Gaining insights into the efficiency of the Indian banking sector

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Abstract

This research paper aims to study the efficiency of around 50 Indian Banks in the period 2009-2014, comparing state banks, nationalized banks, private banks and foreign banks. Banks are key players in, and enablers of, a healthy national financial system, and their efficiency, efficacy and profitability help to pave a country's economic growth and support its population's welfare. Previous studies report two opposite trends: on the one hand that public banks exhibit more efficiency than private/foreign banks: and on the other hand that private/foreign banks are more efficient than public ones. This paper uses Data Envelopment Analysis with an intermediation approach and an input-oriented model, to analyse the sample. Two models are developed to account for the classic approach to banking and the new electronic banking model. The main findings are: (a) "foreign" banks appear to be more oriented towards electronic banking for intermediation purposes, (b) "private" banks showed the greatest efficiency in the period 2009-2012 whereas in the period 2013-2014 state banks were the most efficient in terms of the classic intermediation approach.

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Sobre la eficiencia del
sector bancario de la India

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Resumen

En este artículo se estudia la eficiencia de una cincuentena de bancos indios en el periodo 2009-2014, comparando los bancos públicos, los nacionalizados, los privados y los extranjeros. Los bancos son actores cruciales en (e impulsores de) la salud financiera del sistema financiero doméstico, y su eficiencia, eficacia y rentabilidad y ayudan a allanar el camino del crecimiento económico constituyendo un buen soporte para el bienestar de la población. Estudios previos indican dos tendencias opuestas: (i) los bancos públicos muestran una mayor eficiencia que los privados/extranjeros; (ii) estos últimos son más eficientes que los públicos. Este artículo analiza la muestra de bancos con la técnica del Análisis Envolvente de Datos, con un enfoque de intermediación y un modelo orientado a inputs. Se desarrollan dos modelos para dar cuenta del enfoque clásico bancario y del nuevo modelo de banca electrónica. Los principales resultados obtenidos son los siguientes: (a) los bancos "extranjeros" parecen mostrar una mayor orientación a la banca electrónica en lo que a intermediación se refiere, (b) los bancos "privados" son los más eficientes en el periodo 2009-2012, mientras que en 2013-2014 son los bancos públicos los que asumen esta posición en términos del enfoque clásico de intermediación.

Palabras clave:

Sector bancario, India, eficiencia, análisis envolvente de datos.

■ 1. Introduction

The good performance of a country's financial system brings health to the economy, makes significant contributions to population welfare and enables national growth. What is more, a key driving force in any country is the efficiency and efficacy of the financial system, which stems from the performance of its commercial banks. Banks are the mechanism through which funds are spread through the real economy, leveraging development of other industries and citizens. They can even improve macroeconomic metrics such as GDP, unemployment rate and wages, among others (Verma and Bodla, 2011; Chhikara and Rani, 2012; Kumari and Prasad, 2015). Moreover, studying bank efficiency allows comparison of a particular bank with the best practices of its peers, as well as allowing assessment of whether a policy has an effect on bank efficiency and to quantify that effect (Sahoo and Mandal, 2011). Despite its importance, the banking industry in India does not have a great foothold in the population as only 35% of the population holds a bank account or has access to banking services, whereas the worldwide average stands at 50% (Singh and Singh, 2016).

The banking industry in India has undergone a number of different waves. Before 1950, there was weak state control over the sector, leading to misallocation of funds and triggering associated effects in the development of stakeholders (industries, the general population etc.). Countermeasures implemented in the following period up until 1990, were focused on increase state interventionism imposing constraints to seek more equal funds allocation. This overreaction negatively impacted on banks' profitability and competitiveness. During the next phase in the 90s, The Narasimhan Committee I and II sought industry liberalization. As a consequence, as well as shaping new digital trends, banks developed new business models for products and services, enabling e-banking or internet banking. This model opened up the possibility for customers to make online transactions without a physical presence in a front office. Its growth is supported by the trend for early adoption of technology established in India (Pandey and Singh, 2015).

After reviewing the existing literature on banking efficiency, and specifically referring to the Indian case, two opposite outcomes emerge, even when the approaches are mixed (Production vs Intermediation). Some studies support the contention that public banks are more efficient than private/foreign banks, whereas others found private/foreign banks to be more efficient than public ones.

The contributions made by this research include: (a) efficiency measurement for electronic banking; (b) comparison of the classic intermediation model with the electronic banking intermediation approach for all the different banking groups; (c) the use of an up-to-date sample incorporating the years 2008-2014. In line with the abovemen-

tioned contributions, the research question is stated as follows: Does Data Envelopment Analysis (DEA) reveal any differences in efficiency between an intermediation approach based on electronic banking and a traditional approach for the period 2009-2014?

To operationalize the research question, a frontier model is employed, specifically an input-oriented DEA model with an intermediation approach. The sample comprises around 50 banks (different each year) over a period of time covering 2009-2014.

The research paper is structured as follows: Section 1 introduces the article. Section 2, presents a literature review on the Indian banking sector and efficiency of Indian banks and assesses the findings. Section 3 describes the model employed focusing on the analysis technique, the variables involved and the implications of the efficiency measures produced by the model. Finally, section 4, details and discusses the results, ending with conclusions and outlining future research lines.

2. Literature review

2.1. The Indian banking industry roadmap

The current banking industry set up is the result of a number of reforms over past decades, some structural and others cosmetic. We present below a roadmap these changes. It is important to understand this journey in order to enhance and contextualize the findings of this study.

