E C O N O M I C S   B U L L E T I N

Growth–trade–environment nexus in India

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Abstract

This paper evaluates the environmental impacts of economic growth and trade liberalization in India. The empirical strategy in this paper is to estimate the scale, technique and trade-induced composition effects of trade liberalization on pollution. We collect data across major industrial states of India over the time period 1991-2003 and use panel regression techniques for such estimation. The results establish that the impact of growth and trade liberalization on environmental pollution is not unique across the pollutants. It rather depends upon the specific indicator that is examined. Finally, we conclude that trade promotion in the presence of a dynamic pollution regulatory framework can yield sustainable trade.

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1. Introduction

It has been a tough trade-off decision between economic growth and environmental protection especially in developing countries. Tireless efforts to accelerate economic growth had kept environmental considerations as a secondary objective in policy making in these countries. This indifference towards environmental protection has led to serious environmental problems in developing countries threatening their sustainable future. In response, many developing countries have started enacting and implementing environmental policies to limit the severity of air and water pollution, and solid waste disposal. The stringency of these regulations has been increasing over the years.

This paper makes an attempt to examine the environmental impacts of economic and trade growth in India. India is a leading Asian developing country experiencing a GDP growth rate of over 8 % in the last decade. Similarly, the volume of foreign trade i.e. both exports and imports have increased significantly, achieving two-digit growth rates since the introduction of trade liberalization policies in 1991. Moreover, while the volume of trade has increased at an average annual rate of 19%, the share of trade in the country's gross domestic product (GDP) has gone up to 30% in 2004-05. A comparison of the pre and post trade liberalization period shows that while in the former period (i.e. from 1975 to 1990) the share of trade in GDP had increased marginally from 12% to 15%, the same in the latter period had taken a big leap forward by registering 30% in 2004. This phenomenal rate of growth in the volume of trade reflects the impact of liberalization policies on trade flows.

However, at the same time, serious environmental problems have cropped up in the country. A study by the Economic Survey of India (1998–1999) has estimated the damage caused by pollution in India to cost $14 billion annually amounting to close to 4.5% to 6% of GDP. India like many other developing countries of similar growth pattern faces a serious challenge on the environmental front.

Against such a backdrop, the major objective of this paper is to measure the impact of economic growth and trade liberalization on pollution in the country. The paper is structured as follows – a short literature review is presented in Section 2 after which the model is described in Section3. For estimating the model real pollution data are used from Indian states. The results are presented in Section 4, and finally some conclusions are drawn.

2. Literature review

The debate over the likely environmental impacts of economic development and trade liberalization has been examined and analyzed by economists for decades now. But, neither the theoretical nor the empirical literature on trade, economic development and the environment could yield anything conclusively about the overall impact of trade on the environment.[1] As shown by Grossman and Krueger (1993) as well as Copeland and Taylor (2004), trade openness can affect environment both positively as well as negatively.

The empirical literature on the effects of economic growth and international trade on the environment, which was initiated by Grossman and Krueger (1991, 1995) have been carried forward by many researchers over the years and produced a large amount of empirical studies which has popularly come to be known as "environmental Kuznets curve" (EKC).[2] The EKC literature argues that an inverted

[1] see Jayadevappa and Chhatre (2000) for a survey.

[2] see Dinda (2004), Stern (2004), Managi and Jena (2007) for recent literature.

U–shaped relationship exists between economic growth and environmental quality, which implies that environmental degradation increases with income at low levels of income and then decreases once a threshold level of per capita income is reached. Their argument for such finding is that after a certain level of income, concern for environmental degradation becomes more relevant and a mechanism to reduce environmental degradation is put in place through necessary institutional, legal and technological adjustments.

As more and more studies were undertaken in this direction, researchers had kept on modifying their models to accommodate more relevant variables like trade openness to examine the trade's role in predicting environmental quality. Antweiler *et al.* (2001) for the first time theorized and modeled explicitly trade openness as an explanatory variable to examine the impact of free trade on environmental quality. They had divided trade's impact on the environment into three individual effects such as scale, composition and technique effects. After estimating these effects, they added them up to find an overall impact of free trade on environmental quality. Since then, many other researchers (Dean, 2002; Cole and Elliot, 2003; and Frankel and Rose, 2005) have extended this work by bringing methodological as well as conceptual modifications.

