal to one for the post-liberalization period and zero otherwise.[15] For the exports equation, a positive b_5 indicates that the exports of more pollution-intensive products have increased after trade liberalization, whereas for the imports equation, b_5 is expected to be negative if liberalization has reduced the imports of pollution-intensive products into the country.

Anderson and van Wincoop (2001) show that in equilibrium, bilateral trade depends on the relative prices of the exporting and importing countries, which themselves depend on the existence of trade barriers or 'multilateral resistance' from other countries. Omitting relative prices could, therefore, bias the estimates. To control for this source of bias, we introduce importing country-industry effects, μ_{ijk}, that are obtained by interacting importing country fixed-effects with the industry dummies.[16] Further, to take into account any effects that remain the same for all industries across all country pairs but change over time, we introduce time-specific effects, λ_t, in (9). Finally, ε_{ijkt} is

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13 To include the zero observations in our sample, we follow Eichengreen and Irwin (1998) and Chen (2004), and express $\ln(X_{ij}) \approx \ln(1+X_{ij})$.

14 The common border dummy is not included due to the nature of the dataset.

15 We consider 1990 onwards to be the post-liberalization period since liberalization efforts gained rapid momentum due to the structural adjustment programme.

16 b_3, b_4, b_6, b_7 and b_8 are not identified if u_{ijk} is included and (9) is estimated as a fixed effects model.

the idiosyncratic error term, which is assumed to be independently and normally distributed ($\varepsilon_{ij} \sim N(0,\sigma)$).

4 Data issues and empirical results

Like most of the other developing countries, no comprehensive database on environmental indicators and industrial pollution exists in Pakistan due to lack of plant level monitoring. Past efforts to collect data at the industrial level have been fragmentary, which has resulted in the compilation of incomplete and unreliable information that cannot be used for in depth analysis and time series comparisons.

To overcome the data constraints, we use the toxic pollution intensity index known as the Linear Acute Human Toxicity Index (LAHTI) developed by the Industrial Pollution Projection System (IPPS) of the World Bank specifically for the purpose of estimating pollution loads in developing countries (Hettige *et al.* 1994). IPPS combines the industrial activity data of 200,000 factories in the United States with their pollution emissions data to calculate pollution intensity factors—the level of pollution emissions per unit of industrial activity—for different types of air and water pollutants. The pollution intensity coefficients are combined with toxicity estimates of the pollutants to create LAHTI for different sectors, which is a weighted average of various effluents with weights measuring the risk the pollutants pose to human health.

LAHTI is a useful tool since it takes into account the different types of pollutants released by a sector and gives an overall assessment of the environmental and health risks associated with it. It is preferable to using individual pollutant intensities because sectoral pollution intensity correlations for the various types of pollutants have a diverse pattern—they are higher for pollutants *in* the same category but tend to be lower *across* categories (Hettige *et al.* 1994). For example, an industry might have high pollution intensities for SO_2 and NO_x that are both air pollutants but a lower intensity for BOD, which is a water pollutant. Taking into account the pollution intensity for one or a few pollutants only, therefore, might not accurately depict the total toxicity associated with an industrial sector.[17]

The IPPS pollution intensity coefficients and indices have been widely used to estimate pollution loads and to study the environmental footprint of industrial development in countries with insufficient information on industrial pollution (Cole, Rayner and Bates 1997; Laplante and Smits 1998; Jha and Gamper-Rabindran 2004). The main advantage of estimating pollution loads with IPPS is its relatively modest data requirement, which has made it a convenient and viable option for research purposes. The estimates might not be conclusive in terms of magnitude, but they indicate the overall trend in the industrial pollution of a country.

In most likelihood, the pollution coefficients and indices constructed with US data understate the pollution generated by Pakistani industries.[18] However, we prefer to use

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17 For example, leather is a highly toxic industry and a main source of water pollution. However, it is a moderately polluting industry in terms of air pollution.

18 Studies that estimate pollution loads for developing countries like Brazil, China and Mexico confirm that they have higher pollution intensities in general than their US counterparts (Gallagher 2000). This

LAHTI for two main reasons: first, the ranking of industries on the basis of LAHTI is very similar to the assessment made by the Environmental Protection Agency of Pakistan (EPA).[19] This confirms the observation of earlier studies that the highest polluting sectors are similar across countries though their pollution intensities may vary from one country to another. Second, the purpose of this paper is to identify the compositional changes that have occurred in Pakistan's economy and not to provide estimates of industrial pollution loads *per se*. Thus, LAHTI provides an appropriate approximation for our analysis.[20]

4.1 Data sources

The data on bilateral trade flows from 1975 to 2003 are obtained from the United Nations' Commodity Trade Statistics Database (COMTRADE). These data are grouped according to the United Nations' Standard International Trade Classification (SITC) system, which differs from the International Standard Industrial Classification (ISIC) codes that are used for representing industrial statistics. Hence, we first map the SITC categories to ISIC codes and calculate the value of exports and imports for manufacturing industries in Pakistan according to four-digit ISIC codes. The industrial production data are taken from various issues of the *Census of Manufacturing Industries* (CMI), which are available from 1975-76 to 1995-96 only. Data on real income per capita, population and land area are obtained from World Bank's *World Development Indicators 2004* whereas information on all other variables is taken from Centre d'Etudes Prospectives et d'Informations Internationales and Rose (2004), respectively.

