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Gargi Sanati
Anup Kumar Bhandari

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NATIONAL INSTITUTE OF BANK MANAGEMENT
Pune, Maharashtra, 411048
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ABSTRACT

In the backdrop of an increase in market-based banking activities, we study the operational efficiency of the Indian banking sector during 2009-10 through 2017-18 considering *Market Return* as desirable outputs, in addition to *Advances* and S*lippage* as undesirable byproducts simultaneously. Using data envelopment analysis (DEA) method, we estimate six alternatives but interlinked operational efficiency scores (TES) of the Indian domestic commercial banks. In the second stage, we explain such TES in terms of bank-specific factors, banking industry competition scenario, and interest rate channel. We observe that the private sector banks as a group outperform those under public ownership. Moreover, although the private sector banks could maintain somewhat consistency in their operational efficiency performance over the sample period, public sector banks clearly show a declining tendency. Our second stage econometric estimation results show that the priority sector lending has a negative effect on TES. Interestingly, we get varying results for the relationship between maturity and TES depending on banks' strategies on stressed assets management. Furthermore, our analyses result that banks are not so efficient in managing relatively larger-volume loans. While we find banks' TES positively depends on the *Credit-to-Deposit* (CD) ratio, the overall operational efficiency of the banks to manage their credit risk portfolio improves with a reduction in the lending rate (LR). However, the interaction of lending activities and capital market shows that, with the increase in LR, corporate borrowers may switch to capital market to explore for desired funds, which may induce the banking sector to investment in capital markets and create a positive market sentiment.

Keywords: Traditional and Universal Banking; Operational Efficiency; Ownership Structure; Stressed Assets; Slippage.

JEL Classification: D24, G21, G32, L25.

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Gargi Sanati (*Corresponding Author*)
National Institute of Bank Management, Pune
gargi@nibmindia.org

Anup Kumar Bhandari
Indian Institute of Technology, Madras, Chennai
anup@iitm.ac.in

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1. Introductory Backdrop

India's banking system has become increasingly global and interconnected like many other emerging market economies. In the past two decades, the world economy has experienced a significant evolution in the financial landscape spurred by a more innovative and deregulated financial system and India is not any exception to go through such evolution. The most important part of the new financial system is the coexistence of bank-based and market-based systems and their interlinkages. Interestingly, Sanati (2013) found that for a country like India, the growth of the bank-based economy has a significant impact even on the growth of the market-based financial system. On the contrary, traditional banking operations and the adaptability of the universal banking system have made banks' exposure open to financial turmoil. Most importantly during the market economy's collapse, the banking channel's role comes highlighted as the scarcity of liquidity siphons into the real sector economy which might have a significant multiplier effect.

Against the backdrop, our study focuses on two-fold objectives: *1) estimating the technical efficiency score of the Indian public and private sector banks considering the traditional lending activity and market-led universal banking operations*; and *2) estimating the idiosyncratic and macroeconomic determinants of such operational efficiency of banks in managing credit risk and market-based investment activities*. Our study contributes to the existing literature by measuring the technical efficiency of Indian banks considering the possibility of enhancing traditional lending activities and the market-driven investment portfolio while managing the stressed assets of the banks. We also examine the determinants of technical efficiency of banks against their ownership pattern.

The main purpose of the efficiency measure of banking institutions in managing credit risk is to yardstick an individual bank's relative performance to the 'best practice' bank(s). A great deal of academic research has been conducted to measure operational efficiency and productivity growth in the banking sector across various countries, including India. Also, other extant literature is highly focused on the determinants of Non-performing Assets (NPAs). However, there is no study that measures the operational efficiency of Indian banks considering both the credit portfolio and the investment portfolio of the banks while managing bad loans. As for the treatment of the stressed assets of the Indian banks in the performance evaluation literature is concerned, Jayaraman and Srinivasan (2016) consider *GNPA* as an undesirable output, along with two other desirable outputs and four inputs, to study the *profit efficiency* of the Indian banks. On the other hand, Das et al. (2005) and Zaman and Bhandari (2020) consider *performing loans* (i.e., the *loans* after due adjustment for the volume of *non-performing loans*) to study the *cost efficiency*[1] of the Indian banking sector. Although the study by Misra et al. (2016) and Bajaj et al. (2021) caters to the recovery of bad loans of the Indian

[1] To add further, Das et al. (2005) also study *profit* and *revenue efficiencies* for Indian banking sector.

banks, the emphasis of their study was to investigate into the determining factors of such reduction of stressed assets. While both these studies have considered the *reduction in stressed assets*,[2] whereas the focus of the study by Sanati and Bhandari (2022) is to examine the bank's operational efficiency in *cash recovery of stressed assets*. They estimated the technical efficiency score (TES) of recovery of stressed assets (both *NPA* and *slippage*[3]) for individual commercial banks of India in the context of a cyclical slump when banks were saddled simultaneously with huge NPAs and considerably low recovery.

Over time, with the nationalization of banks in 1969 and 1980 and later financial reforms since 1991, the banking system continues to remain the strongest financial pillar of the Indian economy. Especially, the Indian banking system has proved to be instrumental in laying the inclusive growth path for the Indian economy. Given the positive externalities of the banking sector for the growth of the real sector economy and its interlinkage with market finance, our study argues that banks need to outgrow their existing operational efficiency in managing the traditional lending activity while ripping the benefit of the financial market. In fact, maintaining the right balance between operational efficiency in managing the credit portfolio and investment portfolio might prove to be instrumental to India's long-term economic growth.

Given this backdrop, we examine TES of 21 public sector and 17 private sector banks during 2009-10 through 2017-18.[4] We consider *three* alternative models to address six interlinked scenarios:

Scenario 11*:* To increase both *advances and investment* proportionally, while maintaining the existing *Slippage*;

Scenario 12: To simultaneously increase both *advances* and *investment* proportionally, while reducing the existing *slippage* in the same proportion;

Scenario 21*:* To increase both *advances and capital gain* proportionally, while maintaining the existing *Slippage*;

Scenario 22: To simultaneously increase both *advances and capital gain* proportionally with parallel reduction of *slippage* in the same proportion.

Scenario 31*:* To increase both *advances and Forex gain* proportionally, while maintaining the existing *Slippage*;

Scenario 32: To simultaneously increase both *advances and Forex gain* proportionally with parallel reduction of *slippage* in the same proportion.

Needless to say, each of these models has its own appeal. The first two scenarios of our study estimate the TES of Indian banks considering the lending activity and market-based investment activities as desirable output while slippage is the undesirable

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[2] As per bank's annual report reduction of NPA can have three segments: reduction from upgradation, reduction from write off, and reduction from cash recovery.

[3] *Slippage* is fresh accretion to NPAs during a period.

[4] Due to large scale merger drives of the public sector banks, we keep aside the later periods from our analyses.

output. Similarly, scenarios 3 and 4 estimate the TES of Indian banks in achieving gain from the capital market and lending activity as the desired output. On the other hand scenarios 5 and 6 estimate the TES considering the lending activity and capital gains received from foreign exchange market operations as desirable output. In the second stage, we explain such TES in terms of bank-specific and other macroeconomic factors in order to throw some light on the determining factors of such performance indicators of the Indian domestic commercial banks. To the best of our knowledge, our study is the first attempt that contributes to measuring the TES for credit risk of the Indian banks while considering banks' interplay with the market economy.

Our major preliminary findings suggest that the investment of public sector banks across all asset classes is very high compared to the private sector banks, although private sector banks manage *recovery* much better compared to public sector banks. Hence, the scope of improvement in managing credit risk for public sector banks is more as compared to their counterparts under private ownership. On the other hand, we need to examine if the higher investment amount is in line with the higher return from the capital market and foreign exchange market. This is corroborated in our first-stage results using data envelopment analysis. Interestingly, we find that banks' market investment plays a very significant role in the determination of technical efficiency. Also, we conclude that though public sector banks are the major investor in the market, the private sector banks perform better in terms of the return from the market and also in managing the credit risk. Also, we conclude that an increase in market concentration reduces banks' performance in managing credit risk and market return.

The rest of the paper is organized as follows. In section 2, we present a comprehensive review of the studies that have examined the operational efficiency of the banks. Also, we refer to a few studies that consider the desirable and undesirable output in estimating the operational efficiency of the banks in view of the credit risk of the Indian banking sector. In section 3, we preclude the study with descriptive statistics, to see the dominance of the banks in the market based investments. Section 4 discusses the database and methodology of the study briefly. In section 5, we summarize our findings of different models employed for measuring technical efficiency scores considering both the traditional lending and market related activities of the Indian commercial banks. Also, our findings on second stage regression analyses have been discussed in this section, while Section 6 concludes with some policy implications. Appendix shows some further results.