However, although these studies have provided useful insights into the subject and raised important policy questions they are not free from criticisms. One of the major difficulties facing researchers in this area is scarcity of pollution data. For example, most of the cross-country studies that have attempted to test the EKC, or the scale, composition and technique effects of trade liberalization on the environment have suffered from uneven distribution of pollution data. While, some of the countries such as United States, China, Japan, and Canada have large shares in the data that were used in these empirical exercises, developing countries' share is not very significant. Further, some pollutants, such as SO_2, have been studied quite extensively, while others have been neglected.

Apart from the data issues, existing empirical studies also suffer from methodological shortcomings. First, the cross-country studies have mostly ignored country-specific factors that can significantly affect the outcomes. Countries differ in their monitoring methods and instruments of pollution emissions. So, comparing the pollution data from a host of countries without proper adjustment may lead to misleading results.

In this study, we have taken air pollution data monitored in various industrial cities of India over the period 1991-2003. This panel covers major industrial clusters and therefore provides a good basis to examine the industrial pollution.

3. The Model

This study tests the theory developed by Antweiler *et al.* (2001) that the impact of trade on pollution can be decomposed into scale, technique and composition effects. Since the findings and methodology of Antweiler *et al.* (2001) are central to this paper it is useful to provide a brief outline of the model. They have decomposed pollution (z) into scale, composition and technique effects

$$\hat{z} = \hat{S} + \hat{\sigma} + \hat{e} \qquad (1)$$

where, ^ denotes percentage change. S is the scale effect and represents the change in emissions that would occur, ceteris paribus, if the size of an economy is changed. The variable σ represents the share of the pollution-intensive good X in total output, otherwise known as the composition effect. Finally, *e* represents the pollution intensity of the dirty industry or the technique effect.

A further decomposition of Eq. (1) yields the private sector's demand for pollution. Pollution demand is a positive function of scale, capital abundance and the world price of dirty goods and is a negative function of pollution tax. A reduction in trade frictions affects the composition of output and consequently the pollution emission levels depending upon the source of comparative advantage. In Antweiler *et al.* (2001) model, pollution supply is determined by the price of polluting, as given by a pollution tax. In turn, real income is a determinant of the pollution tax, since the increase in real income per capita will increase the demand for environmental quality. Combining pollution demand and supply yields the following reduced form equation:

$$\hat{z} = \alpha_1 \hat{S} + \alpha_2 \hat{k} - \alpha_3 \hat{y} - \alpha_4 \hat{T} + \alpha_5 \hat{p}^w + \alpha_6 \hat{\delta} \qquad (2)$$

where all α s are positive, *k* denotes the capital-labour ratio, *y* represents real per capita income, *T* represents country type and region-specific characteristics[3], p^w is the world relative price of X (dirty good) and δ denotes the trade friction.

Based on these theoretical considerations, we estimate the following pollution emission function using fixed and random effects models.

$$E_{ijt} = \beta_1 + \beta_2 Y_{jt} + \beta_3 Y_{jt}^2 + \beta_4 TI_t + \beta_5 RELK/L_{jt} TI_t + \beta_6 RELY_{jt} TI_t + \beta_7 I_{jt} + \beta_8 U_{jt} . + \beta_9 EA_{jt} + \beta_{10} P_{ijt} + \beta_{11} H_{ij} + \beta_{12} T_{ij} + \beta_{13} W_{ij} + \varepsilon_{ijt} \qquad (3)$$

where, E_{ijt} is the measurement of environmental indicator at site i in state j in year t, Y_{jt} is the jth state's income per capita, Y_{jt}^2 is jth state's income per capita square, *TI* is trade intensity, REL $K7L_{jt}TI_t$ is the interaction term of relative capital-labour ratio of state j and *TI*, REL $Y_{jt}T_t$ is the interaction term of relative per capita income of state j and *TI*. I_{jt} is the percentage of industrial output to total output in jth state, U_{jt} is a measure of jth state's urbanization, EA_{jt} is a measure of environmental awareness and P_{ijt} is the state population density. H_{ij} is a dummy variable showing whether the site is a high-humid area or a low-humid area, T_{ij} is a dummy variable for temperature, W_{ij} is a dummy for wind speed and finally, ε_{ijt} is the unobservable error term.

Per capita income and its squared term are used to capture the scale and technique effects respectively, which is consistent with the EKC literature. At low-income levels, an increase in income increases pollution but this relation may reverse at very high-income levels. So, when income increases to a sufficiently high level, the linear trend is dominated by the nonlinear part in which pollution actually declines with income. Thus, per capita income is used to measure the scale effect, and its squared term which accounts for the nonlinearity in the relationship between income and pollution, is used for the technique effect.

