Article

The Dynamics of Revenue Diversification and Efficiency of Banks in India

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Abstract

This article attempts to understand how income diversification influences efficiency of scheduled commercial banks in India across ownership and over crises periods. We explore two competing hypotheses prevalent in the literature—strategic focus and conglomeration. Input-oriented technical and pure technical efficiency scores are calculated using data envelopment analysis following two approaches in the literature—intermediation and operating. We find support for the conglomeration hypothesis under the intermediation approach while the strategic focus hypothesis holds under the operating approach regarding influence of revenue diversification on both types of efficiency. Furthermore, foreign banks indulge in higher revenue diversification in the post-crisis period and, therefore, report greater efficiency as compared with their domestic counterparts. These results have important policy ramifications for regulators and supervisors.

Keywords

Banks, revenue diversification, efficiency, data envelopment analysis, intermediation approach, operating approach.

Introduction

Banks constitute the core of a country's financial system and ensure smooth financial intermediation through liquidity, maturity and risk transformation. They are the vital link between savers and borrowers. The more efficient a financial system is in resource generation and allocation, the larger is its contribution to a country's economic growth. Moreover, the ongoing global financial turmoil has proved that efficient banks are also able to contribute better to risk mitigation strategies. Efficiency measures can act as important indicators to analyze evolving strengths and weaknesses of the banking system, thus enabling precautionary steps by regulators and policy-makers when necessary. Hence, investigation and measurement of efficiency of the banking sector has always been a subject of interest to researchers, regulators and policy-makers (Chakrabarty, 2013).

Several factors have been found to be determinants of efficiency of banks (RBI, 2008). While specific factors may differ across developed and developing countries, some common features that predominantly drive higher efficiency are a policy environment facilitating economies of scale, diversification of activities and introduction of state-of-the-art technologies. The global financial crisis has further demonstrated that banks that rely excessively on traditional income-generating activities during periods of volatility compromise on their efficiency. Extensive regulatory changes and technological developments have transformed financial systems to a great extent. Banks have reacted to challenges posed by new operating environments by creating fresh products and services and expanding the already existing ones, which has allowed them to diversify the product mix of their portfolios. The traditional business of simply collecting deposits from households and converting them into loans for agents has reduced in favour of considerable growth in activities that generate non-interest or -fee and commission incomes. Consequently, the sources of revenues and profits of banking institutions have diversified, as non-interest income relative to its interest counterpart from traditional financial activities has significantly increased. Such income diversification

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aids in fostering stability in the overall income portfolio of a bank in the aftermath of a crisis (Gambacorta & Marques-Ibanez, 2011). Therefore, it is generally agreed that a shift in the banking model can have a critical impact on banks' efficiency.

One of the primary objectives of banking sector reforms in India introduced since the early 1990s has been to promote competition in the system to raise banking standards to international best practices (Reddy, 2002). Domestic banks in India have been exposed to increased competition with the enhanced presence of foreign banks. Such a move is expected to enhance efficiency. The literature also suggests that differences in ownership structures can be a significant factor explaining the efficiency of individual banks or bank groups. The theoretical basis of this argument lies in the principal–agent framework. This theory suggests that managers in foreign institutions feel more constrained by the need to adhere to capital market discipline. On the other hand, lack of owner/shareholder control gives management more freedom in pursuing its own agenda and has lesser incentives to be efficient. Based on this argument, foreign banks are expected to be more efficient than domestic banking institutions. In recent times, to keep up with rising competition, there has also been a surge of banks engaging in non-traditional business activities to reap the benefits of income diversification. Researchers have found a multitude of efficiency gains associated with combining several product lines. A diversified bank which has a common information system that can be used across various product lines incurs the cost of garnering information only once. Furthermore, delivery, marketing and physical inputs can be brought together for the production of a larger set of services (RBI, 2008).

The dynamics between revenue diversification and bank efficiency are based on two competing hypotheses in the literature. While the strategic focus hypothesis suggests that banks can improve their efficiency by concentrating on core business activities, the conglomeration hypothesis asserts that diversifying into several business areas can provide a larger advantage in improving bank efficiency. Such digression of bank income away from interest-earning assets towards non-interest earning services may amplify efficiency (Calomiris, 1998; Gallo, Apilado, & Kolari, 1996; Meador, Ryan, & Schellhorn, 2000). The strategic focus hypothesis, however, counters this argument by suggesting that conglomeration may give rise to agency problems in which managers attempt to add new business segments in order to protect their own vested interests. As the costs of diversification may trump the benefits, banks should concentrate on a single source of income generation to reduce agency problems and maximize the merits of management's expertise (Denis, Denis, & Sarin, 1997; Jensen, 1986).

