Chapter V

MODEL ESTIMATION, EMPIRICAL RESULTS AND THEIR INTERPRETATIONS

The present chapter forms the core of this thesis since it seeks to obtain the empirical evidences regarding the effects of financial sector reforms on the X-efficiency of commercial banks in India. Before we move on with the empirical analysis, we run some preliminary test as discussed in the previous chapter. The first test that we conduct is the test for stationarity. To this end, we undertake the Augmented Dickey-Fuller test and the Levin-Lin-Chu test for panel data in Section I. There are broadly two methods by which we conduct our empirical analysis: one is the Generalised Least Square (GLS) estimation and the other is the Maximum Likelihood Estimation (MLE). Because of the use of the panel data, the presence of heteroskedacticity is imminent, which reduces the reliability of the estimations in the Ordinary Least Square method. To this end, we suitably transform the data, which, in addition to removing heteroskedacticity, neutralises the effects of autocorrelation as well. These are what we do in the GLS method. The questions of heteroskedacticity and serial correlation are of no concern in the MLE since it assumes, similar to other approaches in the stochastic frontier analysis that the error term comprises of white noises and inefficiencies. Hence, the correction of heteroskedacticity in this analysis, indeed, removes the inefficiency component from the error term. By the GLS method, we seek to estimate the parameters for the panel spanning over 1994-2012 while the MLE method is used for two alternative panels, one for 1994-2012 and the other for

2000-2012. The use of the same panel in two alternative methods of estimation enables us to make a comparative study between them. Since the MLE appears superior to the GLS estimation, we carry out the former method for alternative scenarios. First, the use of two sets of panel data, as in the present case, enables us to investigate how the efficiencies of commercial banks changed in the wake of the second-generation financial sector reforms in India that commenced in 1998. Secondly, estimations are made with and without the intercept term in the MLE case for 1994-2012. While the former is customary in the literature, we undertake the latter since the suppression of the intercept term increases the explanatory power of the arguments, on the one hand, and leaves the entire unexplained part of the dependent variable in the residual, on the other hand. For the latter reason, no part of X-efficiency component is lost anywhere.

The organisation of this chapter is such, Section I deals with the issue of the unit root problems for the panel data that we use. In Section II, we reports the results of model estimation based on the GLS method, and in Section III, those based on the MLE method. The results thus obtained are also discussed in the respective sections. Section IV makes a comparison between the results of the GLS method and the MLE method. Section V seeks to identify the shortcomings of the study and to indicate the scope of further study in this field. Section VI concludes.

Section I: Unit Root

The stationarity test that provides an idea about the convergence of the series under study, is carried out here using the add-in 'urca'[299] for ADF, and the package 'plm'[300] for Levin Lin and Chu test, as available in the R-statistical environment.

The ADF test can be conducted under three options in the 'urca'. They are with 'drift', with 'trend', and 'none'. These options correspond to the three equations of Chapter 4 Section IV. The 'urca' package runs the equation as

$$z.diff \sim z.lag.1 + 1 + tt + z.diff.lag \qquad (5.1)$$

This corresponds to the equation of Augmented Dickey Fuller test

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \varepsilon_t \qquad (5.2)$$

where the hypotheses are

$$\gamma = 0,$$

$$\gamma = a_2 = 0$$

$$a_0 = \gamma = a_2 = 0$$

These correspond to the test statistics τ_T, φ_3 and φ_2 respectively.[301] Here, $'\gamma'$ is the coefficient of the term 'z.lag'.

The ADF test overlooks the panel structure of the data so that it is less reliable for the panel data. The alternative is the Levin, Lin and Chu (LLC) test. The LLC is conducted by 'purtest' under the 'plm' package in the R environment. This test is more suitable for panel unit root as it takes into account the panel structure of the data. The 'purtest' also runs the unit root test with 'intercept',

[299] Pfaff, 'Analysis of Integrated and Cointegrated Time Series with R'
[300] Croissant and Milo, 'Panel Data Econometrics'
[301] Enders, *Applied Econometric Time series*, p.183

with ‘trend’ and ‘none’. Intercept option captures the individual intercepts whereas the trend option captures both individual intercepts and trend. The acceptance or rejection of the null hypothesis in this case depends upon the p-value. The LLC test is, however, more appropriate when the time period is large. If the time period is considerably smaller than the cross section, as in our panel data, we may not get very reliable estimates of panel root. It may also lead to acceptance of the null hypothesis when there is no unit root.

The results of our ADF test, however, suggest that there is no unit root problem in our panel data. Their calculated values of the variables are -11.5964 for C, -11.8705 for Q_1, -10.1024 for Q_2, -12.451 for r_1,-12.0234 for r_2 and -14.6042 for r_3. The tabulated value of τ with 1076 degrees of freedom is -3.96 at 1 per cent level of significance and -3.14 at 5 per cent level of significance. Since the calculated values are less than the table values we should reject the null hypothesis H_0 that there is unit root, and accept the alternate hypothesis H_1 that there is no unit root.

The Levin Lin and Chu test also rejects the possibility of the unit root in our panel. This test generates a ρ value of -21.96 for C, -24 for Q_1, -48.70 for Q_2, -3.36 for r_1, -15.59 for r_2 and – 18.41 for r_3. The probability value (p values) of ρ statistics are found in the close proximity of 0 suggesting again that the unit root problem is absent in our cases. The non existence of unit root problem suggests that the time series of the variables under study are convergent in their respective populations so that the estimations of the sample statistics from those series are reliable in repeated sampling.

Section II: Generalised Least Square Estimation

We undertake a generalised least square (GLS) estimation[302] to overcome heteroskedacticity and autocorrelation in panel data. In the first step, we run the ordinary least square method of estimation on the panel data for the time period 1994-2012. Table 5.1 presents the estimated values of the parameters of the model along with their relevant statistics like standard errors, t-statistics and their significances. After running the OLS we store the error terms, and report them in the Annexure 12.

Table 5.1 shows that the R^2-value is as high as 0.9915, signifying that the variables under consideration very significantly explain the variations in banking costs. This is also evident in observed value of F-statistic, which is as high as 6282, and, thus attains a significance level of 0.0001. We are thus confirmed about the model's goodness of fit on our panel data. But these inferences should be qualified by that the high R^2-value might also indicate the presence of heteroskedacticity. It should also be noted that all the output and input coefficients assume appropriate signs. Only two squared variables and some joint variables assume negative coefficients in this estimation.

[302]Kmenta, *Elements of Econometrics*, pp.508 - 512.

Table 5.1: The first-stage OLS estimation for the panel 1994-2012

Coefficients	Estimates	SE	t-values	Pr(>|t|)
$Intercept(\alpha_0)$	1.4416	0.3536	4.077	0.0000
$Q_1(\alpha_1)$	0.0440	0.0569	0.774	0.4392
$Q_2(\alpha_2)$	0.6908	0.0738	9.359	0.000
$r_3(\alpha_3)$	0.0953	0.0664	1.435	0.1515
$r_2(\alpha_4)$	0.0261	0.1574	0.165	0.8686
$r_3(\alpha_5)$	0.0883	0.0491	1.798	0.0725
$Q_1^2(\alpha_{11})$	0.0153	0.0082	1.869	0.0619
$Q_2^2(\alpha_{22})$	0.0858	0.0164	-5.235	0.000
$r_1^2(\alpha_{33})$	0.0325	0.0112	2.889	0.0040
$r_2^2(\alpha_{44})$	-0.1075	0.0378	-2.842	0.0046
$r_3^2(\alpha_{55})$	0.0034	0.0070	0.481	0.6307
$Q_1Q_2(\alpha_{12})$	0.0488	0.0115	4.226	0.0001
$Q_1r_1(\alpha_{13})$	-0.0466	0.0072	-6.483	0.0001
$Q_1r_2(\alpha_{14})$	0.1190	0.0136	8.755	0.0001
$Q_1r_3(\alpha_{15})$	0.0041	0.0052	0.782	0.4342
$Q_2r_1(\alpha_{23})$	0.0094	0.0090	1.045	0.2964
$Q_2r_2(\alpha_{24})$	-0.0787	0.0193	-4.087	0.0001
$Q_2r_3(\alpha_{25})$	-0.0158	0.0069	-2.294	0.0220
$r_1r_2(\alpha_{34})$	-0.1042	0.0180	-5.777	0.0001
$r_1r_3(\alpha_{35})$	-0.0191	0.0070	-2.707	0.0069
$r_2r_3(\alpha_{45})$	-0.0148	0.0162	-0.915	0.3603