The trade-induced composition effect is captured through the trade intensity variable that is constructed as the ratio of exports plus imports to GDP [(X + M)/GDP]. This variable captures the relative importance of trade in domestic output, which is an important aspect of the trade liberalization policy. So, a change in trade intensity is expected to measure the change in composition of domestic output. Further, there are two interaction variables in Eq. 3. First are the interactions between *TI* and a region's relative capital-labour ratio, a measure of factor-endowment motive for trade. Second is the interaction between *TI* and relative income per capita, a

[3] Region-specific characteristics are population exposed to emissions and their concern about the environment. This variable also acts as a technique effect. .

measure of environmental regulation motive for trade. These two motives for trade actually act against each other. Apart from trade and scale, composition, and technique variables, several control variables are used to account for the state-specific socio-economic characteristics such as industrialization, urbanization, environmental awareness and population densities.

Furthermore, we note that the role of a dynamic regulatory framework is crucial in the chain of events through which trade liberalization affects environment. This effect depends upon the stringency or efficiency of domestic environmental regulations. In fact, measuring stringency of environmental regulations poses a difficult challenge (Tannewald, 1997). Some of the measures of stringency used in the past studies either are not comparable across states or partially reflect state-specific characteristics that have nothing to do with stringency.

In the present study, an attempt is made to construct an index that would measure the efficiency of State Pollution Control Boards (SPCBs) in implementing the environmental regulations in the respective states of India. Since these regulations are set at the central level and are equally applicable to all states, it is the difference in their ability and efficiency to implement them, which leads to different environmental outcomes in the states. In this study, five major components such as (i) organizational strength, (ii) financial strength, (iii) infrastructure expenditure, (iv)networking strength, and (v) monitoring stringency have been used to construct the pollution regulation index (PRI). These components represent various dimensions of implementing processes of pollution regulations of the SPCBs. This index is used as an additional regressor in the estimating equations.

4. Results

4.1 Scale, Technique and Trade-induced composition Effects

The estimated results from both the *random effects* model and *fixed effects* model are reported in Table I, II, and III for SO_2, NO_2 and SPM respectively. The Hausman test statistic suggests that random effects model is more appropriate for SO_2 and NO_2 while fixed effects model is a better fit for SPM. So while discussing the results we will refer to the estimates for these models for their corresponding pollution parameters. A perusal of the results shows that the scale effect is positive for all the three pollutants. However, the magnitude of this effect varies across the three pollutants with having the strongest effect for SO_2. On the other hand, the technique effect is negative for all three parameters but again having the strongest effect for SO_2. So, the results suggest that there is evidence of negative technique effect which tend to reduce the adverse environmental impacts of the scale effect but the former is decidedly weaker than the latter effect. This finding for India for scale and technique effects is opposite to what Antweiler *et al.* (2001) found for their cross-country study. They have found a stronger technique effect than scale effect. One explanation for this deviation in results is of course the coverage of countries in the data set. Their data is more dependent on observations from developed countries and thus a stronger technique effect is not surprising. However, in a developing country like India, a stronger scale effect is what is expected; nevertheless, a statistically significant technique effect is rather interesting.

Trade intensity (TI), which shows the relative importance of trade (exports and imports) in GDP, is interpreted as trade-induced composition effect. That is the predicted change in concentration when one unit change takes place in the share of trade in GDP. The change in composition of output due to trade liberalization is captured by this variable. A perusal of the TI coefficients shows that the estimates are statistically significant but different across the pollutants. For SO_2 and NO_2, the coefficients of TI are negative; i.e. – 0.04 and – 0.02 respectively. On the other hand, the same is positive for SPM with a magnitude of 0.027. The difference of signs of the coefficients across pollutants indicates that the source of pollution holds significance for the particular effect that trade liberalization would have on those pollutants. For instance, a major source of SPM emissions is the transport sector, which generally grew faster in the post–trade liberalization period in India. This is one possible explanation for a positive relationship between trade liberalization and SPM concentrations.

4.2 Factor endowment vis-à-vis Pollution haven motives for Trade

In our model, we have examined the relative significance of two major motives for trade, such as, factor endowment motives, which is measured by REL.K/L × TI, and the pollution haven motive, which is measured by REL.Y × TI. An analysis of the estimates of these interaction terms shows that coefficients of both REL.K/L × TI and REL.Y × TI are not statistically significant for SO_2 but they are statistically significant for the other two pollution parameters. While REL.K/L × TI is positive for NO_2 and SPM; REL.Y × TI is negative for them. These set of results have two major implications. First, both the factor endowment and pollution haven motives influence the pattern of trade. Second, while it is very difficult to provide a net estimate of the resultant outcome of these motives, the signs suggest that trade driven by factor endowments tend to increase pollution emissions of NO_2 and SPM whereas the pollution haven motive, on the other hand, tends to reduce their emission levels. Although, this interpretation goes with the theory, this needs a closer examination. Cole and Elliot (2003) have done a detailed study on the two sources of comparative advantage, namely the factor-endowment and pollution regulation. They came to a similar kind of conclusion that both these motives influence trade flows but their impact on environmental parameters vary.

