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A DEA MODEL TO IDENTIFY AND ASSES THE RISK OF INDIAN COMMERCIAL BANKS USING NON-PERFORMING ASSETS AS UNDESIRABLE OUTPUTS

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ABSTRACT

This study proposes data envelopment analysis models to identify and asses risk in Indian commercial banks. Risk is believed to surface due to external and internal factors, where the former cannot be controlled and the later can be controlled fully or partially by the bank management. 63 commercial banks comprising public, private and foreign sectors exposed to common frontier production function are considered for performance evaluation. The empirical results are interesting.

KEYWORDS: Data Envelopment Analysis (DEA), Endogenous Risk, Exogenous Risk, Technical Efficiency, Scale Efficiency, Undesirable Outputs, Commercial Bank.

INTRODUCTION

To start with Indian commercial banking was dominated by private ownership; profit and return to investments were its performance indicators. This was the scenario prior to 1969. Subsequently, commercial banks were nationalized adding to their list additional objectives of optimizing social benefit and geographical expansion to meet the growing needs of people. Globalization opened gates to increased competition by the entry of foreign banks. The changes that are taking world wide continued to give shocks to the banking system which resulted in an expansion of banking services both in range, volume and non-performing assets.
Gauging efficiency of commercial banks is an important issue to bank management and the policy maker. Before this task is initiated a commercial bank has to be modeled appropriately to meet the needs and objectives of the analyst.

To model a commercial bank two approaches followed mostly are the intermediation and production approaches. Under the intermediation approach financial institutions are viewed intermediate funds between depositors and borrowers (Piyu, Y., 1992). Banking business has to satisfy both the users and suppliers of bank funds. The intermediation approach is also known as the asset approach. In production approach a commercial bank's resources produce services to the customers
(Berg et.al, 1991; Berg et.al. 1993; Parson et.al, 1993; Shaffnit et.al, 1997). The basic difference is that in production approach deposits are treated as output, where as it has input status in intermediate approach.

The user cost approach or profit approach models a commercial bank differently. According to user cost approach a financial product is an input or output on the basis of its net contribution to bank's revenue. If returns on a financial product exceed the opportunity cost then it is treated as output otherwise input (Berger et.al., 1993; Thompson et.al, 1997). In the name of loan losses a proxy to NPA, Brocket et.al (1997) included variants of loan losses in both input and output list. 'Provision for loan losses' appeared in input list, allowances for loan losses in the output list. The later output variable was defined as, Valuation Reserve-Loan losses. Sueyoshi(2001) attempted to measure financial performance and to group the banks using DEA discriminant analysis. To measure the risk factor a ratio named as 'Bank Loan loss Ratio' was used in the discriminant analysis. In the context of Indian Commercial Banks' performance measurement adequate representation is not given to risk as measured by NPA (Bhattacharya et.al, 1996; Asish Saha, T.S.Ravisankar 2000).

Performance of banks and bank branches was studied by a number of analysts, but unfortunately there is no general agreement of choice of technology in terms of inputs and outputs.(Bhattacharya et.al, 1996; Parson et.al, 1993; Hevary Tulkers 1993; Berget et.al, 1993; English et.al,1993; Chaffai 1997; Brocket et.al 1997;Deyong Reber 1997; Mester Loreta 1997; Humprey David 1993;Berg et.al, 1991; Kumbalar et.al, 1998).

1. DATA:

The present study models a commercial bank in production approach perspective. The study accommodates non-performing assets as an undesirable output which can serve as input invoking user cost approach. Therefore, this work is a blend of production and user cost approaches.
For the inputs we use (1) Number of employees and (2) fixed assets. Desirable outputs are (1) Deposits (2) Loans and advances (3) Investments (4) Non- interest income and undesirable output is Non-performing assets (NPA). (Fare and Grosskopt, 2004; Scheel, 2001; Seiford and Zhu, 2002) The data are secondary arise from the balance sheets submitted to the Reserve Bank of India by the commercial banks.

Adding too many inputs and outputs to DEA list of variables in the presence of too small a number of decision making units leads to loss of discriminatory power of DEA, since in this case a large proportion of DMUs will surface with 100% efficiency score(Hughs and Yaisawarng, 2004). Thus, an analyst shall be objective oriented and parsimonious while inputs and outputs are listed to confront with DEA. The present study considers 63 Public, Private and Foreign sector banks.

2. DEA MODELS:

Charnes, Cooper and Rhodes (1978) introduced a multiplier problem to measure input technical efficiency of a decision making unit in a competitive environment where similar inputs are employed to produce similar outputs. The specification was a fractional programming problem. By employing Charnes-Cooper transformation it can be transformed into a linear programming problem. But this problem implicitly assumes scale efficient environment. Banker, Cooper and Rhodes( ) made the necessary modification to model variable returns to scale. The dual of these problems are called data envelopment problems. The linear programming problems pursued in the study are given in Appendix(1).

(4) NON PERFORMING ASSETS AS UNDESIRABLE OUTPUT:

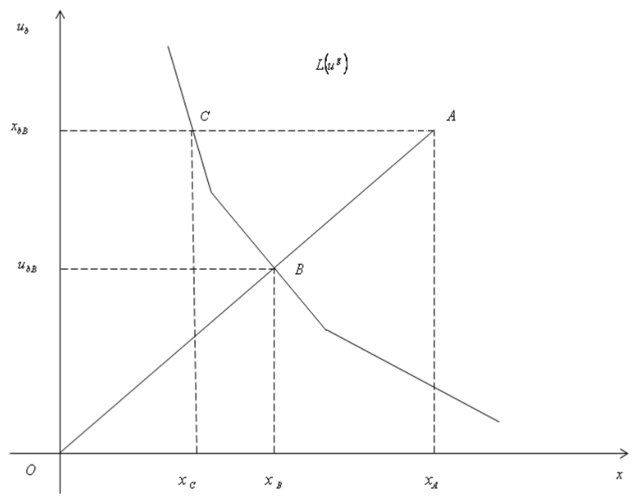

Figure (1)