Of all the variables that enters the first-stage regression equation, fourteen variables (Intercept, lnQ_1, lnQ_2, lnr_1, lnr_2, lnr_3, $SqlnQ_1$,$SqlnQ_2$,$Sqlnr_1$, $Sqlnr_3$, lnQ_1Q_2, lnQ_1r_2, lnQ_1r_3andlnQ_2r_1) assume positive coefficients while seven variables -, $Sqlnr_2$,lnQ_1r_1,LnQ_2r_2,lnQ_2r_3,lnr_1r_2,lnr_1r_3andlnr_2r_3 - have negative slopes. Out of these negative coefficients, two are insignificant at 0.01 per cent level. We are, however, concerned at this stage of estimation only with the residuals which, as the F-statistic and the R^{2-}measure indicate, are free from the effects of any significant variable.

Since the above OLS estimation might suffer from autocorrelation and heteroskedacticity, it no longer stands as an efficient estimator. A correction of these problems is necessary for proper statistical inferences.

We undertake the GLS transformation, *a la* Kmenta,[303] from the residuals of the first-stage regression that have been stored (as discussed in Chapter IV). In the first step, we correct for autocorrelation by taking the estimated values of ρ_i for each bank from the following relationship

$$\varepsilon_{it} = \rho_i \varepsilon_{t-1} + u_{it} \qquad (5.3)$$

where$\varepsilon_{it}$is the residuals obtained from the first step OLS estimation. The estimated values of ρ_i are presented in Annexure 13. The input and output variables are thereafter transformed following the methodology as discussed in the previous chapter. The transformed variables are now free from autocorrelation. In the second step of the GLS transformation, we correct the variables for heteroskedacticity by dividing the variables by their respective

[303] Ibid, p.510

variance terms. For that purpose, the variances of individual variables for each bank are obtained by

$$s_{ui}^2 = \frac{1}{T-K-1}\sum_{t=2}^{T} \hat{u}_{it}^{*2} \quad (5.4)$$

The estimated variances s_{ui}^2 are also reported in Annexure 13. Once these corrections are made, the resultant data series are free from the problems of both autocorrelation and heteroskedacticity. On these transformed data, we undertake the OLS to estimate the model parameters without any loss of the avowed properties of the OLS estimators. The residuals in this stage of regression are again stored as we believe that they contain the effects of X-efficiency along with pure white noise. To segregate the X-efficiency component from random effects, we regress ε_{it} on time (t) as in Equation 5.5.

$$ln\varepsilon_{it} = \alpha_i + \lambda_i t + ln\xi_{it} \quad (5.5)$$

Equation (5.5) breaks the error term into three components - α_i denoting the time invariant X-efficiency component, $\lambda_i t$ denoting the time variant X-efficiency and $ln\xi_{it}$ representing the pure white noise. The estimated parameters of the above equation are shown in Tables 5.2 – Table 5.4.

Table 5.2. Estimated results of Residual on time for PSB under GLS method

BANK	R^2	F	Sig	α_i	t value	Sig	λ_i	t value	Sig
SBI	0.36	9.0409	0.010	0.6116	5.6993	0.001	-0.0298	-3.0068	0.010
SBJ	0.02	0.3673	0.550	0.0190	0.1294	0.900	0.0082	0.6060	0.550
SBH	0.05	0.8990	0.360	-0.2823	-1.5254	0.150	0.0162	0.9482	0.360
SBM	0.01	0.0937	0.760	-0.2348	-1.5190	0.150	-0.0044	-0.3060	0.760
SBP	0.02	0.3363	0.570	-0.2470	-1.0682	0.300	-0.0124	-0.5799	0.570
SBT	0.03	0.4682	0.500	-0.1084	-0.5925	0.560	-0.0116	-0.6842	0.500
ALLB	0.00	0.0231	0.880	0.0254	0.1315	0.900	-0.0027	-0.1520	0.880
ANDB	0.00	0.0610	0.810	-0.1412	-0.7886	0.440	-0.0041	-0.2470	0.810
BOB	0.49	15.6803	0.000	0.3223	3.0150	0.010	-0.0391	-3.9598	0.000
BOI	0.14	2.5382	0.130	0.2058	1.4377	0.170	-0.0211	-1.5932	0.130
BOM	0.00	0.0347	0.850	-0.0815	-0.5011	0.620	-0.0028	-0.1864	0.850
CANB	0.01	0.1093	0.750	-0.2144	-0.8952	0.380	-0.0073	-0.3306	0.750
CENB	0.04	0.6133	0.440	-0.0320	-0.1800	0.860	-0.0129	-0.7832	0.440
CORPB	0.12	2.1948	0.160	-0.0664	-0.4228	0.680	-0.0215	-1.4815	0.160
DENB	0.10	1.7825	0.200	0.4412	4.2476	0.000	-0.0128	-1.3351	0.200
INDB	0.15	2.8078	0.110	0.3916	2.2288	0.040	-0.0272	-1.6756	0.110
IOB	0.20	4.0139	0.060	0.4245	2.8569	0.010	-0.0275	-2.0035	0.060
OBC	0.00	0.0360	0.850	-0.3103	-1.3600	0.190	0.0040	0.1897	0.850
PNSB	0.00	0.0402	0.840	0.1095	0.4469	0.660	-0.0045	-0.2005	0.840
PNB	0.12	2.2351	0.150	0.1195	0.8223	0.420	-0.0201	-1.4950	0.150
SYNB	0.16	2.9626	0.100	0.0824	0.6205	0.540	-0.0211	-1.7212	0.100
UCOB	0.49	15.4284	0.000	0.4644	3.1367	0.010	-0.0537	-3.9279	0.001
UNIONB	0.13	2.4160	0.140	0.0693	0.3567	0.730	-0.0279	-1.5544	0.140
UNITEDB	0.41	11.2788	0.001	1.6861	5.3329	0.000	-0.0981	-3.3584	0.001
VIJB	0.00	0.0131	0.910	0.0408	0.1546	0.880	-0.0028	-0.1145	0.910

