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Abstract:

This paper tries to examine issues of bank consolidation and efficiency for 16 major consolidation deals in India during the period 1995-2013.Using data envelopment analysis (DEA) method of input-oriented efficiency measures and non-parametric median tests and Tobit regression analysis, we find that consolidation improved efficiency in majority of the cases only when pure technical efficiency scores are considered. For overall efficiency and scale efficiency, in majority of the cases there was no significant improvement post consolidation. Further consolidation was a significant determinant for pure technical efficiency but not for overall and scale efficiency. In majority of the cases, the acquirer banks were more efficient than target banks only for pure technical efficiency but not for overall and scale efficiency.

Keywords: Consolidation, Indian Commercial Banks, Pure Technical Efficiency and Scale Efficiency , DEA and Tobit Regression models.

[1]I thank Mandira Sarma and Anushree Paul for their comments, corrections, suggestions and valuable inputs during preparation of this article.

1. Introduction:

Consolidation of banks means that two banks agree to merge together as a single entity. In the banking sector, consolidation happens in two ways, viz., mergers and acquisitions. According to Oxford Dictionary, "mergers mean combining two commercial companies into one'' and "acquisitions mean that one firm takes another firm in a friendly manner or aggressive manner''.

Bank consolidation is expected to improve banking sector performance. It creates changes in the structure of merged bank that may have a considerable effect on its management and operating cost. This may promote economies of scale and scope of consolidated banks. Many studies have found evidence of this (Sufian and Majid, 2007; Peristani, 1997; Khasawaneh, 2006; Berger and Humphrey, 1993; Singh, 2009). However, some empirical studies have found that bank consolidation need not lead to efficiency gains and actually may lead to deterioration in efficiency (Kaur and Kaur, 2010; Altunbas et al., 2000; Sanjeev, 2007).Theoretically, most efficient and well-managed banks take over the less efficient ones as it is expected that a more efficient one is better organized and more capable of handling the management issues. It is evident that when a more efficient bank takes over a less efficient one, it leads to an improvement in the performance of the merged bank due to better management and efficient decision-making which helps in restructuring weak banks. This study tries to measure efficiency scores pre- and post-merger for a selected set of merger and acquisition in India and compares these pre and post-merger efficiency scores to examine whether the acquirer is more efficient than the target banks by using their overall, pure technical and scale efficiency scores of the acquirer and target banks in India. In this paper, we study 16 consolidation deals in the Indian banking sector during the period 1995-2013 in an attempt to investigate whether these consolidation deals have led to efficiency gains. In the Indian context, many studies have examined the performance of the banking sector. However, few studies have addressed whether consolidation has any impact on banks performance. This paper is likely to contribute to the limited literature on the impact of consolidation on efficiency of Indian banking industry. In recent times, there has been a strong emphasis on consolidation in the Indian banking sector. According to RBI (2013), mergers and acquisitions (M&As) can help to stabilize the banking sector and can mitigate financial crisis. An empirical study from US reveals that the

consolidation of the commercial banks reduced the financial distress of merged banks (Berger and Humphrey, 1993). The results and findings of our study are likely to be useful for future ongoing consolidation deals in Indian banking sector, such as the recent State Bank of India (SBI) consolidation.

In this paper, we investigate three specific hypotheses. The first hypothesis is that the acquirer bank is more efficient than target bank. Few studies from Singapore have found evidence against this hypothesis (Sufian and Majid, 2007; Rhoades, 1998). Our study tries to address the issue for Indian banking sector. The second hypothesis is that consolidation leads to improvement of banks' efficiency post consolidation. The third hypothesis is that consolidation is a significant factor in determining banks efficiency. The basic tool for analysis here are efficiency scores, computed by using Data Envelopment Analysis (DEA). We use non-parametric median test to test the first two hypotheses and Tobit regression for the third hypothesis. We discuss the methodology in details in section 4.

This paper is structured as follows: Section 2 presents theoretical literature on various concept of efficiency. Section 3 presents a brief review of empirical literature on consolidation and efficiency. In Section 4 we provide the research methodology along with specification of variables and data used in the study. Section 5 gives a brief discussion of consolidation in Indian banking sector. Section 6 presents results and analysis of the three hypotheses considered in this study. Section 7 concludes the study.

2. Theoretical Background: Overall, Technical and Scale Efficiency[2]

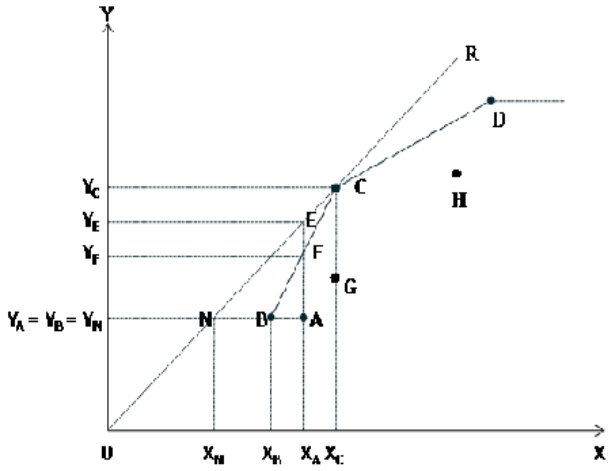
In this paper, we use three measures of efficiency – overall, pure technical and scale efficiency. These efficiency concepts are explained by Farrell (1957) and later extensions were made by Fare et al., (1985) and Fernandez et al.,(2001). Later, these concepts were reformulated by Charnes, Cooper and Rhodes (1978).

Banks' efficiency can be defined from two perspectives, Viz., input-oriented efficiency and output-oriented efficiency. Input-oriented efficiency is measured in terms of how much a firm can minimize input usage relative to other firms, to produce a fixed level of output. Output-

[2]I thank Anushree Paul for her help in writing this section.

oriented efficiency is measured in terms of how much a firm can maximize output relative to other firms, using the same level of input.

Figure 1: Overall, Technical and Scale efficiencies



A firm (eg., a bank) is referred to as a "decision- making unit (DMU)" which produces multiple outputs by using multiple inputs. For example, consider the case of a single output produced by using single input.[3] In Figure 1, X-axis shows input usage of firms and Y-axis shows output produced by firms. Let A, B, C, D, H and G are six representative DMUs (banks). The DMU A produces Y_A amount of output by using X_A amount of input. The DMU B also produces same level of output by using $X_B < X_A$ amount of input. Since DMU B uses less input to produce the same level of output compared to DMU A, hence we can say that DMU A is inefficient compared to DMU B in the input-oriented efficiency sense.

The *best practice frontier* is determined by the DMUs, which use the 'fewest' inputs to produce the given level of output. For simplicity, in Constant Returns to Scale (CRS) production technology, we assume constant returns to scale, i.e., one unit of input produces one unit of output. The ray OR shows the total product line under CRS. Farrell (1957) defined that the technical efficiency measures a DMU's success in producing maximum outputs from a given level of inputs. It shows that any point on the frontier has an efficiency score of unity, where unity denotes efficient (best practice) performance. In general, full technical efficiency satisfies the relation TE = 1. Alternatively, $TE < 1$ implies that the DMU is technically inefficient (Fernandez et al., 2001). The overall technical efficiency (OTE) of representative DMUs is ONCR in Figure 1. This is the most efficient production frontier under CRS. This CRS frontier represents *potential* to actual input and output usage, while holding input and output proportions

[3] In general, firms use a bundle of different inputs to produce their bundle of outputs. In figure 1, we consider a single input and a single output for simplicity.

constant. This overall efficiency can be decomposed to pure technical and scale efficiencies when we consider Variable Returns to Scale (VRS) production technology.

Under the variable returns to scale (VRS), X_BBCD is the technical efficiency frontier in Figure 1. In VRS technology, the firms located in points B, C and D are producing on the boundary of production possibility set for input-output mix (X, Y). The firm B is producing its outputs in the increasing rates of the production frontier. It would turn into more productive by increasing its production scale towards C. On the contrary, D is operating in the decreasing return to scale and can become more productive by reducing its production scale towards C. Hence, B and D are inefficient firms as they lie below the CRS frontier. The firm C is achieving pure technical efficiency and scale efficient as it lies on the CRS frontier and it is measured to be operating at the *most productive scale size (MPSS)*. Firms located in points A, G and H are neither on VRS frontier nor on CRS frontier, hence inefficient firms. The inefficiency of firm A can be measured by comparing with either C or N. The pure (input-oriented) technical efficiency of firm A is measured by the ratio $\left(\frac{OX_B}{OX_A}\right)$by comparing it with bank B.