There is no consensus in the literature regarding the relationship between income diversification, ownership structure, bank crisis and efficiency. Some empirical studies strongly point out that government and foreign banks do not diversify equally into non-traditional sources of income. Berger, Hasan and Zhou (2010) find that foreign-owned banks are associated with fewer diseconomies of diversification, explaining that foreign ownership could play a critical role in the mitigation of diversification discount with respect to Chinese banks. Meslier, Tacneng and Tarazi (2014) find that foreign banks benefit more from a shift towards non-interest activities than domestic banks in emerging market economies. However, there is no significant research regarding this topic on Indian banks. Therefore, this article tries to explore how such dynamics affect Indian banks and fill the gap in the literature.

In light of the above, this article investigates how revenue diversification affects efficiency of scheduled commercial banks (SCBs) in India. This is supplemented by an analysis of how the dynamics of ownership and crises periods affect such efficiency. This article's contribution is manifold. Firstly, it is the first study to empirically examine how the various dynamics of revenue diversification affect Indian banks in the context of the strategic focus and conglomeration hypotheses as well as market competition. Secondly, it undertakes the study of efficiency across a diverse spectrum of bank ownership forms, namely domestic and foreign as well as across various growth phases of the Indian economy, that is, pre- and post-crisis periods. Thirdly, since most of the existing work on this subject belongs to advanced nations, this article is pertinent in its contribution to the literature from the point of view of an important and rapidly growing emerging market economy (EME) like India. In the absence of a significant corporate bond market, the banking system is the most important source of corporate credit in India. Public sector banks dominate with a 72.1 per cent market share, while new private banks that became operational from 1993 onwards have a market share of 16 per cent (Gandhi, 2015). Foreign banks and old private banks have market shares of 7.2 per cent and 4.9 per cent respectively.

In sync with the extant literature, we measure revenue diversification as the ratio of non-interest income to total operating income. As an alternative measure, following Amidu and Wolfe (2013), we also construct the Herfindahl–Hirschman index for revenue diversification (HHI_{Rev}). In line with Das and Ghosh (2006), we employ the intermediation and operating approaches to specify banks' inputs and outputs in order to calculate input-oriented technical efficiency (TE) and pure technical efficiency (PTE)

scores under constant and variables returns to scale respectively. We employ the non-parametric technique of data envelopment analysis (DEA). We have an unbalanced panel dataset, consisting of 1,154 observations which are divided into domestic and foreign banks. Based on Chakrabarty (2013), we divide India's efficiency phases into two time periods: 2000–2006, that is, the pre-crisis period, and 2007–2013, that is, the post-crisis period.

The ensuing article is structured as follows. The second section provides an overview of the existing literature on how revenue diversification, ownership and periods of stress affect banks' efficiency. The third section highlights the data sources and methodology used in the study. The fourth section reports the sample statistics and analyses trends in the same. The fifth section presents the empirical estimation results of the panel data regression analysis and finally, the sixth section concludes with observations and policy recommendations.

Review of Literature

The efficiency of banking system also bears direct implications for social welfare. Society benefits when a country's banking system becomes more efficient, offering more services at a lower cost (Valverde, Humphrey, & Fernández, 2003). The information obtained from banking efficiency analyses can be used either (a) to inform government policy by assessing the effects of deregulation, ownership, diversification, mergers or market structure on efficiency; (b) to address research issues by describing the efficiency of an industry, ranking its firms or checking how measured efficiency may be related to the different efficiency techniques employed or (c) to improve managerial performance by identifying 'best practices' and 'worst practices' associated with high and low measured efficiency, respectively, and encouraging the former practices while discouraging the latter (Berger & Humphrey, 1997; Gulati, 2011).