2. Literature Review

It may be noted that the entire gamut of the research studies on the operational efficiency of the banks is discussed in view of banks' traditional lending aspects. In this background, our study discusses the operational efficiency of the banks considering both traditional lending activity coupled with universal banking activities. The Indian banking industry has been going through a major structural change to adapt and move towards universal banking operations since financial liberalization. The concept of universal banking framework is well studied under the framework of whether (a) the bank-based or market-based systems matter for the economy or (b) the financial services and appropriate legal enforcement plays the major role. It was also well-examined that a country might be more inclined to have a bank-based or market-based financial system (Demirgüç-Kunt and Levine, 1999). While countries, at their developing stages, depend

mostly on banks for finances, developed countries depend on the market as the main source of finances (Levine, 2002). It may be noted that the present financial architecture may require both bank-based and market-based financial systems. Chakraborty and Ray (2006) argued that the legal and institutional framework is the most determining factor for any financial system to work efficiently. Moreover, they have found that the bank-based system outperforms the market-based system in helping industrialization, by bringing down inequality and increasing the per capita income. Interestingly, Sanati (2013) also found that for a country like India, the growth of the bank-based economy has a significant impact even on the growth of the market-based financial system. On the other side, the post-liberalization era of the Indian economy is experiencing an increasing dependency on market finance.

Though bank based economy is predominant in a country like India (Sanati, 2013), the growing interconnectedness between the banking sector and financial markets has become a matter of concern during the financial turmoil. The contagion effect of financial turmoil in the banking sector has become a common phenomenon even in developing countries. Most importantly, it is observed that large turmoil in the financial market leads to scarcity of the overall liquidity condition of the economy, resulting in a lack of confidence and a reduction in lending activities. Moreover, large banks' involvement in market-based activities triggers a debate if it enhances systemic risk (Laeven 2014).

In the current economic condition, the most concerning issue for Indian banking operations is the quality of assets. It is well emphasized in the banking policy domain that treasury management or the management of investment polio and trading portfolios is an important arena to expand the profit business of the banks. In this background, our study focuses on the estimation of operational efficiency of the public and private sector banks by considering both the traditional banking aspects and universal banking aspects. Though, there are many studies that discuss the NPA determinates of banks, however, estimating the operational efficiency considering stressed assets and recovering bad loans are recently looked into by a few research studies (Jayaraman and Srinivasan 2016; Sanati and Bhandari 2022). To the best of our knowledge, there is no study that estimated the operational efficiency of the banks allowing for investment portfolios besides traditional banking activity. Next, we discuss a few pieces of literature on 1) NPA determinants, 2) operational efficiency estimation in view of the lending activity of banks, and 3) operational efficiency estimation considering credit channel, desirable output and undesirable output.

The probability of default (PD) is the most important but sensitive variable in the context of the credit risk of the banks due to the non-availability of account-wise information in the public domain. In India, banks are extremely vigilant in maintaining the high confidentiality of their client's data. Altman et al. (2004) study the defaulted bonds' data for the period 1982 to 2000, which includes the relatively high default years of 1999 and 2000, and observe a negative correlation between the rates of default and recovery. Witzany (2011) studies default and recovery data on a retail portfolio of a large Czech bank over the period 2002 to 2008 and observes that the PD and Loss Given Default (LGD) correlation is positive (viz., 0.0775), although, the level of significance was low. However, too short a sample period may be a reason for such a low level of significance. Asarnow and Edwards (1995) examine the US market scenario by delineating the components of LGD and tested 831 defaulted loans of Citibank during 1970-1993. They have reported an average cumulative recovery rate of 65% by employing discounted cash

flow method. In another study based on the US market, Carty and Lieberman (1996) measured the recovery rate on a sample of 58 defaulted bank loans for the period 1989 to 1996 and reported an average recovery of 71%. In Latin America, Hurt and Felsovalyi (1998) investigate 1149 bank loan losses over the period 1970 to 1996 and reported an average recovery rate of 68.2%. A cross-country study by the Standard & Poor's Risk Solution Department (Franks, Servigny, Davydenko, 2004) on loans to small and medium-sized enterprises reveals that, recovery rates besides collateral may differ across countries where banks respond to different bankruptcy regimes and codes. Similarly, Grunert and Weber (2009) observe a positive relationship between collateral and recovery rate for commercial lending to German companies. Frye (2005) concludes that a high default period might make LGD more sensitive and the losses of the creditors to increase. Grunert and Weber (2009) suggest a negative relation between obligor creditworthiness and recovery rates. Also, a distressed situation in the industry itself might cause low recovery (Acharya et al., 2007). Caselli et al. (2008) assess the sensitivity of LGD to systematic risk in the Italian loan market and report that households are more sensitive to unemployment rates, default-to-loan ratio, and household consumption.

On the other hand, there exists plethora of studies in the context of performance measurement of Indian banks—using both efficiency (e.g., technical efficiency, cost efficiency, profit efficiency, etc.) as well as overall total factor productivity measures. And, factors those have been tested in the concerned literature as determinants of such performances include size of a bank, its ownership pattern, capital adequacy ratio, prevalence of stressed assets, management quality, and the like. Some of the recent studies in this regard include Das et al. (2005), Das and Ghosh (2006), Bhandari (2012; 2014), Jayaraman and Srinivasan (2016), Zaman and Bhandari (2020), and others.

Sanati and Bhandari (2022) have measured the operational efficiency of the Indian banks considering *slippage* and *NPA* as undesirable output and *advances* and *recovery* as the desired output. The DEA measure reveals that public sector banks have larger scope to improve their operational efficiency in lending and recovery while simultaneously reducing their stressed assets. Their second stage econometric analyses conclude that positive economic externalities are predominant for priority sector lending in determining the efficiency of banks while banks are found more efficient in credit risk management for shorter-term loan portfolios and secured loans. Moreover, the overall competitive scenario within the baking sector, economic growth, and low cost of funds play a noteworthy role in improving banks' operational efficiency and reducing credit risk. The study also suggests that collateral type might be more exchangeable to liquid assets to improve the recovery of stressed assets.

So, our critical review of the literature conveys that there hardly exists any study which estimates the banks' operational efficiency considering bank lending and market portfolio simultaneously. Although a large number of studies examine the determinants of NPA. And, also another spectrum of literature estimates the operational efficiency of banks that investigates the credit lending channel with the risk exposure. There is no study that has taken into consideration the investment in financial markets and our study bridges this existing gap. The next section throws light on our preliminary analyses where we hypothesize if there exists any visible difference in the trend of the performance of public and private sector banks in managing their credit risk and market risk.

3. Analytical Background

This section preludes our analysis, highlighting major differences in the trend of concerned important factors for public and private sector banks. Figure 1 shows that Slippage (additional NPA in a particular period) is more for public sector banks. On the contrary, the *recovery* rate of the public sector banks sees a sharp declining trend over this period. Hence, we conjecture that the performance of the private sector banks to manage their stressed assets is better than the public sector banks.

Table 1 shows descriptive statistics of important credit and market indicators of the Indian public and private sector banks during our study period. We find public sector banks are larger contributors to gross *advances* and *slippage* compared to their private sector counterparts. The average *slippage* for public sector banks is almost five times higher compared to its private sector counterpart, whereas in terms of gross advances, the public sector banks hold a share two times larger than that of private sector banks. We can say that while public sector banks are stumbling to manage their own credit risk, their market investment is noteworthy with a lower risk-return relations compared to private sector banks. Moreover, the (excess) kurtosis values of *slippage* show that there exists a much fatter tail for the public sector banks for their credit portfolio while the investment portfolio shows more even distribution for both public and private sector banks.

Tables 2 and 3 show the pairwise correlation structure for (a) major credit indicators and (b) market indicator variables to have an impression of their likely implications on the performance of the Indian domestic commercial banks.

Table 2 shows that each of the *slippage* and *gross advances* have a significant positive pairwise correlation with others within the same ownership group. On the contrary, a strong positive correlation is observed across asset classes for public-sector banks. Although private sector banks experience the same positive correlation, the strength of the relationship is low as indicated by their respective smaller magnitudes/values.

Table 3 shows that the pairwise correlations among bank-specific variables are significant. The negative correlation between *secured loans* (SecLoan) and *maturity*, indicates that short-term loans are more secure than long-term loans. Moreover, the positive and significant correlation between *priority sector lending* (PriSecL) and SecLoan is indicative of the fact that a bank's portfolio of priority sector lending is mostly secured with collateral. However, a negative and significant correlation indicates that PriSecL may not grow even if the *credit to deposit* (CD) ratio grows.

In this table, the Herfindahl-Hirschman index (HHI) is calculated on the basis of *gross advances* of the banks to have an idea of the extent of the competitive scenario that prevails within the Indian banking sector. The negative and significant coefficient indicates that the lending rate (LR) within the economy reduces due to this increased market capturing competitive pressure.

Figure 2 shows the recent trend in investment by the Indian public and private sector banks. Sharp positive trend is visible for Indian public sector banks' investment within India. Similarly, a positive trend holds in investment for the Indian private sector

banks within India. Moreover, public sector banks outperform private sector banks' investment in the overseas market. Furthermore, it is notable that the investment in *debentures and bonds* (excluding *Government Securities and other approved securities*) by public sector banks are outgrown private sector banks. Most interestingly, public sector banks hold a much higher share of investment in equity compared to private sector banks (Figure 3). The only asset class where the average percentage share of investment is higher for private sector banks is the *foreign exchange market*. As we see in Figure 4, private sector banks consistently hold a higher share of forex investment.

To summarize, we observe that the investment across different asset classes is much higher for the public sector banks with the exception of *forex market investment*. In the above backdrop, our objective is to estimate the operational efficiency of public and private sector banks in terms of return from the traditional banking activities; that is lending and market base investment activities. Furthermore, we examine if the ownership pattern, in addition to the bank specific and other macroeconomic variables, determine the technical efficiency of the banks.

