The interrelationships among default risk, capital ratio and efficiency: Evidence from Indian Banks

The Interrelationships among Default Risk, Capital Ratio and Efficiency: Evidence from Indian Banks

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Abstract

Purpose: This paper examined the efficiency of Indian banks and the interrelationships between insolvency risk, capital and efficiency.

Design/methodology/approach: We employed Stochastic Frontier Analysis (SFA) to assess cost and profit efficiencies of Indian banks and a three-stage least squares estimator to investigate relationships between risk, capital and efficiency.

Findings: Cost and profit efficiencies of Indian banks studied are 0.950 and 0.934, respectively; public banks are more cost-efficient, but slightly less profit-efficient than private banks; and bank efficiency experienced an unclear trend over the period 1994-2011. Indian banks benefit from technological progress and scale expansion in reducing costs and increasing profits. A decline in cost efficiency is generally followed by an increase in insolvency risk (bad management) while a rise in insolvency risk in public banks is generally followed by a decline in cost efficiency (bad luck). An increase in profit efficiency in public banks temporarily precedes an increase in the insolvency risk (skimping) but a decrease in capital ratio is generally followed by an increase in the insolvency risk (moral hazard). Better capitalized banks suffer lower insolvency risk and achieve higher profit efficiency.

Practical implications: Bank regulators and supervisors may consider: using cost and profit efficiencies as good predictors of risk; limiting public banks' exposures to external shocks; and considering capital ratio as an efficient tool to reduce insolvency risk and improve profit.

Originality/value: To the best of our knowledge, this is the first comprehensive investigation of the efficiency and its relationship to capital and risk in Indian banks.

Keywords: India, insolvency risk, capital, efficiency, ownership, SFA, Three-stage least square

JEL Classification: G21, G32, C61, C33

Article Classification: Research paper

1. Introduction

The banking system in India plays an important role in the development of the financial system and the economy as a whole. Since the 1990s, India has gradually implemented bank reforms towards deregulation to reduce default risk and improve efficiency of Indian banks. India adopted the Basel Accord on capital standards: Basel I in 1992 and Basel II in 2009; the minimum capital to risk weighted asset ratio (CRAR) was set to 8% by 1995 and 9% by 2000 for commercial banks (Sarma and Nikaidō, 2007). However, to the best of our knowledge, there are no comprehensive studies examining effects of these reforms. This motivates us to investigate the interplay between capital ratio, default risk and operational efficiency of Indian banks since early 1990s.

The literature is scant on the interrelationships between risk, capital and efficiency, but most of these studies are on European or the U.S. banks. Several studies on the efficiency of Indian banks, but only one study by Das and Ghosh (2004) examining the association between risk, capital and efficiency in Indian banks has been identified. However, this study covered only public banks; considered only cost efficiency; and analysed a short period 1992 to 1999. We analyse both cost and profit efficiency and examine effects of the scale and technological progress, and hence, provide a more comprehensive picture about the efficiency of the Indian banking system in the post-reform period. To the best of our knowledge, this is the first examination of the interrelationships between risk, capital and efficiency for the whole Indian banking system as well as its bank types. Our study is also the first to predict the managerial behaviours in Indian banks and to assess if they vary across bank types.

The rest of the paper is organized as follows. Section 2 provides the framework of the management behaviour and the related literature. Section 3 discusses research methodology. Section 4 analyses empirical results and section 5 draws conclusions and addresses policy implications.

2. Managerial hypotheses and Literature review

2.1. Managerial hypotheses

Four managerial hypotheses have been identified by Berger and DeYoung (1997): bad management, bad luck, skimming and moral hazard. The possible relationship between risk, capital and efficiency provides evidence of the management behaviour a bank exhibits as summarized below.

Bad management is identified if a decrease in cost efficiency temporarily precedes an increase in the level of risk. Banks with poor senior management may fail to control operational costs and monitor borrowers, hence, increase risk and then lower cost efficiency. Such banks also tend to have poor loan and investment portfolios, causing low revenue efficiency. In order to improve the low economic efficiency, these poorly managed banks tend to take additional risks, leading to a growth in insolvency risk.

Bad luck has the reverse temporal ordering to bad management: an increase in risk occurs before a reduction in economic efficiency. One possible explanation is that when exogenous events, like regional economic downturns, worsen asset quality and then fuel insolvency risk, bank managers must allocate additional resources, like personnel on monitoring loans and seizing and disposing of collateral, to remedy this adverse situation. As a consequence, banks incur additional operating costs and lose some income, leading to the deterioration of cost and profit efficiency.

Moral hazard is identified if a reduction in capital ratio in the poorly capitalized banks leads to a growth in risk. This is because banks which are suffering risks due to low capital suffer more risks due to the declined capital ratio, thereby facing moral hazard incentives to take risky portfolios. Under this hypothesis, we expect that a reduction in financial capital precede an increase in non-performing loans.

Skimping behaviour is identified if an increase in cost efficiency temporarily precedes an increase in insolvency risk, which is an opposite sign to the bad management behaviour despite having the same temporal order. The possible reason is that banks tend to skimp on operating costs by reducing credit monitoring, collateral valuing and marketing activities to become more economically efficient. However, the improvement in economic efficiency due to the skimping may be achieved only in the short term, since the consequences of skimping

are the deterioration in the quality of loans and investments, resulting in greater insolvency risk.

2.2. Literature review

The literature on bank efficiency in India is vast (Das and Ghosh, 2004; Das *et al.*, 2005; Sensarma, 2005; Das and Ghosh, 2009; Kalluru, 2009; Ray and Das, 2010; Das and Drine, 2011; Sahoo and Mandal, 2011; Wanniarachchige and Suzuki, 2011; Kumar, 2013; Reddy and Nirmala, 2013), but only one study (Das and Ghosh, 2004) examined the interrelationships between risk, capital and cost efficiency in Indian public banks in the 1992-1999 period. The authors found that capital ratio reduced bank risk, while cost efficiency had no effect on bank risk and capital ratio. Moreover, an increase in bank risk led to a decrease in cost efficiency while capital ratio had no effect on banks' efficiency. Other studies documented conflicting results on the efficiency trend, efficiency gap between public banks and private banks, and the effects of capital ratio and risk on economic efficiency. For example, Das *et al.* (2005) found an increase in the profit efficiency, while Sensarma (2005) and Wanniarachchige and Suzuki (2011) found a reverse trend. Kalluru (2009) and Wanniarachchige and Suzuki (2011) found a declining trend in cost efficiency while Sahoo and Mandal (2011) found an increasing trend. Indian public banks were found to be more cost-efficient than private banks in the studies by Sahoo and Mandal (2011), Wanniarachchige and Suzuki (2011), but comparably cost-efficient in the study by Das and Drine (2011), and less profit-efficient than private banks in the study by Sensarma (2005). The effects of capital ratio on profit efficiency were positive in the study by Reddy and Nirmala (2013), but negative in the study by Das and Ghosh (2009), while there was no association between cost efficiency and capital ratio in the study by Kalluru (2009).

