Introduction:

Indian industry is huge in its structure. There exists a belief amongst people from most walks of life, that it has done little to reduce pollution. This is bound to rise as the economy grows. An environmental rating of firms or an indexation would help assess a firm's environmental performance vis-à-vis other firms in the industry and thus act as a benchmark for the firm to act upon. However, it becomes imperative for a firm in any industry to voluntarily disclose data relating to its environmental performance for such a project to be successful.

There are various ways of ranking or rating firms, for any particular purpose be it financial rating or environmental, and most of these are based on different criterion of measuring the requisite performance. The methodologies followed by different agencies involved in environmental rating of firms, for whatever reason, differ mainly due the adoption of different factors as the basis of rating. This is precisely the reason why a firm gets rated differently when rated by different rating agencies. The various factors that are considered while rating a firm have a very wide divergence depending upon the agency which undertakes the rating process and not all of these are considered by all rating agencies while carrying out the exercise. In our rating exercise here, we rate same firms from the same industry using the same criterion but using different methodologies.

In so far as attempts that have already been made in this direction in the field on environmental rating, it is generally found that there have been a certain bias towards the inclusion of technical aspects of production processes that are involved in the manufacture of the end product of a firm in the industry. The Council for Economic Priorities (CEP), a New York based NGO rates US firms on the basis of their social and environmental performance. As several US business persons now want to invest only in socially-responsible and environment-friendly companies, CEP's ratings are used by financial companies which handle these investments to decide which units meet these criterion. In India, most of the funds for industrial
investment come from government financial institutions instead of the stock market as in the US. Government agencies are duty-bound to protect the environment, whereas the stock market has no such responsibility, one would expect these (government) agencies to be interested in the environmental ratings of the firms they invest in. A proper rating is a daunting task specially at the inception of the process in conditions such as ours in India. A rating exercise in India means a detailed environmental audit of each company before it is rated for its environmental performance.

In this exercise, we attempt to create simple index of the environmental performance of firms in the two industries, that of fertiliser and pulp and paper. Our attempt in this chapter would be to explain the different criterion that have been chosen to rate firms here and the rational behind the choice of these factors of rating. We also explain the various methodologies used in the rating of firms. The main difference in the rating process attempted here is that it takes account of the financial aspects of a firm along with the environmental factors which have not been done in previous attempts made so far in this field. The CEP in the US rates firms based on their Toxic Release Inventory database which is a carefully maintained database by the United States Environment Protection Agency (USEPA). It has a year-wise information on the wastes and emissions of companies and is openly accessible. Once this is available, it is easy to set up bench marks and rate firms accordingly in terms of their environmental performance. In India, neither the Central government nor the Central Pollution Control Board (CPCB) maintains any such systematic database and even the data that it has on companies, is not easily available for public consumption. The data available with the government or its agencies like the CPCBs are in no way trustworthy since the data shows that no firms in any industry are polluting and perform well below their permissible limits of pollution in any medium viz. air, water, land etc. This is due to the fact that firms report falsified data to the government since pollution limits if crossed would lead to their closure. This leads to little or no credibility in the data available with the government or its agencies. A company can well say that its financial dealings are its private business but the environmental impact of its operation are public matters since the environment belongs to the public. Thus non-disclosure or falsification of a firms environmental
performance data is just not acceptable. This is supported by global trends. In the West, about 1000 companies voluntarily publish an annual environmental report. So voluntary disclosure in the case of environment is today an accepted business practice.

There are some disadvantages of eco-rating. There is the inherent disadvantage in this method where the firm can be thought of as withholding information which would be a reflection of its environmental performance. In such cases the rating will not reflect the firm’s actual performance vis-à-vis other firms in the industry. This calls for bringing about a change at the policy level whereby it should be made mandatory for firms to make available data on pollution and its control and expenditure on the same and the scale of activity of the firm. In such a case where the firm’s withhold information, those firms in the industry which may see eco-rating as a bench-mark mechanism to control their pollution levels, may not be able to realise their actual potential, their weakness/strengths and thus bench mark its performance against competitors or international standards.

