

**12<sup>th</sup> Money and Finance Conference, 11 – 12<sup>th</sup> March 2010**

**IGIDR, Mumbai**

**Financial Liberalization and Banking Sector Efficiency: The  
Indian Experience<sup>1</sup>**

By

**Santosh Kumar Das**

Research Scholar

Jawaharlal Nehru University, New Delhi

New Delhi - 67

20<sup>th</sup> January 2010

---

<sup>1</sup> The paper is a part of my PhD Research Internship report submitted to the United Nations University – World Institute of Development Economic Research, Helsinki, Finland and a part of my ongoing doctoral thesis work.

## Financial Liberalization and Banking Sector Efficiency: The Indian Experience

### Abstract

The Indian financial sector has undergone a significant structural transformation since the initiation of the financial liberalization in 1990's. It brought significant changes in the Indian economy in general and financial sector in particular. Against this backdrop, the present paper intends to analyze the performance of the Indian banking sector after the initiation of financial liberalization and also aims to measure the cost efficiency of the Indian banking sector during the post reform period. The study finds, after deregulation, the concentration has declined which resulted in increasing competition. The share of private and foreign banks in banking asset, deposit and credit has gone up. The profitability of all bank groups has gone up, but the foreign banks are more profitable. Using Stochastic Frontier Approach (cost frontier) and RBI data for 60 Indian commercial banks and on the basis of empirical investigation (panel estimation), the paper concludes that after financial liberalization there has been no significant change in the cost efficiency of the public sector banks. The finding shows a marginal decline in the cost efficiency of the public sector banks in the post reform period. A comparison among various bank groups in the post reform period shows, the domestic private banks are becoming more efficient in comparison to the public sector and the foreign banks. However, the study finds the public sector banks to be more cost efficient than the private and the foreign banks.

**Key Words:** *Financial Liberalization, Banking Sector, Cost Efficiency & Stochastic Frontier Approach*

**JEL Classification:** *G 21; C 50*

## **Financial Liberalization and Banking Sector Efficiency: The Indian Experience**

### **Introduction**

The Indian financial sector comprises a large network of commercial banks, financial institutions, stock exchanges and a wide range of financial instruments. It has undergone a significant structural transformation since the initiation of financial liberalization in 1990s. Before financial liberalization, since mid 1960's till the early 1990', the Indian financial system was considered as an instrument of public finance (Agarwal, 2003). The evolution of Indian financial sector in the post independent period can be divided in to three distinct periods. During the first period (1947-68), the Reserve Bank of India (RBI) consolidated its role as the agency in charge of supervision and banking control (Sen & Vaidya, 1997). Till 1960's the neo-Keynesian perspective dominated, argued interest rates should be kept low in order to promote capital accumulation (Sen & Vaidya, 1997). During this period Indian financial sector was characterized by nationalization of banks, directed credit and administered interest rates (Lawrence & Longjam, 2003). The second period (1969 - mid 1980's), known as the period of financial repression. The financial repression started with the nationalization of 14 commercial banks<sup>2</sup> in 1969. As a result interest rate controls, directed credit programmes, etc. increased in magnitude during this period (Sen & Vaidya, 1997 & Nair). The third period, mid 1980's onwards, is characterized by consolidation, diversification and liberalization. However a more comprehensive liberalization programme was initiated by the government of India during early 1990's. The impetus to financial sector reforms came with the submission of three influential reports by the Chakravarty Committee in 1985, the Vaghul in 1987 and the Narasimham Committee in 1991. But the recommendations of the Narasimham Committee provided the blueprint of the reforms, especially with regard to banks and other financial institutions. In 1991, the government of India initiated a comprehensive financial sector liberalization programme. The liberalization programme includes de-controlled interest rates, reduced reserve ratios and slowly reduced government control of banking operations while establishing a market regulatory framework (Lawrence & Longjam, 2003).

---

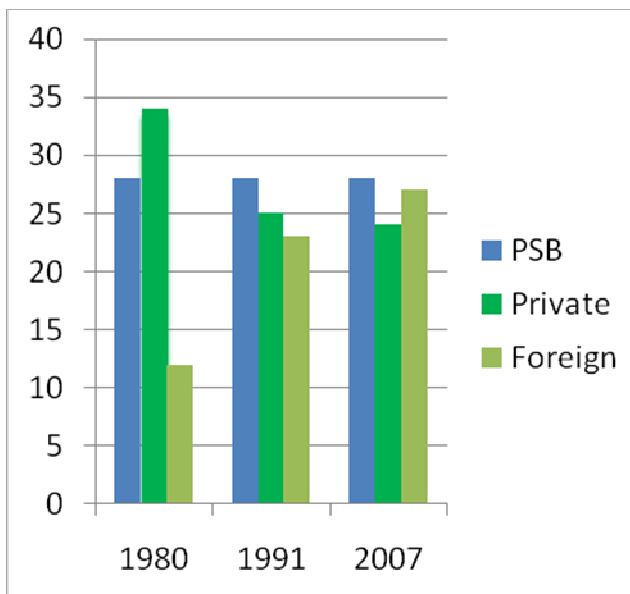
<sup>2</sup> Under the banking companies act 1949.

The major objectives of the financial liberalization were to improve the overall performance of the Indian financial sector, to make the financial institutions more competent and more efficient. As mentioned earlier, the financial sector comprises commercial banks, stock exchanges and other financial institutions. However, Indian financial system continues to be a bank based financial system and the banking sector plays an important role as a resource mobiliser. It remains the principal source of resources for many households, small and medium enterprises and also caters the large industries. And also provides many other financial services. Underlining the importance of the banking sector, several banking sector specific reforms<sup>3</sup> as a part of financial reforms were introduced to improve the performance of the Indian banking sector and to make the Indian banks more competent and efficient. Against this backdrop, the present paper intends to study the performance of the Indian banking sector in the post liberalization period. At the same time, it also aims to determine the cost efficiency of the Indian banks in context of financial liberalization.

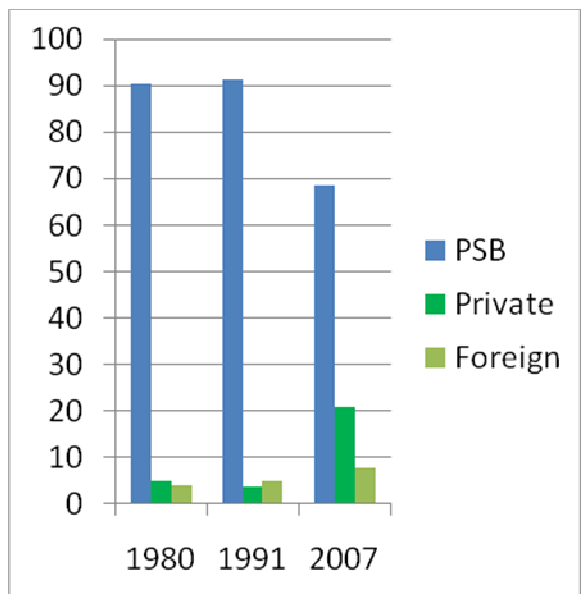
### Indian Banking Sector: An Overview

Figure- 1: Number and Asset Share of Indian Commercial Banks by Ownership

Number of Commercial Banks: 1980, 1991 & 2007



Asset Share: 1980, 1991 & 2007



Source: calculated, RBI

<sup>3</sup> See annexure - 3

The Indian banking sector has been dominated by the public sector banks in terms of number and asset share. The banking sector comprises of 28 public sector banks with majority government ownership (*Box -1*), 23 private banks and 27 foreign banks. It can be seen (*Figure: 1*), that the number of public sector commercial banks has almost remained the same over last three decades. And in terms of asset share, the public sector banks constitute about 70 percent of the total commercial banking asset. But the point to be noted, the asset share of the public sector banks has gone down from about 90 percent in 1980 to about 68 percent in 2007. Even though the number of domestic private banks has declined since 1980s, the asset share of these banks has gone up to about 20 percent in 2007. On the other hand, even though the number of foreign banks has gone up significantly, their asset share has not increased in that way. The total banking sector asset constitutes more than 91.8 percent of the GDP<sup>4</sup> at the end of March 2008 and the commercial banking asset constitutes more than 95 percent of the total banking asset.