The number of international studies, mostly on European or U.S. banks, on the interrelationships between risk, capital and efficiency are also limited: Tan and Floros (2013), Fiordelisi *et al.* (2011), Deelchand and Padgett (2010), Altunbas *et al.* (2007), Williams (2004), Berger and DeYoung (1997), and Kwan and Eisenbeis (1997). Main findings of these studies predicted bad management behaviour in European banks (Williams, 2004; Fiordelisi *et al.*, 2011), Japanese cooperative banks (Deelchand and Padgett, 2010), and the U.S. banks (Berger and DeYoung, 1997; Kwan and Eisenbeis, 1997). Bad luck and moral hazard behaviours were found in Japanese cooperative banks (Deelchand and Padgett, 2010) and the U.S. banks (Berger and DeYoung, 1997; Kwan and Eisenbeis, 1997). Skimping behaviour

was predicted in European banks (Altunbas *et al.*, 2007) and the U.S. banks (Berger and DeYoung, 1997). Banks with more capital were found to suffer less risk in China (Tan and Floros, 2013) and the U.S. (Kwan and Eisenbeis, 1997), but capital was found to have no significant impact on risk in European banks (Williams, 2004; Fiordelisi *et al.*, 2011). Better capitalized banks were found to operate more cost-efficiently in Europe (Fiordelisi *et al.*, 2011), but less efficiently in Japan (Deelchand and Padgett, 2010). In Europe, more cost-efficient banks were better capitalized (Fiordelisi *et al.*, 2011), and took less risk (Altunbas *et al.*, 2007), but reverse stories were found in Japan (Deelchand and Padgett, 2010) and the U.S. (Kwan and Eisenbeis, 1997).

Overall, the literature seems to provide conflicting signs and temporal order of interrelationships between capital, risk and operational efficiency of banks. One may argue that, these results reflect differences in: choice of variables, sample size, analysis periods and estimation methods. However, Berger and DeYoung (1997) suggested that inverse signs and temporal orders may simply reflect different managerial behaviours (e.g., bad luck, bad management, skimping, and moral hazard). One possible way to differentiate these behaviours is to estimate the interrelationships between risk, capital and operational efficiency simultaneously as a system.

3. Methodology

3.1. Efficiency estimation

We apply a stochastic frontier analysis (SFA) approach proposed by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) to estimate cost and profit efficiency scores. We adopt the transcendental logarithm (translog) functional form since it is more flexible and provide desired properties (e.g., monotonicity and asymmetry) to decompose changes in technical efficiency into components of interests such as technological progress and returns to scale (Berger and Mester, 1997; Huang *et al.*, 2010; Košak and Zorić, 2011). To take into account effects of environmental factors, we apply the technical efficiency effects SFA model proposed by Battese and Coelli (1995). Also, the efficiency component was assumed to follow a truncated distribution, and technological changes were proxied by a time trend (t). We follow the intermediation approach, which views a bank as an intermediary between depositors and borrowers, to specify inputs and outputs. Based on data available, the production of banking services in this study involves two outputs – net loans (Y_1) and other earning assets (Y_2)- and three inputs – fund (X_1), fixed assets (X_2) and personnel (X_3).

Therefore, prices of inputs $X_{1\text{-}3}$ are financial capital price (W_1), physical capital price (W_2) and labour price (W_3), respectively.

The translog stochastic cost frontier to estimate cost efficiency for the panel data is as follows:

$$lnTC_{it} = \alpha_0 + \sum_{m=1}^{2} \alpha_m ln\, Y_{itm} + \frac{1}{2}\sum_{m=1}^{2}\sum_{k=1}^{2} \alpha_{mk} ln\, Y_{itm} ln\, Y_{itk} + \sum_{n=1}^{3} \beta_n \ln W_{itn} + \frac{1}{2}\sum_{n=1}^{3}\sum_{l=1}^{3} \beta_{nl} ln\, W_{itn} ln\, W_{itl} + \frac{1}{2}\sum_{m=1}^{2}\sum_{n=1}^{3} \delta_{mn} \ln Y_{itm} \ln W_{itn} + \gamma_1 t + \frac{1}{2}\gamma_2 t^2 + \sum_{m=1}^{2} \gamma_{2+m}\, t \ln Y_{itm} + \sum_{n=1}^{3} \gamma_{4+n}\, t \ln W_{itn} + v_{it} + u_{it}$$

where the subscript *i* denotes the cross-sectional dimension across banks, subscript *t* denotes the time dimension. Parameters α, β, δ and γ of the cost function captures the unknown technology of the banking system and is estimated by maximum likelihood method. TC is the observed total cost, which consists of interest expenses, other operating expenses and personnel expenses. The error term *v* represents the statistical noise, while the error term *u* accounts for the non-negative cost inefficiency, which is assumed to have truncated-normal distribution and to be independent of *v*.

By exploiting the linear homogeneity condition, this model is transformed into a cost function by normalizing the dependent variable and all input prices by the price of input 3 (W_3) as follows (subscripts *i* and *t* are dropped for ease of viewing):

$$\ln(TC/W_3) = \alpha_0 + \sum_{m=1}^{2} \alpha_m ln\, Y_m + \frac{1}{2}\sum_{m=1}^{2}\sum_{k=1}^{2} \alpha_{mk} ln\, Y_m ln\, Y_k + \sum_{n=1}^{2} \beta_n \ln (W_n/W_3) + \frac{1}{2}\sum_{n=1}^{2}\sum_{l=1}^{2} \beta_{nl} ln\, (W_n/W_3)\, ln\, (W_l/W_3) + \frac{1}{2}\sum_{m=1}^{2}\sum_{n=1}^{2} \delta_{mn} \ln Y_m \ln(W_n/W_3) + \gamma_1 t + \frac{1}{2}\gamma_2 t^2 + \sum_{m=1}^{2} \gamma_{2+m}\, t \ln Y_m + \sum_{n=1}^{2} \gamma_{4+n}\, t \ln(W_n/W_3) + v + u$$

We define SFA profit function in a similar manner: replacing the notation of total costs (TC) by that of the profit before tax (PBT), and making the inverse sign for the non-negative component of the error term *u*. We also transform the original profits, which have negative

values, by subtracting the minimum and adding the mean to ensure the validity when taking a natural logarithm.

The individual cost and profit efficiency scores are calculated, respectively, as $CE_{it} = \exp(-u_{it})$ and $PE_{it} = \exp(-u_{it})$. CE and PE will range from 0 (very poorly operate banks) to 1 (best-practiced banks).

Economies of scale

To examine effects of operational scale on costs and profits, we respectively estimate cost elasticity (CES_Y) and profit elasticity (PES_Y) by taking the derivatives of the transformed function with respect to all output variables as follows (note that the transform function is assumed to follow the monotonicity assumption, hence the cost elasticity can be calculated by taking derivatives to output):

$$CES_Y = \sum_{i=1}^{2} \frac{\delta \ln TC}{\delta \ln Y_i}$$

$$PES_Y = \sum_{i=1}^{2} \frac{\delta \ln \mathrm{PBT}}{\delta \ln Y_i}$$

An estimate of CES_Y less than, equal to, or greater than one respectively indicates increasing, constant and decreasing returns to scale. The respective three categories of scale economies for a profit function are defined by having PES_Y less than, equal to, or greater than zero.

Technological progress

To investigate the effects of technological progress on costs and profits of banks, we calculate cost elasticity (CES_T) and profit elasticity (PES_T) with respect to time (t) as follows:

$$CES_T = \frac{\delta \ln TC}{\delta \ln t}$$

$$PES_T = \frac{\delta \ln PBT}{\delta \ln t}$$

Technological progress is defined as having negative time derivatives for cost function (i.e., reduces costs over time) and positive time derivative for profit function (i.e., increases profits over time). Technological regresses occur if the derivatives are negative (for the profit

function) and/or positive (for the cost function) while neutral technological changes occur if the derivatives are equal to zero.

