Does Trade Liberalization Create Pollution Haven? An Indian Experience

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Abstract: *The pollution haven hypothesis refers to the possibility that multinational firms, particularly those involved in highly polluting activities, relocate to the countries with weaker environmental standards. This paper attempts to examine the validity of this hypothesis in the post-trade liberalization era in India. We analyze the composition of the inflow of foreign direct investment (FDI) across the industries in India during the period 1991-2002 and develop an empirical model to find out the impacts of FDI and regional development on environment during this period. We find that though substantial share of foreign investment projects is approved in the polluting sectors, they have not yet been translated into actual figures. In the second part of this paper, we address the validity of* pollution haven hypothesis *by considering a pooled cross-section model using a sample of 17 states, covering the period 1991-2002. To represent the state of environmental quality, air pollution variables such as sulfur dioxide (SO_2), Nitrogen oxide (NO_2), and suspended particulate matters (SPM) are used in the study. The estimated results reveal that foreign investment has played a very negligible role in the concentration of air pollutants whereas; regional economic growth is found to have caused the accumulation of environmental problems. Therefore, we conclude that there is not enough evidence to support* pollution haven hypothesis *in India.*

Key Words: Trade liberalization, Foreign direct investment flow, Environmental impacts, Pollution haven

I. Theoretical background

There has been an inherent fear among the members of the environmental community that trade liberalization is likely to exacerbate environmental problems (Esty, 1994; Lyman, 1993; Strohm and Thompson, 1996)[2]. More trade probably means more production, and that has historically meant more pollution. Moreover, as dirty industries have the tendency to migrate to countries with low wages and lax environmental standards, trade liberalization would have important consequences for the international distribution of polluting industries. Developing countries with their low environmental standards are likely to get a greater share of these polluting industries thus, creating a "pollution haven" (Copeland and Taylor, 1994; Chichilinsky, 1994).

On the contrary, advocates of free trade argue that increase in trade-driven incomes would increase the demand for environmental goods[3]. These income effects would dominate the scale effects that the environmental community is so concerned about (Bhagawati and Srinivasan, 1996). Trade economists also interpret the international movement of dirty industries in different terms. They argue that benefits of the trade are obtained by changing the world pattern of production. There is no reason to interpret this changing pattern of production as a cause for international migration of dirty industries (Strohm and Thompson, 1996).

The heart of the debate between the environmentalists and the advocates of free trade lies in the differences of opinion about the impact of trade liberalization on environmental quality. Theoretical studies have shown that

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[2] Of course, there are varied opinions among environmental community about the effect of trade liberalization on environment. Not all the environmentalists are monolithic and uniformly protectionists (Esty 2001). Many mainstream environmentalists believe in 'sustainable development' and would support free traders if they feel that environmental matters are taken in consideration seriously while framing trade policies.

[3] Environmental goods are those goods which either directly improve environmental quality or help produce instruments that improve environmental quality.

differences in income levels and property rights existing among countries would be the driving forces for the environmental consequences of trade liberalization (Copeland and Taylor 1994; Chichilinsky, 1994). In a liberalized trade regime, both tariff and non-tariff barriers would be relaxed, thus paving the way for comparative advantage driven cost differences to rule in trade decisions. Countries with higher income level would face greater lobby from their citizens to implement stringent environmental regulations. The economic reason behind this proposition is that environmental quality is a normal good and hence, when per capita income level rises, people demand cleaner environment to live in which creates political demands for tougher environmental standards. Pollution intensive industries in such countries where environmental regulations are strict tend to move to low-income countries where regulations are lenient. Environmentalists fear that such movement of pollution intensive industries to low-income level countries would create more pollution than that could be assimilated in their environment, thus creating a 'pollution haven'.

As a matter of fact, the decision to establish a plant depends upon variety of factors like cost of labour and raw materials, access to market, infrastructural availability, social and political stability of the country, and the regulatory framework (Wheeler and Mody, 1992). Environmental regulations are the part of the broader regulatory framework that a country adheres to. The genuineness of the theoretical proposition that low environmental standards in developing and underdeveloped countries would create 'pollution haven' in these countries critically depends upon the empirical evidence on the issue that whether capital flow is responsive to differences in environmental standards[4]. Without this phenomenon holding significantly, the 'pollution haven' argument would only be a theoretical curiosity.

Against this backdrop this paper has two major objectives. Firstly, it analyzes the composition of the inflow of foreign direct investment (FDI) across the industries in India during the period 1991-2002. The trends of the composition of FDI will show the orientation of the foreign investment in the country. If the composition is directed more towards the polluting sectors, then the *pollution haven* hypothesis holds. Secondly, the paper develops an empirical model to find out the impact of FDI on environment in the country during the same period. The rest of the paper is structured as follows: In section II, a brief review of empirical literature on the impact of trade liberalization on environment is provided. The composition and distributional aspects of FDI inflow into India is explained in section III. Section IV outlines the empirical model and discusses about the methodology and data sources. Results from the empirical exercise are presented in Section V. Section VI presents the overall findings of the study and section VII concludes with pertinent policy recommendations.

II. Review of empirical literature

The empirical literature on 'pollution haven' hypothesis is mixed and do not give any conclusive evidences as to whether environmental regulations significantly determine the locational decision of firms. Some early studies have shown that the pollution content of imported goods in the OECD countries have risen faster than that of exported goods in these countries (Robinson, 1988). Evidences from other studies establish that in the OECD countries, the polluting to non-polluting output ratio had declined and at the same time the import to export ratio of polluting industries had increased during the period of 1960-1995. On the other hand, the polluting to non-polluting output ratio grew in general in Latin America and in Asia (excluding Japan), and the import to export ratio of polluting industries had fallen in these regions (Mani and Wheeler, 1999). Another study of majority-owned affiliates of OECD-based companies in developing countries shows that those involved in pollution intensive industries did increase their investment slightly faster than did all manufacturing industries (Jaffe et al., 1993). On the other hand, some studies have presented evidence of polluting industry relocation, but they could not link the phenomenon to trade. They found that although, developing nations as a whole had more toxic intensity growth during the 70's and 80's, this growth was more evident in the closed economies. Therefore, they concluded that trade is not the cause for

[4] Of course, there is a wide range of literature which discusses about the possibility that developing and underdeveloped countries could play the game of attracting pollution intensive industries by lowering their environmental standards (Brander and Spencer, 1985, Barrett 1994, Conrad, 1993, and Kenedy, 1994). This is called 'race to bottom' hypothesis. We, however, are not exploring this possibility in the present study.

the toxic industry flight (Lucas et al., 1992; Birdsall and Wheeler, 1992; and Low and Yeats, 1992).