In the figure above $L(u^g)$ is the input level set consisting of all input (x) and undesirable output (u_b) pairs which can lead to produce u^g, good output. Input and undesirable output are measured respectively along the horizontal and vertical axes. If efforts are needed to control input and NPA losses, the targets occur at B which is reached by radial reduction of $(x_A, \mathrm{u}_{\mathrm{bA}})$. Consequently, the input target is $x_B \left(= \lambda_{\mathrm{CRTS}}^{\mathrm{rcte}} x_A\right)$. If risk is left uncontrolled, then the decision making unit is set target to operate at C, whose input is $x_C \left(= \lambda_{\mathrm{CRTS}}^{\mathrm{ructe}} x_A\right)$. $x_C \leq x_B$

The input target at C dominates the input target at B.

we always have,

$$\lambda_{\mathrm{CRTS}}^{\mathrm{rcte}} \geq \lambda_{\mathrm{CRTS}}^{\mathrm{ructe}}$$
$$\Leftrightarrow \lambda_{\mathrm{CRTS}}^{\mathrm{rcte}} x_0 \geq \lambda_{\mathrm{CRTS}}^{\mathrm{ructe}} x_0$$

This implies that there is a tradeoff between input saving and NPA saving. $(\lambda_{\mathrm{CRTS}}^{\mathrm{rcte}} - \lambda_{\mathrm{CRTS}}^{\mathrm{ructe}})\, x_0$ measures additional input targets over risk controlled input targets. In value terms, if input prices are known, the additional input cost saving is measured by

$(\lambda^{\mathrm{rcte}}_{\mathrm{CRTS}} - \lambda^{\mathrm{ructe}}_{\mathrm{CRTS}})\, p_0^T\ x_0$, where p_0 is observed price vector of $\mathrm{DMU}_0(x_0, \mathrm{u_b}, \mathrm{u_0})$. In risk controlled environment not only input reduction but also NPA (= u_{b}) reduction is sought. The value of recovered NPA is measured by the following expression:

$$(1 - \lambda^{\mathrm{rcte}}_{\mathrm{CRTS}})\, u_{b0}$$

NPA –CHOICE OF ENVIRONMENT:

We assume a trade off between inputs cost and NPA. In a commercial bank if potential inputs cost gains dominate in some sense NPA gains the choice of environment is allocate resources and effort to reduce inputs to their optimum level without bothering NPA. This situation occurs for banks operating at relatively low levels of NPA. Inputs are reduced physically and their productivity is increased simultaneously to achieve risk uncontrolled input technical efficiency. For such commercial banks the in built risk controlling mechanism is strong enough that there is no need to allocate resources to further control NPA. Such allocation leads to only marginal gains of NPA at the expense of sizable inputs cost.

A commercial bank may choose one of risk exogenous or endogenous environments, making use of the following decision rule:

$$(\lambda^{rcite}_{crts} - \lambda^{rcite}_{crts})\, P_0\ \ x_0 \quad \begin{matrix} < \\ > \\ = \end{matrix} \quad (1 - \lambda^{rcite}_{crts})\, u_{bo} \quad \begin{matrix} \Rightarrow \text{Endogenous risk environment} \\ \Rightarrow \text{Exogenous risk environment} \\ \Rightarrow \text{Indifferent from the choice of environment} \end{matrix}$$

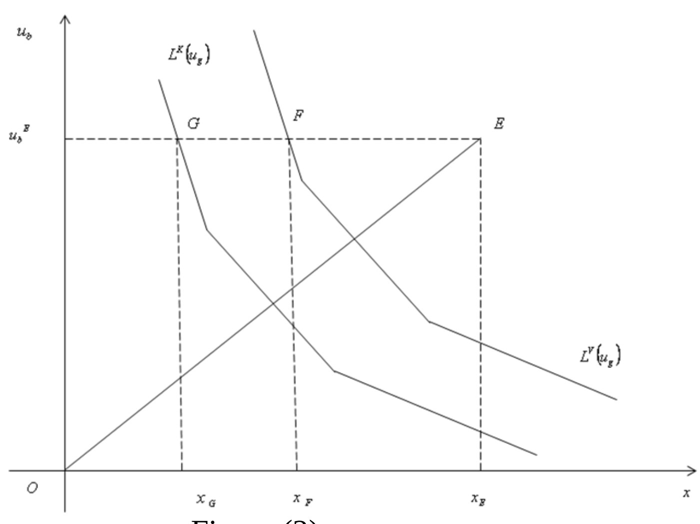

Figure (2)

The input level sets $L^v(u_g)$ and $L^k(u_g)$ are formulated under the hypotheses of variable and constant returns to scale respectively. u_g refers to a scalar valued desirable (good) output.

$$L^v(u_g) \subseteq L^k(u_g)$$

Risk factor as measured by u_b^E is held constant and input x_E is reduced to reach the points F (x_E, u_b^E) and G (x_G, u_b^E) of isoquant $L^v(u_g)$ and isoquant $L^k(u_g)$ respectively.

$$x_F = \lambda_{VRTS}^{rucite} \ x_E$$
$$x_G = \lambda_{CRTS}^{rucite} \ x_E$$

The ratio $\frac{\lambda_{CRTS}^{rucite}}{\lambda_{VRTS}^{rucite}} = \lambda^{rucse}$, measures risk uncontrolled input scale efficiency under constant returns to scale. Risk uncontrolled input technical efficiency can be decomposed into the product of risk exogenous input pure technical and scale efficiency.