3.2. Interrelationships between risk, capital and efficiency

We employ the three-stage least squares (3SLS), introduced by Zellner and Theil (1962), to investigate the interrelationships between risk, capital and efficiency as in the study by Tan and Floros (2013). Some other approaches in the literature are two-stage least squares (Kwan and Eisenbeis, 1997; Deelchand and Padgett, 2010), seemly unrelated regressions (SUR) (Altunbas *et al.*, 2007), Granger causality tests (Berger and DeYoung, 1997; Williams, 2004; Fiordelisi *et al.*, 2011), and decomposing technical efficiency into operating efficiency and risk management efficiency (Yang, 2014). However, results obtained by the Granger causality are sensitive to model specification and the number of lags. Also, the efficiency decomposition approach required data on non-performing loans which we cannot obtain. Therefore, we select the 3SLS estimator, which combines the two-stage least squares and SUR, for our study.

We measure bank risk by Z-score, efficiency by the technical efficiency scores of cost and profit functions, and capital by the ratio of equity to total assets. Z-score is computed by the ratio of return on assets (ROA) plus the capital ratio divided by the standard deviation of ROA, which measures the degree of bank insolvency (Roy, 1952). The choice of Z-score as a risk measure was applied in various studies by Tan and Floros (2013), Beck *et al.* (2013), Demirgüç-Kunt and Huizinga (2010), Houston *et al.* (2010), Laeven and Levine (2009) and many others. The literature also exists other measures of risk such as ratio of loan loss provision to gross loans (Williams, 2004; Tan and Floros, 2013), ratio of loan loss reserves to total assets (Altunbas *et al.*, 2007; Deelchand and Padgett, 2010), ratio of non-performing loans to gross loans (Berger and DeYoung, 1997; Das and Ghosh, 2004; Fiordelisi *et al.*, 2011), and 1 or 5-year expected default frequency (Fiordelisi *et al.*, 2011). However, the later approach (expected default frequency) requires data on stock prices while many Indian banks do not have public traded securities. The three former measures (loan loss/total loans, loan loss/assets, and non-performing ratio) are subject to managerial discretion and capture only credit risks, while non-lending earning assets accounts for approximately 40% of the outputs of Indian banks. Hence, Z-score is more appropriate for measuring bank risk in our study.

The system of simultaneous equations is defined as follows:

$$R_{it} = \propto_0 + \propto_1 E_{it} + \propto_2 C_{it} + \propto_3 A_{it} + \propto_4 A_{it}^2 + \propto_5 RD_{it} + \propto_6 I_{it} + \omega_{it} \quad (1)$$

$$C_{it} = \beta_0 + \beta_1 E_{it} + \beta_2 LD_{it} + \beta_3 G_{it} + \beta_4 I_{it} + \epsilon_{it} \quad (2)$$

$$E_{it} = \gamma_0 + \gamma_1 R_{it} + \gamma_2 C_{it} + \gamma_3 RD_{it} + \gamma_4 LA_{it} + \gamma_5 G_{it} + \gamma_6 I_{it} + \theta_{it} \quad (3)$$

where *R* is the measure of risk (proxied by Z-score), *E* is efficiency, *C* is capital, *A* is assets (in log), *RD* is revenue diversification, *LD* is the ratio of loans to deposits, *LA* is ratio of loans to assets, *G* is GDP growth rate, *I* is inflation rate,; ω, ε and θ are random errors. These variables are described in more detail in Table 1. Because the Z-score is highly skewed, we use the natural logarithm of the Z-score to make its distribution more normal. For brevity, we still use the label ‘‘Z-score’’ to represent the natural logarithm of the Z-score in the remainder of the study. Equation 1 tests whether efficiency and capital temporarily precede variations in bank risk. Equation 2 assesses if efficiency temporarily precedes variations in bank capital, whereas Equation 3 examines whether level of capital together with bank risk determine changes in bank efficiency.

Based on hypotheses explaining the relationships between bank risk, capital and efficiency proposed by Berger and DeYoung (1997) above, bad management, skimping, bad luck, and moral hazard behaviours can be tested by the sign and significant level of parameters α_1 (positive), α_1 (negative), γ_1 (positive), and α_2 (positive), respectively (bearing in mind that a higher Z-score indicates that the bank is more stable). In particular, a positive α_1 confirm that a reduction in cost/profit efficiency precedes an increase in bank risk (i.e., bad management occurs) whilst a negative α_1 suggests an increase in cost/profit efficiency happens just before an increase in risk (i.e., skimping exists). The positive parameter γ_1 is interpreted as an increase in risk precedes a reduction in cost/profit efficiency (i.e., banks face bad luck). The moral hazard hypothesis tests whether low capital leads to risky behaviour of bank managers, which represents by the positive parameter α_2. We focus this test to banks with low capital that moral hazard is more likely to occur. We expect that capital is negatively affected by operational efficiency, thus parameter β_1 is expected to have a negative sign.

In order to check the sensitivity of results on bank management behaviour, we also use two alternative risk measures: volatility of returns on asset (ROA) and volatility of returns on equity (ROE), which are respectively measured by standard deviation of ROA and standard deviation of ROE. A higher volatility of ROA or ROE indicates that the bank is less stable.

3.3. Data

Indian commercial banks are divided into three categories based on ownership criteria: public banks (State Bank of India and its associates and nationalized banks), private banks (old private sector banks and new private sector banks) and joint-venture and foreign banks. A balanced panel, which includes 25 public banks and 15 private banks over the period 1994-2011 and accounts for above 85 per cent of the deposits of the Indian banking system, is selected in this study. The source of data is International Bank Credit Analysis Ltd (Fitch-IBCA).

Table 1 shows that output data (Y_1 and Y_2) indicate that public banks are, on average, two times larger than private banks. The input price data show that public banks have lower financial capital price, but higher physical capital price and labour price than private banks. The period-averaged capital ratio is 5.5 per cent with a lower level in public banks than private banks. Data on risk measures (Z-score, ROA volatility and ROE volatility) show that public banks have greater risk-taking than private banks. Data on the remaining variables show that Indian banks, on average, intermediate 63 per cent of their deposits into loans, with a higher level in public banks than private banks. Lending volume accounts for approximately 50 per cent of total assets, with a slightly lower lending-intensive level in public banks than private banks. However, the income of Indian banks is mainly driven by income from lending. The average annual GDP growth rate and inflation rate are 7.04 per cent and 7.28 per cent, respectively.

