# IMPACT OF ENVIRONMENTAL REGULATION ON THE INDIAN MANUFACTURING INDUSTRIES: AN INTER-STATE ANALYSIS

Dissertation Submitted to the Jawaharlal Nehru University
in partial fulfillment of the requirements
for the award of the Degree of

**MASTER OF PHILOSOPHY**



ADITI JAMALPURIA

CENTRE FOR ECONOMIC STUDIES AND PLANNING
SCHOOL OF SOCIAL SCIENCES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI-110067
INDIA
2005

CENTRE FOR ECONOMIC STUDIES & PLANNING
SCHOOL OF SOCIAL SCIENCES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI-110067, INDIA

July 2005

# Certificate

This is to certify that the dissertation entitled "IMPACT OF ENVIRONMENTAL REGULATION ON THE INDIAN MANUFACTURING INDUSTRIES:AN INTER-STATE ANALYSIS" submitted by me to the Jawaharlal Nehru University in partial fulfillment of the requirement for the award of the degree of **Master of Philosophy** has not been previously submitted for any other degree of this or any other University.

Aditi Jamalpuria

**(Aditi Jamalpuria)**

We recommend that this dissertation be placed before the Examiners for evaluation.

Krishnendu Ghosh Dastidar

**(Prof. Krishnendu Ghosh Dastidar)**
Supervisor

Jayati Ghosh

**(Prof. Jayati Ghosh)**
Chairperson

Phone: 91-11-26717676, 26717557 Ext. 4421/26704421 Cable: JAYENU Fax: 91-11-26717603, 26717585, 26717586

*"Without faith a man can do nothing;*
*With it all things are possible"*

<u>*Sir William Osler*</u>

## Acknowledgement

I would like to acknowledge my gratitude towards certain individuals who have contributed to this Dissertation in more than one way.

First and foremost, I would like to express my deep sense of appreciation and gratitude towards my supervisor, Prof. Krishnendu Ghosh Dastidar for the help and concern during the entire course of this Dissertation. His perspicuous and pertinent comments have helped me to ameliorate this Dissertation while his phlegmatic demeanour has helped me in overcoming the moments of despondency while searching for data. But above all, I am grateful to him for giving me the freedom of thought and for being a patient listener to all my inchoate ideas.

I take this opportunity to thank Prof. Sarmila Banerjee of Calcutta University whose extensive course on Environmental Economics germinated the seeds of research in my mind. Innumerable discussions with her made me aware of the contemporary issues related to the Environmental Economics. A pedagogue in the truest sense; I am more than grateful to her for making me an ardent believer of a positive outlook in life.

I would like to thank the faculty of our centre for being helpful towards the students. In this respect I would especially like to thank Prof. Jayati Ghosh for answering my queries regarding the data availability. I would like to thank the staff of Jawaharlal Nehru University library and the National Institute of Public Finance and Policy library. I am particularly grateful to Mr. S. Chidambram, Senior Library Officer of the National Institute of Public Finance and Policy for personally e-mailing me certain data and for giving me the required information about the availability of the others.

I would like to express my gratitude towards Mr. K. Narang, the advisor at the Ministry of Environment and Forests and Dr. B. Sengupta the Member Secretary at the Central Pollution Control Board for making me aware of the Industrial Pollution Compliance data availability in India. I am thankful towards the congenial staff of the Central Pollution Control Board library for letting me extensively use the library facility. I would also like to thank the staff of Patent Head Office, Kolkata for letting me browse through the patent hard copies and for answering my queries regarding the patent search.

This Dissertation would not have been in its present form without the support and contribution of my seniors and friends. I am thankful to Simanti Di for the initial chiding which propelled me to go in search of data instead of continuously grousing about its unavailability. I am grateful to Sudeshna Di for letting me use the industry specific pollution compliance data for the Appendix Exercise in this Dissertation. I would like to thank Sanchari for clearing my doubts regarding the significance value. I am also thankful to my friends Shumonika, Shuchi and Mudita for supporting me both at the professional and the personal front. I hardly have words to thank my friend Kanakraj for inciting me to initiate the empirical exercise with the available data itself and for spending hours to counsel me whenever I have been in a state of dilemma.

I dedicate this work to my parents whose constant faith in me has always given me the impetus to strive further in life. I don't have apposite words to thank my father for being the guiding force behind my existence and my mother for being my spiritual guru; embedding the importance of 'Purushartha' in my life. I am thankful to my sister and my brother-in-law for being such good friends, and for being there whenever I needed them the most. Lastly I am grateful to God for giving me Siddharth and Saara my nephew and niece whose mere presence in my life makes it beautiful and worth working hard for.

# Impact of Environmental Regulation on the Indian Manufacturing Industries: An Inter-state Analysis


## *Abstract*

Over the past few decades environmental regulation has evolved as a tool for internalizing the environmental externality. The extensive literature on environmental regulation indicates toward two opposing arguments regarding the stringency of environmental regulation. First is the loss in productivity argument which endorses the trade-off between stringent environmental regulation and competitiveness. Stringent environmental regulation compels the firms to invest in pollution control, this diverges the limited resources away from pure productive purposes. The second argument stresses on the fact that properly crafted stringent environmental regulation can trigger off innovation possibilities within the firms which would off-set the increased cost of compliance. Such firms become competitive in the long run by producing "cleaner" as well as "innovative" products.

In this Dissertation, we have tried to show that effective environmental regulation and investment in pollution control play a determinant role in the production and the quality status of manufacturing industries in Indian states. For this purpose we have used state-wise manufacturing data for the year 1997-1998. Our results reveal that investment in pollution control negatively affects the production level of the manufacturing but positively affects the acquisition of quality status certification by the manufacturing units in the Indian states. This raises the issue of optimum investment in pollution control which would ameliorate the quality of manufacturing process without much hampering the production level. Moreover the results reveal that the states with effective environmental regulation perform better on both the production and the quality front. We further show that a certain level of development is a pre-condition for a state's environmental regulation to be effective.

# Contents

# Chapter 1

# Introduction

## 1.1 Introduction

In the past few decades environmental economics has attracted a lot of attention which is a result of growing environmental concern over the years. The reason for such an accretion in environmental concern is the rapid phase of development that has taken place over the past couple of centuries, starting right from the 19th century Industrial Revolution to the 20th century Globalization and Liberalization. Each phase of development has brought with it environmental degradation in various forms, starting from the depletion of resources and the Great Smog of London to the very recent Ozone layer rupture and global warming due to the Green House Gases. This has happened because environment is a commodity having the property of non-excludability and non-rivalry, the essential characteristic of a pure pubic good which results in an over-exploitation of environment. However, the global nature of the incidents like Ozone layer rupture and global warming has lead to a realization that environment can no longer be treated as a public good free for further exploitation; it should rather be treated as a scarce resource which like any other economic good has a price attached to it. This has paved the way for *Environmental Economics* as a branch of economics, whose existence is based on the interlinkages between the economy and the environment.

The two main functions of the environment in conjunction with the economy is that of the "source" i.e. the supplier of resources to the economy and the "sink" i.e. the assimilator of the waste generated as an economic outcome. But rapid phases of economic growth have severely constrained the environment's capacity to act both as the source as well as the sink. This is because the economic growth has been accompanied by an increase in pollution which limits the capacity of the environment as a sink. The explanation lies in the second law of *Thermodynamics* which says that with the increase in the usage of matter, the entropy of the universe increase continuously which thus limits the assimilative capacity of the environment. Even the source function of the environment is today severely constrained due to the overuse of resources. The growth of the economy has thus actually put limits to the growth of the environment as a resource. The need of the hour is to make cautious use of environment as a good for sustainable development.

The discussion of the interlinkages between the environment and the economy brings forth the role of environmental regulations to necessitate the sustainable use of environment as a good. Environmental regulations are required for internalization of environmental externality both in the form of pollution and excessive depletion of resources. Effective environmental regulations are needed for avoiding over-exploitation of environment as an economic good.

## 1.2 Issues Addressed in the Dissertation

In this dissertation we try to analyze the impact of environmental regulations (especially the ones related to the industrial pollution in Indian states) and hence investments in pollution control on the production and the quality status of manufacturing industries in the Indian context. Thereafter we would try to see whether development plays any role in rendering the environmental regulation that is being followed by the government of a particular Indian state effective.

The context of the study lies in the extensive literature on strategic environmental policy which says that even though environmental policies are generally required for internalization of the environmental externality, the governments may sometimes use environmental policy to achieve trade objectives. Particularly in the presence of market imperfections, strategic government intervention in the form of incomplete internalization of environmental externalities stands to fulfill the welfare objectives of a nation. In fact, use of environmental policies to achieve trade goals turn out to be the natural choice of any government when traditional trade instruments like tariff, quota etc. are not available. The government may then deliberately choose to follow an environmental policy which does not internalize the entire environmental externality. Such lax environmental standards give the domestic firm a competitive edge in the international trade market in the form of lower cost. Moreover it has been argued in the literature pertaining to environmental regulation that the use of strong environmental regulations by a nation adversely affects the productivity of the firms exposed to such a policy[1]. The reason for such an argument lies in the fact that stringent environmental regulations compels the firms to diverge some of the resources from directly productive investments to the investment meant for pollution control which has a negative impact on the productivity of the firm. This endorses the conflict between the environmental regulation and the economic competitiveness. It is evident from the foregoing discussion that increased environmental concern has made investment in pollution control and status of environmental regulation important determinants of production; besides conventional inputs like capital and labour. In this dissertation we discuss the following three issues.

We first hypothesize that besides conventional inputs like labour and capital (i.e. the directly productive investments) investments in pollution control (an outcome of effective environmental regulation) and status of environmental regulation (to which the manufacturing units in a particular Indian state is exposed to) are also the important determinants of production level of the manufacturing units. The primary interest here is to find out the direction in which investment in pollution control affects the manufacturing production.

The second issue discussed in the dissertation draws directly on the so called *Porter Hypothesis* which says that properly crafted stringent environmental regulations can trigger off innovations that may partially or at times even more than fully offset the productivity costs of complying them. Such innovations result in product differentiation in the form of production of better quality products by the firms exposed to the stringent environmental regulation. This leads to a sustainable enhancement in the competitiveness of such firms in contrast to the firms which are competitive through the low cost route which is easily duplicable and hence unsustainable in the long run[2]. We hypothesize that investment in pollution control (by the manufacturing units in a state) and status of environmental regulation (in a particular Indian state) has a significant impact on the quality status of manufacturing

[1] See Jaffe et.al. (1995).
[2] See Porter (1990) and Porter and van der Linde (1995).

productions across the Indian states. Here again the primary interest is to find out the direction in which investment in pollution control affects the quality status of the manufacturing process.

The final issue discussed in the dissertation is the one that explores the relationships between development and environmental degradation. The relationship between development and pollution (or to be more precise the relationship between economic growth and environmental quality) has been an extensively debated issue for a long time. At one extreme is the view that greater economic activity leads to an inevitable environmental degradation. While at the other extreme is the view that environmental degradation declines more or less automatically as a consequence of economic growth. It has been argued that with economic growth a country's preference for better quality environment increases which pressurizes the government of the country to undertake stringent and effective environmental regulations along with investments in pollution control to check further environmental degradation. Finally, we try to see whether development plays any such role in rendering the environmental regulation that is being followed by the government of a particular Indian state effective.

## 1.3 Organization of the Dissertation

In the following chapter (Chapter 2) we provide a survey of literature to elucidate the three issues related to environmental regulations discussed in the preceding section. For this purpose both the theoretical as well as empirical studies have been discussed to bring out various aspects of environmental regulations. In Chapter 3, we first discuss the status of environmental regulations in India. This is done because even though the standards related to industrial pollution is same all over the India, the enforcement and the monitoring task is the responsibility of the respective state governments. This results in generating differences in effectiveness of the environmental regulations among the states. Next, by using the regression analysis and various models we try to explore the hypothesis on production of manufacturing in 18 Indian states. In Chapter 4, we try to explore the hypothesis on the quality status of manufacturing in 21 Indian states. This again is done by using regression analysis on different models. In Chapter 5, we try to explore the relationship between development, industrial pollution and compliance taking into consideration 13 major Indian states. The main point here is to see whether development plays any role in rendering the environmental regulation (that is being followed by the government of a particular Indian state) effective. For this purpose three indices Development index, Industrial Pollution Intensiveness index and Industrial Pollution Control index are constructed and the 13 Indian states are ranked in descending order of the index values to bring out the inter-state picture clearly. Finally, a correlation analysis is carried out to see whether the three indices are linearly associated. Non-linear association between the development and the industrial pollution control status is also explored by fitting in quadratic regression line into the scatter of observations. The concluding chapter (Chapter 6) is synoptic which sums up the dissertation and indicates the limitations as well as the direction for future research.

# Chapter 2

# Literature Survey

## 2.1 Introduction

The literature on environmental economics in general and environmental regulation in particular is rich and extensive. In this chapter we will provide a brief survey of this literature. Since our proposed work deals with the impact of stringent environmental regulation on the productivity and competitiveness (through the route of innovations) of the nations as well as the role of environmental regulation in the relationship between development and environmental degradation, the literature survey will also focus on this theme.

The survey is organized in the following manner. We begin with a short discussion on basic economic issues related to environmental economics which also underscores the importance of environmental regulation in the environmental economies. This is followed by a survey of papers which try to investigate the reasons behind the implementation of weak (or strong) environmental policy by the government of a nation. The main emphasis in this section is on the role of strategic environmental policy as an industrial policy in international trade where we review the literature on the motives and incentives of the governments to use either weak (or strong) environmental policy contingent upon the prevailing market structure in the trading countries. In the following section we try to build up a case for usage of stringent environmental regulation by the countries. In this section the impact of stringent environmental regulation on the productivity and competitiveness is explored both theoretically and empirically. Finally, we review the literature which focuses on the relationships between development and pollution status as it is generally hypothesized that economic growth (after a point) reduces the environmental degradation. This happens because development raises a country's preference for better quality environment which leads to actions in the form of stringent environmental regulation and investments in pollution control to prevent further environmental deterioration.

## 2.2 Environmental Economics : the Basic Issues

The most important issue in environmental economics is that of market failure. The market fails because of the presence of environmental pollution, described as a negative externality in Welfare Economics. Presence of environmental pollution, an outcome of the economic activity of production and/or consumption creates a divergence between private marginal cost and the social marginal cost. The producers who fail to take into account this divergence, prices the commodity concerned below its social marginal cost. Hence the market in the presence of such a negative externality fails to correctly take account of the complex set of environmental costs and benefits of economic activity. This results in an over-exploitation of environment as a commodity. Thus, the market if left to itself leads to an over-exploitation of environment. However the market may also fail due to asymmetric information problem. Problems of asymmetric information arise when one of the agents in a transaction does not have adequate information regarding the actions or 'type' of the other. The type here may be the hidden characteristic of the other agent involved or the quality of the commodity concerned. Incomplete information of such kind leads to failure of the market to efficiently allocate resources. A paper by Akerlof (1970) relates quality and uncertainty. The author discusses economic models in which "trust" is important. He finds that if the seller is aware of the quality of the product put on sale while the buyer is not, then informal unwritten guarantees are pre-requisites for successful trade and production to take place. However when these guarantees are indefinite, the transaction suffers. In this case, market fails because of asymmetry in information regarding the quality of product put to sale.

Two traditions in the literature – the tax/subsidy approach associated with Pigou (1938), which focuses on marginal adjustments to damage and benefit function, and the Chicago approach with Coase (1960), which focuses on property rights, prescribe a solution to such a market failure. The former approach essentially aims at corrections of the consequences of market operations while the latter prescribes reformation of market institutions to internalize externalities. The environment is generally not owned and is hence treated as a public good free for exploitation by all. Consequently, no proper rates are paid for its exploitation which permits the polluter to escape the true costs of damage. The Coase School thus prescribes the creation of appropriate property rights so as to initiate a bargaining process among individuals through the market to arrive at an optimal exploitation rate of environment. Creation of property rights solves the problem of over-exploitation of environment because environment is a commodity having the property of non-excludability and non-rivalry, the essential characteristics of a pure public good. While the Pigouvian tax/subsidy approach prescribes adjustments in the prices and costs of the market participants so as to take into account the damage resulting from their actions.

Pigou recommended the introduction of government to internalize the externality. But optimal Pigouvian tax, which is equivalent to marginal damage to the society caused by the polluting activity, is in practice difficult to estimate in practice. This is because Pigouvian tax in spite of being the first best outcome is difficult to attain, as precise measurement of social marginal damage is impossible in practice. Underestimation of damage would lead to insufficient measure and the pollution would prevail, while an overestimation would lead to reduction in output and in consumer surplus. Both the outcomes are undesirable from the welfare point of view. This leads to alternative regulatory options to deal with pollution externality. These can be direct regulation policies of *Command-and-Control* type where the regulatory authority sets the targets for reduction of pollution level and hence accordingly specifies the permissible maximum quantity of pollution level. But it is an inefficient option as it does not provide the polluter with any incentive to adapt pollution abating devices. So the next alternative approach is to use market incentive based regulation to deal with pollution externality. Under this approach a value/price is assigned to the pollution and market exchange then come into picture by incorporating this valuation into its decisions. So the approach utilizes the informational advantages of the price mechanism and the institutional framework provided by the markets to decentralize pollution control to individuals and firms [Helm, 1991].

Broadly, there are two kinds of market based mechanisms. One is the combination of taxes and standards, kind of a *Hybrid Policy* which is the attainable second best outcome. In the *Hybrid Policy* the government sets a standard and designs a tax structure accordingly so that there is sufficient incentive to comply by the standards. The *Hybrid Policy* aims to alter the cost structure in order to bring the pollution back to the target level. The other method, *Tradable Pollution Permit* draws directly on the Coase School of thought discussed earlier. The idea of *tradable pollution permit* is simple. The government first sets the target level of pollution reduction and issues permits in the market equal to the amount of pollution. Those who wish to pollute must buy a permit for the amount they wish to emit. So a market for *tradable pollution permit* develops with producers having lower marginal abatement cost emerging as the sellers of the permit and the ones with higher marginal abatement cost emerging as the buyers of the permit. Equilibrium is attained when price of the permit equates the marginal abatement cost of each of the producers in the market. The advantage of the permit system is that the market here works out the price of the pollution rather than the government. The sole purpose of the government is to ensure that nobody pollutes without a permit. The tradable pollution permit finds its extensive use in the field of global environment protection problem.

The next issue is that of market imperfection. In the above analysis the markets were assumed to be perfectly competitive but in the real world the market structure is imperfect. Deviation from perfect competition changes the results dramatically. Buchanan [1969] argued that an imposition of Pigouvian tax on a monopolist might reduce the welfare considerably. The idea is simple. The monopolistic output level is sub-optimal to begin with; now an imposition of Pigouvian tax lowers the output further, thereby reducing the welfare. Reduction in pollution by the imposition of tax raises the welfare, but the two effects move in opposite directions and hence the net result is ambiguous. Also modern industrial societies are oligopolistic in nature rather than being perfectly competitive. Under oligopolistic framework there may be an additional externality besides output distortion and pollution which can render the standard environmental policies inefficient. Thus under an oligopolistic setting more than one policy instrument might have to be used in conjunction to the standard ones. The presence of market imperfections also gives rise to strategic government intervention in the form of incomplete internalization of environmental externalities to fulfill welfare objectives of the nation. In the absence of traditional trade instruments the government may deliberately choose to follow an environmental policy which does not internalize the entire environmental externality. Such lax environmental regulations give the domestic firm a competitive edge in the international trade market. Imposition of weak environmental regulations may thus lead to a competition with respect to low cost among countries where each country might try to undercut the environmental standard of the other country in order to reduce the relative production cost of the domestic firm. This might lead to an unsustainable depletion of environmental resources. In the following section we review the literature which focuses on the reasons for implementation of such lax environmental policy by the government of a nation.

## 2.3 Environmental Regulation: Weak or Strong

Environmental policies are generally required for internalization of the environmental externality but the governments may use environmental policy measurements to achieve trade objectives. Particularly, in the presence of market imperfections, strategic government intervention in the form of incomplete internalization of environmental externalities stands to fulfill welfare objectives of the nation. In fact, use of environmental policies to achieve trade goals turn out to be the natural choice of any government when traditional trade instruments like tariff, quota etc. are not available. The government may then deliberately choose to follow an environmental policy which does not internalize the entire environmental externality. Such lax environmental standards give the domestic firm a competitive edge in the international trade market. This policy of relaxing environmental standards to enable the domestic firm to sell their products at prices which do not reflect the true cost of product is termed as "Eco-Dumping". Imposition of weak environmental standards may thus lead to a competition among countries where each country might try to undercut the environmental standard of the other country in order to reduce the relative production cost of the domestic firm. This might lead to an unsustainable exploitation of environmental resources.

A large number of theoretical works by Conrad (1993), Rauscher (1994), Kennedy (1994), Barrett (1994), and Ulph (1996) have tried to investigate the reasons for the implementation of such lax environmental policy by the governments in the trading countries. All of these papers depart from the assumption of perfectly competitive market structure. Imperfect competition allows trade pattern to be determined endogenously. All of them consider an olgopolistic market structure, which is a more realistic analytical framework to describe the modern industrial structures. In presence of such imperfections the governments have a tendency to use strategic environmental policy so as to improve the welfare of their countries. Brander (1995) defines strategic environmental policy as an environmental policy that conditions or alters a strategic relationship between the firms involved in trade. A strategic relationship implies that the firms have a mutually recognized interdependence i.e. profit of one firm is directly affected by the individual strategy choices of the other firm, and this must be understood by the firms themselves. Strategic environmental policy would thus arise under imperfect competition, or to be more precise, in the presence of oligopoly.