The quality of operations of the financial sector of a country can be expected to simultaneously affect the functioning and efficiency of all its sectors. Efficient financial intermediation aids in improving economy-wide resource allocation, thereby resulting in robust economic growth. The efficient intermediation of funds from savers to users enables the judicious channelling of available resources to their most efficient uses. It is evident from the extensive literature that the efficiency of the banking system is vital to the performance of the entire economy. Efficiency of banking activities guarantees the smooth functioning of a nation's payment system and effective implementation of its monetary policy.

Deregulation of a country's banking sector is expected to magnify competitive forces. Such competition, in turn, enables banks to alter their input and output combinations, which when merged with technological developments facilitate growth in output. This amplifies overall bank efficiency. Moreover, allowing liberal entry of foreign banks as a part of the deregulation process is expected to raise bank efficiency and technology levels as foreign banks are expected to have superior management practices and technology. Another school of thought that borrows from the public choice framework argues that different ownership structures may engender different efficiency levels. The theoretical argument behind this strand of literature is that the lack of capital market discipline lowers owners' control over management, thereby enabling the latter to pursue their own selfish interests. This also generates lesser incentives for them to be efficient.

Although the impact of income diversification has received a lot of attention recently, there is no consensus thus far, with evidence supporting both the hypotheses. Cummins, Weiss, Xie and Zi (2010) and Berger, Hasan and Zhou (2010) find evidence that the strategic focus hypothesis dominates rather than the conglomeration hypothesis in terms of a financial institution's efficiency scores. As government ownership increases, bank managers may have fewer incentives to diversify their income activities because state-owned banks with their size and market power typically have the capacity to generate more traditional interest-based products instead of non-traditional ones (Floros & Tan, 2013; Pennathur, Subrahmanyam, & Vishwasrao, 2012). Banks successful in traditional income activities may seek long-term relationships with their clients (Nguyen, Skully, & Perera, 2012), and through this behavioural trend be able to change the impact of income diversification on bank efficiency.

Banks that concentrate more on traditional interest-based activities are viewed as desirable for owners and supervisors as interest income can be higher than the bank's fee and commission during economic booms (Nguyen, Skully, & Perera, 2012). During the global recession period, however, banks with 'flight to safety' restructure their assets towards highly liquid securities and cash equivalents. This reflects a substantial decline in private sector credit and leads to a disproportionate strategy to minimize systemic risks. In addition, banks with a considerable decline in profitability tend to get rid of their loans and search for new income sources such as fee-based services and government securities (Gamra & Plihon, 2011). In the meantime, with the government intervention for guaranteeing the stability of the banking system, state-owned banks are constrained to expand their financial product lines, whereas foreign-owned banks through their changes in

products and services have a greater proportion of non-interest income (Pennathur, Subrahmanyam, & Vishwasrao, 2012). Therefore, the global financial crisis can be viewed as a key factor in altering investment behaviour and risk exposure of banks, and we conduct our estimates separately for two sample periods to test for potential differences.

As suggested by the studies of Gamra and Plihon (2011) and Meslier, Tacneng and Tarazi (2014), greater competition in financial markets leads to an increasing need for banks to diversify. Banks with various diversification strategies can produce information that enhances their loan-making by activities such as securities underwriting, brokerage and other trading services. Regarding cost of diversification, Rajan, Servaes and Zingales (2000) show that average misallocation of capital across divisions is increased by higher diversity between segments, leading to higher costs of inefficient investment. This evidence is further confirmed by Stiroh and Rumble (2006), who suggest that the increased switching costs are associated with product-line expansion, worsening the diversification discount.

There is no agreement among researchers regarding the relationship between income diversification, ownership structure and bank efficiency. Some empirical studies strongly suggest that government and foreign banks do not diversify equally into non-traditional sources of income. Pennathur, Subrahmanyam and Vishwasrao (2012) suggest that local banks tend to have considerably lower fee-based income compared with foreign banks. They also suggest that more profitable public banks seek out fewer non-traditional income sources, while the opposite is true for foreign banks. As a result, the pursuit of fee-based income by foreign banks increases their portfolio risks, whereas income diversification benefits public sector banks as measured by the volatility of their profitability variables. Claessens, Demirguc-Kunt and Huizinga (2001) suggest that foreign banks with greater investment experience in financial markets are expected to improve competition and thereby, efficiency of the local banking industry.

