Name: Shreekant Gupta

Title: Dr. (Associate Professor)

Affiliation: Massachusetts Institute of Technology
and
Delhi School of Economics, University of Delhi

Mailing Address: Centre for Energy and Environmental Policy Research
Massachusetts Institute of Technology
One Amherst Street (E40-281)
Cambridge, MA 02139-4307
USA

Telephone: 001-617-253-6017

Fax: 001-617-253-9845

E-Mail: shreekant29@yahoo.com
shreek@mit.edu

Paper Title: ENFORCEMENT OF POLLUTION CONTROL LAWS AND FIRM LEVEL COMPLIANCE: A STUDY OF PUNJAB, INDIA

JEL Codes: Q280, L200

ENFORCEMENT OF POLLUTION CONTROL LAWS AND FIRM LEVEL COMPLIANCE: A STUDY OF PUNJAB, INDIA

Abstract

Effective implementation of pollution regulations is an important concern for industrializing countries such as India. This paper undertakes an empirical analysis of the determinants of compliance with and enforcement of environmental regulations in India. In particular, the paper models: (i) firm-level compliance with water and air pollution control laws in the state of Punjab, and (ii) the decisions of the state regulatory agency, namely, the Punjab Pollution Control Board to enforce these laws through inspections. The two decisions are inter-related. For a sample of 114 large firms in the state our results indicate that the probability of inspection influences firm-level compliance and vice-versa. We also find that more profitable firms are less stringently monitored. The opposite is true for firms that have a history of noncompliance or are energy intensive.

February 15, 2002 **DRAFT**

ENFORCEMENT OF POLLUTION CONTROL LAWS AND FIRM LEVEL COMPLIANCE: A STUDY OF PUNJAB, INDIA

Shreekant Gupta*
Shalini Saksena#

I. Introduction

Early literature on economic approaches to environmental regulation typically assumed compliance by firms. Issues of monitoring and enforcement were therefore not addressed adequately in theoretical or empirical work in this area. The neglect of enforcement strategies in empirical analysis stemmed primarily from a paucity of micro-level data on enforcement and compliance. While there is now a growing body of work in this area[1] there is little research for developing countries such as India. This paper conducts a statistical analysis of enforcement and compliance using primary firm-level data for the Indian state of Punjab. It focuses on air and water pollution by firms and examines the enforcement of two key laws in this area, namely, the Water Act and the Air Act.

In India, implementation and enforcement of pollution control laws is the responsibility of State Pollution Control Boards (SPCBs). Punjab is an industrialized state with diversified industrial activity. The share of manufacturing and secondary sector in state income is about 21 percent and 29 percent, respectively.

The objective of this paper study is to investigate the bi-causality between the enforcement strategy of the board (PPCB) and the compliance behavior of firms, and to determine economic and financial factors that influence enforcement and compliance decisions. Our hypothesis is that the enforcement strategy adopted by the board and the compliance behavior of firms are interrelated. Thus, grossly polluting and recalcitrant firms are likely to face a higher probability of inspections and stricter actions against such behavior, while rigorous enforcement by the board is likely to result in greater compliance by firms.

Apart from a firm's compliance behavior, however, there are likely to be other factors that could determine the board's enforcement actions. These include the contribution by a firm to state employment and output, the size of the firm and its political backing. Similarly, factors other than those pertaining to the existing enforcement regime are likely to determine a firm's compliance behavior.

---

* Delhi School of Economics, University of Delhi, Delhi 110007, India. E-mail: shreek@mit.edu.
Centre for Development Economics, Delhi School of Economics provided financial support.
Delhi College of Arts and Commerce, University of Delhi, Delhi, India.
1. See for example the review by Cohen (1998).

These could include the financial stability of a firm, its capacity to lobby the regulator for favorable terms and conditions, the cost of compliance, etc.

In the paper, the following questions are addressed by way of analyzing the relationship between stringency of enforcement by the board and the compliance behavior of firms:

1. Does the existing enforcement regime have any bearing on compliance behavior of firms?
2. Do economic considerations such as a firm's share in state domestic product or state employment influence the stringency of monitoring and enforcement of pollution control laws by the board?
3. Do large and/or profitable firms manage to get around these laws or do they instead face a higher probability of being inspected since they are expected to be large polluters and/or deep pockets?
4. What are other important economic and social factors that influence enforcement and compliance decisions?

The paper is organized as follows: section II presents an overview of environmental regulation in India and in Punjab in particular; section III reviews existing empirical literature on the subject, section IV covers model specification and describes the data. The final section presents results and concludes.

II. Environmental regulation in India and in Punjab

There are elaborate legislative provisions for environmental protection in India. An extensive network of central and state pollution control boards, covering all states in the country has been established. Actual enforcement of environmental regulations takes place at the state level since the state pollution control boards have been entrusted with this task.

The Punjab Pollution Control Board was constituted in 1975 under the Water (Prevention and Control of Pollution) Act, 1974. The major functions of the board are the prevention, control and abatement of water and air Pollution (excluding vehicular pollution for which the implementing agency is the State Transport Commissioner).

The board collects, *inter alia,* a water cess under the provisions of Water Cess Act, 1977 and meets a part of its expenditure from this cess. The policies and decisions made by the Board are implemented through various cells/branches. All seventeen districts in Punjab are covered through eleven regional offices.

The main sources of air and water pollution in the state are industries, vehicles, sewage and solid waste, road dust and nonpoint sources. Industry is one of the main sources of air and water pollution (surface and groundwater). It also generates hazardous waste. The board has identified 16,676 polluting units in the state as of March 1998. Of these, 277 large units, 327 medium units and 9,423 small-scale units are in the "red" (highly polluting) category while the remaining 6,649 units are in the "green" (marginally/ moderately polluting) category. All large and medium units are classified as "red".

The course of compliance and enforcement events and decisions

A firms' decision to comply with the provisions of the Water and Air Acts is at two levels: (a) *initial compliance* that entails installation of the required pollution control devices, and (b) *continuing compliance* that requires regular operation and maintenance of the pollution control devices and compliance with air and water pollution discharge standards.

All prospective entrepreneurs are required to obtain the consent of the board to establish an industrial plant in the form of a No Objection Certificate or NOC (section 25/26 of the Water Act and section 21 of the Air Act) before their application for an electricity connection is accepted by the State Electricity Board. The construction of the plant and the installation of the pollution control device must be completed within the period of validity of the NOC which otherwise has to be revalidated for this purpose. Obtaining a NOC, however, became mandatory only from October 1994.