Before 1950, the state exercised limited control over financial activities, as a result allowing inequalities in terms of credit distribution. What is worse, a number of sectors outside the banking sector needed credit and that misallocation deprived them of the chance to grow and perform well. The mitigation measures taken were driven by increasing state control over credit allocation. That policy was operationalized by introducing controls on lending rates, establishing liquidity requirements for the banks and enabling a system of development banks. That reform ended with the nationalization of 14 commercial banks in 1969 and 6 major banks in 1980. Those nationalizations represented a landmark in the development of the Indian banking system, because from that point onwards profit was not identified as the primarily objective, and there was a shift to more social-oriented banking. Even though the original objective of the reform was certainly achieved —state control over the environment accounting for 90% of the sector's assets— competitiveness was limited and there was reduced expansion of foreign banks. The result was a drop in profitability and a rise in inefficiency (Tabak and Tecles, 2010; Bhattacharyya and Pal, 2013; Walia and Kaur, 2015).

This new scenario brought on the widespread financial liberalization reform in the period 1991-2004. It was executed in two waves: the first created and controlled by the Committee on the Financial System (The Narasimhan Committee) in 1991 and the second by the Banking Sector Reforms Committee (Narasimhan Committee II) in 1998. This liberalization aimed to establish suitable boundary conditions allowing private banks to play a predominant role in the sector and thus make it more diversified, profitable, efficient and resilient. The key decisions adopted can be summarized as follows: (a) liberalization of the interest rate, (b) clearance for banks to set their own deposit and lending rates, (c) opening the door to private banks, either domestic or foreign and (d) diversification of the ownership structure for the state banks (Bhattacharyya and Pal, 2013; Battaglia and Gallo, 2015).

The global financial crisis of 2008 meant added uncertainty and increased risk exposure for the Indian banking sector but it largely escaped the effects of the crisis thanks to its adequate capitalization and prudential regulation. There were thus no big downturns in the Indian banking system due to contagion of the global financial crisis. In 2010, however, a downturn was reflected in reversals in capital flow, a marked widening of spreads on debt (corporate and sovereign) as well as sharp currency depreciation (Tabak and Tecles, 2010).

By 2011, India had established a stable and well-regulated sector, overseen by the Reserve Bank of India (RBI) acting as a Central Bank that regulates and supervises the banking system. RBI is fully owned by the Indian Government. Additionally, four major groups comprise the Indian banking system: state banks (SBI and associates), nationalized banks, domestic private sector banks (the old private sector that existed before 1991 and the new private sector that emerged after 1991) and foreign private banks (Sinha, 2013).

However, the SBIs and associates plus the nationalized banks still currently occupy a dominant role in the banking system. Most of the shares listed on the stock exchanges belong to these entities although the RBI has adopted a countermeasure by granting licenses to private sector banks. Despite their dominance, they are more profit and efficiency oriented, and competition has also intensified, both of which are successful results of the reforms (Tabak and Tecles, 2010). Nevertheless, private and foreign banks are flourishing and actively contribute to the increased competition facing public banks (Battaglia and Gallo, 2015).

Last but not least, over the past decade the electronic payment systems in India have been gaining momentum with the development of the National Electronic Funds Transfer (NEFT) and Real Time Gross Settlement (RTGS) root electronic payment systems in India. These systems cluster transactions from Internet banking,

mobile banking, electronic pockets. NEFT, which was launched in 2005, allows one-to-one funds transfers whereby users can electronically transfer money from any bank branch to another user with an account in another bank branch belonging to the NEFT network. RTGS, which was introduced in 2004, is quite similar but whereas NEFT transfers are computed in hourly batches RTGS operates in real-time and once a transaction is processed payments are final and irrevocable (Reserve Bank of India, 2016b).

This exploration of the history of the Indian banking sector highlights the need for an efficiency analysis of the Indian banking sector. The value of such an analysis lies in a number of factors: it is a sector made up of a large number of different groups of banks (each with its own background and history that may influence its perform-ance); it forms a central part of the growing Indian economy, is a vital sector for the development of other industries and a key source of funds for the general population; and it is estimated and forecasted to achieve double-digit growth over the 2009-2019 period as shown in Table 1.

● Table 1. **Value and growth of Indian banking sector during 2009-2019**

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
India banks industry value [billion €]	582,2	687,1	802,8	952,3	1083,7	1149	1278,8	1499,6	1707,8	1947,1	2221,2
Growth [%]		18,02	16,84	18,62	13,80	6,03	11,30	17,27	13,88	14,01	14,08

SOURCE: MARKETLINE (2014, 2015).

Taking a closer look at the sector, the attractiveness of the industry can be seen at a glance by means of Porter's "Five Forces Analysis" (1979), as shown in Figure 1.

■ Figure 1. **Five Forces Analysis of the Indian banking industry**
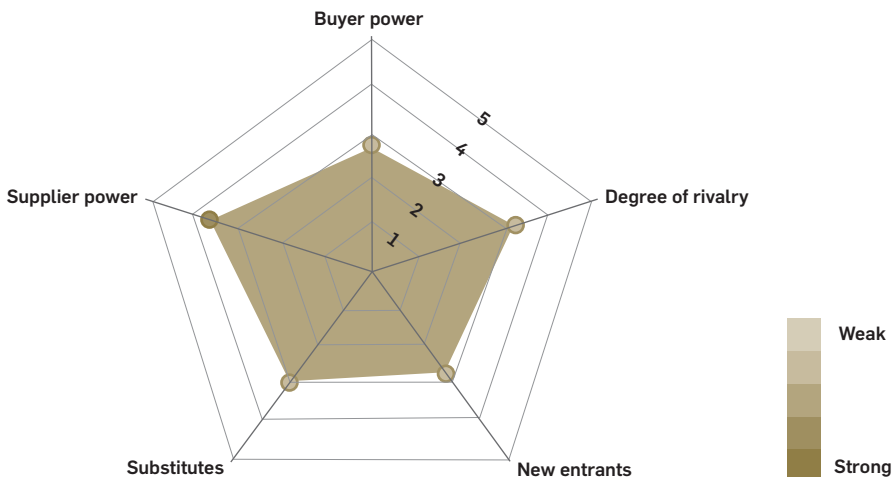
SOURCE: MARKETLINE (2015).