***Scale Efficiency*:** It is possible that a DMU is technically efficient but operating in a sub-optimal scale of operation. This is possible if the unit operates under either *increasing returns to scale* (IRS) or *decreasing returns to scale* (DRS) and not under *constant returns to scale* (CRS). The DMU will become automatically scale efficient if the underlying production technology is CRS. Scale efficiency indicates the amount such that the average productivity can be enhanced by moving towards the point of MPSS. The (input-oriented) scale efficiency of bank A is$\left(\frac{OX_N}{OX_B}\right)$. Thus the overall technical efficiency score for firm A is $\left(\frac{OX_N}{OX_A}\right)$.But, $\left(\frac{OX_N}{OX_A}\right) = \left(\frac{OX_B}{OX_A}\right).\left(\frac{OX_N}{OX_B}\right)$ that is,

$$Overall\,Technical\,Efficiency(OTE)^{crs}_{input} = Pure\,Technical\,Efficiency(PTE)^{vrs}_{input}.Scale\,Efficiency_{input}$$

$$TE^{crs}_{input-oriented} = TE^{vrs}_{input-oriented}.SE_{input-oriented}.$$

This will not be the same as in the output-oriented efficiency measure except for the constant returns to scale technology. In an analogous manner, it can be seen that the factor $\left(\frac{OY_C}{OY_A}\right)$ is a measure of the pure technical (output-oriented) efficiency of firm A. Although a firm may be

technically inefficient in an overall sense, while experiencing scale inefficiencies, it can be purely technically efficient (Fernandez et al., 2001). This is evident in Figure 1 that firms B and D are purely technically efficient but exhibit scale inefficiencies. Firm G is neither scale efficient nor purely technical efficient as it lies below the frontier. Firm H is scale efficient as it produces at input level X_C, but (pure) technically inefficient as it is lying outside the frontier.

3. Empirical Literature Review

Berger and Humphrey (1993) pointed out that efficiency gains are achieved by making changes in inputs and outputs. Efficiency gains are also obtained by reducing costs, increasing incomes, lowering risk on loans. As evident from U.S in 1990s, bank mergers had direct effect on improving cost efficiency of banks, while cost efficiency of banks marginally improved due to mergers in 1980s. Berger and Humphrey (1993) found from US mergers that mergers and acquisitions had slightly achieved scale inefficiency for large banks in the 1980s. Thus, it has performed the part of technological effects that raised its economies of scale on production services. Furthermore, international mergers and acquisitions (cross-border merger) improve cost efficiency of banks and other types of mergers and acquisitions (domestic based deals) have been found to lower efficiency gains in US after mergers. It also showed that few mergers had an insignificant effect on the bank`s efficiency, and some mergers contributed to the bank`s efficiency positively.

Rhodes (1998) summarized nine research papers that analyzed nine merger deals in Singapore banking sector spanning over the period 1980-1990 and their impact on banks' efficiency. Seven out of nine cases supported the hypothesis that the acquirin1g bank is more efficient than target. In two out of the remaining three mergers, the acquirer was less efficient than the target. Further, 8 out of 9 deals were successful in efficiency gains and only one deal did not experience efficiency gain in post-merger. Apart from that, the result of the study found that branch overlap had risen in all cases after the merger activity. It also pointed out that if the acquirer is more efficient than the target bank than it is more likely to result in efficiency gains of the banks (Rhoades, 1998). An empirical study by Sufian and Majid (2007), from Singaporean commercial banks recorded improvement in post-merger than the pre- merger efficiency scores calculated by using DEA technique. By using the methodology of DEA, Sufian and Majid (2007)

found that Singapore commercial banks' aggregate efficiency score of 94.93 percent during the post-merger was higher than 91.68 percent registered in the pre-merger period. This result is observed in both the product and intermediate method of DEA analysis.[4] During the merger, it found some deterioration in scale efficiency and bank size was an important factor in scale inefficiency. Furthermore, it concluded that the acquirer was less efficient than the target bank. The study found that both the product and intermediate models did not support the hypothesis that the acquirer is more efficient than the target bank (Sufian and Majid, 2007).

In the Indian context, Gourlay et al. (2006) has analyzed efficiency gains from bank mergers in India from the period of 1991 to 2005 by using an extended version of Data Envelopment analysis methodology which was developed by Bogetoft and Wang (2005). The efficiency results were divided into two methods namely, *Product method* and *Intermediate method*. In product method, fixed assets, other assets and borrowing was considered as input variables, and advances, deposits and total investment as measured as output variables. In the intermediate method, deposits were considered as input variables and loans were considered as output variables. The results of the study showed that the mergers have a considerable and potential efficiency gains compared with non-merging banks. The results showed that most of the mergers have achieved the potential efficiency gains in Indian banking sector. This potential efficiency gains were achieved in consolidation by restructuring its businesses and product-mix. Apart from that, the restructure of the banking services gave considerable effects on efficiency in post-merger. The synergy of products also gave a substantial benefit for combined banks. Furthermore, consolidation reduced risk on loans. Finally, under both the input and the output models, the merged banks registered higher level of technical efficiency that indicated healthier bank. It reveals that healthier banks are more able to convert its input to output efficiently than the weaker one. Under the production method, three out of five mergers have found a higher level of technical efficiency gains. Apart from that, it is pointed out that, wealthier banks' business policies and management have successfully shifted to the newly created entity that allows making its business in the market efficiently.

[4] Product method means that the banks are considered a service provider for customers and intermediate method means that banks are intermediators between borrowers and savers.

In another study, Singh (2009) has conducted a study of efficiency on 12 selected commercial bank mergers in India from the period of 2000-2005. It investigated the efficiency benefits of 12 mergers deals in India by using the DEA methodology with selected variables such as capital, interest expenses, and operating cost. The study found that mergers have positively impacted profit and cost efficiencies of selected bank mergers. It furthermore revealed that the banks would not move with low expectation toward mergers and they would move with the reason of improving efficiency, market power and profitability, and they can strongly identify and measure the merger's effects rationally.

Kaur and Kaur (2010) considered eleven deals of mergers and acquisitions in India from 1991 to 2007. The overall results found that mergers led to higher level of cost efficiencies for merged entity. The decomposition of cost efficiency is technical efficiency and allocative efficiency. The technical efficiency is the major one for efficiency gains of merged entity rather than allocative efficiency. Further, the merger deal between healthier and distressed banks did not gain any efficiency gains of selected deals. However, forced merger deals succeeded in achieving the interest of depositors and stakeholders did not get any gains from merger.

A case study of Bharat Overseas Bank and Indian Overseas Bank (IOB) merger by Kumar (2013) pointed out that mergers and acquisitions are a way to improve banks performance effectively by sharing banks resources, reducing operating costs and improving products and services, and improving its economics of scale in their businesses. By using simple descriptive statistics and t-test, it found that all the efficiency indicator variables have registered higher value in post-merger. Investment and advances have registered 114.36 percent, and interest income of IOB is registered 116.15 percent. In a different manner, Non-Performing Assets (NPAs) of IOB have declined 26 percent. The t-test showed that there is a considerable improvement in efficiency in post-merger period (Kumar, 2013).

In general, bank consolidation causes in providing compact and stable banking services and also causes a reduction in the cost of production by reducing the operating and interest expenses. Furthermore, it is also helpful in achieving specific targets, i.e. by reducing the non-performing assets, increasing credits by efficiency, and controlling or maintaining the return on assets and the risk on assets (Berger and Humphrey, 1993; Gourlay et al., 2006; Singh, 2009;

Kaur and Kaur, 2010; Kumar, 2013). It may or may not have the same impact on different countries mergers and acquisitions. The main findings of the literature show that the acquirer may be less efficient than the target banks in some cases. Furthermore, the merger and acquisition between the healthier and weaker banks generally improves merged bank's efficiency positively and healthier bank's performance and decision-making unit is shared by weaker banks (Rhodes, 1998; Sufian and Majid, 2007). According to above-mentioned literature, the choice of the variables and period of the mergers deals might affect the results of DEA and might make deterioration on efficiency and profitability. However, the existing literature of Indian banks' mergers does not give a clear cut result of bank mergers. Apart from that, there is no conclusive evidence in support of the argument that the mergers should result in improving banks efficiency especially on scale efficiency. Furthermore, there are inconclusive results due to method of efficiency measurement, and this is mainly due to the differences in time periods, variables and analysis, and more importantly due to variation in definition in measuring scale efficiency of banks by using variable returns to scale in the output-oriented model of DEA.

4. Data and Methodology:

In this paper, we use non-parametric Data Envelopment Analysis (DEA) to compute three types of efficiency measures – overall, pure technical and scale efficiency for all banks in India for the years 1995-2013. The number of banks considered for DEA varies in each year due to entry/exit/ merger etc in the banking sector. The efficiency scores are measured by using a two input-two output model. The inputs used are interest expenditure and total deposit and outputs considered are interest income and total advances. The data are collected and compiled from ``The Statistical Tables Relating to Banks in India'' of RBI.[5] The present study has excluded the regional rural and cooperative banks.