Further, some studies have revealed that trade policy reforms slated for the next two decades in many cases would improve the environment (at least with respect to air and water pollution) and reduce the depletion of natural resources, and in the worst cases add only slightly to environmental degradation and resource depletion even without toughening the enforcement of environmental regulations or adding new ones (Strutt and Anderson, 1998). The economic gains from the trade reforms and the scope for adopting well-targeted environmental and resource policies to reduce any serious damage are such that the social welfare almost certainly is going to be improved substantially by these liberalizations (Antweiler et al., 2001; Dean, 2002).

Literature on environmental impacts of trade liberalization in developing countries also provides a mixed picture. Though, these results are not very reliable due to the unavailability of relevant data, still they unravel some interesting results. There are country-specific case studies which address this question. The China study states that some overseas enterprises did relocate in China due to stricter regulations regarding the environment in developed countries, particularly in the leather goods, paper, smelted products, chemicals and pharmaceutical industries. However, there is no specific evidence provided to support this assertion (Jha et al., 2000). In case of India, it is found that the share of polluting industries in total manufacturing sector has been increasing in the post-liberalization era in comparison to the pre-liberalization period (Jha and Rabindran, 2004). The study also reveals that both FDI and exports have grown in the more polluting sectors relative to the less polluting sectors in the post-liberalization period. Removal of tariff barriers as a part of trade liberalization in Philippines is found to have increased deforestation in the country (Boyd et al., 1993). Similar results are derived from another study on Philippines (Cruz and Repetto, 1993). These studies however, show only a part of the picture in trade-environment domain. There is a lot more to explore in order to be able to ascertain anything discretely about the problems in this field. In an attempt to examine the 'pollution haven' hypothesis in Indian context, this paper endeavors to establish a link between foreign direct investment (FDI) flows and the environmental quality in India.

III. Composition of FDI inflow in India

To understand how the recent changes in trade and foreign investment policies have influenced the composition of FDI, quantitative information is needed on broad dimensions of the investment (and its distribution) across industries, regions and by size of projects; firm and industry level production accounts, and audited financial statements. However, such information is scarce. The most easily available (and widely used) data in India are on FDI approvals by broad industry group (1-digit ISIC), by country of origin, and by states of destination.

The actual FDI inflow is recorded under five broad heads: (i) RBI's automatic approval route for equity holding up to 51%, (ii) FIPB's discretionary approval route for larger projects with equity holdings greater than 51%, (iii) acquisition of shares route (since 1996), (iv) RBI's non resident Indian (NRI) scheme, and (v) external commercial borrowings (ADR/GDR route). Reportedly, the Indian definition of FDI differs from that of the IMF's definition as well as of the UN's *World Investment Report*. IMF's definition includes external, commercial borrowings, reinvested earnings and subordinated debt, while the *World Investment Report* excludes external commercial borrowings.[5]

The FDI inflows have experienced an upsurge since the liberalization of external sector in India in early 1990s. The estimates for FDI have touched Rs 1300.97 bn (roughly around $ 32.49 bn) for the period 1991 to 2002 (Table 2). As there has been a gradual improvement in the actual inflow from a low base and a slow down in the approvals after 1997, there is an increase in the ratio of the actual-to-approved FDI in the last few years. On an average, it is a little over 50 % during the period 1991 to 2002 (Figure 1)[6].

[5] Recently, the definition of FDI in India has been redefined in lieu with the IMF definition and the data according to this new definition was released in 2003. Therefore, FDI data preceding to 2003 can not be compared with the same since 2003. This study uses the FDI data till 2002 in order to maintain consistency in the definition.

[6] Note that in the actual FDI data, ADRs/GDRs are included.

Figure 1: FDI inflow in India, 1991-2002

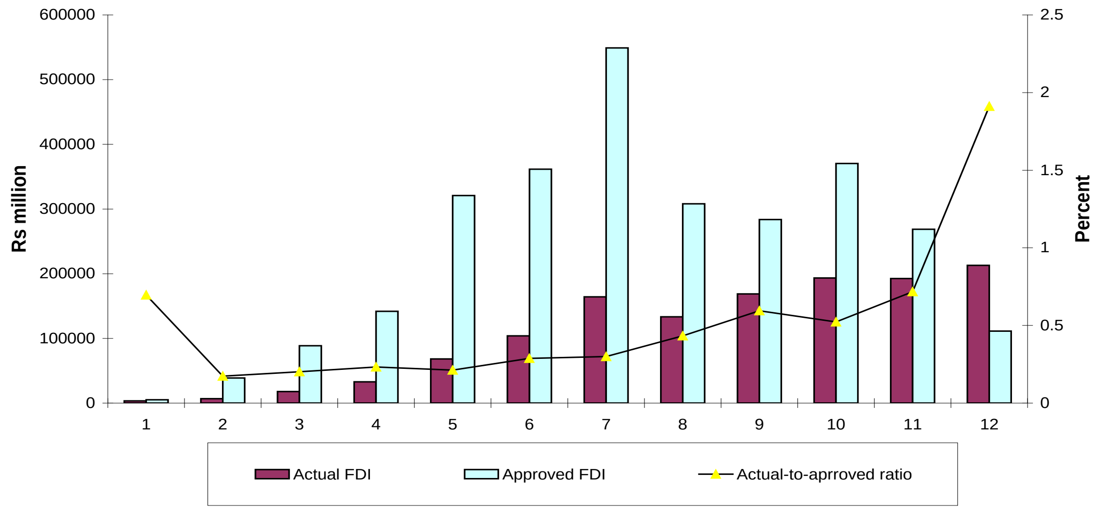


Table 2: Sectoral Distribution of Actual FDI Inflow (1991-2002)