Berger, Hasan and Zhou (2010) examine the effects of focus versus diversification on bank performance using data on Chinese banks during 1996–2006. They construct a measure of economies of diversification and compare the results to those obtained by more conventional focus indices. Diversification is captured through four dimensions: loans, deposits, assets and geography. They find that all four dimensions of diversification are associated with reduced profits and higher costs. These results are robust regardless of alternative measures of diversification and performance. Furthermore, they observe that banks with foreign ownership and banks with conglomerate affiliation are associated with fewer diseconomies of diversification, suggesting that foreign ownership and conglomerate affiliation play an important mitigating role. Meslier, Tacneng and Tarazi (2014) find that foreign-owned banks benefit more from a shift towards non-interest activities than domestic banks. They, therefore, conclude that foreign banks in developing countries generally suffer from insufficient knowledge in local markets and, hence, tend to specialize in non-interest income-generating activities rather than traditional bank activities.

Although empirical studies hypothesize that banking deregulation enhances the efficiency of banks, evidence on such a proposition is mixed. Gilbert and Wilson (1998) investigate the effects of deregulation on the efficiency of Korean banks over the period 1980 to 1994. They find that most Korean banks experience efficiency gains during the period of deregulation when government controls are lifted and relaxed. Likewise, in Turkey (Zaim, 1995), Thailand (Leightner & Lovell, 1998), Portugal (Canhoto & Dermine, 2003) and Australia (Sturm & Williams, 2004), deregulation is found to have had a positive impact on the efficiency of the domestic banking sector.

However, many studies also find that deregulation appears to lead to deterioration or, at least, no significant improvement in efficiency levels. The empirical evidence for the USA shows that measured efficiency decreases following deregulation (Bauer, Berger, & Humphrey, 1993; Humprey, 1993; Humprey & Pulley, 1997; Wheelock & Wilson, 1999). The decline is mainly attributed to interest rate deregulation, inducing a competitive scramble to pay higher interest rates on deposits (Berger & Humphrey, 1997).

Most studies which investigate the relationship between domestic and foreign ownerships and bank efficiency are based on experiences in the US banking sector and find that foreign-owned banks have significantly lower efficiency on an average than domestic banks (Chang, Hasan, & Hunter, 1998; DeYoung & Nolle, 1996; Hasan & Hunter, 1996; Mahajan, Rangan, & Zardkoohi, 1996). Berger, DeYoung, Genay and Udell (2000) investigate the relative efficiency of foreign versus domestic banks in five home countries—France, Germany, Spain, UK and the USA. They find that foreign banks in these countries exhibit both lower cost efficiency and lower profit efficiency in comparison to domestic banks. However, after disaggregating the results by nation of origin, they conclude that foreign banks from the USA are more efficient than their domestic counterparts. In contrast, cross-country evidence from transitional economies suggests that foreign-owned banks are more efficient than domestic-owned banks (Bonin, Hasan, & Wachtel, 2005a, 2005b; Fries & Taci, 2005; Weill, 2003). In addition, some single-country

studies analyze the relationship between ownership and banking efficiency. Isik and Hassan (2002a, 2002b) on the Turkish banking industry, Sturm and Williams (2004) on the Australian banking sector and Kraft, Hofler and Payne (2006) on Croatia's commercial banks generally find that foreign banks have substantially better efficiency scores than domestic banks.

Size has often been found to be an important factor that drives variations in efficiency across banks. As banking in recent times is technology-driven and technological progress augments scale efficiency, the relationship between bank size and efficiency has become relevant. An analysis of the relationship between size and bank efficiency provides useful information to regulators and allows bank managers to assess the optimal scale at which to conduct their operations. Larger banks may have more professional management teams which are more effective in cost control, thereby resulting in higher profits (Evanoff & Israilevich, 1991). It is often argued that larger banks possess more flexibility in financial markets and are better able to diversify their credit risks (Cole & Gunther, 1995). Casu and Girardone (2006) also point out that larger banks may experience economies of scale and scope from growth and joint production opportunities. All these factors enable large banks to exploit their size advantages and achieve more efficient operating outcomes. On the other hand, larger banks are more complex and, therefore, more difficult to manage. Hence, bureaucratic problems may arise in large banks, and these can lead to less efficient operating outcomes for the affected banks (Delis & Papanikolaou, 2009).