Rivalry is intense among players (banks, insurance companies, investment firms, credit unions etc.). Buyer power is weak due to the wide range of customer types. Supplier power is high, certainly due to the importance of ICT infrastructures that enable banks to perform well, differentiate themselves and build relationships of trust with their customers. Providers of ICT services tend to be big players. There is only a low threat of new entrants due to the entry barrier of stringent regulations and presence of large, well-established players. Substitutes are not a big threat due to the fact that friends, family and loan sharks may play a role for small investments, but this will not be the case for corporate funding or personal banking related, for example, to real estate (Marketline, 2015) (Maketline, 2014).

2.2. Efficiency in the Indian banking sector

Efficiency is a widely-used term that needs to be properly defined. However, it always refers to the fullest possible use of the available inputs to produce an optimum mix of outputs, subject to feasibility restrictions (Saha and Ravisankar, 2000). When referring to banks, they are said to be technically inefficient when the current output is lower than the maximum possible output level, with the existing level of resources available. On the other hand, it can also refer to a case where the current level of inputs is greater than the minimum possible input level required to produce the current level of outputs, with the resources available (Bhattacharyya and Pal, 2013). It is also interesting from a managerial point of view, in terms of making trade-off decisions among choices. How much additional quantity of a particular input in the mix is needed to increase the output level by a certain quantity? How much will an input/output increase/decrease by when another input/output increases/decreases? (Prior and Surroca, 2006).

Depending on the case in question, a number of models can be used including ratio models, frontier models and simulation. This section aims to clarify the existing options and the selection of the most appropriate one for this research study.

Regarding possible options, the first group uses ratio analysis methodology. Such models are mostly oriented towards a "return on" rationale, illustrating the relationships between profits and the various inputs needed to generate them. The most popular are Return on Assets (ROA) and Return on Equity (ROE). Nevertheless, those specific metrics are part of the DuPont model, widely used for banking financial performance. The crucial ratio for banks is ROA, as it is the most meaningful for the banking sector (Padake and Soni, 2015). It assesses how efficiently a bank is using its assets to generate profits, although the formulation is understood by researchers and practitioners as a measure of profitability rather than efficiency. A number of studies, however, have found a positive relationship between profitability and effi-

AESTI ⚜ MATIO

ciency (Tabak and Tecles, 2010). This approach is a powerful way to obtain information with no major calculation effort, but it is not particularly effective at capturing particular features of the phenomena studied meaning that other techniques must be employed to gain more insights and reveal information hidden in the data (Zuhroh *et al.*, 2015).

A second possible option is the use of frontier models. A Decision Making Unit (DMU), such as a bank, is ranked relative to a benchmark set by the DMUs that produce the same level of output with fewer inputs or produce more output with the same level of inputs, taking into account exogenous factors such as prices of resources. Hence frontier models that incorporate more information than just input-output levels are more suitable than ratio analysis models (Havranek *et al.*, 2016). There are a number of different frontier model approaches available, two of which are: (a) parametric (Stochastic Frontier Analysis or SFA), (b) non-parametric (DEA).

The non-parametric approach is more suitable for multidimensional outputs and inputs models, where no information regarding resources cost, revenue functions or profit functions is available. This is the case with the banking sector, where the DEA model gathers data from the banks and draws an 'envelope' representing the optimal frontier of the sample, evaluating each institution against the frontier and tracking the differences as a metric of efficiency (Pandey and Singh, 2015). On the contrary, parametric methodology makes assumptions about the structure of the feasible frontier and assumes that inefficiency follows a half-normal distribution. Both of these facts represent points where DEA offers an advantage. However, in the parametric approach the distance to the frontier can be an indication of both inefficiency and data noise. This offers an advantage over DEA in that it allows conventional hypotheses to be tested. Another advantage of SFA over DEA is the smaller influence that outliers have on the results (Ivan, 2015; Bolt and Humphrey, 2015; Havranek *et al.*, 2016). In banking research, DEA is usually employed to analyse both profit and operational efficiency (Herrera-Restrepo *et al.,* 2016).

Although we refer to 'efficiency' in general, the concept may encompass a number of different elements: (a) Profit efficiency involving intermediation and risk management, which is of interest to shareholders (b) Operational efficiency in terms of the provision of financial products/services, aiming to minimize operational inputs while maximizing the products/services outputs, which is important to stakeholders (Chhikara and Rani, 2012). Both concepts are discussed further below:

- **Intermediation approach** – It is centered on the collection of funds (deposits) and the lending of money (credit). Banks generate profits from the difference between interest charged on credits and the interest paid out on deposits. Their goal is to

maximize profits (Herrera-Restrepo, *et al.,* 2016) or minimize costs (Dong *et al.*, 2016), and so this model is known as the profitability model. It explores how efficient a bank is in using inputs and related costs to increase output and the associated income it generates (Eskelinen *et al.*, 2014). Intermediation alters and changes risk and the expiry profile of collected funds to a different risk and maturity profile (Sahoo and Mandal, 2011).

● **Production approach** – It is based on the provision of financial products/services using resources (front offices, labour, fix assets). The bank can generate profits by lowering the level of resources needed, and consequently their cost, to provide a certain level of products/services which are a source of income. On the other hand, the bank can also maximize the level of products/services it provides, hence increasing income, while maintaining the same level of resources and their associated costs (Chhikara and Rani, 2012; Eskelinen *et al.*, 2014; Herrera-Restrepo *et al.*, 2016; Du and Sim, 2016; Dong *et al.*, 2016;). Again, the objective could either be to maximize profits or to minimize costs. This approach focuses on operational efficiency.

The two concepts are not combined in the same model; hence it is necessary to determine the appropriate approach for the research objectives. The intermediation approach is widely employed and best suited to the evaluation of bank efficiency, according to the literature review carried out. It is also a more suitable holistic measure of bank efficiency. The production approach, on the other hand, best fits the evaluation of branch efficiency (Sathye, 2003; Chhikara and Rani, 2012; Bhattacharyya and Pal, 2013; Fujii *et al.*, 2014; Dong *et al.*, 2016) and so it is employed in this article.