Sector / Year	Total Inflow	% Share
Food processing	38228.37	2.93
Sugar	450.85	0.03
Vegetable oils	469.43	0.04
Fermentation industry	2364.31	0.18
Textiles	10778.75	0.83
Paper & pulp	12304.85	0.95
Chemicals	53993.62	4.15
Fertilizers	1487.9	0.11
Dye stuffs	517.84	0.04
Drugs & pharmaceuticals	16893.96	1.30
Metallurgical industry	10590.68	0.81
Rubber goods	5472.68	0.42
Glass	9633.58	0.74
Glue & Gelatin	1475.76	0.11
Electrical Equipment	110912.6	8.53
Leather	1577.11	0.12
Cement	12166.66	0.94
Transportation	98842.98	7.60
Power & Fuel	89848.38	6.91
Telecommunication	98994.41	7.61
Services	65938.62	5.07
Hotel & Tourism	6276.91	0.48
Miscellaneous industry	336992.5	25.90
Sum Total	1300969.62	100

Source: SIA Newsletter, Annual Issues, 2000, 2001, 2002

A close examination of the above table reveals that sectors like electrical equipments (8.52%), telecommunication (7.60%), transportation (7.59 %), power and fuel (6.90 %), services (5.09 %), and chemicals (4.15 %) have obtained greater share in FDI inflow during the period 1991-2002. The top five countries that contribute to FDI inflow in India are Mauritius, U.S., U.K., Germany, and Japan (SIA Newsletter, Annual issue, 2002).

Establishing a link between FDI and environment is a very difficult task mainly due to lack of availability of data. Monitoring of the actual inflow of FDI in India is very poor which posed a serious threat in the process of getting meaningful relationship between FDI and environment. This is precisely the reason why most of the studies relied on the approved FDI to represent FDI inflows. Since it is already shown that the ratio of actual-to-approved FDI is around 50 %, we have taken the approvals in this section as a proxy for actual FDI inflows.

FDI and pollution-intensive industries

With a view to measure the composition effect of FDI on environment, the FDI approvals in the post liberalization period is divided into two categories: FDI into pollution intensive industries and FDI into non-pollution intensive industries. Central Pollution Control Board (CPCB) has classified 17 industries as pollution intensive sectors (termed as Red) – they are Cement, Sugar, Thermal power plants, Tanneries, Textiles, Iron and steel, Drugs and pharmaceuticals, Paper and pulp, Dyes and Dye intermediates, Fermentation industries, Fertilizers, Zinc, Aluminium, Copper smelter, Petrochemicals, Oil refinery, and Pesticides. However, we have reclassified the pollution intensive industries according to the data availability as follows: metallurgical industry, fuels (power and oil refinery), fertilizer, chemicals, dye and dye intermediates, drugs and pharmaceuticals, textiles, paper and pulp, sugar, fermentation industry, leather, cement and gypsum products (these sectors will be considered as falling under Red category henceforth). The share of polluting sectors in total FDI during the period 1991-2002 is calculated as 42.89 %. This gives an early indication that after opening up of the economy, the tendency of foreign investment is significantly tilted towards the polluting sectors. To examine whether the similar trend is also available for the actual inflows, the ratio of FDI to polluting sectors to that of non polluting sectors is calculated for the realized figures which stood at 25.5 %. This difference of ratios between approved FDI and actual FDI is not surprising due to the following reason. Foreign investors intend to harvest profit in short-run which is possible in sectors such as telecommunication, information and technology, and other services that are non-polluting. So, when foreign capital starts flowing, the number of approvals getting realized is more in case of non-polluting sectors than in polluting sectors. Nevertheless, one quarter of total foreign investment going to polluting sectors is a significant trend and indicates that the ‘pollution haven’ arguments can not be taken lightly.

Among the Red category, power and fuels (that is both power plants and oil refinery) account for a major share of 27.21 % in total FDI approvals (Table 3, Col. III). The other two sectors in this category apart from power and fuels which have claimed major shares in attracting FDI are metallurgical industries with a share of 5.43 % and chemicals with a share of 4.56 %**.** Rest of the industries are not significant in terms of their shares in total FDI approvals. The combined share of fuels, metallurgical industry, and chemicals in the total FDI inflow into Red category is a whopping 86.67 % leaving only 13.23 % for the rest of the industries in this category (Table 3, Col. IV). This distribution of foreign investment across the most polluting industries indicates that there is significant interest among foreign investors to invest in power plants, oil refineries, metallurgical industries, and chemicals industries.

An interesting observation is found when the figures for the origin of foreign investment to polluting sectors by country are compiled. It shows that the top five investing countries in these sectors in India are U.S., Mauritius, U.K., Germany, and Australia (Figure 2). Except Mauritius, rest of the countries are from OECD block, which is again a step further in testifying the claim that polluting industries in countries having stricter environmental regulation are incentivized to migrate to countries with lenient environmental standards. Among other determinants, an increasing tightening of regulations in OECD, a lower level of environmental standards and weak monitoring mechanisms in India are the main reasons for inducing FDI into polluting industries in the country. In fact, the relocation of pollution-intensive industries is not a unique phenomenon in India. As one cross-country analysis (Mani and Wheeler, 1997) illustrates that pollution-intensive output as a percentage of total manufacturing has fallen consistently in the OECD and risen steadily in the developing world. Moreover, the periods of rapid increase in net exports of pollution-intensive products from developing countries coincided with periods of rapid increase in the cost of pollution abatement in the OECD economies.