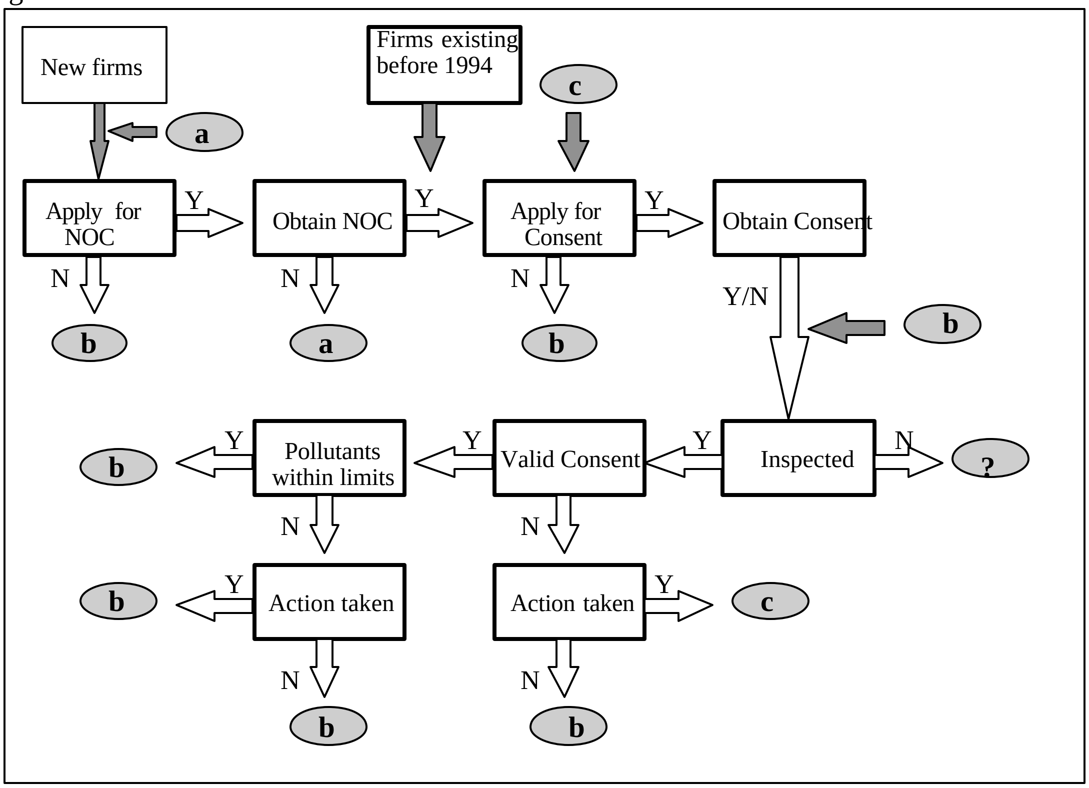
The next step for a firm is to obtain the consent of the board for operating an outlet for discharge of sewage/trade effluent under section 25/26 of the Water Act and for operating an industrial plant under section 21 of the Air Act. Consent is granted for 1, 5, 10, or 15 years as requested by the firm. The consent has to remain valid till such time that the plant modifies its processes or pollution control device (at which time a fresh consent has to be obtained). A firm has to apply for renewal of consent two months prior to its lapse. It is an offence to operate without a valid consent. The firm is also required to operate the pollution control equipment regularly and to get air and water samples analyzed periodically at designated labs. Limits for water quality parameters are shown in Table 1.

Table 1. Standards for discharge of trade effluent under the Water Act

Parameter	*Maximum concentration (mg/litre) except for pH*
pH	5.5-9.0
Biochemical oxygen demand (5 day 20^0 C)	30 (into inland surface water) 100 (on land for irrigation)
Suspended solids	100
Chemical oxygen demand	250
Total dissolved solids	2100
Chloride	1000 (into inland surface water) 600 (on land for irrigation)
Sulphates	1000
Bioassay test	90% survival of fish after 96 hours in 100% effluent

The board issues NOCs to new units on submission of a scheme for pollution control. It also issues consents under Water and Air Acts after the unit takes adequate pollution control measures. *In effect, the board performs its regulatory function through the consent mechanism*. As stated earlier, consents range from 1 to 15 years for highly polluting industries and indefinitely for green category industries.

Figure 1 Course of events and decisions



An oval node preceded by a blank arrow joins the chain at the same node followed by a filled arrow. Thus, for instance when a firm does not apply for NOC, node 'b' leads from 'Apply for NOC' stage and rejoins the chain at the 'Inspected' stage.

The board assesses compliance by a firm through onsite inspections. All large and medium firms and red category small-scale firms are inspected at least once every six months and once a year, respectively. The board carries out two main types of inspections: (i) *compliance evaluation inspections* where a firm's pollution control facilities, monitoring methods and records are examined. This amounts to verification of initial compliance by a firm, and (ii) *compliance sampling inspections* where air/water samples are collected onsite. Pollution control devices and testing procedures with the firm (if any) are also inspected. Such inspections check for continuing compliance by a firm.

Violations by a firm can be in the form of: (i) operating without a valid NOC and/or consent to operate; (ii) absence/inadequacy of pollution control device; (iii) discontinuous operation of pollution control device; (iv) non-submission of Environmental Audit Statement, and (v) exceeding effluent/emission standards. These violations are discovered through routine/surprise inspections or through public complaints that in turn result in inspection of a firm. Violating firms are first sent letters or notices of violation. Reminders are sent to them if necessary to take measures for compliance. If a firm does not respond to these notices, the board issues show cause notices and a hearing is fixed where the firm is given a chance to explain the steps it proposes to take to attain compliance[2].

The board can also file a criminal suit against a firm at any stage of noncompliance. Court cases, however, are usually lengthy and prosecution of the firm if any can take years. In light of this, the Water and Air Acts were amended in 1987 to give executive powers to the Chairman of SPCBs whereby s/he can issue directions to prohibit/regulate/close a violating firm. Thus, as a last resort a board can issue an administrative order to a violating firm for its closure (sections 31-A and 33-A of the Air Act and the Water Act, respectively).

III. Empirical literature on compliance and enforcement

The bulk of economic literature on pollution control monitoring and enforcement assumes that firms act in good faith and comply with environmental regulations. As Cohen (1998), however, notes, "...the consequences of ignoring monitoring and enforcement issues can be disastrous for environmental quality and for social welfare." There has been substantial work on theoretical and empirical aspects of compliance and enforcement during the 1990s.