Raucsher (1994) starts by giving a definition of "ecological dumping" and then goes on to identify the reasons for such an ecological dumping. One of the definitions of ecological dumping defines it as a policy which prices environmentally harmful activities at less than the marginal cost of environmental degradation, thereby enabling the firms to dump their output in the international markets at prices which do not reflect the true social marginal cost of their production. Ecological dumping thus portrays a case where under-internalization of the environmental externality in the form of weaker environmental standard takes place. However, even in a closed economy there is a possibility of incomplete internalization of environmental externality due to several reasons, which can not be termed as ecological dumping. The second definition takes non-traded sector as a point of reference and defines ecological dumping as a scenario in which environmental standards are more stringent in the non-traded than in the traded sectors. This definition takes into account the fact that trade related measures are targeted towards the traded sector and not the non-traded sectors.

The paper considers three objectives namely terms of trade improvement, strategic trade policy and protection of the interests of the sectors supported by powerful lobbies, to justify the adoption of weaker norms. Of these three, strategic trade policies and lobbying activities of the exporters offer a better explanation for eco-dumping. But neither the terms of trade considerations nor the maximization of revenue from the emission taxes can satisfactorily explain the phenomena of ecological dumping. According to the strategic trade policy considerations, usage of weaker environmental norms by the government acts as an implicit subsidy for the domestic firm. This helps the domestic firm to raise profit and hence maximize the nation's net welfare. However, general equilibrium considerations in environmental policy may render such results ambiguous. According to the lobbying activities considerations, ecological dumping comes into picture only if the exporters lobby for softer environmental norms is stronger than the ones which stand for tougher environmental norms.

Kennedy (1994) examines strategic motives to adopt lower than optimal pollution taxes by the governments of free trading economies. The paper assumes an oligopolistic framework in order to depart from traditional bases of trade and hence focus on the strategic effects. The model thus studies the strategic interaction between two large trading countries and examines the equilibrium of the game. The model also introduces transboundary pollution so as to determine the size of strategic distortion as well as the associated welfare loss.

Kennedy (1994) argues that imperfection of global markets creates strategic interactions between governments leading to inefficient distortions of pollution taxes, which can be primarily decomposed into a rent capture effect and a pollution-shifting effect. Besides these, if the pollution is of transboundary nature then the distortion also gives rise to transboundary externality effect. Kennedy defines "rent capture effect" as a phenomenon where a government by lowering the pollution taxes shifts rent away from its trading partner and hence improves its own competitive status. This “rent-capture” effect can be viewed as the low-cost argument by the nations to use ineffective environmental regulation. On the other hand, "pollution-shifting effect” raises equilibrium pollution taxes of each country so as to transfer production and its associated pollution to the trading partner. If, however pollution is perfectly transboundary then this effect is absent because shifted pollution causes as much damage to domestic environment as does domestic pollution. Finally, when pollution is even partially transboundary then this gives rise to equilibrium pollution taxes that are lower than the efficient level. This is the result of "transboundary-externality effect". Transboundary externality arises when a country fails to realize the impacts of its pollution generating activity on the environment of foreign country. In such a scenario lowering of taxes renders the production internationally competitive while at the same time the domestic government has no commitment towards the residents of the foreign country that is getting affected by the pollution externality. Thus giving rise to the strategic effect.

Kennedy considers a case of symmetric equilibrium and shows that rent capture effect and the pollution-shifting effect work in opposite directions canceling out each other in the case of perfect competition with no transboundary pollution. But in case of transboundary pollution, rent capture effect dominates and reinforces the transboundary externality effect. This lowers the pollution taxes below the efficient level. Lowering of taxes adversely affects the welfare of the concerned countries. But as the countries considered are symmetric in nature no rent or pollution is shifted, only the taxes are distorted at lower than the optimal level. So this clearly indicates that the countries are only worse off by setting the taxes at lower levels when they can do better by setting them at an efficient level. This indicates towards a Prisoner's Dilemma kind of game of non-communicative outcome where the strategic effect is not very powerful.

Both Rauscher and Kennedy in their papers consider a single instrument of pollution taxes to deal with the twin problems of pollution externality and imperfect market. But if the market structure is oligopolistic then presence of multiple market externalities renders the use of single policy instrument designed to correct the environmental externality largely sub-optimal. Consequently, the environmental policy must be designed in such a manner so as to take into account the specific characteristics of both the market and the environmental phenomena to be regulated. Conrad (1993) suggests a tax-subsidy programme to deal with the twin externality problem. Conrad shows that given the emission taxes the welfare improving government has an incentive to grant subsidies for abatement efforts or for heavily taxed polluting input. Domestic welfare is thus improved as the domestic firm stands to capture greater share of the world market. The emission taxes are thus imposed in general while the subsidization is done selectively. Emission taxes control the environmental externality while the subsidy improves the competitive advantage of the domestic firm in the international trade market. Conrad shows that, since under subsidy programmes optimal emission tax rates turn out to be much higher than those under no subsidy regime, the governments can easily defend the subsidies as being a part of the package to improve the global environment[3]. However,

[3] Post World Trade Organization negotiations some of the Developed countries have emerged as nations using such tax-subsidy programme.

Conrad points out that the actual motive behind such a subsidy programme is to capture larger market share and not really the improvement of global environment.

Barrett (1994) like others tries to study environmental policy as industrial policy and international strategic interactions. The paper tries to show how the incentive of the domestic government to impose weak (or strong) environmental standards is contingent upon the market structure prevailing in the rival country.

Barrett (1994) shows that if the domestic industry is a monopoly, the rival industry is imperfectly competitive and industrial competition is Cournot then the domestic government has an incentive to set weak environmental standards. According to the paper, weak environmental standards means that marginal cost of abatement is less than the marginal damage from the pollution. The domestic government imposes strategically optimal standard which is lower than the environmentally optimal standard, because the former acts as an export subsidy enabling the domestic government to capture a larger market share. Thus weak environmental standards play a role similar to that of R&D subsidy or an export subsidy. But unlike R&D subsidy and export subsidy it is an inefficient policy choice because it imposes an extra cost on the society in the form of environmental degradation.

Barrett considers a domestic welfare function comprising of domestic firm's profit, rent shifted from the foreign market and the social cost of environmental damage done by the emissions. Weaker environmental standards are justified if the rent-shifting component over-compensates the environmental damages. If the foreign firm is perfectly competitive then the rent-shifting component of the domestic welfare is absent. In such a case the domestic government would rather impose strong environmental standards so as to maximize the domestic welfare function. If the domestic industry is oligopolistic and the foreign country is perfectly competitive then also the domestic governments have an incentive to impose stronger environmental standards. This is done to lower the domestic output which would thus raise the domestic profit. If the foreign country is also imperfectly competitive then this incentive must be balanced against the incentive to shift the rent away from the foreign country by imposing weaker environmental standards. Hence the paper highlights the fact that if the industry is oligopolistic in nature then the strategically optimal standards may be weaker or stronger than the environmentally optimal standards depending upon the market structure prevailing in the foreign country. Opposite results are obtained if the Cournot conjecture is replaced by the Bertrand conjecture[4].

All the papers referred to above concentrate on the strategic behaviour by government. But producers also have an incentive to act strategically as they try to shift rent in their favour for instance through their investments in capacity or R&D. Ulph (1996) thus extends the literature on strategic environment policy by allowing for strategic behaviour on the part of both the producers as well as the government. The model so developed shows that if producers act strategically then this reduces the incentive for government to relax their environmental policy. On the other hand, if the governments act strategically then this increases the incentive of the producer to act strategically. Moreover, welfare is lower when both government and the producers act strategically and strategic behaviour by both of them is greater when the government uses emission tax than when they use emission standards.

So the review of literature in this section reveals that prevalent market structure is generally the reason behind a country following weak or stringent environmental regulations. Moreover, market imperfection is generally the reason behind a country using environmental policy as an industrial policy.

## 2.4 A Case for Stringent Environmental Regulation: the Porter Hypothesis

The conventional wisdom says that the stringent environmental regulation followed by the government of a nation imposes considerable cost on the firms of that nation. The cost may be of the form of slow productivity growth which can adversely affect the competitive position of the firm in the international trade. However, in this era of growing environmental concern stringent regulations are an absolute necessity for preventing further environmental degradation. This kind of a situation indicates towards a trade off between private costs and

[4] It is well known in the Industrial Organization literature that the Quantity competition and Price competition gives different results.

social benefits. This idea was challenged by Porter (1990) and Porter & van der Linde (1995) whose seminal works argued that the environment-competitiveness debate has been framed incorrectly.

In his "The Competitive Advantage of Nations" Porter (1990) states "the conflict between environmental protection and economic competitiveness is a false dichotomy. It stems from ....a static view of competition. Strict environmental regulations do not inevitably hinder competitive advantage against foreign rivals; Indeed they often enhance it. Tough standards trigger innovation and upgrading". He mentions two types of competitive advantage: *lower cost* and *differentiation*. By *Lower cost* competitive advantage, he means the ability of the firm to design, produce and market a comparable product more efficiently than its competitor. While by *differentiation* he means the ability of the firm to provide unique and superior value to the buyer in terms of product or for that matter production quality, special feature, or after-sale service. However, of the two, only differentiation as the source of competitive advantage is sustainable in the long run as the competitive advantage arising due to lower cost is easy to duplicate within a short span of time. *Differentiation* in turn arises from innovative capabilities of the firms. Stringent environmental regulations trigger innovations leading to enhancement in competition through the route of *differentiation.*

Porter and van der Linde (1995) in their paper also argue that the notion of struggle between ecology and the economy stems from a static view of the environmental regulation which assumes technology, consumer products, processes and consumer demand to be given. In such an unrealistic static world choices regarding cost-minimizing production processes have already been made by the firms and the environmental regulations just increase the cost of production, thereby reducing the market share of the domestic firm in the international market. This in turn reduces the competitiveness of the domestic firm in the international market giving rise to the standard trade off talked about in the literature. Instead they argue that what determines a firm's competitive position is its dynamic competitiveness; the capacity to innovate. According to them, properly crafted environmental standards can trigger off innovation that may partially or more than fully offset the costs of complying them. Such "innovation-offsets" not only lower the net cost of meeting environmental standards but also increase the competitiveness of the firms in contrast to their foreign counterparts that are not subjected to same kind of regulations. They use a series of case studies to validate their claim regarding the dynamic competitiveness of the regulated firms.

A wide variety of theoretical and empirical works by Oates, Palmer and Portney (1995), Barbera and McConell (1990), Gallop and Roberts (1983), Simpson and Bradford, III (1996), Xepapadeas and de Zeeuw (1999), Murty and Kumar (2001), Ulph and Ulph (1996), Albrecht (1998), Lanoie, Patry and Lajeunesse (2001), Marklund (2003) explore the Porter hypothesis from various perspectives, to see whether environmental regulations can indeed enhance rather than reduce competitiveness.

In an empirical work by Barbera and McConell (1990), the impact of environmental regulation is studied on the industrial productivity for five US. industries for the period ranging from 1960 to 1980. Industrial productivity is represented by the total factor productivity. The choice of the five US manufacturing industries i.e. Paper; Chemicals; Stone, Clay, and Glass; Iron and Steel; and Non-ferrous metals are based on the fact these are the most affected by the regulations. The impact of environmental regulation can be divided into two components viz. the direct impact and the indirect impact. The direct impact on productivity growth arises due to diversion of resources towards the abatement capital. While the indirect effect arises because of change in the combination of conventional inputs and production processes resulting from the regulation policy. The indirect effect can be thought of as Porter effect. The study reveals that while the direct effect for all the five industries considered unambiguously reduces total factor productivity by increasing costs with no commensurate increase in manufactured output, the indirect though turned out to be positive, negative or zero for different industries. In fact, there was some indirect effect in 4 of the 5 industries considered. In most of which it lead to a fall in the productivity though in some of these it increased the productivity for some period. So this empirical work does not really support Porter hypothesis in general but it stands to validate the former phenomenon only for some particular period.

Gallop and Roberts (1983) also empirically tried to measure the productivity impact of emission regulation. Their paper tries to measure and analyze the effect of sulfur dioxide emission restriction on the rate of productivity growth in the electric power industry covering 56 privately owned utilities for the time period 1973-1979. For this purpose they develop a measure of regulatory intensity, a kind of intensity index which takes into account the severity of emission standards, extent of enforcement and the unconstrained emission rate relevant to each utility. Their results revealed that sulfur dioxide emission regulations for the concerned period resulted in both significantly higher generating costs and lower rates of productivity growth. Generation of high cost was primarily due to the increased use of low-sulfur fuel. Moreover, compared to the unconstrained utilities, the average rate of growth of environmentally constrained utilities was reduced by 0.59 percentage points per year for the time period 1973-1979. The authors observed that the average annual productivity growth would have been higher by 44 percentage points in the absence of the sulfur dioxide emission regulations. So the result confirm to the loss in productivity argument as a result of environmental regulation.

Another empirical work by Murty and Kumar (2001) in the context of India however supports Porter hypothesis. Their paper studies the effect of environmental regulation relating to water pollution by the Indian industry on the productive efficiency of firms. For this purpose they use panel data of 92 water polluting industries subjected to the regulation for the three years 1996-1997, 1997-1998, and 1998-1999. Using a distance function approach they then show that the technical efficiency of these firms increases with the intensity of environmental regulation and water conservation effort. So the paper supports the Porter hypothesis.

The Porter hypothesis has been criticized by Palmer, Oates and Portney (1995) who argue that there is always a trade-off between environmental regulation and competitiveness. They use a simple static model of perfect competition to show that if the new technology was worth investing in before, then its benefit would have been enough to fully offset the cost of compliance even before the regulations are enforced. In other words, given the constraints facing them the firms are already operating on their production possibility frontier, there is no need of stricter regulations to improve the technical efficiency aspect of their production process. They then extend the basic model by introducing strategic interactions among the polluters and the regulators where they cite the results of the paper by Barrett (1994) discussed in the previous section. Barrett (1994) shows that if the domestic industry is oligopolistic and the foreign country is perfectly competitive then the domestic governments have an incentive to impose stronger environmental standards. This is done to lower the domestic output which would thus raise the domestic profit. Also if the two firms compete in prices then there is an incentive for the government to impose stringent environmental regulation. However, the result is not general one. This is so because if the domestic firm is a monopolist in the domestic market and the competition is of Cournot conjecture then the domestic government has an incentive to impose softer environmental regulation to improve the domestic firm's competitive position. Regarding the case studies cited in Porter and van der Linde (1995) paper they argue that of the hundreds of thousands of firms subject to environmental regulation in US it is not difficult to cite instances where regulation has seemingly worked to a polluting firm's advantage. In fact according to them a similar kind of case study can reveal the presence of such firms also which have suffered in productivity as a result of stringent environmental regulation.

Another paper by Simpson and Bradford, III (1996) has criticized the argument that tougher environmental regulation might be effective in motivation of investment in cost-reducing innovation so as to increase domestic industrial advantage. They consider a model similar to that of Brander and Spencer (1985) and argue that theoretically it is possible to conceive the idea that an increase in the stringency of environmental regulation on the part of the government may induce the firm to innovate, lower its marginal cost and consequently increase its profit at the cost of the rival firm. But such a result can not be taken as a general phenomenon rather the result obtained would not even pass the practicality test. They argue that if the domestic firm and its foreign counterpart were Bertrand competitors in differentiated products, then an increase in the cost results in an increase in profitability not due to the induced innovations but rather due to restricted output. Moreover the argument for the use of stringent environmental regulation revolves around its capacity to induce innovation expenditures. If that is the case then, granting of R&D subsidies or for that matter direct production subsidies to the firm is a more efficient option than the introduction of stringent environmental regulation. So according to this paper Porter hypothesis fails on the practical grounds.

Xepapadeas and de Zeeuw (1999) explore the validity of Porter hypothesis by considering firms reactions with respect to both the type and quantity of equipment in which they respond to invest as a result of changes in environmental taxes. They show that the stricter environmental regulation, in the form of an increase in emission taxes is not profitable for the firm. The cost of environmental regulation can be decomposed into two effects : downsizing effect and the modernization effect. Downsizing which refers to a decrease in the total size of capital stock leads to an upward pressure on the prices. While the modernization that refers to reduction in the average age of capital stock leads to an increase in the productivity of the capital stock. Also downsizing and modernization together leads to a lower emission, so that an environmental target can be attained with lower tax than in the absence of such an effect. Thus the implications for the debate on the Porter hypothesis is not that a win-win situation can be expected in the sense of both reducing emission and increasing productivity, but one may expect increased productivity of the capital stock along with a relatively less severe impact on the profit and more reductions in the emission levels induced by the modernization of the capital stock. So downsizing and modernization considerably reduces the sharpness of the trade-off between stringent environmental regulation and competitiveness.

To analyze Porter hypothesis a paper by Ulph and Ulph (1996) develops a model in which there is strategic behaviour by both producers and the governments. The paper further allows for strategic innovations by producers to reduce both the cost of productions and the emissions. In such a framework when the firms take both environmental and process R&D then the environmental regulation i.e. both taxes and standards may be either too lax or too strong. This suggests that when innovation concerns environmental technology then there is a possibility of validating Porter hypothesis but an opposite outcome is also possible.

Albrecht (1998) tries to explore Porter Hypothesis by estimating the direct impact of CFC (chlorofluorocarbons)-regulations on the export performance of CFC using industries like refrigerators, freezers and air conditioning machines. Their empirical analysis is linked to

CFC specific product since all the industrial nations signed the Montreal Protocol on substances that deplete the ozone layer and hence had to impose regulation inline with the agreed CFC-phase-out schedule. Their ordinary lest square estimates revealed that the two countries i.e. the US and Denmark with the most pro-active CFC regulation experienced better export growth for their CFC using industries than the countries that reacted later and with much less convincing regulatory instruments. So according to their paper when the regulation is linked to a particular product then there is a clear case for Porter Hypothesis.

Lanoie, Patry and Lajeunesse (2001) try to empirically analyze the relationship between the stringency of environmental regulation and total factor productivity i.e. TFP in the Quebec manufacturing sector. This they do to explore the Porter hypothesis from the following three directions. First, they capture the dynamic aspect of the hypothesis by using the lagged regulation variables. Second, they try to argue that the hypothesis is more relevant for the more pollution intensive sectors. Finally, they try to argue that the hypothesis is more relevant for the sectors which are more exposed to the international trade. Generalized Least Square estimation method is used on the equation which relates the growth in TFP to a proxy of stringency of environmental regulation and several other explanatory variables. This proxy is defined in the paper as the ratio of the value of investment in pollution control equipment to the total cost in a particular industry at a particular time. In order to capture the dynamics of the Porter hypothesis, along with the contemporaneous measures they also include a one-year, two-year and a three-year lag in the model. For estimation purpose they use pooled cross-section and time series data covering 17 sectors in the Quebec manufacturing industry for the time period 1985-1994. The results revealed that by allowing for the dynamic effects to occur the environmental regulation has less detrimental impact on the manufacturing productivity, rather it is even positive confirming the relevance of Porter hypothesis. The results also revealed that the sectors which were more exposed to competition were more likely to confirm to the hypothesis than the sectors which were less exposed to the competition. Lastly, Porter hypothesis confirmed only for less pollution intensive sectors in contrast to the more pollution intensive sector. An increase in the stringency of environmental regulation hampered the long run productivity of the more pollution intensive industries.

Marklund (2003) empirically investigates the Porter hypothesis by using distance function approach. The paper try to test the hypothesis whether there is significant positive correlation between producer's technical output efficiency and environmental regulation. For this purpose efficiency is estimated using a methodology that represents the production technology by directional output distance function. This is done to simultaneously account for an expansion of market goods and contraction of undesirable emissions. The directional output distance function is estimated using data on the Swedish pulp and paper industry covering 12 Swedish pulp plants for the period 1983-1990. Finally, to test for the Porter hypothesis the efficiency scores are regressed on an index that approximates environmental regulation stringency. The regulatory intensity index used is the one developed by Gallop and Roberts (1983). They divide the regulatory measure into two parts, one measures the severity of emission's standards and the other measures the extent of enforcements. Marklund however uses only the severity part of the Gallop and Roberts's measure. The study finds no evidence that environmental regulation made the pulp plants more resource efficient during the period 1983-1990. The result thus do not corroborate to the Porter Hypothesis.

The vast literature on the Porter hypo hesis which comprises of both theoretical and empirical work speaks both in favour of stringent environmental regulation as well as against it leaving the debate surrounding it unresolved. However, a wide variety of literature comprising of both theoretical and empirical work exists which brings forth the status of development as one of the deciding factors for a nation in following stringent or lax environmental regulation. In the next section we will discuss the literature related to the development issue.

## 2.5 Development and Pollution: the role of Environmental Regulation

The relationship between development and pollution (or to be more precise the relationship between economic growth and environmental quality) has been an extensively debated issue for a long time. At one extreme is the view that greater economic activity leads to an inevitable environmental degradation. While at the other extreme is the view that environmental degradation declines more or less automatically as a consequence of economic growth. In their 1993 pioneering work, Grossman and Krueger established the empirical relationship between measures of environmental quality and national income. An inverted-U hypothesis was established between levels of pollution and income. According to this hypothesis environmental degradation increases with income at low levels of income and then decreases when a threshold level of per capita income is reached. This inverted U-type relationship is generally referred to as the *Environmental Kuznets Curve* because of the similarity with Kuznet curve of income inequality established by Simon Kuznets in 1955. It has been argued that with economic growth a country's preference for better quality environment increases which pressurizes the government of the country to undertake stringent and effective environmental policy along with the investments in pollution control to check further environmental degradation.

A wide variety of theoretical and empirical works by Selden and Song (1995), Gruver (1975), Grossman and Krueger (1995), Lucas, Wheeler and Hettige (1992), Dean (1999), Hettige, Mani and Wheeler (1999), Shafik (1994), Selden and Song (1993), Zaim and Taskin (2000) explore the hypothesis from various perspectives and some of them also try to bring into focus the reasons for such a hypothesis to exists.