The rating procedure or more appropriately the ranking or indexing firms on the basis of their environmental performance has been attempted here using both primary and secondary data available of the firms in the two industries of pulp and paper and fertiliser. The wastes generated by a particular industry is quite different and in some cases totally different from that generated in another industry. Hence it is necessary to rate firms in a particular industry separately from that in another industry when the criterion for rating used are industry specific. Here by we prevent “mixing the oranges and the apples”. The two industries considered here are different in that one, the pulp and paper industry, is one where the main source of pollution is from the raw material and the process involved in the production whereas in the case of the fertiliser industry the main source of pollution is the production process and the product itself.

**Rating Criterion:**

The criterion that we have used in our rating exercise are looked into in greater detail now. We have in our exercise considered four variables and they are more or less general attributes which can be used for forms across industries without
having to face the problem of “mixing the oranges and the apples”. The attributes considered here are the following:

1. The ratio of the capacity of the effluent generation plant to the total amount of effluent generated by the plant during the process of production. This gives us an idea of the importance that the firm imparts to its pollution control measures. An effluent treatment plant has a specific capacity beyond which it cannot treat effluents generated during the production process. Thus this ratio is a measure of the firms stress on pollution control and also it gives one an idea about the amount of effluent generated and whether it can be treated by the firm’s/plant’s in-house treatment plant or not.

2. The second variable is the ratio of the installed capacity of the production plant to the average capacity of the effluent treatment plant. Generally, the installed capacity of the effluent generation plant is in match with the production capacity of the production plant. If the plant overshoots its production capacity, then the effluent generation plant will not be able to treat the effluents generated when the plant is operating beyond its installed capacity. This is another criterion by which the pollution level of the plant and consequently the untreated effluent released by the plant can be gauged.

3. The third variable is the ratio of the capital cost of setting up of the effluent treatment plant to the total asset of the firm that it held when the effluent treatment plant was set up. A firm which spends a larger share of its asset on installing an effluent treatment plant with its production system, can be said to lay greater stress on pollution control than a plant which spends less for the purpose. This factor can, again, be thought of as one which is universally true for firms across all industries.

4. And lastly, the fourth variable is the ratio of the operating cost of the effluent treatment plant to the profit after tax of the firm. This speaks about the operational part of the previous criterion. A plant might have an effluent treatment plant whose capacity is large but does not use it fully. The obvious fallout of it is that a large part of the effluent generated during the production process is released untreated into nature. This variable, thus, is a measure of the actual(in practise) performance of a firm in its pollution control activities.
Most of the variables that are considered here, are calculated from a combination of primary and secondary data sources. All the variables regarding pollution that are considered here are available from primary sources and the financial data were available from secondary sources. More variables that are pertinent for this exercise could not be considered due to lack of data availability mostly primary in nature. These can be listed as employees responsibilities, product stewardship, environmental communication, regulatory relationships, environmental training, process risk reduction, hazardous material management, energy, transportation etc. The other problem that was faced is in the number of firms for which data was available especially for the pulp and paper industry. The data that was required for the exercise was available for only nine firms in the pulp and paper industry. However, for the fertiliser industry, the exercise was carried out for 17 firms for which the required data was available.

Methodologies:

There are different methods of constructing indices which are used in various fields of economics. Most of these methods are used for the purpose of creating indices used in the field of development economics. These indices are used generally to measure levels of development using various indicators which is thought to be suitable by the proponent of these indicators. The most commonly found indices in economics are those that relate to overall economic development, human development, poverty measures etc. These indices are so designed that they either measure the level of achievement attained or the level of deprivation suffered, by the different members of the class which needs to be categorised. The UNDP uses an index to categorise countries on the basis of their levels of development and for the purpose it uses different indicators of development. It basically uses four indicators to calculate its human-development index like life-expectancy at birth, educational attainment measured in terms of adult literacy and combined gross enrolment ratio and adjusted real GDP per capita. The UNDP also has indices to measure gender-related development index and the gender empowerment measure. Though different criterion are used in these areas, but the methodology remains the same. Then the UNDP also has the Human Poverty Index and here again the factors used are the
different but the methodology remains the same. The exercise of creating an index for a particular purpose (which in economics is generally for the purpose of measuring levels of growth or of development), though the methodologies are the same, they vary only in the indicators used in the construction of the index. There are, however, some methodologies which are used in constructing an index that are slightly different from those that are commonly used like the UNDP method and the results may, thus, be slightly different from those that are obtained using the commonly used methods.