One of the earliest studies (for pulp and paper in the United States) examined the impact of inspections on the absolute level of pollution and on whether or not a firm was in compliance in any given period (Magat and Viscusi 1990). Pollution by a firm was assumed to depend on lagged pollution, inspections, capacity, location, nature of output and season. A key finding was that inspections substantially reduced BOD discharges with a lag of about one quarter, and also had a permanent effect on reducing a firm's future pollution levels.

Laplante and Rilstone (1995) extended the work by Magat and Viscusi to measure the impact of inspections on self-reported emissions by pulp and paper plants in Quebec. Unlike Magat and Viscusi who could only test if plants complied or not, Laplante and Rilstone could also test for the impact of inspections on the level of emissions *relative* to the standard and thus measure the *extent* of violation. Their basic model includes both the number of actual inspections and the expected number of inspections as explanatory variables in different equations. The results strongly suggested that both the threat of an inspection as well as actual inspections had an impact on emissions.

Deily and Gray (1991) is one of the most comprehensive studies in this area. Using an approach similar to Magat-Viscusi and Laplante-Rilstone, they estimate three equations to inquire whether: (i) enforcement influenced a firm's compliance behavior; (ii) a firm's compliance decision affected the level of enforcement for its plants, and (iii) enforcement and compliance decisions together affected plant-

2. Show cause notices are served: either (i) in violation of provisions of section 25/26 of the Water Act punishable under section 43, 44, and/or (ii) in violation of provisions of section 21 of the Air Act punishable under section 37, 39 read with section 40.

closing decisions. They found the expected interactions between decisions, namely, (i) at the plant level, greater enforcement led to greater compliance, (ii) greater compliance led to less enforcement, and (iii) plants in a declining industry predicted to face relatively heavy enforcement were more likely to close.

In the absence of micro level data on environmental variables, an alternative approach is to examine the effect of regulation directly on stock prices of affected firms. Hamilton (1995) examined whether data on pollution released by USEPA in the June 1989 Toxic Release Inventory (TRI) was 'news' to journalists and investors. It used the event study methodology to study the impact of the release of TRI data. Pollution figures in TRI provide 'news' to the financial community to the extent that the data deviates from expectations about a firm's pollution patterns. Stockholders in firms reporting TRI pollution figures experienced negative abnormal returns upon the first release of information and ended up with a loss of $4.1 million in stock value on the first day of the release. The study concludes that the TRI represents an innovative attempt by the USEPA to use information as a regulatory tool. A similar study by Badrinath and Bolster (1996) examined the impact of EPA judicial actions on the value of firms cited for violations of environmental laws. It found that while the event of filing of a citation appeared to be anticipated by investors, at the time of settlement of the case, there was a small, but statistically significant drop in the market value of equity of the average cited firm. They concluded that the stock market, at the very least, reinforces the intent of penalties and fines by providing incentives for corporate compliance.

Broadly, the following stylized facts emerge from the empirical studies:

- higher levels of enforcement activity result in lower levels of pollution in subsequent periods
- greater compliance results in less enforcement activity
- inspections are effective at inducing more frequent self-reporting
- plants which are not financially sound are more likely to be in noncompliance.

In India there has been little work on enforcement and compliance and there is no comprehensive environmental database. Even the Central Pollution Control Board (CPCB) has limited information and no system of regular reporting by state boards is in place. Thus empirical work for India has to collect primary data. Pargal, Mani and Huq (1997) use survey data from India to study the link between enforcement stringency and the level of compliance. They use plant-level survey data for 8 states in India, collected in early 1996. The regression model estimates an emissions equation with emissions as a function of factor prices, scale of operation, regulatory pressure as measured by inspections and shift factors such as plant age, other plant-level characteristics (whether they export or not and whether they are publicly traded and the sector to which they belong). Plant inspections are modeled as a function of expected emissions of a firm, plant age and size, the extent of manufacturing activity, the end use of water in the effluent stream and district's level of development (a measure of community pressure). They find that inspections have no impact on emission levels. They attribute this result to the low probability of enforcement as well as the low penalties for noncompliance. Their paper draws attention to shortcomings in the working of the formal regulatory system in India with inspections having no significant impact on emission points. The analysis provides no evidence of significant informal pressure on plants in India.

Our paper extends the earlier work through: (i) a microeonometric study using firm-level data for 196 firms in Punjab across 12 districts. This study is among the first in India to model firm level environmental behavior using primary data; (ii) while earlier studies look at either water or air pollution we analyze both; (iii) a more complete treatment of the factors affecting enforcement—in addition to formal inspections by the board, we also gather data on other enforcement actions such as notices of violation, show cause notices and administrative orders issued to a firm; (iv) our paper models compliance and enforcement decisions as simultaneous decisions (recognizing the potential endogeneity between them) that depend not only on environmental variables but also on plant-level and firm-specific variables, and (v) collection of data for each firm over a period of time (a minimum of five years except for very new firms) to infer a causal relation between inspections and reduced pollution. Since there is a lag between enforcement actions and the consequent change in compliance behavior, it is best to study the relation between present compliance status and lagged enforcement, and present enforcement and lagged compliance status.

IV. Model specification and data

We estimate the relationship between two potentially endogenous decisions, enforcement and compliance. In the first stage, the predicted version of each decision are generated by regressing actual observations on a set of instruments and the resulting predictions are then used in the structural specifications as discussed below.

Assuming profit maximizing behavior each firm weighs the cost of compliance against that of noncompliance before making its compliance decision. The expected cost of noncompliance is determined by probability of detecting violation and the subsequent penalty imposed on the firm. Both the probability of detection and magnitude of penalty must be high enough to pose a credible threat to a firm. The penalty for noncompliance constitutes the benefit of compliance. Cost of compliance includes all capital expenditures for pollution control equipment or for retrofitting current capital, operating and maintenance of pollution control equipment and any lost productivity of the original capital due to pollution control efforts, as well as all expenses incurred in obtaining NOC, consent to operate, sample testing procedures, etc.

The bi-causality between enforcement and compliance arises since enforcement actions are firm specific. It is expected that public complaints, political pressure and recurring noncompliance result in stricter monitoring of a firm by the pollution control board. For a firm against which there are no public complaints or adverse lobbying, the most important factor that could determine the stringency of enforcement would be its record of compliance. Thus, grossly polluting and recalcitrant firms are likely to be grouped together to face both a higher frequency of inspections and stricter action against noncompliance.

The compliance decision

In its simplest version, the compliance decision is determined by frequency of inspections, cost of compliance and plant level characteristics.

$$\text{Compliance} = F(\text{P\_inspections, cost, PCD, case, district dummy, } F)$$

The dependent variable is a dummy that reflects a firm's decision to comply and the equation is estimated using a probit model. Compliance status is determined from the board's inspection reports. A firm is noncompliant if (a) it is operating without a consent to operate and/or (b) it has not installed adequate pollution control device (or is not operating the device properly) and/or (c) it exceeds the concentration limit with respect to any pollution parameter.