The theoretical paper by Selden and Song (1995) brings forth the dynamic relationships between pollution, abatement efforts and economic development. For this purpose they modify the neoclassical model by B.A. Forster (1973) which is one of the simplest and earliest environmental growth models. Using optimal control theory they show the optimal path followed by pollution and abatement over a time period.

Forster's (1973) model is an ordinary one consumption growth model where the role of pollution is added. So according to the model, the social planner's objective is to maximize a representative consumer's utility which is additively separable function of consumption and pollution where pollution is a function of capital stock and expenditure on abatement efforts. It is thus a simple model which tries to capture the idea that the presence of capital generates pollution. Further modification of the model by Selden and Song (1995) generates the optimal trajectories for pollution and abatement efforts. According to them, pollution and abatement efforts both are likely to be low during the earliest stages of development thus initial abatement effort is zero. Abatement efforts start increasing and that to at an increasing rate only once development has instigated enough consumption and environmental damage to merit expenditure on abatement. So abatement effort follows a J-curve path with increase in output of capital which can be viewed as an increase in the development status of an economy. As for the pollution it follows a U-curve path with an increase in the output of capital. That is to say, pollution increases at a decreasing rate with growth. At a certain level of capital stock it reaches its maximum after which it starts decreasing at an increasing rate. According to the authors it is at this level of capital stock from which abatement effort starts rising from zero level. So the pollution level overtime follows the Kuznets type U-curve while the abatement effort follows a J- curve path.

Another theoretical paper by Gruver (1975) tries to measure the optimal division of investment between pollution control capital and directly productive capital in a neoclassical growth model. The model assumes pollution as a flow which is positively related to aggregate output, negatively related to the stock of pollution control and has a negative effect on utility. Under such assumptions the objective of the paper is to analyze how the optimal investment proportion between the two types of capital varies over a time period. For this purpose Gruver maximizes the integral of discounted utility over a fixed planning period by the optimal choice of saving rate and relates proportion of the saving to be allocated to directly productive investment in contrast to the pollution control investment. The investment process is assumed to be irreversible in the sense that once capital is utilized for one use it cannot be simultaneously utilized for the other use. The paper reveals that optimal policy under such assumptions is an unbalanced one where initial specialization of investment is to make in productive capital followed by pollution control capital. So rather than following a balanced programme of investment in both the types of capitals the paper suggests that the optimal investment pattern as to be one of specialization. It suggests the sequence of first building up directly productive capital followed by a subsequent increase in the stock of capital for pollution control purposes.

The paper by Grossman and Krueger (1995) empirically examine the relationship between per capita income and various environmental indicators like urban air pollution, the state of oxygen regime in river basins, faecal contamination of river basins and contamination of river basins by heavy metals. To study the relationship between pollution and growth they estimate several reduced-form equations that relate the level of pollution in a particular location to a flexible function of the current and lagged per capita income in the country and other covariates. The reduced-form estimates gives the net effect of a country's per capita income on pollution. However, the paper finds no evidence of environmental quality degradation with economic growth. Instead what they found was that an increase in GDP or economic growth brought an initial phase of deterioration followed by an improvement in air and water quality with economic growth once some critical level of income is reached. Also the turning points in the U-type relationship varied for the different pollutants, but in most of the cases they came before a country reached a per capita income of $8000 (1985 dollars).

Two papers by Lucas, Wheeler and Hettige (1992) and Dean (1999) empirically focus on the relationship between trade and environment to bring out the inverted U-hypothesis for the trading countries. More specifically they suggest that environmental quality of a country worsens or improves with trade liberalization in a country through the route of per capita income.

Lucas, Wheeler and Hettige (1992) try to address the issue that pollution intensity of the export basket of a country decreases with per capita income of the country. They focus on the toxic intensity of trade flow which is measured as aggregate emissions per unit of GDP (Gross Domestic Product). The main focus of the study is to test for the inverted U relationship between output growth and pollution intensity of output. They regress the growth of toxic intensity per unit of output on initial per capita income, GDP growth calculated over the same period and a measure of trade restrictedness interacted with GDP growth. The period of study is 1960-1988 for 80 countries.

The study revealed that countries with faster rates of GDP growth had lower rate of increases in toxic intensity over the considered time period. They found that the developing countries had a greater toxic intensity growth in 1970's and 1980's. Of these, the poorest countries had the highest toxic intensity growth. The trends for individual countries depended heavily on the growth of income and policy regime. The estimated toxic intensity elasticity of income growth for a less developed country was negligible in 1960's, positive in 1970's and even higher in 1980's. Relatively fast growing low and middle income developing countries had a very rapid change towards toxic intensive structure in both the 1970's and 1980's. Fast growing low and middle income countries with low levels of trade distortions had lower growth of toxic intensity in the 1970's and it actually fell during 1980's. The study thus indicated that trade liberalization might lead to a lower level of pollution.

The above empirical work considers single equation models which focus on the static relationship between trade and environment. The static effect states that for a country having comparative advantage in pollution intensive goods, trade liberalization worsens the environment. But there also exists a dynamic effect of trade liberalization. According to which, trade liberalization raise the per capita income of a country, higher income raises people's preference for better quality environment and thus leads to adoption of cleaner technologies which reduces the pollution level in the long run. The paper by Dean (1999) allows for both static effect and the dynamic effect of trade on income growth and hence on the growth of pollution.

Dean (1999) develops a two equation model which simultaneously determines the growth of income and the growth of emissions. Estimation of this model using Chinese provincial data on water pollution for 1987-1995 reveals the importance of using a simultaneous model to discern the effects of trade liberalization. The results show that there is an indeed both static and dynamic effect of trade liberalization and they are of opposites sign. The static effect or the direct impact of trade liberalization aggravates environmental damage. However, increased openness significantly increases the growth of income, and that growth of income has a negative and significant impact on the pollution growth. So the dynamic effect reduces the environmental damage caused by trade liberalization.

Hettige, Mani and Wheeler (1999) use international data to investigate the relationship between industrial pollution and economic development. To test for Kuznets effect, they measure effect of income growth on three determinants of pollution. First, determinant is the share of manufacturing in total output. This is important for total industrial pollution which is expected to increase with an increase in the concerned share of manufacturing in the total output. Second, they look at the sectoral composition of relatively clean and dirty sectors within the manufacturing sector; and finally they examine the intensity of industrial pollution (as per unit of output) at the end-of pipe.

The paper reveals the following results. First, manufacturing's share of output does follow a Kuznets type trajectory. Second, sectoral composition does get cleaner through the middle income range and then stabilizes. Finally, water pollution intensity declines strongly with income confirming the U-shaped hypothesis. The authors attribute such an outcome partly to usage of stricter environmental regulation as the per capita income rises and partly due to adoption of modern and cleaner production technology. However, when they combine the three relationships they do not find a Kuznets type relationship. Rather they observed a rapid rise in total industrial water pollution through middle income status remaining approximately constant thereafter.

The paper by Shafik (1994) explores the relationship between economic growth and environmental quality by taking into account the following determinants of environmental quality; endowment such as climate and location; per capita income which reflects the structure of production, urbanization and consumption patterns of private goods including those environmental goods and series; exogenous factors such as technology which are available to all countries but change overtime; and policies that reflect social decisions about the provisions of environmental public goods depending on the sum of individual's benefits to the sum of individual's willingness to pay. For this purpose the environmental quality indicators like lack of clean water, lack of urban sanitation, ambient levels of suspended particulate matter, ambient sulfur dioxide, change in forest area between 1961-1986, the annual rate of deforestation between 1962-1986, dissolved oxygen in rivers, municipal waste per capita and carbon emissions per capita were used as dependent variable in a panel regression based on ordinary least squares estimates using data from up to 149 countries for the period 1960-1990.

The results indicate that some environmental indicators like clean water and urban sanitation improves with rising income. While others like particulates and sulfur dioxide first worsen and then improve; and finally some like dissolved oxygen in rivers, municipal solid wastes and carbon emissions worsen steadily. Moreover the turning points at which the relationship with income changes, varies substantially across the environmental indicators. The authors conclude the paper by stating that environmental improvement in any of the countries is not an automatic process. According to their econometric result in most of the societies, environmental improvement has been accompanied by regulations and investments in pollution control to reduce degradation. Such regulations and investments occur in those countries where there are generalized local environmental costs and substantial private and social benefits. Whereas when the cost of environmental degradation is borne by others like poor or by other countries there are few incentives to undertake the action to prevent further environmental damage.

Another empirical paper by Selden and Song (1993) investigates the inverted-U relationship between pollution and economic development using cross-national panel data on emissions of major air pollutants which are suspended particulate matter, sulfur dioxide, oxides of nitrogen and carbon monoxide. They use data on emissions across countries and time from Global Environment Monitoring System (GEMS). Using this pooled cross-section data they measure both the fixed effect and random effect estimates to explore the relationship between GDP and emission for each of the pollutant. The results reveal that the per capita emissions of all the four pollutant exhibit an inverted U relationship with the per capita GDP. Moreover they find substantially higher turning points for these pollutants, for suspended particulate matter and sulfur dioxide they exceed $8000. They conclude by forecasting a sustained rapid growth of emission over a long period of time.

Finally, the paper by Zaim and Taskin (2000) uses nonparametric techniques to develop an environmental efficiency index for the purpose of cross country and overtime comparisons. They use production frontier analysis as the emphasis of the paper is on the transformation of the technology to provide an insight to the *Environmental Kuznets Curve*. All the papers discussed so far fail to account for the underlying mechanism that generates growth and emissions of pollutants. The only explanation put forward is that once a country reaches a certain standard of living then the environmental concerns become important, necessitating institutional, legal and technological adjustment to decrease the environmental degradation. So unlike the other studies, the study by Zaim and Taskin (2000) uses production approach to differentiate between the disposability characteristics of environmentally desirable and undesirable outputs.

The study aims to serve the following two purposes. First, it tries to develop an environmental efficiency index for each of the OECD countries which allows for both cross-section and overtime comparisons on the state of each country's production process in its treatment of undesirable output. Second, it tries to examine the existence of the Kuznets type relationship for environmental efficiency as ensured by the index. The index reveals that there is deterioration in environmental efficiency starting at income level of $11,000 and an improved environmental performance once the critical level of income $16,000 is reached. The results obtained thus provide further empirical evidence for the Environmental Kuznets hypothesis.

From the review of literature on relationship between economic growth and emissions we can rightly argue that with economic growth a country's preference for better quality environment increases which pressurizes the government of the country to undertake stringent and effective environmental regulations along with investments in pollution control to check further environmental degradation. Papers like that of Shafik (1994) bring out the role of regulations and investments in reducing further environmental degradation in a country. Another paper by Gruver (1975) suggests an optimal path to be followed by the investment when it can be used for both productive as well as pollution control purpose.

## 2.6 Conclusion

It is apparent from the survey presented in this chapter that environmental regulation does play a determining role in the productivity of the manufacturing and the competitive status of a country. The survey reveals that though stringent environmental regulations negatively affect productivity in some cases; in the long run it leads to innovation as a result of which the firms become competitive with respect to better production quality. Our survey also reveals that higher economic growth in a nation is generally accompanied with reduction in environmental degradation. This happens because with development people's preference for better quality environment rises which increases the stringency in environmental regulation followed by major investments in pollution control.

In India, there is a basic division of power between the center and the states with respect to the environmental regulations. The mandate of the Central Pollution Control Board (CPCB) is to set environmental standards for all industrial units in India, lay down ambient standards, and coordinate the activities of the State Pollution Control Boards (SPCBs). The implementation of environmental laws and their enforcement, however, are decentralized, and are the responsibility of the SPCBs. Evidence suggests wide variations in enforcement across the states. Such variation in the enforcement gets reflected in the lower compliance status of the polluting units.

As noted in the introductory chapter, in this dissertation we try to see whether the status of environmental regulation in a state and the investment in the pollution control by the manufacturing units significantly affect the production and quality status of manufacturing, and whether there is any significant correlation between development, industrial pollution intensiveness and industrial pollution control status in our country.

# Chapter 3

# Environmental Regulation, Investment in Pollution Control & Manufacturing Production

## 3.1 Introduction

The extensive literature on the strategic environmental policy brings forth environment as a source of competitive advantage. The entire debate revolves around the struggle between nations to capture the international trade market, the source of competitive advantage being environment as a resource in these nations. The general contention being that the imposition of lax environmental regulation gives an opportunity to produce goods at a lower cost and hence such countries have an edge over the ones who are following stringent regulation. The latter ones loose out because their productivity gets hampered. This happens because a part of the limited investment is diverted towards pollution control. This indicates towards a trade-off between environmental regulation and competition. However, the proponents and the supporters of *Porter Hypothesis* brought into focus differentiation in products as a source of competitive advantage. According to them stringent environmental standards trigger innovations and up-gradation which in the long run offsets the increased cost of compliance for the firms subjected to such standards. Thus in the long run stringent environmental regulations lead to an improvement in the competitive position of the firms. So this school of thought expects the quality of the products from regulated firms to be better than the others.

In India there is a basic division of power between the centre and the states, reflecting the federal nature of the Indian Constitution. The mandate of the Central Pollution Control Board (CPCB) is to set environmental standards for all industrial units in India, lay down ambient standards, and coordinate the activities of the State Pollution Control Boards (SPCBs). The implementation of environmental laws and their enforcement, however, are decentralized, and are the responsibility of the SPCBs. Evidence suggests wide variations in enforcement across the states. Such variation in the enforcement gets reflected in the lower compliance status of the polluting units. In this chapter we first bring out the federal nature of the environmental regulation in India and then we will try to check whether the status of environmental regulation in a state (reflected in the compliance status of the manufacturing units in the concerned states) and the investment in pollution control by the manufacturing units in a state significantly affect the production of the manufacturing process in the states.

## 3.2 Environmental Regulation in India: A State of Federalism

The UN conference on *Human Environment* held at Stockholm in 1972 initiated an era of environmental legislation and policy making in India. India became the first country to insert an amendment into its Constitution allowing the State to protect and improve the environment for safeguarding public health, forests and wild life. The 42$^{nd}$ amendment was adopted in 1976 and went into effect on January 3, 1977. The language of the Directive Principles of State Policy (Article 47) requires not only a protectionist stance by the state but also compels the state to seek the improvement of polluted environments which in turn allows the government to impose restrictions on potentially harmful entities such as polluting industries. An important subtlety of the directive's language is the provision that the article "shall not be enforceable by any court, but it shall be the duty of the State to apply these principles in making laws." This allows the directive to be an instrument of guidance for the government, while at the same time, since no law has been passed, no individual can violate existing law.

Politically, India has a three tier structure i.e. the union (centre), state and the local bodies. There are 28 states each having a number of local bodies. The Constitution of India governs the overall functioning of the country. The subjects over which the centre and the states have jurisdiction are specified in the Seventh Schedule to the Constitution as the Union list and the State list respectively. The central and the state governments have the powers to formulate policy and pass legislation on subjects under their jurisdiction. Water, public health and sanitation, land including transfer and alienation of agricultural land, fisheries and agriculture are state subjects, while forests and wildlife fall under the concurrent list on which both the central and the state government can enact laws. Environment is not declared in the list, the sector is governed essentially by policies and legislation at the national level; although a state can form somewhat different rules under the same national legislation. However, implementation of laws takes place through both national and state government initiatives.

The primary agency for implementing various legislations pertaining to environmental protection at the centre is the Ministry of Environment and Forests (MoEF) and the Central Pollution Control Board (CPCB). At the state level environmental protection related issues are dealt by the Departments of Environment and the State Pollution Control Boards (SPCBs).

The **CPCB** was established in 1974 under the provisions of The Water (Prevention & Control of Pollution) Acts, 1974. Subsequently with the evolution of Indian environmental legislation its role expanded to cover the areas of air pollution, hazardous and hospital waste management etc. The main functions of CPCB specified in the Water Act 1974 and the Air Act 1981 are as follows:

- Promotion of cleanliness of streams and wells in different areas of states through prevention, control and abatement of water pollution.
- Improvement of the quality of air through prevention, control and abatement of air pollution in the country.

Some of the specific programmes being carried out by CPCB at present are:

- Air Quality Monitoring at the National Ambient Air Quality Monitoring Stations conducted by SPCBs with assistance from CPCB.
- Water and Soil Quality Monitoring Programmes.
- Application of Hazardous Waste Management across the country.
- Applied Research and Development work with direct relevance to pollution control i.e. the Development of Water Quality Monitoring Indices.
- Extensive training programme in Environmental Management and Pollution Control.
- Development and implementation of clean technologies.
- Scheme of labeling 'Environment Friendly' products, i.e. the ECOMARK Scheme.

The overall objective of the **SPCBs** is to ensure the control of water and air pollution; it is also responsible for enforcement of Water, Air and Environment Protection Acts as well as the collecting authority for collection of dues under the Cess Act and implementing authority of Hazardous Waste Management rules. Typically an SPCB has its central office at the state headquarters and a number of regional offices under its jurisdiction. The task of the Central Office is to lay down general policies pertaining to enforcement of laws and coordination with the other departments. The Regional Offices are responsible for:

- Inspection of industries and local bodies.
- Inspection of sites proposed for setting up industries to verify their environmental suitability.
- Monitoring of Indian National Aquatic Resources Systems (MINARS) programmes and Ambient Air Quality Monitoring under National Ambient Air Quality Monitoring (NAAQM) programme.
- Investigation of complaints.

In India, the entire issue of pollution prevention and control is dealt by *Command and Control* method where the regulatory authority sets the targets for reduction of pollution level and hence accordingly specifies the permissible maximum quantity of pollution level. In India the standards for air and water pollution are determined and enforced by the CPCB and the SPCB.

The focus of our work is industrial pollution for which the CPCB has stipulated baseline standards known as the Minimum National Standards (MINAS), however, the SPCBs can prescribe more stringent standards depending upon the particular requirements. So all over India standards for industrial pollution are common but the evidences suggest that there is difference across the states in the environmental regulation compliance status of the industrial units. This difference in the compliance status arises possibly due to the socio-economic differences across the states and also due to the laxity in enforcement and monitoring on the part of the various SPCBs. States can have effective regulation only if along with the common industrial pollution standards specified by the CPCB, the respective SPCBs carry out the task of enforcement of standards and monitoring of industrial pollution effectively. Thus whether a state has an effective environmental regulation or not, gets reflected in the compliance status in the industrial units in the state, which in turn depends upon the performance of its SPCB. Some of the actions taken by the SPCBs to ensure effective regulation are as follows:

- Surprise Inspections.
- Closure of industrial units not having adequate compliance facilities.
- Stoppage of water supply and electricity if the industrial units are not complying by the standards.
- Imprisonment of concerned officials in case of non-compliance.

But the SPCBs are generally restricted in taking the above mentioned actions due to severe resource constraints they face. The excessive intervention and influence of the respective state government in the decision making of the SPCBs also renders the task of environmental regulation on the part of the otherwise *autonomous* SPCBs ineffective.

So from the above discussion it is clear that there is a case for inter-state differences in the implementation of environmental regulation pertaining to industrial pollution. This difference which basically arises due to the federal nature of the environmental regulation in India gets reflected in the differences in the compliance status across the states. In this chapter and the following chapter (Chapter 4) we try to check whether effective environmental regulation and investment in pollution control (which is also a result of effective environmental regulation) by manufacturing units significantly contribute to the production and the quality status of the manufacturing process in a state.

## 3.3 A Hypothesis for the Inter-State Manufacturing Production

The extensive literature discussed in the preceding chapter raises the issue of trade-off between environmental regulation and competition via the route of loss in productivity. It says that, the usage of stringent environmental regulation by the government of a nation is disadvantageous for the firms in that nation as it leads to a loss in productivity. This is so because post regulation the limited resources are diverted towards pollution control which could have rather been used for production purpose. In this section we will try to check whether the status of environmental regulation in a state (reflected in the compliance status of the manufacturing units in the concerned states) and the investment in pollution control by the manufacturing units in a state (a resultant of effective environmental regulation in the state) has any substantial effect on the production of the manufacturing in the states.

**The Hypothesis:** *Effective environmental regulation in a state and investment in pollution control by the manufacturing units in a state significantly contribute to the production of manufacturing units in the state.* In other words, we hypothesize that manufacturing output, along with being a function of conventional inputs like capital and labour, is also a function of capital invested for pollution control and status of environmental regulation (especially pertaining to industrial pollution) in a state. We are primarily interested in finding out the direction in which investment in pollution control affects the manufacturing production.

The above stated hypothesis is explored using a multivariable log-linear regression model.

## 3.4 Data and Variables

To analyze the effect of environmental regulation in the state and investment in pollution control by the manufacturing units on the production in the states we have used the data collected by Annual Survey of Industries (ASI) 1997-1998. This is a simple *Ordinary Least Squares* regression analysis across 21 states of India where the reference year is 1997-1998. The hypothesis is explored using a cross-section data rather than a time-series data[5]. Of the 21 states; three states respectively Goa, Manipur and Nagaland were dropped. For them the value of R&D expenditures (one of the explanatory variable for the regression analysis) was Rs.0 for the reference period 1997-1998, as the logarithmic value for them could not be computed and were hence dropped from the data set. Thus the final data set considered following 18 states for the analysis Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal.

[5] A time-series analysis would have been definitely better. But in India there is a dearth of data on industrial pollution compliance figures. Only in ASI 1997-1998, fieldwork was carried out during 1998-1999 when the first ever attempt was made to collect such data.

In this cross-sectional analysis Natural logarithm of production of manufacturing in the states is regressed on a number of (Natural logarithm of) explanatory variables whose description and data source are given below. These explanatory variables can be broadly divided into two broad categories; they are ***firm specific*** explanatory variables and ***state specific*** explanatory variables.