Table 1: Description of variables used in the study

Variables	Description	All banks	Public banks	Private banks
Variables used for efficiency estimation				
TC (Total Cost)	The sum of interest expenses, other operating expenses and personnel expenses (million $US)	934.24 *(1840.99)*	1215.92 *(2063.86)*	464.76 *(1263.05)*
PBT (Profit)	Pre-tax profit (million $US)	147.73 *(338.22)*	184.71 *(394.08)*	86.11 *(201.08)*
Y_1 (Output 1)	Net loans measured by gross loans minus reserves for impaired loans (million $US)	6818.58 *(14298.85)*	9024.48 *(16792.18)*	3142.08 *(7356.49)*
Y_2 (Output 2)	Other earning assets measured by investments and other earning assets (million $US)	4577.51 *(8699.21)*	5993.99 *(9950.21)*	2216.71 *(5297.67)*
W_1(Price of input 1)	Financial capital price calculated by the ratio of interest expenses to total funding	0.063 *(0.014)*	0.062 *(0.012)*	0.066 *(0.017)*
W_2(Price of input 2)	Physical capital price computed by the ratio of other operating expenses to fixed assets	0.935 *(0.631)*	0.958 *(0.603)*	0.895 *(0.675)*
W_3 (Price of input 3)[1]	Labour price which is proxied by the ratio of personnel expenses to total assets	0.014 *(0.006)*	0.016 *(0.006)*	0.011 *(0.005)*
t	Time trend which equals 1 for year 1994, 2 for year 1995 … and 18 for year 2011	9.50 *(5.34)*	9.50 *(5.34)*	9.50 *(5.34)*
Variables used for examining the relationships between risk, capital and efficiency				
C	The capital ratio measured by the ratio of equity to total assets	0.055 *(0.027)*	0.047 *(0.016)*	0.067 *(0.036)*
R (Z-score)	The ratio of ROA plus the capital ratio divided by the standard deviation of ROA	12.110 *(6.150)*	11.014 *(5.565)*	13.937 *(6.636)*
R (ROA volatility)	Standard deviation of ROA which shows the volatility of ROA	0.006 *(0.004)*	0.007 *(0.005)*	0.006 *(0.001)*
R (ROE volatility)	Standard deviation of ROE which shows the volatility of ROE	0.156 *(0.174)*	0.187 *(0.212)*	0.104 *(0.031)*
A	Logarithm of total assets which captures bank size	8.603 *(1.344)*	9.211 *(0.894)*	7.589 *(1.357)*
LD	Intermediation ratio computed by the ratio of gross loans to deposits	0.630 *(0.148)*	0.604 *(0.131)*	0.675 *(0.165)*
LA	The ratio of gross loans to total assets	0.496 *(0.097)*	0.490 *(0.102)*	0.505 *(0.087)*
RD	Revenue diversification computed by the ratio of non-interest income to total income	0.138 *(0.056)*	0.128 *(0.038)*	0.154 *(0.073)*
G	The GDP growth rate (annual %)	7.040 *(2.150)*	7.040 *(2.151)*	7.040 *(2.153)*
I	Consumer prices (annual %)	7.28 *(3.07)*	7.28 *(3.07)*	7.28 *(3.07)*

Data on bank-specific variables is from FITCH-IBCA;
Data on GDP growth and inflation are from World bank database;
Standard deviation in parentheses.

[1] we cannot obtain data on the number of employees, this study follows , Bos and Schmiedel (2007), Huang *et al.* (2010) and Liu and Chen (2012) to proxy labour price as a ratio of personnel expenses to total assets

4. Empirical results

4.1. Operational efficiency

To assess the validity of model, we conduct a Likelihood-Ratio (LR) test, which is defined as: $LR = -2[L(H_0) - L(H_1)]$, where $L(H_0)$ is the log likelihood of the unrestricted model and $L(H_1)$ is the log likelihood of the restricted model. The test statistics, which follows the $\chi^2(n)$ distribution with n being the number of restrictions, for the cost and profit models were 133.57 and 64.29, respectively. In our case the number of restrictions is 1 (i.e., u=0), hence the null hypothesis of no efficiency is rejected at 1% level of significance.

Table 2: Cost and profit functions (SFA estimates)

Variables	Cost function		Profit function	
	Coef.	Std. Err.	Coef.	Std. Err.
Constant	1.771***	(0.080)	9.656***	(0.233)
lny_1	0.580***	(0.053)	0.318*	(0.155)
lny_2	0.414***	(0.051)	-0.784***	(0.154)
lnw_1/w_3	0.733***	(0.049)	0.901***	(0.139)
lnw_2/w_3	-0.127***	(0.035)	0.314**	(0.102)
t	-0.027***	(0.005)	0.045**	(0.015)
$(lny1)^2$	0.200***	(0.025)	0.325***	(0.071)
lny_1*lny_2	-0.207***	(0.025)	-0.275***	(0.068)
lny_1*lnw_1/w_3	-0.075***	(0.017)	-0.176***	(0.049)
lny_1*lnw_2/w_3	0.030**	(0.011)	-0.045	(0.031)
lny_1*t	0.001	(0.002)	-0.025***	(0.007)
$(lny_2)^2$	0.214***	(0.025)	0.320***	(0.070)
lny_2*lnw_1/w_3	0.061***	(0.017)	0.176***	(0.048)
lny_2*lnw_2/w_3	-0.026*	(0.011)	0.014	(0.031)
lny_2*t	0.001	(0.002)	0.027***	(0.007)
$(lnw_1/w_3)^2$	0.165***	(0.020)	-0.060	(0.056)
$lnw_1/w_3*lnw_2/w_3$	-0.033**	(0.012)	0.041	(0.034)
lnw_1/w_3*t	0.006**	(0.002)	-0.022***	(0.005)
$(lnw_2/w_3)^2$	0.036***	(0.010)	0.003	(0.029)
lnw_2/w_3*t	0.000	(0.001)	0.002	(0.003)
t^2	0.000	(0.000)	-0.001	(0.001)
σ_u	0.6803 ***		1.3260 ***	
γ (σ_u/σ_v)	21.51 ***		9.34 ***	

***, ** and *: 1%, 5% and 10% levels of significance, respectively
Standard errors in parentheses

Technological progress

Figure 1 indicates that the average time derivatives of the cost function (CES_T) for all banks, public banks and private banks are all below zero (-0.0050, -0.0053 and -0.0046, respectively). Thus, banks in India slightly benefit from technological progress in reducing costs, on average. Specifically, the CES_T for the Indian banking system and its bank types experiences an increasing trend, but the value remains below zero over the period 1994-2011

(except public banks in year 2011). Moreover, CES_T for public banks is slightly lower than private banks from 1994 to 2004, but slightly higher than private banks from 2005 to 2011. This suggests that technological progress has reduced costs incurred by Indian banks at a diminishing rate over the analysis period. Also, compared to private banks, the reduction of costs due to technological advances for public banks was slightly greater for the period 1994-2004, but slightly lower for the period 2005-2011.

Figure 1: Technological progress by cost

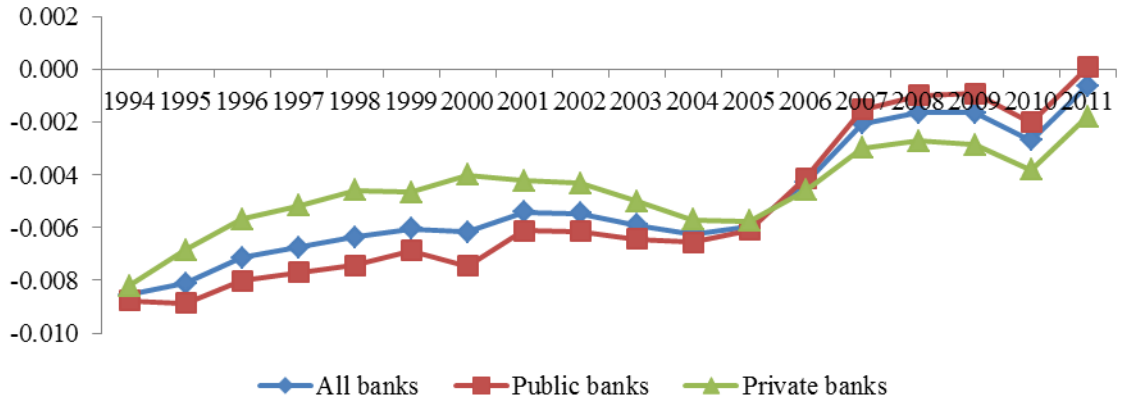
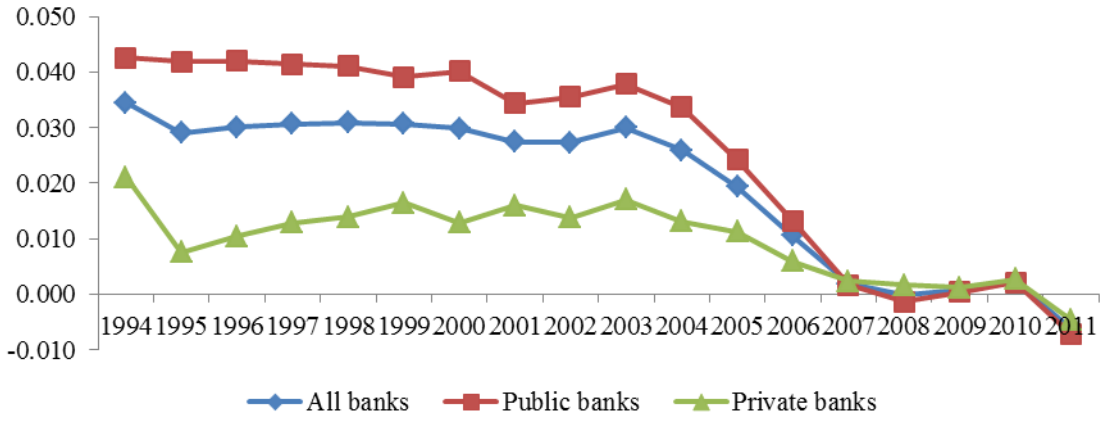