Using efficiency measures of banks for 16 consolidation deals during this period, we try to investigate three hypotheses relating to issues of consolidation and efficiency is Indian banking sector. The three hypotheses are

[5]Banks' data is accessed from, https://rbi.org.in/scripts/AnnualPublications.aspx?head=Statistical+Tables+Relating+to+Banks+in+India&fromdate=11%2f20%2f2013&todate=11%2f22%2f2013 on 27-04-2014.

Hypothesis I →

H_0: {The target bank and the acquirer banks are equally efficient}

Against H_1: {Acquirer bank is more efficient than the target bank}

Hypothesis II →

H_0: {There is no difference in efficiency scores before and after consolidation}

Against H_1: {Post-consolidation efficiency score is higher than pre-consolidation efficiency score}

Hypothesis III →

H_0: {consolidation has no impact on efficiency}

Against H_1: {consolidation has a significant impact on efficiency of banks}

In the following subsections we discuss the methodologies adopted in this paper in detail.

4.1. Data Envelopment Analysis[6]

The non-parametric Data Envelopment Analysis (DEA) approach consists in measuring overall, pure technical and scale efficiency. DEA compares many parameters simultaneously and provide a scalar measure of overall performance by measuring relative efficiency of each of the firms relative to a given set of firms. However, in DEA only a few inputs and outputs are chosen depending on how critical their contribution is to the effective performance of the firm. Another unique characteristic of DEA is that the type of units used for all the inputs and outputs does not have to be the same which makes the measure of efficiency "units invariant" This gives a tremendous flexibility in choosing the inputs and outputs, and a convenient way to compare relative efficiencies of DMUs (Cooper et al., 2000).

The average productivity of a DMU is measured as the ratio of its total outputs to total inputs (Ray, 2004). Under constant return to scale (CRS) technology, average productivity is same as overall technical efficiency (OTE). However, under variable return to scale (VRS) technology, the maximum average productivity at the most productive scale size (MPSS) can be compared with average productivity at the actual scale of production to measure scale efficiency. In the following section we discuss efficiency scores estimation under CRS.

[6]We have extensively used Ray (2004) to write this section.

The measurement of average productivity necessitates aggregation of inputs and outputs. Since market prices of inputs and outputs are not available, we use shadow prices for the aggregation. In the shadow prices, two conditions are imposed. First, all the shadow prices of input and output bundles are nonnegative. Second, the shadow prices are such that the average productivity is less than or equal to unity.

If firm *t* uses *n* inputs to produce *m* outputs, then its average productivity is given by

$$AP_t = \frac{\sum_{r=1}^{m} v_{rt} y_{rt}}{\sum_{i=1}^{n} u_{it} x_{it}}$$

m = No. of outputs; *n* = No. of inputs; AP_t = Average Productivity of t^{th} bank;

u_t (shadow prices of inputs) = ($u_{1t}, u_{2t}, \ldots, u_{nt}$) ; v_t (shadow prices of outputs) = ($v_{1t}, v_{2t}, \ldots, v_{mt}$).

The shadow prices are determined so as to maximize AP_t while satisfying the conditions that shadow prices are non-negative and they generate meaningful average productivity for all other firms. If there are N firms, then the problem is to

$$\text{Maximize } AP_t = \frac{\sum_{r=1}^{m} v_{rt} y_{rt}}{\sum_{i=1}^{n} u_{it} x_{it}}$$

Such that

$$AP_j = \frac{v^{t'} y^j}{u^{t'} x^j} = \frac{\sum_{r=1}^{m} v_{rt} y_{rj}}{\sum_{i=1}^{n} u_{it} x_{ij}} \leq 1 \text{ ; (j = 1, 2…, N)}$$

$$u_{it} \geq 0 \quad \text{; } (i = 1, 2, \ldots, n);$$

$$v_{rt} \geq 0 \text{ ; } (r = 1, 2, \ldots, m);$$

This is a fractional functional programming problem. To transform this into a linear programming problem (LPP), we proceed as Charnes and Cooper (1962)'s method.

When all the shadow prices of input and output bundles are multiplied by a non negative factor (k> 0), that will not affect our objective function (AP_t) as well as constraints. Let

$$w_{it} = ku_{it} (i = 1,2,3,..., n)$$

$$p_{rt} = kv_{rt} (r = 1,2,3,..., m.)$$

Then, the optimization problem is

$$\max \frac{p^{t'} y^t}{w^{t'} x^t};$$

$$s.t. \frac{p^{t'} y^t}{w^{t'} x^t} \leq 1; \ (t = 1, 2\ldots \text{N});$$

$$p^t \geq 0;$$

$$w^t \geq 0;$$

Now, we set $k \equiv \frac{1}{\sum_{i=1}^{n} u_{it} x_{it}}$

Then, $w^{t'} x^t = 1$ and then the optimization problem turns into a linear programming problem as follows

$$\max \sum_{r=1}^{m} p_{rt} y_{rt}$$

$$s.t. \sum_{r=1}^{m} p_{rt} y_{rt} - \sum_{i=1}^{n} w_{it} x_{it} \leq 0;$$

$$\sum_{i=1}^{n} w_{it} x_{it} = 1$$

$$P_{rt} \geq 0 \ \ ; (r=1, 2,\ldots m)$$

$$W_{it} \geq 0 \ ; (i = 1, 2,\ldots n)$$

This linear programming problem can be solved using the simplex method. Thus, the optimal solution of this LPP yields a measure of the output-oriented technical efficiency of firm *t.*The output prices reflect the cost of the inputs drawn away from other uses to produce one unit

of the output, and then the total imputed value of the output bundle exceeding the total imputed cost of the input bundle used would imply that the output bundle is overvalued.

In this paper, the DMUs considered are Indian commercial banks. We consider two-input and two-output model, given by y^t (output bundle) = (y_{1t}, y_{2y}) and x^t (input bundle) = (x_{1t}, x_{2t}). The efficiency scores are measured by using two input and two output variables, viz., X_t (Two Input Bundle) = (Interest Expenditure (X_1), Total Deposits (X_2)); y_t (Two Output Bundle) = (Interest Income (Y_1), Total Advances / Loans (Y_2)). Then, the linear programming problem (LPP) becomes,

$$\max p_{1t} y_{1t} + p_{2t} y_{2t}$$

$$s.t. p_{1t} y_{11} + p_{2t} y_{21} - w_{1t} x_{11} - w_{2t} x_{21} \le 0;$$

$$p_{1t} y_{12} + p_{2t} y_{22} - w_{1t} x_{21} - w_{2t} x_{22} \le 0;$$

$$p_{1t} y_{1t} + p_{2t} y_{2t} - w_{1t} x_{1t} - w_{2t} x_{2t} \le 0;$$

$$p_{1t} y_{1N} + p_{2t} y_{2N} - w_{1t} x_{1N} - w_{2t} x_{2N} \le 0;$$

$$w_{1t} x_{1t} - w_{2t} x_{2t} = 1;$$

$$p_{1t}, p_{2t}, w_{1t}, w_{2t} \ge 0.$$

This is a primal LPP and it is difficult to solve because this LPP includes N+1 constraint (the additional constraint is $w_{1t} x_{1t} - w_{2t} x_{2t} = 1$). The primal of the LPP problem is duel. Then the dual of the linear programming problem has only four constraints, given by

$$min\ \theta$$

$$\text{s. t.} \quad \lambda_1 y_{11} + \lambda_2 y_{12} + \ldots + \lambda_t y_{1t} + \ldots + \lambda_N y_{1N} \ge y_{1t};$$

$$\lambda_1 y_{21} + \lambda_2 y_{22} + \ldots + \lambda_t y_{2t} + \ldots + \lambda_N y_{2N} \ge y_{2t};$$

$$\theta x_{1t} - \lambda_1 x_{11} + \lambda_2 x_{12} + \ldots + \lambda_t x_{1t} + \ldots + \lambda_N x_{1N} \ge 0$$

$$\theta x_{2t} - \lambda_1 x_{21} + \lambda_2 x_{22} + \ldots + \lambda_t x_{2t} + \ldots + \lambda_N x_{2N} \ge 0$$

$$\theta \text{ free}; \ \lambda_j \ge 0, \ (j = 1,2,\ldots,N).$$

Define $\phi = \frac{1}{\theta}$ and $\mu_j = \frac{\lambda_j}{\theta}$. Then, minimization of θin the above dual is equivalent to maximization of ϕ. In terms of redefined variables, the LP problem becomes

$$max\ \phi$$

$$s.t. \sum_{j=i}^{N} \mu_j y_{1j} \geq \phi y_{1t};$$

$$\sum_{j=i}^{N} \mu_j y_{2j} \geq \phi y_{2t};$$

$$\sum_{j=i}^{N} \mu_j x_{1j} \geq \phi x_{1t};$$

$$\sum_{j=i}^{N} \mu_j x_{2j} \geq \phi x_{2t};$$

ϕ free; $\mu_j \geq 0$, (j = 1,2,…,N).