**Box- 1: Private Shareholding in PSBs: 2007**

Shareholding (%)	Number of Banks
Up to 10	3
More than 10 & up to 20	1
More than 20 & up to 30	3
More than 30 & up to 40	3
More than 40 & up to 49	11

Source: RBI

**Table -1: Total Asset, in Rs. billion (1993-94 prices)**

Year	PSBs	Private Banks	Foreign Banks	RRBs	All Banks
1980	1649.56	90.26	70.82	13.35	1823.98
1985	2564.02	122.27	115.22	48.38	2849.89
1990	3619.49	137.15	222.94	84.42	4063.99
1991	3633.15	146.69	254.59	92.25	4126.68
1992	3372.84	159.24	281.69	96.51	3910.28
1993	3434.64	181.96	323.54	100.70	4040.83
1994	3526.59	212.06	311.16	111.66	4161.46
1995	3744.54	326.75	322.83	127.02	4521.13
1996	4010.82	361.92	378.03	150.40	4901.18
1997	4153.99	452.27	417.53	182.03	5205.83
1998	4478.07	558.96	450.35	203.27	5690.66
1999	5100.79	686.03	507.37	237.19	6531.37

<sup>4</sup> RBI (<http://www.rbi.org.in/scripts/PublicationsView.aspx?id=10922>)

2000	5638.22	864.24	524.30	267.28	7294.04
2001	6329.25	1004.18	625.84	304.83	8264.11
2002	6850.84	1586.72	664.47	336.70	9438.74
2003	7345.46	1686.73	665.16	357.20	10054.56
2004	8089.21	2019.11	749.40	385.90	11243.62
2005	9452.16	2279.90	818.61	414.91	12965.58
2006	10361.91	2939.73	1025.24	461.08	14787.97
2007	12206.00	3728.88	1390.77	529.10	17854.76

Source: Calculated, RBI

Since 1990's, there has been spectacular growth of the Indian banking sector. Several variables like total asset, total deposit, total credit and net profit has been analyzed to study the relative progress of the Indian banking sector. In terms of asset, all bank groups have recorded higher asset growth after the financial reforms. It can be seen (*Table-1*) that, during financial reforms the total asset of the Indian banking sector recorded higher growth and since 1999 total asset of the banking sector has grown significantly. During 1999, the total commercial bank asset was Rs. 6531.37 billion, which increased to Rs. 17854.76 billion in 2007.

Total deposits of the commercial banks have gone up significantly since 1999 (*Table – 2*). All bank groups recorded higher deposit especially after 1999. Total deposit of all banks increased to Rs. 13907.54 billion in 2007, which was Rs. 5283.27 billion in 1999.

**Table – 2: Total Deposit, in Rs. billion (1993-94 prices)**

Year	PSBs	Private Banks	Foreign Banks	RRBs	All Banks
1980	1227.23	70.18	38.45	6.95	1342.81
1985	1933.50	95.99	59.86	27.42	2116.78
1990	2577.12	108.68	123.96	55.85	2865.60
1991	2590.46	115.91	144.19	61.79	2912.34
1992	2634.14	137.35	192.91	65.91	3030.32
1993	2713.49	157.02	217.29	71.08	3158.88
1994	2823.89	187.13	241.13	82.49	3334.64
1995	2977.28	248.71	239.18	95.06	3560.23
1996	3098.80	286.92	242.93	112.36	3741.01
1997	3355.46	381.14	279.26	134.24	4150.10
1998	3667.85	479.52	295.74	153.08	4596.18
1999	4217.06	572.81	314.22	179.18	5283.27
2000	4665.95	719.34	312.14	203.94	5901.36
2001	5281.97	839.99	363.80	235.36	6721.13
2002	5742.44	1004.38	382.40	264.01	7393.23
2003	6169.02	1182.58	396.14	283.37	8031.12
2004	6744.57	1476.36	440.59	309.48	8971.00
2005	7654.20	1676.42	460.30	331.10	10122.01
2006	8343.95	2203.42	584.96	367.01	11499.34
2007	9975.96	2761.31	754.34	415.92	13907.54

Source: Calculated, RBI

The total advances of all commercial banks have gone up significantly over last five years (*Table – 3*). Since 2003, the total advances of all commercial banks have been more than double. In 2003 total advances were Rs. 4344.56 billion and increased to Rs. 10147.76 billion.

**Table – 3: Total Advances (Credit), in Rs. billion (1993-94 prices)**

Year	PSBs	Private Banks	Foreign Banks	RRBs	All Banks
1980	779.47	38.13	28.28	8.20	854.08
1985	1173.18	53.24	44.33	29.29	1300.04
1990	1595.78	58.83	77.24	46.97	1778.82
1991	1617.38	60.81	87.49	43.16	1808.84
1992	1608.30	71.99	104.27	44.74	1829.30
1993	1582.05	81.54	108.69	45.69	1817.97
1994	1367.92	91.37	108.10	46.85	1614.25
1995	1516.77	135.01	129.94	51.08	1832.81
1996	1645.57	177.39	178.61	55.96	2057.53
1997	1644.77	213.81	199.78	59.06	2117.41
1998	1792.61	244.33	202.04	62.23	2301.21
1999	1968.95	282.83	195.38	69.92	2517.08
2000	2228.26	352.75	225.40	78.64	2885.05
2001	2548.42	418.31	264.27	92.50	3323.50
2002	2849.32	690.16	288.28	104.98	3932.74
2003	3139.69	787.05	298.17	119.65	4344.56
2004	3478.50	936.69	332.64	137.65	4885.48
2005	4551.44	1179.15	401.31	169.39	6301.30
2006	5689.32	1609.47	501.73	198.16	7998.68
2007	7204.20	2074.81	632.01	236.75	10147.76

Source: Calculated, RBI

**Table – 4: Net Profit, in Rs. billion (1993-94 prices)**

Year	PSBs	Private Banks	Foreign Banks	RRBs	All Banks
1980	1.28	NA	NA	NA	NA
1985	1.67	NA	NA	NA	NA
1990	5.08	0.31	1.61	0.17	8.19
1991	5.71	0.47	1.45	0.24	9.11
1992	8.98	0.92	1.60	-2.75	11.54
1993	-34.41	0.63	-3.01	-3.17	-45.56
1994	-40.49	1.22	1.61	-3.43	-37.36
1995	9.52	3.49	0.82	-3.40	15.57
1996	-2.94	4.33	0.94	-3.58	3.72
1997	23.26	5.14	0.40	-5.99	27.38
1998	34.34	5.81	0.26	0.49	44.98
1999	21.57	4.69	0.47	1.45	32.31
2000	32.36	7.75	0.39	2.71	49.37
2001	26.53	7.14	0.46	3.69	43.64

2002	49.23	10.55	0.43	3.62	72.23
2003	70.27	16.65	0.40	3.32	100.63
2004	90.96	19.14	0.40	4.15	126.58
2005	82.22	18.83	0.35	4.00	115.61
2006	85.05	25.58	0.52	2.51	128.93
2007	100.81	32.34	0.70	2.42	158.51

Source: Calculated, RBI

The net profit of the Indian commercial banks has gone up significantly over last 7 years. It has gone up from Rs. 43.64 billion in 2001 to Rs. 158.51 billion in 2007. The public sector banks and the domestic private banks witnessed manifold rise in net profit.