λ_{VRTS}^{rcite} and λ_{VRTS}^{rucite} are computed in variable returns to scale (VRTS) risk controlled and uncontrolled environment respectively.

$$\lambda_{CRTS}^{rucite} = \left(\frac{\lambda_{CRTS}^{rucite}}{\lambda_{VRTS}^{rcite}} \right) \left(\lambda_{VRTS}^{rucite} \right)$$
$$= \left(\lambda_{VRTS}^{rucite} \right) \left(\lambda^{rucise} \right) \longrightarrow \quad \textbf{(7)}$$

To complete the decomposition of input technical efficiency in risk free and scale efficient environment. Problems (8) and (9) are to be solved.

$$\lambda_{VRTS}^{rcite} = Min\ \lambda$$

subject to

$$\sum_{j=1}^{n} \lambda_j \ x_{ij} \le \lambda \ x_{i0}, i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} \lambda_j \ u_{bj} \le \lambda \ u_{b0}$$

$$\sum_{j=1}^{n} \lambda_j \ u_{rj} \ge \ u_{r0}, r = 1,2,\ldots,s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \ge 0$$

$$\lambda_{VRTS}^{rucite} = Min\ \lambda$$

subject to

$$\sum_{j=1}^{n} \lambda_j \ x_{ij} \le \lambda \ x_{i0} \text{ , i=1,2,…..,m}$$

$$\sum_{j=1}^{n} \lambda_j u_{bj} \leq u_{b0} \qquad \text{----------------------- (9)}$$

$$\sum_{j=1}^{n} \lambda_j u_{rj} \geq u_{r0}, \qquad r=1,2,\ldots\ldots,s$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad , \quad \lambda_j \geq 0 \backslash$$

Input and NPA are reduced proportionally.

$$(x_A \ , \ u_b^A) = \lambda_{vrts}^{rucite} (x_E, u_b^E)$$

$$(x_B \ , \ u_b^A) = \lambda_{crts}^{rucite} (x_E, u_b^E)$$

The ratio, $\lambda^{rcse} = \left(\frac{\lambda_{CRTS}^{rcite}}{\lambda_{VRTS}^{rcite}} \right)$ measures input scale efficiency when risk also is reduced at the same rate as inputs. The risk controlled input technical efficiency can be decomposed into the product of input scale and pure technical efficiency.

$$\lambda_{CRTS}^{rcite} = \left(\frac{\lambda_{CRTS}^{rcite}}{\lambda_{VRTS}^{rcite}} \right) \left(\lambda_{VRTS}^{rcite} \right)$$

$$= \lambda^{rcse} \left(\lambda_{VRTS}^{rcite} \right) \longrightarrow \qquad (10)$$

INPUT CONTROL – EXOGENOUS RISK:

Most of the studies concerned with Indian commercial banks performance ignored the importance of NPA, which is an indicator of risk. If the risk factor is ignored the technical efficiency of a commercial bank is under stated. Let us consider two environments, one which ignores risk and another that minimizes risk in some sense. The most ideal environment for a commercial bank is zero- NPA and no scale inefficiency which prevails if returns to scale are constant. The input technical efficiency under risk free and CRTS environment λ_{CRTS}^{rfite} can be evaluated solving a linear programming problem.

In the risk free environment under constant returns to scale λ_{CRTS}^{rfite} input technical efficiency . If risk efficiency imposed as a constraint in its exogenous form, input technical efficiency is, λ_{CRTS}^{ruite}. Since $\lambda_{CRTS}^{rfite} \leq \lambda_{VRTS}^{rucite}$, we have , $0 \leq \frac{\lambda^{rfite}}{\lambda^{rucite}} \leq 1$ and this ratio measures effective inputs that are accounted for by exogenous risk inducement.

INPUTS CONTROL-ENDOGENOUS RISK:

Every commercial bank posses risk control system to control system to control endogenous risk. Unlike the previous environment where risk is exogenous it is hypothetical that the conversional inputs and NPA can be radially controlled at the same rate as measured by, λ_{CRTS}^{rcite}.

The ratio $\frac{\lambda_{crts}^{rfite}}{\lambda_{crts}^{rcite}}$ measures effective inputs attribute to endogenous risk.

In this environment input scale efficiency can be expressed as, $\frac{\lambda_{crts}^{rcite}}{\lambda_{vrts}^{rucite}}$

If the transition is from no risk to exogenous risk input scale efficiency can be expressed as,

$$0 \le \left(\frac{\lambda_{CRTS}^{rucite}}{\lambda_{VRTS}^{rucite}}\right) \le 1$$

$$\lambda_{CRTS}^{rucite} \le \lambda_{VRTS}^{rucite}$$

The overall input technical efficiency can be decomposed as,

$$\lambda_{crts}^{rfite} = \left(\frac{\lambda_{crts}^{rfite}}{\lambda_{crts}^{rucite}}\right)\left(\frac{\lambda_{crts}^{rcite}}{\lambda_{vrts}^{rcite}}\right)\left(\lambda_{vrts}^{rcite}\right)$$

RISK CONTROL – EXOGENOUS INPUTS:

If inputs are uncontrolled risk targets are enhanced, possible by strengthening the in built risk controlling system to carefully evaluate the consequence of a loan or investment. In this case what ever funds are allocated to increase the productivity of inputs are directed to risk management.

In input uncontrolled risk environment the risk targets dominate those of input controlled risk targets. NPA gains are more where risk is measured in input uncontrolled environment. However, there are input losses due to increased control activity. NPA targets diminish at the rate of, $= \frac{\left(\lambda_{CRTS}^{icre} - \lambda_{CRTS}^{iucre}\right)}{\bar{\lambda}_{CRTS}}$, where $\bar{\lambda} = \frac{\left(\lambda_{CRTS}^{icre} + \lambda_{CRTS}^{iucre}\right)}{2}$ and the conventional input targets will increase at the rate of $\frac{\left(1 - \lambda_{CRTS}^{icre}\right)}{\bar{\bar{\lambda}}_{CRTS}}$, where $\bar{\bar{\lambda}} = \frac{\left(1 + \lambda^{icre}\right)}{2}$. Thus , there is a trade off between risk and input management. λ^{iucre} is called ecological efficiency.