Thus, clearly $\frac{1}{\phi^*}$ from this problem equals $\theta^*$from the previous problem. Further, by standard duality results, θ^*equals $p^{t*'}y^t$, the efficiency score of firm t.

This linear programming problem is solved by using Simplex method and the LPP can be solved for each bank *t* (t=1,2,3,….N).

In variable return to scale (VRS), the above-mentioned linear programming problem is used with additional constraint λ which is equal to 1. Scale efficiency of banks has been measured by using the ratio of Constant Returns to Scale technical efficiency and Variable Returns to Scale technical efficiency. For simplicity, scale efficiency is the ratio of the constant and variable returns to scale average productivity. The banks taken input and output bundles give the average productivity of the banks that is calculated by DEA. This average productivity is the technical efficiency of banks. Based on the constraints of λ (λ =1; λ > 1; λ < 1), return to scale of banks is observed.

In VRS, the average productivity of the input varies along the frontier of the production possibility set. It initially increases, reaching a maximum at particular level, and declines with further increase in *x*.

The input-oriented measure of technical efficiency of any firm *t* under VRS requires the solution of the following LP problem due to Banker, Charnes and Cooper (BCC):

$$\min \theta$$
$$s.t. \sum_{j=1}^{N} \lambda_j x^j \leq \theta\, x^t;$$
$$\sum_{j=1}^{N} \lambda_j y^j \geq y^t;$$
$$\sum_{j=1}^{N} \lambda_j = 1;$$
$$\lambda_j \geq 0 \ \ (j = 1,2,..., N).$$

Let $(\theta^*; \lambda_1^*, \lambda_2^*, ..., \lambda_N^*)$ be the optimal solution. Define $x_*^t = \theta^* x^t$. Then (x_*^t, y^t) is the efficient input-oriented radial projection of (x^t, y^t) on to the frontier and

$$Pure\ Technical\ Efficiency\ (PTE)_{INPUT}(x^t y^t) = \theta^*$$

The output-oriented measure of technical efficiency is obtained from the solution of the following program:

$$\max \phi$$
$$s.t. \sum_{j=1}^{N} \lambda_j x^j \leq x^t;$$
$$\sum_{j=1}^{N} \lambda_j y^j \geq \phi\, y^t;$$
$$\sum_{j=1}^{N} \lambda_j = 1;$$
$$\lambda_j \geq 0 \ \ (j = 1,2,..., N).$$

Again, define $\phi^* y^t = y_*^t$. Now (x^t, y_*^t) is the efficient output-oriented radial projection of (x^t, y^t) and

$$Pure\ Technical\ Efficiency\ (PTE)_{OUTPUT}(x^t y^t) = \frac{1}{\phi^*}$$

4.2. Median Test

A nonparametric median test is used to test hypothesis I and II. Since the efficiency scores lie in (0, 1), hence we cannot assume normal distribution for these scores. Hence conventional t-test is not applicable here. Also, we use three years' pre-consolidation efficiency scores for target and acquirer banks for Hypothesis I and three years' pre- and three years' post-

consolidation data of acquirer bank and merged bank respectively for the Hypothesis II. The use of three years' data for testing the effect of consolidation in efficiency is a standard practice n empirical literature. Rhodes (1998) observed that any efficiency gains should be observed within three-year after deal.

Hogg and Tanis (1988) explained median test, also called sign test. Let (X_1, X_2,.. X_{n1}) and (Y_1, Y_2,.. Y_{n2}) be two random samples from two independent distribution, with medians M_X and M_Y respectively. In median test, the null hypothesis is H_0: $M_X = M_Y$. To do this, combine the two samples and order the combined sample in ascending order. Count the number, say V, of X values in the lower half of this combined sample. If H_0: $M_X = M_Y$ is true, then we would expect V to equal around n_1/n_2. If as an alternative, $M_X < M_Y$, we would expect V to be larger and the alternative $M_X > M_Y$ would suggest a smaller value of V. Then V is our tests statistic and we need to find the distribution of V to construct the critical region of the test.

Let F(x) and G(y) denote the distribution functions of sample X and sample Y respectively. If F(z) = G(z), then H_0: $M_X = M_Y$ is true. While finding the distribution of V, we will assume that F (z) = G (z). If F (z) ≥ G (z), $M_X \leq M_Y$. if the observed value of V is quite large -that is, if the number of values of X falling below the median of the combined sample is large- we would suspect that $M_X < M_Y$. The critical regions for testing H_0: $M_X = M_Y$ against H_1: $M_X < M_Y$ is of the form v ≥ c, where is to be determined to yield the desired significance level (when If F (z) = G (z)). Similarly, the critical region for testing H_0: $M_X = M_Y$ against H_1: $M_X < M_Y$ is of the form v ≤ c. When F (z) = G (z) is true and still assuming continuous-type distributions, we shall argue that V has a hyper geometric distribution. To simplify the discussion, say that $n_1 + n_2 = 2k$, where k is positive integer. To compute P(V=v), we need the probability that exactly v of X_1, X_2 … X_{n1} are in the lower half of the ordered combined sample. Under our assumptions, the probability is zero that any two of the 2k random variables are equal. The smallest k of the $n_1 + n_2 = 2k$ items can be selected in any one of $\binom{2k}{k}$ ways, each having the same probability, provided that F(z) = G(z). Of these $\binom{2k}{k}$ ways, the number in which exactly v of the n_1 values X

and k – v of the n_2 values of Y appear in the lower k items is $\binom{n_1}{v}\binom{n_2}{k-v}$. Hence

$$h(v) = P(V = v) = \frac{\binom{n_1}{v}\binom{n_2}{k-v}}{\binom{n_1+n_2}{k}}, v = 0,1,..., n1 \quad \text{with the understanding that } \binom{j}{i} = 0 \text{ if i > j.}$$

4.3. Tobit regression model:

To test the third hypothesis, we use a Tobit regression model of efficiency scores for all banks for the year 2013 on a set of explanatory variables including dummy variable that defines whether a particular bank has gone through a consolidation process.

The Tobit model is proposed by James Tobin (1958) to identify the relationship between a limited dependent variable (eg., efficiency scores lying between 0 and 1) with some independent variables. This is also called censored regression model, used for estimating linear relationship between variables when there is left and right censoring of dependent variables. The measured efficiency scores of the banks lie between the interval of 0 and 1 ($0 < E^* \leq 1$); hence Tobit regression is more applicable methodology for the analysis of efficiency determinants. DEA scores are used as dependent variable in the Tobit model. Selected banking variables, namely, assets, consolidation dummy, capital, profit or loss and operating cost have been used as independent variables. The Tobit model is

$$\mathbf{y_i} = \alpha + \beta_1 capital_i + \beta_2 profit_i + \beta_3 operating\ cost_i + \beta_4 consolidation\ dummy_i + \varepsilon_i$$

Where y_i = efficiency score of i^{th} bank; Capital = capital of i^{th} bank; Profit = profit of i^{th} bank Operating cost = operating cost of i^{th} bank; Consolidation dummy = 1 if i^{th} bank has gone through consolidation over past 10 year and 0, otherwise.

$\boldsymbol{\varepsilon}_i \sim N(0,\sigma^2)$; $\boldsymbol{\varepsilon}_i$ = error term of i^{th} bank; α , β_1, β_2, $\beta 3$ and β_4 are unknown value of parameters. y is the efficiency scores and y* is the latent variable (dependent variable).[7]For this we use data for 2013 from Statistical Tables Related to the Banks in India, RBI.

[7]The likelihood function (L) is maximized to solve x and y based on 32 observations (banks) of *yi* and *xi* is. The first product is over the observations for which the banks are 100% efficient ($y = 0$) and the second product is over the observations for which

5. Bank Consolidation in India

The mergers and acquisitions in the Indian banking sector are regulated by the Banking Regulation Act (BR Act), 1949. RBI is the regulatory authority to approve and facilitate merger and acquisition processes between or among banks. The BR Act explains two kinds of merger and acquisition process such as (i) voluntary merger and acquisition and (ii) compulsory acquisitions. Voluntary mergers are accepted and regulated by RBI under the BR Act 1949 with special Section 44 (A). Compulsory acquisitions are implemented or obligated by RBI under the BR Act 1949 with the Section 45.[8] However, the BR Act of mergers and acquisitions is not applicable for government owned banks viz., Public sector banks including State Bank of India (SBI) and its Associate Banks. The SBI Act 1955 regulates State Bank of India (SBI) and its Associate Banks and Banking Commercial Act 1970 regulates government owned banks effectively.[9]

Altogether, the Indian banking sector witnessed 25 consolidation deals from 1991-2014.[10] These agreements of consolidation were determined and caused by several reasons such as synergy, low banking efficiency, cost saving and expansion of economies of scale and market power. Table 1 presents some details on these 25 consolidation deals. Most of the merger and acquisition deals of Indian commercial banks were aimed at restructuring of weak banks and expansion of the size, scale and scope.