4.2 Identifying compositional changes

We begin our analysis by estimating the environmental consequences of the compositional changes in Pakistan's manufacturing sector. To do so, we follow the approach of Cole and Neumayer (2004) and calculate the sectoral shares during 1975-76, and then multiply these shares with the aggregate industrial output of 1995-96 to obtain estimates of sectoral output if industrial composition in 1995-96 had remained the same as in 1975-76.[21] Both the actual and counterfactual sectoral production of 1995-96 is then multiplied with the IPPS sectoral pollution intensities for nitrogen oxide (NO_x), sulphur dioxide (SO_2), and carbon monoxide (CO), and for the overall toxicity index LAHTI. The counterfactual statistics indicate the level of emissions *if* industrial composition had remained the same as in 1975-76 and the sign of the difference between the counterfactual and actual emissions indicates if the compositional effect alone has been benign or harmful for environmental quality in Pakistan.

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is due to weaker environmental regulations, low productivity, old technology and the adoption of cost-saving highly pollution-intensive production methods in these countries.

19 See Table A1 in the Appendix.

20 Recently data on pollution intensities have been compiled for a few developing countries, for example, China and Mexico. These datasets are, however, limited in scope since they are highly aggregated and also do not classify industries according to their overall hazardousness.

21 Data for 1995-96 are used because that is the most recent year for which industrial statistics are available.

Table 6
Compositional changes pre and post-liberalization

LAHTI	Environmental effect	Negative
	Percentage change	16.2
NOx	Environmental effect	Negative
	Percentage change	23.2
SO_2	Environmental effect	Negative
	Percentage change	21.17
CO	Environmental effect	Negative
	Percentage change	10.78

Source: Author's own calculations.

Table 7
Sectoral shares in total manufacturing output (in per cent)

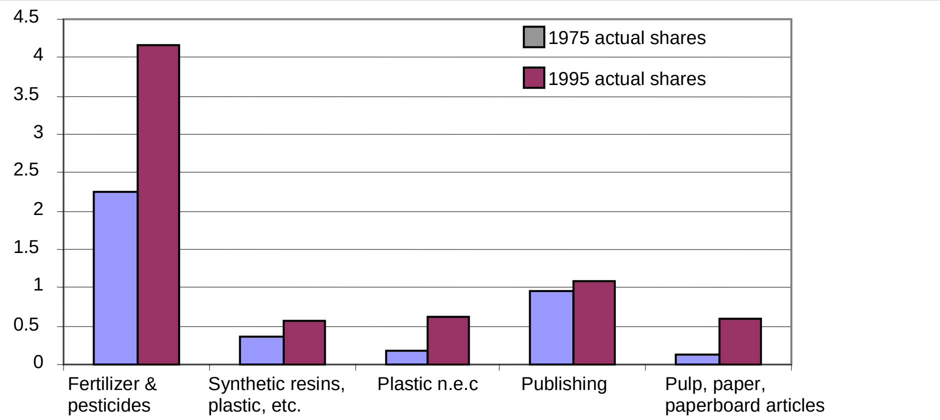
ISIC Codes		1976	1986	1996
Highly polluting industries				
321	Textiles	24.98923	18.96661	30.21233
323	Leather & products	1.782815	2.387724	1.470677
341	Paper & products	1.607184	1.217953	1.574255
342	Printing & publishing	0.891407	1.050652	1.047131
351	Industrial chemicals	4.264837	6.413662	6.086078
352	Other chemical products	5.258972	6.366149	6.628496
355	Manufacture of rubber products	1.633695	1.452844	0.775013
369	Non metallic mineral products	3.12821	4.515127	4.093577
371	Iron & steel basic industries	4.645922	6.425039	4.06738
372	Non-ferrous metals	0.069589	0.020076	0.040129
	Sub-total	48.27186	48.81584	55.99507
Moderately polluting industries				
311	Food	22.62982	22.18148	18.59153
313	Beverages	1.083607	1.533818	1.080597
314	Tobacco	4.347682	4.762733	2.439216
331	Wood & products	0.195513	0.297796	0.219875
362	Glass & products	0.195513	0.495881	0.239712
381	Fabricated metal products	1.650263	0.815761	0.715047
383	Electrical machinery	3.008914	3.47719	4.68309
384	Transport equipment	5.404778	4.24343	4.509552
	Sub-total	38.51609	37.80809	32.47862
Less polluting industries				
322	Wearing apparel	0.304868	1.420723	1.530189
324	Footwear(except rubber/plastic)	0.162375	0.240245	0.588907
332	Furniture & fixture	0.109355	0.080305	0.053152
356	Plastic products	0.159062	0.65649	0.593147
361	Pottery/china/earthenware	0.092786	0.204108	0.131137
382	Non-electrical goods	2.892932	3.323273	1.899978
385	Professional & scientific equipment	0.351261	0.264336	0.338898
390	Others	9.139411	7.186594	6.390905
	Sub-total	13.21205	13.37607	11.52631
	Total	100	100	100

Source: GoP (*CMI* various issues).

The direction of the composition effect and the approximate percentage changes in emissions of the four types of pollutants are presented in Table 6.[22] The per cent changes may be considered as the lower bounds of actual changes since the pollution intensities used here are for the US. The calculations reveal a negative compositional effect in terms of LAHTI as well as for the three air pollutants. This indicates that the emissions from industrial manufacturing in 1995-96 were much higher than if the composition of production had remained the same as in 1975-76.

Table 7 presents the shares of different types of industries classified into highly pollution intensive, moderately pollution intensive and less pollution intensive, based on LAHTI. In 1975 the share of highly pollution-intensive industries in total manufacturing output was 48.2 per cent, which increased to 55.9 per cent in 1996. However, the shares of moderately and less polluting sectors in total industrial output have been decreasing over time. Figure 6 presents the percentage contribution of various pollution-intensive industries to total manufacturing in 1975-76 and 1995-96, and shows that their respective shares have increased over time.