4. Data and Methodology

We use a two-stage methodology in our study. To be specific, we use mathematical programming-based data envelopment analysis (DEA) methodology for our analyses in the first stage to obtain the technical efficiency score (TES) of the banks under study. Thus, we conceptualize the underlying production correspondence for a year by considering all the banks of that year alone, and the TES of a bank in a year is obtained by comparing it vis-à-vis that year's estimated production correspondence. Hence, we would have one TES for each bank each year. This score is used as a yardstick of the performance of a bank. We then regress these TESs in the second stage in terms of certain bank-specific, overall macroeconomic, and other market factors, which are assumed to influence the performance of a bank. As for the second-stage regression, methodology is concerned, we acknowledge that the separate cross-sectional regression for each year is preferred. It is advisable to follow as the estimated technical efficiency scores (obtained at the first stage through the DEA model) are not absolutely comparable over time, since these scores are relative measures, relative to the year-specific benchmark technology, where the benchmark itself is likely to change from one year to another. However, panel data regression is also used in the empirical literature in this regard (e.g., see Bhandari, 2014; Cheng et al., 2015; Samut and Cafri, 2016; and others). Moreover, although Tobit regression is often proposed at this stage for the fact that the value of the dependent variable (i.e., the TES obtained at the first stage) is bounded between zero and unity by definition, it is however not obvious that Tobit is the only, or optimal, approach for explaining DEA scores. In fact, it is shown in the literature that the OLS may actually in many cases replace Tobit as a sufficient second-stage DEA model (e.g., see Hoff, 2007; Banker and Natarajan, 2008; and others). Hence, we follow (a) OLS for our second-stage regression analyses; and (b) both year-specific cross-sectional as well as longitudinal regression using the entire panel of nine years' data.[5]

[5] Another strand of literature is to use bootstrap-based analyses to (a) obtain biased-corrected TES at the first stage; and (b) truncated regression for drawing consistence inference at the second stage, *a la* Simar and Wilson (2007). However, the question of bias at the conventional DEA estimation arises in the absence of true data generating process while using sample data. Nonetheless, we restrain ourselves from doing so, since we use almost the entire set of the banks under the two chosen groups (for which

DEA method, introduced by Charnes, Cooper, and Rhodes (1978) (for the case when underlying production technology is assumed to follow constant returns to scale (CRS) property) and further generalized by Banker, Charnes, and Cooper (1984) (to accommodate the case when underlying production technology follow more general variable returns to scale (VRS) property) requires no *a priori* parametric specification of the production frontier. On the basis of a sample of observed input-output data on a given set of production units, it makes a few assumptions about production technology in order to obtain a production possibility set relevant to the observed units.[6] Irrespective of the ownership, since each bank has some amount of non-performing assets (NPAs), we presume that such bad loan is a byproduct of the Indian banking business, which can't be avoided. Hence, bad loan is treated as an undesirable output.

Let us consider a production process that uses a vector of N inputs $x = (x_1, x_2, \ldots, x_n, \ldots, x_N) \in \Re_+^N$ to produce a vector of M desirable outputs $y = (y_1, y_2, \ldots, y_m, \ldots, y_M) \in \Re_+^M$ and a vector of J undesirable outputs $b = (b_1, b_2, \ldots, b_j, \ldots, b_J) \in \Re_+^J$. The relationship between input and output is represented by the following output set:

$$P(x) = \{(y,b): x \text{ can produce } (y,b)\}, x \in \Re_+^N . \quad \text{(a)}$$

The output set is assumed to satisfy the following properties:

Null-Jointness*:* It implies that production of strictly positive amount of desirable output must be accompanied by strictly positive amount of undesirable one. Formally, if

$$(y,b) \in P(x); b = 0 \Rightarrow y = 0 \quad \text{(b)}$$

Weak Disposability*:* It implies that desirable and undesirable outputs are jointly weakly disposable. Formally, if

$$(y,b) \in P(x) \text{ and } 0 \le \theta \le 1 \Rightarrow \theta(y,b) \in P(x) \quad \text{(c)}$$

In other words, reduction in undesirable output is not possible without reducing the desirable one. So, free disposability of undesirable output may not be possible.

Strong Disposability: Desirable output is strongly disposable, i.e., if

$$(y,b) \in P(x) \text{ and } y^0 \le y, \text{then } (y^0, b) \in P(x) \quad \text{(d)}$$

consistent data is available) and only a handful of them is left out. Hence, extent of bias, if any, is expected to be negligible.

[6] The basic *assumptions* about the production technology that are made in this method are as follows: (a**)** All observed input-output bundles are feasible; (b) the production possibility set is *convex* implying that given a set of *N* feasible input-output bundles, *any* weighted average of these *N* input bundles can produce the same weighted average of the corresponding *N* output bundles and (c) any input or output is *freely disposable.* However, *free disposability* assumption needs to be adjusted if bad output(s) or some input(s) use of which beyond a threshold level may have detrimental effects on production process. Nonetheless, these assumptions enable one to construct a production possibility frontier on the basis of the observed inputs-output bundles of a given set of banks, following the DEA method.

Literally, although undesirable output cannot be reduced without reducing desirable output, the reverse is possible, i.e., the desirable output can be reduced without reducing the undesirable one. So, disposal of desirable and undesirable outputs are asymmetrically treated in our analyses. We measure TE of a bank in output-oriented way[7] (i.e., expansion of desirable output, while keeping the undesirable output and usage of the inputs at their current levels). We assume VRS property for our underlying production technology. For that, we need to solve the following DEA linear programming problem (LPP), once for each bank. For instance, while evaluating k^{th} bank, the problem is:

Maximize β

Subject to

$$\sum_{i=1}^{P} \lambda_i y_i^m \geq \beta\, y_k^m \qquad \forall\ m = 1, 2, \ldots, M\ ; \qquad \text{(i)}$$

$$\sum_{i=1}^{P} \lambda_i b_i^j = b_k^j \qquad \forall\ j = 1, 2, \ldots, J\ ; \qquad \text{(ii)} \quad (1)$$

$$\sum_{i=1}^{P} \lambda_i x_i^n \leq x_k^n \qquad \forall\ n = 1, 2, \ldots, N\ ; \qquad \text{(iii)}$$

$$\sum_{i=1}^{P} \lambda_i = 1 \qquad \forall i = 1, 2, \ldots, P \qquad \text{(iv)}$$

$$\lambda_i \geq 0 \qquad \forall i = 1, 2, \ldots, P \qquad \text{(v)}$$

where P is the number of banks in a year and TES of the k^{th} bank is given by $\left(1/\beta_k^*\right)$ where β_k^* is the optimal solution of the problem (1) above. Alternatively, we have also used directional (technology) distance function to represent the technology. On the basis of Luenberger's (1992) benefit function (see Chambers at al., 1996; Färe and Grosskopf, 2000; and Färe et al., 2005), directional distance function, an extension of Shephard's input and output distance function, provides a platform for representing the joint production of *desirable* and *undesirables*. In the presence of undesirable output, if firm's objective is to simultaneously expand the desirable output and reduce the undesirable one by same proportion without increasing its input use, the directional technology distance function becomes

$$\overrightarrow{D_T}\left(x, y, b; 0, y, -b\right) = \sup\left[\beta : \left[\left(1+\beta\right)y, \left(1-\beta\right)b\right] \in P\left(x\right)\right] \qquad \text{(e)}$$

[7] One may also define an *input-oriented* technical efficiency. This is not done in the present study. See Coelli et al. (1998) and Ray (2004) for further details.

The directional distance function is obtained by solving the maximization problem as follows:

Maximize β

Subject to

$$\left\{ \sum_{i=1}^{P} \lambda_i y_i^m - \beta y_k^m \right\} \geq y_k^m \quad \forall\ m = 1, 2, \ldots, M\ ; \qquad \text{(i)}$$

$$\left\{ \sum_{i=1}^{P} \lambda_i b_i^j + \beta b_k^j \right\} = b_k^j \quad \forall\ j = 1, 2, \ldots, J\ ; \qquad \text{(ii)} \quad (2)$$

$$\sum_{i=1}^{P} \lambda_i x_i^n \leq x_k^n \quad \forall\ n = 1, 2, \ldots, N\ ; \qquad \text{(iii)}$$

$$\sum_{i=1}^{P} \lambda_i = 1 \quad \forall i = 1, 2, \ldots, P \qquad \text{(iv)}$$

$$\lambda_i \geq 0 \quad \forall i = 1, 2, \ldots, P \qquad \text{(v)}$$

and TES of the k^{th} bank is given by $\left\{1/\left(1+\beta_k^{**}\right)\right\}$ where β_k^{**} is the optimal solution of the problem (2) above. Strong disposability of desirable output and weak disposability of undesirable output are imposed through the constraints (i) and (ii) respectively in each of the problems (1) and (2). We have followed three alternative models as summarized in the Table 4 below.

In the second stage of our analyses, we employ both cross-sectional and static panel regressions. We use the estimated TES of all three models as the dependent variable and estimated cross-section regression with bank-specific variables and an ownership dummy. Similarly, we estimate panel regression under two different scenarios: (i) considering the bank-specific variables and interest rate channel; (ii) considering the bank-specific variables, along with the banking industry concentration index HHI in lending and ownership dummy. Table 5 represents the description of the variables used in our second-stage regression analyses.