During 1991-2014, all but one consolidation deals were in the form of acquisition, and only one was a merger deal. In 1993, New Bank of India (NBI) merged with Punjab National Bank (PNB) due to a poor performance of NBI. Also, interestingly, in 2007, the Centurion Bank acquired Lord Krishna Bank (LKB) to restructure a weak bank. However, this consolidation deal did not result in better performance of the consolidated bank. Instead, the Centurion Bank (CB)

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banks are inefficient ($y > 0$). *Fi* is the distribution function of the standard normal evaluated at $\varepsilon xi / \varepsilon$. **Log likelihood fn**.(L) $= \prod pr(y_i = 0) \prod pr(y_i = 1) \prod f(y_i^*)$; $L = \prod(1-F) \prod 1/_{2 \prod \sigma 2}{}^{*} e^{(-1/2\,\sigma 2)} Y_i - \beta x_i$; $F_i = \int^{\beta xi/\sigma} 1/2 \prod^{1/2} e^{-t2/2}$ dt. (Distribution fn.)

[8]Banking Regulation Act, 1949 is accessed from, https://rbidocs.rbi.org.in/rdocs/Publications/PDFs/BANKI15122014.pdf on 16-05-2014.

[9]SBI Act 1955 is accessed from, http://financialservices.gov.in/banking/SBIActandregulation.pdf on 16-05-2014 and Banking Commercial Act, 1970 is accessed from https://www.pnbindia.in/Upload/En/Banking%20Companies%20Act%201970.pdf on 16-05-2014. On 1 April 2017, the SBI has merged with all its Associate Banks. Thus, we do not have any SBI Associate Bank anymore.

[10] During the period 1961-1991, there were 59 consolidation deals. Indian banking sector experienced more than 46 consolidation deals during the period of pre-nationalization (i.e.) from 1961 to 1968. During nationalization, there were 13 consolidation deals between 1969 and 1991.

was later acquired by HDFC bank in 2008. Table 1 shows that the voluntary acquisition may give more benefits for acquiring banks than compulsory consolidation.

Table 1: List of selected Merger and Acquisitions (M&As) in India after 1991.

No	Target Bank	Acquirer Bank	Year	Purpose	Consolidation
1	New Bank of India (NBI), Public Sector Bank	Punjab National Bank (PNB), Public Sector Bank	1993	weak bank	Compulsory
2	Bank of Karad Ltd, Private Sector Bank	Bank of India , Public Sector Bank	1994	weak bank	Compulsory
3	Kashi Nath Seth Bank Ltd, Private Sector Bank	State Bank of India, Public Sector Bank	1996	weak bank	Compulsory
4	Bari Doab Bank Ltd, Private Sector Bank	Oriental Bank of Commerce, Public Sector Bank	1997	weak bank	Compulsory
5	Punjab Co-operative Bank(PCoB), (co-operative)	Oriental Bank of Commerce, Public Sector Bank	1997	weak bank	Compulsory
6	Bareilly Corporation Bank (BCB), Private Sector Bank	Bank of Baroda, Public Sector Bank	1999	Expansion of scale	Voluntary
7	Sikkim Bank Ltd, Private Sector Bank	Union Bank of India(UBI)	1999	weak bank	Compulsory
8	Times Bank Ltd. (TB), Private Sector Bank	HDFC Bank Ltd, Private Sector Bank	2000	Expansion of scale	Voluntary
9	Bank of Madura Ltd. (BoM), Private Sector Bank	ICICI Bank Ltd , Private Sector Bank	2001	Expansion of scale	Voluntary
10	ICICI Ltd, Private Sector Bank	ICICI Bank Ltd , Private Sector Bank	2002	Expansion of size	Voluntary
11	Benares State Bank Ltd (BSB), Private Sector Bank	Bank of Baroda, Public Sector Bank	2002	weak bank	Compulsory
12	Nedungadi Bank Ltd. (NB), Private Sector Bank	Punjab National Bank(PNB), Public Sector Bank	2003	weak bank	Compulsory
13	South Gujarat Local Bank, Private Sector Bank	Bank of Baroda (BoB), Public Sector Bank	2004	weak bank	Compulsory
14	Global Trust Bank Ltd. (GTB), Private Sector Bank	Oriental Bank of Commerce (OBC), Public Sector Bank	2004	weak bank	Compulsory
15	IDBI Bank Ltd, Private Sector Bank	IDBI Ltd , Private Sector Bank	2005	Expansion of size	Voluntary
16	Bank of Punjab Ltd. (BoP), Private Sector Bank	Centurion Bank Ltd , Private Sector Bank	2005	Expansion of scale	Voluntary
17	Ganesh Bank of Kurundwad (GBK), Private Sector Bank	Federal Bank Ltd(FB),, Private Sector Bank	2006	weak bank	Compulsory
18	United Western Bank Ltd(UWB), Private Sector Bank	IDBI Ltd, Private Sector Bank	2006	weak bank	Compulsory
19	Bharat Overseas Bank Ltd. (BovB), Private Sector Bank	Indian Overseas Bank (IovB), Public Sector Bank	2007	weak bank	Compulsory
20	Sangli Bank Ltd. (SB), Private Sector Bank	ICICI Bank Ltd, Private Sector Bank	2007	Expansion of scale	Voluntary
21	Lord Krishna Bank Ltd. (LKB), Private Sector Bank	Centurion Bank of Punjab, Private Sector Bank	2007	Expansion of scale	Voluntary
22	Centurion Bank of Punjab (CB), Private Sector Bank	HDFC Bank Ltd, Private Sector Bank	2008	Expansion of scale	Voluntary
23	The Bank of Rajasthan (BoR), Private Sector Bank	ICICI Bank Ltd, Private Sector Bank	2010	weak bank	Compulsory
24	State Bank of Indore (SBoI), Public Sector Bank	State Bank of India(SBI), Public Sector Bank	2010	Expansion of scale	Voluntary
25	ING, Private Sector Bank	Kodak Mahindra Bank, Private Sector Bank	2013	weak bank	Compulsory

Source: Report on Currency and Finance (2008), RBI and various news papers.

In 2016, Government of India announced the merger of all the State Bank Group Banks and Bharatiya Mahila Bank into State Bank of India. The government of India approved the merger of SBI and its five associate bank merger in 2017. This merger brings all SBI group banks into one and SBI will become the biggest bank in India in terms of asset, capital, deposit, lending, employee, profit and market share, etc. The prime motive behind this deal is to make Indian banking more competitive and efficient one. On 1 April, 2017, this merger has taken place.[11]

6. Empirical Analysis

Our results and conclusions are very similar with respect to input-oriented or output-oriented technique. Hence, we are only showing the results of input- oriented method for brevity.

6.1. Efficiency scores:

If the efficiency score of any bank is equal to 1 that indicates that the bank is fully efficient. If it is less than 1, it indicates that the bank is inefficient and if the efficiency value is equal to zero we conclude that the bank is completely inefficient. Table 2 presents bank group-wise mean of efficiency scores for the period 1995-2014, computed by DEA using intermediary approach for three groups of banks operating in India: Public sector, Private Sector and Foreign Banks. We have presented input-oriented mean efficiency scores for these bank groups. Input-oriented efficiency implies how a bank can minimize its inputs to produce a given level of output. The efficiency scores have been divided into three important measures, Namely, Overall Technical Efficiency (OTE), Pure Technical Efficiency (PTE) and Scale Efficiency (SE). Pure Technical Efficiency and Scale Efficiency are measured under Variable Return to Scale (VRS).

The results of Table 2 can be summarized as follows: the mean level clearly revealed that public sector and private sector banks are less efficient compared to foreign banks. It is found that the overall mean value of efficiency scores for public sector banks has registered less than foreign banks during 1995 to 1998 and private sector banks are more scale efficient than the public sector banks but less than foreign banks. Public sector banks registered higher efficiency scores compared to private sector banks during 2000 to 2006. This seems to indicate that

[11]Our study does not cover this merger as the required data will be available only later.

domestic public and private sector banks are performing and utilizing their resources poorly compared to foreign banks.