## Performance of the Indian Banking Sector: Impact of Reform

### Management Performance

The credit deposit ratio reflects the management performance of the banks. It can be seen after financial liberalization, most of the banks reported higher C-D ratio. The C-D ratio is the highest in case of the foreign banks and lowest in case of the public sector banks. The over commercial banking sector witnessed an increase in the credit-deposit ratio. In 1980, the C-D ratio for all commercial banks was 63.32 percent, and increased to 73.46 percent in 2007. The investment deposit ratio has also increased, but marginally.

**Table – 5: Credit-Deposit Ratio (in percent)**

Year	PSBs	Private Banks	Foreign Banks	All Banks
1980	66.63	54.33	73.55	63.32
1985	61.72	55.46	74.06	60.82
1990	65.29	54.13	62.31	61.64
1995	52.56	54.28	54.33	51.42
1996	55.12	61.83	73.52	55.16
1997	50.81	56.1	71.54	51.26
1998	50.76	50.95	68.32	50.39
1999	47.35	49.38	62.18	47.95
2000	48.37	49.04	72.21	49.26
2001	48.23	49.8	72.64	49.82
2002	49.03	68.71	75.39	53.69
2003	50.36	66.55	75.27	54.53
2004	51.43	63.45	75.5	54.82
2005	58.74	70.34	87.18	62.63
2006	68.27	73.04	85.77	70.07
2007	73.27	75.14	83.78	73.46

Source: Calculated, RBI



### Asset Quality

The asset quality reflects the structural soundness of the banking sector. The ratio of contingent liability shows, the foreign banks are more exposed to default, which implies the foreign banks provide most sophisticated services. It is because most of the foreign banks are concentrated in urban areas and mostly cater to large clients. The contingent liability to asset ratio of the total commercial banks shows, it has declined from 25 percent in 1980 to 16 percent in 2007 (*Table – 6*). The foreign banks and the private banks are exposed to more losses in case of default and the public sector banks are less exposed to default.

**Table – 6: Ratio of Contingent Liability to Asset**

Year	PSBs	Private Banks	Foreign Banks	All Banks
1980	0.27	0.21	0.44	0.25
1985	0.25	0.21	0.47	0.24
1990	0.16	0.09	0.18	0.14
1995	0.17	0.18	0.16	0.15
1996	0.20	0.13	0.25	0.17
1997	0.16	0.09	0.22	0.14
1998	0.14	0.08	0.23	0.12
1999	0.14	0.11	0.29	0.13
2000	0.14	0.11	0.31	0.13
2001	0.13	0.11	0.33	0.13
2002	0.12	0.31	0.33	0.16
2003	0.12	0.24	0.29	0.14
2004	0.12	0.21	0.30	0.14
2005	0.14	0.19	0.31	0.16
2006	0.15	0.17	0.31	0.16
2007	0.14	0.19	0.34	0.16

Source: Calculated, RBI

The ratio of investment in securities to assets indicates that banks invest about 20 to 30 percent in government securities in response to SLR (*Table – 7*). The public sector banks have higher percentage of investment in government securities and the foreign bank's investment is the lowest. The public sector banks prefer to invest more in the government securities because; it is more liquid and the safest investment. Even after financial reforms the PSBs's investment in government securities has gone up.

**Table – 7: Ratio of Investment in Securities to Assets**

Year	PSBs	Private Banks	Foreign Banks	All Banks
1980	0.21	0.20	0.19	0.22

1985	0.23	0.23	0.15	0.22
1990	0.22	0.25	0.14	0.22
1995	0.30	0.21	0.23	0.28
1996	0.27	0.21	0.19	0.26
1997	0.29	0.23	0.21	0.28
1998	0.28	0.23	0.22	0.27
1999	0.28	0.23	0.22	0.27
2000	0.29	0.24	0.23	0.28
2001	0.31	0.24	0.23	0.29
2002	0.32	0.24	0.22	0.29
2003	0.36	0.25	0.27	0.33
2004	0.37	0.26	0.24	0.33
2005	0.34	0.23	0.22	0.30
2006	0.27	0.23	0.21	0.25
2007	0.22	0.21	0.20	0.22

Source: Calculated, RBI

The ratio of term loans to asset shows, over years it has increased to about 58 percent in 2007 (*Table – 8*). The private banks have increased the term loans to about 70 percent and the public sector banks have been almost consistent about 30 percent on average till 2003 and thereafter witnessed a rapid increase in their term loans.

**Table – 8: Ratio of Term Loans to Assets**

Year	PSBs	Private Banks	Foreign Banks	All Banks
1992	29.56	23.41	23.18	29.44
1993	26.95	24.99	20.76	27.12
1994	26.97	24.70	24.45	26.88
1995	24.28	23.47	27.82	24.77
1996	24.87	24.17	38.79	26.41
1997	27.50	25.42	54.66	30.22
1998	30.91	25.26	53.35	32.78
1999	33.92	28.39	48.33	34.80
2000	34.88	29.50	48.81	35.81
2001	35.05	32.48	46.10	36.09
2002	36.30	60.55	48.75	41.84
2003	39.26	64.05	47.86	44.50
2004	45.10	65.02	45.02	49.01
2005	51.64	65.49	49.16	54.04
2006	53.28	68.40	48.04	55.92

2007	54.86	70.31	49.25	57.74
------	-------	-------	-------	-------

Source: Calculated, RBI

### **Profitability**

Profitability can be measured with two indicators; Return on Asset (ROA) and the Return on Equity (ROE). The return on asset is defined as the ratio of net profit to average asset. It can be seen (*Table -9*) that, after financial reforms the banks are more profitable. The foreign banks are more profitable than the domestic private banks and the public sector banks. After financial liberalization, the private and the foreign banks recorded higher rate of return on asset. During the early phase of reforms, the return on asset was negative. But after that it increased from -0.89 percent in 1994 to 1 percent in 2007.

**Table - 9: Return on Assets**

Year	PSBs	Private Banks	Foreign Banks	All Banks
1980	0.09	NA	NA	NA
1985	0.07	NA	NA	NA
1990	0.15	0.25	1.37	0.22
1991	0.16	0.35	1.18	0.23
1992	0.26	0.63	1.71	0.38
1993	-0.80	0.38	-2.96	-1.14
1994	-0.91	0.65	1.76	-0.89
1995	0.34	1.34	1.96	0.47
1996	0.04	1.30	1.74	0.17
1997	0.64	1.30	1.29	0.70
1998	0.89	1.19	1.04	0.88
1999	0.49	0.77	0.98	0.53
2000	0.67	1.02	1.30	0.72
2001	0.48	0.77	1.10	0.54
2002	0.77	0.83	1.39	0.82
2003	1.00	1.04	1.59	1.05
2004	1.18	1.05	1.78	1.21
2005	0.95	0.89	1.37	0.97
2006	0.88	1.00	1.74	0.96
2007	0.90	0.98	1.92	1.00

Source: RBI

Return on equity can be taken as proxy to measure profitability. The private banks are more consistent since 1990's in terms of the return on equity, where as the foreign banks have been the most inconsistent. During early 1990's the return on equity of the foreign banks was about 132 percent and in 2007 it is about 16 percent (*Table – 10*). The public sector banks are performing better with 16.14 percent return on equity.