Figure 2 shows that time derivatives of the profit function (PES_T) are positive, on average. In particular, the PES_T for the samples of all banks, public banks and private banks is 0.020, 0.026 and 0.010, respectively. This result suggests that, overall, the average bank in India benefits from technological progress in increasing profits. Specifically, PES_T for the Indian banking system and its bank types reveals a declining trend, but the value remains above zero between 1994 and 2011 (except for the years 2008 and 2011). Moreover, PES_T for public banks is greater than private banks from 1994 to 2006, but comparable to private banks after that. This implies that technological progress has enhanced the profits of Indian banks at a diminishing rate over the analysis period (except years 2008 and 2011). Also, compared to private banks, the increase in profits caused by the technological advances for public banks was greater for the period 1994-2006, but comparable for the remaining analysis period.

Figure 2: Technological progress by profit



Return to scale

Figure 3 shows that the average output derivatives of the cost function (CES_Y) of all banks, public banks and private banks are 0.997, 0.999 and 0.993, respectively. Thus, overall, the average bank in India slightly benefits from scale in reducing costs. Specifically, from 1994 to 2003, CES_Y experiences an increasing trend and is slightly below one, with a higher level in public banks than in private banks. However, from 2004 to 2011, CES_Y is slightly above or equal to one. This suggests that the Indian banking system and its bank types had reduced costs at a diminishing rate from expanding loans and investments over the period 1994-2003, but suffered constant or decreasing returns to scale over the period 2004-2011. Also, the reduction of costs from scale expansion was greater for private banks than public banks for the period 1994-2003.

Figure 3: Returns to scale by cost

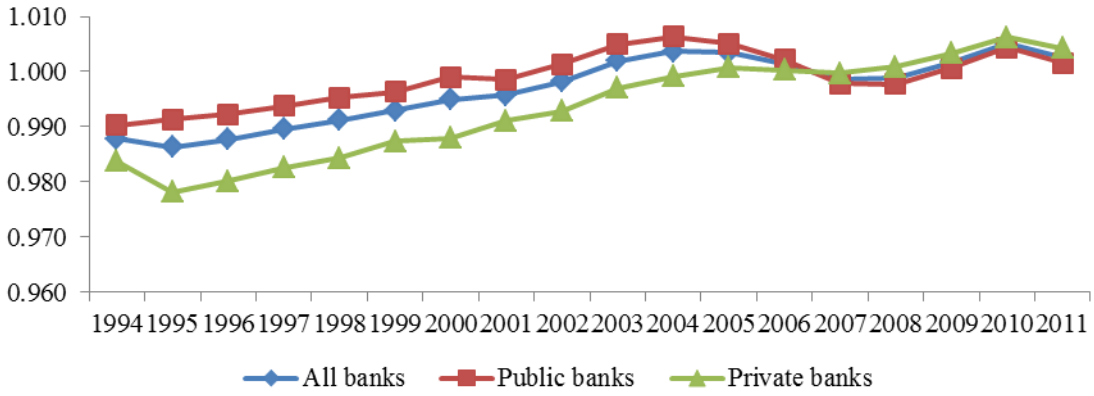
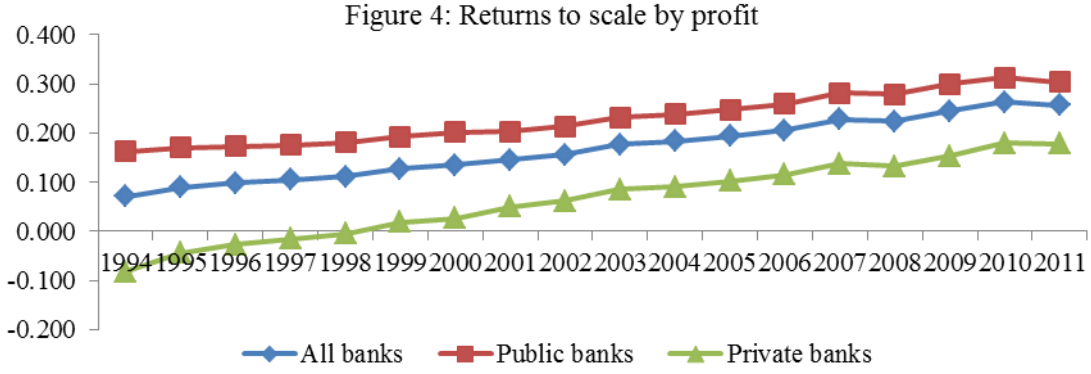


Figure 4 shows that the average profit elasticity (PES_Y) of all banks, public banks and private banks are 0.167, 0.229 and 0.064, respectively. This finding suggests that an average bank in

India benefits from increasing returns to scale regarding profits. PES_Y experienced a steadily increasing trend and is above zero (except private banks in the years 1994-1997) and elasticity of public banks is consistently higher than that of private banks. Thus, Indian banks in the sample, regardless of bank types, have increased profits at an increasing rate from expanding loans and investments over the study period, and public banks outperform their private counterparts in this aspect.

Figure 4: Returns to scale by profit



Technical efficiency

Figures 5-6 show the yearly-mean cost and profit efficiency of the Indian banking system and its bank types while Table 3 displays the t-test for the null hypothesis that technical efficiencies are indifferent among bank types. Over the period 1994-2011, there is an unclear trend in both cost and profit efficiencies for all banks as well as both bank types except that cost efficiency of public banks experiences a slightly upward trend. The average cost and profit efficiency scores of banks in the 1994-2011 period are 0.950 and 0.934, respectively (i.e., banks can reduce costs by 5%, and increase profits by 6.6%, compared with best practices). This overall cost and profit efficiency levels are similar to the studies by Sensarma (2005) and Kalluru (2009). The results show that public banks are more cost-efficient, which is similar to the studies by Sahoo and Mandal (2011) and Wanniarachchige and Suzuki (2011). But these banks are slightly less profit-efficient, which is consistent with the study by Sensarma (2005). Specifically, public banks have comparable cost efficiency to private banks in the 1994-1998 period, but they have greater cost efficiency in the remaining period. Profit efficiency of public banks is lower in years 1999-2001, 2004-2005 and 2010, but comparable to private banks in the remaining years. Moreover, there is a significant and negative association between cost and profit efficiency scores, but the magnitude is weak (the correlation coefficient is -0.11 and has a p-value of 0.005). One possible explanation is that bank' managers practice both bad management (low efficiency leads to high risk) and moral

hazard (low capital leads to high risk) behaviours. For example, banks with low capital may focus more attention to cost saving (i.e., improve costs efficiency) and take more risks damaging reputation and profits (i.e., decline profit efficiency).