RISK CONTROL – ENDOGENOUS INPUT:

Risk uncontrolled input technical efficiency: λ^{rucite}

Risk controlled input technical efficiency: λ^{rcite}

If risk is exogenous to a commercial bank, arises, for example, due to political intervention, the welfare schemes introduced by the govt, Reserve Bank of India monitory policies, competition from other commercial banks and financial institutions, conventional input losses can be estimated with a knowledge from λ^{rucite}. In risk environment which is endogenous risk can be controlled by further strengthening its internal risk control system.

$\lambda^{rucite} \le \lambda^{rcite}$

When risk is left free so that it is exogenous to the commercial bank, all the resources and efforts are diverted to further reduce inputs physically and increase their productivity. Input targets when risk is exogenous dominate risk endogenous input targets.

Input target values diminish at the rate of $\frac{\left(\lambda_{CRTS}^{rcite} - \lambda_{CRTS}^{rucite}\right)}{\overline{\lambda}_{CRTS}}$ and the associated risk targets will increase at the rate of, $\frac{\left(1 - \lambda_{CRTS}^{rcite}\right)}{\overline{\overline{\lambda}}_{CRTS}}$.

However, Input Control – Endogenous Risk and Risk Control – Endogenous input environments are chosen to be the same in this study.

Empirical Analysis:

We evaluate the performance of 63 commercial banks operating on Indian soil. Unlike traditional decomposition, input technical efficiency measure in risk free constant returns to scale environment is decomposed into the product of risk, scale and pure input technical efficiency. Risk in bank's competitive environment is measured by non-performing assets (NPA). It is the only way to account for risk in bank's business. The most ideal environment that a commercial bank would like to function is no-NPA and constant returns to scale. We shall name this risk free scale efficient environment. Input losses experienced by public and private sector banks in this environment are significantly larger than those experienced by foreign sector banks.

Table (1):
RISK FREE, CONSTANT RETURNS TO SCALE INPUT TECHNICAL EFFICIENCY:

Sectors	Minimum	Maximum	Mean	SD	Coefficient of Variation (%)
Public Sector Banks	0.1807	0.7833	0.3174	0.1132	35.66
Private Sector Banks	0.0584	0.6919	0.2965	0.1508	50.86
Foreign Sector Banks	0.1208	1.0000	0.6845	0.2831	41.36

If risk is treated as non-discretionary input, so that it influences the bank environment exogenously, under scale efficient environment, the risk uncontrolled input technical efficiency, λ_{crts}^{ruite} can be derived solving the linear programming problem (9).

Table (2):
RISK UNCONTROLLED INPUT TECHNICAL EFFICIENCY IN CONSTANT RETURNS TO SCALE ENVIRONMENT:

Sector	Minimum	Maximum	Mean	SD	Coefficient of Variation (%)
Public Sector Banks	0.4520	1.0000	0.7908	0.1797	22.72
Private Sector Banks	0.0584	1.0000	0.5464	0.2688	49.19
Foreign Sector Banks	0.3739	1.0000	0.8507	0.2039	23.93

In risk uncontrolled scale efficient environment the risk constraint dramatically increases input technical efficiency. State bank of India, the largest commercial bank experienced 70 percent input losses in risk free environment, but no inputs are lost in exogenous risk environment, caused by factors like political intervention, implementation of govt. schemes and so on . Failure to control risk leads to input losses more in private sector banks than public and foreign sector banks.

Table (3):
RISK CONTROLLED INPUT TECHNICAL EFFICIENCY IN CONSTANT RETURNS TO SCALE ENVIRONMENT(Inputs Controlled Risk Efficiency):

Sector	Minimum	Maximum	Mean	SD	Coefficient of Variation (%)
Public Sector Banks	0.4673	1.0000	0.8138	0.1671	20.53
Private Sector Banks	0.2339	1.0000	0.5995	0.2339	39.02
Foreign Sector Banks	0.3739	1.0000	0.8727	0.1849	21.19

The risk controlled input technical efficiency in scale efficient environment treats risk endogenous, which can be controlled strengthening internal risk control mechanism, for example, by administering controls on the size of the loan, careful evaluation of the credibility of the borrower and the collateral security, investments leading to the best opportunity costs, motivating employees to make them feel their belongedness and spreading risk are some ways of controlling risk in commercial bank business. The private sector banks experienced huge input losses compared to the public and foreign sector banks. In private sector of commercial banks 40 percent of inputs are lost on the average due to input technical inefficiency measured in endogenous risk and scale efficient environment. On the average foreign and public sector banks experienced 13 and 19 percent of input losses respectively due to technical inefficiency. The built in risk control system is weakest for private sector banks. In this sector irrational leading has lead to failure of a number of private sector banks.

Thus, due to input technical inefficiency the private sector banks suffered from significantly more input losses than the public and foreign sector banks. These banks should strive hard to reach input saving and endogenous risk reducing bench marks, possible if efforts simultaneously strengthen technical efficiency and the inbuilt risk control mechanism.

EXOGENOUS INPUTS – RISK CONTROL:

Letting the conventional inputs exogenously fixed, the potential NPA recovery can be assessed solving the following problem:

$\lambda^{iucre} = Min\ \lambda$

subject to

$$\sum_{j=1}^{n} \lambda_j\, x_{ij} \le x_{i0}\ , \text{i=1,2,…..,m}$$

$$\sum_{j=1}^{n} \lambda_j\, u_{bj} \le u_{b0} \qquad \text{----------------------- (9)}$$

$$\sum_{j=1}^{n} \lambda_j\, u_{rj} \ge u_{r0}, \qquad \text{r=1,2,……,s}$$

$$\lambda_j \ge 0 \backslash$$

The resultant efficiency estimate is called 'ecological efficiency', which provides a lower bound to risk efficiency.