**Table – 10: Return on Equity (%)**

Year	PSBs	Private Banks	Foreign Banks	All Banks
1980	10.46	NA	NA	NA
1985	5.96	NA	NA	NA
1990	9.26	20.78	131.91	13.57
1991	9.27	21.81	131.28	12.84
1992	12.36	32.15	68.63	16.55
1993	-21.58	16.21	-61.43	-40.40
1994	-17.12	23.06	27.61	-21.74
1995	8.96	28.63	23.30	8.25
1996	3.49	19.68	17.10	2.68
1997	13.12	18.30	11.63	11.09
1998	15.96	17.86	9.10	13.26
1999	8.93	12.62	9.44	8.59
2000	13.44	17.18	13.55	12.56
2001	10.08	13.52	11.97	9.98
2002	16.11	13.99	15.11	15.13
2003	20.10	16.41	14.24	18.42
2004	22.64	16.81	15.17	20.61
2005	17.61	13.28	11.72	15.74
2006	15.79	13.34	14.18	14.77
2007	16.14	13.71	15.98	15.51

Source: RBI

### Concentration

The Indian banking sector is dominated by the public sector banks. However, with the initiation of financial liberalization, several private and foreign banks started functioning, which ushered in competition in the Indian banking sector. Even the share of public sector banks in total asset, deposit and credit has declined; still they dominate the Indian banking sector. To measure the degree of concentration, Herfindahl-Hirschman Index (HHI) has been calculated<sup>5</sup>. It can be seen (Table – 5) that over years the concentration in the banking sector has decreased. The Herfindahl-Hirschman Index score shows, there has been a decline in the concentration of asset, deposits and credit.

**Table 5: Herfindahl-Hirschman Index Score**

Year	Asset	Deposit	Credit
1980	0.82	0.87	0.84
1985	0.81	0.86	0.82

<sup>5</sup> Formula for the calculation of Herfindahl-Hirschman Index

$$H = \sum_{i=1}^N s_i^2$$

1990	0.80	0.85	0.81
1991	0.78	0.84	0.80
1992	0.75	0.82	0.78
1993	0.73	0.81	0.76
1994	0.73	0.79	0.73
1995	0.70	0.77	0.70
1996	0.68	0.76	0.66
1997	0.65	0.73	0.62
1998	0.64	0.71	0.63
1999	0.63	0.71	0.63
2000	0.62	0.69	0.62
2001	0.61	0.69	0.61
2002	0.56	0.67	0.56
2003	0.57	0.66	0.56
2004	0.56	0.64	0.55
2005	0.57	0.65	0.56
2006	0.54	0.62	0.55
2007	0.52	0.61	0.55

**Source: Calculated**

### **The Concept of Efficiency**

The efficiency of the banking sector can be decomposed in to scale efficiency, scope efficiency, pure technical efficiency and allocative efficiency (Chen, 2001). The bank is said to have scale efficiency, when it operates in the range of constant returns to scale and have scope efficiency, when it operates in different diversified locations. Maximizing output from a given level of input is called technical efficiency and when a bank chooses the revenue maximizing mix of output, the allocative efficiency occurs (Chen, 2001). According to Berger, the most important origin of the cost problems in banking is the X-efficiency, which is the differences in the managerial ability to control cost for a given level of production (as discussed in Chen, 2001). The X-efficiency includes both the technical and allocative efficiency. The X-efficiency can be estimated in four ways. These are the Data Envelopment Analysis (DEA), the Stochastic Frontier Approach (SFA), the Thick Frontier Approach (TFA) and the Distribution Free Approach (DFA) (Chen, 2001).

### **Methods of Efficiency Measurement**

Broadly, the approaches to efficiency measurement can be divided into parametric and non-parametric. The basic difference between the two is how much shape is imposed on the frontier

and the distributional assumptions imposed on the random error and inefficiency (Berger & Humprey, 1997 as discussed in Tahir & Haron, 2008). There are three parametric approaches for efficiency measurement: the Stochastic Frontier Approach (SFA), the Thick Frontier Approach (TFA) and the Distribution Free Approach (DFA). On the other hand, widely the Data Envelopment Analysis (DEA) is being widely used as the non-parametric approach to measure efficiency. The parametric method includes production, cost, profit and the revenue function as alternative methods of estimating efficiency, where as the non parametric method uses the linear programming techniques (Ajibefun, 2008). However, there has been no consensus on the superiority of any of the two approaches. But some studies have tried to explain the superiority of SFA method over the DEA method.

Farrel's (1957) work on 'the measurement of productive efficiency' laid the basic framework for studying and measuring inefficiency with a frontier. Inefficiency has been defined as 'the deviations of actual from optimum behaviour' (Kaparakis et. al, 1994). The relevant frontier can be constructed and estimated using statistical and mathematical programming techniques. Broadly the techniques can be clubbed in two groups, the deterministic and the stochastic frontiers. The deterministic frontier assumes no statistical noise, where as the stochastic frontier considers the stochastic properties and thus seems statistically more accurate and acceptable. However, this technique is also not error free. Kaparakis et. Al (1994), points out some important problems that exist with the parametric stochastic frontier approach. One of them is, it is required to choose an explicit functional form for the production and the cost function, in many occasions its appropriateness has been questioned. However, the use of flexible functional forms like the translog attempts to avoid this concern to some extent.

Over years, two principal methods, the data involvement analysis (DEA) and stochastic frontiers have dominated the efficiency measurement literature (Coelli et. Al, 2000). The DEA method is non-parametric, involves mathematical programming and the stochastic frontiers is a parametric method, which involves the econometric method. The major advantage of the DEA method is it measures the relative efficiency and major drawback is, it is a deterministic model (Quyyam & Khan, 2007). On the other hand, the major advantage of using SFA method is it allows the measurement error and provides a firm specific efficiency estimate (Staikouras et. al, 2008).

Several studies have indicated that the efficiency results can be sensitive to the method selected for efficiency measurement (Johansson, 2005). Some studies reported to have found different efficiency scores for different methods of efficiency measurement (Chen, 2002 & Johansson, 2005). However, some studies report that there is no significant difference in the level of efficiency scores (Resti, 1999).

However, both the methods have some merits and demerits. According to Ajibefun (2008), the main advantage of the parametric frontier analysis is, being a stochastic frontier production function, it allows the test of hypothesis concerning the goodness of fit of the model. On the other hand, the major disadvantage of the method is, it requires the ‘specification of technology’ (Ajibefun, 2008). Whereas the non-parametric method, which is otherwise known as the Data Envelopment Analysis (DEA), does not require such kind of specification of a particular functional form certain technology. And the major disadvantage with the non-parametric technique is that it is not possible to estimate parameters for the model and therefore impossible to test hypothesis of the model concerned (Ajibefun, 2008).

### **Banking Sector Efficiency: A Review**

Several studies have tried to estimate the banking sector efficiency in the light of the financial liberalization and banking sector reforms. Some of them have estimated the technical efficiency (Akmal & Saleem, 2008), some the scale efficiency (Akmal & Saleem, 2008; Quyyam & Khan, 2007; Craft & Tirtiroglu, 1998; Karvalo & Kasman, 2005), allocative efficiency (refer studies), profit and cost efficiency (Karvalo & Kasman, 2005; Craft, 2002; Hasan & Marton, 2003; Staikouras et. al, 2008) and also X-efficiency (Craft & Tirtiroglu, 1998 ; Altunbas et. al, 2001; Fu and Heffernan, 2007; Quyyam & Khan, 2007).