Even though the Technical Efficiency (TE) approach is selected as a parameter of the study, since it can be decomposed into Pure Efficiency (PE) and Scale Efficiency (SE) an additional parameter needs to be defined: either Constant Returns to Scale (CRS) efficiency or Variable Returns to Scale (VRS) efficiency. CRS represents technical efficiency, measuring inefficiencies due to input/output configuration and also the size of operations, whereas VRS represents pure efficiency, removing the effect of scale efficiency (SE) (Singh and Kaur, 2016). This research adopts the PE approach using a VRS model.

An in-depth literature review has been conducted focusing on articles addressing banking efficiency, and narrowing it down to those using DEA and with a focus on the Indian banking sector. The complete set of studies is outlined in Table 2, detailing information regarding the authors, technique employed, data sample, and model inputs and outputs.

Gaining insights into the efficiency of the Indian banking sector: *Elvira Herranz, R. and De', R.*
AESTIMATIO, THE IEB INTERNATIONAL JOURNAL OF FINANCE, 2016. 13: 70-89

78

AESTI ⊗ MATIO

● Table 2. **Literature review of efficiency in the banking sector**

Article	Technique	Data	Input	Output
(Herrera-Restrepo, Triantis, Seaver, & Paradi, 2016) (Paradi, Zhu, & Edelstein, 2012)	Cluster + DEA (Production model, input oriented)	Canadian banks (966 branches) in 2004	Services FTEs Sales FTEs Management FTEs	Day to day transaction volume Investment transaction volume Borrowing transaction volume OTC transaction volume
(Eskelinen, Halme, & Kallio, 2014)	Value Efficiency Analysis (VEA)	25 branches of Helsinki OP bank operating in Helsinki during 2007-2010	Total cost of sales force	Transaction volume of banking services provided to customers by sales people (financing, investment, daily banking services and insurance services).
(Du & Sim, 2016)	DEA	960 observations between 2002 and 2009, from 120 banks distributed across six countries – China, India, Indonesia, Malaysia, Russia, and Thailand	Fixed assets Non-interest operating expenses Interest expenses	Net interest income Other operating income
(Chen, Skully, & Brown, 2005)	DEA	43 Chinese banks during 1993-2000	Labour, deposit and physical capital	Loans, deposits and non-interest income
(Ariff & Can, 2008)	DEA	28 Chinese banks during 1995-2004	Loanable funds, number of employees and physical capital	Loans and investments
(Fu & Heffernan, 2007)	SFA	14 Chinese banks during 1985-2002	Funds, labour and fixed assets	Total loans, total deposits total investments and non-interest income
(Krumbhakar & Wang, 2007)	SFA	14 Chinese banks during 1993-2002	Labour, fixed assets, total Deposit and total borrowed funds	Total loans net, other earning assets
(Berger, Hasan, & Zhou, 2009)	SFA	38 Chinese banks during 1994-2003	Interest expenses and non-interest expenses	Total loans, total deposits, liquid assets, other earning assets
(Jiang, Yao, & Zhang, 2009)	SFA	310 observations Chinese banks during 1995-2005	Model 1. Inputs: total interest expense and non-interest expense Model 2. Inputs: total interest expense, labour costs and physical capital Model 3. Inputs: total interest expense, physical capital, and labour costs	Model 1. Outputs: Net interest income and non-interest income Model 2. Outputs: Total loans, total deposits and non-interest income Model 3. Outputs: Total loans, total deposit and other earning assets
(Asmild & Matthews, 2012)	DEA	14 Chinese banks during 1997-2008	Number of employees, fixed assets, total deposits	Net interest earnings and non-interest earnings
(Hou, Wang, & Zhang, 2014)	DEA	44 Chinese banks during 2007-2011	Total deposits, fixed assets and number of employees	Total net loan, other earning assets
(Wang, Huang, Wu, & Liu, 2014)	DEA	16 Chinese banks during 2003-2011	Fixed assets and labour	Non-interest income and interest income
(Ivan, 2015)	DEA	99 Japanese banks during 2010-2012	Provisioning expenses, interest paid, fees and commissioning expenses	Net income, received interest and fee and commissioning revenue
(Havranek, Irsova, & Lesanovska, 2016)	DEA + SFA	30 Czech Republic banks over 2004-2013	Fixed assets, borrowed funds, number FTEs, expenditures on fixed assets, expenditures on borrowed funds, expenditures on labour	Commercial loans, interbank loans, investment assets

(Tabak & Tecles, 2010)	Bayesian SFA	67 Banks in India over 2000-2006	Price of funds, price of labour; price of capital	Loans, deposits and other earning assets
(Bhattacharyya & Pal, 2013)	SFA	103 Indian commercial banks over 1989-2009	Investments, loans, deposits, labor, capital	Euclidean norm of investment, Euclidean norm of loans + advances, capital adequacy ratio
(Singh & Kaur, 2016)	DEA (intermediary)	46 Indian banks 2004-2014	Interest expenses, cost of management, term deposits and demand deposits	Interest received, total advances and non-fund income
(Padake & Soni, 2015)	DuPont ratios	12 Indian banks	Net Profit, ROA, ROE, ROS	Correlation coefficient
(Pandey & Singh, 2015)	DEA (Productivity)	40 Indian banks over 2008-2013	Branches, staff, deposits	Loans and advances, profit
(Sinha, 2013)	DEA	49 Indian banks over 2006-2011	Deposits	Total assets and other income, gross non-performing asset
(Chhikara & Rani, 2012)	DEA	26 Indian banks in 2010	Advances, investments, interest income, other income	Deposits, capital & reserve & surplus, interest expended
(Verma & Bodla, 2011)	DEA (Production approach)	88 Indian banks over 1998-2008	Interest expenses and operating of non-interest expenses.	Deposits, advances, investment and spread (interest earned minus interest expended)
(Sahoo & Mandal, 2011)	DEA	80 Indian banks over 1997-2005	Production Capital, labour, non-financial inputs Intermediation Borrowed funds, number of employees, Fixed assets	Production Deposits, advances, Services Intermediation Investments, Performing Loan Assets, Non-Interest fee-based income.
(Fujii, Managi, & Matousek, 2014)	DEA	37 Indian banks over 2004-2011	Fixed assets, deposits, employees	Loans, Other Earning Assets, non-performing loans
(Saha & Ravisankar, 2000)	DEA	25 Indian banks over 1992-1995	Branch (number of branches), staff (number of employees), establishment expenditure, non-establishment expenditure (excluding interest expenditure).	Deposits, advances, investments, spread, total income, interest income, non-interest income and working funds.
(Sathye, 2003)	DEA	103 Indian banks over 1997-1998	Model 1. Interest expenses, non-interest expenses Model 2. Deposits, staff	Model 1. Net interest income, non-net interest income Model 2. Net loans