Figure 5: Cost efficiency

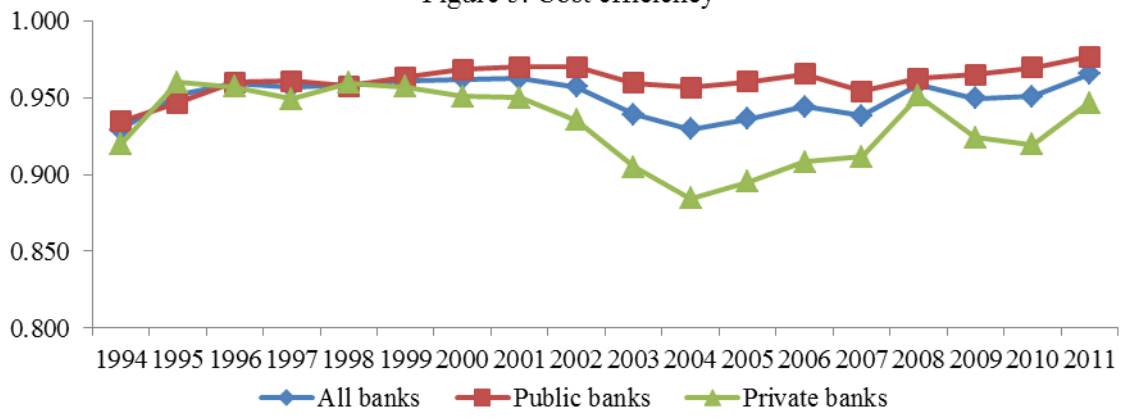


Figure 6: Profit efficiency

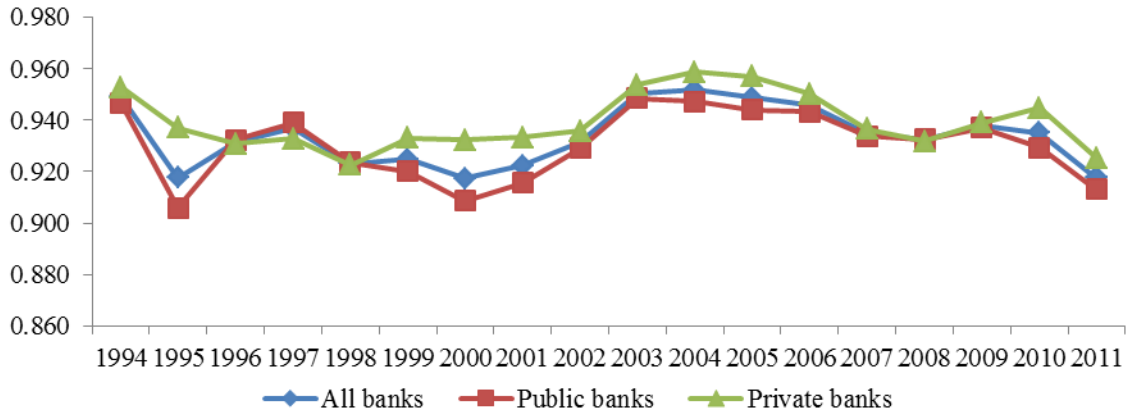


Table 3: Cost and profit efficiencies of the Indian banking system and its bank types

Year	Cost efficiency				Profit efficiency			
	All	Public	Private	Gap	All	Public	Private	Gap
(1)	(2)	(3)	(4)	(3)-(4)	(6)	(7)	(8)	(7)-(8)
1994	0.929	0.935	0.920	0.015	0.949	0.947	0.953	-0.006
1995	0.952	0.947	0.960	-0.013	0.918	0.906	0.937	-0.031
1996	0.959	0.960	0.957	0.003	0.932	0.932	0.931	0.001
1997	0.957	0.961	0.949	0.012	0.937	0.939	0.933	0.006
1998	0.958	0.958	0.960	-0.002	0.923	0.924	0.923	0.001
1999	0.961	0.963	0.957	0.006	0.925	0.920	0.933	-0.013 **
2000	0.962	0.968	0.951	0.017	0.917	0.909	0.932	-0.024 ***
2001	0.962	0.970	0.950	0.020 **	0.922	0.916	0.933	-0.018 ***
2002	0.957	0.970	0.935	0.035 ***	0.932	0.929	0.936	-0.007
2003	0.939	0.960	0.905	0.055 ***	0.950	0.948	0.954	-0.005
2004	0.930	0.956	0.885	0.072 ***	0.952	0.947	0.959	-0.011 ***
2005	0.936	0.960	0.895	0.065 ***	0.949	0.944	0.957	-0.013 ***
2006	0.944	0.965	0.908	0.057 ***	0.946	0.943	0.950	-0.007
2007	0.938	0.954	0.911	0.043 ***	0.935	0.934	0.937	-0.003
2008	0.958	0.962	0.951	0.011	0.932	0.933	0.932	0.001
2009	0.950	0.965	0.924	0.041 ***	0.938	0.937	0.939	-0.002

2010	0.951	0.969	0.920	0.050 ***	0.935	0.929	0.945	-0.016 *
2011	0.965	0.977	0.947	0.030 ***	0.918	0.913	0.925	-0.012
Mean	0.950	0.961	0.932	0.029 ***	0.934	0.931	0.939	-0.009 ***

t-test is used to check mean differences in efficiency among bank types;
***, ** and *: 1%, 5% and 10% levels of significance, respectively.

4.2. Interrelationships between risk, capital and efficiency

Table 4 displays the 3SLS estimation for the system of three simultaneous equations (1-3). The χ^2 values obtained from the 3SLS estimator indicate that the systems of three simultaneous equations for the samples of all banks, public banks and private banks are significant. Regarding Equation 1, cost efficiency is found to have positive and significant effect on Z-score (risk is proxied by Z-score that higher values indicate more stability) of all banks studied, regardless of type. Since the deterioration in cost efficiency leads to an increase in insolvency risk, this finding supports the bad management hypothesis. Also, our results show that an increase in profit efficiency leads to an increase in insolvency risk with the exception of private banks, hence supporting the skimping hypothesis. These contrary behaviours could be due to the presence of moral hazard behaviour, which explains a negative correlation between the cost and profit efficiency scores discussed above. We found that moral hazard behaviour does exist as expected and more detailed results on the test for moral hazard are presented at the end of this section.

Better capitalized banks are found to suffer less insolvency risk when both bank types are combined. This finding is consistent with that of Tan and Floros (2013) for Chinese banks and Kwan and Eisenbeis (1997) for the U.S. banks. When capital is increased, the shareholders of private banks – individuals and organizations - tend to have more incentives to monitor the management performance than those of public banks – all citizens with the government being their representative. This leads to the fact that the negative effect of capital ratio on insolvency risk is significant in private banks, but insignificant in public banks. There is an inverse U-shape relationship between bank size (proxied by total assets) and risk when both bank types are combined, suggesting that Indian banks intensify risk management activities when their total assets exceed a certain level. Revenue diversification in Indian banks seems to reduce the insolvency risk, as non-interest income is less vulnerable to idiosyncratic shocks.