Mainly we extracted data from Reserve Bank of India (RBI) database of *Statistical Tables Relating to Banks in India (STRBI).* From the STRBI, we have collected other market investment data. For capital gain or forex gain we have considered both the realized gain and mark to market revaluation. We have extracted case recovery data of the current period from the *Annual Reports* of respective banks, which provides the data from 2009-10 to 2017-18. Information on LR are extracted from the world development indicator of the World Bank.

Below, we first represent cross-sectional regression equation (1) which captures the impact of the significant determinants of the TES of the banks for each of the sample years.

$$TES_{ji} = \beta_1(Maturity_i) + \beta_2(PriSecL_i) + \beta_3(CD_i) + \beta_4(D) + \beta_5(MktIncSh_i) + \alpha + u_i \ \ldots\ldots \qquad (1)$$

In equation (1) we have used an ownership dummy defined as D = 0 for all public sector banks, and D = 1 for all private sector banks to examine the distinctive implication of ownership on TES, if any, and u_i is the idiosyncratic error term. Also, while 'i' symbolizes cross-sectional analysis, j = 1, 2, and 3 to specify three different models as we have explored.

We use static panel regression as fixed effects and random effects model in our analysis considering two important channels, for example, the *interest rate channel* and *concentration index* for lending, in addition to *bank-specific channels* and *ownership patterns of banks*. The fixed effects model controls for all time-invariant differences between the individuals. It enables one to study the causes of changes within an entity and a time-invariant characteristic cannot cause such a change, because it is *fixed* for each individual. Our analysis of *bank-specific* and other *macroeconomic factors* like lending rate channel is represented in *Panel Estimation-I*.

Panel Estimation-I.

$$TES_{jit} = \beta_1(Maturity_{it}) + \beta_2(SecLoan_{it}) + \beta_3(PriSecL_{it}) + \beta_4(CD_{it}) + \beta_5(LR_{it}) + \beta_6(MktIncSh_{it}) + \alpha_i + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$TES_{jit} = \beta_1(Maturity_{it}) + \beta_2(SecLoan_{it}) + \beta_3(PriSecL_{it}) + \beta_4(CD_{it}) + \beta_5(LR_{it}) + \beta_6(MktIncSh_{it}) + \alpha + u_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Here, in the specification of the equation (2) with α_i is the *fixed* unknown intercept for each entity. The rationale behind the random effects model is that, unlike the fixed effects model, the variation across entities is assumed to be random and uncorrelated with the predictors or the independent variables included in the model. In equation (3) *between entity error* is represented by u_{it} and *within entity error* is noted as ε_{it}.

The *Panel Estimation -II* examines equation (4) and equation (5) with *bank specific factors, macroeconomic factor* and *concentration index for lending* and *ownership* pattern of the banks

$$TES_{jit} = \beta_1(Maturity_{it}) + \beta_2(SecLoan_{it}) + \beta_3(PriSecL_{it}) + \beta_4(LR_{it}) + \beta_5(MktIncSh_{it}) + \beta_6(D_i) + \beta_7(HHI_i) + \alpha_i + \varepsilon_{it} \quad \ldots\ldots\ldots \quad (4)$$

$$TES_{jit} = \beta_1(Maturity_{it}) + \beta_2(SecLoan_{it}) + \beta_3(PriSecL_{it}) + \beta_4(LR_{it}) + \beta_5(MktIncSh_{it}) + \beta_6(D_i) + \beta_7(HHI_i) + \alpha + u_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

In all the above equations, *j* stands for efficiency scores derived from three different DEA models summarized in the Tables 4 and 6 and hence *j* = 1, 2 and 3. More specifically, Model 1 in Table 4 have been estimated using DEA methodology under two different scenarios: Scenario 11 and Scenario 12 (as elaborated in the introductory section) and obtained TES are denoted as TE11 and TE12 respectively in Table 6. Similarly for Models 2 and 3 in Table 4 and obtained TES are clubbed under TE21 and TE22 & TE31 and TE32 respectively in Table 6. This notational convention have been followed in all the subsequent Tables, including those in the Appendix, and in Figure 5. As usual, *i* stands for cross sectional unit and varies from 1 to 39 (incorporating 24 public

sector banks and 15 private sector banks) and *t* stands for time series unit and varies from 2009-10 to 2017-18,[8] indexed respectively by 1 to 9 for all the equations.

5. Empirical Findings

5.1 First Stage DEA Analyses

We summarize the findings of our (first stage) DEA analyses in this section. Table 6 reports the pairwise correlation coefficients of estimated TES for each of the alternative models we have considered: TE11 through TE32. It shows that our results are robust throughout, since TES across all the pairs are positive and significant at 1% level. Moreover, very high value of the correlation coefficient for the pairs of TE11 and TE12 (about 99%), TE21 and TE22 (about 97%), and TE31 and TE32 (96%). Such high correlation is expected also since the input-output sets are the same within each pair, however, only difference between them is that, once the TES is estimated (i) keeping undesirable output at its present level and in the other case, (ii) by allowing the possibility of reducing the undesirable output (following the idea of directional distance function). We also plot average performance scenario of the group of publicly and privately owned domestic banks in the Figure 5. It shows that, private sector banks as a group outperform those under public ownership. Moreover, although the private sector banks could maintain somewhat consistency in their operational efficiency performance over time, public sector banks clearly show a declining tendency, except for the last year in a few cases. To be specific, average TES of the public (private) sector banks as a group for our entire sample period are 97.8% (98.3%), 97.8% (98.3%), 96.3% (98.5%), 96.3% (98.6%), 95.7% (98.4%), and 95.5% (98.6%) respectively for our six models TE11 through TE32. In other words, according to the TE11, an average public (private) sector bank has an opportunity to proportionally expand its *Advances* and *Non-Interest Income* by 2.26% (1.77%) further while keeping its *Slippage* and four inputs (viz. *total fixed assets*; *deposits*; *operating expenses*; and *Investments*) at their current levels. One may have similar interpretation for other models TE21 and TE31 as well. For the directional distance function results in TE12 model, an average public (private) sector bank has an opportunity to proportionally expand its *Advances* and *Non-Interest Income* and simultaneously contract its *Slippage* by 2.28% (1.71%) further while keeping its four inputs (viz. *total fixed assets*; *deposits*; *operating expenses*; and *Investments*) at their current levels. And, likewise one may have similar explanation of the results for the Models TE22 and TE32. Further details on individual bank-wise average TES over our entire sample period is reported in the Table A1 of the Appendix. Table A2 is simply Table A1's counterpart, interpreting TES in terms of further possibility of (proportional) expansion of desirable output(s) (in models TE11, TE21, and TE31) and that along with contraction of undesirable output (in models TE12, TE22, and TE32).

Figure 5 presents a comparative framework of TES of banks on the basis of ownership pattern. Overall, we can conclude that private sector banks have been outperforming the public sector banks in managing credit risk with a widening gap over time. Hence, opportunity of the public sector banks is relatively more to improve their

[8] For extensive mergers and acquisitions of public sector banks in India in the year 2018, 2019 and 2020, we exclude these years from our analyses. This helps us to keep the standard of the data without losing much of information.

performance even better as compared with their counterparts under the private ownership.

5.2 Second Stage Econometric Analysis

Our estimated cross-sectional regression results (reported in Table 7) reveal important factors determining the technical efficiencies of Indian commercial banks from 2009-10 to 2017-18. We have reported the best-fitted model for respective years. Overall, we observe banks' technical efficiency increases with the increase in *credit-deposit ratio* (CD). However, with the increase in the share of income from market-based investment, banks experienced reduction in technical efficiency scores linked to traditional lending activity of the banks and forex gain for the years 2013, 2015, 2016 and 2017. On the contrary, it shows positive impact on technical efficiency of the banks estimated from lending activity and capital gain during 2012 and 2014. Moreover, banks are more efficient in handling short-term loans better than long-term loans. It is also observed that the priority sector lending norm clearly has negative implications on banks' efficiency, possibly through the concerned constraint on a bank's operational flexibility. Nonetheless, such norm can be justified from its overall contribution to social development. Also, private sector banks are better performers in the technical efficiency scale compared to public sector banks in most of the sample periods.

Our estimated panel regression analyses of *Panel Estimation I and Panel Estimation II* as reported in the Tables 8 and Table 9 respectively, show similar kind of results. Notably, the priority sector loans show negative and significant impact on TES for the models TE21, TE22, TE31 and TE32. It might be an important finding as priority sector loan gets special emphasis due to their likely social benefit and overall contribution to economic growth. So, it is expected that if the desirable output is C*apital Gain* and gain from the *Forex Market*, lending towards the priority sector reduces the banks' TES. Interestingly, the negative and significant coefficient values for maturity in models relating to TE32 (in both Tables 8 and 9) reveals that the banks manage credit risk more efficiently for short-term loan portfolios when we allow the slippage to fall proportionately to the increase in the return from the credit channel and investment channel. On the contrary, if slippage is allowed to be at the same rate while there is an increase in traditional lending and market-based investments (TE21 in Table 8; and TE31 in both Tables 8 and 9) we find that banks' TES is better for the longer term loans. So, we can conclude that if banks are to reduce their stressed assets, they might have to rely on shorter-term loans. Also, negative and significant coefficient value for *Secured Loans* reveals that the bank's TES is low as the size of the collateral increases (possibly as the loan size increases). Banks are not so efficient in managing large-size loans. It is also observed that the lending practices have further chances to improve the *credit-to-deposit* (CD) ratio, which in turn would improve the banks' efficiency in managing their credit risk. In Tables 8 and 9, we observe the relationship between the lending rate and the TES is mostly negative and significant. It implies that the overall operational efficiency of the banks to manage their credit risk portfolio improves with a reduction in the lending rate. This is due to the fact that a decrease in the cost of funds would have some favourable effect on the demand for loans. However, the interaction of lending activity and capital market returns in Models TE21 and TE22 (in Table 8) shows a positive impact of TES of the banks. It may be because that with the increase in lending rate, corporate borrowers may switch to capital market for desired funds, which induces banks to explore investment opportunities therein, which in turn has a positive market sentiment. Also,

share of income from capital market shows a positive and significant impact on the TES of banks linked to lending and gain from capital market investment (TE21 and TE22 in both Tables 8 and 9. However, a negative relationship exists for this income share with TES for TE32 in Table 9. It may be due to the fact that gain from the forex market engagements is subject to global market conditions.