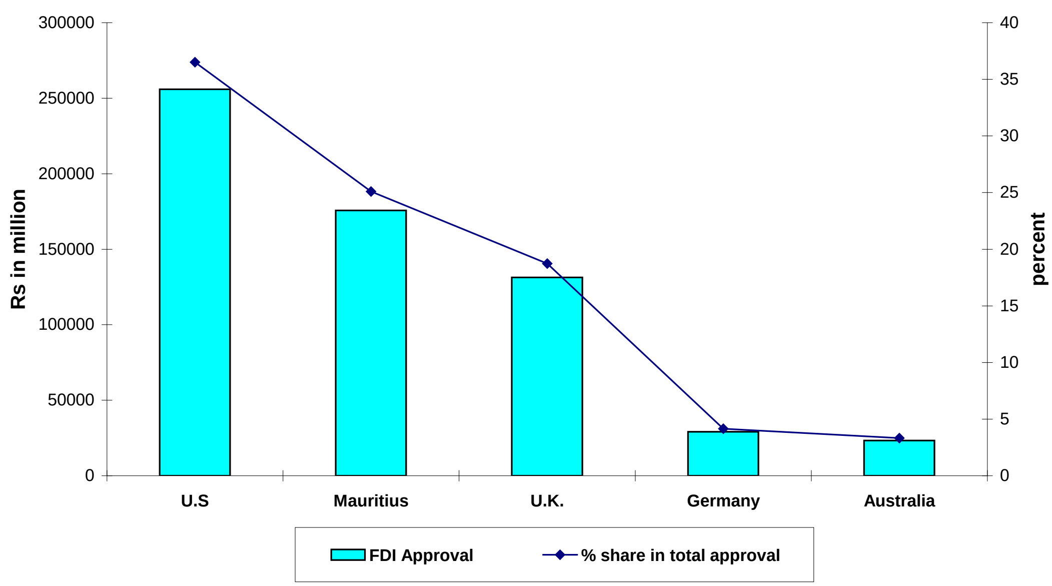
Table 3: Share of Polluting Industries in Total FDI Approval (During August 1991 to December 2002)

(Amount in million Rs)

I Polluting Industries	II Amount of FDI approved	III % share in total approval	IV % share in the approvals in polluting industries
Metallurgical industry	154560.4	5.43	12.65
Fuels (power & oil refinery)	774719.6	27.21	63.42
Fertilizers	3256.69	0.91	0.26
Chemicals	129602.2	4.56	10.60
Dye stuffs	1253.21	0.04	0.10
Pharmaceuticals	30045.92	1.10	2.46
Textiles	34713.89	1.22	2.84
Paper & pulp	35264.33	1.24	2.88
Sugar	10581.81	0.37	0.86
Fermentation industry	20788.05	0.73	1.70
Leather/Leather goods	5670.06	0.20	0.46
Cement and gypsum	21139.06	0.74	1.73

Source: SIA Newsletter, Ministry of Commerce and Industry

Figure 2: FDI distribution in polluting industries by origin



Regional distribution of FDI

States have been showing considerable interest in attracting foreign investments since the inception of liberalisation policy in early 1990s. In this context and in the context of wide inter-state disparities in industrialisation, location of projects with foreign investments has assumed significance. The available information has serious limitations in reflecting the actual amounts that are likely to flow to different states. If one goes by the official figures for the period up to January 2002, Maharashtra will be receiving the maximum amount of foreign investment followed by Delhi. More importantly, in about 30 per cent of the cases, location was not indicated at the time of the approval. These projects account for approximately one-third of the total investment. While Delhi stands one of the top destinations of FDI, it is obvious that most of these projects will not be located in Delhi. Delhi, in all probability must be representing the neighbouring states or the foreign investors might have used the services of local agents for communication and for doing the initial spadework. Depending upon the nature of the project, the actual location could be somewhere else in the country.

In spite of the lack of adequate data to demonstrate the locational distribution of FDI, efforts are made in this section to observe the concentration of foreign investment in the country. A casual observation of the state-wise and industry-wise FDI approvals (compiled in Table 4) reveals that Maharashtra stands at the top with a share of 17.3 % followed by Delhi with 12.8 % and Karnataka with 8.29 %. Next in importance are Tamilnadu (7.37 %), Gujarat (6.50 %), Andhra Pradesh (4.62 %), and Madhya Pradesh (3.48 %). We have gone a step further by calculating the states that have received substantial amount of FDI in the most polluting industries. This analysis points that the states that are major beneficiaries of total FDI have also topped the list in case of FDI in polluting industries. In the latter case, Maharashtra again topped the ranking by securing a share of 23.43 % followed by Gujarat with 18.45 %, and Tamilnadu with 16.23 % (Figure 3). However, there is only one exception that Delhi didn't figure in the polluting industries list which suggests that most of the FDI that have flown into polluting industries didn't land up in Delhi. Since Delhi is also a major recipient of FDI in general it might be the case that most of the non-polluting industries like telecommunications, IT etc. have set up in the state.

Table 4: State-wise distribution of FDI approval (August 1991 to December 2002)