The method followed by the UNDP in constructing their Human Development Index (HDI) is as follows; there are four components that are considered while constructing the index. For any component of the index, individual indices are computed according to the general formula

\[
\text{INDEX} = \frac{\text{Actual } x \text{ value} - \text{Minimum } x \text{ value}}{\text{Maximum } x \text{ value} - \text{Minimum } x \text{ value}}
\]

where 'x' is the component in consideration.

The index so obtained is also known as the Achievement Index. These indices measure the achievement of a firm (here) in comparison with other firms in a particular criterion. The numerator in the above formula states how far ahead is one firm in comparison with other firms under the same criterion. The denominator gives the overall picture of all firms taken together. Thus the index measures how well has the firm performed when all firms are taken together. This index basically measures the achievement of a firm. If the index was such where the above formula was like;

\[
\text{INDEX} = 1 - \frac{\text{Actual } x \text{ value} - \text{Minimum } x \text{ value}}{\text{Maximum } x \text{ value} - \text{Minimum } x \text{ value}}
\]

in such a case, the index would have been a measure of the deprivation of the firm. This index is known as the Deprivation Index. Since in this case the actual value of the firm would have been subtracted from the maximum value attained by any firm under that particular criterion. Then, in such a situation, the ranking of the firms based on this criterion would be just the reverse of what would have been achieved with the previous formula.

Under either of the above formula, once the indices are calculated for a particular criterion/component, they are then added up and divided by the number of components. The choice of the index, that is whether to go for the achievement or the
deprivation index depends on the motive behind the construction of the index. A poverty index would prefer to see the deprivation suffered by the populace whereas a development index would like to see the extent of achievement that has been attained by the region or the country in consideration.

The gender development index (GDI) of the UNDP is much similar to its the HDI; the difference is that the GDI adjusts average achievements of each country (in the various factors that constitute the index) in accordance with the disparity in achievement between men and women. For this gender sensitive adjustment the UNDP uses a weighting formula that expresses a moderate aversion to inequality, setting the weighting parameter, ε, equal to 2. This is the harmonic mean of the male and female values.

The GDI also adjusts the maximum and minimum values of the components by not considering either the maximum or the minimum values as was done in the HDI.

The Human Poverty Index (HPI), is constructed as;

$$\text{HPI} = \frac{1}{4}(P_1 + P_2 + P_3 + P_4)$$

where $P_1$, $P_2$, $P_3$ and $P_4$ are the different variables considered in the construction of this index, the HPI.

There are various other methods of ranking apart from the methods discussed above. The above are mainly those that are followed by the UN for its various purpose. There are methods which use positional rules which are easy to compute and also have considerable intuitive appeal. Three such rules to assess the relative performance on different fronts of the subject are (a) Borda’s Rule; (b) Copeland’s Rule and (c) Simpson’s Rule. These three rules are inter-related but strictly different ordinal approaches for assessing relative performance of states in measurable attributes, including child labour.

The **Borda Rule** involves summation of the difference between the number of firms (in our case here) being compared and its rank in terms of the attribute being considered. A firm, say ‘A’, for any one attribute may have a score of say, $10 - 1 = 9$, where 10 is the total number of firms and one is its rank in that particular attribute that is being considered. Similarly for each of the attributes being considered, firm
'A' s score is computed and all these are added. The total score for each firm is used to rank the firms for its overall performance.

Mathematically, Borda Rule can be summed up as;

$$\text{Borda Score} = \sum_{k=1}^{m} (n - a'k)$$

where \( k = \text{characteristics} \)
\( n = \text{no. of firms} \)
\( i = \text{rank of firms according to characteristics.(k)} \)

Number of characteristics in which a firm performs better get no weight.

The Copeland Rule requires comparison of each firm with all others on a pair-wise basis taking all the attributes together. If in a majority of attributes the firm performs better, it gets score of +1. For worse performance it gets a score of -1 and for equal performance it gets a score of zero. These scores are then added together to get an overall score. Based on the overall score the firms are ranked. If out of a total of 10 firms, firm ‘A’ has outperformed all other firms on a majority of attributes then it gets a score of 10 and another firm which is a worst performer may well have a score of -10, 10 being the number of firms being compared.