Figure 6
Shares of pollution-intensive industries (%)



Source: Author's own calculations.

4.3 Empirical results

Factor content of trade

We investigate changes in the pattern of embodied environmental factor services (EEFS) in Pakistan's traded goods by examining bilateral trade data between Pakistan and the Organisation for Economic Co-operation and Development (OECD) countries from 1975 to 2000. The OECD countries, which are Pakistan's principal trading partners, are considered to have the most stringent environmental regulations in the

22 These estimates are constructed using the statistics from CMI, which covers only registered firms (firms with at least ten employees) and does not take into account production by small scale, unregistered firms. Consistent time-series data for small scale and household manufacturing industries (SSHMI) are unavailable. Prior to 1988-89, ad hoc surveys were conducted with different geographical coverage. Information gathered by the relatively recent census of SSHMI is therefore not comparable to the previous surveys (GoP 1989).

world.[23] If PHH holds true for Pakistan, then we would expect a rise in the *net* exports of EEFS to the OECD countries in the post-liberalization period.[24]

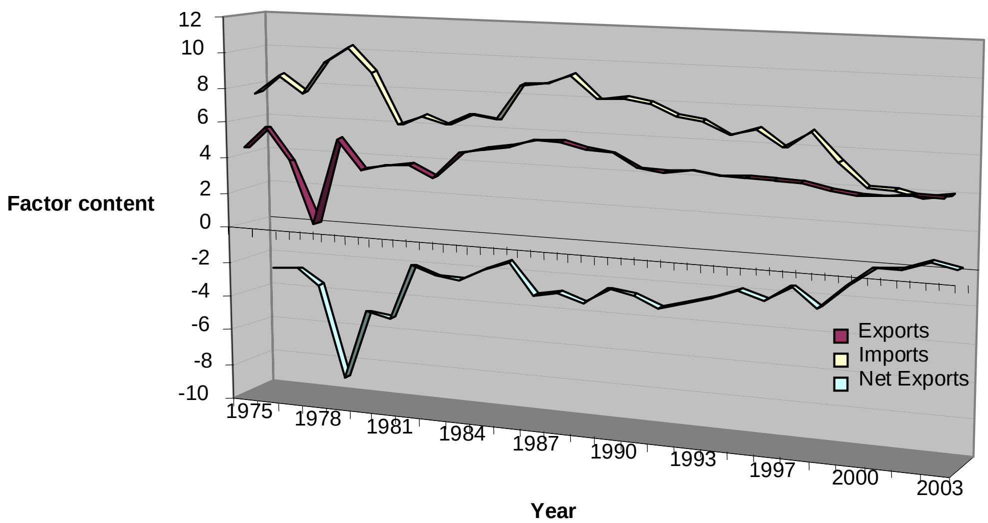
The average EEFS in tradable commodities is measured using LAHTI. Since time-series industrial pollution data are unavailable for most countries, we assume that LAHTI is applicable to all countries in our sample. This assumption is justifiable considering that the most pollution-intensive industries tend to be the same globally. Another important measurement issue pertains to the indirect input requirements as measured by the Leontief's inverse matrix. Under the assumption of identical technology across countries, the input-output coefficients are the same for exports and imports. If this assumption is violated, then per unit input requirements might be different across countries and the factor content of trade must be measured using producers' technology (Deardorff 1982). However, due to difficulty in obtaining sufficiently disaggregated

Table 8
Net exports of embodied environmental factor services to OECD economies

Year	1975-79	1980-84	1984-89	1990-94	1995-99	2000-03
All OECD countries	-1.590	-0.994	-0.910	-0.966	-0.651	0.015
Australia	-0.953	0.5365	1.477	1.095	1.343	-1.238
Canada	-0.732	-0.002	0.076	0.128	0.127	0.097
Europe*	-5.839	-3.574	-2.507	-3.745	-2.385	-0.358
Japan	-0.568	-0.236	-0.094	-0.184	-0.245	-0.150
USA	-2.498	-3.150	-3.870	-3.413	-2.161	0.742

Note: * Includes European OECD member countries only.
Source: Author's own calculations.

Figure 7
Net exports of embodied environmental factor services to OECD economies



Source: Author's own computation.

[23] See Table A2 in the Appendix for the direction of trade statistics.

[24] A notable exception to this is Mexico, which is therefore not included in our sample.

input-output tables for countries, we could either calculate the direct input requirements instead of total input requirements or apply the same input-output table to the exporting and importing countries. We apply both methods but do not gain much since the curve obtained from the latter method is simply shifted upwards.[25] We, therefore, present and discuss the results of the direct factor input requirement methodology only.

Our findings are presented in Table 8 where the successive columns indicate the average net exports of EEFS during each period. Following Xu and Song (2000), we facilitate comparison across the years by taking 1975-79 as our base year and normalizing the average net exports in that period to unity. The normalization yields a negative unity for Pakistan, which indicates that the effluent content of Pakistan's imports was higher than the effluent content of its exports to the OECD countries in 1975-79. Over time, however, the trend has reversed and the embodied effluent content of Pakistan's exports has increased whereas the embodied effluent content of its imports has decreased (Figure 7).

The increase in the net exports of EEFS is the largest during 1990s, which coincides with the time when liberalization efforts heightened in the country. Table 8 also reveals interesting trends in terms of the trading partners. For Canada and the USA, we observe significant structural changes in the pollution content of trade as the sign of the net exports of EEFS changes from negative in 1975 to positive in 2003. For Europe and Japan, Pakistan remains a net importer of EEFS although its exports to the two regions have increased substantially over time. Australia was a net importer of EEFS during the 1980s and the 1990s, but became a net exporter during 2000-03.