Regarding Equation 2, a decrease in cost efficiency is found leading to an increase in capital ratio in Indian banks, which aligns with studies by Deelchand and Padgett (2010) and Kwan

and Eisenbeis (1997) for the U.S. banks. Banks often respond to a deterioration in cost efficiency by raising capital (numerator of capital ratio) as a precautionary step, while public banks respond to profit efficiency improvement by using their retained earnings as a supplement to equity (numerator of capital ratio). Ratio of loans to deposits is found to be positively and significantly related to capital ratio irrespective of bank ownership and efficiency measurement. One possible explanation is that banks with higher intermediation of deposits into loans have higher earnings to supplement the equity (numerator of capital ratio).

Table 4: The relationships between risk, capital and efficiency for Indian banks

Models	Cost efficiency			Profit efficiency		
	All banks	Public banks	Private banks	All banks	Public banks	Private banks
Eq.(1) Dependent variable is risk (Z-score)						
Efficiency	2.6035***	4.7340***	1.6269**	-3.5804**	-7.2236***	-3.2190
	(0.4943)	(1.1350)	(0.5537)	(1.2824)	(1.6365)	(1.8147)
Equity to Total Assets	6.3685***	1.9718	3.8148***	5.9253***	3.8797	2.3918*
	(0.7124)	(3.9205)	(0.9392)	(0.6333)	(3.7833)	(1.0400)
Ln(Total Assets)	-0.1293**	-0.0803	0.1316*	-0.1102**	0.2036	0.2915***
	(0.0418)	(0.2139)	(0.0584)	(0.0380)	(0.2611)	(0.0862)
Ln(Total Assets)^2	0.0091***	0.0070	-0.0066	0.0083***	-0.0051	-0.0170**
	(0.0024)	(0.0103)	(0.0039)	(0.0023)	(0.0127)	(0.0053)
Revenue Diversification	1.0789***	0.1688	1.0145***	0.1792	1.4101***	0.1684
	(0.2112)	(0.2488)	(0.2207)	(0.1163)	(0.4136)	(0.1910)
Inflation	-0.0012	-0.0023	0.0013	-0.0073**	-0.0034	0.0007
	(0.0022)	(0.0033)	(0.0035)	(0.0026)	(0.0041)	(0.0050)
Constant	0.8021	-1.2074	0.8591	6.7063***	8.2501***	5.0360***
	(0.6118)	(1.7588)	(0.5590)	(1.1977)	(1.6882)	(1.4807)
Eq.(2) Dependent variable is capital (ratio of equity to total assets)						
Efficiency	-0.1931***	-0.4647***	-0.1409**	1.3475	0.5816***	-0.1078
	(0.0396)	(0.1044)	(0.0504)	(1.2903)	(0.1304)	(0.3049)
Loans to Deposits	0.0569***	0.0764***	0.0497***	0.0438*	0.0508***	0.0435**
	(0.0067)	(0.0101)	(0.0136)	(0.0193)	(0.0071)	(0.0133)
GDP Growth	0.00001	-0.0009*	-0.0001	-0.0013	-0.0010	0.0007
	(0.0005)	(0.0003)	(0.0010)	(0.0035)	(0.0005)	(0.0013)
Inflation	0.0003	-0.0010***	0.0021**	0.0015	-0.0002	0.0016
	(0.0003)	(0.0003)	(0.0007)	(0.0017)	(0.0003)	(0.0008)
Constant	0.1998***	0.4612***	0.1502**	-1.2330	-0.5167***	0.1229
	(0.0392)	(0.0974)	(0.0521)	(1.2007)	(0.1218)	(0.2858)
Eq.(3) Dependent variable is efficiency						
Z-score	0.0321	0.0796**	0.0592	-0.0158	-0.0578	0.1599
	(0.0310)	(0.0251)	(0.1267)	(0.0217)	(0.0323)	(0.1235)
Equity to Total Assets	-1.4088***	-2.2261***	-1.4126***	0.4463**	2.4934**	0.1005
	(0.1541)	(0.6505)	(0.2904)	(0.1584)	(0.8629)	(0.2560)
Revenue Diversification	-0.2636***	0.0220	-0.4081***	-0.0036	0.0241	-0.1410
	(0.0353)	(0.0350)	(0.0828)	(0.0138)	(0.0511)	(0.0799)
Loans to Total Assets	0.1338***	0.1495***	0.1434*	-0.0319***	-0.0964**	-0.0796
	(0.0229)	(0.0264)	(0.0656)	(0.0078)	(0.0353)	(0.0615)
GDP Growth	-0.0027***	-0.0010	-0.0062***	0.0017*	0.0002	0.0038**
	(0.0007)	(0.0007)	(0.0018)	(0.0007)	(0.0008)	(0.0014)
Inflation	-0.0004	-0.0015**	0.0029	-0.0011*	0.0005	-0.0033*
	(0.0005)	(0.0005)	(0.0015)	(0.0005)	(0.0007)	(0.0013)
Constant	0.9127***	0.7445***	0.8390*	0.9747***	1.0442***	0.4479
	(0.0902)	(0.0629)	(0.3820)	(0.0625)	(0.0814)	(0.3706)
χ^2 for Equation 1	230.1263	139.1742	54.3503	264.4973	125.6213	36.9606

χ^2 for Equation 2	136.4323	69.7912	44.7499	9.0442	67.3049	20.5772
χ^2 for Equation 3	297.1047	54.1641	175.1209	57.2339	13.7683	16.8237
Observations	720	450	270	720	450	270

***, ** and *: 1%, 5% and 10% levels of significance, respectively
Standard errors in parentheses

The results also show that an increase in GDP growth leads to a decrease in capital ratio in public banks, but it is only significant at 10% and only occur in the cost function. This could be because public banks expand lending and investment when the economy is in a good shape (e.g., GDP growth increases, unemployment decreases), resulting in an increase in total assets, which is the denominator of capital ratio. An increase in inflation rate is associated with a decrease in capital ratio in public banks, but an increase in this ratio in private banks. We argue that when inflation grows, public banks may still expand lending for the purpose of improving the economy under the influence of the government, while private banks can reduce lending (a main source of denominator of capital ratio) due to higher probability of loan default.

Results for Equation 3 show that Z-score creates positive and significant impacts on the cost efficiency of public banks (i.e., an increase in risk leads to a significant decrease in cost efficiency). This finding supports the bad luck hypothesis in the Indian public banks. However, this finding is not significant when a profit function is analyzed, which could be due to the negative and significant relation between cost efficiency and profit efficiency. An increase in capital ratio is found to temporally precede a decrease in cost efficiency, but a reverse sign occurs at the profit aspect. Banks which raise equity as a funding source for loans usually involve higher costs, but they generate higher revenue than those relying on income from deposits (Berger and Mester, 1997). Revenue diversification is found to have a negative effect on cost efficiency of Indian banks with the exception of public banks. This could be because the expenses for non-lending products are greater than those for lending-products, and private banks tend to intensify revenue diversification more than public banks.

The ratio of loans to total assets is found to be associated positively with cost efficiency, but negatively with profit efficiency. One possible explanation is that loans are increased by lowering both deposit and lending interest rates, but the decreased interest expenses (paid to depositors) do not offset the reduced interest incomes (received from borrowers). GDP growth is found to decrease cost efficiency and increase profit efficiency of Indian banks (except public banks). This could be because in a better economy, the demand for loans is

higher while the supply for deposits is lower, so banks spend additional costs to mobilize funds for loans and hence, interest income is offset. However, private banks could be more dynamic in this business than public banks, so effects of increased funding cost are not significant in public banks.

