budget cuts, the conventional regulatory approaches will perform inadequately, and it is a sound strategy to use community and market incentives and voluntary programs as the primary vehicles for influencing environmental behavior of firms.

The results presented in this document also apply to the other Asian economies undergoing economic reform and financial crisis. To the best of our knowledge, this is the first attempt at quantifying the impacts of the financial crisis based on enterprise level data. It is important to note that this analysis was made feasible through the data collected by BAPEDAL for the PROPER program. We believe that the findings of this ongoing work will be helpful to BAPEDAL and USAEP in formulating their environmental strategy during the crisis period.

This note is structured into four short sections. The first section provides a brief description of the data. The second section presents the estimate of the decline in production. In the third section we analyze the impact of the crisis on water pollution. The final section discusses the implications of the results for policy initiatives during the crisis period.

1. Data

The Environmental Impact and Management Agency (BAPEDAL) uses a very sophisticated system for data collection and analysis of the facilities monitored by the PROPER program. The program covers around 350 major water polluting factories from more than 20 industrial sectors. The enterprises that participate in PROPER report their data on monthly production and the laboratory results of the major water pollutants discharged into the environment once every quarter. Most of the factories that are rated in PROPER are large water polluting industrial units, and even though the total number of participating firms is small, they collectively account for a large share of industrial water pollution in the country. For the purpose of the analysis in this note, we focus on the factories from the following major industrial sectors: sugar, rubber, pulp & paper, textiles, palm oil and plywood. Our dataset on production and pollution trend covers more than 150 factories for the period 1995-97.

2. Financial Crisis and Industrial Production

Industrial production will be adversely affected by the crisis through both price effects that increase the cost of production and income effects that decrease the demand for products in the markets. However it is unclear how large and widespread the impact is. It is also possible that some enterprises may benefit from the crisis; for instance, sectors that utilize domestic raw material and export all their products. Therefore, one will expect considerable variation in the production trend both within and across industrial sectors. To illustrate this point, a sample of charts on factory level output for various sectors are shown in Figures 1-5. The y-axis shows the monthly production and the x-axis shows the range of months from