Summing up some findings from the literature review on Indian bank efficiency, two different streams can be identified. The first identifies public banks as the most efficient, while the second shows that private/foreign banks are most efficient. Some specific findings are highlighted as follows: (a) Public banks are the most cost efficient, and size adversely affects efficiency (Sensarma, 2006; Das and Ghosh, 2006); (b) Public banks are more efficient than private domestic banks, which in turn are more efficient than foreign banks (Tabak and Tecles, 2010); (c) Public banks more efficient than foreign banks followed by private banks (Sathye, 2003); (d) Foreign banks are more cost efficient than public banks (Sarkar *et al.*, 1998; Sahoo and Tone, 2003); (e) Private banks more efficient than public ones (Sing and Kaur, 2016); (f) Foreign and private banks more efficient than public ones (Pandey and Singh, 2015); (g) New private sector commercial banks more ef-

Gaining insights into the efficiency of the Indian banking sector: Elvira Herranz, R. and De', R.
AESTIMATIO, THE IEB INTERNATIONAL JOURNAL OF FINANCE, 2016. 13: 70-89

80

AESTI ⊗ MATIO

ficient than old private banks, followed by nationalized banks, with the SBI group coming last (Sinha, 2013); and (h) Foreign banks are more efficient than state public banks (Fujii *et al.* 2014).

3. Model

This research paper focuses on measuring the PE of banks removing the effect of SE and without any a priori information about the frontier configuration. Hence a DEA analysis is selected following a VRS model, such as BCC with input-oriented (I/O) approach. There are n DMUs that consume m inputs to produce s outputs. DMU under evaluation (DMU_0) is computed using the model formulated by Toloo and Nalchigar (2009) representing the dual BCC I/O model:

$$Max \sum_{r=1}^{s} u_r y_{rj} - u_0 \qquad (1)$$

$$s.t.$$

$$\sum_{i=1}^{m} w_i x_{i0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - u_0 - \sum_{i=1}^{m} w_i * x_{ij} \leq 0 \ ; \ j = 1,2,\ldots, n$$
$$u_0 \ \ free$$

$$w_i \geq \varepsilon \ ; \ i = 1,2,\ldots, m$$
$$u_r \geq \varepsilon \ ; \ r = 1,2,\ldots, s$$

Where

- DMU_j represents the j–th Bank ($j = 1,2,\ldots, n$)
- x_{ij} stands for the consumption level of the i–th input ($i = 1,2,\ldots, m$) from the j–th DMU
- y_{rj} is the production level of the r–th output ($r = 1,2,\ldots, s$) of the j–th DMU.
- DMU_0 is the DMU under evaluation
- x_{i0} stands for the consumption level of the i–th input ($i = 1,2,\ldots, m$) from the DMU_0 under evaluation
- y_{r0} is the production level of the r–th output ($r = 1,2,\ldots, s$) of the DMU_0 under evaluation
- w_i shows the weight of input i–th
- u_r represents the weight of output r–th
- u_0 is the output weight of the DMU_0 under evaluation for a specific output.
- ε is a non-Archimedean infinitesimal constant.

The constraints are mainly focused on maintaining non-negativity and frontier convexity. Of the two possibilities for setting the model, an intermediation approach is followed but two models are computed. The first one is based on the general approach found in the literature review, whereas the second makes a novel contribution by assessing electronic. Input and output variables are detailed in Table 3(a)(b).

● Table 3(a). **Classic intermediation approach**

	Input(x_{ij})	**Output (y_{rj})**
Model 1	Deposits [M€] / Labour	Investment [M€] / Labour
	Borrowings [M€] / Labour	Loans & _Advances_ [M€] / Labour
	Net fixed assets [M€] / Labour	

The model shown in Table 3(a) computes efficiency in terms of the ability of the bank to lend a certain amount of funds per employee in form of Investment, Loans and Advances, with the minimum level of collected funds per employee in the form of Deposits and Borrowings, by using the lowest level of fix assets per employee in that intermediation. Banks that lend high amounts of funds while collecting less and with low levels of fixed assets operate with a relatively low tolerance to risk.

● Table 3(b). **Electronic intermediation approach**

	Input(x_{ij})	**Output (y_{rj})**
Model 2	Total inward transactions volume / Labour	Total outward transactions volume / Labour
	Total inward transactions value [M€] / Labour	Total outward transactions value [M€] / Labour
	Net fixed assets [M€] / Labour	

The second model aims to compute the PE of banks, when they receive money and handle transactions electronically, from other banks or users, and transform them into new transactions and money transferred to other banks or users. This intermediation is linked to the labour force and net fixed assets.

The model in Table 3(b) computes efficiency as the ability of the bank to perform outward fund transactions per employee (total volume of transactions and their value), with the minimum level of inward fund transactions per employee (volume and value) by using the lowest level of fix assets per employee. Banks that exhibit higher efficiency levels are more oriented towards electronic banking, as are their customers.

