Chapter – V

SUMMARY AND CONCLUSIONS
5.0. In a production process the inputs combined may produce not only good outputs but also one or more bad outputs. In commercial banking business one such bad output exists and it is non-performing assets (NPA). Implementation of best practices not only improves operating efficiency but reduces NPA of a commercial bank. Usually, advances, one of the leading outputs of a commercial bank co-exists with NPA, an undesirable output. The undesirable output can be reduced, with a reduction in desirable outputs, which implies the fact that an undesirable output can not be freely disposed. Free disposability is one of the axioms of convex data envelopment analysis as proposed by Banker, Charnes and Cooper* (BCC).

Let $T$ stands for the BCC production possibility set

Let $x \in \mathbb{R}^n$,

$u \in \mathbb{R}^p$,

where $x$ and $u$ are the input and output vectors respectively of a commercial bank.

$(x, u) \in T$

$x' \geq x, \quad u' \leq u$

$\Rightarrow (x', u') \in T$

which refers to the strong disposability of inputs and outputs. The convex

production possibility set $T$ yields convex input and output sets. But the converse is not true*.

The coexistence of undesirable outputs and good outputs no more leads to bad outputs costlessly disposed of and one can think of two prominent approaches to measure eco-efficiency of a decision making unit, the first method treats NPA as an input and the second recognizes the reciprocal of NPA as a desirable output. Yet a third method is explored to measure deep ecological efficiency.

5.1. To implement DEA the first step is identification of inputs and outputs. One being very ambitious would declare a sizable list of inputs and outputs. Never-the-less DEA suffers from the problem of dimensionality. If an additional input or output is augmented to the already existing list of inputs and outputs the envelopment solution space contracts and minimum on later space will be larger than minimum on the former solution space and the input efficiencies are exaggerated, so that more commercial banks inefficient previously, now emerge with 100 percent efficiency score. Consequently, DEA looses its discriminatory power and fails to rank 100 percent input efficient commercial banks. Therefore, one shall be more parsimonious than generous, while inputs and outputs of DEA are identified.

The present study not only proposes linear programming problems to measure ecological efficiency of decision making units, but implements the method to assess eco and deep eco-efficiency of Indian commercial banks.

The envelopment study identified two inputs and two desirable outputs and one undesirable output of Indian commercial banks.

Inputs:  
(1) Number of employees.  
(2) Total assets.  

Desirable Outputs:  
(1) Advances.  
(2) Non-interest income.  

Undesirable output: Non-Performing Assets (NPA).  

The inputs and outputs are selected invoking the principle of 'translation invariance' of DEA and performing sensitivity analysis.

5.2. To measure ecological efficiency of Indian commercial banks the DEA models proposed and pursued are as follows:

(1) Input based eco-efficiency:

\[ \text{IBE} = \min \lambda \]

subject to

\[ \sum_{i=1}^{n} \lambda_i x_{i} \leq x_{o}, \quad i=1,2. \]

\[ \sum_{i=1}^{n} \lambda_i u_{o} \leq \lambda u_{o}. \]
\[ \sum_{j=1}^{\lambda} \lambda_j u_{r_j} \geq u_{r_0}, \ r=1, 2. \]  \hspace{1cm} (5.2.1) \\
\[ \sum_{j=1}^{\lambda} \lambda_j = 1 \]
\[ \lambda \geq 0. \]

Figure (5.2.1)

(2) Input based Input Eco-Efficiency Indicator:

Input based Input eco-efficiency indicator can be derived solving the following linear programming problem:

\[ \text{IBIEI} = \text{Min } \lambda \]

subject to \[ \sum_{i=1}^{\lambda} \lambda_i x_i \leq \lambda x_{i_0}, \ i=1, 2. \]

\[ \sum_{i=1}^{\lambda} \lambda_i u_{r_i} \leq \lambda u_{r_0} \]

\[ \sum_{i=1}^{\lambda} \lambda_i u_{r_i} \geq u_{r_0}, \ r=1, 2. \]  \hspace{1cm} (5.2.2) \\
\[ \sum_{i=1}^{\lambda} \lambda_i = 1 \]

172
\( \lambda \geq 0 \)

Every feasible solution of (5.2.2) is feasible for (5.2.1).

Therefore, we have,

\[ \text{IBE} \leq |\text{BIE}_I| \]

In the figure (5.2.1) if input and undesired output are reduced radially \( u_o^{\lambda} \) is reduced to \( u_i^{\mu} \). However if undesired output is reduced radially, \( u_i^{\lambda} \) is reduced to \( u_i^{\mu} \).

\[ u_i^{\lambda} \leq u_i^{\mu} \leq u_i^{\hat{\lambda}} \]

If effort is kept on recovery of NPA with other things being the same,

\[ \hat{\lambda} \leq \lambda_o \]

where \( \hat{\lambda} \) and \( \lambda_o \) respectively measure eco-efficiency and eco-input efficiency indicators.