$\lambda^{iucre}_{CRTS} \le \lambda^{icre}_{CRTS} \le 1$

Inputs Uncontrolled Risk Efficiency in Constant Returns to Scale Environment:

Sector	Minimum	Maximum	Mean	SD	Coefficient of Variation (%)
Public Sector Banks	0.0001	1.0000	0.4325	0.4027	93.12
Private Sector Banks	0.0000	1.0000	0.1411	0.2854	202.24
Foreign Sector Banks	0.0008	1.0000	0.6151	0.4238	68.90

There are six ecology efficient among the public sector banks, State Bank of India, State Bank of Patiala, Andhra Bank, IDBI Ltd. And Oriental Bank of Commerce, given that inputs are exogenous these banks cannot be reduce their NPA since their internal risk control system is strong enough that there is no need to expend resources to further strengthen it. This conclusion appears to match with the null-joint hypothesis postulated by Fare et.all. when they dealt with undesirable outputs.

It is possible to reduce NPA only by reducing desirable outputs not necessarily in the same proportion. For these banks risk is exogenous which is in concurrence with choice of environment analysis.

Bank of India and the Corporation Bank can succeed to gain NPA only marginally. When risk and inputs are radially controlled its risk efficiency rating emerged to be unity which implies that the most suitable environment appears to concentrate on risk as measured by NPA and try to reduce it.

The structural ecological efficiency of the public sector banks is 0.4325 inferring that under inputs exogenous hypothesis 53 percent of observed NPA would not have taken place if the public sector banks had adequate strength to control endogenous risk.

Among private sector banks, the axis bank and ICICI bank are the only two commercial banks enjoyed eco efficiency. In choice of environment analysis these banks were advised to function under risk exogenous input control environment. If Catholin Syrian Bank, Dhana Lakshmi Bank, Lord Krishna Bank, Saugli Bank strengthen their endogenous risk control system NPA can be recovered completely. The mean eco-efficiency of these commercial banking sectors is 0.1411 implying that about 86 percent of the NPA can be recovered if greater commitment is shown and efforts are made. The risk faced by banks of Private sector is more endogenous than exogenous.

Among foreign sector banks ABN Amro Bank, Bank of Tokyo-Mitsubhishi UFJ, China trust commercial Bank, City Bank, Deutsche Bank and JB Morgan Chase Bank have attained 100% eco-efficiency score. For these banks NPA accumulation is not due to endogenous factors. In choice of environment analysis also these banks are adviced to choose to compete in risk exogenous environment. The structural eco-efficiency of foreign sector banks is 0.6151. if inputs are exogenous strengthening the interval risk control system this banking sector would have prevented 38 percent of NPA from accuring.

TABLE: (5)
INPUT SCALE EFFICIENCY

Sector	Risk Uncontrolled Environment (Average)	Risk Controlled Environment (Average)
Public	0.9406	0.8471
Private	0.8579	0.6102
Foreign	0.9391	0.8774

Input scale efficiency is measured by the ratio, $\frac{\lambda_{crts}^{rcite}}{\lambda_{vrts}^{rcite}}$ and $\frac{\lambda_{crts}^{rucite}}{\lambda_{vrts}^{rucite}}$ in endogenous and exogenous risk situations respectively.

Under exogenous risk hypotheses marginal input losses (6%) are experienced by the public and foreign sector banks due to scale inefficiency where as 14 percent of inputs are lost in private sector.

In risk controlled environment 39 percent of inputs are freely disposed in private sector due to scale inefficiency; however, in public and foreign sector these losses are 15 and 12 percents respectively.

TABLE: (6)
INPUT PURE TECHNICAL EFFICIENCY

Sector	Exogenous Risk Hypothesis	Endogenous Risk Hypothesis
Public	0.8398	0.9587
Private	0.6451	0.9829
Foreign	0.9004	0.9943

Under exogenous risk and variable return to scale environment, private sector banks significantly more input losses compared to public and private sector banks. The pure technical efficiency is obtained removing the influence of exogenous risk, and scale inefficiency from overall input technical efficiency measured in no-NPA, scale efficient environment all the three sectors experienced input losses only marginally in endogenous risk environment.

Among public sector banks exogenous risk environment is consistent with only the banks, viz., State Bank of Hyderabad, State Bank of Mysore and Indian Bank. For these banks the existing risk control mechanism in strong enough, and there is no need of expending any more resources to control risk, but efforts are needed to increase the productivity of inputs. Five public sector banks are efficient in both the environments in which case risk is left uncontrolled. The remaining inefficient commercial banks require to choose endogenous risk environment.

71 percent of the public commercial banks are required to reduce their inputs and NPA. And the rest shall operate in exogenous risk environment.

Among 23 private sector banks 22 banks should control their inputs as well as risk. The ICICI bank appears to be efficient in risk exogenous and endogenous environment. 96 percent of commercial banks of private sector should perform in endogenous risk environment, strengthening their inbuilt risk control system.

Among 12 foreign sector banks 6 banks are efficient in both the risky environments. But these banks are already exposed to uncontrolled risk environment. Four banks are required to reduce their inputs and non-performing assets while two banks should choose to work in exogenous risk environment. 67 percent of the foreign sector banks should function in exogenous risk environment and 33 percent should choose to work in endogenous risk environment.

CONCLUSIONS:

This study decomposes multiplicatively input technical efficiency measured in risk free scale efficient environment into overall risk, scale and pure technical efficiency. A decision rule is proposed for the choice of environment. The risk faced by commercial bank arise from two sets of forces operating from outside and within named respectively leading to exogenous and endogenous risk. The former inefficiency emanates from factors that the commercial bank cannot control, and the later due to the weakness of the inbuilt risk control system.

The study compares 63 commercial banks comprising public, private and foreign sector banks against a common non-parametric production frontier. The empirical results reveal that exogenous risk is menace more to the public sector banks than foreign and private sector banks.

The in built risk control system are equally strong for public and foreign sector banks, 0.8138 for public and 0.8727 for foreign sector banks. Irrational loan advances investments are prominent move in private sector than public sector. Consequently, the private sector banks should strengthen their internal risk control system measured by the endogenous input risk efficiency estimate 0.5995. Due to scale inefficiency more inputs are lost in private sector banks than public sector banks. The Foreign sector banks are well ahead in their performance in all respects than public and private sector banks.