AESTI MATIO

■ 4. Data

The data sample is obtained from Prowess database owned by the Centre for Monitoring Indian Economy (Centre for Monitoring Indian Economy, 2015) and the Reserve Bank of India (Reserve Bank of India, 2016a). Financial data has been audited by CMIE. This information comprises bank balance sheets, bank type, annual number of employees, volume and value of inward transactions (NETF, RTGS), and volume and value of outward transactions (NETF, RTGS).

The currency employed in this research is the Euro (EUR) and the measurement unit is million euros (M€). Financial values employed for variable computation are non-annualized. When currency exchange is required, rates reported by the Reserve Bank of India are used. They have been determined from March to March, computing daily average quotations, and are displayed in Table 4.

● Table 4. **INR/EUR exchange rates**

Year	Exchange rate (INR/EUR)	Year	Exchange rate (INR/EUR)
2009	66,6851	2012	70,0669
2010	60,2135	2013	81,1399
2011	65,8952	2014	77,4697

SOURCE: RESERVE BANK OF INDIA (2016c).

The sample distribution for the longitudinal study of the period 2009-2014 is decomposed in Table 5. There are no missing values in the sample for model 1 variables, though there are some in model 2. Those observations for model 2 are discarded. Regarding outliers, only two banks were removed as they yielded values two orders of magnitude higher than other banks.

● Table 5. **Distribution of sample**

	2009	2010	2011	2012	2013	2014
SBI and associates	6	6	6	6	6	6
Nationalized	13	13	13	13	13	13
Private	13	13	13	13	11	11
Foreign	22	16	18	20	22	22
Total (N)	**54**	**48**	**50**	**52**	**54**	**52**

SOURCE: OWN ELABORATION.

5. Results, discussion and conclusions

After running the model, two annual efficiency values are obtained for each bank. The first value corresponds to model 1, shown in Table 3 (a), whereas the second value is obtained with model 2 described in Table 3 (b). The complete information is presented by bank in Table 6, which shows bank name, its category and both efficiency metrics.

● Table 6. **Indian banks' efficiency computed with model 1 and model 2**

Bank Name	Category	2009		2010		2011		2012		2013		2014	
		Mod. 1	Mod. 2	Mod.1	Mod.2	Mod.1	Mod.2	Mod.1	Mod.2	Mod.1	Mod.2	Mod.1	Mod.2
A B Bank Ltd.	Foreign Banks	1.0000	1.0000	0.2222	1.0000	0.1794	1.0000	0.2904	1.0000	0.2064		1.0000	
Abu Dhabi Commercial Bank	Foreign Banks	1.0000	0.6288	0.1400	0.8335	0.3966	0.9212	0.2649	0.6059	0.3704	1.0000	1.0000	1.1056
Allahabad Bank	Nationalized Banks	0.8285	0.9261	0.8866	0.8561	0.8954	0.7621	0.7673	0.2843	0.9024	0.3377	0.7603	0.6688
American Express Banking Corpn	Foreign Banks	1.0000	0.1030	1.0000	0.2092	1.0000	0.0794	0.8370	1.0000	1.0000	1.0000	1.0000	1.0000
Andhra Bank	Nationalized Banks	0.9461	0.7613	0.9068	0.7793	0.9190	0.8404	0.8282	0.4827	1.0000	0.5130	1.0000	1.0080
Antwerp Diamond Bank N V	Foreign Banks	1.0000	0.7908	1.0000	1.0000	1.0000	0.2456	1.0000	1.0000	1.0000	1.0000	1.0000	0.2891
Australia & New Zealand Banking	Foreign Banks					1.0000	1.0000	0.4537	0.7689	1.0000	0.6985	0.9165	0.6640
Axis Bank Ltd.	Private Sector Banks	0.8267	0.8818	0.8919	0.8962	0.8588	0.8443	0.6698	0.5436	0.8073	0.4813	0.7399	0.5574
Bank International Indonesia	Foreign Banks									1.0000	1.0000	1.0000	1.0000
Bank of Bahrain & Kuwait Bsc	Foreign Banks	0.8323	1.0000	0.9313	1.0000	0.8502	1.0000	0.5928	1.0000	0.9358	1.0000	1.0000	1.0000
Bank of Baroda	Nationalized Banks	0.8611	0.7709	0.8861	0.7800	0.8978	0.7864	0.8079	0.3278	1.0000	0.3201	0.9303	0.6449
Bank of Ceylon	Foreign Banks	1.0000	0.6943	1.0000	0.6376	1.0000	0.4784	0.9272	0.4159	0.9347	0.3355	1.0000	1.0524
Bank of India	Nationalized Banks	0.8378	0.7162	0.8385	0.7654	0.8683	0.7509	0.7704	0.2758	0.8727	0.2675	0.6685	0.3852
Bank of Maharashtra	Nationalized Banks	0.7812	0.7458	0.8402	0.7769	0.8883	0.7822	0.7504	0.3261	0.7545	0.2812	0.6372	0.4482
Bank of Nova Scotia	Foreign Banks	1.0000	1.0000	1.0000	0.8602	1.0000	0.7939	0.7016	0.7930	1.0000	0.6436	1.0000	0.7110
City Union Bank Ltd.	Private Sector Banks	0.9173	0.7232	1.0000	0.8115	0.9120	0.7682	0.9353	0.7837	0.9057	0.6056	1.0000	0.9187
H S B C Bank Oman S A O G	Foreign Banks	0.2036		0.5505		0.5703		0.1291		0.0399		0.0903	
I N G Vysya Bank Ltd.	Private Sector Banks	0.7564	0.8498	0.8391	0.7898	0.7975	0.7696	0.7088	0.9171	0.7683	0.4403	0.7466	0.5134
J P Morgan Chase Bank, Nationa	Foreign Banks	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.8550	1.0000	1.0000	1.0000	1.0000	1.0000
Jammu & Kashmir Bank Ltd.	Private Sector Banks	1.0000	1.0000	0.8960	0.8433	1.0000	0.8606	0.7620	0.3692	1.0000	0.3549	1.0000	0.9023
Karnataka Bank Ltd.	Private Sector Banks	0.8536	0.7895	0.9278	0.7990	1.0000	0.7734	0.7885	0.5185	1.0000	0.4322	1.0000	1.0000
Karur Vysya Bank Ltd.	Private Sector Banks	0.9313	0.7517	0.9440	0.7909	0.9111	0.7756	0.8212	0.4108	0.8225	0.3549	0.7410	0.6612
Kotak Mahindra Bank Ltd.	Private Sector Banks	0.8441	0.8925	0.8957	0.8675	0.8944	0.8765	0.5580	0.7285	0.7746	0.6090	0.8954	0.5694
Krung Thai Bank Public Co. Ltd	Foreign Banks	0.8311	1.0272	0.5751	0.9707	0.9306	0.9157	0.0625	0.5398	0.1654	0.5246	0.9487	1.0000
Lakshmi Vilas Bank Ltd.	Private Sector Banks	0.8837	0.8195	0.9298	0.8209	0.8254	0.7892	0.8586	0.5064	0.8670	0.3000	0.7483	0.6377
Mashreqbank P S C	Foreign Banks	1.0000	1.0376	0.2556	0.9301	0.2645	0.9648	0.0948	1.0000	1.0000	0.7911	1.0000	1.0183
Mizuho Bank Ltd.	Foreign Banks	1.0000	1.0000	1.0000	0.9113	0.3598	0.9747	1.0000	0.6726	1.0000	0.6838	1.0000	0.7332
Nainital Bank Ltd.	Private Sector Banks	0.7409	1.0000	1.0000	0.9549	1.0000	0.7956	1.0000	0.5884	1.0000	0.5118		
National Australia Bank Ltd.	Foreign Banks							1.0000	0.3556	1.0000	0.7780	1.0000	0.8346
Oriental Bank of Commerce	Nationalized Banks	0.9478	0.7260	1.0000	0.7409	1.0000	0.7404	0.8357	0.2826	1.0000	0.2885	0.8553	0.5359
Punjab & Sind Bank	Nationalized Banks	0.7672	0.9193	0.8530	0.8998	0.9372	0.8548	0.8083	0.3580	0.9781	0.3008	0.9046	0.4643
Punjab National Bank	Nationalized Banks	0.8331	0.7444	0.8802	0.8593	0.8551	0.7725	0.7634	0.3082	0.8161	0.3002	0.7005	0.6156
Ratnakar Bank Ltd.	Private Sector Banks	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000		
Royal Bank of Scotland N V	Foreign Banks	1.0000	0.3617	0.9891	0.2875	0.9089	0.8868	0.5410	0.9488	0.8365	0.8894	1.0000	0.9102
S B E R Bank	Foreign Banks					1.0000	0.8240	1.0000	0.6522	0.9539	0.9921	1.0000	0.9001
Shinhan Bank	Foreign Banks	1.0000	1.0000	1.0000	1.0139	0.9711	0.9640	0.8255	0.6912	1.0000	0.6118	1.0000	0.7689