Trade in goods

The gravity model as specified in equation (9) is estimated using Pakistan's bilateral trade data (at the four-digit ISIC level) with the OECD countries during 1975-2003. The measure of pollution intensity is the ranking of sectors according to LAHTI where the most pollution-intensive sector has the highest rank (= 63) and the least polluting sector has the lowest score (= 1).[26]

The first five columns of Table 9 report the regression results for the exports equation where the gravity model is estimated with and without fixed effects. The results obtained are satisfactory and correspond to the theoretical predictions of the model. The traditional variables of the gravity model, income and population, have statistically significant and positive coefficients in all estimations. The geographical distance between the trading partners, the size of the land area, and the landlockedness of countries have a negative influence on exports in the estimation without fixed effects. Historical colonial ties and common language positively affect exports although the effect is insignificant for the latter.

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25 This is because we use the same input-output table for the entire period. More accurate results might be obtained if annual tables are used but this is not possible in our case due to unavailability of data.

26 The model was estimated with the actual values of LAHTI and the results obtained were almost identical. However, we prefer to use the ranking of sectors as it coincides with the ranking made available by EPA Pakistan.

Table 9
Liberalization and pollution intensity of exports

	OLS			Fixed effects		Tobin model		
Variable	(1)	(2)	(3)	(4)	(5)		(6)	(7)
Log(YiYj)	0.439	0.257***	0.305***	0.257***	0.305***		0.821***	2.109***
	(33.85)***	(5.29)	(4.52)	(6.31)	(5.46)		(4.81)	(7.75)
Log(NiNj)	-0.078***	0.104	0.283*	0.104	0.283**		0.830**	1.935***
	(5.86)	(0.88)	(1.93)	(1.04)	(2.27)		(2.03)	(3.97)
Log(AiAj)	-0.055***							
	(8.06)							
Log(DIST)	-0.108***							
	(2.96)							
Pk×T	**0.001**	**0.004*** **	**0.007*** **	**0.004*** **	**0.007*** **		**0.013*** **	**0.027*** **
	(0.91)	**(10.49)**	**(12.31)**	**(13.02)**	**(14.88)**		**(10.01)**	**(14.63)**
LANDLOCK	-0.323***							
	(11.98)							
DCOL	1.003***							
	(17.28)							
DLANG	0.026							
	(1.10)							
Time effects	No	No	Yes	No	Yes		No	Yes
Industry-country	No	Yes	Yes	Yes	Yes		Yes	Yes
N	85652	85652	85652	85652	85652	N	85652	85652
F-stat	767.04	830.60	711.81	1243.68	137.23	LR chi2	64859.24	65276.93
Prob. > F	0.00	0.00	0.00	0.00	0.00	Prob. > chi2	0.00	0.00
R2-overall	0.07	0.65	0.65	0.78	0.78	Pseudo-R2	0.32	0.32

Note: The independent variable is the log of exports, values in parentheses are the robust t-statistics, a constant is included in all regressions, * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level

Table 10A
Liberalization and pollution intensity of imports

	OLS			Fixed effects			Tobit model	
Variable	(1)	(2)	(3)	(4)	(5)		(6)	(7)
$Log(Y_iY_j)$	0.809*** (51.25)	-0.256*** (3.93)	0.257*** (2.68)	-0.257*** (5.21)	0.257*** (3.71)		-0.955*** (7.84)	0.717*** (3.65)
$Log(N_iN_j)$	0.144 (8.87)***	1.332*** (8.43)	2.271*** (12.02)	1.332*** (10.97)	2.271*** (14.96)		3.963*** (13.43)	5.893*** (16.79)
$Log(A_iA_j)$	-0.226*** (27.69)							
Log(DIST)	-0.547*** (13.02)							
$P_k \times T$	**-0.009***** **(18.64)**	**-0.002***** **(3.09)**	**-0.001*** **(1.92)**	**-0.002***** **(4.27)**	**-0.001***** **(2.64)**		**-0.004***** **(4.42)**	**-0.004***** **(2.92)**
LANDLOCK	-0.038 (1.06)							
D_{COL}	1.893*** (33.78)							
D_{LANG}	-0.267*** (9.92)							
Time effects	No	No	Yes	No	Yes		No	Yes
Industry-country	No	Yes	Yes	Yes	Yes		Yes	Yes
N	85652	85652	85652	85652	85652	N	85652	**85652**
F-stat	3412.87	830.60	1149.38	376.83	50.06	LR chi2	81619.78	**81968.88**
Prob. > F	0.00	0.00	0.00	0.00	0.00	Prob. > chi2	0.00	**0.00**
R2-overall	0.23	0.65	0.61	0.80	0.79	Pseudo-R2	0.25	**0.25**

Note: The independent variable is the log of imports, values in parentheses are the robust t-statistics, a constant is included in all regressions, * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level