Mathematically, the Copeland Rule can be summed up as;

Rank firms according to Copeland score. Compare firm \( i' \in A \) with firm \( i \in A, \ i' \neq i \). If for a majority of characteristics \( i' \) performs better than \( i \), then \( i' \) gets a score of 1. If for a majority of characteristics \( i \) performs better than \( i' \), then \( i' \) gets a score of -1. Compare \( i' \) with every firm other than \( i' \in A \) in this way. The sum of all such scores is Copeland Score.

The Simpson's Rule uses the Copeland method of comparisons but uses the number of attributes in which a firm performs better than every other state. The Simpson score can vary between zero and the total number of attributes being considered.

Mathematically the Simpson Rule can be summed up as;

Compare \( i' \in A \) in turn with each \( i' \neq i \in A \). Compute the number \( N (i', i) \) of characteristics in terms of which \( i' \) performs better than \( i \).

$$\text{Simpson score} = (0 \leq S \leq m)$$
Firm with highest Simpson score (S) is considered a Simpson winner.

In terms of relative merits of Borda and Copeland rules it is important to note that their policy implications are rather different. The Borda measure allows a firm to compensate for poor performances in one area by their better performance in another while Copeland score does not. Simpson’s rule provides a clear guide to spotting the winners but it is hardly satisfactory as a ranking device.

**Principal Component Method:** Principal Components are linear combinations of statistical variables which have special properties in terms of variances. As an example, the first principal component is the normalised linear combination (i.e., sum of squares of the coefficients being one) with maximum variance.

The principal components turn out to be the characteristic vectors of the covariance matrix. The method of principal component is used to find the linear combinations with large variance. In many studies the number of variables under consideration is too large to handle. Some of it is the deviations in these studies which are of interest. A way of reducing the number of variables to be treated is to discard the linear combinations which have small variances and study only those which have large variances.

If $X_1, X_2, X_3, \ldots, X_k$ are the random variables (which may or may not be independent), such that

$$E_x x_k = 0 \quad \forall k, k' = 1(1) k$$

$$E_x x_k x_k' = \sigma_{kk'}$$

has a covariance matrix $\Sigma = (\sigma_{kk'})$

Since our interest lies in variance and co-variance only, we shall assume that the mean vector is zero. We shall also assume $\Sigma$ is singular and $\Sigma$ has multiple roots.

Now we formulate a normalised linear function of $\kappa = \alpha'X$, where $X$ is a column matrix with $x_1, x_2, x_3, \ldots, x_k$ as the elements.

Principal component is a normalised linear combination of $x_1, x_2, x_3, \ldots, x_k$ which has the maximum variance.

$$1/N. X'X \approx \Sigma_{xx} = \Sigma$$

$$\tau.\Sigma.\approx$$ may be used as a measure of total variation in the whole set of $X$ variable. Now transferring $X$ to a set of $Z$'s which are orthogonal to each other. This
is nothing but an orthogonal transformation from \( X \rightarrow Z \), \((z_1, z_2, z_3, \ldots, z_k) = XA\), where \( X \) is the set of characteristics vector.

\[
E.Z = E(\alpha'X) = \alpha'(EX) = 0
\]

\[
V.Z = V(\alpha'X)^2 = E(X'\alpha)(X'\alpha) = \alpha'(EXX')\alpha = \alpha'\Sigma\alpha \tag{1}
\]

We denote the vector \( \alpha \) by the column matrix \( \alpha_1, \alpha_2, \alpha_3, \ldots, \alpha_k \) such that

\[
\text{Max. } V.z = \alpha' \Sigma \alpha
\]

subject to \( \alpha'. \alpha = 1 \) (the normalisation rule).