Table 2: Bank Group-Wise Mean and Aggregate Mean from 1995 to 2013.											
Input-Oriented											
Year	Name	Public Banks	Private Banks	Foreign Banks	All Banks	Year	Name	Public Banks	Private Banks	Foreign Banks	All Banks
	OTE	0.68874	0.72143	0.88407	0.741		OTE	0.5067	0.49662	0.66267	0.547
	PTE	0.89181	0.80687	0.95707	0.869		PTE	0.81174	0.64083	0.7909	0.744
1995	SE	0.77481	0.905	0.92421	0.859	**2005**	SE	0.63256	0.78548	0.8349	0.745
	OTE	0.52574	0.61506	0.79036	0.616		OTE	0.63896	0.63854	0.84014	0.696
	PTE	0.77967	0.67258	0.86536	0.748		PTE	0.77367	0.67457	0.86705	0.764
1996	SE	0.68089	0.92661	0.9095	0.834	**2006**	SE	0.83937	0.95593	0.96836	0.919
	OTE	0.67744	0.68544	0.85914	0.715		OTE	0.4727	0.47832	0.67359	0.534
	PTE	0.88067	0.72847	0.92879	0.821		PTE	0.7867	0.71488	0.85173	0.782
1997	SE	0.77141	0.94529	0.92264	0.878	**2007**	SE	0.60604	0.68788	0.79832	0.691
	OTE	0.46215	0.46547	0.68856	0.511		OTE	0.4983	0.52913	0.78195	0.594
	PTE	0.88944	0.67129	0.86725	0.789		PTE	0.80407	0.70233	0.90468	0.801
1998	SE	0.5217	0.70721	0.79525	0.66	**2008**	SE	0.62493	0.77425	0.86927	0.748
	OTE	0.60389	0.53952	0.69312	0.596		OTE	0.48915	0.46909	0.71464	0.552
	PTE	0.8963	0.69339	0.854	0.8		PTE	0.82931	0.70961	0.87082	0.803
1999	SE	0.67481	0.78297	0.81165	0.751	**2009**	SE	0.59092	0.67917	0.82886	0.693
	OTE	0.602	0.56153	0.74761	0.619		OTE	0.46427	0.50365	0.71914	0.554
	PTE	0.88085	0.71534	0.864	0.808		PTE	0.8315	0.7073	0.8491	0.796
2000	SE	0.688	0.78778	0.86917	0.772	**2010**	SE	0.5615	0.73826	0.85	0.706
	OTE	0.63241	0.60665	0.79033	0.659		OTE	0.38189	0.41624	0.68267	0.485
	PTE	0.87733	0.6871	0.85817	0.795		PTE	0.84754	0.67086	0.81224	0.782
2001	SE	0.72533	0.89232	0.92467	0.841	**2011**	SE	0.45315	0.65876	0.84924	0.639
	OTE	0.67841	0.63363	0.81305	0.697		OTE	0.22835	0.2599	0.4038	0.291
	PTE	0.87926	0.70773	0.87138	0.811		PTE	0.84746	0.6992	0.7682	0.779
2002	SE	0.77496	0.89633	0.93419	0.865	**2012**	SE	0.27115	0.4058	0.5781	0.405
	OTE	0.59893	0.56014	0.78086	0.634		OTE	0.22835	0.2599	0.4038	0.291
	PTE	0.84652	0.68962	0.8721	0.794		PTE	0.84746	0.6992	0.7682	0.779
2003	SE	0.71037	0.81731	0.89376	0.801	**2013**	SE	0.27115	0.4058	0.5781	0.405
	OTE	0.47511	0.4482	0.64595	0.511						
	PTE	0.80026	0.6549	0.78962	0.742						
2004	SE	0.60096	0.69947	0.8139	0.696						
Note: Authors own calculation; Pure Technical Efficiency ≡ Variable Return to Scale Technical Efficiency ; Overall Technical Efficiency≡ Constant Return to Scale Technical Efficiency.											

6.2. Is the acquirer more efficient than the Target?

Our study tries to compare the difference between the acquirer and target banks' efficiency scores before the consolidation to examine our first objective.

Table 3 indicates average efficiency scores before consolidation of target and acquirer banks for 16 selected consolidation deals from 1991 to 2013. The efficiency scores are reported for overall, pure technical and scale efficiency. We use 3 year pre-merger efficiency scores for target and acquirer banks to test whether target banks are significantly less efficient than acquirer banks.

Table 3: Mean of Efficiency Scores of Selected Mergers and Acquisitions in India three-year pre-merger.									
Input-Oriented									
Deal No	**Name of the Bank**	**OTE**	**PTE**	**SE**	**Deal No**	**Name of the Bank**	**OTE**	**PTE**	**SE**
1	Oriental Bank of Commerce(A)	0.669	0.88867	0.74967	9	Federal (A)	0.50367	0.68967	0.729
	Punjab Co-Operative (T)	0.564	1	0.564		Ganesh Bank of (T)	0.379	0.39867	0.95167
2	Bank of Baroda (A)	0.556	0.932	0.59767	10	IDBI Bank (A)	0.796	0.88433	0.89733
	Bareilly Corporation (T)	0.522	0.595	0.87467		United Western (T)	0.47767	0.58633	0.80967
3	HDFC Bank (A)	0.66	0.81	0.81133	11	Indian Overseas Bank (A)	0.56467	0.855	0.66433
	Times Bank (T)	0.51367	0.65933	0.781		Bharat Overseas (T)	0.55433	0.63233	0.87733
4	ICICI Banking (A)	0.492	0.67867	0.72367	12	ICICI Banking (A)	0.479	1	0.479
	Bank of Madura (T)	0.50933	0.707	0.72067		Sangli Bank (T)	0.47333	0.55067	0.85867
5	Bank of Baroda (A)	0.624	0.984	0.63433	13	Centurion Bank (A)	0.57867	0.729	0.79833
	Benares State (T)	0.49233	0.551	0.89767		Lord Krishna (T)	0.44733	0.53167	0.83633
6	Punjab National Bank (A)	0.65033	0.987	0.65867	14	HDFC Bank (A)	0.67467	0.98567	0.686
	Nedungadi Bank (T)	0.53867	0.608	0.89667		Centurion Bank (T)	0.59767	0.73567	0.817
7	Oriental Bank of Commerce (A	0.62333	0.89933	0.693	15	ICICI Banking (A)	0.488	1	0.488
	Global Trust (T)	0.52133	0.612	0.85033		Bank of Rajasthan (T)	0.44833	0.57833	0.77667
8	Centurion Bank (A)	0.53933	0.736	0.73633	16	State Bank of India (A)	0.525	1	0.525
	Bank of Punjab (T)	0.53533	0.671	0.79567		State Bank of Indore (T)	0.46967	0.75633	0.62267
Source: Author's own calculation									
OTE =Overall Technical Efficiency (OTE ≡ CRSTE)									
PTE = Pure Technical Efficiency (PTE ≡ VRSTE)									
SE = Scale Efficiency									
(A) = Acquirer ; (T) = Target bank									

Table 3 shows the pre-merger comparison of acquirer and target banks efficiency scores. The efficiency scores of acquirer banks are denoted by (A) and target banksare indicated by (T) for 16 consolidation deals in India. It is evident that 12 out of 16 consolidation deals have recorded that the acquirer is more efficient in OTE than the target.

The efficiency scores of table 3 indicate that none of the banks involved in these selected consolidation deals was fully efficient as there OTE scores were less than 1. Thus, none of these banks operated under *most productive scale size* (MPSS). Looking at OTE scores it is observed that in almost all cases the acquirer banks were having higher efficiency scores than the target bank except in the cases of deal 4,8,11 and 12. As far as PTE is concerned, it is found that in all cases acquirer was more efficient than target except for deal 1 and 4. However, in majority of the cases (12 out of 16 cases) acquirer banks were found to be less scale efficient than target banks. Thus, if we decompose overall efficiency into pure technical and scale efficiency than the

acquirer banks' higher OTE scores compared to target banks seem to be driven by their higher pure technical efficiency scores.

The decomposition of OTE results shows that PTE of acquirer banks has recorded higher than the target banks in case of almost all deals except 1 and 4. For all other deals, target banks have higher scale efficiency than acquirer. These results have been observed in cases of deals 2, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15 and 16. Furthermore, in case of deal 3 and 10, we find that the acquirers are more efficient and register higher efficiency scores in BCC terms of efficiency (PTE and SE) measurement.[12] HDFC and IDBI banks have registered higher efficiency than the target. However, during the pre-merger period, under deal 4, acquirer bank has registered lower efficiency scores than target bank and it's happened by higher level of assets and its input usage to generate outputs. A few banks, namely, ICICI, SBI and Punjab Co-operative banks recorded full pure technical efficiency scores which reveal that these banks' PTE are lying on the OTE frontier. This further reveals that the usage of resources by banks is functioning well and there is no wastage of inputs to convert outputs and it is a possibility that scale inefficiency also exists in it.

Whether the difference between efficiency scores of target and acquirer banks are significantly different or not has been tested by using non-parametric median test. Table 4 presents the result of these tests for the hypothesis that acquirer and target banks are equally efficient against the alternative that the acquirer is more efficient than the target.

Coming to the results of the median test, the null hypothesis is rejected for OTE scores in only 4 out of the 16 cases (in cases of deal 5,6,10 and 16). This seems to indicates that in OTE scores acquirer banks were efficient than the target banks only in these 4 cases and for the rest of the 12 cases there was no significant difference between median OTE of target and acquirer banks before the merger.

[12]We have used Banker et al., (1984)'s model of efficiency composition.