It is evident that there is no consensus among the studies about the relationship between bank size and banking efficiency. Berger, Hancock and Humphrey (1993) use both the logarithm of total bank assets and the logarithm of the number of bank offices to proxy for bank size. They find a significant positive relationship between the two size measures and the level of banking efficiency, suggesting that the larger US banks tend to be more efficient. Other studies find similar results (Hasan & Marton, 2003; Miller & Noulas, 1996; Perera, Skully, & Wickramanayake, 2007). Isik and Hassan (2003) divide Turkish banks into three size categories according to their total assets, namely small banks, medium-sized banks and large banks. Such a size classification allows for the testing of a potentially non-monotonic relationship between banks size and efficiency. They find that medium-sized banks are more efficient than both small and large banks in terms of TE. Similarly, Aly, Grabowski, Pasurka and Rangan (1990), Mester (1993), Pi and Timme (1993), Berger and Hannan (1998) and Havrylchyk (2006) do not report a significant relationship between size and banking efficiency. A number of other studies, however, find a significant negative relationship between size and banking efficiency and suggest that small banks may possess operational advantages that bring about higher efficiencies (De Young & Nolle, 1996; Girardone, Molyneux, & Gardener, 2004; Hermalin & Wallace, 1994; Isik & Hassan, 2002a, 2002b; Kumbhakar & Wang, 2007).

Studies using DEA to analyze bank efficiency have found divergent results. Berg, Forsund and Jansen (1992) examine the efficiency of Norwegian banks before and after deregulation based on the value added approach. Their analysis reveals that efficiency is low in the pre-deregulation years, mainly due to the emergence of idle capacity in anticipation of increased competition. Efficiency growth is, however, rapid post-1987, with significant convergence in efficiency levels, implying increased competition in the deregulated period. Zaim (1995) examines the effect of financial liberalization on the TE of Turkish commercial banks using DEA. In the study, the years 1981 and 1990 represent the pre- and post-financial liberalization periods, respectively. He finds that the TE of Turkish banks improves by 10 per cent on an average after the implementation of the liberalization programme by the Turkish Government, thus creating a more competitive environment. The study further decomposes overall TE into PTE and scale efficiency. It finds that most Turkish banks operate under constant returns to scale (CRS) and that technical inefficiency is mainly attributable to low PTE.

Using DEA on a cross section of 427 banks in eight developed countries, the mean efficiency value is found to be 0.86 with a range of 0.55 for the UK to 0.95 for France (Pastor, Pérez, & Quesada, 1997). Ataullah, Cockerill and Le (2004) provide a comparative analysis of the efficiency of commercial banks in India and Pakistan for the period 1988–1998. They employ two alternative DEA specifications (loan-based and income-based models) to measure TE. They find that the overall TE of both Indian and Pakistani banks improves gradually over the sample period. In the case of Indian banks, the improvement is attributed to both increases in PTE and scale efficiency. For Pakistani banks, however, the increased overall TE is primarily attributed to an improvement in scale efficiency. Moreover, comparing the results of the loan-based and income-based models, they find that banks are relatively more efficient in generating earning assets than in generating income.

In the context of the Indian banking sector, there are a few studies that analyze how ownership affects efficiency. Noulas and Ketkar (1996) use the intermediation approach with three inputs and two outputs. They determine the TE and scale efficiency of public sector banks for 1993.

They find an average technical inefficiency of 3.75 per cent, of which two-thirds is due to scale inefficiency. Hence, they conclude that efficiency of banks in India could increase by increasing the scale. Das (1997) studies technical, allocative and scale efficiency of different public sector banks for the period 1990–1996 using DEA. He uses the intermediation approach with two inputs—labour and loanable funds—and one output measure. Efficiencies are calculated for each year for all the banks. The study finds a decline in overall efficiency over time and decline in TE with a slight improvement in allocative efficiency. Thus, changes in inefficiency are due to technical inefficiency rather than allocative inefficiency. State Bank of India (SBI) is found to be more efficient than other public sector banks.

Saha and Ravishankar (2000) analyze the performance of Indian banks using the DEA approach. They examine the performance of 25 public sector banks over the period 1992–1995. The analysis is done in two stages. In the first stage, efficiency is measured as a ratio of certain outputs to inputs. Number of branches, number of employees, establishment expenses and non-establishment expenses are taken as inputs. Deposits, advances, investments, spread, total income, interest income, non-interest income and working funds are considered as measures of outputs. In the second stage, DEA is used on the same data to determine the efficiency frontier. Their findings indicate that efficiency of public sector banks has improved over the sample time period.