4.3 Impact of Pollution Regulation Index

The pollution regulation index (PRI), which is included in the random effects model measures the impact of efficiency of implementing environmental regulations on pollution level. The estimated coefficient values show that PRI is statistically significant and negative for SO_2 with a magnitude of – 0.067, meaning thereby a reduction in its concentration levels due to higher efficiency in the implementation of regulations. But the estimated coefficients are not statistically significant for NO_2 and SPM. However, the negative coefficients of PRI for SO_2 suggest that implementation of environmental standard has significant bearing on pollution levels.

4.4 Environmental Awareness and Other Control Variables

The estimated coefficient of education index, which represents environmental awareness, is found statistically significant and negative across the pollutants. It shows that higher level of education helps disseminating knowledge about environmental degradation and a need to protect it. As a higher percentage of population becomes educated they try to create a lobby group and can pressurize industries to reduce pollution emissions. They can also influence the government to direct polluting industries to comply with the specified standards.

Among other control variables, urbanization and state population density are found to have positive and statistically significant coefficients, which is along the line of expectation. This is because higher urban population induces growth of commercial activities, transportation etc. that in turn increases the pollution level.

5. Concluding Observations

We have argued previously that our model presents estimates of both scale and technique effects, which are interpreted as the change in pollution concentrations due to change in the value of domestic output and real income induced by trade liberalization. However, it is important to use a caveat here that these scale and technique effects are the indirect effects of trade liberalization on environment. We have not estimated the direct impact of trade liberalization on growth or real income and then the impact of the latter on environment. Instead, we have assumed that taking factor endowments fixed a lowering of transport costs or trade barriers raises the value of domestic output and real income in an open economy. The value of output and the value of income rise by same percentage and this creates both scale and technique effects. But, we have estimated the direct composition effect of trade liberalization on environment, which is called the trade–induced composition effect.

Our estimates indicate that the net effect of trade–induced increase in output and income has been a rise in concentrations of air pollution in India. An interesting feature of these results is that though the net effect of both scale and technique effects is positive for all the three parameters; it is relatively much larger in case of SPM since the technique effect is almost negligible for the later. This finding in fact points towards the complex inter-relationship between economic growth and environment. There are other important factors, which play a decisive role in shaping the environmental outcomes. Further, the trade-induced composition effect is negative for both SO_2 and NO_2, it is relatively smaller for the later, which is not sufficient to nullify the large net positive scale elasticity and thereby yields a deteriorating environmental impact of trade liberalization for this parameter.

This is a very interesting piece of result since it shows that the trade-environment nexus is more complicated than it was previously thought. The question here is of course what determines the pollution-sensitivity of the trade system. Though this paper falls short of finding out these determinants, a brief note regarding this is provided.

This differential impact can be explained by the fact that the pollutants examined in this study are not similar in their nature and impact. Some pollutants like SO_2 is emitted mostly from industrial sources and the industries have installed the abatement equipments. But the abatement technologies for other kind of pollutants are not appropriately installed since their volume of emission is not as high as SO_2; nevertheless they are equally harmful to the environment. Moreover, a recently released annual report of CPCB (2005) has admitted that it is more difficult to deal with pollutants such as NO_2 and SPM rather than SO_2. A summary of air quality status in India shows that the number of violation cases of air quality standard for sulfur dioxide have reduced drastically while the same for nitrous oxide and suspended particulates continues to be high.

Costs of adapting to the abatement technologies and complying with the regulations play a very important role in industries' response towards emission mitigation in India. Particularly, for the small and medium scale industries that account for 60% of the total industrial production, this abatement cost may be a significant part of their total production cost. Our results crucially point towards the efficiency in management of environmental regulations. In other words, if environmental regulations are properly complied with, then trade liberalization may improve environmental quality in the country.

Some general policy implications are drawn from this study. First, since the technique effect, which arises due to increasing levels of income, is weak in the Indian context, the pressure to force industries to adapt greener technology would also be weak. So, there is a greater role to be played by the regulatory system. It has been highlighted by this study that the engagement in trade liberalization by India is confronted with weak compliance capacity of the industries. The implementation of pollution regulations has been poor in many states that led to higher level of pollution when the country moves ahead with greater liberalization. From personal interviews with the top functionaries of several state pollution control boards it is revealed that the implementation process has been hindered by many structural bottlenecks such as inadequacy and irregularity in inspections, prior information of inspections to the units etc.