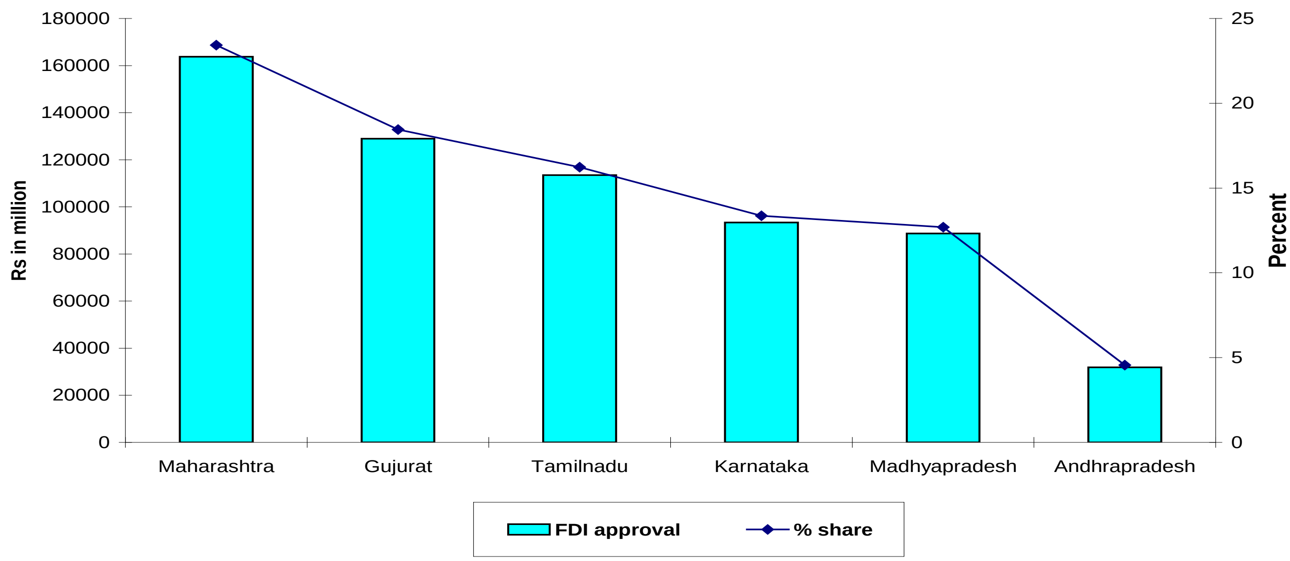
States	% share in total FDI	% share in FDI in polluting industries	Ranking
Maharashtra	17.37	23.43	1
Delhi	12.86		7
Karnataka	8.29	13.36	4
Tamilnadu	7.37	16.23	3
Gujarat	6.50	18.45	2
Andhra Pradesh	4.62	4.56	6
Madhya Pradesh	3.48	12.69	5

Source: SIA Newsletter, Ministry of Commerce and Industry

IV. Empirical Model

In this section, we have developed a model to test the *pollution haven hypothesis* in India. As it is already mentioned that *pollution haven hypothesis* refers to the possibility that in the face of weaker environmental standards in developing countries, multinational firms would relocate to these countries and raise the pollution level, thereby degrading the environment. To this end, we have attempted to conceptualize a model in which the impacts of the inflow of FDI on environment can be captured. There is huge literature in this context that test for the existence of an E*nvironmental Kuznet Curve* (EKC) which proposes a hump-shaped relationship between economic growth and environment (Selden and Song, 1996; Grossman and Krueger, 1993; and Theil, 1995). These studies have taken per capita GDP and air pollution and water pollution variables to represent economic growth and environment respectively. Some studies have also used an openness variable to account for the liberalization policies of the government.

Figure 3: Major destination of FDI approval in polluting industries



The hypothesis of the EKC and the ensuing empirical tests are subject to a fair amount of debate. The empirical tests are criticized for several reasons. First, there are criticisms on the way the hypothesis is being tested, using samples of different countries (for example, Dijkgraaf and Vollebergh, 2001; List and Gallet, 1999). Second, most empirical studies that perform straightforward regression analysis yield relatively little insight into the driving forces that give rise to an EKC. At best, they conclude time trends to test for development unrelated to per capita income. These trends may reflect technological progress resulting in lower energy intensities, but they may as well be the resultant of, for example, substitution away from energy in periods of rising energy prices. These problems can be overcome to some extent by decomposition techniques (for example, de Bruyn, 1997; Selden et al., 1999; Sun, 1998, Anteweiler et al., 2001; and Cole and Elliot, 2003). These techniques decompose changes in pollution of energy use into a scale effect, a technique effect, and a structural effect. Thereby, they give some descriptive idea of the quantitative importance of the factors that may give rise to an EKC.

This model however, introduces yet another explanatory variable except income per capita, i.e. FDI inflow. The purpose is to assess the effects of both foreign investment and regional economic growth on the regional environment. Therefore, we have used a pooled time series and cross-section analysis. Despite the criticisms discussed in the previous section, the empirical assessment of the FDI-income-emission relationship (FIER) for India is in our view useful as a descriptive device aimed at detecting some general patterns as well as region-specific effects. In order to allow for the detection of the wide range of potentially relevant functional relationships between FDI inflow, income and emissions, we use a flexible specification of the regression equation that allows for linear and quadratic polynomial relationships between pollution, FDI, and income.

Data and variable description

The model uses three specifications where the air pollutants such as sulphur dioxide (SO_2), nitrogen oxide (NO_2), and suspended particulate matter (SPM) are the dependent variables respectively. These air pollution variables are monitored by CPCB. It has its monitoring stations for the air pollutants in each state at various industrial and residential areas. These monitoring stations monitor the concentration of the pollutant on daily basis. The annual average data for these variables are published for each of these stations. We have taken all such stations for each of our interest variables and averaged them to arrive at one value for each variable for all the states. So, the pollution variables used in this study are the annual average of all the stations in each state. Further, as we claim that trade liberalization will induce the polluting multinationals to relocate to countries like India where environmental standards are low; we have taken state-wise FDI approvals as the explanatory variable. However, we have corrected this data by multiplying it with the ratio of total FDI approvals during 1991-2002 to actual FDI inflow during the same period. Data for FDI is available in the secretariat of industrial assistance (SIA) newsletters.

Moreover, net state domestic product (NSDP) is taken as another explanatory variable to measure the impact of regional economic growth on regional environment. This relationship is conventionally known as Environmental Kuznet Curve (EKC)[7]. Data for NSDP is collected from the handbook of statistics, RBI. The sample of this study consists of 17 states for which pollution data is available and the study period spans 1991 to 2002. Data for FDI beyond 2002 is not comparable to the earlier data due to the definitional problems. Therefore, to maintain consistency we are contained with this time period.