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APPENDIX-I:

DEA Models:

$$\lambda_{CRTS}^{rfite} = Min\left\{\lambda : \sum_{j=1}^{n} \lambda_j \, x_{ij} \le \lambda \, x_{i0} \, , \sum_{j=1}^{n} \lambda_j \, u_{rj} \ge \, u_{r0} \, , i = 1,2,\ldots,m\right\}$$

$$\lambda_{CRTS}^{rucite} = Min\left\{\lambda : \sum_{j=1}^{n} \lambda_j \, x_{ij} \le \lambda \, x_{i0} \, , \sum_{j=1}^{n} \lambda_j \, u_{rj} \ge u_{r0} \, , \sum_{j=1}^{n} \lambda_j \, u_{bj} \le u_{b0} \, , i = 1,2,\ldots,m; r = 1,2,....,s\right\}$$
$$\lambda_{VRTS}^{rucite} = Min\left\{\lambda : \sum_{j=1}^{n} \lambda_j \, x_{ij} \le \lambda \, x_{i0} \, , \sum_{j=1}^{n} \lambda_j \, u_{rj} \ge u_{r0} \, , \sum_{j=1}^{n} \lambda_j \, u_{bj} \le u_{b0} , \sum_{j=1}^{n} \lambda_j = 1, \; i = 1,2,\ldots,m; r = 1,2,....,s\right\}$$
$$\lambda_{CRTS}^{rcite} = Min\left\{\lambda : \sum_{j=1}^{n} \lambda_j \, x_{ij} \le \lambda \, x_{i0} \, , \sum_{j=1}^{n} \lambda_j \, u_{rj} \ge u_{r0} \, , \sum_{j=1}^{n} \lambda_j \, u_{bj} \le u_{b0} \, , i = 1,2,\ldots,m; r = 1,2,....,s\right\}$$
$$\lambda_{VRTS}^{rcite} = Min\left\{\lambda : \sum_{j=1}^{n} \lambda_j \, x_{ij} \le \lambda \, x_{i0} \, , \sum_{j=1}^{n} \lambda_j \, u_{rj} \ge u_{r0} \, , \sum_{j=1}^{n} \lambda_j \, u_{bj} \le u_{b0} , \sum_{j=1}^{n} \lambda_j = 1, \; i = 1,2,\ldots,m; r = 1,2,....,s\right\}$$
$$\lambda_{CRTS}^{iucre} = Min\left\{\lambda : \sum_{j=1}^{n} \lambda_j \, x_{ij} \le x_{i0} \, , \sum_{j=1}^{n} \lambda_j \, u_{rj} \ge u_{r0} \, , \sum_{j=1}^{n} \lambda_j \, u_{bj} \le \lambda u_{b0} \, , i = 1,2,\ldots,m; r = 1,2,....,s\right\}$$
$$\lambda_{VRTS}^{icre} = \lambda_{VRTS}^{ricte}$$

APPENDIX-II:

PUBLIC SECTOR BANKS:

S.NO	Bank Name	λ_{CRTS}^{rfite}	λ_{CRTS}^{rucite}	λ_{VRTS}^{rucite}	λ_{CRTS}^{rcite}	λ_{VRTS}^{rcite}	λ^{rucse}	λ^{rcse}
1	State Bank of India	0.2992	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	State Bank Bikaner & Jaipur	0.3408	0.8849	0.9435	0.9037	0.9958	0.9379	0.9075
3	Statebank of Hyderabad	0.3439	0.8837	0.8905	0.9097	0.9543	0.9924	0.9533
4	State Bank of Indore	0.3809	0.8469	0.9651	0.8510	0.9979	0.8775	0.8528
5	State Bank of Mysore	0.2946	0.7238	0.7260	0.7725	0.9666	0.9970	0.7992
6	Statebank of Patiala	0.4284	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	State bank of Saurashtra	0.2218	0.4773	0.4944	0.4950	0.9591	0.9654	0.5161
8	State Bank of Travancore	0.3679	0.8764	1.0044	0.8783	1.0000	0.8726	0.8783
9	Allahabad Bank	0.2651	0.5593	0.6164	0.5962	0.9082	0.9074	0.6565
10	Andhra Bank	0.3463	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
11	Bank of Baroda	0.3107	0.9386	0.9589	0.9488	0.9589	0.9788	0.9895
12	Bank of India	0.3201	0.9960	1.0000	0.9964	1.0000	0.9960	0.9964
13	Bank of Maharashtra	0.2689	0.6861	0.7930	0.7618	0.9763	0.8652	0.7803
14	Canara Bank	0.2783	0.6269	0.6310	0.6612	0.8181	0.9935	0.8082
15	Central bank of India	0.2060	0.6772	0.7627	0.7038	0.9268	0.8879	0.7594
16	Corporation Bank	0.3752	0.8978	0.8993	0.9192	0.9728	0.9983	0.9449
17	Dena Bank	0.2430	0.5360	0.7739	0.5454	0.9760	0.6926	0.5588
18	IDBI Ltd.	0.7833	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19	Indian Bank	0.2012	0.7119	0.7233	0.7556	0.8951	0.9842	0.8442
20	Indian Overseas Bank	0.3006	0.8673	0.8744	0.8856	0.9310	0.9919	0.9512
21	Oriental Bank of Commerce	0.4353	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
22	Punjab & Sind Bank	0.1807	0.4520	0.4543	0.4673	0.9442	0.9949	0.4949
23	Punjab national Bank	0.2677	0.8601	0.8697	0.8707	0.8767	0.9890	0.9932
24	Syndicate Bank	0.2912	0.7692	0.7692	0.8229	0.9313	1.0000	0.8836
25	UCO Bank	0.2730	0.6683	1.0000	0.7266	1.0000	0.6683	0.7266
26	Union bank of India	0.3163	0.7941	0.8355	0.8329	0.9462	0.9504	0.8803
27	United Bank of India	0.1880	0.4635	0.5830	0.5360	0.9257	0.7950	0.5790
28	Vijaya Bank	0.3588	0.9446	0.9450	0.9463	0.9819	0.9996	0.9637