A brief survey of literature shows that the cost and X-efficiency measurement is becoming more popular in banking efficiency study. Craft & Tirtiroglu (1998), estimated X-efficiency and the scale efficiency during 1994 and 1995 for both the new and old, state and the private banks in Croatia. Altunbas et. al (2001), estimated the scale economies and the X-efficiency for the European banks between 1989 – 1997. Christopoulos et. al (2002), in their study attempted to estimate the cost efficiency of the Greek banking system during 1993-98. Hasan and Marton (2003), estimated the profit and cost inefficiency of the Hungarian Banking sector during the

transition period. Canhoto and Dermine (2003), attempted to investigate the magnitude of efficiency in the Portugal banking sector during the period 1990 – 95. Karvalo and Kasman (2005), measured the cost inefficiency, and scale and scope economies of a panel of 461 banks from 16 Latin American countries during 1995-99. Patti & Hardy (2005), in their study attempted to determine the banking efficiency by ownership. Havrylchuk (2006), examined the efficiency of the Polish banking industry between 1997 and 2001. Fu and Heffernan (2007), examined the cost x-efficiency of the china's banking sector for the period 1985 – 2002. Staikouras et. al (2008), analyzed the cost efficiency in the banking sector of the six South Eastern European countries. Koutsomanoli-Filippaki et. al (2009), analyzed banking sector efficiency and productivity growth in the banking sector of the central and the eastern Europe for the period 1998-2003.

### **Studies on Banking Sector Efficiency in India: A review**

Several studies have been carried out to study the banking sector performance in India in context of financial liberalization. However, few studies have been done on the cost efficiency of the Indian banking sector. Studies by Bhattacharya et. al(1997),Sathye (2003), Das & Ghosh (2006), Ray & Das (2009) have tried to measure the efficiency of the Indian banking sector. Bhattacharya et. al (1997), in their study examined the productivity efficiency of 70 Indian commercial banks during 1986 to 1991. Using Data Evolvement Analysis (DEA), their study concludes, the public sector banks have been the most efficient followed by the foreign and the private banks. Sathye (2003), using the DEA to estimate efficiency, found the private banks are less efficient than the public and the foreign banks. Das and Ghose (2006) used the non-parametric DEA to estimate the efficiency of the Indian commercial banks in the post reform period, 1992-2002. Using non-parametric DEA to estimate the cost and profit efficiency of the Indian banking sector in the post reform period, Ray and Das (2009) found, the public sector banks are more efficient than the private banks.

### **Estimating Efficiency Using the Stochastic Frontier Approach**

In recent years the frontier analysis method has been quite popular. Several studies have been carried out to measure the banking sector performance (efficiency) using the frontier analysis method (Abbasoglu et. al, 2007; Carbo et. al, 2002). The frontier analysis separates the institutions those perform better relative to a particular standard from the institutions those



performances are poor. Such separations can be done by using a parametric or non-parametric frontier analysis. The parametric approach includes the stochastic frontier analysis (Sathye, 2003). The Stochastic Frontier Method has been extensively used over last decade (Craft & Tirtiroglu, 1998; Karvalo & Kasman, 2005; Hasan & Marton, 2003; Craft et. al, 2002; Altunbas et. al, 2001; Staikouras et. al, 2008; Fu and Heffernan, 2007).

Studies on efficiency attempts to measure a firm’s position relative to an efficient frontier. The DEA and the SFA are two techniques which help in estimating the position of a firm relative to an efficient frontier (Johansson, 2005). The present study uses the SFA method to estimate the cost efficiency of the Indian banking sector, since using SFA estimation is possible via the production, cost or, the profit function (Johansson, 2005). The Stochastic Frontier Approach (SFA), which is referred as the Econometric Frontier Approach<sup>6</sup> (EFA) was developed by Aigner, Lovell and Schmidt and Van den Broeck in 1977. It specifies a functional form for the cost, profit or the production frontier and allows for random error (Tahir and Haron, 2008).

The cost frontier can be constructed by using the following regression function (Abbasoglu et. al, 2007 & Carbo et. al, 2002).

$$TC = f \Sigma (\text{INPUTS}) + \Sigma (\text{OUTPUTS}) + e$$

Where, TC is the total cost.

e is the random error component.

The inputs include, the interest cost<sup>7</sup>, labor cost<sup>8</sup> and the capital cost<sup>9</sup>. The output includes three variables like total loans, investment in securities and other investments. The efficiency indices are calculated by the difference between the cost frontier constructed and the realized total cost (Abbasoglu et. al, 2007).

The basic stochastic frontier model can be written as the followings (Anderation et. al, 2000):

$$\ln TC_i = \ln TC(Q_i, P_i) + U_i + V_i \quad \text{-----(1)}$$

---

<sup>6</sup> However, the first econometric approach to efficiency measurement was developed by Aigner & Chu in 1968, but did not include a stochastic term to control for random disturbances (Resti, 1997). Subsequently, the SFA was developed with a composite error term, which can be divided in to two parts.

<sup>7</sup> Interest cost = total interest expense / total borrowings

<sup>8</sup> Labor cost = Personal expenses / number of employees

<sup>9</sup> Capital cost = capital expenditure (depreciation) / book value of the total asset

Where, TC stands for the total cost, Q are the vector of outputs and the P for the vector of input prices.  $U_i$  is the one sided disturbance term for the cost frontier, which captures the inefficiency (Karvalo & Kasman, 2005; Anderation et. al, 2000).  $V_i$  is the random error or, noise term.

And  $U_i + V_i = E_i$ .

The stochastic cost frontier can be written as (Anderation et. al, 2000):

$$TC(Q_i, P_i) \exp(V_i) \text{-----}(2)$$

The cost frontier can be estimated by using the maximum likelihood method and efficiency scores are estimated using the regression errors (Karvalo & Kasman, 2005).

Given the half normal inefficiency stochastic frontier approach, the present study uses the Fourier Flexible (FF) form to examine the cost function specifications, which best fits the cost structure of the Indian banking system (as discussed in Carbo et. al, 2002). Carbo et. al (2002) in their study have used the FF form with the translog functional form. A normal translog cost function with three inputs and three outputs can be of the following form (Anderation et. al, 2000).

$$\ln TC_i(p, Q) = \alpha_0 + \sum_{i=1}^3 \alpha_i \ln p_i + 1/2 \sum_{i=1}^3 \sum_{j=1}^3 \alpha_{ij} \ln p_i \ln p_j + \alpha \ln Q_i + \alpha_{qq} \ln Q_i^2 + \varepsilon_i \text{----}(3)$$

However, the reason behind using the FF form with translog functional form is that, the translog features may not fit the data, which are far from the mean in terms of output size or mix (Carbo et. al, 2002). The FF can solve the problem by approximating any continuous function and any of its derivatives<sup>10</sup> (Carbo et. al, 2002). This method was first introduced by Gallant in 1981 and subsequently discussed and used by many including Carbo et. al (2002). The present study uses the methodology developed by Carbo et. al (2002).

---

<sup>10</sup> According to Carbo et. al (2002), “Since the FF is a combination of polynomial and trigonometric expansions, the order of approximation can increase with the size of the sample size”.

$$\begin{aligned}
 \ln TC = & \alpha_0 + \sum_{i=1}^3 \alpha_i \ln Q_i + \sum_{l=1}^3 \beta_l \ln P_l + t_1 T + \\
 & 1/2 \left[ \sum_{i=1}^3 \sum_{j=1}^3 \delta_{ij} \ln Q_i \ln Q_j + \sum_{l=1}^3 \sum_{m=1}^3 y_{lm} \ln P_m + t_{11} T^2 \right] \\
 & + \sum_{i=1}^3 \sum_{m=1}^3 \rho_{im} \ln Q_i \ln P_m + \sum_{i=1}^n \psi_i T \ln Q_i + \sum_{l=1}^3 \theta_l T \ln P_l + \\
 & \sum_{i=1}^3 [a_i \cos(Z_i)] + \sum_{i=1}^3 \sum_{j=1}^3 a_{ij} \cos(Z_i + Z_j) + b_{ij} \sin(Z_i + Z_j) + \\
 & \sum_{i=1}^3 \sum_{m=1}^3 \sum_{k>j, k \neq i}^3 [a_{ijk} \cos(Z_i + Z_j + Z_k)] + \epsilon
 \end{aligned}$$

------(4)

The inefficiency measures can be calculated by using the above equation (4), which includes a standard translog function, second and third trigonometric terms and two components error terms using a maximum likelihood procedure.