Table 5.3. Estimated results of Residual on time for PDB

BANK	R^2	F	Sig	α_i	t value	Sig	λ_i	t value	Sig
AXISB	0.01	0.0195	0.890	-0.1999	-0.9036	0.380	0.0029	0.1396	0.890
CATSYRB	0.01	0.0443	0.840	0.2113	1.1126	0.280	0.0037	0.2105	0.840
CITYUNIB	0.14	2.5931	0.130	-0.4852	-3.0543	0.010	0.0236	1.6103	0.130
DLAXB	0.20	3.9762	0.060	-0.4272	-2.4491	0.030	0.0321	1.9940	0.060
FEDB	0.02	0.3194	0.580	-0.0766	-0.4669	0.650	-0.0086	-0.5652	0.580
HDFC	0.19	3.6804	0.070	-0.1711	-0.9877	0.340	0.0307	1.9184	0.070
ICICI	0.17	3.2464	0.090	3.0273	1.6507	0.120	-0.3053	-1.8018	0.090
INDUSB	0.01	0.0115	0.920	0.0155	0.1095	0.910	0.0014	0.1071	0.920
INGVYSB	0.01	0.1724	0.680	0.1603	0.8441	0.410	-0.0073	-0.4152	0.680
JKB	0.01	0.0514	0.820	1.0233	1.7960	0.090	-0.0119	-0.2267	0.820
KARB	0.01	0.0276	0.870	-0.0555	-0.2338	0.820	-0.0036	-0.1661	0.870
KVYSB	0.06	1.0606	0.320	-0.3353	-2.4126	0.030	0.0132	1.0299	0.320
LVILB	0.14	2.5171	0.130	0.0337	0.2406	0.810	0.0205	1.5865	0.130
NAINB	0.41	11.2491	0.001	-0.7402	-5.2108	0.001	0.0440	3.3540	0.001
RATNB	0.05	0.8445	0.370	-0.3723	-2.6480	0.020	-0.0119	-0.9190	0.370
SOUINB	0.02	0.3830	0.540	0.2637	1.9818	0.060	0.0076	0.6189	0.540
TAMNB	0.19	3.7885	0.070	-0.2625	-1.5935	0.130	0.0296	1.9464	0.070

Table 5.4. Estimated results of Residual on time for PFB

BANK	R^2	F	Sig	α_i	t value	Sig	λ_i	t value	Sig
ADCOMB	0.11	1.903	0.190	1.3645	0.6786	0.500	-0.2563	-1.3794	0.180
BOA	0.01	0.078	0.780	0.0888	0.3012	0.760	-0.0076	-0.2784	0.780
BBK	0.01	0.012	0.920	-0.1707	-0.1071	0.910	-0.0158	-0.1076	0.910
BNOVA	0.05	0.876	0.360	0.8985	2.1204	0.050	-0.0367	-0.9362	0.360
BOT	0.03	0.415	0.530	-2.8835	-1.1692	0.250	0.1468	0.6443	0.520
BNP	0.42	11.439	0.000	-0.1128	-1.0362	0.310	0.0340	3.3821	0.000
BARCB	0.17	3.364	0.090	-1.3920	-1.5199	0.140	0.1552	1.8340	0.080
CITI	0.23	4.695	0.050	1.6645	4.1237	0.001	-0.0808	-2.1668	0.040
DBS	0.24	4.932	0.040	-1.4034	0.0082	0.001	0.0954	2.2209	0.040
DEUTB	0.02	0.397	0.540	2.1636	0.9169	0.370	-0.1373	-0.6299	0.050
HSBC	0.11	1.901	0.190	2.8571	1.5513	0.140	-0.2346	-1.3787	0.180
JPMC	0.17	3.211	0.090	2.3433	2.2344	0.040	-0.1736	-1.7919	0.090
OMINB	0.06	1.033	0.320	-1.4381	-0.8968	0.380	0.1506	1.0163	0.320
SGB	0.01	0.001	1.000	-0.9197	-0.5218	0.600	-0.0002	-0.0012	0.990
STANCB	0.40	10.480	0.010	2.2202	4.9183	0.001	-0.1350	-3.2373	0.010

The sign and significance of λ_i indicate the temporal variability of X-efficiency. If λ_i is not found significant, we reject temporal variability. A significant λ_i suggests temporal variability of X-efficiency and the sign denotes the direction of this change. If the sign of λ_i is positive, it suggests diminution of X-efficiency, and a negative value its improvement. Similarly, a positive, significant value of α_i indicates the presence of X-inefficiency at the beginning of the study period, and vice versa.

However, the OLS estimates on the transformed data in the second stage generate R^2 at 0.7896. It is indeed in a lower side, but surely confirms that most of the variations in the cost have already been explained in the first step regression. The estimated parameters of the regression of the residuals on time, and also their relevant statistics, are reported in the Table 5.2. – Table 5.4. The R^2-values of bank-wise estimations at this final stage are found in the range of 0.001-0.49. For more than 50 per cent banks, the R^2 values stand at less than 0.1000; it is in between 0.100-0.300 for about 35 per cent of the banks, and in between 0.300 - 0.500 for about 12 per cent.

To assess the X-efficiency among the banks, let us first considerα_i, which ranges between 3.0272.3 to -2.8835. Out of the 57 banks that have been taken into consideration, 30 banks have a positive α_i and the remaining 27 banks have its negative values. These imply that majority of the banks were X-inefficient at the beginning of the study. But many of them are statistically insignificant so that our findings regarding their efficiency levels should not be considered seriously. We note in this connection that out of the 30 banks with a positive α_i, 13 banks have a positive significant α_i while the rest 17 banks assume insignificant estimates. Based on these statistical findings, we infer that only 13 were X-inefficient at the beginning of the study period. Those are SBI, BOB, DENB, INDB, IOB, UCOB, UNITEDB, JKB, SOUINB, BNOVA, CITI, JPMC and STANCB. This list thus includes seven public sector banks (SBI, BOB, DENB, INDB, IOB, UCOB and UNITEDB), and two private domestic banks (JKB and SOUINB) which had been in business for a considerable period of time prior to 1994. The private foreign banks (BNOVA, CITI, JPMC and STANCB) ran inefficiently at the beginning. On the other hand, 27 banks are found X-efficient (i.e. having negative intercept), but only six of them (CITYUNIB, DLAXB, KVYSB, NAINB, RATNB and DBS) are seen statistically significant. The conclusions that follow from this GLS analysis are thus: (a) out of 57 banks under study, 30 banks were X-inefficient and 27 X-efficient at the beginning of the study period; and (b) all these statistical findings are not statistically significant – only 13 values in the former and six in the latter are statistically significant.

The value of λ_i representing the time-variant component of X-efficiency ranges between 0.1551 to - 0.3052. Tables 5.2 - 5.4 show that 19 banks have a positive λ_i and 38 banks have a negativeλ_i so that we infer the majority of the banks to have increased their X-efficiency over the reform period. But the Student's t-statistic indicating the significance level of the relevant estimators disappoints us in that only about 28 per cent of these estimations (31.5 per cent of X-inefficient values and 26 per cent of X-efficient values) are statistically significant. We are thus able to conclude that only ten banks (SBI, BOB, IOB, UCOB, UNITEDB, ICICI, CITI, DEUTB, JPMC and STANCB) improved their level of X-efficiency over time, and six banks (HDFC, NAINB, TAMNB, BNP, BARCB and DBS) became X-inefficient over time.

The terms α_i and λ_i are, however, transformed into the normalised X-efficiency measure following Equations 5.6 and 5.7, and the normalised values are reported in Table 5.5.

$$TIV_{XE} = \exp\left(ln\alpha_i^{min} - ln\alpha_i\right) \qquad (5.6)$$

$$TV_{XE} = exp\left(\lambda_{it}^{min} - \lambda_{it}\right) \qquad (5.7)$$

Table 5.5 Normalised time-variant and time-invariant X-efficiency under GLS method (in percentage)