Table 10B
Liberalization and pollution intensity of imports

Variable	OLS (1)	OLS (2)	OLS (3)	Fixed effects (4)	Fixed effects (5)		Tobin model (6)	Tobin model (7)
$Log(Y_iY_j)$	0.827***	-0.272	-0.103	-0.272	-0.103		-0.185	0.065
	(18.71)	(0.63)	(0.63)	(0.86)	(0.33)		(0.27)	(0.09)
$Log(N_iN_j)$	0.181***	1.277	3.649***	1.277*	3.649***		2.12	6.139**
	(4.15)	(1.38)	(2.41)	(1.91)	(3.20)		(1.51)	(2.84)
$Log(A_iA_j)$	-0.237***							
	(12.02)							
Log(DIST)	0.104							
	(1.02)							
$P_k \times$Tariff	0.001***	0.000	0.000	0.001**	0.001**		0.001	0.001*
	(15.48)	(1.55)	(1.50)	(2.26)	(2.21)		(1.25)	(1.85)
Tariff	-0.012***	-0.002	-0.003	-0.002	-0.003		-0.002	-0.005
	(8.91)	(0.63)	(1.15)	(0.92)	(1.72)*		(0.42)	(1.03)
LANDLOCK	-0.082							
	(0.96)							
D_{COL}	1.337***							
	(10.28)							
D_{LANG}	-0.083							
	(1.27)							
Time effects	No	No	Yes	No	Yes		No	Yes
Industry-country	No	Yes	Yes	Yes	Yes		Yes	Yes
N	15180	15180	15180	15180	15180	N	15180	15180
F-stat	586.39	290.71	285.43	5.53	26.46	LR chi2	16100.03	16179.52
Prob. > F	0.00	0.00	0.00	0.00	0.00	Prob. > chi2	0.00	0.00
R2-overall	0.22	0.64	0.65	0.87	0.87	Pseudo-R2	0.26	0.26

Note: The independent variable is the log of imports, values in parentheses are the robust t-statistics, a constant is included in all regressions, * indicates significance at 10% level, ** indicates significance at 5% level, *** indicates significance at 1% level

When the country-industry fixed effects are controlled for, all time-invariant variables drop from the model (columns (2)-(5)).[27] In all specifications, we find evidence to support that the share of exports grew in the dirty, pollution-intensive sectors as liberalization gained momentum. This is because the coefficient on the interaction term ($P_k \times T$) is positive and highly significant, indicating that with increased liberalization exports of pollution intensive sectors have risen.

In general, disaggregated bilateral trade datasets have a significant number of zero observations. This represents the case when either no exchange between countries took place or it was very small and remained unrecorded. For data configuration it is well-known that OLS estimators are inconsistent and biased downwards. Further, if the zero observations are excluded and the model is estimated with the positive value of exports only, then there is no guarantee that $E(\varepsilon_{ijkt})$ will be zero, and in most likelihood the coefficient estimates would be inconsistent and biased upwards.

For these types of datasets, it is suggested that all observations should be retained in the sample and the limited dependent variable estimation technique, such as the Tobit model, should be applied (McDonald and Moffitt 1980). Hence, we re-estimate (9) using the maximum likelihood Tobit procedure and report the result in the last two columns of Table 9. The signs and significance of all coefficients are similar to those obtained earlier, although, as expected, the magnitude of the coefficients is larger.

The above analysis is repeated for imports into Pakistan from the OECD countries (Table 10A). In this case, we obtain a statistically negative coefficient for the interaction term, suggesting that imports of pollution-intensive commodities have decreased after trade liberalization. For imports, we also estimate an alternate specification where the sectoral tariff rates are used as a proxy for trade liberalization. This estimation, however, is conducted for a smaller sample, since disaggregated tariffs data are available from 1995 onwards only. The positive coefficient of b_5 reported in Table 10B confirms the earlier findings that a reduction in tariffs may have been accompanied by a decrease in the import of pollution-intensive products from the OECD countries. Interestingly, the tariff rate has a negative and statistically significant coefficient, which suggests that tariff reductions have positively affected the imports from the OECD countries.

5 Do environmental regulations matter to trade?

Next, we analyse the PHH from a slightly different perspective and investigate if the differences in environmental regulations across Pakistan's trading partners have any effect on its exports of dirty products. Our study differs from previous studies in two notable ways. First, we use bilateral trade flow data between Pakistan and its trading partners disaggregated at the sectoral level. Earlier studies have used either single country and multilateral trade flow data (Low and Yeats 1992; Tobey 1990) or data for

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[27] To confirm that fixed-effects approach is the appropriate estimation technique, the Hausman test is undertaken. We obtain a significant Hausman statistic for the exports equation (chi2=10.72) and a significant statistic for the imports equation (chi2=68.29), which indicate the presence of fixed effects in both cases.

multiple countries and bilateral trade flows (van Beers and van den Bergh 1997; Cole and Elliott 2003).

Second, we differ in our measure for the strictness of domestic environmental regulations. A majority of studies use 'input oriented' measures of environmental stringency, such as industrial or firm level pollution abatement costs (Ederington and Minier 2001; Levinson and Taylor 2004).[28] van Beers and van den Bergh (1997) argue that input oriented measures might not accurately reflect the state of environmental stringency in a country if governments compensate the pollution-intensive industries by providing them financial assistance in the form of subsidies, export rebates, etc. They, therefore, propose to use 'output oriented' measures that capture the ultimate outcome of environmental regulations and use a regulatory indicator developed by the UNCTAD, which relies on self-reporting by national governments, as a proxy for environmental governance.

In this analysis, we apply both input and output oriented measures of environmental stringency by using two components of the Environment Sustainability Index (ESI)—the Social and Institutional Capacity (CAP) and Environmental System (SYSTEM)—which to our knowledge have not been applied for this type of empirical exercise before. SYSTEMS captures the state of natural and managed environmental systems, such as cultivated systems, air and water quality, water quantity, forests, biodiversity, and therefore appears to be an appropriate indicator for regulatory outcome. In contrast, CAP includes indicators for environmental governance, the use of environmentally friendly production methods, and private sector responsiveness to environmental problems. It is a broader measure than the traditionally used input-oriented regulatory stringency measures since it includes sources of formal regulation (e.g., legislation, government effectiveness) as well as sources of informal regulations (e.g., social pressure, market oriented incentives).