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FOREIGN SECTOR BANKS:

S.NO	Bank Name	λ_{CRTS}^{rfite}	λ_{CRTS}^{rucite}	λ_{VRTS}^{rucite}	λ_{CRTS}^{rcite}	λ_{VRTS}^{rcite}	λ^{rucse}	λ^{rcse}
29	ABN Amro bank	0.6895	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
30	Abu Dhabi Commercial Bank	0.9239	0.9239	1.0000	0.9239	1.0000	0.9239	0.9239
31	American Express Bank	0.1208	0.5921	0.5930	0.7690	0.9905	0.9985	0.7764
32	Bank of Bahrain & Kuwait	0.3739	0.3739	0.4821	0.3739	0.9979	0.7756	0.3747
33	Bank of Ceylon	0.8064	0.8064	1.0000	0.8064	1.0000	0.8064	0.8064
34	Bank of Tokyo-Mitsubishi UFJ	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
35	Chinatrust Commercial Bank	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
36	Citi Bank	0.7371	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
37	Deutsche Bank	0.6148	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
38	Hongkong & Shanghai BankingCorporation	0.4722	0.8009	0.8024	0.8266	0.9520	0.9981	0.8683
39	JB Morgan Chase bank	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
40	Standard Chartered Bank	0.4755	0.7107	0.9270	0.7723	0.9909	0.7667	0.7794

PRIVATE SECTOR BANKS:

S.NO	Bank Name	λ_{CRTS}^{rfite}	λ_{CRTS}^{rucite}	λ_{VRTS}^{rucite}	λ_{CRTS}^{rcite}	λ_{VRTS}^{rcite}	λ^{rucse}	λ^{rcse}
41	Axis Bank	0.5112	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
42	Bank of Rajasthan	0.2238	0.5351	0.5355	0.5632	0.9680	0.9993	0.5818
43	Catholin Syrian Bank	0.1644	0.3254	0.4828	0.3919	0.9905	0.6740	0.3957
44	Centurion Bank of Punjab	0.1159	0.2515	0.3286	0.3891	0.9303	0.7654	0.4183
45	Citi Union Bank	0.2725	0.4994	0.5441	0.5641	0.9922	0.9178	0.5685
46	Development Credit bank	0.2082	0.3646	0.4271	0.4358	0.9889	0.8537	0.4407
47	Dhanalakshmi bank	0.1893	0.3041	0.3660	0.4082	0.9920	0.8309	0.4115
48	Federal Bank	0.3419	0.7654	0.7655	0.7745	0.9726	0.9999	0.7963
49	HDFC Bank	0.2874	0.8221	0.8351	0.8514	0.9008	0.9844	0.9452
50	ICICI Bank	0.6919	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
51	Induslnd Bank	0.5864	0.9127	1.0000	0.9164	1.0000	0.9127	0.9164
52	Ing Vysys bank	0.2961	0.4889	0.4944	0.5056	0.9572	0.9889	0.5282
53	Jammu & Kashmir Bank	0.3601	0.8196	0.9619	0.8262	0.9966	0.8521	0.8290
54	Karnataka Bank	0.3180	0.7031	0.8354	0.7200	0.9909	0.8416	0.7266
55	Karur Vysya Bank	0.3007	0.5790	0.5793	0.6086	0.9760	0.9995	0.6236
56	Kotak Mahindra bank	0.2920	0.5697	1.0000	0.7157	1.0000	0.5697	0.7157
57	Lakshmi Vilas bank	0.2953	0.5581	0.7730	0.6160	0.9967	0.7220	0.6180
58	Lord krishna Bank	0.1389	0.1666	0.8597	0.3457	0.9990	0.1938	0.3460
59	Ratnakar bank	0.1355	0.1355	0.1547	0.2449	0.9952	0.8759	0.2461
60	Sangli Bank	0.0584	0.0584	0.0611	0.1326	0.9837	0.9558	0.1348
61	SBI Comm.& Intl Bnak	0.4509	0.4509	0.4966	0.4509	0.9976	0.9080	0.4520
62	South Indian Bank	0.3063	0.7056	0.7621	0.7266	0.9879	0.9259	0.7355
63	Tamilnad Mercantile Bank	0.2748	0.5516	0.5740	0.6003	0.9901	0.9610	0.6063

NOTE:

1. $\lambda^{rucse} = \lambda_{CRTS}^{rucite} / \lambda_{VRTS}^{rucite}$
2. $\lambda^{rcse} = \lambda_{CRTS}^{rcite} / \lambda_{VRTS}^{rcite}$