Das, Nag and Ray (2004) empirically estimate and analyze various efficiency scores of Indian banks during 1997–2003 using DEA. It is observed that Indian banks are not very different in terms of input- or output-oriented TE and cost efficiency. However, they differ sharply in respect of revenue and profit efficiencies. Bank size, ownership and listing on the stock exchange are some of the factors that are found to have a positive impact on the average profit efficiency and to some extent revenue efficiency scores. Finally, the authors observe that the median efficiency scores of Indian banks, in general, and of bigger banks, in particular, have improved considerably during the post-reform period.

Ray (2004) uses data from the years 1997 through 2003 to evaluate the size efficiency of Indian banks. Following Maindiratta (1990), we consider a bank to be too large if breaking it up into a number of smaller units would result in a larger output bundle than what could be produced from the same input by a single bank. When this is the case, the bank is not size efficient. The analysis shows that many of the banks are, indeed, too large in various years. He also finds that often a bank is operating in the region of dimin ishing returns to scale but is not a candidate for break up.

Chakrabarti and Chawla (2005) apply DEA to evaluate the relative efficiency of Indian banks during 1990–2002. Their results suggest that from a value perspective, foreign banks are considerably more efficient than all other bank groups, followed by domestic private banks. From a quantity perspective, however, private banks seem to be doing the best, while foreign banks are the worst performers. This seems to reflect the general policy of foreign banks to 'cherry-pick' more profitable businesses, rather than offer banking services to a wider section. Public sector banks in comparison lag behind their private counterparts in performance.

Roy (2014) suggests that TE and scale efficiency of the foreign banks have increased through manifold over pre-Basel, Basel I and Basel II periods. Private sector banks show marginal variation across the three eras in case of both the efficiencies. However, in case of SBI and its associates as well as nationalized banks, there has been a significant decrease in the TE scores with the major cause of such inefficiency being improper size allocation. The problem of improper size and resource allocation remains an area of concern for the banks across all the four ownership structures.

The above review highlights the fact that there is a dearth in the literature with respect to how revenue diversification and its dynamics based on ownership and cycles facing the economy affect efficiency of Indian banks. Therefore, the aim of this article is to fill this deficiency by addressing this issue for the Indian banking sector and providing policy insights for regulators and supervisors.

Data and Methodology

Annual figures of individual banks for the period 1999–2000 to 2012–2013 have been collated from the various issues of Reserve Bank of India's (RBI's) yearly publication *Statistical Tables Relating to Banks in India*. Following Chakrabarty (2013), this entire period has been divided into two sub-periods—2000–2006, that is, the pre-crisis phase, and 2007–2013, that is, the post-crisis phase. The former is a period characterized by stabilization post-financial sector reforms, advancements such as computerization, devising strategies for technology implementation, challenges regarding lowering of non-performing assets (NPAs) and banks approaching markets for capital. This was also considered the growth phase, when the impact of reforms was fully felt. But it was also the period of build-up of risks due to recklessness exhibited by market players. In contrast, the latter phase has been dominated by the global financial crisis and post-crisis pains. The risks accumulated in the previous phase have crystallized

during this period. The period is also marred by reforms fatigue, lack of financial inclusion, absence of internal reforms and ineffective structure, systems and people. The data encompasses domestic banks (SBI and its associates, nationalized and private sector banks) as well as foreign banks. Based on the number of banks for which data is available, we arrive at an unbalanced panel dataset consisting of 1,154 observations. We also take into account that new private banks became operational only in 1996 and, hence, the number of reporting banks has witnessed wide fluctuations. The Indian banking industry has also witnessed a lot of consolidation activity, both domestic and international, in recent times. Therefore, the number of reporting banks varies from year to year.