Table 4: Test results for hypothesis of equal efficiency score between acquirer and target					
OTE		**PTE**		**SE**	
Merger Deals	**Median Test P value**	**Merger Deals**	**Median Test P value**	**Merger Deals**	**Median Test P value**
Deal 1	0.45	Deal 1	0.05**	Deal 1	0.05**
Deal 2	0.45	Deal 2	0.05**	Deal 2	0.05**
Deal 3	0.45	Deal 3	0.05**	Deal 3	0.45
Deal 4	0.45	Deal 4	0.45	Deal 4	0.45
Deal 5	0.05**	Deal 5	0.05**	Deal 5	0.05**
Deal 6	0.05**	Deal 6	0.05**	Deal 6	0.05**
Deal 7	0.45	Deal 7	0.05**	Deal 7	0.05**
Deal 8	0.45	Deal 8	0.45	Deal 8	0.45
Deal 9	0.45	Deal 9	0.05**	Deal 9	0.05**
Deal 10	0.05**	Deal 10	0.05**	Deal 10	0.45
Deal 11	0.45	Deal 11	0.05**	Deal 11	0.45
Deal 12	0.45	Deal 12	0.05**	Deal 12	0.05**
Deal 13	0.45	Deal 13	0.05**	Deal 13	0.45
Deal 14	0.45	Deal 14	0.05**	Deal 14	0.45
Deal 15	0.45	Deal 15	0.05**	Deal 15	0.05**
Deal 16	0.05**	Deal 16	0.05**	Deal 16	0.05**
Note: Authors own calculations. ***,** and * = 1% , 5% and 10% level of significance respectively					

When we look PTE, the median test rejects the hypothesis of equality of efficiency between acquirer and target in 14 out of 16 cases. Therefore, acquirer banks had higher technical efficiency than target banks in majority of the consolidation cases considered here. In terms of scale efficiency, the acquirer bank is found to be more scale efficient than target bank in 9 out of 16 cases. The results of median test therefore points towards mixed results as to whether acquirer bank is more efficient than target bank. While in majority of the cases acquirer bank is found to be more efficient than target bank in case of PTE scores and scale efficiency scores, in terms of OTE scores the hypothesis of acquirer being more efficient than target is supported for only 4 cases. In cases of consolidation deals 5, 6 and 16, acquirer was more efficient than target in all three efficiency scores. Thus, median test results do not clearly support the hypothesis that acquirer bank is always more efficient than target.

6.3. Has efficiency improved after consolidation?

Table 5 shows the average of three years' pre and post-merger input- oriented efficiency scores of selected consolidation in India. The pre -merger mean efficiency scores indicate

average of three-year pre-merger efficiency scores for acquirer bank. The post-merger average efficiency scores are calculated as the average of 3 year's efficiency scores after merger, of the merged bank.

Table 5: Mean of Efficiency Scores of Selected Mergers and Acquisitions in India (Input-Oriented) three-year pre and post-merger.

Deal No	Pre-Merger Mean Value				Post-Merger Mean Value			
	Name of the Bank	**OTE**	**PTE**	**SE**	**Name of the Bank**	**OTE**	**PTE**	**SE**
1	Oriental Bank of Commerce(A)	0.669	0.88867	0.74967	Oriental Bank of Commerce (A)	0.62333	0.893	0.69733
	Punjab Co-Operative (T)	0.564	1	0.564	Punjab Co-Operative (T)	-	-	-
2	Bank of Baroda (A)	0.556	0.932	0.59767	Bank of Baroda (A)	0.643	0.981	0.656
	Bareilly Corporation (T)	0.522	0.595	0.87467	Bareilly Corporation (T)	-	-	-
3	HDFC Bank (A)	0.66	0.81	0.81133	HDFC Bank (A)	0.70033	0.88967	0.788
	Times Bank (T)	0.51367	0.65933	0.781	Times Bank (T)	-	-	-
4	ICICI Banking (A)	0.492	0.67867	0.72367	ICICI Banking (A)	0.696	1	0.696
	Bank of Madura (T)	0.50933	0.707	0.72067	Bank of Madura (T)	-	-	-
5	Bank of Baroda (A)	0.624	0.984	0.63433	Bank of Baroda (A)	0.53767	0.918	0.58567
	Benares State (T)	0.49233	0.551	0.89767	Benares State (T)	-	-	-
6	Punjab National Bank A)	0.65033	0.987	0.65867	Punjab National Bank A)	0.57633	1	0.57633
	Nedungadi Bank (T)	0.53867	0.608	0.89667	Nedungadi Bank (T)	-	-	-
7	Oriental Bank of Commerce (A)	0.62333	0.89933	0.693	Oriental Bank of Commerce (A)	0.51333	0.75667	0.67933
	Global Trust (T)	0.52133	0.612	0.85033	Global Trust (T)	-	-	-
8	Centurion Bank (A)	0.53933	0.736	0.73633	Centurion Bank (A)	0.54833	0.65633	0.83367
	Bank of Punjab (T)	0.53533	0.671	0.79567	Bank of Punjab (T)	-	-	-
9	Federal (A)	0.50367	0.68967	0.729	Federal (A)	0.50667	0.73667	0.68767
	Ganesh Bank of (T)	0.379	0.39867	0.95167	Ganesh Bank of (T)	-	-	-
10	IDBI Bank (A)	0.796	0.88433	0.89733	IDBI Bank (A)	0.43267	0.98367	0.44
	United Western (T)	0.47767	0.58633	0.80967	United Western (T)	-	-	-
11	Indian Overseas Bank (A)	0.56467	0.855	0.66433	Indian Overseas Bank (A)	0.49533	0.83467	0.59433
	Bharat Overseas (T)	0.55433	0.63233	0.87733	Bharat Overseas (T)	-	-	-
12	ICICI Banking (A)	0.479	1	0.479	ICICI Banking (A)	0.558	1	0.558
	Sangli Bank (T)	0.47333	0.55067	0.85867	Sangli Bank (T)	-	-	-
13	Centurion Bank (A)	0.57867	0.729	0.79833	Centurion Bank (A)	0.533	0.705	0.757
	Lord Krishna (T)	0.44733	0.53167	0.83633	Lord Krishna (T)	-	-	-
14	HDFC Bank (A)	0.67467	0.98567	0.686	HDFC Bank (A)	0.52533	1	0.52533
	Centurion Bank (T)	0.59767	0.73567	0.817	Centurion Bank (T)	-	-	-
15	ICICI Banking (A)	0.488	1	0.488	ICICI Banking (A)	0.36767	1	0.36767
	Bank of Rajasthan (T)	0.44833	0.57833	0.77667	Bank of Rajasthan (T)	-	-	-
16	State Bank of India (A)	0.525	1	0.525	State Bank of India (A)	0.292	1	0.292
	State Bank of Indore (T)	0.46967	0.75633	0.62267	State Bank of Indore (T)	-	-	-

Source: Author's own calculation

OTE =Overall technical Efficiency (OTE ≡ CRSTE)

PTE = Pure Technical Efficiency (PTE ≡ VRSTE)

SE = Scale Efficiency ; (A)= Acquirer ; (T) = Target bank

It is observed in Table 5 that the deal 1, 6, 10, 14, 15, and 16 recorded less post-consolidation overall efficiency compared to the period before consolidation. In pre-mergers, OTE of these deals have registered 50 percent to 80 percent and post mergers have found more

likely a deterioration on OTE efficiency scores which is registered approximately 30 percent to 62 percent. This OTE deterioration is not fully caused by pure technical inefficiency rather caused by scale inefficiency. However for these deals post-merger pure technical efficiency has shown improvement. It shows that consolidation could bring an improvement in its pure technical efficiency. These results have been observed for the deal 1, 6, 10, 14, 15, and 16 which is registered 80 percent to 100 percent efficiency gains.

Apart from that, 3 out 16 consolidation deals, viz., deal 3, 4 and 9 have registered an improvement on overall technical efficiency. Furthermore, the deal 8 has recorded higher improvement on overall technical efficiency and scale efficiency and registered lower efficiency gains in pure technical efficiency. Furthermore, 2 out of 16 consolidation deals namely, 2 and 12 have achieved higher efficiency scores in all OTE, PTE and SE.

It is observed from Table 5 that 4 out of 16 deals namely, 5, 7, 11 and 13 have recorded deterioration in all three efficiency scores (OTE, PTE, SE) after consolidation.

Table 5 clearly shows that overall, selected consolidation deals have a positive impact on the bank's efficiency, except some consolidation deals like Centurion bank. The OTEand PTE have been registered with improvement in most of the cases except some cases. However, some well-managed consolidation in the Indian context makes a distinct improvement in the efficiency as well as their overall performance of loans and services. Sometimes, weaker banks have been taken over by well assets sized banks, which create a considerable effect on their efficiency. Apart from that, certain acquisition was such that an acquirer bank becomes a target one, for example, HDFC Bank has taken Centurion Bank due to uncertain acquisition deal between the Centurion Bank and Lord Krishna Bank.

The median test is used to test whether pre- and post consolidation efficiency scores of acquirer and merged banks are significantly different.