PUBLIC SECTOR BANKS			PRIVATE DOMESTIC BANKS			PRIVATE FOREIGN BANKS		
BANK	α_{0i}	λ_i	BANK	α_{0i}	λ_i	BANK	α_{0i}	λ_i
SBI	3.03	75.92	AXISB	6.83	73.48	ADCOMB	1.43	95.22
SBJ	5.49	73.09	CATSYRB	4.53	73.42	BOA	5.12	74.25
SBH	7.42	72.51	CITYUNIB	9.09	71.97	BBK	6.64	74.87
SBM	7.07	74.02	DLAXB	8.57	71.36	BNOVA	2.28	76.44
SBP	7.16	74.61	FEDB	6.04	74.33	BOT	100.00	63.63
SBT	6.23	74.55	HDFC	6.64	71.46	BNP	6.26	71.23
ALLB	5.45	73.89	ICICI	0.27	100.00	BARCB	22.5	63.10
ANDB	6.44	73.99	INDUSB	5.51	73.59	CITI	1.06	79.89
BOB	4.05	76.63	INGVYSB	4.77	74.23	DBS	22.7	66.99
BOI	4.55	75.26	JKB	2.01	74.58	DEUTB	0.64	84.54
BOM	6.07	73.90	KARB	5.91	73.96	HSBC	0.32	93.17
CANB	6.93	74.23	KVYSB	7.82	72.72	JPMC	0.54	87.66
CENB	5.78	74.65	LVILB	5.41	72.20	OMINB	23.5	63.39
CORPB	5.98	75.29	NAINB	11.73	70.52	SGB	14.0	73.71
DENB	3.60	74.64	RATNB	8.12	74.58	STANCB	0.61	84.34
INDB	3.78	75.72	SOUINB	4.30	73.13	**Average**	**13.8**	**76.8**
IOB	3.66	75.75	TAMNB	7.27	71.54			
OBC	7.63	73.40	**Average**	**6.2**	**74.5**			
PNSB	5.01	74.03						
PNB	4.96	75.19						
SYNB	5.15	5.26						
UCOB	3.52	77.76						
UNIONB	5.22	75.78						
UNITEDB	1.04	81.29						
VIJB	5.37	73.90						
Average	**5.22**	**72.2**						

It appears from the above table that the Bank of Tokyo (BOT) enjoys the highest level of time-invariant X-efficiency, and the ICICI Bank that of time-variant X-efficiency. But there are great variations in these indices (especially in the former case) across the banks. Compared to the BOT, the time-invariant X-efficiency is seen as low as 3-8 per cent for the public sector banks, and 0.27-12 per cent for private domestic banks. Even the performances of private foreign banks are not at all satisfactory. Only BARCB , DBS and ONINB get scores around 22.5 to 23.5 per cent. The deviations in respect of time-variant X-efficiency are comparatively less. Comparative to the ICICI, the public sector banks score the index at 73-81 per cent, the private foreign banks at 63-95 per cent and the private domestic banks (excepting the ICICI Bank) at 71-75 per cent.

But these inferences are subject to the qualification that they involve a number of estimated parameters, which are statistically doubtful in view of their low t-values. For quite a large number of banks, then, our inferences are inconclusive. In addition to the theoretical issues that we have discussed in Chapter IV, this empirical aspect motivates us to use the MLE method in our study.

Section III: Maximum Likelihood Estimation

The Battese-Collie (1992) method that is based on the MLE technique is adopted in this section to estimate the parameters. The Model 4.35 of Chapter IV is rewritten to incorporate the trend element and is represented as in equation 5.8.

$$
\begin{aligned}
LnC_{it} = \alpha_0 &+ \alpha_1 lnQ_{1t} + \alpha_2 lnQ_{2t} + \alpha_3 lnr_{1t} + \alpha_4 lnr_{2t} + \alpha_5 lnr_{3t} \\
&+ {}^{1}/_{2}\, \alpha_{11} lnQ_{1t} lnQ_{1t} + {}^{1}/_{2}\, \alpha_{22} lnQ_{2t} lnQ_{2t} + {}^{1}/_{2}\, \alpha_{33} lnr_{1t} lnr_{1t} \\
&+ {}^{1}/_{2}\, \alpha_{44} lnr_{2t} lnr_{2t} + {}^{1}/_{2}\, \alpha_{55} lnr_{3t} lnr_{3t} + \alpha_{12} lnQ_{1t} lnQ_{2t} \\
&+ \alpha_{13} lnQ_{1t} lnr_{1t} + \alpha_{14} lnQ_{1t} lnr_{2t} + \alpha_{15} lnQ_{1t} lnr_{3t} \\
&+ \alpha_{23} lnQ_{2t} lnr_{1t} + \alpha_{24} lnQ_{2t} lnr_{2t} + \alpha_{25} lnQ_{2t} lnr_{3t} \\
&+ \alpha_{34} lnr_{1t} lnr_{2t} + \alpha_{35} lnr_{1t} lnr_{3t} + \alpha_{45} lnr_{2t} lnr_{3t} + \alpha_t t + \alpha_{tt} t^2 \\
&+ \alpha_{1t} lnQ_1 t + \alpha_{2t} lnQ_2 t + \alpha_{3t} lnr_1 t + \alpha_{4t} lnr_2 t + \alpha_{5t} lnr_3 t \\
&+ \varepsilon \qquad (5.8)
\end{aligned}
$$

This model is estimated with and without intercept term for the reason discussed in the previous chapter. Table 5.6 presents the estimated parameters and their statistics for the model for 1994-2012 without intercept and Table 5.7 presents the estimated parameters for the same with intercept. We also run MLE to estimate the model with intercept for 2000-12 with a view to finding out the effect of the second phase of reforms. The results of this estimation are presented in Table 5.8. If we compare the alternative estimations for 1994-2012 (i.e. with and without intercept) on the basis of the significance levels of the estimates for individual parameters, it appears that the results for the model for the alternative ‘with intercept’ are more significant. It is for the very same reason that we concentrate on the equation with intercept for the period 1994-2012 (Table 5.7) for our analysis.

The significance test for the estimates is based on the p value of $z$distribution rather than the traditional t distribution. It is more suitable in our case with a sample size as large as 1083 since, with the increase in the sample size, a t-distribution tends to a z-distribution.

Table 5.6. Maximum Likelihood Estimates for cost function with trend and without intercept, 1994-2012

Coefficients	**Estimates**	**SE**	**Z values**	**Pr(>|z|)**
$Q_1(\alpha_1)$	1.0400	0.8627	1.2021	0.2293
$Q_2(\alpha_2)$	1.6590	1.1980	1.3849	0.1661
$r_1(\alpha_3)$	-2.2900	1.0496	-2.1819	0.2910
$r_2(\alpha_4)$	-1.8837	2.0780	-0.9060	0.3646
$r_3(\alpha_5)$	1.5906	0.9425	1.6877	0.0915
$Trend(\alpha_T)$	-2.4350	2.2690	-1.0733	0.2831
$Q_1^2(\alpha_{11})$	0.0117	0.0071	1.6441	0.1000
$Q_2^2(\alpha_{22})$	-0.0810	0.1560	-5.1580	0.0000
$r_1^2(\alpha_{33})$	-0.0147	0.0175	-0.8360	0.4032
$r_2^2(\alpha_{44})$	-0.9660	0.0330	-2.9270	0.0030
$r_3^2(\alpha_{55})$	-0.0121	0.0060	-1.8930	0.0580
$Trend^2(\alpha_{TT})$	1.3120	1.0340	1.2680	0.2050
$Q_1Q_2(\alpha_{12})$	0.0631	0.0100	6.1740	0.0000
$Q_1r_1(\alpha_{13})$	-0.0580	0.0070	-7.4660	0.0000
$Q_1r_2(\alpha_{14})$	0.1035	0.0110	9.2890	0.0000
$Q_1r_3(\alpha_{15})$	0.0050	0.0050	1.0100	0.3130
$Q_1Trend(\alpha_{1T})$	-0.2380	0.1940	-1.2260	0.2200
$Q_2r_1(\alpha_{23})$	0.0110	0.0120	0.9500	0.3420
$Q_2r_2(\alpha_{24})$	-0.0700	0.0170	-3.9530	0.0000
$Q_2r_3(\alpha_{25})$	-0.0090	0.0060	-1.4660	0.1430
$Q_2Trend(\alpha_{2T})$	-0.2640	0.2750	-0.9600	0.3380
$r_1r_2(\alpha_{34})$	-0.0200	0.0179	-1.1260	0.2600
$r_1r_3(\alpha_{35})$	0.0268	0.0100	2.6250	0.0090
$r_1Trend(\alpha_{3T})$	0.6320	0.2390	2.6490	0.0080
$r_2r_3(\alpha_{45})$	0.0480	0.0140	-3.4320	0.0010
$r_2Trend(\alpha_{4T})$	0.4050	0.4680	0.8660	0.3860
$r_3Trend(\alpha_{5T})$	-0.3730	0.2140	-1.7450	0.0810
σ^2	0.1480	0.0250	5.8860	0.0000
γ	0.8840	0.0220	39.9120	0.0000
$time$	-0.0350	0.0090	-3.7210	0.0000