**Firm Specific Explanatory Variables:**

1. $\mathbf{K_{pur}}$ which is defined as the average spending on capital investment by the state's manufacturing units (in Rs. Lakhs) for categories other than pollution control. ASI 1997-1998 published the state-wise figures of total Gross Value of Plants and Machinery for all the factories in a state and also state-wise figures of Gross Value of Plants and Machinery for pollution control for all the factories in the state. So to get the figures for $K_{pur}$, Gross Value of Plants and Machinery for pollution control was deducted from the total Gross Value of Plants and Machinery for each of the 18 states and the resultant figure was then divided by the total number of factories in each of the 18 states. This gives the average spending of factories in each of the 18 states on Plants and Machinery for purposes other than pollution control.

2. $\mathbf{K_{pol}}$ which is defined as the average spending on capital investment by the state's manufacturing units (in Rs. Lakhs) for pollution control. The figures for the 18 states were again obtained from ASI 1997-1998. To arrive at the figures for $K_{pol}$, Gross Value of Plants and Machinery for pollution control was divided by the total number of factories in each of the 18 states. This gives average spending of factories in each of the 18 states on Plants and Machinery for the purpose of pollution control.

3. **L** which is defined as the total number of workers involved in any kind of manufacturing process in each of the 18 states divided by the total number of factories in these states. This gives average number of workers involved in manufacturing process in the factories in each of the 18 states.

All the firm specific explanatory variables are divided by the total number of factories in each state in order to avoid the problem of heteroscedasticity which might arise in a cross-section study.

**State Specific Explanatory Variables:**

1. **R&D** which is the state level expenditure on research and development for each of the 18 states (in Rs. Lakhs) for the year 1997-1998. The data is collected by the Department of Science and Technology, Government of India. The benefits of R&D works have its spill over effect on the manufacturing industries along with the fields of agriculture and commerce. It is thus expected to contribute positively to the manufacturing production in the states.

2. **Dv_Effreg** is the dummy variable for effective environmental regulation status of the 18 states. To construct the dummy variable for effective environmental regulation in the 18 states a weighted sum of three components was considered all of which were obtained from ASI 1997-1998. So,

   **Dv_Effreg = 1 if [1/3 (% of factories taken up pollution abatement facilities) + 1/3 (% of capital investment of the total capital investment for pollution control) + 1/3 (% of running expense of the total running expense for pollution control)][6] > 9.53**

   **= 0 otherwise**

   To obtain the critical value of 9.53 the average of the weighted sum was considered for the 18 states which came out to be 11.53. The critical value was the taken as 9.53[7].

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[6] Equal weights are assigned to all the three components of the dummy variable. This is done because a higher percentage of all the three components are expected to contribute equally in rendering the environmental regulation in a state effective.

[7] We could have taken the critical value as 11.53 but that would have rendered some of the states like Himachal Pradesh, Rajasthan, Karnataka and Bihar as having ineffective environmental regulation even though the

In India environmental standards are specified by CPCB which is the advisory body of MoEF. These standards are common to all the states. But the task of enforcement of the standards and monitoring is assigned to the various SPCBs for each of the states. Whether a state has an effective environmental regulation or not depends on the performance of its SPCB. Some of the actions taken by SPCBs to ensure effective regulation are as follows:

- Surprise Inspections
- Closure of firms not having adequate compliance facilities
- Electricity and water supply cut off if the firms are not complying by the standards
- Imprisonment of concerned officials in case of non-compliance.

So the components of the weighted sum are due to the initiatives of the SPCBs. Higher weighted sum would imply that adequate actions are being taken by the SPCB to render the environmental regulation effective in a particular state.

For example: West Bengal Pollution Control Board over the years has closed down a number of firms not having adequate compliance facilities. WBPCB has also discontinued electricity supply in the industrial units not complying by the standards[8]. Also, as per the weighted sum calculated for the state the value of Dv_Effreg is 1 for West Bengal.

Besides West Bengal the other states which showed the environmental regulation to be effective as per the dummy variable are Assam, Bihar, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Punjab and Rajasthan.

3. **Dv_Ineffreg** is the dummy variable for ineffective environmental regulation in the 18 states. So,

weighted sum value for these states was just marginally lower than the average value of 11.53. So we have taken the critical value as 9.53.

[8] See the West Bengal Pollution Control Board website i.e. www.wbpcb.com.

**Dv_Ineffreg = 1 if [1/3 (% of factories taken up pollution abatement facilities) + 1/3 (% of capital investment of the total capital investment for pollution control) + 1/3 (% of running expense of the total running expense for pollution control)][9] < 9.53**

**= 0 otherwise.**

Here we can cite the examples of Gujarat Pollution Control Board (GPCB) and Tamil Nadu Pollution Control Board (TPCB). According to the weighted sum calculated for the state the value of Dv_Ineffreg for GPCB is 1 and also various facts over the past few years indicate towards dismal performance of GPCB on the front of industrial pollution regulation. First, in December 1994 Mr. Dilip Biswas, head of the Central Pollution Control Board, publicly declared Gujarat, with its industrial belt between Ahmedabad and Vapi, the most polluted state in the country. And Mr.Biswas specifically criticized the state board for being too lenient with industries. In another incidence in 1995 a farmer filed a petition against large-scale pollution of a canal called Kharicut. This brought into notice of Supreme Court the fact that the state of Gujarat had passed a resolution in the legislation under the Article 252 to not to introduce the 1988 amendments which strengthened the implementation provisions of the Water Act of 1974. The 1988 amendments empowered the state boards to close down a defaulting unit and also raised the penalties. So by not adopting the amendments the GPCB allowed the industries to pollute land and water bodies[10]. Similarly, in 1996 Tamil Nadu Pollution Control Board (TPCB) went to the Supreme Court seeking a relaxation of effluent standards for the Tanneries set by TPCB[11]. This is indicative of the relaxation in the enforcement task of the TPCB. Even according to the weighted sum calculated for the state the value of Dv_Ineffreg for TPCB is 1.

[9] Equal weights are assigned to all the three components of the dummy variable. This is done because a lower percentage of all the three components are expected to contribute equally in rendering the environmental regulation in a state ineffective.
[10] See Mandal, S. and M.G.Rao (2005).
[11] See Gupta, S. (1996).

Besides Gujarat and Tamil Nadu the other states which showed the environmental regulation to be ineffective as per the dummy variable were Andhra Pradesh, Jammu & Kashmir, Kerala, Madhya Pradesh, Orissa, Tripura and Uttar Pradesh.

The only limitation of these two dummy variables is that they divide the 18 states considered into two extreme ends i.e., either effective environmental regulation or ineffective environmental regulation, it leaves very little scope for the mediocre performers. To over-come this limitation the next three dummy variables were constructed.

4. **Dv_pooreg, Dv_medreg, Dv_excreg** the three dummy variables are constructed to take into consideration poor, mediocre and excellent performers among the 18 states with respect to the environmental regulation. Also a slightly different criterion was selected to assign the values to the dummy variables. To construct the dummy variables percentage of factories in a particular state taken up pollution abatement facilities in the year 1997-1998 is considered, the source of the data is ASI 1997-1998.

**Dv_pooreg = 1 if 0 < % of factories taken up pollution abatement facilities < 25%**
**= 0 otherwise.**

**Dv_medreg = 1 if 25% < % of factories taken up pollution abatement facilities < 35%**
**= 0 otherwise.**

**Dv_excreg = 1 if 35% < % of factories taken up pollution abatement facilities < 100%**
**= 0 otherwise.**

The interval 25% to 35% was chosen because an average of percentage of factories taken up pollution abatement facilities in all the 18 states was calculated which came out to be 30.54%. So the mediocre performers were made to lie between the interval of 25% to 35%, the poor performers between the interval 0% to 25% and the excellent performers between the interval 35% to 100%. As per the Dv_pooreg the poor performers are Andhra Pradesh, Gujarat, Jammu & Kashmir, Kerala, Madhya Pradesh, Orissa, Tamil Nadu and Tripura. As per Dv_medreg the mediocre performers are Bihar, Himachal Pradesh, Karnataka, Rajasthan and Uttar Pradesh. As per Dv_excreg the excellent performers are Assam, Haryana, Maharashtra, Punjab and West Bengal.

**Dependent Variable**:

- **Prdn** which is defined as the output (in Rs. Lakhs) of the manufacturing units in a particular state divided by the total number of factories in that state. The source of the output and the number of factories data is again ASI 1997-1998.

The dependent variable is also divided by the total number of factories in each state in order to avoid the heteroscedastcity problem.

Table 3.4(a) below gives the name of the variables considered for the exercise and their corresponding description.

| **Table 3.4(a): Description of the Variables** | |
|---|---|
| **VARIABLES** | **DESCRIPTION** |
| **DEPENDENT** | |
| Prdn | Output of the manufacturing units in a state / total number of manufacturing units in the state. |
| **EXPLANATORY** | |
| **<u>Firm Specific</u>** | |
| $K_{pur}$ | Capital investment in a state for pure production purpose / total number of manufacturing units in the state. |

| | |
|---|---|
| $K_{pol}$ | Capital investment in a state for pollution control / total number of manufacturing units in the state. |
| L | Total number of workers involved in manufacturing in a state / total number of manufacturing units in a state. |
| **State Specific** | |
| R&D | State level expenditure on research and development: a proxy for innovative capabilities of the state. |
| Dv_Effreg | A dummy variable for effective environmental regulation in a state.<br>Dv_Effreg = 1 if [1/3 (% of factories taken up pollution abatement facilities) + 1/3 (% of capital investment of the total capital investment for pollution control) + 1/3 (% of running expense of the total running expense for pollution control)] > 9.53<br>= 0 otherwise |
| Dv_Ineffreg | A dummy variable for ineffective environmental regulation in a state.<br>Dv_Ineffreg = 1 if [1/3 (% of factories taken up pollution abatement facilities) + 1/3 (% of capital investment of the total capital investment for pollution control) + 1/3 (% of running expense of the total running expense for pollution control)] < 9.53<br>= 0 otherwise. |
| Dv_pooreg | A dummy variable for poor environmental regulation in a state.<br>Dv_pooreg = 1 if 0 < % of factories taken up pollution abatement facilities < 25%<br>= 0 otherwise. |
| Dv_medreg | A dummy variable for mediocre environmental regulation in a state.<br>Dv_medreg = 1 if 25% < % of factories taken up pollution abatement facilities < 35%<br>= 0 otherwise. |
| Dv_excreg | A dummy variable for excellent environmental regulation in a state.<br>Dv_excreg = 1 if 35% < % of factories taken up pollution abatement facilities < 100%<br>= 0 otherwise. |

Table 3.4(b) below gives the descriptive statistics of the variables considered in the analysis.

| Table 3.4(b): Descriptive Statistics of the Variables | | | | | |
|---|---|---|---|---|---|
| Variables | N | Minimum | Maximum | Mean | Standard Deviation |
| Prdn | 18 | 108.657 | 1046.230 | 597.357 | 255.577 |
| $K_{pur}$ | 18 | 107.401 | 1579.963 | 387.195 | 366.271 |
| $K_{pol}$ | 18 | 0.012 | 16.590 | 5.900 | 4.367 |
| L | 18 | 29.512 | 95.517 | 60.616 | 16.271 |
| R&D | 18 | 10.03 | 12059.90 | 5146.332 | 3512.335 |
| Dv_Effreg | 18 | 0 | 1 | 0.50 | 0.514 |
| Dv_Ineffreg | 18 | 0 | 1 | 0.50 | 0.514 |
| Dv_pooreg | 18 | 0 | 1 | 0.50 | 0.514 |
| Dv_medreg | 18 | 0 | 1 | 0.28 | 0.461 |
| Dv_excreg | 18 | 0 | 1 | 0.22 | 0.428 |

N: the number of observations.

## 3.5 Methodology

To analyze the effect of environmental regulation in a state and investment in pollution control by the manufacturing units on the production in the 18 states we will consider a multivariable log-linear regression model. The model is non-linear in the dependent and the quantitative explanatory variables but linear in the logarithm of these variables. Two models are considered for the analysis. In the first model the dummy variable for the environmental regulation status is taken to be Dv_Effreg and Dv_Ineffreg while the second model considers Dv_pooreg, Dv_medreg and Dv_excreg in order to take into account the environmental regulation status of the 18 states. This was done to check how the results would change if instead of dividing the states into mere good and bad performers, the states were rather divided into good, bad and mediocre performers with respect to the environmental regulation status. We first specify the general *Production function* for the analysis in terms of the various firm-specific and state-specific variables and then we specify the two models.

**Production function:**

$$Prdn = f\,(K_{pur}, K_{pol}, L, R\&D, Env_{Reg}) \text{ ------------------ } (1)$$

Where,

**Prdn:** Output of the manufacturing units in the 18 states.

**$K_{pur}$ :** Capital investment meant for pure production purpose exclusive of pollution control purpose.

**$K_{pol}$ :** Capital investment meant for pollution control purpose.

**L:** Labour required for the production purpose.

**R&D:** Research and development expenditure of the states a proxy for innovative capabilities of a state.

**$Env_{Reg}$ :** Status of Environmental Regulation in a state.

So the production function in this analysis, besides considering the conventional determinants like capital and labour of the state, also considers capital investment meant for pollution control, environmental regulation status and innovation status of the state.

We now specify the two models considered for the analysis. We first write the production function in the non-linear form taking into account the dependent variable and the quantitative explanatory variables like $K_{pur}$, $K_{pol}$, L and R&D. We are considering a Cobb Douglas production function.

$$\mathbf{Prdn_i = \beta_0 \, K_{puri}{}^{\beta 1} \, K_{poli}{}^{\beta 2} \, L_i{}^{\beta 3} \, R\&D_i{}^{\beta 4} \, e^{ui}} \qquad \text{where i=1......... 18 ------- (2)}$$

$\beta_0$ = Technological coefficient = 1[12]

**u** = Stochastic disturbance term

**e** = Base of natural logarithm

**i**= Number of states for which the regression analysis is done

It is clear from equation (2) that the relationship between output and the quantitative explanatory variables is non-linear. If we log transform this model we obtain,

$$\mathbf{\ln Prdn_i = \ln \beta_0 + \beta_1 \ln K_{puri} + \beta_2 \ln K_{poli} + \beta_3 \ln L_i + \beta_4 \ln R\&D_i + u_i}$$

$$\mathbf{\ln Prdn_i = \beta_1 \ln K_{puri} + \beta_2 \ln K_{poli} + \beta_3 \ln L_i + \beta_4 \ln R\&D_i + u_i} \text{ ------ (3)}$$

So equation (3) represents the production function in a double-log or log-linear form highlighting the non-linear relationship between output and the explanatory variables. We now write the two models taking into account the last explanatory variable i.e. the effective environmental regulation status in the states in the form of a dummy variable. In the first model the dummy variable for the environmental regulation status is taken to be Dv_Effreg and Dv_Ineffreg while the second model considers Dv_pooreg, Dv_medreg and Dv_excreg so as to take into account the environmental regulation status of 18 states.

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[12] We are taking the technological coefficient to be 1 as ours is a cross-sectional study and not a time-series analysis where the role of technological coefficient becomes important in the Cobb Douglas production function. So there is no constant term in our model.

**MODEL 1:**

$$\ln Prdn_i = \beta_1 \ln K_{puri} + \beta_2 \ln K_{poli} + \beta_3 \ln L_i + \beta_4 \ln R\&D_i + \beta_5 Dv\_Effreg + u_i$$

**MODEL 2:**

$$\ln Prdn_i = \beta_1 \ln K_{puri} + \beta_2 \ln K_{poli} + \beta_3 \ln L_i + \beta_4 \ln R\&D_i + \beta_5 Dv\_medreg + \beta_6 Dv\_excreg + u_i$$

In Model 1 the dummy for ineffective environmental regulation i.e. Dv_Ineffreg has been dropped in order to check for the collinearity problem. Thus the coefficient of effective environmental regulation would be interpreted in comparison with that of the reference category which in this case would be the dummy for ineffective environmental regulation. Similarly, in the Model 2 to avoid the dummy variable trap that may arise due to using all the three dummies of environmental regulation i.e. Dv_pooreg, Dv_medreg and Dv_excreg we are taking dummy variable for poor regulation as the reference category. The coefficients of dummies for mediocre environmental regulation and excellent environmental regulation can be thus interpreted with respect to that of poor environmental regulation.

## 3.6 The Results

**MODEL 1:**

The table 3.6(a) gives the values of the partial regression coefficients and their corresponding t-values for model 1. From a statistical viewpoint the estimated regression line fits the data very well. The adjusted $R^2$ value of 0.998 implies that about 99% of the variation in the (lognormal of) output is explained by the (lognormals of) explanatory variables and the dummy variable.

| Table 3.6(a) Result of Model 1 | | |
|---|---|---|
| VARIABLES | Coefficients | t-value |
| ln $K_{pur}$ | 0.350* | 3.726 |
| ln $K_{pol}$ | -0.059* | -3.495 |
| ln L | 0.247* | 2.238 |
| ln R&D | 0.411* | 5.964 |
| Dv_Effreg | 0.052* | 3.815 |
| $R^2 = 0.999$ | | |
| adj $R^2 = 0.998$ | | |

* Significant at 0.01 level

As was expected the value of the partial regression coefficient for pure capital investment is significantly positive. The partial regression coefficient of pure capital investment i.e. elasticity of output with respect to $K_{pur}$ is 0.350. This implies that holding other explanatory variables constant a 1% increase in pure productive capital led on an average to a 0.35% increase in the manufacturing output for the 18 Indian states in 1997-1998.

Capital investment in a state for pollution control is also a significant determinant of the production. The partial regression coefficient of capital investment for pollution control i.e. the elasticity of output with respect to $K_{pol}$ is -0.059. This implies that holding other explanatory variables constant a 1% increase in investment in pollution control capital led on an average to a 0.05% decrease in the manufacturing output for the 18 Indian states in the year 1997-1998. However the elasticity of output with respect to $K_{pol}$ though negative, is very low. One reason for this low elasticity of output with respect to $K_{pol}$ could be that the capital investment in a state for pollution control is a very small percentage of the total capital investment in almost all the 18 states in 1997-1998. Following table 3.6(b) shows the state-wise percentage of capital investment for pollution control to the total capital investment in the 18 states.

| 3.6(b) State-wise Percentage of Capital Investment for Pollution Control | | |
|---|---|---|
| Sl No. | State | % of Capital Investment for Pollution Control |
| 1 | Andhra Pradesh | 1.64 |
| 2 | Assam | 1.35 |
| 3 | Bihar | 0.98 |
| 4 | Gujarat | 1.71 |
| 5 | Haryana | 0.93 |
| 6 | Himachal Pradesh | 2.86 |
| 7 | Jammu&Kashmir | 7.59 |
| 8 | Karnataka | 3.26 |
| 9 | Kerala | 3.33 |
| 10 | Madhya Pradesh | 0.5 |
| 11 | Maharashtra | 1.29 |
| 12 | Orissa | 1.61 |
| 13 | Punjab | 1 |
| 14 | Rajasthan | 1.91 |
| 15 | Tamil Nadu | 1.8 |
| 16 | Tripura | 0.01 |
| 17 | Uttar Pradesh | 1.32 |
| 18 | West Bengal | 0.89 |

The above table shows that capital investment, i.e., the gross value of plant and machinery used for pollution control in proportion to total gross value of plant and machinery was very low. ASI 1997-1998 reveals that it was 1.41% for All-India and was below 1% for 5 States.

Labour also like Capital investment is a significant and positive determinant of state level manufacturing production. The partial regression coefficient of Labour i.e. elasticity of output with respect to Labour is 0.247. This implies that holding other explanatory variables constant a 1% increase in labour led on an average to a 0.25% increase in the manufacturing output for the 18 Indian states in 1997-1998.

The benefits of R&D works have its spill over effect on manufacturing industries. So as was expected the value of the partial regression coefficient for R&D expenditure is significantly positive. The partial regression coefficient of R&D expenditure i.e. elasticity of output with respect to R&D expenditure is 0.411. This implies that holding other explanatory variables constant a 1% increase in R&D expenditure (i.e. increase in the innovative capabilities of the state) led on an average to a 0.41 % increase in the manufacturing output for the 18 Indian states in 1997-1998.

To get the relative change in mean output of the manufacturing units for the dummy variable for effective environmental regulation in the 18 states we will use the device suggested by Halvorsen and Palmquist in 1980. They suggested taking the antilog (to base e) of the estimated dummy coefficient and subtracting 1 from it. Following Halvorsen and Palmquist we find the antilog for 0.052=1.053376. Subtracting 1 from this, we obtain 0.053376. Thus the mean output of states with effective environmental regulation is significantly higher than the states with ineffective environmental regulation by 5.34%. The states with effective environmental regulation are performing better on the production front in contrast to the states with ineffective environmental regulation.

**MODEL 2:**

The table 3.6(c) gives the values of the partial regression coefficients and their corresponding t-values for model 2. This estimated regression line also fits the data very well. The adjusted $R^2$ value of 0.998 implies that about 99% of the variation in the (lognoral of) output of manufacturing units in the 18 Indian states is explained by the (lognormals of) explanatory variables and the dummy variable.

| 3.6(c) Result of Model 2 | | |
|---|---|---|
| VARIABLES | Coefficients | t-value |
| ln $K_{pur}$ | 0.298* | 2.485 |
| ln $K_{pol}$ | -0.062* | -2.816 |
| ln L | 0.305* | 2.197 |
| ln R&D | 0.416* | 4.756 |
| Dv_medreg | 0.031** | 2.036 |
| Dv_excreg | 0.024 | 1.687 |
| $R^2 = 0.998$ | | |
| adj $R^2 = 0.998$ | | |

* Significant at 0.01 level

** Significant at 0.05 level

The value of the partial regression coefficient for pure capital investment is significantly positive. The partial regression coefficient of pure capital investment i.e. elasticity of output with respect to $K_{pur}$ is 0.298. This implies that holding other explanatory variables constant a 1% increase in pure capital led on an average to a 0.30% increase in the manufacturing output for the 18 Indian states in 1997-1998.