P_inspections is the predicted number of inspections estimated in the first stage regression. It is expected to have a positive sign since an increase in the frequency of inspections should induce greater compliance. The stringency of enforcement is only captured through the number of inspections per firm since other types of enforcement actions such as show cause notices, warnings or administrative orders follow automatically from past noncompliance as per inspection report.

To model costs of compliance, an appropriate measure would be one that represents the expenditure required to bring a plant into full compliance and maintain it. Since the data includes different kinds of industries it is difficult to assess the total capital cost of bringing every kind of firm into compliance. The variable 'cost' measures the expenditure on installing and maintaining the pollution control device (actual and expected). This, however, need not be the total expenditure required to attain full compliance. The sign of the coefficient cannot be predicted a priori. On one hand, a firm that incurs large expenditure on pollution control is likely to return to compliance if it violates in a particular time period unintentionally. On the other hand, firms could have large pollution abatement expenditures in absolute terms only because of they are large, *per se*, and yet they may fall well short of the required expenditure for full compliance.

PCD is a dummy variable that takes the value 1 if a firm is required to install a pollution control device (PCD)[3]. Not all firms are required to install a PCD. A firm that has adequate arrangements to recirculate all the trade effluent it generates does not need to install an effluent treatment plant (ETP). Similarly, firms that do not use rice husk in loose form as fuel, do not need to install a fluidized bed combustion system[4]. For firms that do not require a PCD, compliance is determined on the basis of adequacy of alternative methods to control pollution (i.e. recirculation system and/or adequate stack height) and possession of a valid consent to operate.

3. An effluent treatment plant (ETP) for trade effluent and an air pollution control device (APCD) for emissions.

4. In fact, as long as generation of air and water pollution is within manageable limits, a recirculation system for trade effluent and adequate stack height for air pollutants are deemed to be adequate and there is no need for an ETP or APCD.

Similarly, case is a dummy that takes the value 1 if a case was ever filed against that firm under the provisions of Water and Air Acts during the period of study. *A priori*, it is expected to have a positive coefficient since firms that are being prosecuted/have been prosecuted are already under close supervision by the board and this must induce greater compliance.

A district dummy is included to capture regional variation in compliance behavior of firms. The sample covers 12 districts that come under the jurisdiction of 11 regional offices. F is a vector of plant level characteristics that includes:

(i) The rate of return or profit after tax as a measure of the financial health of a firm. Since compliance is expensive financially sound firms are more likely to invest in costly abatement technology and be in compliance. Such firms, however, could also spend money to avoid action by the pollution control board against them for noncompliance. Thus, *a priori* the sign of the variable is ambiguous;

(ii) Allowing for economies of scale in pollution abatement technology, larger firms are expected to have higher compliance rates because of lower unit costs of abatement. Gray and Deily (op. cit.) point out that such economies might arise "if there are fixed costs to learning about the regulations, or in researching their implementation." Thus, turnover measures the value of total output for sale or for internal consumption.

(iii) Age is measured since the year of commissioning of the plant. Older plants using outdated abatement technology and dirtier production processes are *ceteris paribus* more likely to be in violation.

(iv) The ownership dummy variable classifies firms as state owned or private on the presumption that the corporate culture and management systems of private firms are superior, and that this has a bearing on their compliance behavior.

(v) Listed is a dummy for firms that are listed on any of the stock exchanges (national or state level). A listed firm is more likely to be concerned about its image and reputation as an environmentally friendly firm, and consequently it may be more likely to comply.

(vi) Type is a category dummy for firms belonging to pulp and paper, sugar and fertilizer industries. These industries are relatively dirty and the variable is expected to have a negative sign.

The enforcement decision

The regression model estimates the enforcement equation in the second stage as

Inspections = G(P_Compliance, PCD, case, Y)

The dependent variable is the total number of inspections faced by a firm during the reference period as a measure of enforcement stringency. Other enforcement actions are not included as explained above.

P_compliance is the predicted level of compliance computed in the first stage regression. A priori, this variable is expected to have a negative sign since firms that are complying are likely to face a lower frequency of inspections. PCD devices are required where pollution is relatively more severe. Such firms are likely to be monitored closely. Thus, this variable is expected to have a positive sign. Though the case variable seems to capture the same effect as P_compliance for a firm, it is different in nature. While a firm may have a poor compliance record only because of marginal violation only very persistent and intentional violators are taken to court. Thus, the difference between case and P_compliance is one of the extent of violation as also the intention and attitude of a firm towards environmental problems.

Y is a includes plant level characteristics described earlier such as rate of return, turnover, ownership and age, and also a measure of the plant's total employment reflecting concern for the local economy. Thus, firms that are large employers may face more lenient enforcement by the Board. In the absence of employment data, however, we use wages as a proxy.

Because of endogeneity we estimate the following two equations using two-stage least squares. The compliance equation is estimated using a probit model in both first and second stage regressions. Inspections being a count variable, is estimated using quasi maximum likelihood estimation techniques. Further details are provided in the following section.

Compliance = F(P_inspections, cost, PCD, case, district dummy, F)

Inspections = G(P_compliance, PCD, case, Y)

Data

Primary data on environmental variables at firm level has been collected from files for each firm maintained with the Punjab Pollution Control Board at Patiala, Punjab. The data in the files is confidential and was made available for this paper on request from the Central Pollution Control Board, Delhi. The consent management cell at PPCB maintains files for each firm and all paperwork with the firm is recorded in these files. While the regional offices maintain such files for small scale and medium scale industries, the files for large and large-medium scale industries are maintained with the PPCB at Patiala. Since the study is restricted to large and large-medium scale industries, all the required data was available at PPCB.

Wholesale price indices for manufactured products were used to deflate turnover of industries while the total wage bill was deflated using consumer price indices for industrial workers. The former indices are available in RBI bulletins and the latter were be obtained from the Monthly Review of the Indian Economy published by Centre for Monitoring the Indian Economy (CMIE), Mumbai. Firm level financial data was extracted from the CMIE corporate database PROWESS. This database is regularly updated and has data on over 6000 companies since 1988-89 such as information from a company's profit and loss statement, balance sheet, information on cash flows, products manufactured, raw materials consumed, changes in capital structure, share price movements, returns, investment plans, etc.