The bank management considers to implement best practices to recover NPA, other things being the same. if,

\[ P'x_o < \frac{\lambda_o - \hat{\lambda}}{1 - \lambda_o} p_o u_{so} \]

where \( P \) is a column vector of good input prices and \( P_o \) is price/ rupee of NPA. A proxy of \( p_o \) is the rate of interest imposed by the commercial bank whose efficiency is under evaluation, on its advances.
\[ \lambda_0 \quad \text{if } p^T x_o \geq \frac{\lambda_0 - \lambda}{1 - \lambda_0} p_o u_{b0} \]
\[ \lambda = \lambda \quad \text{if } p^T x_o < \frac{\lambda_0 - \lambda}{1 - \lambda_0} p_o u_{b0} \]

In India several private banks perished and failed to repay the deposits they collected from the public. Such banks which are closer to liquidation shall identify role models (peer banks) and implement their best practices to recover NPA.

There are nine commercial banks attained eco-efficiency and eco-input efficiency. Remaining commercial banks with an exception of State Bank of Hyderabad, State Bank of Sourashtra and Nainital Bank experienced significant losses due to NPA. Tamilnad Mercantile Bank (26.55), South Indian Bank (26.77), Karnataka Bank (26.86), Dhanalakshmi Bank (27.10), Catholic Syrian Bank (29.06), Dena Bank (28.12), United Bank of India (29.68) are the commercial banks falling at the bottom in the ranked table of eco-efficiencies. These banks also fall at the bottom of the ranked table of eco-input efficiencies.

If eco-efficiency is considered the efficient banks in the peer list of Tamilnad Mercantile Bank are, the State Bank of Bikaner and Jaipur, ING Vysya Bank, SBI Comm. & Intl Bank and UTI Bank. The magnitudes of the remaining intensity parameters reveal that SBI Comm. & Intl Bank is highly influential peer of the Tamilnad Mercantile Bank. To recover its NPA’s the
Tamilnad Mercantile Bank shall adopt the practices of SBI Comm. & Intl Bank as its best practices to recover its NPA.

If the goal of Tamilnad Mercantile Bank is to recover its input losses and NPA, its peer list consists of State Bank of Bikaner and Jaipur, IDBI Ltd., ICICI Bank and SBI Comm. & Intl Bank. The role model peer of Tamilnad Mercantile Bank is again SBI Comm. & Intl Bank.

In DEA often it is desirable to rank the decision making units (DMUs), in the present context commercial banks of India. In DEA analysis, oriented or non-oriented, some commercial banks emerge with 100 percent scores; consequently DEA fails to rank these banks. The loss of discriminatory power of DEA can be reduced to a greater extent by computing its input or output super efficiency. For inefficient DMUs standard and super efficiency scores turns out to be the same. All extremely efficient commercial banks are found to be super efficient. But, there are extremely super efficient DMUs whose super efficiency scores can not be numerically determined since for these DMUs no referent DMU exists so that their super efficiency score is said to be ‘BIG’.

To rank the 50 commercial banks eco-super efficiency and eco-input-super efficiency are computed for each of the nine extremely efficient commercial banks. In eco-super efficiency case 5 commercial banks emerged
to fall in the category “BIG” where as only two commercial banks fell in the same category when eco-input-super efficiency is pursued.

The Spearman’s rank correlation reveals that more is the eco-efficiency of a bank more is eco-input efficient also.

Eco-efficiency can be explored by output orientation also. If bad output is totally ignored the good output pure technical efficiency can be derived solving the following linear programming problem.

$$\hat{\theta} = \max \{ \theta : \sum \lambda_j x_{j2} \leq x_{02}, \sum \lambda_j u_{n2} \geq u_{n0}, \sum \lambda_j = 1 \}$$

In the presence of NPA if good output augmentation is the desired goal, one may solve the following problem:

$$\theta_o = \max \{ \theta : \sum \lambda_j x_{j2} \leq x_{02}, \sum \lambda_j u_{n2} \leq u_{n0}, \sum \lambda_j u_{n2} \geq \theta u_{n0}, \sum \lambda_j = 1 \}$$

Since the later optimization problem is more constrained.

$$\theta_o \leq \hat{\theta}$$, which reveals that if NPA is ignored the output technical efficiency is exaggerated.

$\theta_o$ is evaluated for all the 50 commercial banks. In this approach only 5 commercial banks emerged to be output technical efficient by taking NPA into account. The SBI Comm. & Intl Bank is output super efficient and fallen in the category ‘big’. Among other super efficient commercial banks State Bank of Bikaner and Jaipur is found to be more output super efficient, meaning that if the inputs of State Bank of Bikaner and Jaipur are assigned to a convex
combination of other banks they would have jointly produced 89.52 percent less of the output that the State Bank of Bikaner and Jaipur has produced. Thus, output gain due to super efficiency by State Bank of Bikaner and Jaipur is 89.52 percent.