APPENDIX: III Data in lakhs

S. No	Bank Name	No. of Employees	Fixed Assets	Deposits	Advances	Investments	Non-Interest income	NPA
1	State Bank of India	185,388	281,886	43,552,109	33,733,649	14,914,888	617,556.11	525,772
2	State Bank Bikaner & Jaipur	11,752	14,225	2,848,049	2,052,622	868,367	40,373.74	22,280
3	State Bank of Hyderabad	12,800	24,222	4,150,267	2,810,925	1,391,915	50,033.34	6,130
4	State Bank of Indore	6,517	10,455	1,997,649	1,535,138	599,244	23,300.46	15,906
5	State Bank of Mysore	9,604	13,338	2,202,235	1,646,553	698,975	37,311.27	7,488
6	State Bank of Patiala	11,329	16,351	3,918,363	2,876,976	1,235,766	36,070.12	23,841
7	State Bank of Saurashtra	7,148	19,643	1,580,488	1,108,114	501,100	12,061.99	7,751
8	State Bank of Travancore	11,607	16,036	3,098,401	2,478,628	956,169	24,315.60	26,762
9	Allahabad Bank	20,379	105,634	5,954,366	4,129,004	1,874,606	41,274.88	44,019
10	Andhra Bank	13,831	19,234	4,145,402	2,788,907	1,430,073	48,016.42	4,725
11	Bank of Baroda	38,086	108,880	12,491,598	8,362,087	3,494,364	130,263.03	50,167
12	Bank of India	41,511	78,930	11,988,173	8,493,590	3,549,275	174,213.50	63,203
13	Bank of Maharashtra	13,893	21,490	3,391,934	2,291,939	1,129,840	29,257.12	27,738
14	Canara Bank	46,359	286,135	14,238,144	9,850,569	4,522,553	160,982.20	92,697
15	Central Bank of India	39,055	76,727	8,277,628	5,179,547	2,774,190	53,014.61	87,800
16	Corporation Bank	11,880	28,103	4,235,689	2,994,965	1,441,750	63,791.99	14,193
17	Dena Bank	10,120	44,187	2,768,991	1,830,339	923,504	42,458.34	36,480
18	IDBI Ltd.	7,482	277,835	4,335,403	6,247,082	2,567,532	111,108.07	72,193
19	Indian Bank	20,892	55,118	4,709,091	2,905,812	2,087,772	79,169.60	10,213
20	Indian Overseas Bank	23,861	51,067	6,874,042	4,706,028	2,397,449	45,241.26	25,783
21	Oriental Bank of Commerce	14,730	38,268	6,399,597	4,413,847	1,980,835	67,282.01	21,566
22	Punjab & Sind Bank	9,325	25,301	1,931,875	1,173,751	669,308	24,378.95	7,704

23	Punjab national Bank	57,316	100,983	13,985,968	9,659,652	4,518,983	110,447.31	72,562
24	Syndicate Bank	24,360	77,154	7,863,357	5,167,044	2,523,402	73,207.43	39,101
25	UCO Bank	24,773	66,669	6,486,001	4,698,891	1,952,487	48,661.52	100,606
26	Union Bank of India	27,536	82,500	8,518,023	6,238,643	2,798,178	73,928.07	60,122
27	United Bank of India	16,793	60,522	3,716,666	2,215,632	1,460,182	35,963.30	33,300
28	Vijaya Bank	10,765	18,617	3,760,449	2,422,355	1,201,841	31,344.54	14,396
29	ABN Amro Bank	3,549	12,404	1,599,830	1,838,755	640,667	86,930.38	2,128
30	Abu Dhabi Commercial Bank	40	672	47,379	20,344	14,356	1,649.69	128
31	American Express Bank	1,982	5,648	266,411	159,318	195,896	39,870.39	1,231
32	Bank of Bahrain & Kuwait	76	587	36,430	17,090	10,894	455.68	19
33	Bank of Ceylon	33	13	8,649	4,094	3,087	333.14	608
34	Bank of Tokyo-Mitsubishi UFJ	142	1,237	96,049	158,857	52,238	5,481.23	113
35	Chinatrust Commercial Bank	21	26	10,287	11,590	4,115	136.49	32
36	Citi Bank	5,194	79,797	3,787,501	3,286,110	1,602,114	159,923.55	33,610
37	Deutsche Bank	1,040	13,030	697,838	494,506	620,354	77,769.33	42
38	Hongkong & Shanghai Banking Corporation	6,564	70,216	3,482,465	2,314,168	1,413,083	144,066.33	9,858
39	JB Morgan Chase Bank	130	202	166,656	79,925	436,669	23,511.83	1,738
40	Standard Chartered Bank	7,321	87,727	3,417,405	3,010,379	1,190,229	151,252.67	43,190
41	Axis Bank	9,980	67,320	5,878,560	3,687,648	2,689,717	120,141.87	26,633
42	Bank of Rajasthan	3,908	13,888	1,081,593	570,402	364,069	13,669.61	1,367
43	Catholin Syrian Bank	2,791	5,986	474,859	301,264	155,329	3,763.45	5,968
44	Centurion Bank of Punjab	14,458	33,731	1,486,372	1,122,135	461,496	50,273.16	14,150
45	Citi Union Bank	1,871	3,922	469,933	332,923	130,700	6,113.87	3,625
46	Development Credit bank	1,809	8,144	441,520	265,852	184,663	10,787.78	4,364
47	Dhanalakshmi Bank	1,385	4,957	308,796	183,950	86,519	3,241.07	3,224
48	Federal Bank						31,362.39	

		6,029	18,609	2,158,444	1,489,910	703,266		6,505
49	HDFC Bank	21,477	96,667	6,829,794	4,694,478	3,056,480	167,873.52	20,289
50	ICICI Bank	33,321	392,341	23,051,019	19,586,56 0	9,125,783	685,869.60	199,204
51	Induslnd Bank	2,613	36,958	1,764,481	1,108,420	589,166	26,577.49	27,375
52	Ing Vysya Bank	4,982	39,596	1,541,858	1,197,617	452,780	20,829.17	11,402
53	Jammu & Kashmir Bank	6,829	18,345	2,519,428	1,707,994	739,218	16,614.98	19,394
54	Karnataka Bank	4,456	10,682	1,403,744	955,268	504,816	18,169.23	11,604
55	Karur Vysya Bank	3,286	9,669	934,031	704,048	287,395	13,184.00	1,597
56	Kotak Mahindra Bank	5,437	14,108	1,100,009	1,092,406	686,196	37,640.07	21,680
57	Lakshmi Vilas Bank	1,926	3,549	501,987	361,271	130,930	4,952.76	5,695
58	Lord krishna Bank	1,163	2,061	187,252	101,782	72,398	1,398.72	4,447
59	Ratnakar Bank	553	1,622	87,638	53,052	31,583	504.51	1,020
60	Sangli Bank	1,770	8,124	132,589	20,507	79,647	614.56	1,451
61	SBI Comm.& Intl Bnak	97	4,675	48,785	32,950	12,567	433.99	61
62	South Indian Bank	3,868	8,959	1,223,921	791,892	343,013	11,468.17	7,781
63	Tamilnad Mercantile Bank	2,227	4,928	601,988	404,672	231,639	8,929.49	3,979