Again capital investment for pollution control as an input is a significant determinant of the manufacturing production in the 18 states for the year 1997-1998. In this model, the partial regression coefficient of capital investment for pollution control i.e. elasticity of output with respect to $K_{pol}$ is -0.062. This implies that holding other explanatory variables constant a 1% increase in pollution control capital led on an average to a 0.06% decrease in the manufacturing output for the 18 Indian states in the year 1997-1998. Again the same reason as the Model 1 could be cited for the low elasticity of output with respect to $K_{pol}$.

Labour also like Capital investment in a state is a significant and positive determinant of state level manufacturing production. The partial regression coefficient of Labour i.e. elasticity of output with respect to Labour is 0.305. This implies that holding other explanatory variables constant a 1% increase in labour led on an average to a 0.31% increase in the manufacturing output for the 18 Indian states in 1997-1998.

The partial regression coefficient of R&D expenditure i.e. elasticity of output with respect to R&D expenditure in model 2 is 0.416. This implies that holding other explanatory variables constant a 1% increase in R&D expenditure led on an average to a 0.42% increase in the manufacturing output for the 18 Indian states in 1997-1998.

To get the relative change in mean output of the manufacturing units for the dummy variable for mediocre status of environmental regulation in the 18 states we will again use the device suggested by Halvorsen and Palmquist. Antilog for obtained coefficient for the dummy variable for mediocre status of environmental regulation is 0.031= 1.031486, subtracting 1 from this we obtain 0.031486. Thus the mean output of states with mediocre status of environmental regulation is significantly higher than the states with poor status of environmental regulation by 3.15%.

However, insignificant partial regression coefficient was obtained for the dummy variable for excellent status of environmental regulation in the 18 states. So no significant comparisons can be made between the states with excellent status of environmental regulation and the states with poor status of environmental regulation with respect to the production of manufacturing units. But states with mediocre status of environmental regulation were performing better on the production front in contrast to the states with poor status of environmental regulation.

## 3.7 Conclusion

From the above regression analysis we can conclude that the investment in pollution control in a state does contribute significantly and negatively to the production of manufacturing units in the state. This seems to validate the fact that when the resources are diverted towards pollution control purposes it has a negative impact on the manufacturing production. But, states with effective environmental regulation were performing better on the manufacturing production front in contrast to the states with ineffective environmental regulation. Similar conclusions can be drawn between states with mediocre status of environmental regulation and states with poor status of environmental regulation. That is to say, states with mediocre status of environmental regulation were performing better on the production front in contrast to the states with poor status of environmental regulation. However nothing conclusive could be ascertained about the excellent performers with regards to the environmental regulation status as significant comparisons could not be made between the excellent and the poor performers. The benefits of R&D works have its spill over effect on manufacturing industries. So as was expected the value of the partial regression coefficient for R&D expenditure is significantly positive. So the innovative capabilities of the state also positively and significantly contribute to the state level manufacturing production.

Our results in the chapter validates our hypothesis that the status of environmental regulation in a state and investment in pollution control, along with conventional inputs like capital and labour contribute significantly to the production of manufacturing in the states. The regression analysis carried out in the chapter revealed that the investment in pollution control (an outcome of the effective environmental regulation in a state) negatively affects the production of the manufacturing units in the states. The results obtained corroborates to the issue of trade-off between environmental regulation and competition through the route of loss in productivity.

# Chapter 4

# Environmental Regulation, Investment in Pollution Control & Quality Status of Manufacturing

## 4.1 Introduction

In the preceding chapter (Chapter 3) we explored the hypothesis for inter-state manufacturing production. Our results in the chapter validated the hypothesis that status of environmental regulation in a state and investment in pollution control, along with the conventional inputs like capital and labour contribute significantly to the manufacturing production in the states. The regression analysis carried out in the chapter revealed that the investment in pollution control (an outcome of the effective environmental regulation in a state) negatively affects the production of the manufacturing units in the states thus corroborating to the issue of trade-off between environmental regulation and competition through the route of loss in productivity. However, another issue that the extensive literature on Environmental Regulation brings forth is widely known as the Porter Hypothesis which says that '.....tougher environmental standards trigger innovation and upgrading'. Such innovations offset the increased cost of compliance for the firms who are subjected to the stringent environmental standards. This in long run leads to an improvement in the competitive position of the firm. In his book 'The Competitive Advantage of Nations' (1990) Michael E. Porter mentions two types of competitive advantage: *lower cost* and *differentiation*. He defines *lower cost* competitive advantage as the ability of the firm to design, produce and market a comparable product more efficiently than its competitor. While *differentiation* he defines as the ability of the firm to provide unique and superior value to the buyer in terms of product or for that matter production quality, special feature, or after-sale service. However of the two, only *differentiations* as the source of competitive advantage is sustainable in the long run as the competitive advantage arising due to *lower cost* is easy to duplicate within a short span of time. *Differentiation* in turn arises from innovative capabilities of the firms and is expected to off-set the trade-off between environmental regulation and competition that arises due to loss in productivity.

In this chapter we will try to check whether the status of environmental regulation in a state (reflected in the compliance status of the manufacturing units in the concerned states) and the investment in pollution control by the manufacturing units in a state (a resultant of effective environmental regulation in the state) has lead to any such differentiation (with respect to the quality status of manufacturing process) among the manufacturing units in the 21 Indian states for the year 1997-1998.

## 4.2 A Hypothesis for the Inter-State Quality Status of Manufacturing Process

**The Hypothesis:** *Effective environmental regulation in a state and investment in pollution control by the manufacturing units in a state significantly contribute to the quality status of manufacturing process in the state.* In other words, we hypothesize that status of environmental regulation in the states and investment in pollution control plays a pivotal role in determining the acquisition of quality status certification by the manufacturing units in the states. The primary interest here is to know the direction in which the investment in pollution control affects the quality status of the manufacturing process.

The above stated hypothesis is explored using a multivariable linear regression model.

## 4.3 Data and Variables:

To analyze the effect of environmental regulation in the state and investment in pollution control by the manufacturing units on the quality status of manufacturing process in the states we have again used the data collected in the Annual Survey of Industries (ASI) 1997-1998. This is a simple *Ordinary Least Squares* regression analysis across 21 states of India where the reference year is 1997-1998. The hypothesis is explored using a cross-section data rather than a time-series data[13]. The 21 states considered for the analysis are as follows Andhra Pradesh, Assam, Bihar, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal.

In this cross-sectional analysis ratio of ISO9000 certified factories to the total number of factories in each of the 21 states is regressed on a number of explanatory variables whose description and data source are given below. These explanatory variables can be broadly divided into two categories; they are ***firm specific*** explanatory variables and ***state specific*** explanatory variables.

**Firm Specific Explanatory Variables:**

1. $\mathbf{K_{pur}}$ which is defined as the average spending on capital investment by the state's manufacturing units (in Rs. Lakhs) for categories other than pollution control. ASI 1997-1998 published the state-wise figures of total Gross Value of Plants and Machinery for all the factories in a state and also state-wise figures of Gross Value of Plants and Machinery for pollution control for all the factories in the state. So to get the figure for $K_{pur}$, Gross Value of Plants and Machinery for pollution control was deducted from the total Gross Value of Plants and Machinery for each of the 21 states and the resultant figure was then divided by the total number of factories or manufacturing units in each of the 21 states. This gives average spending of factories in each of the 21 states on Plants and Machinery for purposes other than pollution control.

2. $\mathbf{K_{pol}}$ which is defined as the average spending on capital investment by the state's manufacturing units (in Rs. Lakhs) for pollution control. The figures for the 21 states were again obtained from ASI 1997-1998. To arrive at the figures for $K_{pol}$, Gross

[13] Again a time-series analysis would have been definitely better. But only in ASI 1997-1998, fieldwork was carried out during 1998-1999 when the first attempt was made to collect data on pollution compliance figures as well as the quality status of manufacturing process was made.

Value of Plants and Machinery for pollution control was divided by the total number of factories in each of the 21 states. This gives average spending of factories in each of the 21 states on Plants and Machinery for the purpose of pollution control.

Both the *firm specific* explanatory variables are divided by the total number of factories in each state in order to avoid the problem of heteroscedasticity which might arise in any cross-section study.

**State Specific Explanatory Variables:**

**1. Dev** which is the proxy for development status of the states. For Dev we have considered per capita Net State Domestic Product for each of the 21 states for the year 1997-1998. Per capita NSDP (State Income) at current prices is expressed in rupees and is collected by Directorate of Economics and Statistics of the respective state governments. Generally states which are on the higher end of per capita NSDP can be expected to be more developed. Also historically speaking more developed countries are the ones which are more industrialized having a mature manufacturing sector. pcNSDP is being considered as one of the explanatory variables for the analysis in order to check how the development status of the state contributes to the quality status certification by the manufacturing units.

**2. R&D** which is the state level expenditure on research and development for each of the 21 states (in Rs. Lakhs) for the year 1997-1998. The data is collected by the Department of Science and Technology, Government of India. The benefits of R&D works have its spill over effect on manufacturing industries along with the fields of agriculture and commerce. It is thus expected to contribute positively to the manufacturing's quality status in the states.

**3. Dv_Inf** is the dummy variable for infrastructure status of the 21 states considered for the analysis. To construct the dummy variable for the 21 states, percentage of actual plan expenditure on infrastructure facilities for the period 1997-1998 was considered. The data source for this explanatory variable is Human Development Report 2001 which clubs Energy, Industry & Minerals, Transport, Communication, Science, Technology and Environment under the heading of Infrastructure. Also data for the year 1997-1998 is actually an average of the period 1996 to 1998. To construct the dummy average of all the 21 state's infrastructure percentage was calculated which turned out to be 32.85%, i.e.

**Dv_Inf = 1 if % of actual plan expenditure on infrastructure > 32.85%**
**= 0 otherwise**

The states which are being assigned the value 1 are definitely the ones with better infrastructure facilities, also since the data set is an average for the period 1996-1998 it takes into consideration the dynamic process of evolvement of infrastructure facilities from 1996 to 1998. Of the 21 states considered for the analysis for 10 states the dummy variable took up the value of 1. These states were Andhra Pradesh, Jammu & Kashmir, Kerala, Maharashtra, Manipur, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.

4. **Dv_Effreg** is the dummy variable for effective environmental regulation status of the 21 states. To construct the dummy variable for effective environmental regulation in the 21 states a weighted sum of three opponents was considered all of which were obtained from ASI 1997-1998. So,

**Dv_Effreg = 1 if [1/3 (% of factories taken up pollution abatement facilities) + 1/3 (% of capital investment of the total capital investment for pollution control) + 1/3 (% of running expense of the total running expense for pollution control)][14] > 8.73**
**= 0 otherwise**

[14] Equal weights are assigned to all the three components of the dummy variable. This is done because a higher percentage of all the three components are expected to contribute equally in rendering the environmental regulation in a state effective.

To obtain the critical value of 8.73 the average of the weighted sum was considered for the 21 states which came out to be 10.73. The critical value was taken as 8.73[15].

The states which showed the environmental regulation to be effective as per the dummy variable are Assam, Bihar, Goa, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Punjab, Rajasthan and West Bengal.

5. **Dv_Ineffreg** is the dummy variable for ineffective environmental regulation in the 21 states. So,

**Dv_Ineffreg = 1 if [1/3 (% of factories taken up pollution abatement facilities) + 1/3 (% of capital investment of the total capital investment for pollution control) + 1/3 (% of running expense of the total running expense for pollution control)][16] < 8.73**

**= 0 otherwise.**

So as per the dummy variable for ineffective environmental regulation in a state following states showed the environmental regulation to be ineffective Andhra Pradesh, Gujarat, Jammu & Kashmir, Kerala, Madhya Pradesh, Manipur, Nagaland, Orissa, Tamil Nadu, Tripura and Uttar Pradesh.

The only limitation of this dummy variable is that it divides the 21 states considered into two extreme ends i.e., either effective environmental regulation or ineffective

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[15] Again we could have taken the critical value as 10.73 but that would have rendered some of the states like Himachal Pradesh, Rajasthan, Karnataka and Bihar as having ineffective environmental regulation even though the weighted sum value for these states was just marginally lower than the average value of 10.73. So we have taken the critical value as 8.73.

[16] Equal weights are assigned to all the three components of the dummy variable. This is done because a lower percentage of all the three components is expected to contribute equally in rendering the environmental regulation in a state ineffective.

environmental regulation, it leaves very little scope for mediocre performers. To overcome this limitation the next three dummy variables were constructed.

6. **Dv_pooreg, Dv_medreg, Dv_excreg** the three dummy variables are constructed to take into consideration poor, mediocre and excellent performers among the 21 states with respect to the environmental regulation. To construct the dummy variables percentage of factories in a particular state taken up pollution abatement facilities in the year 1997-1998 is considered, the source of the data is ASI 1997-1998.

**Dv_pooreg = 1 if 0 < % of factories taken up pollution abatement facilities < 25%**

**= 0 otherwise.**

**Dv_medreg = 1 if 25% < % of factories taken up pollution abatement facilities < 35%**

**= 0 otherwise.**

**Dv_excreg = 1 if 35% < % of factories taken up pollution abatement facilities < 100%**

**= 0 otherwise.**

The interval 25% to 35% was chosen because an average of percentage of factories taken up pollution abatement facilities in all the 21 states was calculated which came out to be 28.43%. So the mediocre performers were made to lie between the interval of 25% to 35%, the poor performers between the interval 0% to 25% and the excellent performers between the interval 35% to 100%. As per the Dv_pooreg the poor performers are Andhra Pradesh, Gujarat, Jammu & Kashmir, Kerala, Madhya Pradesh, Manipur, Nagaland, Orissa, Tamil Nadu and Tripura. As per Dv_medreg the mediocre performers are Bihar, Karnataka, Himachal Pradesh, Rajasthan and Uttar Pradesh. As per Dv_excreg the excellent performers are Assam, Goa, Haryana, Maharashtra, Punjab, and West Bengal.

**Dependent Variable**:

- $Q_s$ which is defined as the ratio of the number of ISO9000 certified factories in a state to the total number of manufacturing factories in the state. The dependent variable represents the quality status of the manufacturing in the 21 states considered for the analysis. The data source again is the ASI for the year 1997-1998. ISO9000 certificate is given to those factories which take up all round measures in their industrial projects for quality maintenance. We are considering ISO9000 certification as the proxy for quality status for the manufacturing in a state. This was done because first, pollution auditing is a must for obtaining the ISO9000 certification, so the ISO9000 certified factories are cleaner factories. Second, the certification is based on 8 basic principles one of which requires the firm opting for ISO9000 certification to continually improve. This improvement process is based on the following two preconditions.
    - Knowledge of appropriate measures and methodologies for continual improvement and use as appropriate for their products or services
    - Allocation of appropriate resources for innovative quality improvements

  So we an easily assume that the ISO9000 certified factories are not only relatively cleaner in the production process but are also the ones with innovative capabilities which is required for differentiation and hence for attaining long run competitive advantage.

The dependent variable is also divided by the total number of factories in each of the state, in order to avoid the heteroscedastcity problem that may arise in a cross-section study.

Table 4.3(a) below gives the name of the variables considered for the exercise and their corresponding description.

**Table 4.3(a): Description of the Variables**

| VARIABLES | DESCRIPTION |
|---|---|
| **DEPENDENT** | |
| $Q_s$ | Ratio of total number of ISO9000 certified factories in a state to the total number of factories in that state. |

| EXPLANATORY | |
|---|---|
| **Firm Specific** | |
| $K_{pur}$ | Capital investment in a state for production purpose / total number of manufacturing units in the state. |
| $K_{pol}$ | Capital investment in a state for pollution control / total number of manufacturing units in the state. |
| **State Specific** | |
| Dev | Per capita Net State Domestic Product of the states: a proxy for status of development. |
| R&D | State level expenditure on research and development: a proxy for innovative capabilities of the state. |
| Dv_Inf | A dummy variable depicting infrastructure status of a state<br>Dv_Inf = 1 if % of actual plan expenditure on infrastructure >32.85%<br>= 0 otherwise |
| Dv_Effreg | A dummy variable for effective environmental regulation in a state.<br>Dv_Effreg = 1 if [1/3 (% of factories taken up pollution abatement facilities) + 1/3 (% of capital investment of the total capital investment for pollution control) + 1/3 (% of running expense of the total running expense for pollution control)] > 8.73<br>= 0 otherwise |
| Dv_Ineffreg | A dummy variable for ineffective environmental regulation in a state.<br>Dv_Ineffreg = 1 if [1/3 (% of factories taken up pollution abatement facilities) + 1/3 (% of capital investment of the total capital investment for pollution control) + 1/3 (% of running expense of the total running expense for pollution control)] < 8.73<br>= 0 otherwise. |
| Dv_pooreg | A dummy variable for poor environmental regulation in a state.<br>Dv_pooreg = 1 if 0 < % of factories taken up pollution abatement facilities < 25%<br>= 0 otherwise. |

| | |
|---|---|
| Dv_medreg | A dummy variable for mediocre environmental regulation in a state. Dv_medreg = 1 if 25% < % of factories taken up pollution abatement facilities < 35% = 0 otherwise. |
| Dv_excreg | A dummy variable for excellent environmental regulation in a state. Dv_excreg = 1 if 35% < % of factories taken up pollution abatement facilities < 100% = 0 otherwise. |

Table 4.3(b) below gives the descriptive statistics of the variables considered in the analysis.

**Table 4.3(b): Descriptive Statistics of the Variables**

| Variables | N | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| $Q_s$ | 21 | 0.000 | 0.076 | 0.029 | 0.0206 |
| $K_{pur}$ | 21 | 49.194 | 1579.963 | 363.546 | 349.886 |
| $K_{pol}$ | 21 | 0.0124 | 16.590 | 5.714 | 4.310 |
| Dev | 21 | 4014 | 32647 | 12993.10 | 5988.647 |
| R&D | 21 | 0.00 | 12059.90 | 4411.142 | 3727.090 |
| Dv_Inf | 21 | 0 | 1 | 0.48 | 0.512 |
| Dv_Effreg | 21 | 0 | 1 | 0.48 | 0.512 |
| Dv_Ineffreg | 21 | 0 | 1 | 0.52 | 0.512 |
| Dv_pooreg | 21 | 0 | 1 | 0.52 | 0.512 |
| Dv_medreg | 21 | 0 | 1 | 0.19 | 0.402 |
| Dv_excreg | 21 | 0 | 1 | 0.29 | 0.463 |

N: the number of observations.

## 4.4 Methodology:

To analyze the effect of environmental regulation in the state and investment in pollution control by the manufacturing units on the quality status of manufacturing process in the 21 states we will consider a multivariable linear regression model. The model is linear in the dependent and the explanatory variables. Two models are considered for the analysis. In the first model the dummy variable for the environmental regulation status is taken to be Dv_Effreg and Dv_Ineffreg while the second model considers Dv_pooreg, Dv_medreg and Dv_excreg so as to take into account the environmental regulation status in the 21 states. This was done to check how the quality status results would change if instead of dividing the states into mere good and bad performers, the states were rather divided into good, bad and mediocre performers with respect to the environmental regulation status. We first specify the general *Quality Status function* for the analysis in terms of the various firm-specific and state-specific variables and then we specify the two models.

**Quality Status function:**

$$Q_s = f\,(K_{pur}, K_{pol}, Dev, R\&D, Inf, Env_{Reg})$$

Where,

**$Q_s$:** Quality status of the manufacturing process in the 21 states.

**$K_{pur}$:** Capital investment meant for pure production purpose exclusive of pollution control purpose.

**$K_{pol}$:** Capital investment meant for pollution control purpose.

**Dev:** Development status of the state.

**R&D:** Research and development status of the states a proxy for innovative capabilities of a state.

**Inf:** Infrastructure status of the 21 states

**$Env_{Reg}$:** Status of Environmental Regulation in a state.

We now specify the two models considered for the analysis.

**MODEL 1:**

$$Q_{si} = \beta_1 K_{puri} + \beta_2 K_{poli} + \beta_3 Dev_i + \beta_4 R\&D_i + \beta_5 Dv\_Inf + \beta_6 Dv\_Effreg + u_i$$

**MODEL 2:**

$$Q_{si} = \beta_1 K_{puri} + \beta_2 K_{poli} + \beta_3 Dev_i + \beta_4 R\&D_i + \beta_5 Dv\_Inf + \beta_6 Dv\_medreg + \beta_7 Dv\_excreg + u_i$$

Where,
**i** = 1..........21 is the number of states considered for the analysis.
**u:** the random error term

In Model 1 the dummy for ineffective environmental regulation i.e. Dv_Ineffreg has been dropped in order to avoid the dummy variable trap i.e. to check for the collinearity problem in the model. Thus the coefficient of effective environmental regulation would be interpreted in comparison with that of the reference category which in this case would be ineffective environmental regulation. Similarly, in the Model 2 to avoid the collinearity problem that may arise due to using all the three dummies of environmental regulation i.e. Dv_pooreg, Dv_medreg and Dv_excreg, we are taking dummy variable for poor regulation as the reference category. So the coefficients of dummies for mediocre environmental regulation and excellent environmental regulation can be interpreted in comparison with that of poor environmental regulation.

## 4.5 The Results:

### MODEL 1:

The table 4.5(a) below gives the values of the partial regression coefficients and their corresponding t-values for model 1.

**Table 4.5(a): Result of Model 1**

| VARIABLES | Coefficients | t-value |
|---|---|---|
| $K_{pur}$ | -0.064 | -0.513 |
| $K_{pol}$ | 0.449* | 3.273 |
| pcNSDP | 0.450* | 3.068 |
| R&D | 0.105 | 0.891 |
| Dv_Inf | -0.176*** | -1.807 |
| Dv_Effreg | 0.247* | 2.475 |
| $R^2 = 0.930$ | | |
| adj $R^2 = 0.902$ | | |

* significant at 0.01 level

*** significant at 0.1 level

From a statistical point of view the estimated line fits the data quit well. The adjusted $R^2$ value of 0.902 implies that about 90% of the variation in the quality status of the manufacturing in the 21 states is explained by the explanatory and the dummy variables considered in the analysis.