In addition, we also observe that the coefficient of the HHI is negative and significant for the models presented in Table 9 (TE21 and TE22). Given that HHI is a measure of market concentration, we can conclude that banks' operational efficiency to extend *Advances* (earning loans) and with a high capital gain decreases with the increase in market concentration (i.e., reduction of market competition). Moreover, Table 9 shows that private sector banks' TES in capturing market return while doing traditional lending activities is higher than the public sector banks and gets strengthened during the later periods.

6. Conclusion

In the backdrop of an increase in market-based banking activities, our study contributes to the literature by estimating Indian banks' operational efficiency scores during 2009-10 to 2017-18 considering *Capital Gain and Gain from Forex Market* (as desirable outputs) and S*lippage* (as undesirable byproducts) simultaneously. We introduce such capital market factors along with *Advances*—a desirable output considered in the traditional literature pertaining to the performance assessment of the banking sector. To the best of our knowledge, there exists no such study that estimates the technical efficiency score (TES) of banks considering traditional banking, that is lending, and market-based banking activities. We employ the DEA method to estimate six (i.e., three separate models, each having two variants) alternatives but interlinked operational efficiency scores in managing the credit risk and market investment of Indian commercial banks. In the next step, using the estimated TES as the yardstick of a bank's performance, we examine the determinants of such performance by considering bank-specific factors, banking industry competition scenario, and interest rate channel.

We observe that the private sector banks as a group outperform those under public ownership. Moreover, although the private sector banks could maintain somewhat consistency in their operational efficiency performance over the sample period, public sector banks clearly show a declining tendency, with a minor exception for a few cases. To be specific, average TES of the public (private) sector banks as a group for our entire sample period are 97.8% (98.3%), 97.8% (98.3%), 96.3% (98.5%), 96.3% (98.6%), 95.7% (98.4%), and 95.5% (98.6%) respectively for our six models TE11 through TE32. In other words, according to the TE11, an average public (private) sector bank has an opportunity to proportionally expand its *Advances* and *Non-Interest Income* by 2.26% (1.77%) further while keeping its *Slippage* and four inputs (viz. *total fixed assets*; *deposits*; *operating expenses*; and *Investments*) at their current levels. For the model TE12, an average public (private) sector bank has an opportunity to proportionally expand its *Advances* and *Non-Interest Income* and simultaneously contract its *Slippage* by 2.28% (1.71%) further while keeping its four inputs (viz. *total fixed assets*; *deposits*; *operating expenses*; and *Investments*) at their current levels.

Our second stage of econometric estimations shows interesting results. Notably, the priority sector loans show a negative and significant impact on TES as banks oblige

to such loans under regulatory constraints which are to be considered as a part of social obligation that have likely beneficial effects. Interestingly, we get varying results for the relationship between maturity and TES depending on banks' strategies on stressed assets management. We conclude that the banks' TES is high for the short-term loan portfolios when we allow the slippage to fall proportionately to the increase in the return from the credit and investment channels. On the contrary, banks' TES is high for long-term loans if slippage is allowed to be at the same rate while there is an increase in traditional lending and other market-based investments. Furthermore, our analyses result that banks are not so efficient in managing relatively larger-volume loans. We conclude that banks' TES positively depends on the *Credit-to-Deposit* (CD) ratio. We find that the overall operational efficiency of the banks to manage their credit risk portfolio improves with a reduction in the lending rate. However, the interaction of lending activity and capital market shows that, with the increase in *Lending Rate* (LR), corporate may move to the capital market for exploring investment opportunities, which in turn has a positive market sentiment. Also, income share from capital and forex market activities shows a positive and significant impact on the TES where the return from traditional banking is linked with the gain from the capital market investment. We get the opposite result for forex market investment possibly due to its high volatility on the basis of the global market conditions.

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Table 1: Descriptive Statistics for Public and Private Sector Banks during the Sample Period 2009-10 to 2017-18

Public Sector Banks			
	Slippage	***Gross Advances***	***Total Investment***
Average (Rupees Crore)	9062.5	225348.3	30165.84
Standard Deviation (Rupees Crore)	14778.0	317674.8	7885.96
Coefficient of Variation	163%	141%	0.2614
Skewness	6.47	4.16	– 0.7567
Kurtosis	59.77	18.48	– 0.9650
Private Sector Banks			
Average (Rupees Crore)	1972.8	79131.6	11718.51
Standard Deviation (Rupees Crore)	4929.3	124087.6	4830.33
Coefficient of Variation	250%	157%	0.4122
Skewness	4.90	2.55	0.0894
Kurtosis	26.05	6.32	– 1.2992

Source: Authors' Own Calculation using RBI Database and Banks' Annual Reports

Table 2: Correlation of Market and Credit Variables of Public and Private Sector Banks Comparison (2009-10 to 2017-18)

Market Investment						
	Gsec_Pub	***SH_Pub***	***DB_Pub***	***Gsec_Prv***	***SH_Prv***	***DB_Prv***
Gsec_Pub	1					
SH_Pub	0.83***	1				
DB_Pub	0.9146***	0.7881***	1			
Gsec_Prv	0.1378*	0.2274***	0.4702***	1		
SH_Prv	0.416***	0.5212***	0.5786***	0.6162***	1	
DB_Prv	0.1269*	0.1758**	0.3607***	0.7494***	0.5683***	1

Credit Risk				
	Slipp_Pub	***GrAdv_Pub***	***Slipp_Prv***	***GrAdv_Prv***
Slipp_Pub	1			
GrAdv_Pub	0.7623***	1		
Slipp_Prv	– 0.0019	– 0.1269	1	
GrAdv_Prv	0.0316	– 0.1053	0.7741***	1

Note: *, **, and *** indicate significance at respectively 10%, 5%, and 1% levels.

Pub: Public sector Banks; Prv: Private Sector Banks. Under Market Investment, Gsec: in Government Securities; SH: in Shares; and DB: in Debentures and Bonds. Under Credit Risk, Slipp: Slippage; and GrAdv: Gross Advances.

Source: Authors' Own Calculation using RBI Database

Table 3: Correlation of Bank Specific Variables[9] and Macroeconomic Variables during 2009-10 to 2017-18

Bank-Specific Variables				
	Maturity	***SecLoan***	***PriSecL***	***CD***
Maturity	1			
SecLoan	– 0.43***	1		
PriSecL	– 0.34***	0.50***	1	
CD	0.35***	– 0.22***	– 0.41***	1
Macroeconomic Variables				
	LR	***HHI***		
LR	1			
HHI	– 0.74**	1		

Note: ** and *** indicate significance at respectively 5% and 1% levels.

SecLoan: Secured Loan; PriSecL: Priority Sector Lending; CD: Credit to Deposit Ratio; LR: Lending Rate; and HHI: Herfindahl-Hirschman Index.

Source: Authors' Calculation using RBI database

[9] For description of the variables, see Section 4.

Table 4: Description of the Alternative Models used in the First Stage DEA Analyses

	Model		
	Model 1	***Model 2***	***Model 3***
Desirable Output	Advances; and Non-Interest Income	Advances; and Capital Gain	Advances; and Forex Gain
Undesirable Output	Slippage	Slippage	Slippage
Common Inputs	Total Fixed Assets; Deposits; and Operating Expenses.		
Fourth Input	Investment	Equity, Bond, and other Assets.	

Note: Models 1, and 2 are based on LPP (1), while Model 3 is based on LPP (2);
$M = 2, J = 1$ and $N = 4$ in all three Models;
We follow RBI definition for each of the variables.

Source: Authors' Compilation.

Table 5: Summarization of Variable for 1st stage and 2nd stage model

Variable	***Description***
Maturity	Ratio of share of term loans to total loans. This ratio is an indicator of longer term loan contract to fund medium to long-term projects, which reflect better relationship between banks and borrowers
Secured loan (SecLoan)	Proportion of secured loans to total loans. This ratio indicates how much collateral cushion the bank has against the loan amount and reflects the bank's approach towards risk management.
Priority Sector Loan (PriSecL)	Priority sector loan to total loan. This ratio is taken in order to account for the argument that the priority sector loans are responsible for most number of defaults in banks in India.
Credit-Deposits Ratio (CD)	It reflects credit orientation of the bank to earn more money through deposits. This variable is considered in order to capture aggressiveness of the banks' lending activity, which can lead to NPAs. The higher the ratio, the higher the loan-assets created from deposits.
Slippage	Fresh Addition to NPAs during the year as a percentage of total standard advances at the beginning of the period. Strong credit appraisal and timely monitoring of loans is a foundation to avoid slippages in the account. Recent crisis suggest negative relationship between rising slippages and recovery of the banks
Operating Expenses	It is an indicator of banks' usual day-to-day operations and other business-related activities in carrying out due diligence in application, credit deployment, monitoring and recovery of loans[10].