Figure 1: Palm Oil

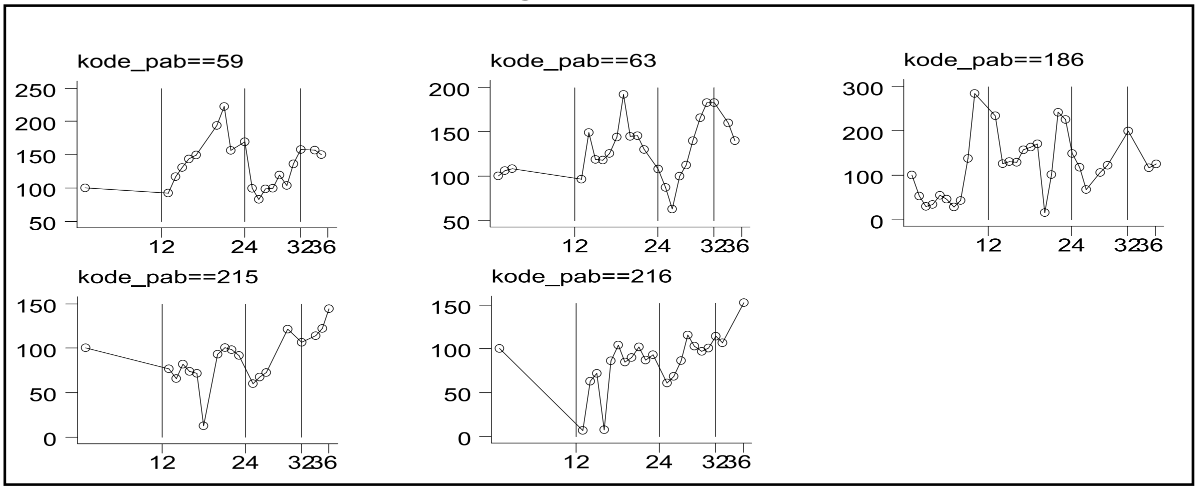


Figure 2: Plywood

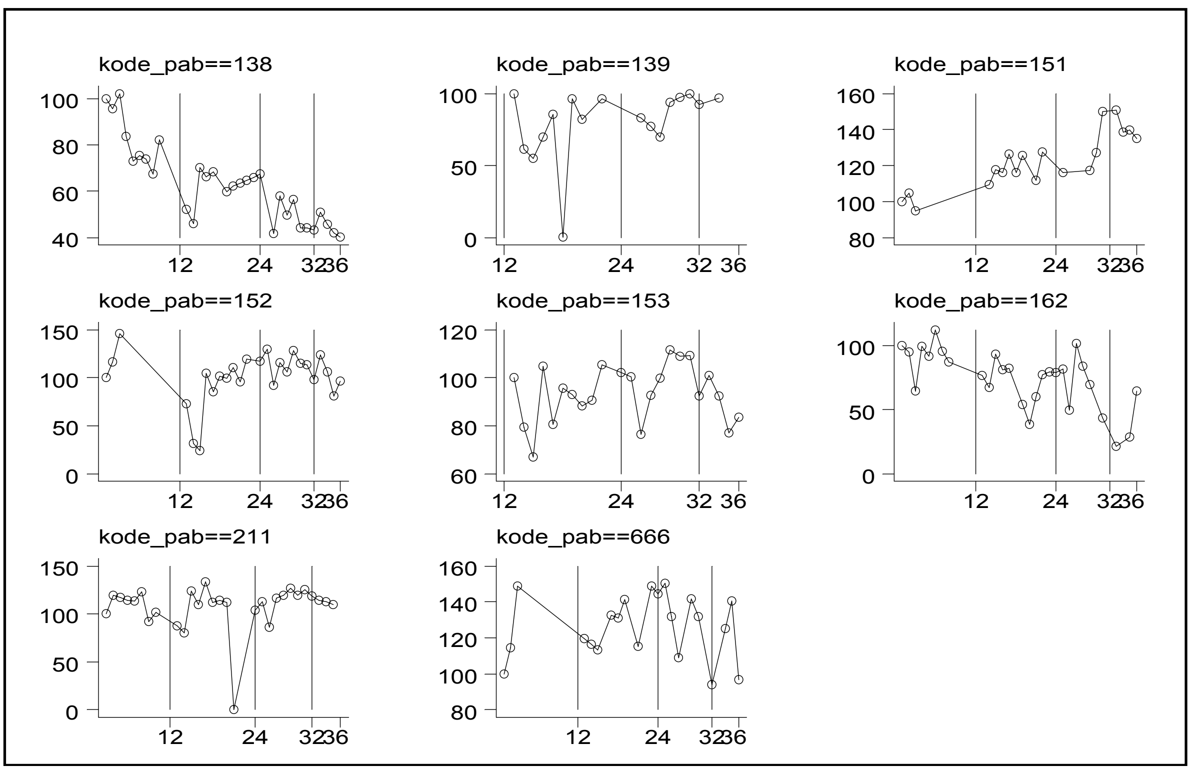


Figure 3: Pulp & Paper

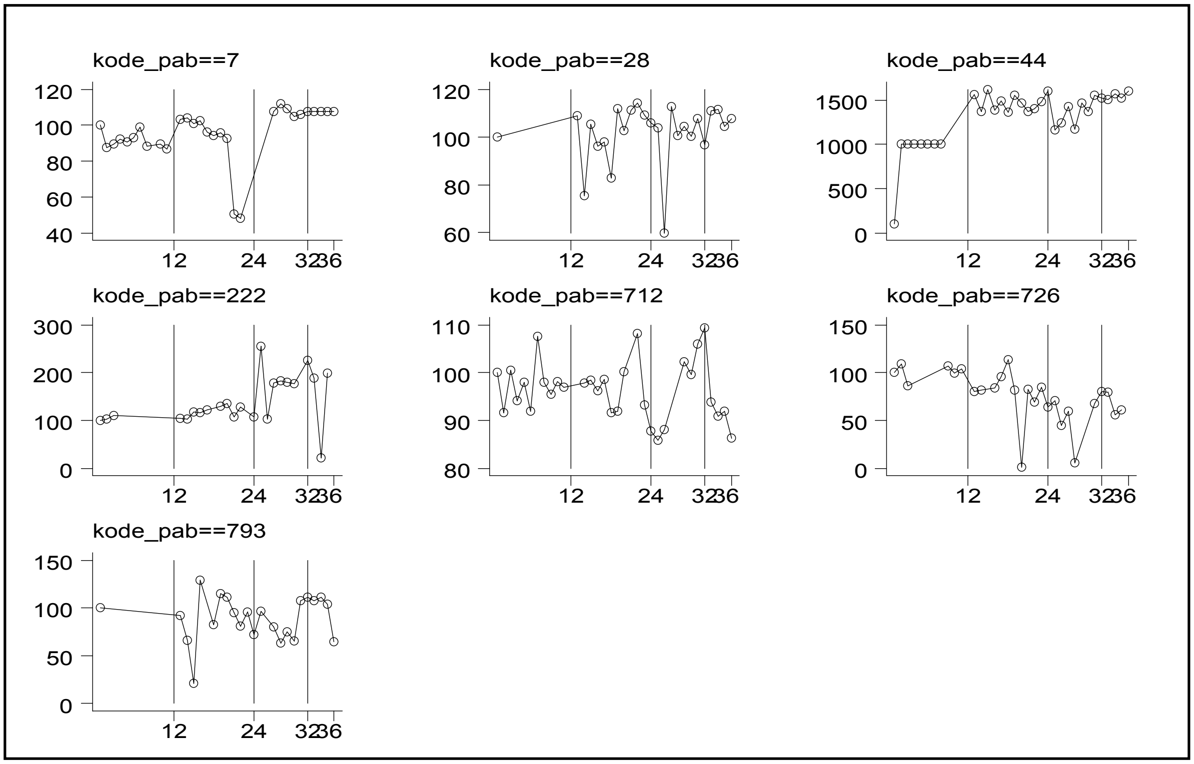


Figure 4: Rubber

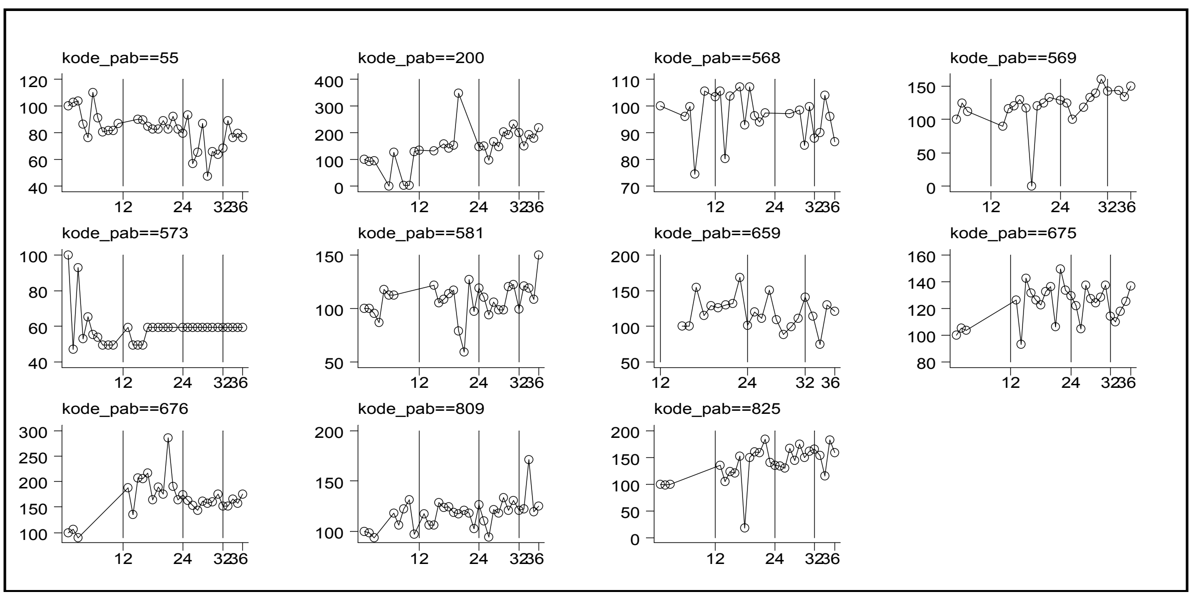
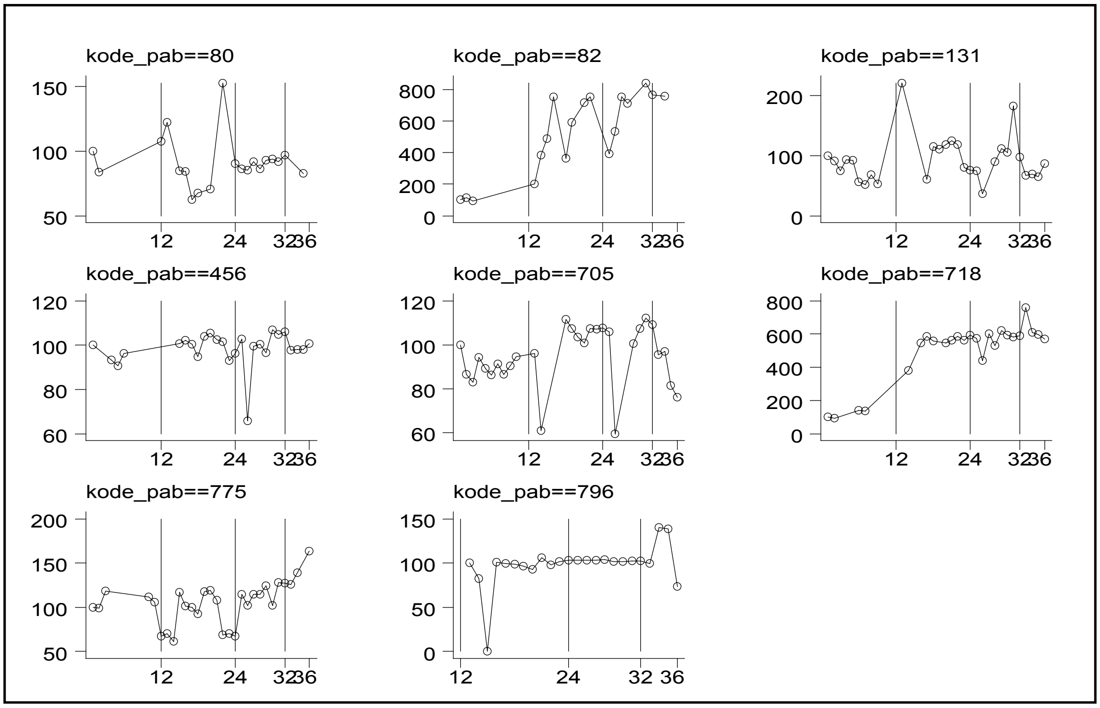


Figure 5: Textiles



Jan-95 to Dec-97, marked sequentially from 1-36. Thus 1-12 represent 1995, 13-24 are for 1996 and 25-36 are for 1997 respectively. Month 32 that stands for Sep-97 marks the start of the period when the effect of the crisis started to sink in. Though the crisis in Indonesia started around Jun-Jul 97, our econometric results show that it took a couple of months for the effects to show up.

Just a casual visual analysis will show that several factories continue to increase their production. We also observe that there is considerable variation in monthly production for some factories. Clearly, it is impossible to draw any firm conclusion about the production pattern in the post-crisis period from the trend charts alone. We therefore do regression analysis using the panel data on around 152 factories covering the periods Jan-95 to Dec-97. As shown in Figure 6, we want to evaluate if the production trend is following the path shown by the dotted curve "$\text{Output}_{\text{with-crisis}}$". Using a random effects model, the following equation was estimated:

$$Ln(Q_{it}) = \alpha_0 + \alpha_1 Trend + \alpha_2 Crisis + \alpha_3 Ln(Emp_i) + \sum \beta_i Indus_i + \sum \theta_k Quarter_k + \varepsilon$$

where Q_{it} is the log of enterprise level monthly output, *Trend* is the monthly trend variable, *Crisis* is a dummy variable for the months starting form Sep-97, *Emp* is log of employment, $Indus_i$ controls for the industrial sectors and $Quarter_k$ controls for the cyclical quarterly effects. As shown in Table 1, the variable *Crisis* is significant at the 5% level. Based on the results shown in Table 1, we calculate that the crisis has led to around 18% decline in the monthly output[1].