Insignificant partial regression coefficient was obtained for pure capital investment which was quite expected. Pure capital investment is generally not expected to explain variation in the quality status of manufacturing units.

The value of the partial regression coefficient for capital investment for pollution control is significantly positive. The partial regression coefficient for capital investment for pollution control is 0.449. This means that a 1% increase in capital investment for pollution control in the manufacturing units on an average led to 0.45% of improvement in the quality status of manufacturing units in the 21 states considered for the regression analysis. So the investment in pollution control by the manufacturing units in a state which is a resultant of effective environmental regulation in the state has lead to differentiation with respect to the quality status of manufacturing process among the manufacturing units in the 21 Indian states for the year 1997-1998. This can be viewed as an indirect effect of environmental regulation on the quality status of the manufacturing in the states. ISO9000 certification is based on the overall quality maintenance in the manufacturing. ISO9000 certification thus requires factories to follow various standards specified by the government which would also imply following the standards set up for industrial pollution control. So to get the certification pollution auditing is must. For successful pollution auditing, investment in pollution control is required i.e. to say for obtaining the ISO9000 certification investment in pollution control is required which in turn would happen only if the environmental regulation is effective. So the value of the partial regression coefficient for capital investment for pollution control can be viewed as the indirect effect of environmental regulation on the quality status of the manufacturing in the states.

The proxy for development status across the 21 states i.e. Dev for the year 1997-1998 is explaining 0.45% of variation in the average quality status of manufacturing units across the 21 states. This is so because the partial regression coefficient for Dev is 0.450 and it is significant at 1% level. Explanation of such a result lies in the fact that a high level of pcNSDP is generally associated with higher development status which leads to consumer awareness and aware consumers are sensitive towards the quality status of the product they are consuming. This is indicative of the fact that the development status of the states positively and quite significantly explains the quality status of the manufacturing units.

The benefits of R&D works have its spill over effect on manufacturing industries along with the fields of agriculture and commerce. It is thus expected to contribute positively to the manufacturing quality status in the states. But our results indicate towards insignificant effect of R&D on quality status of manufacturing. One reason for such insignificance could be that since this is a state specific explanatory variable i.e. spending of various state governments in R&D, it does not really have an impact on the quality status of the manufacturing. In fact R&D expenditure by the manufacturing units in the different states would have been a better explanatory variable for the quality status analysis. The insignificance points towards the fact that the state governments spending on R&D had no significant spill over effect on acquisition of quality status certification by the manufacturing units in the states for the year 1997-1998.

The partial regression coefficient for dummy variable for infrastructure status is negatively significant. Thus, the mean quality status of manufacturing for states with better infrastructure facility is lower than the states with below average infrastructure facilities by 0.18%. This does not support the view that the states with better infrastructure facilities are more developed and hence should positively contribute to the acquisition of quality certification by the manufacturing units.

Significant and positive partial regression coefficient was obtained for the dummy variable for effective environmental regulation. The partial regression coefficient for the dummy variable for effective environmental regulation is 0.247. This implies that the mean quality status of the manufacturing process of the states with effective environmental regulation is significantly higher than the states with ineffective environmental regulation by 0.25%. That is to say, on an average for states with effective environmental regulation acquisition of quality status certification is more than the states with ineffective environmental regulation.

We now analyze the results obtained in the model 2; this is done to check if, the states are divided into good, bad and mediocre performers with respect to the environmental regulation status then does it have an impact on the acquisition quality status certification by the manufacturing units across the 21 states considered for the analysis.

MODEL 2:

The table 4.5(b) below gives the values of the partial regression coefficients and their corresponding t-values for model 2.

| **Table 4.5(b): Result of Model 2** | | |
|---|---|---|
| VARIABLES | Coefficients | t-value |
| $K_{pur}$ | -0.060 | -0.580 |
| $K_{pol}$ | 0.443* | 3.794 |
| pcNSDP | 0.382* | 3.039 |
| R&D | 0.111 | 1.113 |
| Dv_Inf | -0.147*** | -1.790 |
| Dv_medreg | 0.087 | 1.317 |
| Dv_excreg | 0.315* | 4.051 |
| $R^2 = 0.955$ | | |
| adj $R^2 = 0.933$ | | |

* significant at 0.01 level

*** significant at 0.1 level

From a statistical point of view the estimated line fits the data well. The adjusted $R^2$ value of 0.933 implies that about 93% of the variation in the quality status of the manufacturing in the 21 states is explained by the explanatory and the dummy variables considered in the analysis.

Insignificant partial regression coefficient was obtained for pure capital investment which was quite expected. Pure capital investment is not expected to explain variation in the quality status of manufacturing units in the states.

The value of the partial regression coefficient for capital investment for pollution control is significantly positive. The partial regression coefficient for capital investment for pollution control is 0.443. This means that a 1% increase in capital investment for pollution control in the manufacturing units on an average led to 0.44% of improvement in the quality status of manufacturing units in the 21 states considered for the regression analysis. So the investment in pollution control by the manufacturing units in a state which is a resultant of effective environmental regulation in the state has lead to differentiation with respect to the quality status of manufacturing process among the manufacturing units in the 21 states of India for the year 1997-1998.

The proxy for development status across the 21 states i.e. Dev for the year 1997-1998 is explaining 0.38% of variation in average quality status of manufacturing units across the 21 states. This is so because the partial regression coefficient for Dev is 0.382 and it is significant at 1% level. The development status of the states thus positively and quite significantly explains the quality status of the manufacturing units.

Insignificant Coefficient was obtained for R&D. The reason for the insignificance is same as in model 1.

The partial regression coefficient for dummy variable for infrastructure status is negatively significant. Thus, the mean quality status of manufacturing for states with better infrastructure facility is lower than the states with below average infrastructure facilities by 0.15%.

Insignificant partial regression coefficient was obtained for the dummy variable for mediocre environmental regulation status in the states. So no significant comparisons can be made between the states with mediocre status of environmental regulation and the states with poor status of environmental regulation with respect to the acquisition of quality status certification by the manufacturing units.

However, the partial regression coefficient for dummy variable for excellent environmental regulation status in the states is positively significant. The partial regression coefficient of 0.315 implies that for states with poor environmental regulation status, acquisition of quality certification by the manufacturing units is on an average higher by 0.32% than the states with poor environmental regulation status. So the states with excellent environmental regulation status are performing better in acquiring quality status certification in comparison with the states with poor environmental regulation status, but nothing conclusive could be ascertained about the mediocre performers. This seems to indicate towards the fact that the states having maximum number of factories with pollution abatement facility are most successful in acquiring the quality status certification.

## 4.6 Conclusion:

From the above regression analysis we can conclude that investment in pollution control in a state does contribute significantly and positively to the quality status of manufacturing units in the states. Similarly, status of development also significantly affects on an average, the acquisition of quality certification across the 21 states. However, the State level expenditure on research and development; a proxy for innovative capabilities of the state had no such significant impact on the quality status of manufacturing units in the states for the year 1997-1998. Also effective environmental regulation in a state had a significant impact on the quality status. When the 21 states were divided into poor, mediocre and excellent performers with respect to the environmental regulation status some significant results were obtained. The results revealed that states with excellent status of environmental regulation were performing better in acquiring quality status certification in contrast to the states with poor status of environmental regulation. But nothing conclusive could be said about the performance of the states having mediocre status in contrast to the states with poor status of environmental regulation.

Our results in this chapter validate the hypothesis that quality status of the manufacturing in the states is a positive and significant function of capital investment for pollution control; a resultant of effective environmental regulation in a state. Similarly, effective environmental regulation positively contributes to the acquisition of quality status certification in the 21 states considered for the analysis. Also, with regards to the impact of poor, mediocre and excellent environmental regulation statuses on the quality status we could ascertain that the states having maximum number of factories with pollution abatement facility are most successful in acquiring the quality status certification. The effective environmental regulation and investment in pollution control thus does lead to *differentiation* among the quality of the manufacturing process in different states, making them more competitive in the long run.

# Chapter 5

# Development, Industrial Pollution and Compliance: an Inter-State Scenario

## 5.1 Introduction

The extensive literature on environmental economics also brings into focus a non-linear relationship between stages of development in a country and the level of environmental degradation. The issue has been extensively covered as the *Inverted U-Hypothesis* or the *Environment Kuznets Curve*. It says that, there is a non-linear relationship between the level of development and environmental degradation in a country. According to this non-linear relationship, in the initial stages of development, there is an increasing rate of environmental degradation which reaches its maximum at a certain level of development after which it starts declining. The explanation of increasing environmental degradation comes directly from the Development Economics which says that the initial stage of development in a country is generally accompanied by rapid industrialization. Also it has been observed historically that rapid industrialization leads to depletion of resources and accretion of pollution within the country, as most of the developed nations have gone through this stage of development and environmental degradation via industrialization. So in the initial stage of development there is an increase in the rate of environmental degradation. However, after the country achieves a certain level of development the environmental degradation starts declining, which can be explained by the fact that with development a country's preference for better quality environment increases. Consumers in such developed countries become aware of the environment intensiveness of the product they are consuming and with more disposable income at hand their demand for 'environment friendly' high quality product increases. Rising consumer awareness, thus, pressurizes the domestic government to adopt efficient environmental regulation in order to control pollution and environmental degradation.

Consumer awareness in such countries acts as a kind of an informal regulation taking care of the country's environment.

In this chapter, we will try to check if there is any relationship between development, industrial pollution intensiveness and industrial pollution control status in the Indian context. Our primary interest would be to ascertain whether development plays any role in rendering the environmental regulation in an Indian state effective. For this purpose we will consider the following 13 major Indian states: Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Maharashtra, Punjab, Rajasthan, Kerala, Karnataka, Tamil Nadu, Uttar Pradesh and West Bengal.

First, we build up an Index of Development, Index of Pollution Intensiveness and Index of Pollution Control which would take into consideration the development, industrial pollution intensity and compliance status for the 13 states. Then, based on these indices the 13 states are ranked in descending order of development, pollution intensity of industrial units and pollution abatement of industrial units. The ranking would bring forth the performance of these 13 states with respect to development, industrial pollution intensiveness and industrial pollution control. Finally, using the Correlation Analysis we try to determine the linear degree of association between the three indices, if at all there is any. We will also check for non-linear association between the development and the industrial pollution control status by fitting in quadratic regression lines into the scatter of the observations through a number of graphs.

## 5.2 Index of Development and State Ranking

To build up the index of development we use *per capita Net State Domestic Product* (pcNSDP) data published by Directorate of Economics and Statistics of respective State Governments and percentage of Actual plan Expenditure on *Infrastructure* by the 13 states published in National Human Development Report, 2001, Government of India. Energy, Industry & Minerals, Transport, Communication, Science, Technology and Environment are clubbed under the heading of Infrastructure. For both pcNSDP and Infrastructure, data for the years 1991-1992 and 1997-1998 are used. Our data source provides infrastructure figures for the year 1991-1992 as an average over the years 1990-1993 and figures for 1997-1998 as an average over the years 1996-1998.

To build up the development index, we first calculate the growth rate of pcNSDP from 1991-1992 to 1997-1998[17]. Next, we calculate the growth rate of infrastructure percentage from 1991-1992 to 1997-1998. Finally, a weighted sum of the two growth rates is considered to come up with final Development Index. The following formula gives the Development Index:

**Development Index = λ (growth rate of pcNSDP) + (1- λ) (growth rate of Infrastructure spending percentage)**

Where, $\lambda > \frac{1}{2}$

The selection of the weights is based on the criteria that more weight should be given to pcNSDP which is expected to be highly correlated with income status of a state and hence plays a pivotal role in the determination of overall development within a state. While the infrastructure component considers the percentage spending of each of the 13 states on Energy, Industry & Minerals, Transport, Communication, Science, Technology and Environment (clubbed under the infrastructure category) which are necessary for further development of a state. So to assign an index value to each of the 13 states we use the weight of ¾ for pcNSDP and ¼ for the infrastructure[18].

After calculating the Index of Development for the 13 states we rank them in descending order of the Index value, where, the high Index value denotes higher level of development in a state. This is so because a high value is a result of high value of the two components. A high

[17] We consider, the initial year as 1991-1992 because New Economic Policy came into existence in that particular year. We consider the final year as 1997-1998 because for the other two indices that we are going to build, data was available only for the year 1997-1998. So to keep parity among the three indices the final year is taken as 1997-1998.

[18] Other weights satisfying the condition $\lambda > \frac{1}{2}$ were also tried which did not make any difference in the inter-state ranking.

value pcNSDP implies that a state is developed with respect to the income level and a high value of the other component implies that the concerned state government is spending a high amount on infrastructure which is required for further development. Table 5.2(a) below ranks the 13 states in the descending order of Development index value, the index value is also given in the table.

**Table 5.2(a):Development Index value & State Ranking**

| Rank | State | Development Index value |
|---|---|---|
| 1 | Kerala | 1.307557 |
| 2 | Tamil Nadu | 1.230046 |
| 3 | Gujarat | 1.1163523 |
| 4 | Rajasthan | 1.115695 |
| 5 | Maharashtra | 0.961261 |
| 6 | West Bengal | 0.906578 |
| 7 | Andhra Pradesh | 0.838682 |
| 8 | Karnataka | 0.785029 |
| 9 | Haryana | 0.726209 |
| 10 | Punjab | 0.691884 |
| 11 | Uttar Pradesh | 0.613024 |
| 12 | Assam | 0.460303 |
| 13 | Bihar | 0.186632 |

As per the Development Index build up in this sub-section Kerala has attained the highest rank while Bihar is ranked lowest. One point worth mentioning here is that, of the 13 states considered only Punjab and West Bengal had registered a positive growth rate of infrastructure spending while for all the other 11 states growth rate of infrastructure spending turned out to be negative which suggests that post New Economic Policy for these 11 states percentage of infrastructure spending has gone down. So only these two states had taken steps for development in all the fields while the other 11 seemed to stress on the growth aspect and not really on the overall development.

## 5.3 Index of Industrial Pollution Intensiveness and State Ranking

To build up the Index of Industrial Pollution Intensiveness and Ranking we use the data published by Annual Survey of Industries (ASI) 1997-1998. Industrial pollution is an externality recognized by the Indian industry. Industries in the states have also adopted measures for pollution control in order to deal with the eternality under the executive and judicial pressure. But, unfortunately there is a dearth of database in the country which would give us the level of pollution abatement taken up by the industrial units in the states. Only, in ASI 1997-1998, fieldwork was carried out during 1998-1999 when the first attempt was made to collect such data. The ASI 1997-1998 published the data at both the state level and the industry level. At the industry level, the ASI 1997-1998 follows National Industrial Classification (NIC) 1987 which covers the industries at both 2-digit level and 3-digit level.

The first task in front of us was to assign a weight for pollution intensity for each of the 28 2-digit industries that fall under the manufacturing category. To work out the formula for the weight, following information was utilized. Ministry of Environment and Forests (MoEF), Government of India (GOI) has categorized industrial activities as Red, Orange and Green categories. Red and Orange are considered to be polluting or dirty categories while Green is the cleanest category. Each of the 2-digit categories of industry is further disaggregated into a number of 3-digit categories. Of these 3-digit categories some of them fall under the Red and the Orange activities implying that these 3-digit categories of industrial activities are pollution intensive in nature. To determine the overall pollution intensity of each of the 2-digit categories the ratio of the number of Red and Orange 3-digit categories to the total number of 3-digit categories under a particular 2-digit category was considered. For this purpose a matching up exercise of the list of Red, Orange and Green category of industrial activities with the NIC 1987 list of 3-digit categories of industrial activities was carried on[19]. For example, the 2-digit category 20 i.e. manufacture of food products is further disaggregated into 10, 3-digit category of industrial activities. Of these 10, 8 fall under the Red and the Orange category while the remaining 2 were green category activities. So the weight for

[19] In India each of the SPCB's has their own list of Red, Orange and Green category of industrial activities. But for our matching exercise we have used the list of Karnataka State Pollution Control Board. See the Karnataka State Pollution Control Board's website www.kspcb.kar.nic.in.

pollution intensiveness for the category 20 was taken as 8 divided by 10 i.e. 0.8. Similarly, for the other 27, 2-digit categories the weights of pollution intensiveness were determined. Table 5.3(a) below gives the pollution intensiveness of each of the 28, 2-digit category of industries.

| **Table 5.3(a):Pollution Intensiveness of NIC 2-digit Category of Industries** | | |
|---|---|---|
| NIC 2-digit | Description of the Category | Weight for Pollution Intensiveness |
| 20 | Mfg. of food products | 0.8 |
| 21 | Mfg. of food products | 0.6 |
| 22 | Mfg. of beverages, tobacco, & related products | 0.3 |
| 23 | Mfg. of cotton Textiles | 0.29 |
| 24 | Mfg. of wool, silk & man made fibre textile | 0.67 |
| 25 | Mfg. of jute & other vegetable fibre textiles (except cotton) | 0.3 |
| 26 | Mfg. of textile products (including wearing apparel) | 0 |
| 27 | Mfg. of wood & wood products, furniture and fixtures | 0.2 |
| 28 | Mfg. of paper & paper products and printing publishing & allied industries | 0.2 |
| 29 | Mfg. of leather & leather products, fur & substitutes of leather | 0.1 |
| 30 | Mfg. of basic chemicals & chemical products | 0.8 |
| 31 | Mfg. of Rubber, Plastic, Petrol & Coal products | 0.9 |
| 32 | Mfg. of Non-Metallic Mineral products | 0.7 |
| 33 | Mfg. of Basic Metals & Alloy Industries | 0.9 |
| 34 | Mfg. of Metal products | 0.4 |
| 35 | Mfg. of Non-Electrical Machinery | 0.2 |
| 36 | Mfg. of Electrical Machinery | 0.1 |
| 37 | Mfg. of Transport Equipments & parts | 0 |
| 38 | Other mfg. industries | 0.2 |
| 39 | Repair of capital goods | 0 |
| 41 | Gas & steam generation and distribution through pipes | 0 |
| 42 | Water works and supply | 0 |

| | | |
|---|---|---|
| 43 | Non-conventional energy generation and distribution | 0 |
| 74 | Storage & Warehousing Services | 0.5 |
| 91 | Sanitation & Similar Services | 1 |
| 95 | Motion Picture & video film production | 0 |
| 96 | Laundry , cleaning & dyeing services | 0 |
| 97 | Repair Services | 0.1 |

So the *Weight for Pollution Intensiveness* varies from 0 to 1. 0 is the cleanest category and 1 is the dirtiest category.

Next, for each of 28, 2-digit categories top 5 states were determined with respect to the number of factories under that particular category[20]. Similarly, the other four ranks were assigned. For example, for the 2-digit category 20 i.e. manufacture of food products, Andhra Pradesh was given the first rank as it had maximum number of factories i.e. 3946 in this category. Similarly, other 4 states for the ranking were determined. Following formula was then developed to determine the Index of Industrial Pollution Intensiveness for each of the 13 states, which came out from the series of top 5 rankings for each of the 28, 2-digit categories.

$$\textbf{Industrial Pollution Intensiveness Index} = \frac{\Sigma_i\,(W_{PI})_i\,(Nf)_i}{\Sigma_i\,(W_{PI})_i} \qquad i=1\ldots n$$

Where,

$\mathbf{W_{PI}}$ : Weight for pollution intensiveness in a particular 2-digit category

$$W_{PI} = \frac{\text{Number of 3-digit Red \& Orange activities in a category}}{\text{Total number of 3-digit activities in that category}}$$

**Nf:** Number of factories in a state for a particular 2-digit category.

[20] Only top 5 states were considered because for some of the 2-digit categories figures were not available for all the 21 states. Because of this reason the exercise is carried out for only 13 major Indian states.

**Wr:** Weight rank of a state in a particular category (Weight of 1 was assigned for rank 1, 2 for rank 2 and so on.)

**n:** Number of categories in which a state has occurred.

A high value of Industrial Pollution Intensiveness index denotes high industrial pollution intensity in a state. Table 5.3(b) below ranks the 13 states in the descending order of Industrial Pollution Intensiveness (IPI) Index value, the index value is also given in the table.

**Table 5.3(b): IPI Index value & State Ranking**

| Rank | State | Industrial Pollution Intensiveness Index value |
|---|---|---|
| 1 | Maharashtra | 267.82 |
| 2 | Andhra Pradesh | 221.29 |
| 3 | Gujarat | 161.91 |
| 4 | Tamil Nadu | 150.34 |
| 5 | Uttar Pradesh | 138.01 |
| 6 | Rajasthan | 116.85 |
| 7 | Punjab | 97.16 |
| 8 | Bihar | 73.78 |
| 9 | Assam | 59.86 |
| 10 | Kearla | 56.4 |
| 11 | West Bengal | 32.5 |
| 12 | Haryana | 28.01 |
| 13 | Karnataka | 11.4 |

According to the Industrial Pollution Intensiveness Index, Maharashtra has turned out to be the most pollution intensive state in the sense of spatial concentration of red and orange category of industries, while Karnataka is the least pollution intensive state with respect to the spatial concentration of pollution intensive category of industries.

## 5.4 Index of Industrial Pollution Control and State Ranking

To build up the Index of Industrial Pollution Control and Ranking again we use the data published in ASI 1997-1998. The first task in front of us was to assign a weight for pollution control for each of the 28, 2-digit category of industries. To work out the formula for the Weight of pollution Control the following information was used. The weight for pollution control in a particular 2-digit was taken as the ratio of number of factories in that category which had taken up pollution abatement facilities to the total number of factories in that particular category. For example, under the 2-digit category 20 i.e. manufacture of food products, there are in total 14695 factories of which 3030 had taken abatement measures for pollution control. So the corresponding weight of pollution control turned out to be 0.2061925. Similarly, for the other 27, 2-digit categories the weights of pollution control were determined. Table 5.4(a) below gives the pollution control status of each of the 28, 2-digit categories.