We construct a Lagrangian function;

\[
U = \alpha' \Sigma \alpha - \lambda (\alpha' \alpha - 1);
\]

where \( \lambda \) = Lagrangian multiplier

we partially differentiate \( U \) with respect to \( \alpha \) and set it equal to zero.

\[
\frac{\delta U}{\delta \alpha} = \left| \frac{\delta U}{\delta \alpha_1} \right| = 0
\]

\[
\Rightarrow 2. \Sigma \alpha - 1. \lambda. \alpha = 0
\]

\[
\Rightarrow (\Sigma. \lambda. I) \alpha = 0 \tag{2}
\]

In order to get a rotation of (2) with \( \alpha' \alpha = 1 \), we must have \( (\Sigma - \lambda I) \) singular, or in other words \( \lambda \) must satisfy \( |\Sigma - \lambda I| = 0 \)

\[\Rightarrow \text{Rank of } |\Sigma - \lambda I| < k\]

Pre-multiplying (2) by \( \alpha' \), we have

\[
\alpha'(\Sigma - \lambda I) \alpha = 0
\]

\[
\Rightarrow \alpha' \Sigma \alpha = \lambda. \alpha' \alpha = \lambda \text{ (since by normalisation rule } \alpha' \alpha = 1)\]

\[\Rightarrow \text{we should choose the largest value of } \lambda, \text{ since } |\Sigma - \lambda I| = 0 \text{ is a polynomial }\]

\[
\text{equation of degree } k \text{ in } \lambda. \text{ So there are '}k' \text{ roots of the characteristic equation. Let us assume that the roots are all distinct. Arranging the roots in ascending order of magnitude such that } \lambda_1 > \lambda_2 > \ldots > \lambda_k; \text{ then } \lambda_1 \text{ is the largest root.}\]

Again \( \alpha' \Sigma \alpha = \lambda \alpha' \alpha = \lambda \) shows that if \( \alpha \) satisfies \( (\Sigma - \lambda I)\alpha = 0 \) and \( \alpha' \alpha = 1 \), then the variance of \( \alpha'X \) is \( \lambda \). Thus, for the maximum variance we should use \( \lambda \) in \( (\Sigma - \lambda I)\alpha = 0 \) as the largest root \( \lambda_1 \).

We now try to solve \( (\Sigma - \lambda I)\alpha = 0 \) with \( \lambda = \lambda_1 = \lambda_{\text{max}} \) for \( \alpha \).

Let, \( \alpha^{(1)} \) be a singular matrix with the elements being \( \alpha_1^{(1)}, \alpha_2^{(1)}, \alpha_3^{(1)}, \ldots, \alpha_k^{(1)} \), such that

\[
\sum_{i=1}^{k} \alpha_i^{(1)} = 1,
\]

so that the normalisation condition \( \alpha' \alpha = 1 \) is satisfied.
\[ \alpha^{(i)} \] is the normalised solution of \((\Sigma - \lambda I)\alpha = 0\)

Now, we know that \((\Sigma - \lambda I)\alpha = 0;\)

\[ \Rightarrow \Sigma \alpha^{(i)} = \lambda \alpha^{(i)} \] ............(3)

Now, \(z^{(i)} = \alpha^{(i)'X}\) is a normalised linear combination with maximum variance

is the first principal component of \(X\). We have to find \(z = \alpha'X\) such that it is

uncorrelated with \(z^{(0)} = \alpha_1X\).

\[ E_{zz}^{(y)} = E(\alpha'XX'\alpha^{(i)}) = \alpha'\Sigma\alpha^{(i)} = \lambda_1\alpha'\alpha^{(i)} \] (since \(\Sigma\alpha^{(i)} = \lambda \alpha^{(i)}\)) ............(4)

Thus, \(\alpha'X\) is orthogonal to \(Z\) in both the statistical sense (for lack of
correlation) and the geometric sense (the product of the vectors \(\alpha\) and \(\alpha^{(i)}\) being
zero)[i.e., \(\lambda_1\alpha'\alpha^{(i)} = 0\) only if \(\alpha'\alpha^{(i)} = 0\) when \(\lambda_1\neq 0\) and \(\lambda_i\neq 0\) if \(\Sigma \neq 0\)].

We have to maximise \(U = \alpha'\Sigma\alpha - \lambda(\alpha'\alpha - 1) - 2 \mu(\alpha' \Sigma \alpha^{(i)} - 0)\)

where \(\lambda, \mu\) are the Lagrangian multipliers.