Figure 6: Production Trend--With and Without the Crisis

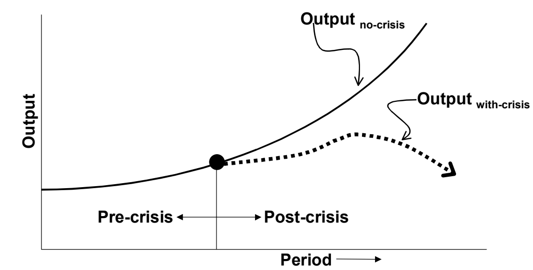


Table 1

Ind.Variable	Coeff.	z
Crisis	-0.194	-2.655
Trend	0.012	5.199
Emp	0.411	3.611
Plywood	-0.481	-0.829
Pulp & Paper	-0.158	-0.270
Rubber	-1.373	-2.553
Sugar	-0.523	-0.773
Textile	-3.109	-6.035
Quarter2	0.045	0.934
Quarter3	0.097	1.898
Quarter4	0.169	2.609
Constant	5.949	8.543

3. Impact of the Financial Crisis on Pollution Levels

In the event of a financial or economic crisis, environmental concerns are put on the back burner. One factor driving this behavior is the perception that the decline in production will automatically lead to a lower level of pollution. We show, on the contrary, that the pollution problem may become worse during the crisis period. The net effect on pollution is determined by the interactions of three factors: decline in production, increase in the abatement cost due to the higher input prices, and decrease in the expected cost of non-compliance due to the lower inspection and enforcement rate caused by budget cuts. As a result, the reduction in pollution due to lower production is cancelled out by the increase in pollution resulting from higher pollution abatement cost and lower inspection and enforcement rates.

A simple framework for this analysis is shown in Figure 7. Let p_1 be the expected cost of non-compliance given the rates of inspection and enforcement. To minimize pollution control costs, the factory will abate up to the level x_1 as shown by the intersection of p_1 and x_1 on the pre-crisis marginal abatement cost curve. During the crisis period there are budget cuts that reduce the probability of inspection and enforcement. This will shift the expected cost of non-compliance to p_2. At the same time, pollution control cost will increase due to the higher interest rates and increases in the cost of the imported materials required for the operation of the treatment system. These effects will shift the

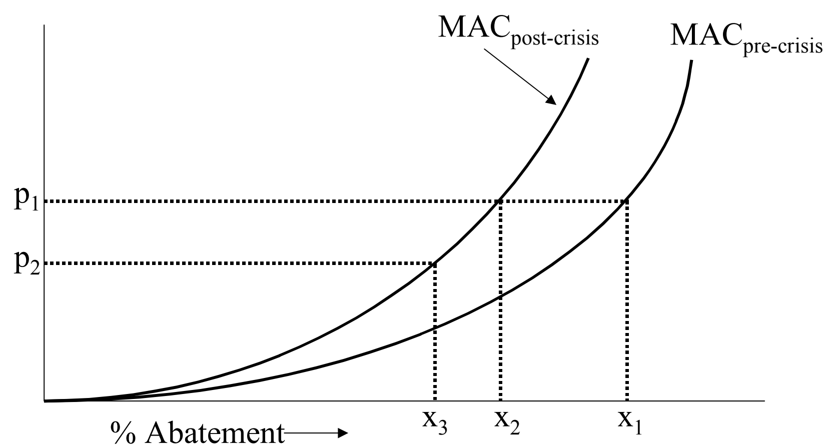
---

1

$$\ln(Q)_{crisis} - \ln(Q)_{no\,crisis} = -.194 \Rightarrow \frac{Q_{crisis}}{Q_{no\,crisis}} = \exp(-.194) \Rightarrow \frac{Q_{crisis} - Q_{no\,crisis}}{Q_{no\,crisis}} = \exp(-.194) - 1 = -17.6\%$$

marginal abatement cost curve inwards as shown in the figure. These two effects combined will lower the total abatement level from x_1 to x_3. It is possible that the increase in pollution due to the lower abatement level can more than compensate for the decrease in production due to the decline in production. If the environmental agencies maintain their inspection and enforcement levels, the abatement level will be limited to x_2.