[10] Banking Stability Map and Indicator – CAMELS rating (see the link https://rbidocs.rbi.org.in/rdocs/PublicationReport/Pdfs/9FSRDECANNEX21FA6045AFD51466D877FA56DFEB448F1.pdf)

Herfindahl-Hirschman index (HHI)	This is calculated by squaring the market share of each bank gross advances and then summing the resulting numbers. This is an indicator of market competition.
Lending Rate (LR)	Lending rate in India at which banks lend to its most creditworthy customer.
Market Income Share (MktIncSh)	Income from Capital Market Engagement, defined as the ratio of sum of Capital Gain and Incomes from Forex Market as a Share of Total Income.
Dummy	Represent bank ownership. Public sector banks are scaled as *zero* and private sector banks as *one*
Capital gain	Describes the realized gain and mark to market revaluation
Forex gain	Describes the realized gain and mark to market revaluation
Interest earned on Investment	Describes the total interest income earned from the investment.
Abbreviation, if any, is shown in the parenthesis.	

Source: Authors' Own Compilation.

Table 6: Correlation of Technical Efficiency Scores of the Banks during 2009-10 to 2017-18

	TE11	***TE12***	***TE21***	***TE22***	***TE31***	***TE32***
TE11	1					
TE12	0.9896***	1				
TE21	0.4906***	0.4808***	1			
TE22	0.4653***	0.4606***	0.9661***	1		
TE31	0.5923***	0.5769***	0.6914***	0.6546***	1	
TE32	0.5693***	0.5586***	0.6515***	0.6547***	0.9575***	1

Note: *** indicate significance at 1% level.

Source: Authors' Own Estimation using RBI Database and Annual Report of Individual Banks.

Table 7: Determinants of DEA Technical Efficiency Scores - Cross Section Regression Analysis

2010		***2011***		***2012***	
T32		***T31***		***TE21***	
Maturity	– 0.0016**	Maturity	– 0.002	Maturity	– 0.0014**
CD	0.0056***	PriSecL	– 0.007958***	CD	0.0027**
D	0.0240	D	0.0435**	D	– 0.0092
MktIncSh	0.7468	MktIncSh	– 0.6664	MktIncSh	1.9772*
Constant	0.6169***	Constant	1.3126***	Constant	0.8339***
	Adjusted R^2 =27.38%		Adjusted R^2 =27.35%		Adjusted R^2 =20.76%
	F=4.39***		F=4.35***		F=3.36**
2013		***2014***		***2015***	
TE32		***TE22***		***TE32***	
Maturity	– 0.0006	Maturity	0.000	PriSecL	– 0.0025**
PriSecL	– 0.0020	PriSecL	– 0.001	D	0.0216
CD	0.00179*	CD	0.001	MktIncSh	– 1.6877***
D	0.02374*	D	0.0393***	Constant	1.0849***
MktIncSh	– 1.9344**	MktIncSh	1.5666*		
Constant	.94086***	Constant	0.9166***		
	Adjusted R^2 =30.36%		Adjusted R^2 =20.31%		Adjusted R^2 =34%
	F=4.14***		F=2.84**		F=7.18***
2016		***2017***		***2018***	
TE32		***TE31***		***TE11***	
Maturity	– 0.0007	Maturity	– 0.00191**	Maturity	– 0.0008
PriSecL	– 0.0017	PriSecL	– 0.0022	CD	0.00413***
CD	0.0035**	CD	0.0065***	D	– 0.0560**
D	– 0.0172	D	– 0.0653**	MktIncSh	– 0.3314
MktIncSh	– 2.3859**	MktIncSh	– 0.7735*	Constant	0.7491***
Constant	0.8476***	Constant	0.7318***		
	Adjusted R^2 =28.24%		Adjusted R^2 =50.8%		Adjusted R^2 =35.6%
	F=3.83***		F=8.4***		F=6***

Note: *, **, and *** indicate significance at respectively 10%, 5%, and 1% levels.

We have presented only the best fitted model selected on the basis of Adjusted R-square value for the respective years.

#Variable description is reported in Table 7

Source: Authors' Own Estimation

Table 8: Panel Estimation – I: Impact of Bank Specific and Credit Channel on TES

	TE11		***TE12***		***TE21***	
	FE	***RE***	***FE***	***RE***	***FE***	***RE***
Maturity	0.0001	– 0.0001	0.0001	– 0.0001	– 0.0001	0.0006*
SecLoan	0.0001	– 0.0001	0.0001	0.0000	– 0.0002	– 0.0001
PriSecL	– 0.0001	– 0.0002	– 0.0001	– 0.0002	– 0.0018**	– 0.0014**
CD	0.0015***	0.0016***	0.0015***	0.0014***	0.0036***	0.0031***
LR	– 0.0011	– 0.0033	– 0.0005	– 0.0029	0.0130*	0.0142*
MktIncSh	0.0633	– 0.0056	0.0836	0.0170	0.8367***	0.7566***
Constant	0.860***	0.917***	0.8542***	0.9132***	0.6344***	0.6662***
Hausman	Chi2: 3.58(p=0.7335)		Chi2: 3.31(p=0.7688)		Chi2: 6.51(p=0.3685)	
	TE22		***TE31***		***TE32***	
	FE	***RE***	***FE***	***RE***	***FE***	***RE***
Maturity	8.45E-06	0.0005	– 0.0004	0.0011***	0.0003	– 0.0009***
SecLoan	– 0.0001	0.0001	– 0.0011**	– 0.0008	– 0.0007	– 0.0005
PriSecL	– 0.00164**	– 0.0013**	– 0.0014*	– 0.0012*	– 0.0014*	– 0.0012*
CD	0.0030***	0.0027***	0.0032***	0.0034***	0.0028***	0.0031***
LR	0.0120*	0.0125*	– 0.0085	– 0.0115	– 0.0096	– 0.0129*
MktIncSh	0.8349***	0.7585***	– 0.0299	– 0.1708	0.03281	– 0.112
Constant	0.6642***	0.6928***	0.9793***	0.9979***	0.9807***	1.0010***
Hausman	Chi^2: 4.71(p=0.5815)		Chi^2: 11.36(p=0.0779)		Chi^2: 16751(p=0.0104)	

Note: *, **, and *** indicate significance at respectively 10%, 5%, and 1% levels.

We couldn't reject the null hypothesis of the Hausman test for all of the models except TE31 and TE32. Other than these two models, the Hausman test reveals there exists no systematic difference between fixed effects and random effects model

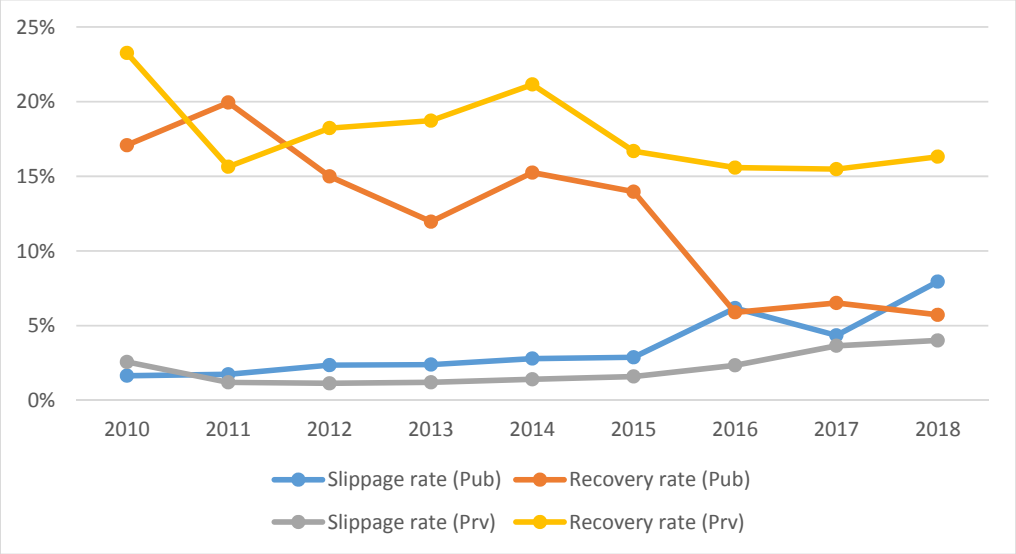
Source: Authors' Own-Estimation.