$\ln TC$  = log of total cost

$\ln Q_i$  = log of bank outputs (total loans, investment in securities and other investments)

$\ln P_i$  = log of bank inputs (the interest cost, labor cost and the capital cost)

$T$  = Time Trend

$Z_i$  = the adjusted values of the log output  $\ln Q_i$

### The Data

On banking statistics in India, the Reserve Bank of India (RBI) remains the most reliable source. The data has been taken from the ‘Statistical Tables Relating to Banks in India’ data base. The present study analyses the efficiency of public sector banks both at pre and the post reform period, and efficiency of the public, private and foreign banks in the post reform period. All the variables used in the study have been deflated with the GDP deflator and converted to constant prices (1993-94 prices). To determine the cost efficiency of the public sector banks both during the pre and post reform period, analyze 27 public sector banks have been taken in to account.

Due to data limitation the pre-reform period has been taken as from 1980 to 1988 and the post reform period has been taken as, 1992 to 2007. To examine the efficiency level of the Indian banks by ownership, 27 PSBs, 17 private banks and 16 foreign banks have been taken in to account. The banks those have been included have been operating continuously since 1996 and banks those discontinued have not been considered.

### Analysis of Result

The mean efficiency scores of the Indian public sector banks have been explained in the following table (*Table - 6*). The result shows, the mean efficiency value of the public sector banks during the post reform period has declined marginally.

**Table - 6: Descriptive Statistics of Efficiency Scores -Public Sector Banks: Pre (1980-87) and the Post (1992-2007) Reform Period**

Period	Observations	Mean	SD	Min	Max
Pre Reform (1980-87)	216	0.974	0.007	0.950	0.988
Post Reform (1992-2007)	416	0.969	0.009	0.928	0.986

The efficiency values of the Indian public sector banks show, there has not been much variation between the two time periods (*Figure – 1 & 2*). During the whole study period, the efficiency scores of the public sector banks vary from 0.974 to 0.969. It is important to note that after the initiation of the financial sector reform, the efficiency value of the public sector banks has declined marginally.

Figure: 1

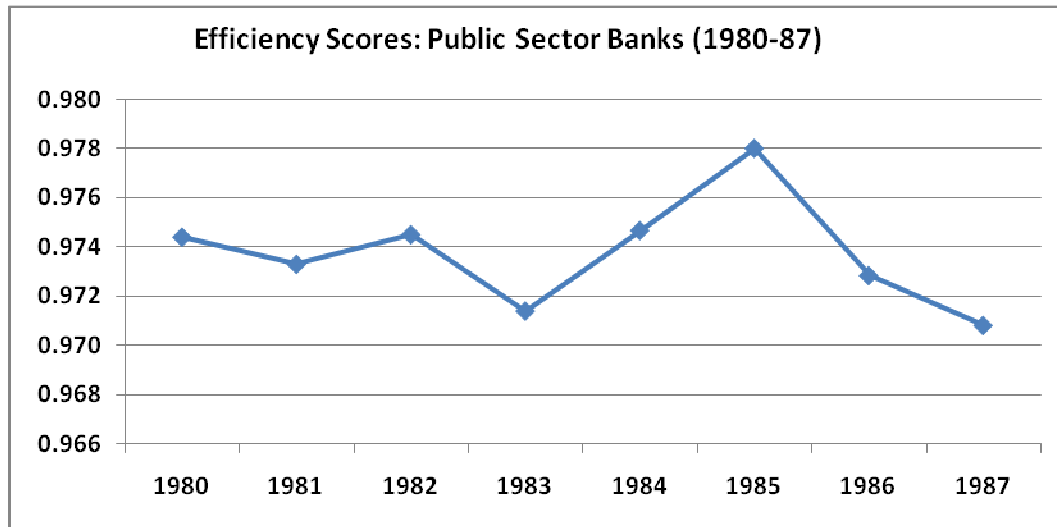


Figure: 2

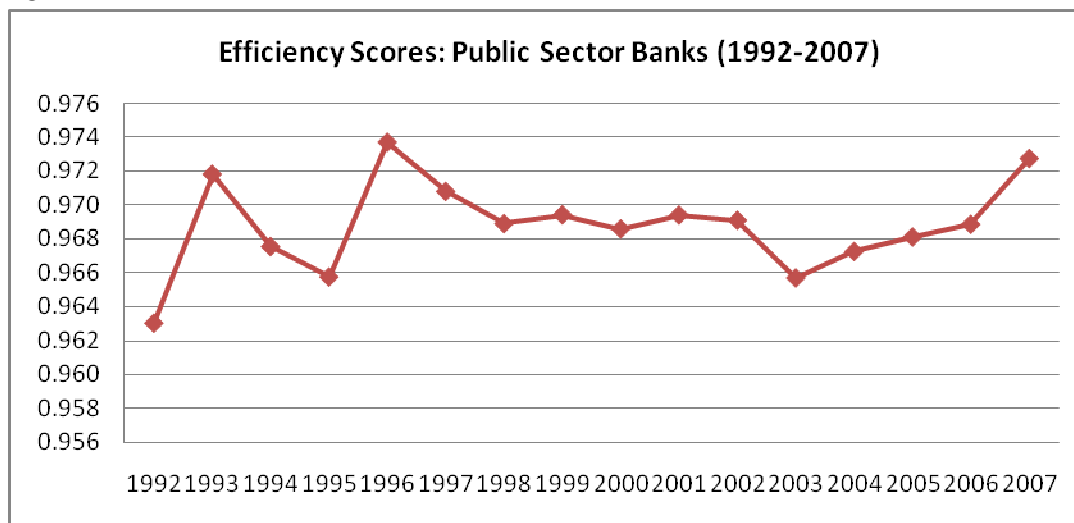
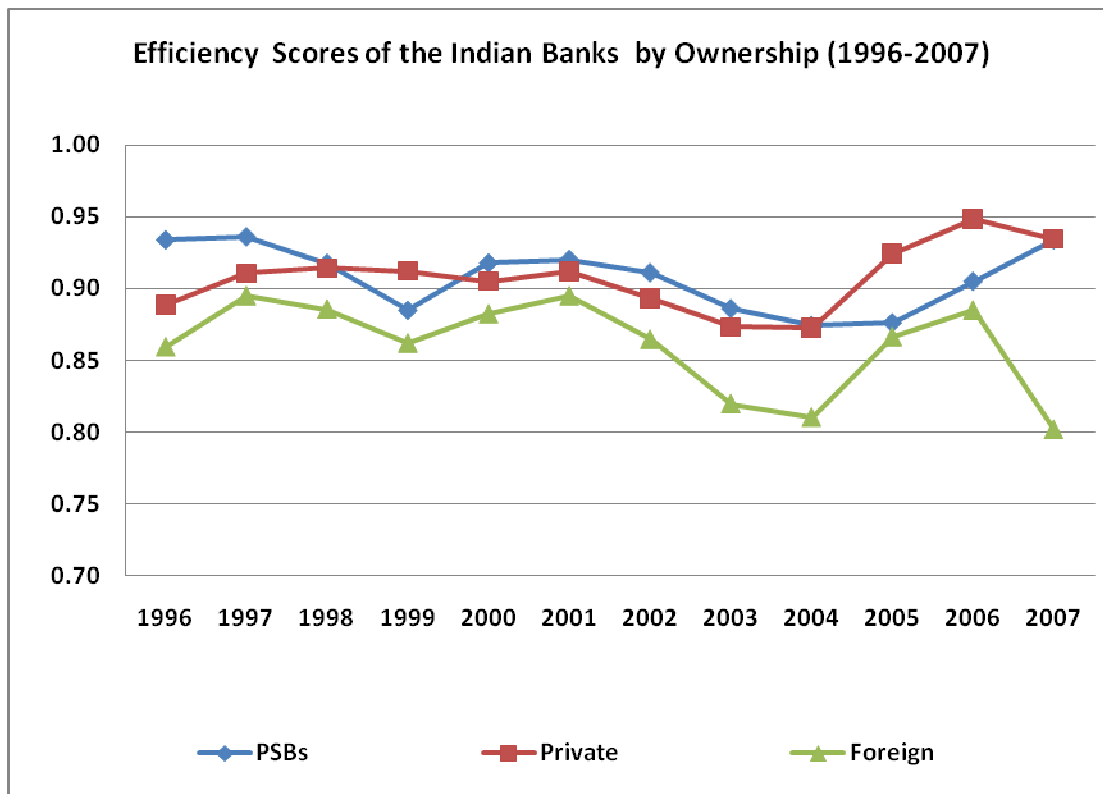