Figure 7: Changes in the Abatement Level Due to the Crisis



To understand the change in the enterprise-level environmental performance, we analyze whether or not pollution intensity (defined as pollution per unit output) has increased during the crisis period. We use the data on BOD concentration, the most commonly used indicator for organic waste in industrial effluents, as the indicator of pollution intensity. The following algebra will show how the change in BOD concentration reflects the change in pollution intensity. Let I, L, C, V and Q denote pollution intensity, pollution load, pollution concentration, flowrate and output respectively. We can express intensity as:

$$I = \frac{L}{Q}$$

Since $L = C \cdot V$, intensity can be expressed as:

$$I = C \cdot \left(\frac{V}{Q} \right) \tag{1}$$

where V/Q measures the flowrate per unit output, a ratio that is expected to remain constant unless the production process change. Taking log of (1) and differentiating it with respect to time and assuming that the production process remains fixed in the short-term, we get:

$$\frac{1}{I}\cdot\frac{dI}{dt}=\frac{1}{C}\cdot\frac{dC}{dt} \text{ Or } \%\,\textbf{\textit{Change in Intensity}} = \%\ \textbf{\textit{Change in Concentration}}$$

Accordingly, we use log of BOD concentration in our econometric model to analyze whether or not factories have reduced the average abatement effort during the crisis period. To test if the pollution trend is potentially moving in the direction as shown by the dotted line in Figure 8, we estimate the following equation using the random effects model:

$$Ln(BOD_{it}) = \alpha_0 + \alpha_1 Trend + \alpha_2 Crisis + \alpha_3 Ln(Emp_i) + \alpha_4 Ln(Q_{ti}) + \sum \beta_m Indus_m + \varepsilon$$

As shown in the results in Table 2, the coefficient on *Crisis* is positive and significant at the 5% level. This implies that the average BOD concentration in the effluent has increased during the crisis period. Based on the coefficient of the model, the average increase in the BOD concentration is around 15.5%[2]. This result strongly indicates that the factories in Indonesia have a strong tendency to dump waste without treatment during the crisis period.

Figure 8: Pollution Intensity Trend With and Without the Crisis

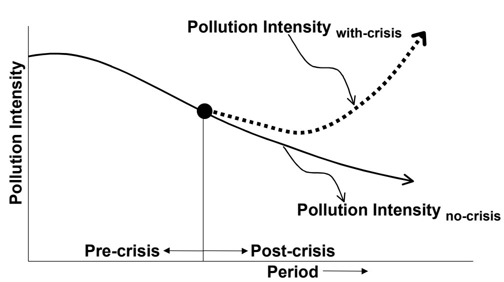


Table 2

Ind.Variable	Coeff.	z
Crisis	0.144	4.307
Trend	-0.014	-13.05
Emp	0.010	0.183
Production	0.010	0.425
Plywood	-1.916	-6.509
Pulp & Paper	-1.420	-4.657
Rubber	-0.999	-3.654
Sugar	-1.438	-4.263
Textile	-1.396	-5.203
Constant	5.443	15.00

2

$$\ln(BOD)_{crisis} - \ln(BOD)_{no\,crisis} = .144 \Rightarrow \frac{BOD_{crisis}}{BOD_{no\,crisis}} = \exp(.144) \Rightarrow \frac{BOD_{crisis} - BOD_{no\,crisis}}{BOD_{no\,crisis}} = \exp(.144) - 1 = 15.5\%$$

4. Implications for Environmental Policies and International Assistance

These findings have several significant implications for the government policies and international assistance. The increase in the BOD levels in the wastewater should be interpreted as a broad indicator of the overall deterioration of the pollution control effort at the factory level. Consequently, the air pollution problem and the illegal dumping of toxics will also worsen. At least three immediate recommendations emerge from this analysis. First, it is essential for BAPEDAL to continue the monitoring and inspection of factories for water pollution and hazardous waste. Immediate budgetary allocations may be necessary for this. Through the USAEP's technical assistance, BAPEDAL is expected to inspect approximately500 factories this year. This assistance is both timely and highly valuable.