Inflation is found to decrease cost efficiency of public banks, but decrease profit efficiency of private banks. One possible explanation is that when inflation grows, public banks still expand loans under the influence of the government while private banks reduce lending, so public banks suffer higher loan losses than private banks. However, the income generated from lending expansion in public banks offset the loans losses; thereby profit efficiency of public banks is not affected by inflation.

Table 5: Moral hazard test (Eq. 1)

	Cost efficiency	Profit efficiency
Eq.(1) Dependent variable is risk (Z-score)		
Efficiency	1.3620	-1.5357
	(0.9112)	(1.1366)
Equity to Total Assets	13.0781***	13.0321***
	(2.8710)	(2.9475)
Ln(Total Assets)	-0.0582	-0.0752
	(0.0492)	(0.0517)
Ln(Total Assets)^2	0.0047	0.0057
	(0.0032)	(0.0033)
Revenue Diversification	1.0322***	0.8581***
	(0.1955)	(0.1881)
Inflation	0.0028	0.0007
	(0.0024)	(0.0026)
Constant	1.4074	4.2467***
	(0.8732)	(1.1883)

***, ** and *: 1%, 5% and 10% levels of significance, respectively

Standard errors in parentheses

Low capitalized banks: banks have capital ratio below than the sample median (N=360)

We test the moral hazard hypothesis by re-estimating the system of equations 1-3 for the subsample of banks with the capital ratio below the sample median. Results of Equation 1 show that the capital ratio creates a positive effect on Z-score irrespective of the efficiency measurement (see Table 5). In other words, a decrease in capital leads to an increase in the risk of insolvency, supporting the moral hazard hypothesis.

Robust tests of managerial hypotheses by other risk measures

In order to have robust inferences on the managerial behaviour in Indian banks, we re-estimate the system of the three simultaneous equations for the samples of all banks, public

banks, private banks, and low capitalized banks by using the two alternative measures of risk: volatility of ROA and volatility of ROE. Partial results of these re-estimations are presented in Table 6. For convenience in comparison, we also put partial results of the system of three simultaneous equations when risk is measured by Z-score. Note that a higher Z-score indicates that the bank is more stable while a higher volatility of ROA or ROE indicates that the bank is less stable. It can be seen that findings remain robust when risk is measured by the volatility of ROA and volatility of ROE.

Table 6: Robust tests

	Model	Cost efficiency			Profit efficiency		
		Risk=Z-score	Risk=ROA Volatility	Risk=ROE Volatility	Risk=Z-score	Risk=ROA Volatility	Risk=ROE Volatility
A	***Robust test on hypotheses bad management, bad luck and skimping***						
A.1	*In Indian banks (sample of all banks: N=720 obs)*						
	Eq.(1) Dependent variable is risk						
	Efficiency	2.6035***	-0.0177	-0.6302	-3.5804**	0.0548	3.4430*
		(0.4943)	(0.0118)	(0.5580)	(1.2824)	(0.0295)	(1.4561)
	Eq.(3) Dependent variable is efficiency						
	Risk	0.0321	-2.7984	-0.0613	-0.0158	0.7102	0.0318
		(0.0310)	(2.7767)	(0.0737)	(0.0217)	(2.2685)	(0.0606)
A.2	*In public banks (sample of public banks: N=450 obs)*						
	Eq.(1) Dependent variable is risk						
	Efficiency	4.7340***	-0.1617***	-7.5598***	-7.2236***	0.1811***	9.2551**
		(1.1350)	(0.0330)	(1.7903)	(1.6365)	(0.0513)	(2.9023)
	Eq.(3) Dependent variable is efficiency						
	Risk	0.0796**	-6.4946***	-0.1571***	-0.0578	4.9585***	0.1192***
		(0.0251)	(1.2455)	(0.0268)	(0.0323)	(1.1096)	(0.0188)
A.3	*In private banks (sample of private banks: N=270 obs)*						
	Eq.(1) Dependent variable is risk						
	Efficiency	1.6269**	-0.0143**	0.0059	-3.2190	0.0243	0.2822
		(0.5537)	(0.0052)	(0.1097)	(1.8147)	(0.0154)	(0.3317)
	Eq.(3) Dependent variable is efficiency						
	Risk	0.0592	-9.7461	0.3918*	0.1599	-13.8083*	-0.2933**
		(0.1267)	(8.4124)	(0.1929)	(0.1235)	(5.8871)	(0.0894)
B	***Robust test on hypothesis moral hazard***						
	Sample of low capitalized banks (N=360 obs)						
	Eq.(1) Dependent variable is risk						
	Equity to Total Assets	13.0781***	-0.2804***	-17.9074**	13.0321***	-0.3049***	-19.9204***
		(2.8710)	(0.0829)	(5.6229)	(2.9475)	(0.0846)	(5.7273)

***: 1% level of significance; **: 5% level of significance; *: 10% level of significance

Standard errors in parentheses

Low capitalised banks: banks have capital ratio greater than the median

In general, findings on managerial behaviour in Indian banks are similar to those of Berger and DeYoung (1997) and Kwan and Eisenbeis (1997) for US commercial banks which were found to exhibit bad management, bad luck, skimming and moral hazard behaviour; those of

Williams (2004) and Fiordelisi *et al.* (2011) for European banks which were found to be affected by bad management; those of Deelchand and Padgett (2010) for Japanese cooperative banks which were found to exhibit bad management, bad luck and skimping; and those of Das and Ghosh (2004) for Indian public banks which were found to show bad luck.

5. Conclusion and policy implication

We used stochastic cost and profit frontier models to comprehensively assess the efficiency of 40 Indian banks during the 1994-2011 period. We found that the average cost and profit efficiency scores are 0.950 and 0.934, respectively. Public banks are more cost-efficient, but slightly less profit-efficient than private banks, and with the efficiency experiencing an unclear trend over the study period. Indian banks benefit from technological progress and scale expansion in reducing costs and increasing profits. Further, we employed three-stage least square estimation for the system of three simultaneous equations to investigate the relationships between risk, capital and efficiency. We found that a decline in cost efficiency is generally followed by an increase in insolvency risk ("bad management"). A decrease in capital ratio is generally followed by an increase in the insolvency risk ("moral hazard"). In public banks, a rise in insolvency risk is generally followed by a decline in cost efficiency ("bad luck") while an increase in profit efficiency temporarily precedes an increase in the insolvency risk ("skimping"). Better capitalized banks suffer lower insolvency risk and achieve higher profit efficiency. Each of these results have a small impact on banks on average, but may have a considerable impact on individual banks that are most subject to bad luck, bad management, skimping and/or moral hazard.

These findings may have some policy implications. The bad management evidence in both public and private banks suggests that bank regulators and supervisors should consider cost efficiency as a good predictor of risky banks. The bad luck in public banks evidence implies that bank regulators and supervisors should limit public banks' exposures to external shocks by diversifying income streams or restricting loan to assets ratio. The skimping hypothesis in public banks suggests that bank regulators and supervisors should consider profit efficiency as a proxy for insolvency risk in public banks. The moral hazard hypothesis implies that bank regulators and supervisors should carefully monitor capital ratio in the low capitalized banks in order to require them to quickly raise this capital when it declines. The finding that capital ratio has a negative effect on the risk of insolvency, but a positive effect on profit efficiency

suggests that capital ratio could be an efficient tool to reduce the insolvency risk and improve the profit performance.

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