Model specification

For expositional purposes, we distinguish between two basic classes of models that can be estimated. These models contain the FDI and NSDP as the explanatory variables. Extensions to more explanatory variables are straightforward and will be mentioned in the text when they are introduced. The index i will denote the state and t refers to time. The first model is:

$$Z_{it} = \alpha_i + \beta_1 FDI_{it} + \beta_2 FDI_{it}^2 + \beta_3 Y_{it} + \beta_4 Y_{it}^2 + \varepsilon_{it}$$

where, Z_{it} refers to the pollution indicator. In this model, the intercepts are region specific but the slope coefficients are uniform. This model is thus based on the idea that states experience a similar pattern of development of emissions as they are infused with foreign investment and develop, albeit at potentially different levels.

The second model is a log linear model where all the variables are taken in logarithm form. The slope coefficients in this equation will measure the respective elasticities.

$$\ln Z_{it} = \alpha_i + \beta_1 \ln FDI_{it} + \beta_2 \ln FDI_{it}^2 + \beta_3 \ln Y_{it} + \beta_4 \ln Y_{it}^2 + \varepsilon_{it}$$

All regressions are estimated with a full set of fixed effects to control for unobserved state-specific heterogeneity. Special case is required in controlling for autocorrelation and heteroscedasticity. Autocorrelation has been addressed by estimating an AR(1) model. To account for heteroscedasticity, we estimate and report White's heteroscedasticity consistent estimators.[8] We refer to Gujarati (2003) and Johnston and Dinardo (1997) for econometric details.

V. Results of panel regression

The estimation results for SO_2 as dependent variable are reported in Table 5. There is a positive relationship found out between FDI and SO_2 concentration in level but, the coefficient is too small (0.0001) to provide any meaningful information. Interestingly, the quadratic term of FDI is found to have a negative relationship with SO_2 concentration suggesting a positive influence on air quality and the coefficient is also fairly large. This is surprising since there is difference of impact between linear term and the quadratic term though the former is almost insignificant in its effect. On the other hand, both the linear and quadratic terms of NSDP bear strong negative relation with SO_2 concentrations in levels and are highly statistically significant. This finding suggests that higher economic growth tends to reduce the concentration levels of pollution which is in contradiction with the findings of earlier studies (Selden and Song, 1994, Heil, 1996). A possible explanation for this contradiction is that the earlier studies have considered a cross-country approach where the environmental regulatory practices and income patterns are very different. Where as, in our study within a country, there is homogeneity in regulation practices and the income patterns are not widely different.

In the second model, where variables are taken in logarithmic form, the coefficient of FDI in linear term is again positive and dominates over the quadratic term. This means the rate of change of concentration of SO_2 has a positive

[7] There is wide range of literature which examines the impact of economic growth on environment, popularly known as Environmental Kuznets Curve (Grossman and Krueger, 1993; Selden and Song, 1994).

[8] The brief methodology of panel regression models used is provided in Appendix A.

relation with the rate of change of FDI inflow. The other explanatory variable, namely NSDP is not statistically significant.

The fixed effects for each of the states that are reported in the results table demonstrates that some states having greater inclination towards manufacturing activities have large fixed effects, for example, Gujarat, Bihar, West Bengal, and Uttar Pradesh. High fixed effects suggest that these states have greater concentration of SO_2. This result is in expected lines since states like Uttar Pradesh has cities that are very pollution intensive, e.g. Kanpur; whereas Bihar is known for its mining activities which is polluting. Some of the advanced states like Maharashtra, Delhi, Tamilnadu and Karnataka have shown moderate fixed effects. However, the only exception is Punjab that has a very large fixed effect which we are not able to explain.

Table 5: Panel regression estimates for SO_2

Dependent variables	SO_2 in levels	SO_2 in logarithm
FDI	0.0001* (115.29)	0.05* (2.88)
FDI^2	-6.40E – 05* (-39.55)	-1.10*** (-1.65)
NSDP	-7.97E – 10* (-147.47)	0.001 (1.21)
$NSDP^2$	-6.18E – 11* (-8.46)	0.03 (0.81)
Andhra Pradesh	17.78	11.12
Bihar	42.51	11.89
Delhi	23.38	11.07
Goa	7.60	8.68
Gujarat	36.96	11.85
Haryana	2.20	11.43
Himachal Pradesh	31.82	7.80
Karnataka	9.51	11.62
Kerala	29.01	10.53
Madhya Pradesh	23.81	11.37
Maharashtra	26.18	11.83
Orissa	18.41	10.78
Punjab	279.84	11.81
Rajasthan	16.06	11.02
Tamilnadu	16.67	11.15
Uttar Pradesh	40.06	12.24
WestBengal	45.15	12.14
R^2	0.79	0.97
F-statistic	209.64	2198.39
DW statistic	1.65	1.75
Observations	187	187

Note: Values in parentheses are the t-statistics. The reported t-statistics are White-heteroscedasticity consistent t-statistics. They are robust to heteroscedasticity within each cross-section, but do not account for the possibility of contemporaneous correlation across cross-sections. Significance levels are indicated with stars: *, **, and *** means significant at 1, 5, and 10 percent respectively. The fixed effects are reported for each cross-section. The coefficients which are significant at specified level of significance have undergone Wald coefficient test.

In the regression with NO_2 in levels, all the coefficients are statistically significant as shown in Table 6. There are opposite impacts of FDI and FDI^2 on this type of pollutant. While the linear term exerts a negative effect on the dependent variable, the quadratic term has a positive effect; though, the linear term dominates over its quadratic counterpart in terms of the magnitude of the effect. Similar is the case with income; where the linear term has a positive impact, but the quadratic term has a negative impact. Again, linear term dominates the net impact. Therefore, we can infer that income growth has positive influence on concentration of NO_2. This finding is supported when we analyze the elasticity values. In the second model, both the quadratic terms are significant while their linear counterparts are not. Foreign investment inflows seem to have reduced the concentration of NO_2, where as regional economic growth has a detrimental effect on this pollutant. One possible explanation for this result is that the major sources of emission of nitrogen oxide[9] are transport and energy transportation which are likely to rise with income growth. Whereas, industry has relatively less contribution towards the emission of this pollutant and that could be the reason why FDI is found to have negative coefficient with NO_2.