The second recommendation calls for increased reliance on voluntary approaches, and community and market incentives to influence pollution control behavior of polluters. During the crisis period we expect that the conventional enforcement system will perform inadequately. In this context, BAPEDAL should focus on maintaining PROPER-PROKASIH, as well as other programs such as KENDALI and BLUE SKY.

The third recommendation pertains to new investments: It will be essential to ensure that all new investments minimize reliance on the end-of-pipe treatments and maximize use of clean technologies and pollution prevention approaches. The USAEP's ongoing technology transfer program aptly fulfills this need.

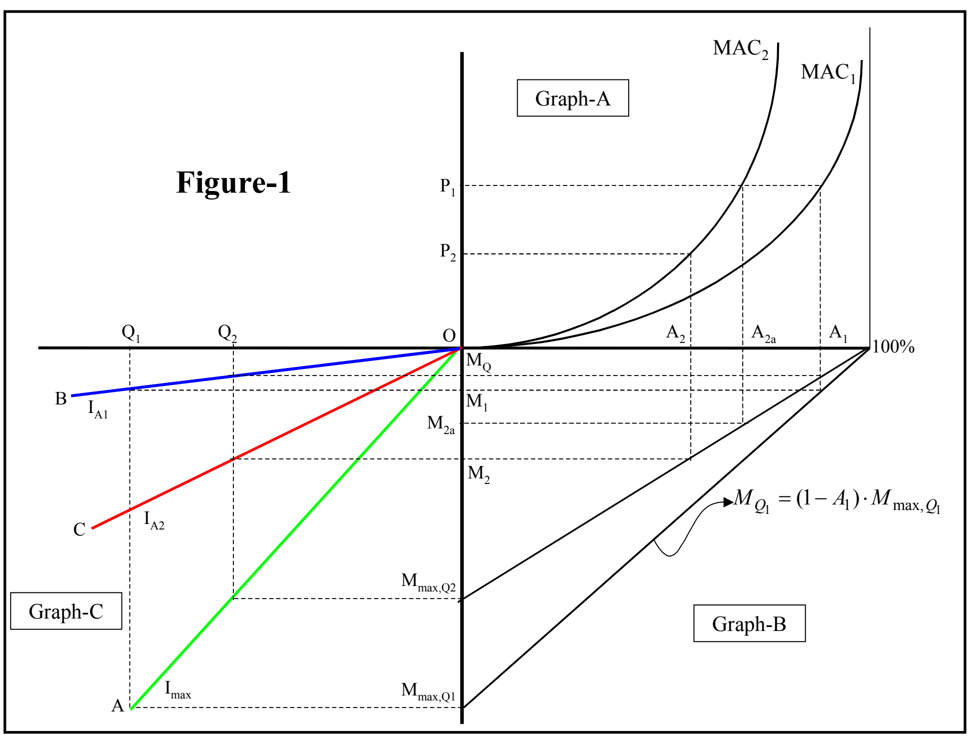
Finally, ongoing research on these topics will help us to identify characteristics of enterprises that have continued to flourish during the crisis as well as those that have been most adversely affected. Analysis of enterprise characteristics and environmental performance will enable BAPEDAL to identify polluters that have retained the ability to comply during the crisis. Such targeting will be essential for cost-effective implementation of the environmental programs. As part of these continuing efforts, we hope to update these results in the near future with data from the first two quarters of 1998.