Table 5.7 Maximum Likelihood Estimates for cost function with intercept and trend, 1994-2012

Coefficients	Estimates	SE	Z values	Pr(>|z|)
$Intercept(\alpha_0)$	-299.02	87.365	-3.4227	0.000
$Q_1(\alpha_1)$	1.226	0.862	1.4209	0.155
$Q_2(\alpha_2)$	0.161	1.234	0.1302	0.896
$r_1(\alpha_3)$	-6.679	1.647	-4.0542	0.000
$r_2(\alpha_4)$	-2.278	2.177	-1.0462	0.2954
$r_3(\alpha_5)$	0.660	1.00	0.660	0.5092
$Trend(\alpha_T)$	131.02	39.070	3.3536	0.000
$Q_1^2(\alpha_{11})$	0.014	0.007	2.0316	0.042
$Q_2^2(\alpha_{22})$	-0.085	0.015	-5.5228	0.000
$r_1^2(\alpha_{33})$	-0.045	0.020	-2.2735	0.022
$r_2^2(\alpha_{44})$	-0.101	0.033	-3.0625	0.126
$r_3^2(\alpha_{55})$	-0.010	0.006	-1.5293	0.001
$Trend^2(\alpha_{TT})$	-28.502	8.779	-3.2468	0.000
$Q_1Q_2(\alpha_{12})$	0.062	0.010	6.0460	0.000
$Q_1r_1(\alpha_{13})$	-0.059	0.008	-7.4645	0.000
$Q_1r_2(\alpha_{14})$	0.101	0.011	9.0974	0.000
$Q_1r_3(\alpha_{15})$	0.007	0.005	1.2842	0.199
$Q_1Trend(\alpha_{1T})$	-0.282	0.194	-1.4543	0.145
$Q_2r_1(\alpha_{23})$	-0.002	0.013	-0.1191	0.905
$Q_2r_2(\alpha_{24})$	-0.063	0.018	-3.5156	0.000
$Q_2r_3(\alpha_{25})$	-0.012	0.007	-1.8075	0.070
$Q_2Trend(\alpha_{2T})$	0.080	0.282	0.2848	0.775
$r_1r_2(\alpha_{34})$	-0.017	0.018	-0.9235	0.355
$r_1r_3(\alpha_{35})$	0.019	0.010	1.7546	0.079
$r_1Trend(\alpha_{3T})$	1.626	0.373	4.3564	0.000
$r_2r_3(\alpha_{45})$	-0.044	0.014	-3.0560	0.002
$r_2Trend(\alpha_{4T})$	0.475	0.491	0.9690	0.332
$r_3Trend(\alpha_{5T})$	-0.163	0.227	-0.7188	0.472
σ^2	0.162	0.038	4.2146	0.000
γ	0.895	0.026	34.9618	0.000
$time$	-0.040	0.009	-4.4988	0.000

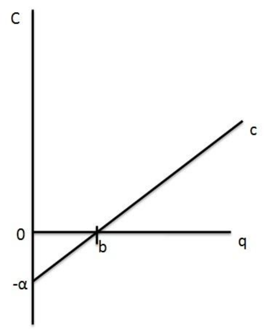
Table 5.8 Maximum Likelihood Estimates for cost function with intercept and trend, 2000-2012

Coefficients	**Estimates**	**SE**	**Z values**	**Pr(>|z|)**
$Intercept(\alpha_0)$	285.970	133.5100	2.1420	0.0322
$Q_1(\alpha_1)$	2.3941	1.2780	1.8730	0.0610
$Q_2(\alpha_2)$	2.6383	1.5945	1.6550	1.6550
$r_1(\alpha_3)$	2.5371	1.6811	1.5100	0.1310
$r_2(\alpha_4)$	-9.5102	3.5766	-2.6590	0.0080
$r_3(\alpha_5)$	-0.1459	1.2711	-0.1140	0.9070
$Trend(\alpha_T)$	-138.97	58.986	-2.3560	0.0190
$Q_1^2(\alpha_{11})$	0.0477	0.0090	5.2220	0.0000
$Q_2^2(\alpha_{22})$	-0.0397	0.0180	-2.2410	0.0250
$r_1^2(\alpha_{33})$	0.0031	0.0210	0.1500	0.8810
$r_2^2(\alpha_{44})$	0.0367	0.0690	0.5320	0.5940
$r_3^2(\alpha_{55})$	-0.0656	0.0110	-6.0310	0.0000
$Trend^2(\alpha_{TT})$	33.752	13.069	2.5830	0.0100
$Q_1Q_2(\alpha_{12})$	0.0178	0.0130	1.4200	0.1560
$Q_1r_1(\alpha_{13})$	-0.0223	0.0110	-2.0890	0.0370
$Q_1r_2(\alpha_{14})$	-0.0238	0.0210	-1.1320	0.2580
$Q_1r_3(\alpha_{15})$	-0.0282	0.0080	-3.5060	0.0010
$Q_1Trend(\alpha_{1T})$	-0.6057	0.2850	-2.1220	0.0340
$Q_2r_1(\alpha_{23})$	0.0117	0.0150	0.7910	0.4290
$Q_2r_2(\alpha_{24})$	0.0128	0.0220	0.5750	0.5650
$Q_2r_3(\alpha_{25})$	0.0422	0.0100	4.3510	0.0000
$Q_2Trend(\alpha_{2T})$	-0.3927	0.0350	-1.1110	0.2670
$r_1r_2(\alpha_{34})$	-0.0.655	0.0350	-1.8650	0.0620
$r_1r_3(\alpha_{35})$	0.0090	0.0130	0.6730	0.5010
$r_1Trend(\alpha_{3T})$	-0.5447	0.3840	-1.4180	0.1560
$r_2r_3(\alpha_{45})$	-0.0280	0.0210	-1.3850	0.1660
$r_2Trend(\alpha_{4T})$	2.2710	0.4781	2.9080	0.0350
$r_3Trend(\alpha_{5T})$	-0.0490	0.2860	-0.1700	0.8650
σ^2	0.0770	0.0200	3.8820	0.0000
γ	0.8720	0.0360	24.3250	0.0000
$time$	-0.0560	0.0110	-5.1630	0.0000

In Table 5.7, there are 12 positive coefficients (associated with Q_1, Q_2, r_3, $trend$, SqQ_1, Q_1Q_2, Q_1r_2, Q_1r_3, Q_2Trend, r_1r_3, r_3Trend and r_2Trend), and 17 negative coefficients (associated with α_0, r_1, r_2, SqQ_2, Sqr_1, Sqr_2, Sqr_3, $SqTrend, Q_1r_1$, Q_1Trend, Q_2r_1, Q_2r_2, Q_2r_3, r_1r_2, r_2r_3, r_3Trend and $time$). But, theoretically, only the negative values of intercept coefficient and timevariable are relevant. The former's negative valueimplies that the vector of explanatory variables should have a floor, corresponding to which C = 0, below which all the vectors are irrelevant.[304] On the other hand, the negative coefficient of time variable indicates that the cost frontier shifts inward with time, signifying the gain in efficiency in production.