To measure eco-efficiency another alternative DEA model one can employ is the additive model. In this approach the sum of the slacks is minimized. It seeks simultaneous input reduction and output augmentation, provides target closer than those suggested by radial DEA. An additional advantage of the additive model is that it is translation invariant. Pooling the slack of optimal solution suitably input and output efficiencies can be determined for the banks. In slack based efficiency measurement a bank is said to be efficient if and only if all its slacks vanish.

The non-orientation approach identifies 9 out of 50 commercial banks eco-input efficient. The additive, non-oriented model identified 24 commercial banks whose NPA slacks do not vanish, for these banks Grass NPA reduction and best practice NPA are computed and presented in the table (4.8.3).

Economic data of inputs and outputs are often constrained by returns to scale. Six out of 50 commercial banks are evaluated and seen to be input scale efficient. 14 banks face decreasing returns to scale and 22 banks admit increasing returns to scale.
Another suggested approach to measure eco-efficiency is output approach, where the reciprocal of NPA is treated as good output and DEA model with two inputs and three outputs is solved for the 50 commercial banks, one problem for one bank. The eco-output efficiency is found in only five out of 50 commercial banks. These are State Bank of Bikaner and Jaipur, State Bank of India, IDBI Ltd Bank, ICICI Bank and SBI Comm. & Intl Bank. The remaining 45 banks are eco-output inefficient. Punjab and Sind Bank (213.28), Bank of Rajasthan (201.94), Catholic Syrian Bank (230.15), Dhanalakshmi Bank (204.51) and Ratnakar Bank (244.80) fall at the bottom of eco-output efficiency table.

The potential NPA values encourage the eco-output inefficient commercial banks to be benefited implementing the practices of their most influential role models as their best practices. As an example, consider the Dhanalakshmi Bank where peer members are State Bank of Bikaner and Jaipur (0.10), IDBI Ltd (0.02) and SBI Comm. & Intl Bank (0.88). The most influential peer bank of Dhanalakshmi Bank is the SBI Comm. & Intl Bank and the practices of this bank are the best practices of the Dhanalakshmi Bank.

The additive model under non-orientation is solved one problem each to one commercial bank, viewing the reciprocal of NPA as good output and seeking its augmentation simultaneously increasing the other good outputs and reducing the inputs. All slacks vanished for five commercial banks. State Bank
of Bikaner and Jaipur, State Bank of India, IDBI Ltd, ICICI Bank and SBI Comm. & Intl Bank. For 23 banks the slacks of inverse NPA did not vanish when sum of all slacks is minimized, in the optimal solution. In such commercial banks employment of best practices can reduce NPA significantly.

5.3. For decision making units deep ecological efficiency can be computed solving the DEA problem:
\[
\begin{align*}
\text{Min } & \lambda \\
\text{subject to } & \sum_{i=1}^{n} \lambda_i u_{n_i} \leq \lambda u_{o} \\
& \sum_{i=1}^{n} \lambda_i u_{n_i} \geq u_{o} \\
& \sum_{i=1}^{n} \lambda_i = 1
\end{align*}
\]
This problem is free from the input, seeks to maximize a weighted sum of good outputs to a weighted sum of undesirable output. In the context of Indian commercial banks, one may solve the multiplier problem in fractional form
\[
\begin{align*}
\text{Max } & \frac{\sum_{i=1}^{n} \mu_i u_{n_i} + w}{v u_{n_i}} \\
\text{subject to } & \frac{\sum_{i=1}^{n} \mu_i u_{n_i} + w}{v u_{n_i}} \leq 1, \quad j=1,2,\ldots, n.
\end{align*}
\]
Linear programming equivalent of the above fractional programming problem is.
\[
\text{Max} \sum_{r \in R} \mu_r u_{r0} + w \\
\text{subject to} \quad vu_{s0} = 1 \\
\sum_{r \in R} \mu_r u_{rj} - vu_{sj} \leq 0, j = 1, 2, \ldots, n.
\]

\(w\) is unrestricted for sign.

Ignoring the constraint of bad output an input technical efficiency problem is solved for all the commercial banks. Seven banks emerged to be eco-efficient and only five banks are found to be input technical efficient. The output efficiency problems ignoring (NPA)\(^1\) constraint revealed that only five banks emerged to be efficient. A greater proportion of commercial banks appear to be more eco than technical inefficient. To rank the banks super efficiency problems are formulated and solved for eco-efficient and input technical efficient banks. Combining the eco and technical efficiencies, eco-input technical efficiency indicators are obtained under different hypotheses.

The DEA study of ecological efficiency of Indian commercial banks reveals that, NPA is an intimidating factor that will push a commercial bank in the direction of liquidity. If the practices of the most dominating extremely efficient role model banks are implemented as best practices, significant recovery of NPA is possible in at least half of the commercial banks analysed in the present study.