Once again we use the gravity model for our analysis, specified as:

$$\begin{aligned}\ln(X_{ij,k}) = \log\beta_0 + \beta_1 \log(Y_i Y_j) + \beta_2 \log(N_i N_j) + \beta_5 \log(A_i A_j) + \log\beta_4 \log(DIST)_{ij} \\ + \beta_5 \log(ENV)_j + \beta_6 LAND + \beta_7 LANG + \beta_8 BORDER + \beta_9 COL + u_{ijk}\end{aligned} \quad (10)$$

where X_{ijk} represents the exports of industry k from country i to country j, ENV_j denotes the strictness of environmental regime in the importing country j, and the definitions of the remaining variables are the same as in (9). The SYSTEM and CAP variables are used alternately as measures of environmental strictness where a higher score represents better performance and vice versa.[29] Equation (10) is estimated for the ten most pollution-intensive sectors as identified by LAHTI using data for the year 2002. The sectors include: fertilizers and pesticides, industrial chemicals, tanneries and leather finishing, synthetic resins and plastic materials and manmade fibres, paper and paperboard containers, other plastic products, textiles, printing and publishing, non-ferrous metals, and iron and steel.

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28 These studies tend to focus on the US because consistent time-series data on pollution abatement costs are most easily available for the US.

29 The correlation between SYSTEM and CAP is 0.23, which validates the need for using both the indicators as proxies for environmental strictness.

Table 11
Tobit estimation results for sector specific 'dirty' export flows

Variable	Pooled [a)]	Pooled [a)]	Industrial chemicals	Industrial chemicals	Leather tanneries	Leather tanneries	Plastic	Plastic	Plastic n.e.c	Plastic n.e.c.
$Log(Y_iY_j)$	0.407***	0.316***	0.393**	0.192*	0.316**	0.239*	0.383*	0.288*	0.528***	0.414
	(0.057)	(0.057)	(0.189)	(0.169)	(0.137)	(0.135)	(0.237)	(0.235)	(0.168)	(0.159)***
$Log(N_iN_j)$	3.038***	2.507***	5.555***	4.326***	3.569***	2.683**	5.143***	4.367***	3.518***	2.876
	(0.364)	(0.326)	(1.352)	(1.048)	(0.777)	(0.704)	(1.643)	(1.473)	(1.100)	(0.944)***
$Log(A_iA_j)$	-0.315	0.217	-1.744*	-0.425	-0.329	-0.496	-0.126	0.676	-0.289	-0.383
	(0.278)	(0.260)	(1.022)	(0.874)	(0.609)	(0.576)	(1.182)	(1.136)	(0.831)	(0.768)
Log(DIST)	-3.576***	-4.498***	-7.264***	-9.33***	-2.519*	-3.091***	-7.988***	-9.310***	-3.873**	-5.254
	(0.647)	(0.875)	(2.373)	(2.311)	(1.389)	(1.363)	(2.891)	(3.012)	(1.906)	(1.915)**
Log(SYSTEM)	9.391***		16.874***		19.366***		11.377		10.214	
	(2.127)		(7.392)		(4.806)		(9.216)		(6.331)*	
Log(CAP)		8.073***		15.615***		10.360**		9.348**		10.030
		(0.988)		(3.297)		(2.218)		(4.251)		(2.907)***
LAND	-5.288***	-5.586***	-12.077***	-12.16***	-3.525*	-3.693**	-7.408*	-7.746**	-3.488	-3.937
	(0.907)	(0.875)	(3.592)	(3.155)	(1.871)	(1.796)	(3.951)	(3.846)	(2.577)	(2.437)
LANG	3.778***	2.504***	4.985*	2.262	0.844	-1.168	5.927**	4.471	6.711	5.177
	(0.713)	(0.688)	(2.399)	(2.105)	(1.649)	(1.610)	(2.961)	(2.880)	(2.083)**	(1.956)***
BORDER	-3.661*	-3.605*	-5.597	-5.871	-4.042	-4.227	-9.105	-9.375	-0.399	-0.484
	(1.974)	(1.904)	(6.401)	(5.597)	(4.77)	(4.601)	(7.856)	(7.676)	(5.732)	(5.405)
COL	4.296**	4.002**	-0.796	-1.167	0.846	0.786	4.005	3.816	4.918	4.404
	(2.071)	(1.982)	(6.837)	(5.858)	(5.259)	(5.068)	(8.269)	(8.007)	(6.188)	(5.788)
Observations	1170	1170	117	117	117	117	117	117	117	117
Log-likelihood	-1799.47	-1775.37	-180.61	-170.91	-285.58	-283.26	-174.53	-172.81	-198.74	-193.76
LR-chi2	736.00	784.20	65.61	85.02	56.11	60.74	50.52	53.97	55.03	64.99
Prob. >chi2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudo R2	0.17	0.18	0.15	0.20	0.09	0.10	0.12	0.14	0.12	0.14

Table 11 continues

Note: a) Industry specific fixed effects included; Industrial chemicals includes fertilizers and pesticides; * indicates significant at 10% level, ** indicates significant at 5% level, *** indicates significant at 1% level; values in parentheses are standard errors, all regressions include a constant term not reported here.