**Table 5.4(a):Pollution Control Status of NIC 2-digit Category of Industries**

| NIC 2-digit | Description of the Category | Weight for Pollution Control |
|---|---|---|
| 20 | Mfg. of food products | 0.2061925 |
| 21 | Mfg. of food products | 0.3963497 |
| 22 | Mfg. of beverages, tobacco, & related products | 0.0721042 |
| 23 | Mfg. of cotton Textiles | 0.3279505 |
| 24 | Mfg. of wool, silk & man made fibre textile | 0.4128854 |
| 25 | Mfg. of jute & other vegetable fibre textiles (except cotton) | 0.252485 |
| 26 | Mfg. of textile products (including wearing apparel) | 0.1369938 |
| 27 | Mfg. of wood & wood products, furniture and fixtures | 0.0889886 |
| 28 | Mfg. of paper & paper products and printing publishing & allied industries | 0.1592639 |
| 29 | Mfg. of leather & leather products, fur & substitutes of leather | 0.4408725 |
| 30 | Mfg. of basic chemicals & chemical products | 0.6683766 |
| 31 | Mfg. of Rubber, Plastic, Petrol & Coal products | 0.3622482 |

| | | |
|---|---|---|
| 32 | Mfg. of Non-Metallic Mineral products | 0.2145745 |
| 33 | Mfg. of Basic Metals & Alloy Industries | 0.528561 |
| 34 | Mfg. of Metal products | 0.1645032 |
| 35 | Mfg. of Non-Electrical Machinery | 0.1606965 |
| 36 | Mfg. of Electrical Machinery | 0.2063381 |
| 37 | Mfg. of Transport Equipments & parts | 0.256314 |
| 38 | Other mfg. industries | 0.1279536 |
| 39 | Repair of capital goods | 0.096875 |
| 41 | Gas & steam generation and distribution through pipes | 0.425 |
| 42 | Water works and supply | 0.0375426 |
| 43 | Non-conventional energy generation and distribution | 0.25 |
| 74 | Storage & Warehousing Services | 0.1048237 |
| 91 | Sanitation & Similar Services | 0.0462962 |
| 95 | Motion Picture & video film production | 0.0980392 |
| 96 | Laundry , cleaning & dyeing services | 0.4042553 |
| 97 | Repair Services | 0.1709053 |

So the *Weight of Industrial Pollution Control* ranged between 0.0375426 and 0.6683766. Category 42 i.e. Water works and supply had taken up least pollution control abatement efforts, interestingly this category is also the least pollution intensive category. On the other hand, category 30 i.e. Manufacture of Basic Chemicals & Chemicals products had taken up maximum pollution control effort. Again, category 30 is also the most pollution intensive category with respect to the weight of industrial pollution intensiveness.

Next, for each of the 28, 2-digit categories, top 5 states were determined with respect to the number of factories in that particular 2-digit category. First rank was assigned to that state of the top 5 which had maximum number of factories under that particular category. Similarly, the other four ranks were assigned. For example, the 2-digit category 20 i.e. manufacture of food products, Andhra Pradesh was given the first rank as it had maximum number of factories i.e. 3946 in this category. Similarly, other 4 states for the ranking were determined. Following formula was then developed to determine the Index of Industrial Pollution Control for each of the 13 states, which came out from the series of top 5 rankings for each of the 28, 2-digit categories.

$$\textbf{Industrial Pollution Control Index} = \frac{\Sigma_i \, (W_{PC})_i \, (Nf)_i}{\Sigma_i \, (Wr)_i} \qquad i=1 \ldots n$$

Where,

**$W_{PC}$ :** Weight for pollution control in a particular 2-digit category

$$W_{PC} = \frac{\text{Number of factories taken up abatement facilities in a category}}{\text{Total number of factories in that category}}$$

**Nf:** Number of factories in a state for a particular 2-digit category.

**Wr:** Weight rank of a state in a particular category (Weight of 1 was assigned for rank 1, 2 for rank 2 and so on.)

**n:** Number of categories in which a state has occurred.

A high value of Industrial Pollution Control Index denotes high industrial pollution control status in a state. Table 5.4(b) ranks the 13 states in descending order of Industrial Pollution Control (IPC) Index value, the index value is also given in the table. According to the Industrial Pollution Control Index, Tamil Nadu is ranked first with regards to industrial pollution control status. In this set of ranking Kerala is ranked lowest. One point worth mentioning here is that as per the Development Index build up in section 5.2(a) Kerala had turned out to be the most developed state among the 13 states considered for the exercise. This does not seem to validate the fact that the most developed state is also the one with best pollution control status. However, Gujarat is one state which has attained same rank i.e. the third position with respect to the development status, pollution intensity status and pollution control status.

| Table 5.4(b): IPC Index value & State Ranking | | |
|---|---|---|
| Rank | State | Industrial Pollution Control Index value |
| 1 | Tamil Nadu | 230.58 |
| 2 | Maharashtra | 160.1 |
| 3 | Gujarat | 100.6 |
| 4 | Andhra Pradesh | 83.59 |
| 5 | Uttar Pradesh | 65.56 |
| 6 | Rajasthan | 59.01 |
| 7 | Punjab | 43.13 |
| 8 | Assam | 32.75 |
| 9 | Bihar | 20.18 |
| 10 | West Bengal | 19.16 |
| 11 | Haryana | 17.14 |
| 12 | Karnataka | 14.32 |
| 13 | Kerala | 12.24 |

In the next section, we use Correlation Analysis to check if there is any linear association between the three statuses i.e. development, industrial pollution intensity and industrial pollution control in the 13 states.

## 5.5 A Correlation Analysis

In this section, we use Correlation Analysis to check if there is any linear association between the three statuses i.e. development, industrial pollution intensity and industrial pollution control in the 13 states considered for the exercise. For this purpose we use both Pearson's Product-Moment and Spearman's Rank Correlation method.

### 5.5(A) Correlation between Pollution Intensiveness and Pollution Control Status

To determine the correlation between Industrial pollution Intensiveness Index and Industrial Pollution Control Index we will use both Pearson's method as well as Spearman's method.

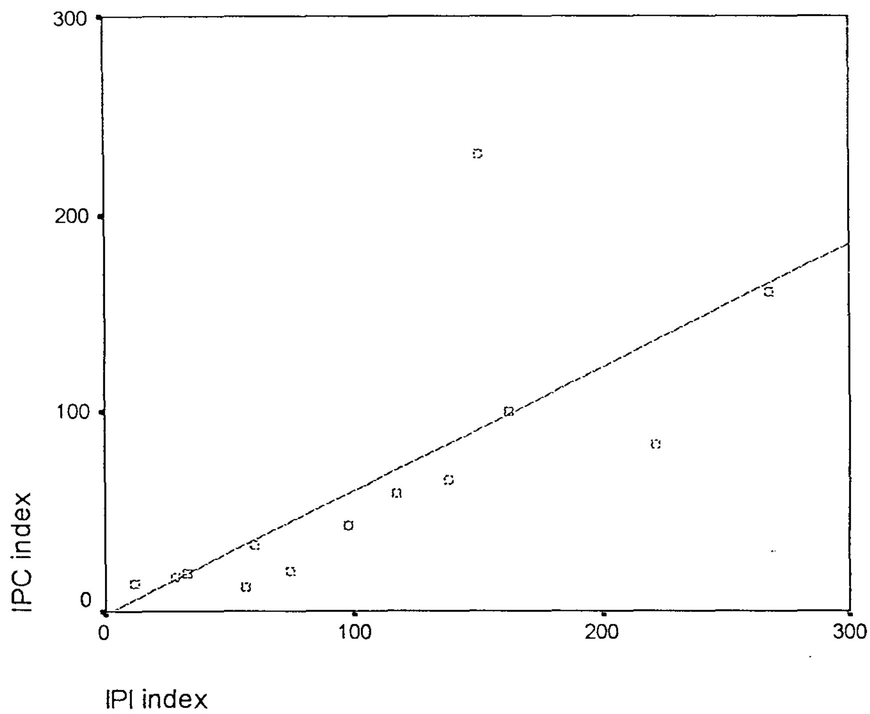
Table 5.5(a) below gives the Product Moment Correlation Coefficient between Industrial Pollution Intensiveness index (IPI index) and Industrial Pollution Control index (IPC index). While Graph 5.5(i) depict the scatter of observation of the variables Industrial Pollution Intensiveness Index and Industrial Pollution Control Index.

**Table 5.5(a): Pearson's Correlation between IPI Index & IPC Index**

| Variables | | IPI index | IPC index |
|---|---|---|---|
| IPI index | Pearson Correlation | 1 | 0.732* |
| | N | 13 | 13 |
| IPC index | Pearson Correlation | 0.732* | 1 |
| | N | 13 | 13 |

* Correlation is significant at the 0.01 level.

N is the number of observation.




**Graph 5.5(i)**

**Interpretation:** Both the Pearson's Product Moment correlation coefficient between the two indices i.e. r = 0.732 and the graph suggest that there is strong but not perfect positive linear relationship between the indices of Industrial Pollution Intensiveness and Industrial Pollution Control in the 13 states. The degree of association between the two is high implying that a high value of one is associated with high value of the other and vice versa. In the graph 5.5(i) the plot of scatter indicates a straight line tendency which confirms the high correlation coefficient obtained in Table 5.5(a). It means that the states with high industrial pollution intensity are also the ones with high pollution control status.

**Limitation:** However, the high value of 'r' does not signify that there is a high degree of linear relationship between the variables. The high value of 'r' may be due to the influence of any third variable which in this case may be the weight of the rank of states considered in both the index formula. So there is a need to eliminate the effect of this third variable and then the partial correlation between the two must be found out.

We next consider the Partial Correlation coefficient between IPI index and IPC index. Table 5.5(b) below gives the partial correlation coefficient between IPI index and IPC index after controlling for the effect of weight of rank of states.

| **Table 5.5(b): Partial Correlation between IPI Index & IPC Index** | | | |
|---|---|---|---|
| Variables | | IPI index | IPC index |
| IPI index | Partial Correlation | 1 | 0.445** |
| | DoF | 0 | 10 |
| IPC index | Partial Correlation | 0.445** | 1 |
| | DoF | 0 | 10 |

**Correlation is significant at the 0.05 level.

DoF is the Degree of Freedom.

**Interpretation:** The partial correlation coefficient between IPI index and IPC index after controlling for the effect of the weight of rank of states is 0.445 which is significant at the 0.05 level. So this clearly indicates that high Correlation coefficient of 0.732 obtained in Table 5.5(a) is a result of weight of rank considered for the construction of both the indices. After controlling for the weight of rank the two indices show a very low degree of positive linear association between the two indices.

We next consider Rank Correlation coefficient between the two indices. Rank Correlation Coefficient is generally used as a measure association between two attributes when measurements are either not available or not reliable, but the elements can be arranged in an order of preference. For this purpose we use the Spearman's Rank Correlation method.

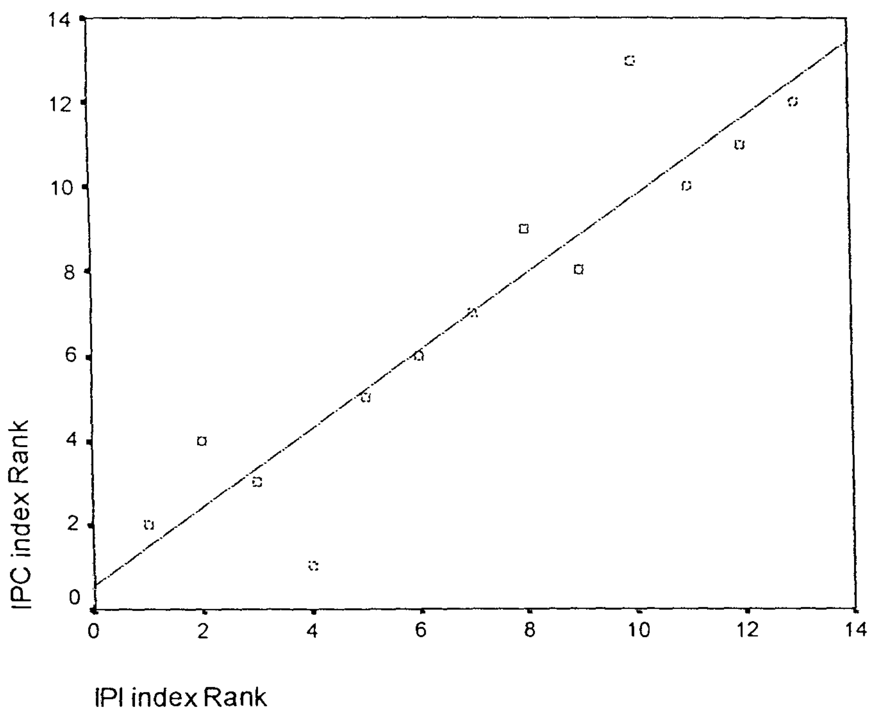
Table 5.5(c) gives the Rank Correlation result between Industrial Pollution Intensiveness Index (IPI index) and Industrial Pollution Control Index (IPC index). While the Graph 5.5(ii) depicts the scatter of observation of the two series of ranks i.e. rank of IPI index and rank of IPC index.

**Table 5.5(c): Rank Correlation between IPI Index & IPC Index**

| Variables | | IPI index | IPC index |
|---|---|---|---|
| IPI index | Spearman's Correlation | 1 | 0.923* |
| | N | 13 | 13 |
| IPC index | Spearman's Correlation | 0.923* | 1 |
| | N | 13 | 13 |

* Correlation is significant at the 0.01 level.

N is the number of observation.




<u>**Graph 5.5(ii)**</u>

**Interpretation:** Spearman's significant rank correlation coefficient R= 0.932 and the plot of scatters both suggest a very high and near perfect linear positive association between the two ranks i.e. the rank for IPI index and the rank for IPC index for the 13 states considered for the exercise. States like Gujarat, Uttar Pradesh, Punjab and Rajasthan have similar ranks with respect to both the indices. Even for the remaining states there is a small difference in the ranking for both the indices. This ranking again is a resultant of the index formula which has a common variable included i.e. the weight of ranks of the 13 states.

### 5.5(B) Correlation between Development and Industrial Pollution Intensiveness Status

Table 5.5(d) and 5.5(e) respectively shows the Product Moment correlation coefficient and Rank correlation coefficient between the Development index (Dev index) and the Industrial Pollution Intensiveness index (IPI index).

**Table 5.5(d): Pearson Correlation between Dev Index & IPI Index**

| Variables | | Dev index | IPI index |
|---|---|---|---|
| Dev index | Pearson Correlation | 1 | 0.257 |
| | N | 13 | 13 |
| IPI index | Pearson Correlation | 0.257 | 1 |
| | N | 13 | 13 |

N is the number of observation

**Interpretation:** From Table 5.5(d) and 5.5(e) it is evident that there is no significant correlation between the development and the industrial pollution intensiveness status of the 13 Indian states considered for the exercise.

| Table 5.5(e): Rank Correlation between Dev Index & IPI Index | | | |
|---|---|---|---|
| Variables | | Dev index | IPI index |
| Dev index | Spearman's Correlation | 1 | 0.264 |
| | N | 13 | 13 |
| IPI index | Spearman's Correlation | 0.264 | 1 |
| | N | 13 | 13 |

N is the number of observation

### 5.5(C) (i) Correlation between Development and Industrial Pollution Control Status

Table 5.5(f) and 5.5(g) respectively shows the Product Moment correlation coefficient and Rank correlation coefficient between the Development index (Dev index) and the Industrial pollution Control index (IPC index).

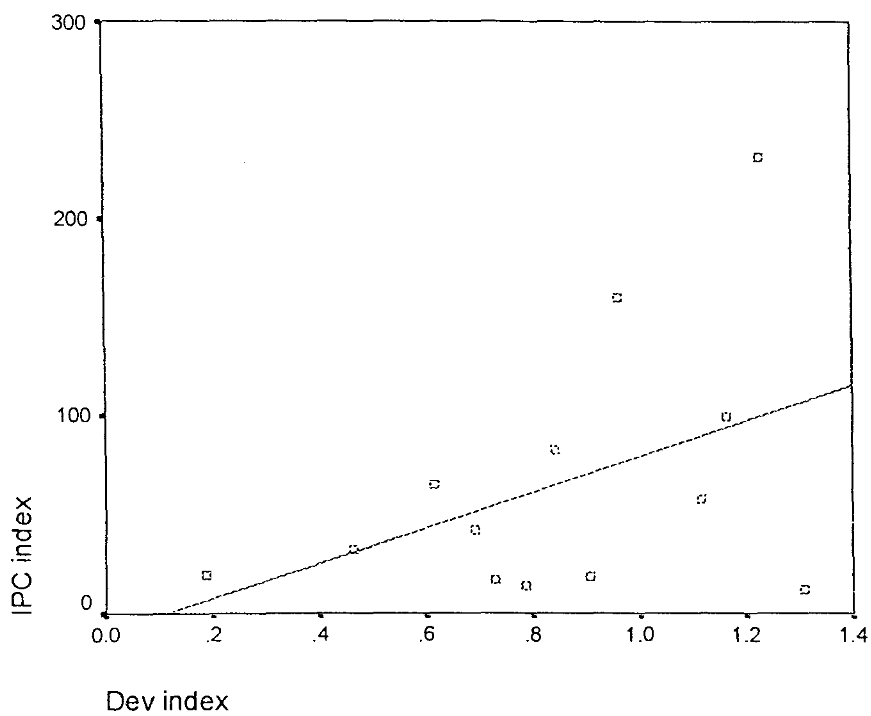
| Table 5.5(f): Pearson Correlation between Dev Index & IPC Index | | | |
|---|---|---|---|
| Variables | | Dev index | IPC index |
| Dev index | Pearson Correlation | 1 | 0.442** |
| | N | 13 | 13 |
| IPC index | Pearson Correlation | 0.442** | 1 |
| | N | 13 | 13 |

** Correlation is significant at the 0.05 level.

N is the number of observation.

| Table 5.5(g): Rank Correlation between Dev Index & IPC Index | | | |
|---|---|---|---|
| Variables | | Dev index | IPC index |
| Dev index | Spearman's Correlation | 1 | 0.231 |
| | N | 13 | 13 |
| IPC index | Spearman's Correlation | 0.231 | 1 |
| | N | 13 | 13 |

N is the number of observation.

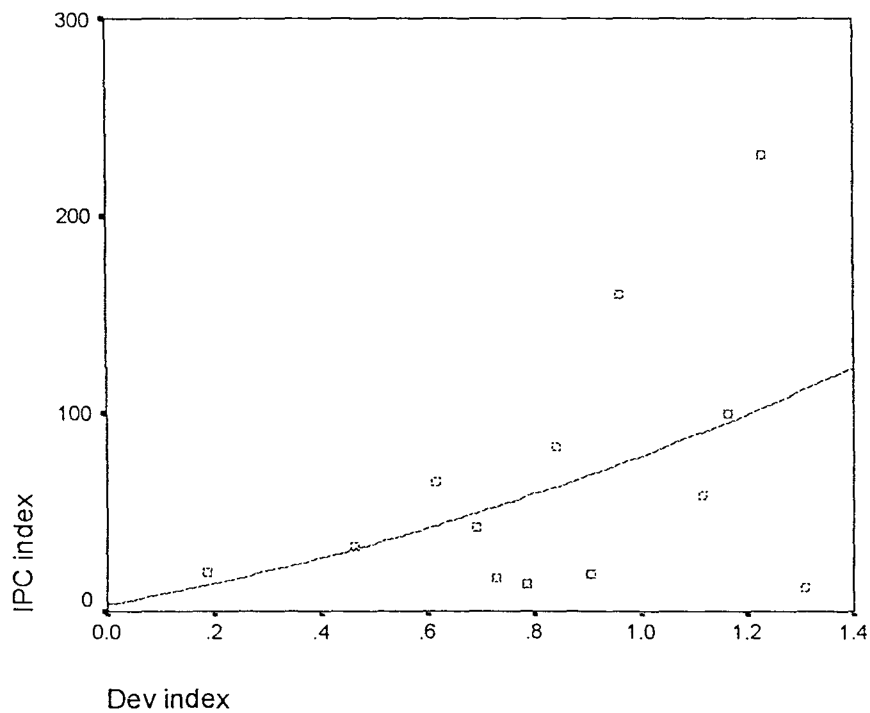



**Graph 5.5(iii)**

**Interpretation:** As per the Pearson's method there is a positive and significant correlation between development status and the pollution control status. However, the value of correlation coefficient is not very high suggesting that there is very low degree of linear association between the development and industrial pollution control status within the states. The scatter of plot in the Graph 5.5(iii) above also depicts a positive and low degree of linear association between the Development index and the Industrial Pollution control index.