Bank	Category												
Shinhan Bank	Foreign Banks	1.0000	1.0000	1.0000	1.0139	0.9711	0.9640	0.8255	0.6912	1.0000	0.6118	1.0000	0.7689
South Indian Bank Ltd.	Private Sector Banks	0.8237	0.8246	0.9254	0.8027	1.0000	0.7904	0.9275	0.3656	0.8667	0.3568	0.7260	0.6776
Standard Chartered Bank - Indi	Foreign Banks	0.7984	1.0296	0.8582	0.9805	0.9224	0.9745	0.6714	0.6012	0.7992	0.6386	0.7147	0.7084
State Bank of Bikaner & Jaipur	SBI and its ssociates	0.9379	1.0000	0.9555	1.0000	0.8977	1.0492	0.9164	0.7153	0.9669	0.7386	1.0000	1.0000
State Bank of Hyderabad	SBI and its ssociates	0.9167	0.7788	0.9457	0.8571	0.9084	0.8497	0.8570	0.5194	1.0000	0.5125	1.0000	0.7021
State Bank of India	SBI and its ssociates	0.8714	0.8222	0.9358	0.7397	0.9022	0.8321	0.7902	0.4748	0.8465	0.4535	0.8353	0.7108
State Bank of Mauritius Ltd.	Foreign Banks	0.8936	0.9934	1.0000	0.9304	1.0000	0.9194	0.6030	0.7743	1.0000	0.6627	1.0000	0.5964
State Bank of Mysore	SBI and its ssociates	0.7505	0.7596	0.8629	0.7532	0.8515	0.7664	0.8103	0.3192	0.8326	0.4276	0.6384	0.6491
State Bank of Patiala	SBI and its ssociates	0.9750	0.9410	0.9356	0.9867	0.8774	1.0000	0.7208	0.5957	0.9227	0.5100	0.8925	0.9920
State Bank of Travancore	SBI and its ssociates	0.9701	0.8951	0.9640	0.9067	0.9126	0.9107	0.7561	0.5760	0.9479	0.5423	0.9662	1.0173
Sumitomo Mitsui Banking Corp.	Foreign Banks									1.0000	0.4444	1.0000	1.0000
Syndicate Bank	Nationalized Banks	0.8925	0.7916	0.9065	0.8172	0.8965	0.8049	0.8445	0.3381	0.9123	0.3133	0.7581	0.6918
Tamilnad Mercantile Bank Ltd.	Private Sector Banks	1.0000	0.9224	1.0000	0.8644	1.0000	1.0010	1.0074	0.4802	1.0000	0.4436	1.0000	0.8152
Uco Bank	Nationalized Banks	0.8375	0.8682	0.9107	0.7420	0.8763	0.7661	0.7763	0.3527	0.9345	0.3931	0.8118	0.8175
Union Bank of India	Nationalized Banks	0.7970	0.7497	0.9115	0.7883	0.8912	0.7704	0.8161	0.3039	0.8692	0.2852	0.6388	0.7977
United Bank of India	Nationalized Banks	0.7740	0.8251	0.8795	0.7947	0.8594	0.7806	0.7914	0.3548	0.8190	0.3612	0.9540	0.4254
United Overseas Bank - Mumbai	Foreign Banks			0.0737			0.0488	1.0000	0.9596	0.7363	0.3245	0.9889	
Vijaya Bank	Nationalized Banks	0.8131	0.7530	0.9737	0.7746	1.0000	0.7554	0.7633	0.3091	0.9251	0.3328	1.0000	0.7444
Yes Bank Ltd.	Private Sector Banks	0.8598	1.0443	1.0000	0.9547	0.9499	0.9792	0.5339	0.8329	0.8558	0.8665	0.9593	0.9695

SOURCE: OWN ELABORATION.