Second, since the impact of growth and trade is not unique across the pollutants, there is a need to design carefully appropriate mechanism to tackle each pollutant individually. A universal system for pollution prevention may not achieve desirable goals. Third, there is no need to put any check on the ongoing liberalization process. Rather, its deepening further would create more favourable conditions for improvement of environment. Finally, there is a need to formulate economic and environmental policies simultaneously in order to achieve sustainability of the growth process. Persistent efforts should be made to find common ground between both the policy frameworks.

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Table I: Results for SO_2

Estimation Method	**Random effects model**	**Fixed effects model**
Intercept	2.64* (8.49)	2.74* (8.87)
Income (Y)	0.161* (4.40)	0.185* (3.12)
Y^2	-0.005* (- 5.25)	-0.007* (- 3.76)
Trade Intensity (TI)	-0.040* (- 4.27)	-0.056* (- 3.44)
RKL.TI	0.0008 (0.20)	0.007 (-1.11)
RY.TI	-0.001 (-0.366)	0.013 (1.17)
Industrialization	0.03* (3.84)	0.022** (1.98)
Urbanization	0.006 (0.84)	0.005 (0.31)
Env. Awareness	-0.025*(- 6.45)	-0.019* (- 3.1)
Population density	0.014* (2.52)	0.02*** (1.57)
PRI	-0.067* (2.54**)**	
Humidity	0.49** (2.39)	
Temperature	0.014 (0.044)	
Wind speed	0.15 (0.748)	
Coastal	-0.11 (- 0.314)	
Observations	663	663
R^2	0.40	0.74
LM stattistics	955.74*	1118.13*
F- statistics		27.06*
Hausman statistics	16.41	

Note: Values in parentheses are the t-statistics. The reported t-statistics are White-heteroscedasticity consistent t-statistics. Significance levels are indicated with stars: *, ** and *** means significant at 1, 5 and 10 percent respectively.

Table II: Results for NO_2

Estimation method	Random effects model	Fixed effects model
Intercept	3.39* (13.67)	3.56* (15.16)
Income (Y)	0.07*** (1.98)	0.077*** (1.78)
Y^2	-0.001***(-1.62)	-.0008***(-1.57)
Trade Intensity (TI)	-0.020***(- 1.85)	-0.042* (- 2.45)
RKL.TI	0.009* (2.63)	0.012** (2.22)
RY.TI	-0.01* (-2.75)	-0.02** (-2.08)
Industrialization	0.010 (-1.44)	0.005 (-0.56)
Urbanization	0.007 (1.10)	0.008 (-0.06)
Env. awareness	-0.01* (- 3.07)	-0.004 (-0.74)
Population density	0.007 (1.23)	0.007 (0.7)
PRI	-0.095 (-0.70)	
Humidity	0.20*** (1.45)	
Temperature	0.065 (0.29)	
Wind speed	-0.22*** (-1.58)	
Coastal	-0.086 (-0.37)	
Observations	663	663
R^2	0.35	0.62
LM stattistics	533.49*	956*
F- statistics		15.63*
Hausman statistics	13.18	

Note: As above in Table1

Table III: Results for SPM

Estimation method	Random effects model	Fixed effects model
Intercept	5.03* (21.58)	4.99* (12.82)
Income (Y)	0.112* (4.75)	0.115* (2.818)
Y^2	-0.0002 (-0.432)	-0.0005 (-0.509)
Trade Intensity (TI)	0.027* (3.854)	0.019 (1.367)
RKL.TI	0.020* (4.025)	0.02* (2.251)
RY.TI	-0.020* (-2.697)	-0.014 (-1.015)
Industrialization	0.0001**(2.151)	0.0001 (1.194)
Urbanization	0.015* (3.625)	0.021*** (1.707)
Env. Awareness	-0.009* (-3.668)	-0.008** (-1.73)
Population density	-0.015 (-4.661)	-.015*** (-1.841)
PRI	-0.11 (-0.809)	
Humidity	-0.89 (-0.592)	
Temperature	0.318 (1.280)	
Wind speed	-0.445 (-2.852)	
Coastal	-1.068* (-4.242)	
Observations	559	559
R^2	0.54	0.83
LM stattistics	782.92*	1025*
F- statistics		42.91*
Hausman statistics	55.76*	

Note: As above in Table1