Among the states, the fixed effects are high in West Bengal, Punjab, Rajasthan, Bihar, Delhi, Uttar Pradesh and Orissa. The inefficient use of energy in transports could be the reason for high concentrations of NO_2 in these states. The industrially advanced states such as Maharashtra, Gujarat, and Karnataka have low fixed effects which again suggest that industry as a source of NO_2 emission is not prominent.

Table 6: Panel regression estimates for NO_2

Dependent variables	NO_2 in levels	NO_2 in logarithm
FDI	-4.19E – 05* (2.71)	0.05 (1.55)
FDI^2	0.0002* (5.37)	-2.50* (-3.18)
NSDP	7.04E – 10* (6.35)	-0.003 (-1.54)
$NSDP^2$	-1.46E – 09* (-7.12)	0.12* (3.58)
Andhra Pradesh	19.97	15.47
Bihar	42.88	16.15
Delhi	33.43	16.03
Goa	12.87	14.35
Gujarat	25.55	15.57
Haryana	10.12	14.53
Himachal Pradesh	9.14	14.78
Karnataka	14.35	15.06
Kerala	20.53	15.584
Madhya Pradesh	24.22	15.50
Maharashtra	15.64	14.96
Orissa	31.68	15.83
Punjab	40.69	15.95
Rajasthan	48.53	16.17
Tamilnadu	10.49	14.97
Uttar Pradesh	26.21	15.47
WestBengal	62.34	16.33
R^2	0.89	0.99
F-statistic	450.81	9338.61
DW statistic	1.61	1.63
Observations	187	153

Note: Values in parentheses are the t-statistics. The reported t-statistics are White-heteroscedasticity consistent t-statistics. They are robust to heteroscedasticity within each cross-section, but do not account for the possibility of contemporaneous correlation across cross-sections. Significance levels are indicated with stars: *, **, and *** means significant at 1, 5, and 10 percent respectively. The fixed effects are reported for each cross-section. The coefficients which are significant at specified level of significance have undergone Wald coefficient test.

The coefficients of FDI and FDI^2 in regression with SPM in levels are statistically significant and negative, but they are very small. So, it can be inferred that the impact of FDI on the concentration of this type of pollutant is negligible. However, NSDP has strong positive impact on the concentration of particulate matters. Both the linear and quadratic terms are large and significant. Further, in the second specification, coefficients of FDI^2 and $NSDP^2$ are significant whereas, their linear counterparts are not. The rate of change of FDI has positively influenced the rate of change of the concentration of SPM, while rate change of economic growth has negative impact on the latter.

Table 7: Panel regression estimates for SPM

Dependent variables	SPM	SPM

9 The sources of emission of different air and water pollutants are provided in Appendix B.

	in levels	in logarithm
FDI	-0.0004* (-3.13)	0.04 (1.35)
FDI^2	-0.0006* (-4.11)	3.62* (8.54)
NSDP	5.36E-09* (7.23)	-0.002 (-0.79)
$NSDP^2$	3.94E-09* (4.61)	-0.18* (-8.20)
Andhra Pradesh	179.53	-13.61
Bihar	320.10	-13.02
Delhi	431.78	-12.74
Goa	109.96	-13.10
Gujarat	256.69	-13.26
Haryana	211.95	-13.44
Himachal Pradesh	315.75	-12.48
Karnataka	131.69	-13.98
Kerala	136.69	-13.98
Madhya Pradesh	217.33	-13.45
Maharashtra	451.06	-12.69
Orissa	228.96	-13.35
Punjab	302.84	-13.07
Rajasthan	258.42	-13.23
Tamilnadu	126.15	-14.04
Uttar Pradesh	432.74	-12.59
West Bengal	297.46	-13.08
R^2	0.85	0.99
F-statistic	304.45	8264.54
DW statistic	1.96	1.93
Observations	187	187

Note: Values in parentheses are the t-statistics. The reported t-statistics are White-heteroscedasticity consistent t-statistics. They are robust to heteroscedasticity within each cross-section, but do not account for the possibility of contemporaneous correlation across cross-sections. Significance levels are indicated with stars: *, **, and *** means significant at 1, 5, and 10 percent respectively. The fixed effects are reported for each cross-section. The coefficients which are significant at specified level of significance have undergone Wald coefficient test.

The fixed effects are large for the states such as Bihar, Delhi, Maharashtra, Punjab, Uttar Pradesh, and West Bengal suggesting that there is greater concentration of particulate matters in these states. This result is again in the expected lines as these states are either relatively industrially advanced, e.g. Maharashtra, or they employ inefficient techniques in fuel use in transport or mining etc. such as Uttar Pradesh, West Bengal, Delhi, and Bihar.

VI. Findings of the study

The findings of both the composition of FDI in India and the panel regression yield important results. The composition of FDI shows that foreign investment in India in the post trade liberalization period has flown more into the non-polluting sectors such as telecommunication, IT, services, and manufacturing of equipments. In actual FDI inflow, the share of non-polluting sectors is little less than three fourth of the total inflow, where as polluting sectors have received around one fourth of the investment. But, the interesting result is that half of the FDI approvals were given to the projects in the polluting sectors. Therefore, though, the approvals have significant inclination towards dirty sectors, they have not actually translated into realized figures. There could be several reasons for this finding. One possible explanation is that foreign capital tries to harvest profit in a small period of time which is possible in sectors like telecommunication, Information and technology etc., which are non-polluting. So, when foreign capital starts flowing, the number of approvals getting realized is more in case of non-polluting sectors than in polluting sectors. Nevertheless, one quarter of total foreign investment going to polluting sectors is a significant trend and indicates that the ‘pollution haven’ arguments can not be taken lightly.

Our panel regression results show that foreign investment has negative impact on the concentration of sulphur dioxide across the states. So, the growth of concentration of this air pollutant is not caused by the trade liberalization induced-foreign investment. It is also found out that state domestic product has negative impact on concentration of SO_2 which we are not able to explain. In case of nitrogen oxide, we found that foreign investment has no role in causing the concentration of this pollutant rather; it is the state domestic product that has a positive relation with NO_2. Similar results are found in the regression estimates with suspended particulate matter. It reveals that foreign investment is not the cause for the concentration of this type of pollutant. Instead, the regional economic growth across the states has positive relation with the concentration of particulate matters.