Table -7: Descriptive Statistics of Efficiency Scores by Bank Ownership (1996-2007)

Ownership	Observations	Mean	SD	Min	Max
PSBs	323	0.911	0.038	0.760	0.982
Private	204	0.907	0.043	0.751	0.977
Foreign	179	0.866	0.093	0.570	0.991
All	706	0.898	0.061	0.570	0.991

The mean efficiency score of the Indian banking sector as a whole is about 0.9 (Table-7). The public sector banks and the private banks have the mean efficiency which is higher than the all banks mean efficiency. The foreign banks are found to be least efficient among the bank groups. The public sector banks are the most efficient, followed by the domestic private banks. The average efficiency score of the public, private and the foreign banks (Figure – 3) shows, even the public sector banks are the most efficient, in recent years since 2004, the private banks are becoming more efficient and the foreign banks are becoming almost equally less efficient.

Figure: 3



The efficiency scores of the individual banks show<sup>11</sup>, out of 27 public sector banks, only 2 banks are found to score less than the mean efficiency during the post reform period (1996-2007). The Bank of Maharashtra seems to be the most efficient public sector bank in the post reform period (Table – 1.1A, annexure – 1). Out of 17 private banks, 4 banks found to score less than the mean efficiency (Table – 1.2A, annexure – 1). The efficiency score of the Tamiland Mercantile Bank is the highest among the private sector banks. Out of 16 foreign banks, only 3 banks are found to

<sup>11</sup> See annexure - 1

have obtained a higher efficiency score which is higher than the mean efficiency score. The Citi Bank found to be the most efficient foreign bank operating in India (Table – 1.3A, annexure – 1).

### **Summary**

The study finds, there has been significant change in the performance of the banking sector after the initiation of financial liberalization in India. Being a bank based financial system; the banking performance has an obvious impact on the economy. Using RBI data from the ‘Statistical Tables Relating to Banks in India’ data base, the study finds there has been significant transformation in the structure of the banking sector. The relative importance of the public sector banks has been declining which results in the emergence of the domestic private sector banks and more foreign banks. The asset, the deposit and the credit share shows the share of public sector has been declining and the share of the private banks going up, which implies declining concentration and increasing competition. The indicators of profitability demonstrate, all bank groups recorded an increase in the rate of profit and the foreign banks are found to be the more profitable in comparison to the domestic private banks and the public sector banks. The X-efficiency results show that there has been no significant change in the level of efficiency of the public sector banks. There has been marginal decline in the efficiency of the public sector banks in the post reform period. An analysis of the post reform period shows, the domestic private banks are becoming more efficient. However, taking the post reform period as a whole the study found that the public sector banks are more efficient than the private and the foreign banks. And the foreign banks seem to be the least efficient banks in India.

## References

1. Abbasoglu, Osman Furkan, Aysan, Ahmet Faruk and Gunes, Ali (2007), “Concentration, Competition, Efficiency and Profitability of the Turkish Banking Sector in the Post-Crises Period”, *MPRA Paper No. 5494*.
2. Abdmoulah, M, (), “Banking sector liberalization and efficiency: The Tunisian experience from 1990 to 2006”
3. Agarwal, R. N (2003), “Capital Market Development, Corporate Financing Pattern and Economic Growth in India”, *Asian Economic Review*, Vol. 45, No.1, April 2003, Pp. 23-34.
4. Akmal, M and Muhammad Saleem (2008), “Technical Efficiency of the Banking Sector in Pakistan”, *SBP Research Bulletin*, Volume 4, Number 1, November, 2008, pp. 61-80.
5. Altunbas, Y; E.P.M. Gardener; P. Molyneux and B. Moore (2001), “ Efficiency in European Banking”, *European Economic Review*, 45, pp. 1931-1955.
6. Anderson, Randy I .; Danielle Lewis and Leonard V. Zumpano (2000), “Inefficiencies in the Residential Real Estate Market: A Stochastic Frontier Approach”, *JRER*, Vol.20, No. ½, pp. 93-103.
7. Aydin, Nurhan; Abdullah Yalama and Mustafa Sayim (2009), “Banking Efficiency in Developing Economy: Empirical Evidence from Turkey”, *Journal of Money, Investment and Banking*, Issue 8 (2009), pp. 49-70.
8. Bhattacharya, A., Lovell, C.A.K., and Sahay, P. 1997. “The impact of liberalization on the productive efficiency of Indian commercial banks”, *European Journal of Operational Research*, 98, 332-345.
9. Bolt, W and David Humphrey (2008), “Bank Competition Efficiency in Europe: A Frontier Approach”, *DNB Working Paper No. 194*.
10. Button, Kenneth J. and Thomas G. Weyman-Jones (1994), “ X-Efficiency and Technical Efficiency”, *Public Choice*, Vol. 80, No. 1/2 (1994), pp. 83-104.
11. Camanho, A. S. and R. G. Dyson (2005), “Cost Efficiency, Production and Value-Added Models in the Analysis of Bank Branch Performance”, *The Journal of the Operational Research Society*, Vol. 56, No. 5 (May, 2005), pp. 483- 494.
12. Caner S. and V. Kontorovich (2004), “Efficiency of the Banking Sector in the Russian Federation with International Comparison”.