Table 9: Panel Estimation – II: Impact of Bank-Specific Variables, Credit Channel, and Ownership Pattern on TES

	TE11	***TE12***	***TE21***	***TE22***	***TE31***	***TE32***
Maturity	0.0001	0.0001	– 0.0003	– 0.0002	0.0007*	– 0.0006*
SecLoan	– 0.0002	– 0.0001	– 0.0002	– 0.0001	– 0.0008	– 0.0006
PriSecL	– 0.0008*	– 0.00082*	– 0.0026***	– 0.0024***	– 0.0027***	– 0.0025***
LR	– 0.0120*	– 0.0118*	– 0.0008	– 0.0005	– 0.0219**	– 0.0233**
MktIncSh	– 0.1335	– 0.0989	0.5209***	0.5595***	– 0.4549**	– 0.3451*
D	0.0041	0.0050	0.0283***	0.0303***	0.0272**	0.03144**
HHI	– 1.1858	– 1.2629	– 2.0209637*	– 1.7755*	– 1.0276	– 1.2000
Constant	1.2357***	1.2355***	1.2497***	1.2044***	1.4721***	1.4626***

Note: *, **, and *** indicate significance at respectively 10%, 5%, and 1% levels.
Source: Authors' Own-Estimation.

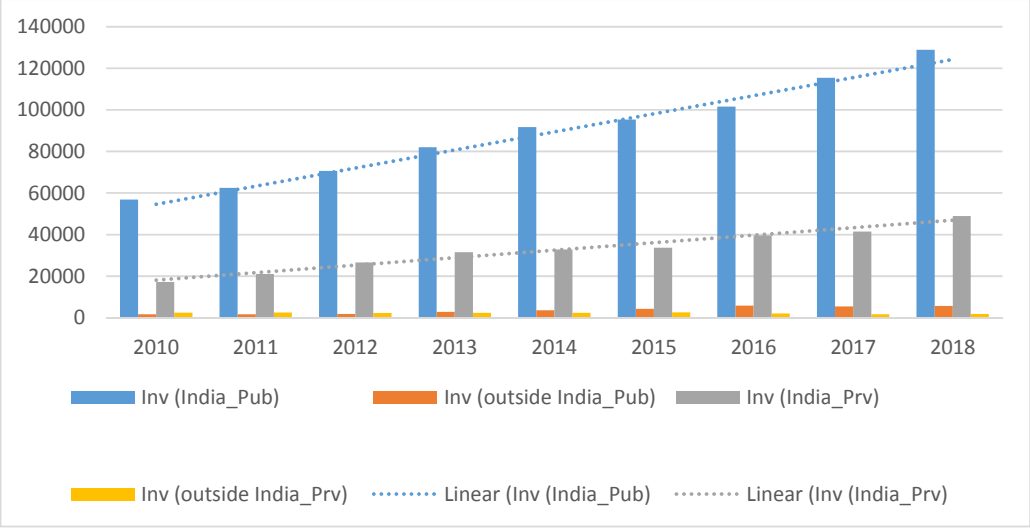
Figure 1: Trend in Slippage and Recovery between Public and Private Sector Banks (2009-10 to 2017-18)



Note: Slippage - Fresh Addition to NPAs during the year as a percentage of total standard advances at the beginning of that year. Strong credit appraisal and timely monitoring of loans are foundations to avoid slippages in the account. Recent crises suggest a negative relationship between rising slippages and recovery of the banks; Recovery -- The cash recovery of the bank. This does not include the amount of write-off and/or upgradation.

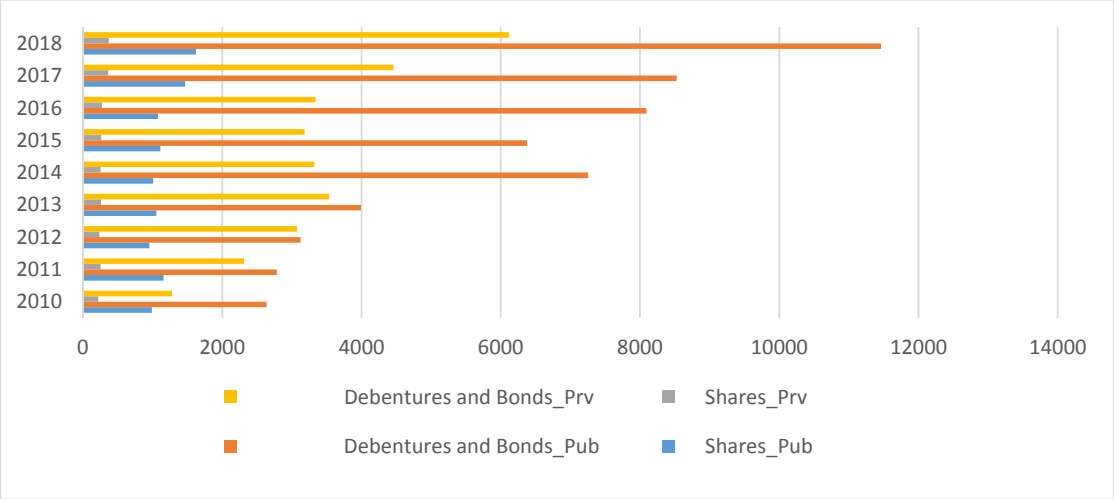
Source: Authors' Own Compilation using RBI Database.

Figure 2: Investment Trend of Public and Private Sector Banks – Within and Overseas



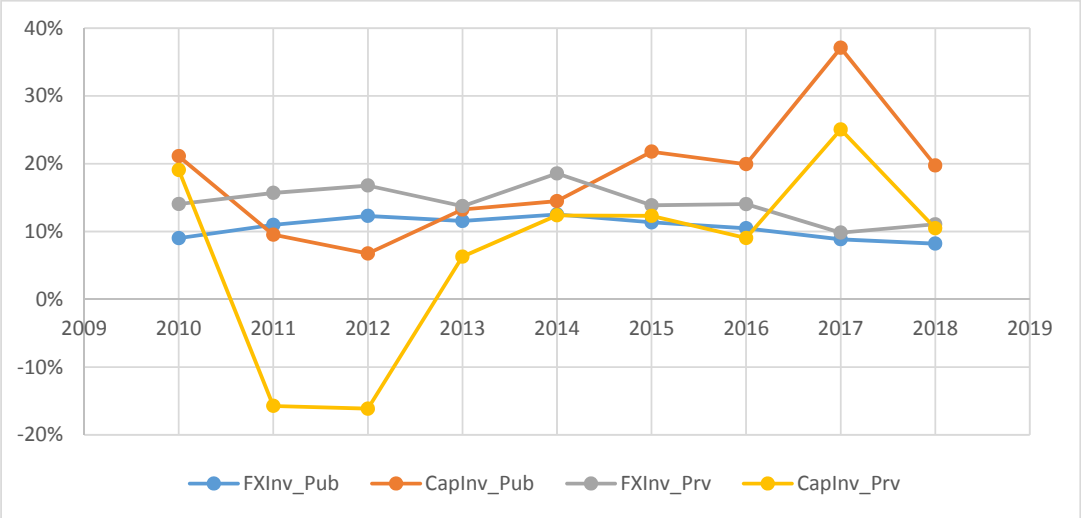
Source: Authors' Own Calculation: RBI Database

Figure 3: Equity and Bond Investments for Public and Private Sector Banks



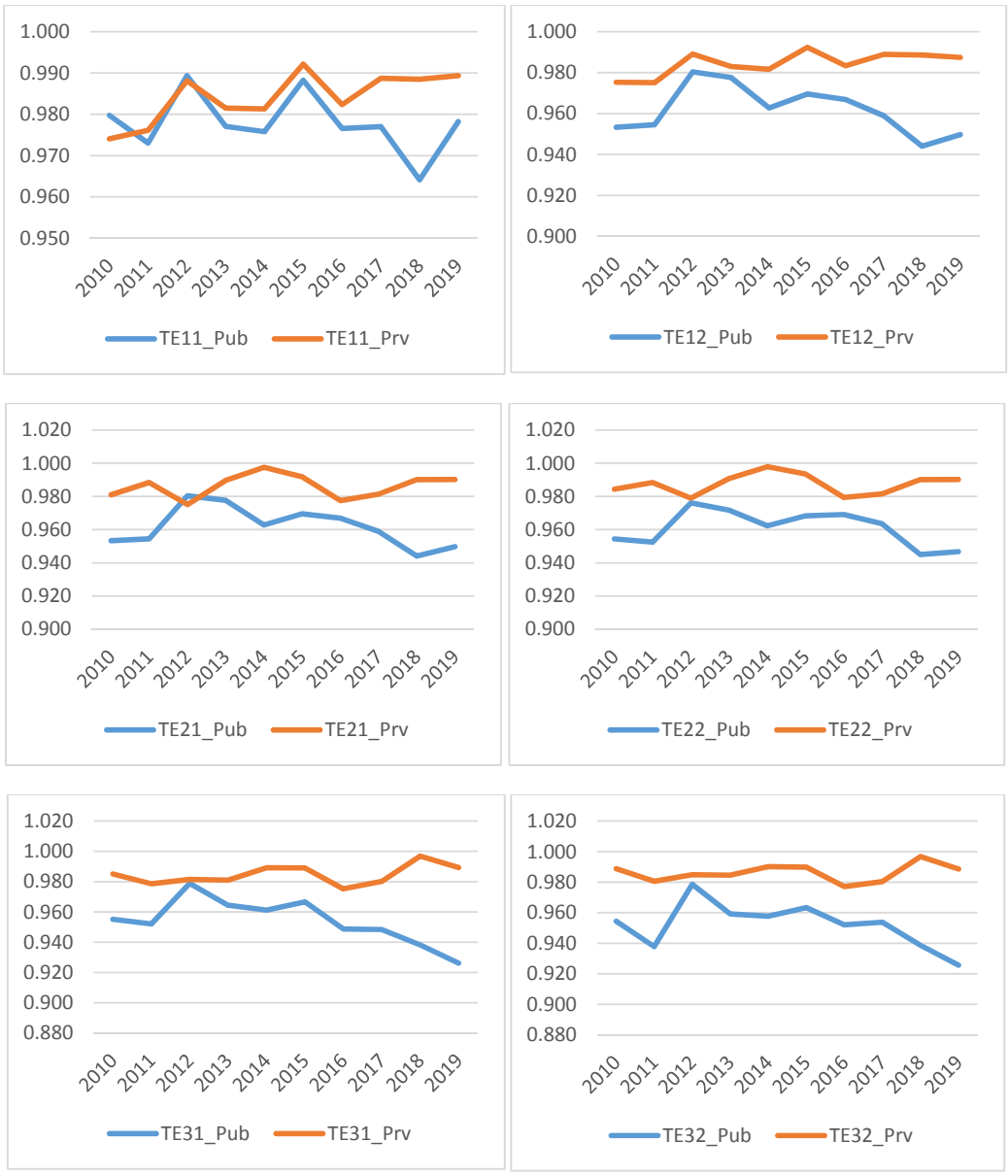
Source: Authors' own calculation from the RBI database