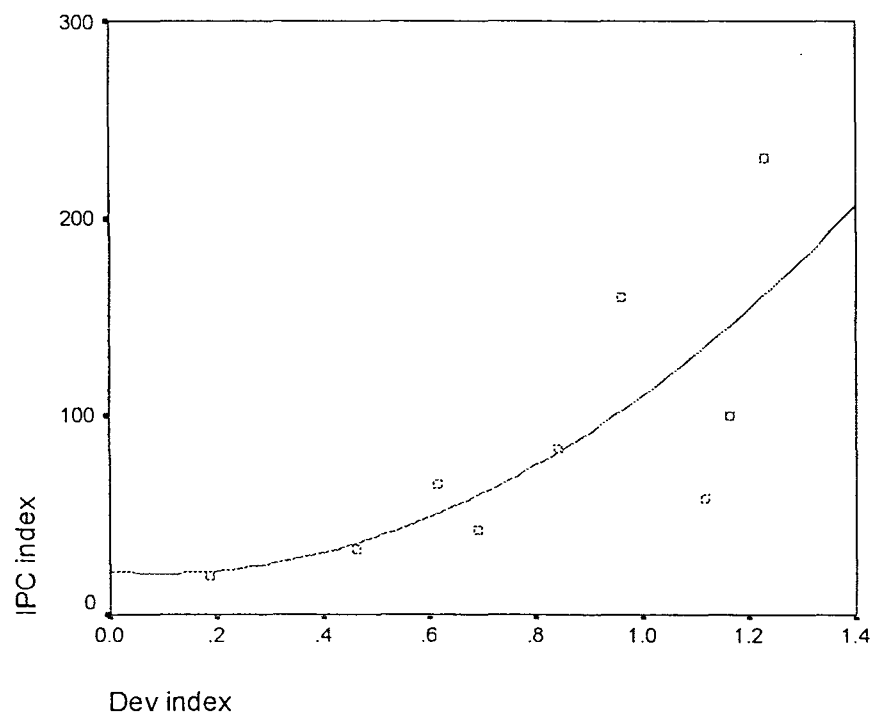
### 5.5(C) (ii) Non-Linear Association between Development and Industrial Pollution Control Status

To check for non-linear degree of association between Development and industrial pollution control status we try to fit quadratic curve into the above scatter of points. We obtain an upward sloping curve as shown in Graph 5.5(iv). The curve obtained in Graph 5.5(iv) depicts that as the development status among the 13 states increases, the level of pollution control (as shown by the IPC index) increases at an increasing rate




**Graph 5.5(iv)**

However, more interesting result is obtained if we drop the observation for the following four states: Kerala, West Bengal, Karnataka and Haryana which are the lowest four rankers as per the IPC index. Now when we try to fit in a quadratic curve into this new scatter of observation, we obtain a J-shaped curve which is similar to the J-curve of abatement effort with time as developed by Selden and Song (1995) [Section 2.5 of Chapter 2]. Graph 5.5(v) shows the J-curve obtained from new scatter of points. According to this J-curve as the development status of 0.613024 (as per the development index value) is attained, the pollution control status starts increasing at an increasing rate. In other words, after the turning point of 0.613024 is reached in any state the environmental regulation starts becoming effective at an increasing rate. So when we try to fit a non-linear curve into the scatter of observations it gives results which somewhat confirm to the hypothesis developed by the extensive literature on development and pollution abatement status.




**Graph 5.5(v)**

## 5.6 Conclusion

The three indices constructed in this chapter ranks the 13 major Indian states in decreasing order of development, industrial pollution intensiveness and industrial pollution control status. Development index so constructed gives the development status of the 13 states. It is dynamic in nature as it covers the time period of 1991-1992 to 1997-1998. A higher Development index value implies high development status for a state. Industrial Pollution Intensiveness index i.e. IPI index gives the spatial concentration of pollution intensive industries in each of the 13 states. A higher IPI index value denotes a higher degree of pollution intensiveness in a state and such a state is ranked high in contrast to the other states. Finally, Industrial Pollution Control index i.e. IPC index gives the pollution control status of manufacturing industries in the 13 states considered for the exercise. IPC index value is a direct outcome of the functioning of SPCB in a particular state. A high IPC index value implies a better compliance status in a state which thus is a result of effective environmental regulation being followed in the concerned state. So the significant and positive correlation that we are getting between the Development index and the IPC index actually implies that there is a positive and significant (even though low) linear association between development status and the effectiveness of environmental regulations (especially the ones related to industrial pollution control) in a state. One point worth mentioning here is that Kerala even though is ranked first as per the Development index is actually placed last with respect to the IPC index. This does not seem to support the view that the most developed state is also the most controlled states with respect to the pollution control. Moreover, if we drop the 4 low rankers as per the IPC index i.e. Kerala, West Bengal, Karnataka and Haryana from our observation set then we obtain a J-shaped curve which is similar to the J-curve of abatement as developed by Selden and Song (1995). According to this J-curve as the development status of 0.613024 (as per the development index value) is attained in any state the environmental regulation starts becoming effective at an increasing rate. But we obtained a very low level of linear association between industrial pollution intensiveness and industrial pollution control statuses in the 13 states. Also, nothing conclusive could be ascertained between development and industrial pollution intensiveness of the states. This was also expected because as per the extensive literature discussed in section 2.5, the degree of association between development and pollution is expected to be non-linear. While this exercise checks only for the linear degree of association between development and pollution among the Indian states.

One major limitation of this exercise is that it is not a dynamic analysis which is required for testing the relationship between development, pollution and compliance. Due to the lack of time-series data on state-wise compliance in the manufacturing sector, the IPI index and the IPC index takes into consideration only one year i.e.1997-1998. We would have obtained more conclusive results if state-wise manufacturing compliance figures were available for the time period 1991-1992 to 1997-1998. Nevertheless the exercise does seem to validate the fact that environmental regulation in any Indian state starts becoming increasingly effective only after it has attained a certain level of development.

# Chapter 6

# Conclusion

## 6.1 Summary

In this dissertation we have tried to analyze the impact of environmental regulations (especially the ones related to the industrial pollution in Indian states) on the production and the quality status of manufacturing in the Indian context. We have also tried to check whether development plays any role in rendering the environmental regulation that is being followed by the government of a particular Indian state effective.

In **Chapter 1**, we started with a short introduction to bring into focus the interlinkages between the economy and the environment. We also stated the role that environmental regulation plays in this context. Thereafter, we discussed very briefly, the three issues addressed in this dissertation. The three issues were the impact of investments in pollution control and status of environmental regulations on the production and the quality status of manufacturing in the Indian context and the role of development in determining the effectiveness of environmental regulation in a particular state. Finally, the chapter briefly outlined the organization of the dissertation.

In **Chapter 2**, we attempted a survey of literature to understand the three issues to be analyzed in the dissertation. Both the theoretical as well as empirical studies were discussed to bring into focus various aspects related to environmental regulations. After a brief introduction, the chapter began with a discussion on some essential issues related to environmental economics which introduced the importance of environmental regulation in various forms to internalize the pollution externality. This was followed by a section where a survey of papers was attempted to investigate the reasons for the implementation of weak (or strong) environmental policy by the government of a nation. The main emphasis in this section was on the role of strategic environmental policy as an industrial policy in international trade where we reviewed the literature on the motives and incentives of the governments to use either weak (or strong) environmental policy contingent upon the prevailing market structure in the trading countries. The review of the theoretical literature revealed that that prevalent market structure is generally the reason behind a country's decision to follow weak or stringent environmental regulations. Moreover, market imperfection is generally the reason behind a country using environmental policy as an industrial policy. In the next section of this chapter we tried to build up a case for usage of stringent environmental regulation by the countries. The section reviewed theoretical and empirical literature related to Porter Hypothesis. In this section the impact of stringent environmental regulations on the productivity and competitiveness were also explored both theoretically and empirically. In the following section we reviewed the literature which focuses on the relationships between development and pollution status; as it is generally hypothesized that economic growth reduces the environmental degradation after a certain time period. So from the review of literature on relationship between economic growth and emissions we could rightly argue that with economic growth a country's preference for better quality environment increases which pressurizes the government of the country to undertake stringent and effective environmental regulations along with the investments in pollution control to check further environmental degradation. Some of the papers brought out the role of regulations and investments in reducing further environmental degradation in a country. One of the theoretical paper reviewed also suggested the optimal path to be followed by the investment, when it can be used for both productive as well as pollution control purpose. The final section summarized the entire chapter.

In **Chapter 3**, we first discussed the status of environmental regulations in India. This was done because even though the standards related to industrial pollution control is same all over the India, the enforcement and the monitoring task is the responsibility of the respective state governments. This results in generating differences in the effectiveness of the environmental regulation among the states. Next, we attempted a regression analysis to determine whether investments in pollution control by a state's manufacturing units and status of environmental regulation in a particular state play any significant role in the production of the manufacturing in the states. We explored the hypothesis on the manufacturing production by using log-linear regression models for the year 1997-1998. From the regression analysis we could conclude that investment in pollution control in a state does contribute significantly but negatively to the production of manufacturing units in the state. This seemed to validate the fact that when the resources are diverted towards pollution control purposes it has a negative impact on the manufacturing production. However, states with effective environmental regulation were performing better on the manufacturing production front in contrast to the states with ineffective environmental regulation. Moreover when the states were divided into poor, mediocre and excellent performers with respect to the status of environmental regulation, the states with mediocre status of environmental regulation were performing better on the production front in contrast to the states with poor status of environmental regulation. But nothing conclusive could be ascertained about the excellent performers with regards to the environmental regulation status, as significant comparisons could not be made between the excellent and the poor performers. Significant and positive regression coefficients were obtained for the proxy of innovative capabilities of the states. Our results in the chapter thus validated our hypothesis that status of environmental regulation in a state and investment in pollution control, along with conventional inputs like capital and labour contribute significantly to the production of manufacturing in the states.

In **Chapter 4**, we attempted a regression analysis to determine whether investments in pollution control by a state's manufacturing units and status of environmental regulation in a particular state play any significant role in the acquisition of quality status certification by the manufacturing units in the states. We explored the hypothesis on the quality status of manufacturing by using multi-variable linear regression models for the year 1997-1998. Our results in this chapter validated the hypothesis that quality status of the manufacturing in the states is a positive and significant function of capital investment for pollution control; a resultant of environmental regulation in a state. Also, effective environmental regulation positively contributes to the acquisition of quality status certification in the 21 states considered for the analysis. But, with regards to the impact of poor, mediocre and excellent environmental regulation status on the quality status, significant results were obtained only for two extreme status of environmental regulation. That is to say, states with excellent status of environmental regulation were performing better in contrast to the states with poor status of environmental regulation on the quality status front. Thus the states having the maximum number of factories with pollution abatement facilities were also the most successful ones in acquiring the quality status certificates. Hence we could conclude that the status of environmental regulation and investment in pollution control does lead to *differentiation* among the different state's manufacturing units (with respect to the quality of the manufacturing process).

The following conclusions could be drawn from the amalgamation of the two chapters i.e. **Chapter 3 & Chapter 4.** Status of environmental regulation in a state can have two effects: one *indirect effect* which is reflected in the investment for pollution control by the state's manufacturing units and the other is the *direct effect* which is captured by the dummy variable for effective environmental regulation. According to the *direct effect*, states with effective environmental regulation status perform better than the states with ineffective environmental regulation status both at the production front as well as the quality status front. So if there is a demand for high quality product then the states with effective environmental regulation have a competitive advantage over the states with ineffective environmental regulation in terms of differentiation. Moreover, this gain in competitive advantage is not accompanied with a loss in manufacturing production. It thus seems reasonable enough for states to improve the enforcement and monitoring of environmental regulation especially pertaining to the industrial pollution. But investment in pollution control, the *indirect effect* of environmental regulation in a state gave opposite direction results for the manufacturing production and acquisition of quality status certification. The results revealed that an increase in investment for pollution control was accompanied by a decrease in the manufacturing production and but an increase in the acquisition of quality status certification among the manufacturing units for the year 1997-1998. This raises the issue of optimum amount of investment in pollution control which would enhance the quality of manufacturing production with a lower negative impact on the manufacturing production. In the era of increased environmental concern, investments in pollution control should thus become an important determinant of production along with conventional inputs like capital and labour.

From these chapters we can conclude that both the investments in pollution control as well as the status of environmental regulations in a state are the significant determinants of the production and the quality status of manufacturing in the Indian context. This appears to be true at least at the state level manufacturing exercise. But is the investment for pollution control an important determinant of production at the industry level too? For this we need to consider the industry level production function; an exercise which has been tried in the Appendix. The results obtained in the Appendix confirm the importance of investment in pollution control as a determinant of production at the industry level. At the industry level too investment in pollution control has a significant and negative impact on the manufacturing production.

In **Chapter 5**, we tried to explore the relationship between development, industrial pollution intensiveness and compliance taking into consideration 13 major Indian states. The main emphasis here was to see whether development plays any role in rendering the environmental regulations that is being followed by the government of a particular Indian state effective. For this purpose three indices Development index, Industrial Pollution Intensiveness index and Industrial Pollution Control index were constructed and the 13 Indian states were ranked in descending order of the index values to bring out the inter-state picture clearly. Finally, a correlation analysis was carried out to see whether the three indices are linearly associated. Non-linear association between the development and the industrial pollution control status was also explored by fitting in quadratic and cubic regression lines into the scatter of observations through a number of graphs. Development index so constructed gave the development status of the 13 states. A higher Development index value denoted higher development status for a state. Industrial Pollution Intensiveness index i.e. IPI index gave the spatial concentration of pollution intensive industries in each of the 13 states. A higher IPI index value denoted a higher degree of pollution intensiveness in a state and such a state was ranked high in contrast to the other states. Finally, Industrial Pollution Control index i.e. IPC index gave the pollution control status of manufacturing in the 13 states considered for the exercise. IPC index value is a direct outcome of the functioning of SPCB in a particular state. So a high IPC index value implied a better compliance status in a state which is a result of effective environmental regulation that is being followed in the concerned state. The correlation analysis so carried out in the chapter gave significant and positive correlation coefficient between the Development index and the IPC index. The significant and positive correlation that we obtained between the Development index and the IPC index actually implied that there was a positive and significant (even though low) linear association between development status and the effectiveness of environmental regulations (especially the ones related to industrial pollution control) in a state. To explore the non-linear association between the development and the pollution control status we tried to fit in quadratic regression line into the scatter of observations. The graph so obtained depicted that as the development status among the 13 states increases, the level of pollution control (as shown by the IPC index) increases at an increasing rate. We could thus conclude that with development the effectiveness of the environmental regulation in a state increased at an increasing rate. More interesting result was obtained when the 4 low rankers as per the IPC index were dropped from the observation set. This new scatter of observation gave a J-shaped curve when quadratic regression line was fitted into the scatter. According to this J-curve as the development level of 0.613024 (as per the development index value) is attained the environmental regulation starts becoming effective at an increasing rate. So from this chapter we could conclude that a certain level of development is a pre-condition for environmental regulation in any state to be effective.

*From this dissertation we can conclude that effectiveness of environmental regulation in a state and hence investment in pollution control by the manufacturing in a state, play a determinant role in the production and the quality status of manufacturing in the state. Our results revealed that investment in pollution control negatively affects the production level of the manufacturing, but at the same time it positively contributes to the acquisition of quality status certification by the manufacturing units. This raises the issue of optimum investment in pollution control which would ameliorate the quality of manufacturing process without much hampering the production level. That is to say, such an optimum investment in pollution control would make the manufacturing units competitive with respect to the differentiation attribute without much hampering the production level. But whether the environmental regulation in a state would be effective or ineffective depends upon the status of development in a state. In fact, after attaining a certain level of development the effectiveness of environmental regulation increases at an increasing rate. This increasing effectiveness of environmental regulation stands to positively affect the production and quality status of the manufacturing industries.*

## 6.2 Limitations

The major shortcoming of this Dissertation is that it is not a time-series analysis. It is a cross-section analysis which takes into account just on year i.e.1997-1998. An exercise similar to the ones in Chapter 3 and Chapter 4, but based on the panel data, which would take into consideration a number of years would have definitely yielded better and concrete results. Such an exercise would have revealed the long run effect of the investments in pollution control on production and quality status of manufacturing in the Indian states. Also a similar exercise with industry level panel data would have yielded the results from industry's perspective. This would have helped us in finding out the optimum amount of investment in pollution control along with the investment in capital for pure production purpose, which would help the industry to attain certain quality standards without much hampering the level of production.

Similarly the major limitation of the exercise attempted in Chapter 5 is that it's not a dynamic analysis which is required for testing the relationship between development, pollution and compliance. Due to the lack of time series data on state-wise compliance in the manufacturing sector the IPI index and the IPC index considers only one year i.e.1997-1998. We would have obtained more conclusive results if state-wise manufacturing compliance figures were available for the time period 1991-1992 to 1997-1998 (because Development index considers the time period 1991-1992 to 1997-1998).

## 6.3 An Agenda for Future Research

The major shortcoming of this study is that it is not a time-series analysis. It is a cross-section study which takes into account just one fiscal year i.e. 1997-1998 because of the lack of availability of compliance figures for other years. To overcome this limitation a time-series compliance data is required for the Indian industries which unfortunately is not available at the ASI level. So a similar type of time-series analysis of the three issues addressed in the dissertation is at the moment not possible. However, the results obtained in Chapter 3 and Chapter 4 does give us an agenda for future research.

We saw in Chapter 3 and Chapter 4 that an increase in investment for pollution control in the states was accompanied by a decrease in the manufacturing production and but an increase in the acquisition of quality status certification among the manufacturing units for the year 1997-1998. This thus raised the issue of optimum amount of investment in pollution control which would enhance the quality of manufacturing production with a lower negative impact on the manufacturing production. An agenda for future research could be to theoretically determine the optimum amount of investment in pollution control which would ameliorate the quality status of manufacturing process without much hampering the production level. That is to say, how to divide the limited resources between pure production purpose and pollution control purpose so as to improve the quality status of manufacturing process without much hampering the production level?

## Appendix

Impact of investment in pollution control on production at NIC-87 3-digit level

**Production function:**

$$Prdn = f(K_{pur}, K_{pol}, L) \text{ ------------------------- } (1)$$

Where,

**Prdn:** output of the manufacturing units in each of the 163 industries (NIC-3 Digit level)

$K_{pur}$ **:** Capital investment meant for pure production purpose exclusive of pollution control purpose.

$K_{pol}$ **:** Capital investment meant for pollution control purpose.

**L:** Labour required for the production purpose.

The production function in this analysis, besides considering the conventional determinants like capital and labour also considers capital investment meant for pollution control in each of the NIC-3 Digit 163 industries. We next specify the model considered for the analysis. We first write the production function in the non-linear form taking into account the dependent variable and the quantitative explanatory variables like $K_{pur}$, $K_{pol}$, and L.

$$Prdn_i = \beta_0 \, K_{puri}^{\beta 1} \, K_{poli}^{\beta 2} \, L_i^{\beta 3} \, e^{ui} \qquad \text{where } i=1 \ldots\ldots\ldots 163 \text{ ------- } (2)$$

Where,

$\beta_0 =$ Technological coefficient = 1[21]

[21] We are taking the technological coefficient to be 1 as ours is a cross-sectional study and not a time-series analysis where the role of technological coefficient becomes important in the production function. So there is no constant term in our model.

**u** = Stochastic disturbance term

**e** = Base of natural logarithm

**i**= Number of NIC 3-Digit industries for which the regression analysis is done i.e. i=1...163.

It is clear from equation (2) that the relationship between output and the quantitative explanatory variables is non-linear. If we log transform this model we obtain,

$$\ln Prdn_i = \ln \beta_0 + \beta_1 \ln K_{puri} + \beta_2 \ln K_{poli} + \beta_3 \ln L_i + u_i$$

$$\ln Prdn_i = \beta_1 \ln K_{puri} + \beta_2 \ln K_{poli} + \beta_3 \ln L_i + u_i \text{ ------ } (3)$$

All the above firm specific explanatory variables and the dependent variable are divided by the total number of factories in each of the 163 (NIC-3 Digit) industry in order to avoid the problem of heteroscedasticity which might arise in any cross-section study.

Table A(i) gives the descriptive statistics of the industry variables.

**Table A(i) Descriptive Statistics of the industry variables**

| Variables | N | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Prdn | 163 | 38.05 | 17659.11 | 1148.16 | 2157.70 |
| Kpur | 163 | 3.33 | 16821.95 | 502.95 | 1502.22 |
| Kpol | 163 | 0.007 | 136.93 | 8.41 | 21.76 |
| L | 163 | 10.40 | 2085.04 | 99.45 | 220.46 |

N: number of observations.

## The Results:

The table A(ii) gives the values of the partial regression coefficients and their corresponding t-values for the model. From a statistical viewpoint the estimated regression line fits the data very well. The adjusted $R^2$ value of 0.988 implies that about 99% of the variation in the (lognormal of) output is explained by the (lognormals of) explanatory variables.

| **Table A(ii) Result of the Industry Model** | | |
|---|---|---|
| VARIABLES | Coefficients | t-value |
| ln $K_{pur}$ | 0.551* | 12.880 |
| ln $K_{pol}$ | -0.038* | -3.954 |
| ln L | 0.450* | 10.560 |
| $R^2 = 0.988$ | | |
| adj $R^2 = 0.988$ | | |

* Significant at 0.01 level

As was expected the value of the partial regression coefficient for pure capital investment is significantly positive. The partial regression coefficient of pure capital investment i.e. elasticity of output with respect to $K_{pur}$ is 0.551. This implies that holding other explanatory variables constant a 1% increase in pure capital led on an average to a 0.55% increase in the output for the 163 (NIC-3Digit) industries in 1997-1998.

Capital investment in an industry for pollution control is also a significant determinant of the production. The partial regression coefficient of capital investment for pollution control i.e. elasticity of output with respect to $K_{pol}$ is -0.038. This implies that holding other explanatory variables constant a 1% increase in pollution control capital led on an average to a 0.04% decrease in the output for the 163 (NIC-3Digit) industries in the year 1997-1998. However the elasticity of output with respect to $K_{pol}$ though negative, is very low. One reason for this low elasticity of output with respect to $K_{pol}$ could be that the capital investment in an industry for pollution control is a very small percentage of the total capital investment in almost 163 industries in 1997-1998.

Labour also like Capital investment in an industry is a significant and positive determinant of industry level production. The partial regression coefficient of Labour i.e. elasticity of output with respect to Labour is 0.450. This implies that holding other explanatory variables constant a 1% increase in labour led on an average to a 0.45% increase in the output for the 163 (NIC-3Digit) industries in 1997-1998.

So we can conclude that the investment for pollution control is an important determinant of production function (along with conventional inputs like investment for pure productive purposes and labour) at the industry level too.

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