The outputs loans/advances and investment, i.e. Q_1 andQ_2, are both positive, which implies that an increase in those output variables would raise the operating cost. The effect of squared output variable Q_1 on cost is also positive, and so also the combined effect of Q_1 and Q_2. Amongst the input prices, only r_3, the price of capital bears a positive estimated coefficient. Note also that the combined effects of Q_1 and r_2, as also Q_1 and r_3, are positive. Positive coefficient is found associated with the

[304] For a two-variable cost function c = c(q), a negative intercept is represented by a curve like c in the following figure.



Since negative costs are irrelevant, the part bα is irrelevant, and only bc is relevant. Thus, the minimum output level in this cost function is b.

combined variable, the price of labour (r_1) and the price of capital (r_3). These findings are also in line with the theoretical underpinning that higher output in association with higher price of fund and higher price of capital would lead to higher operating costs.

Next we move to the negative coefficients. The price of labour (defined as labour expenses divided by the number of workers) and the price of fund (defined as interest expenditure divided by the total of borrowings and deposits) are seen bearing negative causations with cost. It seems *prima facie* to go against the common reasoning, but, on closer examination, the negative signs may be logical.

Let us first consider r_1. The price of labour (r_1) may fall under three alternative situations: (i) when the labour expenses are constant and the number of workers increases, (ii) when there is an increase in labour expenses but this increase is less than the increase in the number of workers, and (iii) when labour expenses fall along with a constant or rising workforce. Then, in the wake of lower labour price, cost hikes may not be illogical on two grounds. First, the alternatives, noted above, might represent underpayment to employees which leads to discomfort and discontent among the workforce. As a result, workers' productivity might go down, and hence, a hike in cost. The case of underpayment for banking jobs is of special concern in the post-liberalisation period when the mushroom growth of banking jobs in the private sector is associated with a lower band of pay. Secondly, overstaffing at low wage rates is also not uncommon, so that some of the banks might have been passing through the phase of decreasing marginal productivities.

Moving on to r_2, we notice that the price of fund which should bear a positive causation is opposite in the present case. Our argument here again is that price of fund can fall under three situations: (i) when interest expenses rise along with a rise in deposits and borrowings but the former is less than the latter; (ii) when the former is constant but the latter rises; and (iii) when the former falls along with the rise in the latter. The last scenario is most unlikely. The second scenario seems more plausible as the interest rates remain constant over a period of time in India, and the fluctuations, if any, take place across the board so that deposits and borrowing for individual banks remain largely unaltered. In such situations, the fall in the fund price generates surplus fund in banks. Now, if the banks are unable to invest the fund properly, there would be hikes in cost. The case of surplus fund is so prominent in India in the post-reform period that the phrase 'lazy banking' is often associated with their style of functioning.[305]

The rationales of negative impacts of r_1 and r_2, as argued above, possibly explains also the negative influences of the combined variables Q_1 and r_1, Q_2 and r_2, and r_2 and r_3.

However, efficiency questions are often dealt with by the variables time and trend. There is a growing wisdom in the literature that the variable time represents technological progress/regress, depending on whether it is negative or positive.[306]If their interpretation of time variable is correct, the negative coefficient of the variable time, as found in this exercise, certainly suggests that there is technological progress in Indian banking in the post-reform period under study. Indeed, this is what we find in reality. Indian commercial banks have undertaken mechanisation in various banking processes, and have been providing core banking service, ATM services, internet banking, mobile banking and so on. But the overall effect of such technological progress seems to be very insignificant in our estimation. Our empirical

[305] Mohan, Economic Growth, Financial Deepening and Financial Inclusion, p. 1
[306] See, Hunter and Timme (1986), Kauko (2009), Turk Ariss (2010), Coelli et al (2005) and Ray (1982)

work-sheet indicates that such technological progress contributed only 0.0402 (Table 5.7, last row). But we should emphasise that this coefficient is extremely significant.

But, *pari passu* with the time variable, we should also study the trend variable which has multifaceted effects in the model. In the first place, it has a positive coefficient as large as 131- carrying the probability of occurrence at more than 0.001 in its z distribution. However, the quadratic effect of the variable trend, i.e. the coefficient of its squared term, is negative signifying the augmentation of efficiency. With a highly significant value of z (as much as 0.001 level), its estimated coefficient is of the value of -28.50. If we take the linear and quadratic effects together, the net effects comes to 1025 (the average of linear effects for 19 years is 1310, and the equivalent quadratic effect is 285). Therefore, our inference is that there is a fall in efficiency from the variable trend.

Our model has also taken into account the trend effects of all explanatory variables - $lnQ_1, lnQ_2, lnr_1, lnr_2$ and lnr_3, i.e. taking the combine effects of these variables with the variable trend. It appears that, of all these variables, only the variable Q_1 has favourable impact on cost (i.e. a negative coefficient) but this estimated coefficient is grossly insignificant; its significance level is a slow as 0.145. The trend effect of other combined explanatory variables Q_1, r_1, r_2 and r_3 are positive and, those too, as significant as 0.775, 0.000, 0.332 and 0.472. We thus expect that the trend effects of these explanatory variables, save Q_2, were adverse on the efficiency level.

We are thus compelled to conclude that, from the viewpoints of these efficiency measures, Indian commercial banks fail to achieve the expectation of the policy makers. Instead of attaining technical and cost efficiencies, their performance deteriorated, on the average.

If we compare the results obtained for 1994-2012 and 2000-2012 (Tables 5.7 and 5.8), it appears that those are quite similar in certain cases, but different in other instances. The estimated coefficients of $Q_1$and Q_2 are of positive signs in both cases in line with the theoretical cost function. For 2000-2012, the coefficient of r_1 is also positive. Only r_2 andr_3 are with negative coefficients in this case, and the latter is grossly insignificant.

Also the coefficients of the variable 'time' are negative in both cases, which support the hypothesis of technological progress to have taken place during the reform period. However, a comparison between the 1994-2012 and 2000-2012 confirms that the technological progress was accelerated during the second-generation reform. For, as against the coefficient of the variable 'time' at -0.040 for the former period, it is -0.056 for the latter.

But the variable 'trend' gives us a different scenario. For data relating to the second-generation period, the trend value is associated with an estimated coefficient of -138.97, significant at the 0.019 point level. Since the value is negative, it signifies that the second generation reforms bred a higher level of efficiency in the banking system. Indeed, the quadratic effect of the trend variable is positive. Taking the net effect of the trend variable the value is -647.834 (-138.97 x 13 + 33.753 x 13). This negative trend effect signifies a gain in efficiency after the second generation reform. Also, the effects of the variables Q_1, Q_2, r_1 and r_3 combined with 'trend' are also suggestive of growing efficiency as their estimated coefficients are negative.

However, we are so far concerned with different fields of inefficiency other than what we intend to study in this dissertation, namely the X-inefficiency. For the measure of this inefficiency, we should look into the error term ε_i. This term comprises of stochastic noise (v) and inefficiency components (u). The term σ^2 in Tables 5.6-5.8 is the summation of σ_u^2 and σ_v^2; and γ represents the ratio of σ_u^2 and σ^2. Noting that the γ value lies between 0 and 1, we stress that, theoretically, two alternative scenarios might crop up – one, it may be close to zero, signifying that the inefficiency component is virtually absent; two, it stands at the neighbourhood of unity, and thus accounts almost entirely for inefficiency. In our exercise, the value of γ comes to about 0.90. It is 0.870 for 2000-12 and 0.895 for 1994-2012. We are, therefore, inclined to conclude that both the noise and inefficiency components are present in the estimated error term.