The fixed effects from the estimated results describing differences between states are statistically significant and imply that there are major differences among the states. States with high level of transportations, mining and industrial activities show high level of air pollution emission. These states are Delhi, Gujarat, Uttar Pradesh, Bihar, and West Bengal. However, more in-depth statistical analysis would be required to further substantiate this conclusion.

VII. Conclusions and policy recommendations

In this paper, we have analyzed the impact of foreign investment and the regional economic growth on environment in India. The major findings of this study point out that foreign investment has played very little role in the accumulation of the air pollution problems in various states of India. Moreover, there is positive relationship exists between regional development and air pollution in the country. While the states have achieved higher level of economic growth, they have also experienced higher environmental damages in the process of industrialisation and urbanisation. This is reflected in the findings that the state which are involved in higher level of industrial and transportation activities have higher level of concentration of air pollutants. However, we would like to pass a note of caution that this issue is very serious and needs further empirical investigation with more sophisticated analytical framework before drawing strong conclusions. Still, we are convinced that the approach adopted in this paper is relevant and makes headway for further analysis in future.

The findings of our study have important implications for policy perspective. Since, foreign investment has been found to play negligible role in environmental damage, environmental community should not be suspicious about the trade liberalization policies. In this context, what is more important is to implement the environmental regulations effectively so that the fruits of economic growth do not turn sour. There might be some room for the economic instruments such as pollution permits and levies. Industrially developed countries in the world have successfully utilised these instruments in their country. This will also be suitable for our country where state regulation is declining and market forces are gaining importance and expected to play important role in future. The shortcomings of government intervention and market failure seem to have contributed to India's growing pollution problems rather than the liberal trade and foreign investment regimes. It is important to care about now to determine as to who is responsible for pollution damage and how to improve upon the environmental regulation implementation process. In addition, it is also important to recognize the institutions that are instrumental in managing better environmental practices in order to accomplish a sustainable economic growth in the fully liberal economic world.

Appendix A

A pooled regression model can be shown as;

$$y_{it} = X_{it}\beta + \varepsilon_{it}$$

where, y_{it} = the value of the dependent variable for cross-section unit i at time t with i = 1, … n and t = 1, … ,T

X^j_{it} = the value of the jth explanatory variable for unit i at time t. there are k explanatory variables indexed by j = 1, …, K.

β = slope coefficient vector, ε_{it} is the error term and assumed to follow iid (0, σ^2) for all i and t.

A fixed effect model for two time periods is the following:

$Y_{it} = X_{it}\beta + Z_i\sigma + \varepsilon_{it}$, i = 1, …, N and t = 1, 2

where, X = a matrix of explanatory that varies across time and individuals.

Z = a matrix of variables observed that vary across individuals but for each individual are constant across the two periods and $\varepsilon_{it} = \alpha_i + \eta_{it}$.

Fixed effect model requires the following assumptions:

$E[\eta] = 0$ $\quad$ $E[\eta\,\eta'] = \sigma^2_\eta\, I_{nT}$

$E[\alpha_i\alpha_j] = 0$, for $i \neq j$ $\quad$ $E[\alpha_i\alpha i] = \sigma^2\alpha$

$E[\alpha_i\, \eta_{jt}] = 0$ $\quad$ $E[\alpha_i\,] = 0$

where all expectations are conditional on X and Z. The substitute difference between the present case and the random effects model involves another assumption pertaining to the individual specific effect. Now letting W_{it} = $[X_{it}\ Zi]$, it is assumed that

$E[W^{/}_{it}\, \varepsilon_{it}] \neq 0$

Now, considering OLS estimation on only first period data, we will have the following equation.

$Y_{i1} = X_{i1}\beta + Z_i\,\sigma + \varepsilon_{i1}$

Similarly, for the second period data, we have the following regression model

$Y_{i2} = X_{i2}\ \beta + Z_i\,\sigma + \varepsilon_{i2}$

If the above two equations are valid representation of the data then any linear combination of the relationships is also true. Specifically,

$Y_{i1} = X_{i1}\ \beta + Z_i\,\sigma + \varepsilon_{i1}$,

$Y_{i2} = X_{i2}\ \beta + Z_i\,\sigma + \varepsilon_{i2}$,

$Y_{i2} - Y_{i1} = (X_{i2} - X_{i1})\beta + (Z_i - Z_i)\,\sigma + \varepsilon_{i2} - \varepsilon_{i1}$

$\Delta Y = \Delta X\beta + \Delta Z\sigma + \Delta\varepsilon$

where, Δ is the difference operator.

For example, $\Delta X = X_{i2} - X_{i1}$ is also equivalent to $\Delta Y = \Delta X\beta + \Delta\,\eta$.

In this equation, we have dropped the time invariant terms Zi and α_i after applying the difference operator. The whole transformation has been made to yield unbiased estimates of the co-efficient on the X variables. This is the essence of the fixed effects model.

Appendix B

Information on the pollutants

Sources/Pollutants	SO_2 [a]	NO_2 [a]	CO_2 [b]
% from transport	6.5%	53.7%	21.4%
% from industries	30.2%	17.5%	20.6%
% from energy transformation	51.2%	23.2%	42.4%
%from agriculture	NR	NR	NR
Atmospheric life	1 –10 days	1 day	50 – 200 days
Local impacts	Yes	Yes	No
Transboundary	Yes	Yes	No[c]
Global	No	No	Yes
Correlation between pollution intensity & capital intensity	0.42	0.44	NR

This table is reproduced from Cole and Elliot (2003).

NR = not reported

[a] Sources for SO_2 and NO_2 emissions are based on a sample of OECD countries for 1996

[b] Sources of CO_2 emissions are based on a sample for 1997

[d] CO_2 does not have a transboundary effect in the sense that the dispersion of CO_2 would never be restricted to a certain region or group of countries.

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