(see Table 2 for a sample). For Punjab, PROWESS contains data on 196 firms on variables such as turnover, cost of raw materials, total wage bill, export earnings, research and development expenditure, sales, net profits etc[5]. (details in Table 3). Table 4 describes the variables used in the paper and summary statistics are presented in Table 5.

V. Results

The compliance equation

Preliminary regression results for the compliance equation are shown in Table 6. COMP is regressed on variables representing enforcement activities (INSP and CASE), firm level characteristics such as ownership (OWNER), stock market listing (LISTED), type of industry the firm belongs to (TYPE), and plant characteristics such as AGE of plant, cost of compliance (COST), treatment plant requirement (PCD), and rate of return (ROR) as a proxy for the financial health of the firm.

As expected plant characteristics such as SALES, TURNOVER, WGS and ENERGY are highly correlated (Table 8). Thus, separate compliance equations are estimated by including one correlated variable at a time. Table 7 reports the Jarque-Bera statistic for each variant and confirms normality of the corresponding error terms. Thus a probit model is used for estimating the compliance equation.

Figure 2. Graph of residuals of compliance equation

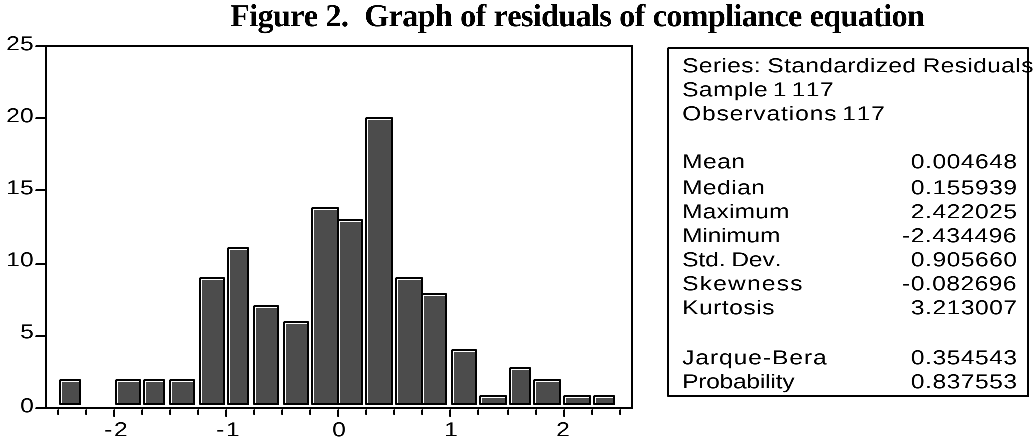


Table 7. Normality test for error terms of compliance equation

Variants	1. Sales	2. Turnover	3. Wages	4. Energy
Jarque-Bera	0.671	0.55	0.3545	0.677
Probability	0.715	0.759	0.837	0.712

Note: Chi-Square (df=2) is 5.99 (5%), 7.37(2.5%) and 9.21(1%)

5. Broadly, PROWESS is arranged into the following sections: (i) basic company background; (ii) financial performance; (iii) capital history; (iv) stock prices; (v) products manufactured; (vi) raw materials consumed, and (vii) other.

Table 8. Correlation matrix

	ENERGY	SALES	TURNOVER	WAGES
ENERGY	1			
SALES	0.790419	1		
TURNOVER	0.787369	0.986186	1	
WAGES	0.707133	0.920749	0.954011	1

The coefficients of PCD and COST have the expected sign but are not significant thus implying that requirement of a treatment plant or the cost of attaining full compliance does not affect compliance behavior. In fact, coefficients of other firm characteristics such as ROR, OWNER, TYPE, LISTED and EXPORT are all insignificant. Variants 1 and 2 show that sales' or 'turnover' of the firm also has no significant impact on compliance status. Thus the data reveals no evidence that scale economies increase compliance.

Since variables such as SALES and TURNOVER[6] capture the same effect on compliance, the first and second variants of the model give more or less similar results. In fact, the fourth variant that includes ENERGY also gives similar results. All these three variables have negative coefficients but are not significant.

The coefficient of number of Inspections faced by a firm is significant but has the wrong sign. A negative coefficient indicates that enforcement activities decrease compliance. We should, however, be cautious in interpreting this coefficient. To study the link between inspection frequency and compliance pattern, a measure of lagged inspections should have been used. Firms, however, are not inspected every year and sometimes not inspected for a number of years (Table 9). Thus, about 10% of the firms in the dataset were not inspected in five years and only about a quarter of the firms faced more than one inspection in a year. Compliance status (which is known only for the years when firms are inspected or notified through court summons or violation notices), is not known in many cases for the period after inspections. The data can thus be used to obtain the compliance status and the number of inspections faced during the same time period.

Table 9. Frequency distribution of inspections during 1994-99

Number of inspections (n) over 5 years	0	1	2	3	4	5	= 6
Number of firms (total firms = 117)	12	23	15	12	10	12	33
% firms with n inspections in 5 years	10.3	19.7	12.8	10.3	8.5	10.3	28.2

6. Other firm level variables were also tried such as net value added/gross value added. The results did not change significantly.

In such a case COMP and INSPECT may actually reflect reverse causality: firms that are more likely to be out of compliance, face higher inspection frequency. The potential endogeneity is of particular interest. Some of the district dummies have significant coefficients indicating some differences in compliance pattern across districts. The compliance equation does fairly well, predicting compliance status correctly 72% of the time.

<u>The inspections equation</u>

Three variants of the inspections equation are reported[7]. Inspection being a count variable, is estimated using quasi maximum likelihood estimation techniques. In the first stage the model is tested for overdispersion and after confirming overdispersion and calculating the fixed variance parameter, the model is re-estimated using Negative Binomial Quasi Maximum Likelihood Estimation (NB-QMLE) technique[8]. The fixed variance parameters worked out from first stage regressions are reported in Table 10 along with results of NB-QMLE.

Given the inspections equation, INSP = G(PCD, COST, COMP, ROR,….) possible endogeneity of COMP is expected. To test for this, INSP is regressed on all regressors including COMP and COMP_RESID where the latter is generated in the first stage regression of COMP on regressors of the original model. A significant coefficient for COMP_RESID would confirm endogeneity. However, the NB-QMLE of INSP equation gives the following result for the two variables

	Coefficient	z-statistic	Probability
COMP	-0.8006	-0.4534	0.65
COMP_RESID	0.2980	0.1674	0.87

The test fails to confirm endogeneity.

In Table 10, PCD has a positive coefficient and is significant implying that firms that do need an effluent treatment plant are likely to be inspected more to judge the adequacy of the treatment plant and to confirm its proper and regular use. Note that firms that are not large water polluters do not need a treatment plant. They recirculate wastewater and thus only need a water recirculation system.