Section IV: Efficiency Estimates

As discussed in chapter 4, the cost efficiencies are estimated from the error component. The general specification of the cost frontier is

$$lnC_{it} = lnC(Q_{it},;r_{it}\beta) + u_{it} + v_{it} \qquad (5.9)$$

We estimate the efficiency for two periods, 1994-2012 and 2000-2012. These efficiency estimates are calculated using Farrell's distance function. Let us emphasise that the time variable in equation 5.8 takes into account the technological change so that the u_i term stands for the measure of X-efficiency, not technical efficiency. The averageefficiency estimates of the three categories of banks over the years are shown in table 5.9. Further average is worked out for each category, and presented in the last row. The public sector banks are seen to have the highest efficiency at 80.24, followed very closely by private foreign banks at 79.93, whereas the private domestic banks lag at around 77.3 per cent X-efficiency. Amongst the public sector banks we observe that SBI scores the highest at 98 percent while the least is for the UNITEDB at 68 per cent. In the category of private foreign banks, we have the BBK, the DBS and SGB with the highest score of 98 percent while the least is scored by the CITI and DEUTB at 55 percent. In the private domestic bank category, the ICICI bank scores the highest with 91 percent while the least score is obtained by the CATSYRB at 68 percent.

The Tables 5.10 - 5.12 show the individual X-efficiency scores of the banks from 1994 to 2012. From the tables it transpires that the efficiency for all the banks falls over time. This can be explained by the fact that trend t in the MLE estimation is positive, so that the efficiency frontier goes up year to year. It represents growing inefficiency since we deal with the cost frontier. This study divides the banks into three groups so that there is neutrality in estimation with respect to ownership. The State Bank of India (SBI) is by far the largest banks among them.

Table 5.9: Average X- efficiency scores of banks (in %)

1994-2012

Public Sector Banks	Average X-efficiency	Private Domestic Banks	Average X-efficiency	Private Foreign Banks	Average X-efficiency
SBI	98	AXISB	81	ADCOMB	86
SBJ	74	CATSYRB	68	BOA	87
SBH	82	CITYUNIB	75	BBK	98
SBM	73	DLAXB	71	BNOVA	95
SBP	80	FEDB	82	BOT	81
SBT	82	HDFC	78	BNP	81
ALLB	80	ICICI	91	BARCB	81
ANDB	75	INDUSB	79	CITI	55
BOB	83	INGVYSB	72	DBS	98
BOI	86	JKB	81	DEUTB	55
BOM	74	KARB	81	HSBC	63
CANB	88	KVYSB	77	JPMC	87
CENB	79	LVILB	74	OMINB	71
CORPB	83	NAINB	70	SGB	98
DENB	78	RATNB	79	STANCB	63
INDB	78	SOUINB	77		
IOB	82	TAMNB	78		
OBC	87				
PNSB	72				
PNB	86				
SYNB	76				
UCOB	81				
UNIONB	85				
UNITEDB	68				
VIJB	76				
Average	**80.24**		**77.3**		**79.93**

Of the total banks that have been taken into consideration in this study, six banks are seen belonging to the efficiency slab of 90-99 per cent. Out of those six banks, four banks (BBK, BNOVA, DBS and SGB) are private foreign banks while one bank each is in public sector and private domestic sector, SBI and ICICI respectively.

In the next X-efficiency slab, 80 - 90 per cent, there are altogether 23 banks, with the majority (SBH, SBP, SBT, ALLB, BOB, BOI, CANB, CORPB, IOB, OBC, PNB, UCOB and UNIONB) belonging to the public sector. Only six of them (viz. ADCOMB, BOA, BOT, BNP, BARCB and JPMC) are private foreign banks, and four (AXISB, JKB, FEDB and KARB) are private domestic banks. In the slab of 70 - 80 per cent, there are 22 banks in total. Out of them, 11 banks (DLAXB, INDUSB, CITYUNIB, HDFC, INGVYSB, KVYSB, LVILB, NAINB, RATNB, SOUINB and TAMNB) belong to the private domestic sector, and 10 to the public sector (SBH, SBM, ANDB, VIJB, BOM, PNSB, SYNB, CENB, DENB and INDB). Only OMINB is a private foreign bank. In the slab of 60 - 70 per cent, two banks (HSBC and STANCB) are in the private foreign sector, one each in the public and private domestic sectors, UNITEDB and CATSYRB respectively. To the lowest rung of 50-60 per cent belong two banks, CITI and DEUTB, which are of foreign origin.

The period 1994-2012, however, incorporates two important sub-periods, a part of 1991-1997 (i.e. the first-generation reform period) and 1998 onwards (i.e. the second-generation reform period). To make a comparative study between these sub-periods, we undertake empirical exercises for 2000-12 similar to those for 1994-2012, and present them in Table 4.10.

Table 5.10: Average X- efficiency scores of Banks (in %)

2000-2012

Public Sector Banks	Average X-efficiency	Private Domestic Banks	Average X-efficiency	Private Foreign Banks	Average X-efficiency
SBI	98	AXISB	88	ADCOMB	84
SBJ	82	CATSYRB	79	BOA	96
SBH	91	CITYUNIB	91	BBK	99
SBM	82	DLAXB	82	BNOVA	98
SBP	89	FEDB	91	BOT	93
SBT	90	HDFC	84	BNPB	89
ALLB	87	ICICI	94	BARCB	79
ANDB	85	INDUSB	85	CITI	66
BOB	88	INGVYSB	78	DBS	91
BOI	89	JKB	90	DEUTB	60
BOM	84	KARB	93	HSBC	71
CANB	91	KVYSB	89	JPMC	88
CENB	82	LVILB	88	OMINB	66
CORPB	92	NAINB	83	SGB	99
DENB	85	RATNB	94	STANCB	72
INDB	83	SOUINB	87		
IOB	88	TAMNB	90		
OBC	92				
PNSB	79				
PNB	88				
SYNB	84				
UCOB	88				
UNIONB	89				
UNITEDB	76				
VIJB	87				
Average	**87**		**88**		**83**

A comparison between Tables 5.9 and 5.10 underscores greater efficacy of the second-generation reforms. Group-wise efficiency comparison, however, shows that every group gets higher efficiency scores for the period of the second-generation reform. The efficiency of PSBs is higher by 8.42 percent, from 80.24 percent for 1994-2012 to 87 percent for 2000-2012; that of PDBs by 13.8 per cent i.e. from 77.3 per cent to 88 per cent for respective periods; and that of PFBs by 3.8 percent, from 79.93 percent to 83 per cent respectively. We note that this comparison is based on the period of second-generation reforms and the entire reform period. Had the comparison be made between two distinct time period of the first and second generation reforms, the gain in X-efficiency would have been much higher.

Bank-wise comparison also brings out higher efficacy of the second-generation reform. Tables 5.9 and 5.10 suggest that all the banks in public sector and private domestic sector, save SBI, have improved their X-efficiency during 2000 - 2012. For banks in the former group, the gain in efficiency ranges in 2-16 per cent, and that for the latter in 6-20 per cent in most of the cases. One bank in the latter category, the CITYUNIB, scores more than 20 per cent gain in efficiency. For the private foreign banks, the scenario is not such encouraging. Out of 15 PFBs, only 6 banks gained efficiency in this period, the gain confining largely to the range of 8-16 per cent. Moreover, as many as 4 such banks, representing more than 25 per cent of the group, suffered from the loss of X-efficiency during the spell of the second-generation reform. By and large, however, this empirical exercise corroborates the proposition that the financial sector reforms since 1998 were more powerful than the earlier measures.

It seems that the results that we have obtained so far (that is, results for 1994-2012 and 2000-2012 based on the MLE methodology, and those for 1994-2012 based on the GLS methodology) are quite different. Notwithstanding the differences in numerical values, as also in ranking, an in-depth study of the results reveals that the banks, which score high values of X-efficiency under the MLE methodology for 1994-2012, also belong to the top echelon of estimated marks in alternative calculations. Table 5.11 justifies this proposition.