Table 11 (cont'd): Tobit estimation results for sector specific 'dirty' export flows

Variable	Printing	Printing	Textiles	Textiles	Iron & steel	Iron & steel	Non-ferrous Metals	Non-ferrous Metals
Log(Y_iY_j)	0.479	0.358	0.028	0.003	0.849	0.797	0.704	0.548
	(0.164)***	(0.152)**	(0.061)	(0.061)	(0.306)***	(0.309)**	(0.297)**	(0.287)*
Log(N_iN_j)	2.934	1.904	1.450	1.378	7.929	8.013	5.483	4.003
	(1.099)**	(0.908)**	(0.330)***	(0.308)***	(2.528)***	(2.456)***	(2.386)**	(2.013)**
Log(A_iA_j)	-0.378	0.555	-0.110	-0.020	-4.421	-4.508	-1.630	-0.377
	(0.824)	(0.735)	(0.258)	(0.243)	(1.953)**	(1.901)**	(1.679)	(1.509)
Log(DIST)	-7.736	-9.325	0.038	-0.182	1.522	0.595	-3.674	-5.431
	(2.109)***	(2.172)***	(0.582)	(0.580)	(3.707)	(3.739)	(3.805)	(3.983)
Log(SYSTEM)	16.633		1.869		-5.888		20.789	
	(6.492)***		(1.995)		(11.806)		(12.718)*	
Log(CAP)		11.970		2.128		3.117		14.128
		(2.913)***		(0.958)**		(5.384)		(6.108)**
LAND	-4.039	-4.436	-2.628	-2.737	-10.098	-11.325	-3.087	-3.462
	(2.582)*	(2.379)*	(0.785)***	(0.773)***	(6.653)*	(6.613)*	(5.141)	(4.912)
LANG	8.288	6.519	0.258	-0.027	-2.805	-2.256	7.147	4.991
	(2.153)***	(1.955)***	(0.707)	(0.694)	(4.222)	(4.014)	(4.030)*	(3.747)
BORDER	-3.313	-3.567	-2.448	-2.413	-3.508	-2.853	-9.090	-9.180
	(5.531)	(5.089)	(2.147)	(2.108)	(9.764)	(9.797)	(11.612)	(11.374)
COL	3.534	3.193	0.886	0.692	8.872	7.998	-0.641	0.771
	(5.923)	(5.398)	(2.388)	(2.345)	(9.773)	(9.665)	(10.434)	(9.555)
Observations	117	117	117	117	117	117	117	117
Log-likelihood	-172.342	-166.61	-297.58	-295.60	-119.72	-119.67	-94.27	-92.504
LR-chi2	58.13	69.59	50.54	54.49	37.58	37.67	22.94	26.47
Prob. >chi2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudo R2	0.14	0.17	0.08	0.08	0.14	0.14	0.11	0.13

Note: All regressions include a constant term not reported here; Values in parentheses are standard errors; * indicates significant at 10% level, ** indicates significant at 5% level, *** indicates significant at 1% level

The results from the Tobit estimation of (10) are reported in Table 11. The estimated coefficients show theoretically expected signs. The effect of income per capita and population is significantly positive on exports, whereas distance between the trading partners and being landlocked have a negative effect. Common language and colonial ties are significant and positive in a few specifications only. The negative sign of BORDER may seem counterintuitive as adjacent countries are expected to trade more. However, considering the fact that Pakistan's trade relations with most of its neighbouring countries are restrained due to historical and political factors, a negative and mostly insignificant effect of sharing a border on Pakistan's exports is not surprising.

The estimates of the coefficient of SYSTEM and CAP are significant and positive in all estimations except for the iron and steel and textile sectors. The estimated elasticity of exports with respect to environmental stringency in the remaining specifications is relatively large, ranging from 9.0 to 20.0. This suggests that environmental regulations of the importing countries play an important role in determining Pakistan's exports of the dirty sectors and countries with relatively stronger governance import more of these products.

6 Industrial pollution in Pakistan: implications for poverty

The objectives of Pakistan's trade and industrial policies have been to spur the manufacturing sector and promote economic growth. The main reason behind the lax implementation of environmental regulations is the popular belief that the domestic industry is not yet prepared to bear additional costs and to factor in environmental considerations in its production methods. The lack of an environmental policy framework might not have had such important implications for the country if industrial emissions were growing from very low levels. However, this is clearly not the case and the existing emission levels are already high with severe environmental and human health impacts. Thus, the 'pollute first, clean up later' path that Pakistan is currently following may entail significant long-run costs and needs to be reviewed.[30]

Pollution control is imperative for fighting poverty in the country. Pakistan's national poverty rate is 34 per cent of the total population with almost 31 per cent of the population living below \$1 a day and 85 per cent living below \$2 a day. Around 60 per cent of the population live in rural areas—with more than half of it living below the national poverty line—and these depend directly on natural resources and ecological services for their livelihood. Industrial pollution is worst in the poorest areas, as heavily pollution emitting factories are usually located in suburban regions close to farmlands and villages where incomes of the residents are well below the national average. Poor bear the brunt of factory pollution due to lack of awareness and also because in many cases these factories provide a source of employment and income for them. At the same

30 Cole and Neumayer (2004) suggest that the implications of the EKC hypothesis are not that straightforward for the developing countries. For example, for Asian countries (excluding India and China), the authors find that it would take them at least another 60-80 years to reach the per capita income levels where enough social and political pressure is generated for most of the air pollutants to start exhibiting a declining trend. Considering the status of environmental quality in most of the developing countries, such a timeframe may be too late to prevent irreversible damage.

time, however, they are more vulnerable to pollution because of their low nutritional intake, crowded living and poor hygienic conditions.

Industrial pollution has serious effects for agriculture as well. According to survey conducted by national and international agencies, air pollution has severely damaged production of wheat and rice in many areas of Pakistan (Moss 2001). The industrial effluents and wastewater released in agricultural lands have contaminated groundwater, destroyed the fertility of soil and affected the nutritional quality of food produce. These factors exacerbate poverty, jeopardize long-run growth and pose daunting challenges for the economy.