COST has a negative coefficient but is not significant. Thus the board does not use incurred costs of compliance as an indicator of actual efforts towards compliance, which is understandable since acquisition and installation of expensive treatment plants (ETP cost constitutes the major part in COST) does not ensure compliance. ETP has to be adequate, operated regularly and maintained properly.

7. The inspections equation is also estimated using other firm level variables such as sales and net value added. The results are not very different from the ones obtained in variant 1 where TURNOVER is included as a regressor.
8. Results of tests for overdispersion are not reported here. They are available from the authors on request.

ROR has a significant negative coefficient indicating that firms with a good rate of return in terms of net profit as a percentage of total assets, are likely to face fewer inspections than firms with a low rate of return. One (charitable) interpretation is that using ROR as a proxy for the financial health of a firm, the board may not closely watch firms that are doing well since these firms are more likely to be in compliance than the firms that are not in a position to meet abatement expenses. On the other hand, it could be that firms with 'deep pockets' can buy off the regulators.

Surprisingly, none of the district dummies are significant indicating no variation in enforcement activity across districts. One can clearly mark out districts such as Ludhiana and Kapurthala which are recognised as focal points for manufacturing industries while districts such as Rupnagar and Patiala are predominantly centres for services or non-manufacturing industries.

CASE has a significant positive coefficient indicating a tendency for the Board to exert greater pressure on firms, which have a history of noncompliance. A court case is usually filed in cases of gross violations and such firms need to be closely monitored even after the court case has been sorted out. COMP is significant and has the expected sign: frequency of inspections increases for firms that are frequent violators, while firms which are mostly in compliance, face fewer inspections. However the possibility of endogeneity has to be considered here.

OWNER has a positive coefficient indicating that private firms are likely to be inspected more frequently than Government firms. This along with the significant coefficient on ROR indicates strong possibility of lobbying by large and influential firms for preferential treatment.

The coefficient of LISTED is negative and significant. This is an interesting result as it indicates more regulatory actions against firms, that are not listed. Perhaps the regulators recognize that firms that are listed in stock markets, are likely to be more disciplined in as much as their reputation is at stake. AGE has a coefficient with the right sign but is not significant. Similarly the EXPORT dummy is not significant.

TYPE has the expected sign. Firms belonging to the three major polluting industries namely: pulp and paper, sugar and fertilizer industry, are likely to be inspected frequently. In fact, 15 out of 18 firms belonging to this category faced 5 or more than 5 inspections during the reference period. Firm level characteristics such as TURNOVER and WAGES (a proxy for employment) are surprisingly not significant. ENERGY, however, which was essentially providing the same information as TURNOVER in the compliance equation, plays a different role in the inspections equation. While the board does not change its regulatory efforts depending on turnover of a firm, it does exert more pressure towards firms that are energy intensive. Firms with higher power and fuel expenses are likely to generate more pollutants and thus need to be closely watched.

References

Badrinath, S.G. and P.J. Bolster. (1996). "The role of market forces in EPA enforcement activity." *Journal of Regulatory Economics* 10.

Cohen, M.A. (1998). "Monitoring and Enforcement of Environmental Policy," Vanderbilt University, Mimeo (August).

Hamilton, J.T. (1995)."Pollution as News: Media and Stock market reactions to the Toxic Release Inventory data." *Journal of Environmental Economics and Management* 28.

Laplante, B. and P. Rilstone. (1996). "Environmental inspections and emissions of the pulp and paper industry in Quebec." *Journal of Environmental Economics and Management* 31.

Magat, W.A.and W.K.Viscusi. (1990). "Effectiveness of EPA's regulatory enforcement: the case of industrial effluent standards." *Journal of Law and Economics* 33.

Mani, M.S., S.Pargal and M.Huq. (1997)."Does Environmental Regulation Matter? Determinants of the Location of New Manufacturing Plants in India in 1994." World Bank Policy Research Working Paper (February).

Mary E. Deily and W. B. Gray. (1991). "Enforcement of pollution regulations in a declining industry." *Journal of Environmental Economics and Management* 21.

Nadeau, L.W.(1997). "EPA effectiveness at reducing the duration of plant-level noncompliance." *Journal of Environmental Economics and Management* 34.

Pargal, S., M.Mani and M.Huq. (1997). "Inspections and Emissions in India. Puzzling survey evidence about Industrial Pollution," World Bank Policy Research Working Paper. (August).

Russell, C.S., W.Harrington and W.J.Vaughan. (1986). *Enforcing Pollution Control Laws.* Resources for the Future, Washington.D.C.

Wayne B. Gray and M.E. Deily. (1996). "Compliance and Enforcement : Air pollution regulation in the U.S. steel industry." *Journal of Environmental Economics and Management* 31.

Table 2. Sample list of variables for which data is available in PROWESS

AMRITSAR											
Company Name	**Plant location**	**Ownership Group**	**Other_ share**	**inc_yr**	**Listing _flag**	**solvency _ratio**	**debt_ equity ratio**	**Sales**	**total_ income**	**wages**	**net_ profit**
Arihant Threads Ltd.	Goindwal Sahib	Arihant Group	44.76	1992	B2	3.2	0.43	16.1	16.88	0.77	0.04
Bharat Heavy Electricals Ltd.	Goindwal	Central Govt. - Commercial Enterprises	0.96	1964	A	1.58	0.15	6647.18	6827.75	952.46	719.53
Birla V X L Ltd.	Chheharta	Birla S.K. Group	27.82	1948	B1	1.32	2.56	678.75	748.33	68.65	-1.14
Chaman Lal Setia Exports Ltd.	Meerankot Road	Private (Indian)	14.64	1994	B2	3.49	0.24	35.39	34.22	0.47	1.19
Gupta Fibres Ltd.	Amritsar	Gupta Carpet Group	52.05	1985	B2	3.64	0.26	1.55	1.98	0.1	-0.44
Hindustan Vegetable Oils Corpn. Ltd.	Amritsar	Central Government - Takenover Enterprises	0	1984		1.98	0.16	111.96	114.7	12.19	-1.72
K J International Ltd.	Chabba	Private (Indian)	26.22	1991	B2	1.53	1.68	73.43	72.19	1.47	0
National Textile Corpn. (Delhi, Pun. & Raj.) Ltd.	Amritsar	Central Government - Takenover Enterprises	0	1974		0.12	-0.66	41.94	53.36	23.47	-41.51
Nijjer Agro Foods Ltd.	Jandiala Guru	Joint Sector	53.81	1988	B2	1.21	2.1	28.4	28.58	1.58	-0.27
Partap Steel Rolling Mills (1935) Ltd.	Chheharta	Partap Group	46.22	1971	B2	0.72	-1.87	22.69	22.82	2.6	-11.73
Prakash Industries Ltd.	Rayya	Prakash (Surya Roshni) Group	14.34	1980	B1	0.95	-15.82	759	770.41	15.22	-320.07
Rana Sugars Ltd.	Buttar Savian	Joint Sector	39.56	1991	B2	1.37	1.92	55.11	55.95	2.1	1.76
Satnam Overseas Ltd.	Amritsar	Private (Indian)	20.49	1989	B1	1.48	1.71	286.49	309.97	1.82	8.54