13. Canhoto, Ana and Jean Dermine (2003), “A note on banking efficiency in Portugal, New vs. Old banks”, *Journal of Banking and Finance*, 27, pp. 2087 – 2098.
14. Carbo, S, E.P.M. Gardener and J. Williams (2002), “Efficiency in Banking: Empirical Evidence from the Savings Banks Sector”, *Econ Papers*, 2002, vol. 70, issue 2, pages 204-28
15. Chen, Tser-yieth (2002), “A Comparison of Chance-Constrained DEA and Stochastic Frontier Analysis: Bank Efficiency in Taiwan”, *The Journal of the Operational Research Society*, Vol. 53, No. 5 (May, 2002), pp. 492- 500.
16. Chen, Yi-Kai (2001), “Three Essays on Banking Efficiency”, Unpublished PhD Thesis Submitted to Drexel University.
17. Christopoulos, D. K; Sarantis E.G. Lolos and Efthymios G. Tsionas (2002), “Efficiency of the Greek banking system in view of the EMU: a heteroscedastic stochastic frontier approach”, *Journal of Policy Modeling*, 24, pp. 813-829.
18. Das, Abhiman & S. Ghosh (2006), “Financial Deregulation and Efficiency: An Empirical Analysis of Indian Banks During the Post Reform Period”, *Review of Financial Economics*, Vol. 15, Issue. 3, Pp, 193-221.
19. Fu, Xiaoqing and Shelagh Heffernan (2008), “Cost X-efficiency in China's banking sector”, *China Economic Review*, 18, pp. 35-53.
20. Hajargasht, Gholamreza (), “Some New Semiparametric Panel Stochastic Frontiers A Bayesian Penalized Approach”, School of Economics, University of Queensland.
21. Hasan, I and K. Marton (2003),”Development and Efficiency of the Banking Sector in a Transitional Economy: Hungarian Experience”, *Journal of Banking and Finance*, No. 27, pp. 2249-2271.
22. Hasan, Iftekhar and Katherin Marton (2003), “Development and efficiency of the banking sector in a transitional economy: Hungarian experience”, *Journal of Banking and Finance*, 27, pp. 2249-2271.
23. Havrylchyk, Olena (2006), “Efficiency of the Polish banking industry: Foreign versus domestic banks”, *Journal of Banking and Finance*, 30, pp. 19975-1996.
24. Jackson, Peter M., Meryem Duygun Fethi, and Gozde Inal (1998), “Efficiency and Productivity Growth in Turkish Commercial Banking Sector: A non-parametric

- approach”, Paper presented at the European Symposium on: Data Envelopment Analysis-Recent Development and Applications, Wernigerode, Germany, 16-18 October, 1998.
25. Johansson, Helena (2005), “Technical, Allocative, and Economic Efficiency in Swedish Dairy Firms: The Data Development Analysis Versus the Stochastic Frontier Approach”, Poster background paper prepared for presentation at the XI:th International Congress of the European Association of Agricultural Economists (EAAE), Copenhagen, Denmark, August 24-27, 2005
  26. Kaminsky, G L & S. L. Schmukler (2003), “Short-run Pain, Long-run Gain: The Effects of Financial Liberalization”, *IMF Working Paper* No. WP/03/04.
  27. Kaparakis, Emmanuel I.; Stephen M. Miller, Athanasios G. Noulas (1994), “Short-Run Cost Inefficiency of Commercial Banks: A Flexible Stochastic Frontier Approach”, *Journal of Money, Credit and Banking*, Vol. 26, No. 4 (Nov., 1994), pp. 875-893.
  28. Karvalo, Oscar and A. Kasman (2005), “Cost Efficiency in the Latin American and Caribbean Banking Systems”, *Journal of International Financial Markets, Institutions and Money*, No. 15, pp. 55-72.
  29. Koutsomanoli-Filippaki, Anastasia , Dimitris Margaritis and Christos Staikouras (2009), “Efficiency and productivity growth in the banking industry of Central and Eastern Europe”, *Journal of Banking and Finance*, 33, pp. 557-567.
  30. Kraft, Evan and Dogan Tirtiroglu (1998), “Bank Efficiency in Croatia: A Stochastic Frontier Analysis”, *Journal of Comparative Economics*, 26, pp.282–300.
  31. Laurenceson, James and Zhao Yong (2008), “Are foreign banks the efficiency benchmark in China’s banking sector?” East Asia Economic Research Group Discussion Paper No. 18, December 2008, School of Economics, The University of Queensland. Queensland.
  32. Lawrence, Peter and I. Longjam (2003), “Financial Liberalization in India: Measuring Relative Progress”, *Keele Economics Research Paper* No. 2003/8, Kele University. [www.keele.ac.uk/depts/ec/kerp](http://www.keele.ac.uk/depts/ec/kerp).
  33. Luciano, Elisa and Luca Regis (2007), “Bank Efficiency and Banking Sector Development: The Case of Italy”, International Centre for Economic Research Working paper No. 5/2007.

34. Mohan, Rakesh (2005), “Reforms, Productivity and Efficiency in Banking: The Indian Experience”, *Pakistan Development Review*, Vol. 44, No. 4, Pp. 505-538.
35. Mukherjee, A; P. Nath and M. Pal (2003), “Resource, Service Quality and Performance Triad: A Framework for Measuring Efficiency of Banking Services”, *The Journal of the Operational Research Society*, Vol. 54, No. 7 (Jul., 2003), pp. 723- 735
36. Patti & Hardy (2005), Financial sector liberalization, bank privatization, and efficiency: Evidence from Pakistan”, *Journal of Banking and Finance*, 29, pp. 2381-2406.
37. Prasad, A and S. Ghosh (2005), “Competition in Indian Banking”, *IMF Working Paper* WP/05/141.
38. Puig-Junoy, Jaume and Vicente Ortún (2003), “Cost Efficiency in Primary Care Contracting: A Stochastic Frontier Cost Function Approach”, *Universitat Pompeu Fabra, Department of Economics and Business, Research Centre on Economics and Health (CRES)*
39. Qayyum, Abdul and Sajawal Khan (2007), “X-efficiency, Scale Economies, Technological Progress and Competition: A Case of Banking Sector in Pakistan”, *Pakistan Institute of Development Economics Working Paper* No.2007:23.
40. Ram Mohan, T T (2007), “Banking Reforms in India: Charting a Unique Course”, *Economic and Political Weekly* March 31, 2007, Pp. 1109-1120.
41. Ray, S. C & A. Das (2009), Distribution of Cost and Profit Efficiency: Evidence from the Indian Banking”, *European Journal of Operational Research*.
42. Resti, A (1997), “Evaluating the cost-efficiency of the Italian Banking System: What can be learned from the joint application of parametric and non-parametric techniques”, *Journal of Banking and Finance*, No. 21, pp. 221-250.
43. Samolyk, Katherine A. (1992), “Bank Performance and Regional Economic Growth: Evidence of a Regional Credit Channel”, *Working Paper* 9204, Federal Reserve Bank of Cleveland.
44. Sathye, Milind (2003), “Efficiency of Banks in a Developing Economy: The Case of India”, *European Journal of Operational Research*, Volume 148, Issue 3, 1 August 2003, Pages 662-671
45. Sen, Kunal & R. Vaidya (1997), “The Process of Financial Liberalization in India”, Oxford University Press, Delhi.

46. Shirai, Sayuri (2001), “Assessment of India’s Banking Sector Reforms from the Perspective of the Governance of the Banking System”, presented at the ESCAP-ADB Joint Workshop on “Mobilizing Domestic Finance for Development: Reassessment of Bank Finance and Debt Markets in Asia and the Pacific”, Bangkok, 22-23 November 2001.
47. Staikouras, Christos, Emmanuel Mamatzakis , and Anastasia Koutsomanoli-Filippaki (2008), “Cost efficiency of the banking industry in the South Eastern European region”, *Journal of International Financial Markets, Institutions and Money*, 18, pp. 483 – 497.
48. Staikouras, Christos, Emmanuel Mamatzakis and Anastasia Koutsomanoli-Filippaki (2008), “Cost efficiency of the banking industry in the South Eastern European region”, *International Financial Markets, Inst. and Money* 18 (2008) 483–497.
49. Tahir, Izah Mohd and Sudin Haron (2008), “Technical efficiency of the Malaysian commercial banks: a stochastic frontier approach”, *Banks and Bank Systems*, Volume 3, Issue 4, 2008.
50. Wagenvoort, Rien and Paul Schure (2005), “A Recursive Thick Frontier Approach to Estimating Production Efficiency”, *Econometrics Working Paper EWP0503*, Department of Economics, University of Victoria.