Table 5.11: Comparative results of X-efficiency under MLE and GLS methods

Banks	Average X-efficiency: MLE		Total X-efficiency*
	1994-2012	2000-2012	GLS
PSB			
SBI	98	98	79
CANB	88	91	82
OBC	87	92	81
BOI	86	89	80
PNB	86	88	80
UNIONB	85	89	81
PDB			
AXISB	81	88	80
FEDB	82	91	80
ICICI	91	94	100
JKB	81	90	77
KARB	81	93	80
PFB			
ADCOMB	86	84	97
BOA	87	96	79
BBK	98	99	79
BNOVA	95	98	82
JPMC	87	88	88
SGB	98	99	88

NB. It is the sum of variant and invariant X-efficiency.

To begin with the public sector banks, Table 5.11 underlines that, for the period 1994-2012 under MLE, there are six banks (SBI, CANB, OBC, BOI, PNB and UNIONB) which score X-efficiency at 85 per cent and above. Indeed, these are the banks which obtain good scores in other estimations as well, 88-98 per cent under the MLE methodology for 2000-2012, and 79-82 per cent under the GLS methodology. Similarly, for the private domestic banks, the best banks securing efficiency scores at 81 per cent and above (AXISB, FEDB, ICICI, JKB, and KARB) under the MLE for 1994-2012 are seen to have obtained 88-93 per cent scores under the MLE for 2000-2012, and 77-100 per cent under the GLS methodology. For the private foreign banks, our findings are that the top six banks under the MLE for 1994-2012 are ADCOMB, BOA, BBK, BNOVA, JPMC and SGB securing 86-98 per cent X-efficiency. Their scores in other estimations are 84-99 per cent and 79-97 per cent respectively. Notwithstanding these similar results between the MLE methodology and the GLS methodology, we recognise the comparative strength of the former vis-a-vis the latter, and finally accept the results of the former.

From Table 5.9 and 5.10 we may infer that, as there is no significant difference in the performance of the banks, be it a public sector bank or a private bank, the ownership pattern does not affect the overall performance of the banks. A further inference is that the private domestic banks could have improved their performance to a good extent in the second generation reforms – from being the lowest scorer for 1994-2012 to the top scorer for 2000-2012. Possibly, this was due to their policy of performance-linked remuneration scheme, and also the competitive environment in the market.

Section V: Shortcomings of the study

The major shortcomings of the empirical exercise are as follows:

(i) In view of data constraints, this study employs proxy variables relating to costs and various input prices. The results we have obtained are subject to the qualification that the proxy variables can not exactly reflect the real variables.

(ii) The time-span of this study appears not to be long enough to capture the impacts of the financial sector reforms in India. The statistical problems associated with a limited time-frame have been sorted out here by way of employing the panel data. But, in India, reforms have not been undertaken by a one-time policy formulation. Rather, those have been undertaken step-by-step. In fact, some of the reforms took place at the close of our study period. In such circumstances, one should not expect that this study has captured the entire effects of India's financial sector reforms.

(iii) The time constraint has also come in the way of the comparison between the impacts of the first- and second-generation reforms. For the shorter time-span, we have not been able to consider explicitly the effects of the first-generation. What this study has done is to consider the effects of entire reforms (1994-2012), and those of the second generation (1998-2012). The difference between them is taken to represent the effects of the first-generation reforms.

(iv) The study employs a balanced panel data-set for empirical analysis. We are, therefore, constrained to exclude the banks with missing values for one or more variables under study, and also those which did not exist at the beginning of our study period.

It should be noted that this study has not sought to identify the reasons for the existence of X-inefficiency. Leibenstein's X-inefficiency should be searched out, as we have discussed, among the micro-micro units of a firm. The study of aggregates like the present one will not be able to identify the causes for such inefficiency. We suggest that there is a bright scope of study at the firm level for the examination of underlying causes for X-inefficiency among India's commercial banks.

Section V: Conclusion

This chapter thus estimates the X-efficiency among Indian commercial banks by two alternative methods, the GLS and the MLE. In the former methodology, there are two types of X-efficiency, the time-invariant X-efficiency (measured by (α_i) and the time-variant X-efficiency (measured by λ_i). Out of the 57 banks that have been taken into consideration, 30 banks have a positive α_{0i} and the remaining 27 banks have its negative values, indicating that majority of the banks were time-invariant X-inefficient at the beginning of the study. But, given their statistical significance, we conclude that only seven banks were X-inefficient at the beginning of the study period. Those are BOA, UNIONB, VIJB, LVILB, ALLB, SBJ and INDUSB. This list thus includes four public sector banks, two private domestic banks and one private foreign bank. Again, 27 banks are found time-invariant X-efficient (i.e. having negative intercept), but only three of them (SBJ, KARB and BBK) are seen statistically significant. The group-wise analysis of normalised time-invariant X-inefficiency, however, indicates that it is, on the average, 5.22 per cent for PSBs, 6.2 per cent for PDBs and 13.8 per cent for PFBs. As to the time-variant X-efficiency, our findings are that the public sector banks score 72.2 per cent, the private domestic banks 74.5 per cent and the private foreign banks 76.8 per cent.

For the MLE, we have considered two alternative periods, 1994-2012 and 2000-12, so that we understand the overall effects of financial sector reforms, and also the specific effects of the second-generation reforms. This model enables to assess the technical efficiency, *pari passu* with the X-efficiency. In this connection, a comparison of statistical results between 1994-2012 and 2000-2012 confirms that the technical progress contributed to cost reductions in the reform period and also that it was accelerated during the second-generation reforms. For, as against the coefficient of the variable ‘time’ at -0.040 for the entire reform period under study, it is -0.056 for the period of the second-generation reforms. Thus, in respect of cost reduction, technical progress contributed by 5.60 per cent during the second-generation reform, as against 4 per cent during the entire period.

The X-efficiency of the three categories of banks – public sector banks, private domestic banks and private foreign banks - are recorded at 80.24 per cent, 77.3 percent and 79.93 per cent respectively for the entire period, 1994-2012. Taking only the second generation reform period, 2000-12, their X-efficiencies are seen to have increased to 87 per cent, 88 per cent and 83 per cent respectively. Bank-wise comparison between these periods, however, suggests that, during the second generation reforms, all the banks (save SBI) in the public banking sector gain in X-efficiency. The highest gain is for the VIJB at 14.5 per cent, and the least is for the PNB at 2.32 per cent. The same is true for the private domestic sector, where we find the efficiency gain ranging from 3.3 per cent for the ICICI bank to 21.3 per cent for CITYUNIB. For the private foreign banking sector, however, there are mixed results. The X-efficiency score is seen lower for some of them during the second generation reforms – such as the ADCOMB (by 2.3 per cent), the BARCB (2.5 per cent), the DBS (7 per cent) and the OMINB (7.1 per cent). On the other hand, the gainers in this group are the CITI bank (20 per cent), followed by the BOT (15 per cent) while the least gainer is the BBK (1.02 percent).

Comparing the alternative methods of analysis of efficiency, MLE and GLS, and also two alternative periods for MLE, we find that bank-wise variations prevail among them. A broad agreement is, however, noticed among them at the group level for the most efficiency banks. In fact, the best six banks in the public sector under the MLE for 1994-2012 are also found to have scored high in other two estimations. Similar results are obtained for five banks in the private domestic sector in the MLE estimates for 2000-12 and six banks in the GLS estimates. In view of the inherent problems of the GLS methodology – such as the loss of information due to their transformation and two stages of regression, we rely on the MLE methodology for final judgement.