It is of interest to group banks according to category and calculate some descriptive statistics for each group, such as average efficiency, standard deviation, variance and number of cases. Those statistics are computed annually for the two models. The results obtained are shown in Table 7.

● Table 7. **Descriptive efficiency statistics by bank type**

		2009		2010		2011		2012		2013		2014	
		Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
SBI	Average	0.903600	0.866117	0.933250	0.873900	0.891633	0.901350	0.808467	0.533400	0.919433	0.530750	0.888733	0.842333
	Std. Dev.	0.084077	0.095154	0.036213	0.111858	0.023162	0.107102	0.070384	0.132887	0.066969	0.110187	0.138779	0.171128
	Variance	0.007000	0.009000	0.001000	0.013000	0.001000	0.011000	0.005000	0.018000	0.004000	0.012000	0.019000	0.029000
	N	6	6	6	6	6	6	6	6	6	6	6	6
Nationalized	Average	0.839762	0.792123	0.897946	0.798039	0.906500	0.782085	0.794092	0.331085	0.906454	0.330354	0.816877	0.634439
	Std. Dev.	0.059130	0.070881	0.046961	0.047518	0.047151	0.033585	0.031244	0.053361	0.078528	0.064964	0.133586	0.181636
	Variance	0.003000	0.005000	0.002000	0.002000	0.002000	0.001000	0.001000	0.003000	0.006000	0.004000	0.018000	0.033000
	N	13	13	13	13	13	13	13	13	13	13	13	13
Private	Average	0.879808	0.884562	0.942285	0.861215	0.934546	0.847969	0.813154	0.618839	0.897531	0.519762	0.868773	0.747491
	Std. Dev.	0.086731	0.103586	0.053857	0.070597	0.073622	0.090164	0.162129	0.211644	0.092093	0.207510	0.126706	0.178310
	Variance	0.008000	0.011000	0.003000	0.005000	0.005000	0.008000	0.026000	0.045000	0.008000	0.043000	0.016000	0.032000
	N	13	13	13	13	13	13	13	13	13	13	11	11
Foreign	Average	0.661773	0.844427	0.782625	0.789913	0.797433	0.777289	0.642495	0.777842	0.817205	0.750930	0.939050	0.857484
	Std. Dev.	0.448602	0.283734	0.321477	0.314377	0.294733	0.326350	0.329064	0.213411	0.312938	0.230565	0.199637	0.203857
	Variance	0.201000	0.081000	0.103000	0.099000	0.087000	0.107000	0.108000	0.046000	0.098000	0.053000	0.040000	0.042000
	N	22	15	16	16	18	18	20	19	22	20	22	19
TOTAL	Average	0.783982	0.843830	0.875927	0.821923	0.872744	0.811780	0.742067	0.594675	0.869387	0.562589	0.887835	0.768374
	Std. Dev.	0.306161	0.175741	0.197892	0.189739	0.188433	0.205867	0.231409	0.247006	0.210920	0.245693	0.167747	0.200994
	Variance	0.094000	0.031000	0.039000	0.036000	0.036000	0.042000	0.054000	0.061000	0.044000	0.060000	0.028000	0.040000
	N	54	47	48	48	50	50	52	51	54	52	52	49

SOURCE: OWN ELABORATION.

The banks in the category "SBI and associates", "nationalized" and "private" are more efficient in terms of the traditional intermediation approach than with the electronic banking transaction intermediation model. It would seem that they are less oriented towards electronic banking and tend instead towards using front office and ATMs for collecting and lending funds. "Foreign" banks, however, show more efficiency in the latter model, with the exception of only three years, though the two values are very close for these years.

These results suggest that those banks coming from abroad try to compete with a business model that is more digital than that of banks originating in India. When computing the compound average of the differences for the two models (efficiency model 1 minus efficiency model 2) over the entire period (2009-2014), the biggest gap is found in the "nationalized" group, followed by the "private", with "SBI and associates" coming last. For the "foreign" banks that metric is negative, meaning that the efficiency of model 2 is higher than that of model 1, reflecting the previous finding that "foreign" banks are more oriented towards electronic banking for intermediation purposes.

Focusing on efficiency in terms of the traditional intermediation model, represented by model 1, the groups are ranked as shown in Table 8. It shows "private" banks dominating the efficiency rankings between 2009-2012, followed by the public ones (alternating between "SBI" and "nationalized") with the "foreign" banks at the tail end. In 2013 and 2014, "SBI" banks registered the highest efficiency of all groups. Rankings fluctuate over the last years in the sample and is not possible to establish a pattern for the other three groups.

● Table 8. **Ranking of banking group efficiency according to model 1**

	2009	2010	2011	2012	2013	2014
SBI	1	2	3	2	1	2
Nationalized	2	3	2	3	2	4
Private	3	1	1	1	3	3
Foreign	4	4	4	4	4	1

SOURCE: OWN ELABORATION.

In order to expand the baseline knowledge and to gain even more insights, a suggested future research line could be to correlate both intermediation efficiency approaches used in this research with profitability ratios (ROA and ROE). Are those banks registering greater efficiency in terms of the electronic banking intermediation approach or the classical intermediation approach more profitable? Another interesting area of research may be to study Scale Efficiency with both approaches, in order to complement the Pure Efficiency angle presented here.

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88

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89