Dixon and Perry (1986) observe that most of the effects of environmental mismanagement in Pakistan are rooted in environmental literacy and lack of awareness of the population. Knudsen (1999), however, argues that even where people know they have a stake in environmental protection, the problem resides in the structures and institutions which prevent them from playing any meaningful role in environmental management. Raising environmental awareness and providing channels for the poor to voice their concerns are important ways through which pollution can be monitored.

To tackle the widespread poverty, it is imperative that an integrated and holistic approach be adopted, which improves governance and promotes economic growth while achieving environmental objectives and protecting the most vulnerable segments of the society. To maximize the gains from liberalization, and to achieve a sustainable and high-quality growth path, Pakistan must minimize the environmental costs associated with its industrial development. It is important to recognize that even if the composition effect is held constant, the scale effect induced by growth implies an increase in output and an increase in total industrial pollution. To keep the scale effect in check, the pollution intensity of industrial activity must be decreased. This is possible through the transfer of cleaner technology if sectoral pollution is a function of the vintage of technology and through the enforcement of environmental regulation where pollution depends on end-of-pipe treatment, as in the paper, leather and textiles industries (Gallagher 2000). In industries where pollution is the result of inefficient management of resources, awareness and capacity building may play an important role in reducing the environmental footprint.[31]

7 Conclusion

One of the most heatedly contended issues in the globalization debate is the impact of increased openness on the environment of developing countries. It is argued that asymmetries between the environment regulations of developed and developing economies create a competitive advantage for the latter to specialize in the production of pollution-intensive products, which entails significant environmental, economic and social repercussions. The purpose of this study is to revisit the issue in the context of Pakistan.

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31 For example, according to estimates, the industrial sector could save approximately 22 percent of its total energy consumption without any loss of output if it utilizes the inputs more efficiently (GoP *Economic Survey 2000-01*).

Using a combined toxicity index of manufacturing industries, we examine the composition of Pakistan's exports and find evidence to support the claim that exports have grown in the pollution-intensive sectors relative to cleaner ones after liberalization efforts gained momentum. Despite data limitations, we make a modest empirical assessment using the IPPS database developed by the World Bank. Although US pollution intensities are not a substitute for actual data, a comparison of the ranking of industries according to their pollution intensities in Pakistan and the US reveals very high correlation, indicating that the most pollution-intensive sectors are similar across both countries.

Our results suggest that earlier estimates of a negligible impact of laxity of environmental regulations on trade flows based on cross-country regressions should be viewed with scepticism. While identifying the compositional changes that might have occurred in Pakistan's economy, we find evidence that the manufacturing sector has switched to more pollution-intensive production over time. Applying the sectoral shares in output for 1975-76 to the manufacturing data for 1995-96, we find that total air emissions would have been significantly lower if industrial composition had remained as in 1975-76.

The results of the factor content approach reveal that the total net exports of embodied environmental services to the OECD economies have increased from 1975 to 2003. The trade-in-goods approach supports these findings and shows that liberalization has been accompanied by an increase in the exports and a decrease in the imports of pollution-intensive products to and from the OECD countries, respectively. Further, the environmental policy-trade analysis confirms that the stringency of environmental regulations in the importing countries is an important determinant of Pakistan's exports of dirty products.

Our findings, therefore, point to a change in the composition of output and exports towards more pollution-intensive manufacturing that parallels the opening of the economy. This suggests that Pakistan's transition from a closed to an open economy may have had non-trivial consequences in terms of industrial pollution since policies to internalize adverse externalities were not strengthened simultaneously. Thus, the gaps in environmental policy must be filled to protect natural assets, public health and the poor, and to secure long-term growth. The analysis also highlights the importance of undertaking systematic empirical investigations of this nature for developing countries that are contemplating further trade liberalization—but lack statistics on environmental quality—to draw broad inferences regarding changes in pollution levels due to shifts in industrial activity and assess the implications of their reforms.

Appendix

Table A1
Ranking comparison of most pollution-intensive industries

LAHTI ranking	EPA ranking
Fertilizers and pesticides	Fertilizers and pesticides
Industrial chemicals	Industrial chemicals
Tanning and leather finishing	Pulp and paper
Synthetic resins, plastic materials and manmade fibres	Tanning and leather finishing
Paper and paperboard	Textile processing
Plastic products	Rubber products
Textiles	Paints, varnishes and lacquers
Printing and publishing	Printing
Non-ferrous metals	Steel industry
Iron and steel	Petroleum refining

Source: Compiled by the author with data from Government of Sindh (1999) and Hettige *et al.* (1994)

Table A2
Pakistan's direction of trade statistics

Year	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98
	Percentage share in total imports						
OECD	62.2	58.6	52.6	49.3	49.9	48.7	46.5
OIC	16.5	16.9	20.9	21.3	22.4	26	23.3
ASEAN	7.3	8.5	9.5	12.6	11.2	9	12.6
SAARC	1.5	1.5	1.6	1.4	1.5	2.4	2.3
Other	12.5	14.5	15.4	15.4	15	13.9	15.3
	Percentage share in total exports						
OECD	54.9	56.7	60	58.6	55.3	59.7	59.5
OIC	14.6	16	13.7	12.9	12.9	11.8	12.5
ASEAN	5.6	5.2	3.7	4	5.3	2.5	3.2
SAARC	4.7	3.8	3.1	3.4	2.7	2.5	3.5
Other	20.2	18.3	19.5	21.1	23.8	23.5	21.3

Note: OIC is the Organization of Islamic Countries.
Source: GoP (Statistical Supplement of *Economic Survey* 1997-98).

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