Table 3. Description of datafields extracted from PROWESS and availability of data for 196 firms in Punjab

VARIABLE	EXPLANATION	BLANK OBS	ZERO_ OBS	NON ZERO OBS	TOTAL
OWNERSHIP GROUP	BROADLY DIVIDES INDUSTRY INTO GOVT & PVT. Cos.	0	0	196	196
OTHER_SHARE	% SHARES HELD BY PUBLIC	0	86	110	196
INC_YR	YEAR OF INCORPORATION	0	0	196	196
LISTING_FLAG	WHETHER LISTED ON ANY STOCK EXCHANGE (NATIONAL OR REGIONAL)	34	0	162	196
SOLVENCY_ RATIO	FORMULA AVAILABLE IN PROWESS MANUAL	0	0	196	196
DEBT_EQUITY_R ATIO	FORMULA AVAILABLE IN PROWESS MANUAL	0	3	193	196
SALES	GROSS INCOME FROM SALE OF MANUFACTURED AND TRADED GOODS	0	1	195	196
TOTAL_INCOME	TOT INCOME OF COMPANY FROM ALL ACTIVITIES	0	1	195	196

Table 3 continued.

VARIABLE	EXPLANATION	BLANK OBS	ZERO_ OBS	NON ZERO OBS	TOTAL
TOT_RAW_ MATERIAL_ EXPENSE	EXPENDITURE ON RAW MATERIALS	0	2	194	196
ENERGY	POWER & FUEL EXPENSES	0	7	189	196
WAGES	WAGES & SALARIES TO ALL EMPLOYEES INCLUDING ALL BONUSES, INCENTIVES etc.	0	3	193	196
NET_PROFIT	PROFIT AFTER TAX i.e. EXCESS OF INCOME OVER ALL EXPENSES	0	2	194	196
R_AND_D_ CAPITAL	R & D CAPITAL EXPENSES	0	160	36	196
R_AND_D_ CURRENT	R & D REVENUE EXPENSES	0	145	51	196
RESERVES	REFLECTS ACCUMULATED RETAINED PROFITS OF A COMPANY	0	0	196	196
GFA	GROSS FIXED ASSETS	0	0	196	196
NFA	NET FIXED ASSETS	0	0	196	196

Table 4. Description and definition of variables used

S.No	**Variable**	**Description**	**Definition**	**Units**	**Source**
1.	**Comp**	Compliance status of a plant	A dummy variable = 1 if the plant is complying. Compliance/non compliance is determined from inspection reports. Compliance over the most recent 5 year period for which data is available, is determined using a simple majority rule. If a plant is out of compliance more often than not, then Comp = 0 or else 1.	0/1	Primary
2.	**Comp_num**	Number of times found in compliance	Number of times a plant is found to be in compliance in the last 5 years. This variable is not defined for plants which have not been inspected in 5 years.	0,1,2,3,...	Primary
3.	**Pcomp_num**	Predicted Comp_num	Predicted number of times a plant is in compliance as obtained from first stage regression of Comp_num on all exogenous variables in the model.	0,1,2,3,...	Estimated
4.	**Insp**	Total number of inspections	Number of times a plant was inspected during the most recent 5 year period. It includes general inspections for verification and for sample collection.	0,1,2,3,...	Primary
5.	**P_Insp**	Predicted inspections	Predicted number of inspections as obtained from first stage regression of inspections on all exogenous variables in the model.	0,1,2,3,...	Estimated
6.	**Cost**	Cost of compliance	Installation and annual operation and maintenance cost of the pollution control device(ETP).	1980 rupees	Primary
7.	**PCD**	Pollution control device	A dummy = 1 if the plant requires an ETP/PCD as per PPCB guidelines.	0/1	Primary

S.No	*Variable*	Description	**Definition**	**Units**	**Source**
8.	**Case**	Court case under provisions of Water Act.	A dummy variable = 1 if a case was filed against the plant by the board during the reference time period.	0/1	Primary
9.	**Z_i**	Zonal dummy	3 zonal dummies for 4 zones as defined by PPCB. Reference category is zone 4.	0/1	Primary
10.	**ROR**	Rate of return	Obtained as a ratio of net profits to total assets of the plant where total assets include fixed assets, investments and current assets.	1980 rupees	Prowess
11.	**Turnover**	Value of output	Value of total output for sale and intermediate consumption.	1980 rupees	Prowess
12.	**Wages**	Wages and salaries	Total expenditure incurred by an enterprise on all employees, including the management. Besides salaries and wages, items such as payment of bonus, contribution to employee's provident fund and staff welfare expenses are also included under wages.	1980 rupees	Prowess
13.	**Listed**	Listing flag	A dummy variable = 1 if company is listed on the Bombay stock exchange.	0/1	Prowess
14.	**Age**	Age of plant	Age = 1998 - Year of commissioning of the plant.	Number	Primary
15.	**Export**	Exporting or not	Dummy = 1 if the plant exports.	0/1	Prowess
16.	**Owner**	Govt/Private	Dummy = 1 if Government owned plant (Central, State or Co-operative).	0/1	Prowess
17.	**Paper**	Paper industry	Dummy = 1 if the plant belongs to the paper industry	0/1	Prowess
18.	**Sugar**	Sugar industry	Dummy = 1 if the plant belongs to the sugar industry	0/1	Prowess
19.	**Chemical**	Chemical industry	Dummy = 1 if the plant belongs to the chemical industry.	0/1	Prowess