The vector of partial derivatives is

\[ \delta u/\delta \alpha = 2\Sigma\alpha - 2 \lambda \alpha - 2 \mu \Sigma \alpha^{(i)} = 0 \] ............(5)

multiplying (5) by \(\alpha^{(i)'}, \) we obtain

\[ 0 = 2 \alpha^{(i)'\Sigma\alpha} - 2 \lambda \alpha^{(i)'\alpha} - 2 \mu \alpha^{(i)'\Sigma \alpha^{(i)}} \]

\[ = -2 \mu \lambda_1 \] [from (4) above]

Therefore \(\mu = 0\) and \(\alpha\) must satisfy \((\Sigma - \lambda I)\alpha = 0\) and \(|\Sigma - \lambda I| = 0\).

Let \(\lambda_2\) be the maximum of \(\lambda_1, \lambda_2, \ldots, \lambda_k\) such that there is a vector \(\alpha\)
satisfying \((\Sigma - \lambda_2 I) \alpha = 1, \alpha'\alpha = 1\) and eqn. (4) above. We call this vector \(\alpha^2\) and the
corresponding combination \(z^2 = \alpha^{(2)}X\). Similarly \(z^3 = \alpha^{(3)}X\). \(X\) corresponds to \(\lambda_3\) and
so on.

\[ \therefore z^{(1)}, z^{(2)}, z^{(3)}, \ldots, z^{(k)} \] are successive principal components corresponding to \(\lambda_1, \lambda_2, \ldots, \lambda_k\). So we can see that the roots of \(|\Sigma - \lambda I| = 0\) are the diagonal elements of

\[ \Lambda = \begin{bmatrix} \lambda_{(1)} & 0 & \cdots & 0 \\ 0 & \lambda_{(2)} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \lambda_{(k)} \end{bmatrix} \]

i.e., \(\lambda_{(1)} = \lambda_1, \lambda_{(2)} = \lambda_2, \lambda_{(3)} = \lambda_3, \ldots, \lambda_{(k)} = \lambda_k\).

Analysis of principal components is most suitable if all the components of \(X\) are
measured in the same units. If they are not measured in the same units, the rationale
of maximising $\alpha' \Sigma \alpha$ relative to $\alpha' \alpha$ is questionable, in fact analysis will depend on the various units of measurement.

The proportion of variation allocated by the successive principal components are:

\[ \text{Var. } z^{(1)} = \lambda_1/\Sigma \lambda_k = \text{proportion of variation allocated by the first principal component,} \]

and so on till

\[ \text{Var. } z^{(k)} = \lambda_k/\Sigma \lambda_k = \text{proportion of variation allocated by the last principal component.} \]

The first principal component will itself allocate a fairly large proportion of total variation explained. If one uses ‘$k$’ principal components, then their total variation is explained.

There are certain advantages of the principal component method. They are;

* Principal component method is excellent for forecast.
* The best estimates of ‘$y$’ are obtained by regressing $y$ on $z$. this requires fairly small number of $z$’s which are able to compute entire variation in $X$; at least 99% and hence small number of observations would suffice for the purpose.
* The method of Principal Components helps get rid of the problem of multicollinearity.
* It is generally used in the field of index numbers in order to assess the reliability of such indices. Tintner suggests that with the application of Principal Components one may tentatively answer such questions such as: how good is the representation of all the various prices in the general price index? What proportion of the total variation of the various quantities produced in the different industries is accounted for by an index of industrial output.

The disadvantages of the method are the following;

* This method can’t be used for any policy prescription since it is not possible to interpret the coefficients $\delta$ of the principal components as they are linear combinations of the $X$’s. So the question of marginal change in ‘$y$’ due to unit change in $X$ cannot be obtained.

We have used three methods here in this exercise to rank a firm vis-à-vis other firms on the basis of their performance in terms of the above mentioned variables. The first is the Achievement Score, the second is the Borda Method and thirdly we have used the Principal Components Method for rating firms in a industry using the
In the next chapter we discuss the results of the exercise where we construct an index of the firms in these two industries that of pulp and paper and fertiliser based on the four criterion that we have selected and discussed above.