Figure 4: Capital Market and Forex Market Investment of Public and Private Sector Banks



Source: Authors' Own Calculation from RBI database

Figure 5: Ownership-Wise Performance of Indian Commercial Banks



Note: Comparative performance as per the ownership pattern.

Source: Authors' Own estimation.

Appendix

Table A1: Individual Bank-Wise Average TE Score during 2009-10 to 2017-18

Public Sector Banks						
	TE11	***TE12***	***TE21***	***TE22***	***TE31***	***TE32***
Allahabad	0.947	0.945	0.936	0.934	0.918	0.912
Andhra Bank	0.992	0.992	1.000	1.000	1.000	1.000
Bank of Baroda	0.998	0.999	0.996	0.997	1.000	1.000
Bank of India	0.984	0.988	0.975	0.968	0.994	0.991
Bank of Maharashtra	0.950	0.949	0.915	0.917	0.914	0.916
Canara Bank	1.000	1.000	0.993	0.991	0.987	0.989
Central Bank of India	0.951	0.951	0.867	0.876	0.863	0.867
Cooperation Bank	1.000	1.000	1.000	1.000	1.000	1.000
Dena Bank	0.940	0.939	0.890	0.889	0.881	0.877
IDBI Bank	1.000	1.000	1.000	1.000	1.000	1.000
Indian Bank	0.975	0.972	0.940	0.940	0.959	0.962
Indian Overseas Bank	0.980	0.978	0.966	0.955	1.000	0.990
Oriental Bank of Commerce	0.982	0.980	0.954	0.950	0.959	0.949
Punjab and Sind Bank	0.986	0.986	0.971	0.976	0.971	0.976
Punjab National Bank	0.991	0.989	0.977	0.973	0.977	0.972
Syndicate Bank	0.988	0.988	0.987	0.982	0.984	0.979
UCO Bank	0.982	0.983	0.960	0.963	0.964	0.968
Union Bank of India	0.990	0.991	0.973	0.975	0.990	0.990
Syndicate Bank	0.986	0.986	0.970	0.970	0.974	0.972
UCO Bank	0.982	0.983	0.960	0.963	0.964	0.968
Union Bank of India	0.990	0.991	0.973	0.975	0.990	0.990
United Bank of India	0.910	0.913	0.976	0.973	0.799	0.794
Vijaya Bank	0.990	0.990	0.949	0.956	0.940	0.927
State Bank of India and Associates	1.000	1.000	1.000	1.000	1.000	1.000
Overall Public Sector Banks	**0.979**	**0.979**	**0.964**	**0.963**	**0.959**	**0.958**

Private Sector Bank						
	TE11	***TE12***	***TE21***	***TE22***	***TE31***	***TE32***
City Union Bank	0.987	0.988	1.000	1.000	1.000	1.000
Federal Bank	0.975	0.976	0.970	0.974	0.939	0.944
Jammu and Kashmir Bank	0.950	0.951	0.943	0.954	0.898	0.916
Karnataka Bank	1.000	1.000	1.000	1.000	1.000	1.000
Karur Vysya Bank	0.954	0.957	0.972	0.973	0.972	0.973
Lakshmi Vilas Bank Ltd	0.991	0.987	1.000	1.000	1.000	1.000
Ratnakar Bank	1.000	1.000	1.000	1.000	1.000	0.997
South Indian Bank	0.931	0.934	0.985	0.987	0.985	0.976
Tamilnad Mercantile Bank Ltd	0.978	0.979	0.957	0.959	0.972	0.987
Development Credit Bank Ltd.	1.000	1.000	1.000	1.000	1.000	1.000
HDFC Bank Ltd	1.000	1.000	1.000	1.000	1.000	1.000
ICICI Bank Ltd	1.000	1.000	0.983	0.983	1.000	1.000
Kotak Mahindra Bank Ltd	0.968	0.970	0.960	0.963	1.000	1.000
Axis Bank	0.988	0.990	0.988	0.990	0.978	0.982
Yes Bank	1.000	1.000	1.000	1.000	1.000	1.000
Overall Private Sector Banks	**0.981**	**0.982**	**0.984**	**0.986**	**0.983**	**0.985**

Source: Authors' Own Compilation.

Table A2: Individual Bank-Wise Scope of Further Improvement

Public Sector Banks						
	TE11	***TE12***	***TE21***	***TE22***	***TE31***	***TE32***
Allahabad	0.056	0.058	0.068	0.070	0.090	0.096
Andhra Bank	0.008	0.008	0.000	0.000	0.000	0.000
Bank of Baroda	0.002	0.001	0.004	0.003	0.000	0.000
Bank of India	0.016	0.012	0.026	0.033	0.006	0.009
Bank of Maharashtra	0.052	0.054	0.093	0.091	0.094	0.092
Canara Bank	0.000	0.000	0.007	0.009	0.013	0.011
Central Bank of India	0.051	0.052	0.153	0.141	0.159	0.154
Cooperation Bank	0.000	0.000	0.000	0.000	0.000	0.000
Dena Bank	0.064	0.065	0.124	0.125	0.135	0.140
IDBI Bank	0.000	0.000	0.000	0.000	0.000	0.000
Indian Bank	0.026	0.029	0.063	0.064	0.042	0.040
Indian Overseas Bank	0.021	0.022	0.036	0.047	0.000	0.010
Oriental Bank of Commerce	0.018	0.020	0.048	0.053	0.043	0.054
Punjab and Sind Bank	0.015	0.015	0.030	0.025	0.030	0.025
Punjab National Bank	0.010	0.011	0.024	0.028	0.024	0.029
Syndicate Bank	0.012	0.012	0.013	0.018	0.016	0.022
UCO Bank	0.018	0.017	0.041	0.038	0.037	0.033
Union Bank of India	0.010	0.010	0.028	0.026	0.010	0.010
Syndicate Bank	0.014	0.014	0.030	0.031	0.027	0.029
UCO Bank	0.018	0.017	0.041	0.038	0.037	0.033
Union Bank of India	0.010	0.010	0.028	0.026	0.010	0.010
United Bank of India	0.099	0.096	0.025	0.028	0.251	0.260
Vijaya Bank	0.010	0.010	0.054	0.046	0.064	0.079
State Bank of India and Associates	0.000	0.000	0.000	0.000	0.000	0.000
Overall Public Sector Banks	**0.022**	**0.022**	**0.039**	**0.039**	**0.045**	**0.047**

Private Sector Bank						
	TE11	***TE12***	***TE21***	***TE22***	***TE31***	***TE32***
City Union Bank	0.013	0.013	0.000	0.000	0.000	0.000
Federal Bank	0.026	0.025	0.031	0.027	0.065	0.059
Jammu and Kashmir Bank	0.053	0.052	0.060	0.048	0.113	0.092
Karnataka Bank	0.000	0.000	0.000	0.000	0.000	0.000
Karur Vysya Bank	0.048	0.045	0.029	0.028	0.029	0.028
Lakshmi Vilas Bank Ltd	0.009	0.014	0.000	0.000	0.000	0.000
Ratnakar Bank	0.000	0.000	0.000	0.000	0.000	0.003
South Indian Bank	0.074	0.071	0.015	0.013	0.015	0.025
Tamilnad Mercantile Bank Ltd	0.022	0.021	0.045	0.043	0.029	0.013
Development Credit Bank Ltd.	0.000	0.000	0.000	0.000	0.000	0.000
HDFC Bank Ltd	0.000	0.000	0.000	0.000	0.000	0.000
ICICI Bank Ltd	0.000	0.000	0.017	0.017	0.000	0.000
Kotak Mahindra Bank Ltd	0.033	0.031	0.042	0.039	0.000	0.000
Axis Bank	0.012	0.010	0.012	0.010	0.022	0.018
Yes Bank	0.000	0.000	0.000	0.000	0.000	0.000
Overall Private Sector Banks	**0.019**	**0.019**	**0.017**	**0.015**	**0.018**	**0.016**

Source: Authors' Own Compilation.