Table 5. Summary statistics of variables

	Units	Mean	Median	Maximum	Minimum	Std. dev.	Jarque-Bera	No. of obs.
Age	Years	17.61	13	119	2	17.47	594	117
Case	0/1	0.13	0	1	0	0.34	138.8	117
Comp	0/1	0.53	1	1	0	0.50	19.5	117
Comp_rate	0-100	46.35	42.86	100	0	37.08	8.51	105
Comp_num	Number	1.78	1	7	0	1.69	31.21	105
Cost	Rs. crores	0.27	0	15.18	0	1.48	39193	117
Energy	Rs. lakhs	2.57	0.61	36.7	0	5.19	1701.5	117
PCD	0/1	0.83	1	1	0	0.38	65	117
Export	0/1	0.61	1	1	0	0.49	19.68	117
Insp	Integer	4.53	3	35	0	5.10	1283.63	117
Listed	0/1	0.83	1	1	0	0.38	65.034	117
Owner	0/1	0.97	1	1	0	0.18	3387.7	117
ROR	Number	1.75	2.86	25.73	-86.3	10.88	6449	117
Sales	Rs. lakhs	58.93	14.02	1501	0	162.41	15483	117
Turnover	Rs. lakhs	50.24	12.6	1383.56	0	141.05	23329	117
Type	0/1	0.15	0	1	0	0.36	85.584	117
Wages	Rs. lakhs	3.87	0.55	208.35	0	19.56	51599	117

Rs. lakhs = 100,000 Indian rupees, Rs. crores = 10,000,000 Indian rupees

Table 6. Probit estimation of compliance equation

Dep. Variable	Variant 1		Variant 2		Variant 3		Variant 4	
Comp	Coefficient	z-statistic	Coefficient	z-statistic	Coefficient	z-statistic	Coefficient	z-statistic
Regressors								
PCD	-0.6282	-1.37	-0.6151	-1.34	-0.5912	-1.30	-0.6157	-1.35
COST	-0.1890	-0.27	-0.2023	-0.29	-0.2108	-0.30	-0.0388	-0.11
ROR	-0.0025	-0.15	-0.0020	-0.12	-0.0016	-0.09	0.0002	0.01
D1	-0.0280	-0.04	0.0323	0.04	0.1948	0.25	0.1733	0.22
D2	1.1332	1.34	1.1611	1.37	1.2041	1.43	1.0808	1.29
D3	1.1904	1.07	1.2177	1.10	1.2477	1.13	1.1939	1.12
D4	1.3700	1.27	1.3806	1.28	1.4293	1.32	1.3817	1.27
D5	-0.1532	-0.15	-0.1328	-0.13	-0.0552	-0.06	-0.1466	-0.15
D6	-0.2472	-0.32	-0.2274	-0.29	-0.2111	-0.27	-0.0997	-0.13
D7	0.5348	0.59	0.5405	0.60	0.5752	0.64	0.4856	0.54
D8	0.5530	0.53	0.5779	0.55	0.6203	0.59	0.5788	0.54
D9	1.3976	**2.61**	1.4118	**2.62**	1.4589	**2.68**	1.3787	**2.57**
D10	0.2964	0.57	0.3121	0.60	0.3733	0.72	0.3161	0.62
D11	1.0844	1.65	1.0946	1.66	1.1272	1.70	1.0476	1.57
CASE	-0.5528	-0.85	-0.5602	-0.87	-0.6108	-0.94	-0.6946	-1.04
INSP	-0.1875	**-3.06**	-0.1871	**-3.05**	-0.1863	**-3.04**	-0.1780	**-2.88**
OWNER	0.4509	0.75	0.4118	0.68	0.2965	0.48	0.3417	0.57
LISTED	0.3161	0.74	0.3295	0.77	0.3641	0.85	0.3725	0.86
AGE	0.0132	1.15	0.0133	1.16	0.0135	1.16	0.0162	1.35
EXPORT	-0.0383	-0.12	-0.0291	-0.09	0.0046	0.01	0.0082	0.02
TYPE	-0.4187	-0.77	-0.4343	-0.79	-0.4673	-0.85	-0.5808	-1.02
SALES	-0.0003	-0.259125						
TURNOVER			-0.0005	-0.422814				
WGS					-0.0125	-0.59269		
ENERGY							-0.0412	-1.06432
Log likelihood	-53.6952		-53.6339		-53.2196		-53.1053	
R square	0.3807		0.3807		0.3831		0.3863	
% correct predictions	76.0600		76.0600		76.0600		76.0600	

Table 10. Negative Binomial Quasi Maximum Likelihood Estimation of Inspections equation

Dep Var : INSP	Variant 1			Variant 2			Variant 3	
Regressors	Coefficient	z-Statistic		Coefficient	z-Statistic		Coefficient	z-Statistic
PCD	0.6720	**3.17**		0.6908	**3.25**		0.6460	**3.15**
COST	-0.0192	-0.54		-0.0197	-0.56		-0.0237	-0.71
ROR	-0.0142	**-2.09**		-0.0138	**-2.04**		-0.0138	**-2.13**
D1	-0.4184	-1.28		-0.3711	-1.11		-0.5130	-1.63
D2	0.5016	1.49		0.5226	1.55		0.5460	1.72
D3	0.1258	0.35		0.1498	0.42		0.0941	0.28
D4	0.4254	1.00		0.4315	1.01		0.3986	0.99
D5	-0.3132	-0.78		-0.3096	-0.77		-0.2316	-0.61
D6	0.2359	0.89		0.2713	1.04		0.0802	0.31
D7	-0.6827	-1.31		-0.6820	-1.31		-0.6276	-1.23
D8	0.5651	1.40		0.6072	1.51		0.4716	1.23
D9	0.1304	0.56		0.1432	0.61		0.1518	0.68
D10	-0.3373	-1.47		-0.3206	-1.39		-0.3226	-1.48
D11	0.2039	0.69		0.2180	0.73		0.1819	0.63
CASE	0.5410	**2.79**		0.5486	**2.84**		0.5573	**3.02**
COMP	-0.5061	**-3.65**		-0.5039	**-3.64**		-0.4634	**-3.44**
OWNER	1.1257	**4.14**		1.0876	**3.95**		1.0978	**4.34**
LISTED	-0.3601	**-2.23**		-0.3482	**-2.16**		-0.3497	**-2.28**
AGE	-0.0024	-0.50		-0.0022	-0.45		-0.0042	-0.91
EXPORT	0.1707	1.23		0.1810	1.29		0.1488	1.12
TYPE	0.5421	**3.19**		0.5321	**3.14**		0.6030	**3.66**
TURNOVER	0.0004	0.75						
WAGES				0.0003	0.07			
ENERGY							0.0312	**2.42**
Fixed variance parameter	0.1110			0.1100			0.0850	
Sum squared resid	1158.390			1188.927			1021.050	
Log likelihood	-254.5663			-254.8248			-252.7060	
R square	**0.62**			**0.61**			**0.66**	