Appendix A

Pollution Equation

The net change in pollution is shown graphically in Figure 1, which has three back-to-back graphs. Graph-A shows the marginal abatement cost function with % abatement on the X-axis and P_i shows the pollution price or the expected cost of non-compliance. Graph-B converts the abatement level into actual pollution using the relationship $M_{Q_i} = \beta_k \cdot M_{\max,Q_i}$, where $M_{\max,Q_i}$ is the pollution released when abatement is 0% and β_k is the share of unabated pollution. Graph-C shows the relationship between output and pollution such that the rays from the origin are pollution intensities at different levels of abatement.

During the period of financial crisis, output will decline (Q_1 to Q_2) and marginal abatement cost curve will shift inwards from MAC_1 to MAC_2, and the expected cost of non-compliance will fall from P_1 to P_2. As shown in the figure, the net change in total pollution is given by (M_2M_1 - OM_Q). The total change in pollution has three components. OM_Q is the decrease in pollution associated with the decline in output from Q_1 to Q_2. The increase in pollution M_2M_1 has two components—M_1M_{2a} and $M_{2a}M_2$, which are the effects of pollution reduction due to lower abatement (A_{2a}) caused by increased prices, and lower expected penalty from reduced inspection and enforcement (A_2).



To estimate the change in the pollution levels we express total pollution as:

$$M_Q = Q \times I_{Ak}, \tag{1}$$

where M_Q, Q, and I_A are total pollution at output Q and pollution intensity at abatement level A respectively. We define unabated pollution level as β, such that $\beta_k = (1 - A_k)$ and pollution for a given output level can be expressed as:

$$M_{Q_i} = \beta_k \cdot M_{\max, Q_i},$$

where β_k is the share of pollution unabated and $I_{\max}$ is the pollution intensity when the abatement level is 0%. Therefore, we can express intensity I_{A_k} as :

$$I_{A_k} = \beta_k \cdot I_{\max},$$

and equation (1) can be expressed as:

$$M_Q = Q \times \beta_k \cdot I_{\max} \tag{2}$$

Taking total differential of (2) we get:

$$dM_Q = \beta \cdot I_{\max,Q} \cdot dQ + Q \cdot I_{\max,Q} \cdot d\beta \tag{3}$$

We now expand on $d\beta$. The degree of unabated pollution, β, is function of input prices (p) and the expected cost of non-compliance (υ). The expected cost of non-compliance changes due to the changes in the inspection rate. We express β as $\beta(p, \upsilon)$. Therefore,

$$d\beta = \frac{\partial \beta(.)}{\partial p} dp + \frac{\partial \beta(.)}{\partial \upsilon} d\upsilon \tag{4}$$

Substituting (4) in (3) and dividing both sides of the equation by M_Q, we get:

$$\frac{dM_Q}{M_Q} = \frac{\beta \cdot I_{\max,Q} \cdot dQ}{I \cdot Q} + \frac{Q \cdot I_{\max,Q} \cdot}{I \cdot Q} \left[\frac{\partial \beta(.)}{\partial p} dp + \frac{\partial \beta(.)}{\partial \upsilon} d\upsilon \right] \tag{5}$$

After some manipulation of (5) we can express percentage change in pollution as:

$$G_M = G_Q + \varepsilon_{\beta, p} \cdot G_p + \varepsilon_{\beta, \upsilon} \cdot G_\upsilon \tag{6}$$

where G_M, G_Q, G_p and G_υ are percentage changes in pollution, output, input prices and the expected non-compliance cost. $\varepsilon_{\beta, p}$ and $\varepsilon_{\beta,\upsilon}$ are elasticity of unabated pollution with respect to input prices and penalty levels respectively. We can express (6) in terms of elasticity of the abatement level as follows:

$$G_M = G_Q - \varepsilon_{A,p} \cdot G_p - \varepsilon_{A,\upsilon} \cdot G_\upsilon \qquad (7)$$

where $\varepsilon_{A,p}$ and $\varepsilon_{A,\upsilon}$ are elasticity of abatement level with respect to input prices and inspection rate such that $\varepsilon_{A,p} < 0$ and $\varepsilon_{A,\upsilon} > 0$. In the pollution change accounting equation (7), the first term gives the effect of output on pollution, and the second and the third term give the effects on pollution from the changes in the abatement level due increased input costs from higher capital costs and devaluation leading to higher costs for imported raw materials.