6.3.1. Median test results:

The median test of the overall efficiency of post-merger and pre-merger comparison shows that for 13 out of 16 consolidation deals the null hypothesis is accepted. It indicates the post-consolidation efficiency score is equal to the pre-consolidation efficiency scores in 13 out of

16 cases. The test rejects the null hypothesis for 3 out of 16 consolidation deals at 5 percent level. These are deal numbers 10, 14, and 16, namely, IDBI Bank, HDFC and SBI.

Table 6: Test results of hypothesis of equal efficiency score between pre and post-consolidation			
	OTE	**PTE**	**SE**
	Median Test	**Median Test**	**Median Test**
Acquirer	**P value**	**P value**	**P value**
Oriental Bank of Commerce (OBC)	0.45	0.45	0.45
Bank of Baroda (BOB)	0.45	0.05**	0.45
HDFC Bank	0.45	0.05**	0.45
ICICI Banking	0.45	0.05**	0.45
Bank of Baroda	0.45	0.05**	0.45
Punjab National Bank (PNB)	0.45	0.05**	0.45
Oriental Bank of Commerce	0.45	0.05**	0.45
Centurion Bank (CB)	0.45	0.45	0.45
Federal Bank (FB)	0.45	0.45	0.45
IDBI Bank	0.05**	0.45	0.05**
Indian Overseas Bank (IOB)	0.45	0.45	0.45
ICICI Banking	0.45	0.05**	0.45
Centurion Bank	0.45	0.45	0.45
HDFC Bank	0.05**	0.05**	0.05**
ICICI Banking	0.45	0.05**	0.45
State Bank of India (SBI)	0.05**	0.05**	0.05**
Note: Authors own calculations. ***,** and * = 1% , 5% and 10% level of significant respectively			

Thus, by OTE measure, the median test rejects the hypothesis of efficiency improvement post-consolidation in majority of the cases. Post-consolidation overall efficiency measures were higher than pre-consolidation overall efficiency scores only in three cases.

As far as pure technical efficiency (PTE) is concerned, the median test accepts the null hypothesis for 10 out of 16 consolidation and rejects the null hypothesis for 6 deals out of 16 consolidation deals at 5 percent level. For scale efficiency, the test rejects the null hypothesis for 3 deals out of 16 consolidation deals and accepts the hypothesis for 13 deals out of 16 consolidation deals at 5 percent level. Thus, for OTE and SE scores the median test rejects the hypothesis of better post-merger efficiency in majority of the cases. In PTE, however, in majority of the cases (10 out of 16), consolidation improved efficiency.

6.4. Does consolidation impact efficiency?

The measured DEA efficiency scores are used as dependent variable in a Tobit regression. The explanatory are profit and loss of the banks, operating cost, capital and consolidation dummy. For the standardization, all the variables of banks are divided by total

assets of banks except consolidation dummy and efficiency scores. The data covers 66 banks in India (26 public, 20 private and 20 foreign banks) in 2013.

In the Tobit regression a positive coefficient of an independent variable indicates that the efficiency of banks is positively affected by the variable and opposite results show that there is deterioration in efficiency due to the variable. The table 7 includes the results with three formats of efficiency scores which have been considered as dependent variables and selected variables of banks have taken as independent variables. It is divided into three panels, viz., determinants of overall technical efficiency performance, pure technical efficiency performance and scale efficiency performance. The table 7 (Panel-A, B, and C) shows the Tobit regression results of an input-oriented model of efficiency scores and selected independent variables of banks in 2013 including consolidation dummy.

It is observed that operating cost is not a significant factor in determining overall efficiency (OTE). Consolidation dummy and profit variables are also found to be insignificant for OTE. More interestingly, banks capital to assets ratio has significant and positive effect on overall technical efficiency. Thus, increased capital to assets improves banks OTE. Thus, consolidation does not have any significant impact on overall technical efficiency of banks.

The Table 7 (Panel-B) indicates the Tobit regression results of PTE scores on selected independent variables of banks in 2013. It is evident from Table 7 (Panel-B) that among these variables, consolidation dummy is the only variable that is found to be significant with a positive sign. All other variables are insignificant.

Table 7 (Panel-C) shows the Tobit regression results of scale efficiency (SE) scores. It is apparent from Table 7 (Panel-C) that the consolidation dummy, operating cost and profit are not significant. But capital is significant at 1 percent level of significant. Thus, the Tobit regression results indicate the consolidation had a positive effect on banks' efficiency only for pure technical efficiency.

Table 7 (Panel-A): Tobit Regression: (CRSTE = OTE)						
Tobit estimates Number of obs = 66						
Prob > chi2= 0				LR chi2(4) = 67.65		
Log likelihood = 73.164273				Pseudo R2 = -0.8599		
CRSTE	Coef.	Std.	T	P>|t|	[95%	Conf.
Consolidation Dummy	0.0030729	0.02607	0.12	0.907	-0.04904	0.05519
Op. cost	0.2380656	0.43681	0.55	0.588	-0.63511	1.11124
Profit	0.0720002	1.01483	0.07	0.944	-1.95661	2.10061
Capital*	**0.94434**	**0.09767**	**9.67**	**0***	**0.749103**	**1.13958**
Cons.	0.2330892	0.01921	12.13	0	0.194688	0.27149
_se	0.0734312	0.00655	(Ancillary parameter)			
(Panel-B) Tobit Regression: (VRSTE = PTE)						
Tobit estimates Number of obs = 66						
Prob > chi2= 0.0740				LR chi2(4) = 8.53		
Log likelihood = -6.5861473				Pseudo R2 = 0.3930		
VRSTE	Coef.	Std.	T	P>|t|	[95%	Conf.
Con. Dummy*	**0.212974**	**0.08179**	**2.6**	**0.012***	**0.04947**	**0.37648**
Op.cost	0.4031212	1.31333	0.31	0.76	-2.2222	3.02844
Profit	4.273417	3.17386	1.35	0.183	-2.07104	10.6179
Capital	0.1453075	0.30611	0.47	0.637	-0.4666	0.75722
Cons.	0.7096212	0.05829	12.17	0	0.593097	0.82615
_se	0.2171938	0.02213	(Ancillary parameter)			
(Panel-C) Tobit Regression: (SE)						
Tobit estimates Number of obs = 66						
Prob > chi2= 0.0000				LR chi2(4) = 47.76		
Log likelihood = 31.509086				Pseudo R2 = -3.1293		
SE	Coef.	Std.	T	P>|t|	[95%	Conf.
Con. Dummy	-0.0790645	0.05099	-1.55	0.126	-0.181	0.02287
Op.cost	0.4072007	0.85477	0.48	0.635	-1.30147	2.11587
Profit	-0.140685	1.98229	-0.07	0.944	-4.10323	3.82186
Capital	1.322805	0.19415	6.81	0	0.93471	1.7109
Cons.	0.3378294	0.03752	9	0	0.262826	0.41283
_se	0.143403	0.01274	(Ancillary parameter)			

Source: Author's own calculation. . Note: *=1%, **=5% and ***=10% level significant.
Note: the independent variable is banks efficiency scores in 2013 which derived from DEA (model 1): Profitability is measure of bank's profit as the ratio of net profit divided by total assets of banks: capital is the ratio that is divided by total assets of banks: operating cost is also as mentioned is a ratio which is divided by total assets.

It is found that the bank consolidation is a considerable factor in determining banks' pure technical efficiency. The PTE scores will tell us which banks are working on which returns to scale. It may be increasing, decreasing and constant return to scale. If it is constant, overall technical efficiency and pure technical efficiency scores will be same. If there is a gap between overall and pure technical efficiency measurement, scale inefficiency will exist. Furthermore, it found that banks capital increases more efficiency gains by gaining more market and share prices. As far as overall and scale efficiency are concerned consolidation did not seem to help.

7. Conclusion:

Using the non-parametric DEA methods, this paper analyses the overall, pure technical and scale efficiency of Indian commercial banks over the period of 1995-2013. It is found that public sector and domestic private banks had less average efficiency scores than foreign banks during this period. This paper also examines issues of efficiency and consolidation in Indian banks using efficiency scores for 16 consolidation deals during the study period. We find that acquirer banks were not necessarily more efficient than the target banks in overall efficiency, although for PTE scores, acquirer banks were found to be more efficient than target banks in majority of the cases (9 out of 16). In scale efficiency measures, only in 6 cases the acquirer was more efficient than target. Similarly, only for PTE measures, the post merger efficiency were found to be significantly higher than pre-merger efficiency scores in majority of the deals. For OTE and SE measures, this was not the case in majority of the cases. The Tobit regression analysis of whether consolidation is an important determinant of efficiency score indicates that this is so only for PTE measures, and not for OTE and SE. Thus, we can conclude that for the 16 consolidation deals we considered in this paper, pure technical efficiency scores improved in majority of these deals, while for overall and scale efficiency scores, majority of the deals did not register efficiency gains.

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