To explore the effect of revenue diversification on Indian banks' efficiency, we estimate the following regression specification:

$$\mathbf{E_{it} = \alpha_i + \beta_1 Revd_{it} + \beta_2 (Oship \times Prd \times Revd)_{it} + \beta_3 BS_{it} + u_{it}} \quad (1)$$

E represents an efficiency indicator and α_i represents bank-specific fixed effects (FE). *Revd* is revenue diversification calculated as the ratio of non-interest income to total operating income. *Oship* stands for a dummy variable, where domestic banks = 1 and foreign banks = 0. Similarly, *Prd* is also a dummy variable, where pre-crisis period = 1 and post-crisis period = 0. *BS* is the vector of bank-specific controls costs and size. Cost is the ratio of overhead expenses to total assets while size is taken as the log of an individual bank's total assets.

Following Amidu and Wolfe (2013), the alternate measure of revenue diversification that we employ is HHI_{Rev} which is the Herfindahl–Hirschman index for revenue diversification. We then estimate the following regression specification:

$$\mathbf{E_{it} = \alpha_i + \beta_1 HHI_{Revit} + \beta_2 (Oship \times Prd \times HHI_{Rev})_{it} + \beta_3 BS_{it} + u_{it}} \quad (2)$$

$$\mathbf{HHI_{Rev} = (NON/NETOP)^2 + (NET/NETOP)^2} \quad (3)$$

where, *NON* = non-interest income, *NET* = net interest income (interest income – interest expenses) and *NETOP* = net operating income (non-interest income + net interest income).

We further test the above equations by dropping the control variables cost and size to see how results are affected. Therefore, we have the following regression specifications:

$$\mathbf{E_{it} = \alpha_i + \beta_1 Revd_{it} + \beta_2 (Oship \times Prd \times Revd)_{it} + u_{it}} \quad (4)$$

$$\mathbf{E_{it} = \alpha_i + \beta_1 HHI_{Revit} + \beta_2 (Oship \times Prd \times HHI_{Rev})_{it} + u_{it}} \quad (5)$$

Contrary to the case of a typical manufacturing firm, a bank does not churn out a definite product or output. It is a multiproduct-producing unit. Therefore, the yardsticks used to measure the efficiency of a manufacturing firm cannot be accurately implemented in the case of banks (RBI, 2008). Also, there is no consensus in the literature regarding which approach is the most appropriate to measure banks' inputs and outputs. Under the intermediation approach, banks are considered to be intermediaries of funds between savers and investors. They collect deposits and other liabilities and then channelize them into interest-earning assets, such as loans, securities and investments. This approach considers both operating and interest costs as inputs, while loans and other assets are treated as outputs. Another framework employed is the operating approach, also known as the income-based approach. It states that banks operate as business units with their main aim being revenue generation from the total cost incurred for running their various business activities (Leightner & Lovell, 1998). Accordingly, a bank's output is defined as the total revenue (interest and non-interest incomes) and inputs are the total expenses (interest and operating expenses; Das & Ghosh, 2006). All four variables are considered separately as outputs and inputs respectively.

Following Das and Ghosh (2006), TE and PTE scores under the intermediation and operating approaches—intermediation approach technical efficiency (IATE), intermediation approach pure technical efficiency (IAPTE), operating approach technical efficiency (OATE) and operating approach pure technical efficiency (OAPTE) respectively—have been calculated employing DEA.

The advantage of DEA is that unlike parametric approaches, it does not necessitate the specification of a particular functional form of the frontier. DEA identifies the units/banks that achieve the best results. Therefore, DEA allows for the examination of best performers and their best practices, thereby giving the efficiency score for each bank. This is important for this particular study, where financial institutions are aggregated and, hence, it is important to know how each different form of financial institution performs. The DEA solution is unique for each decision-making unit (DMU)/bank under investigation, which allows a direct comparison to be made against a peer or a combination of peers. Finally, DEA uses data on various inputs and outputs (sources) and shows the magnitude of the inefficiency.

All the above variables are further defined in detail in Tables 1 and 2. Table 3 highlights the variable number of reporting banks in each year. Moreover, the

Table 1. Definitions of Variables

Technical Efficiency (TE)	The technical efficiency of a bank helps to draw inferences regarding its success or failure in transforming inputs into outputs under CRS.
Pure Technical Efficiency (PTE)	Further refinement is attempted by considering pure technical efficiency that generates results under VRS.
Revenue Diversification (Revd)	It is calculated as the ratio of non-interest income to total operating income. Non-interest income includes fee and service income, trading income, commission and brokerage, fiduciary income, etc.
HHI Revenue Diversification (HHI_{Rev})	This measure is computed for each bank. An increase in HHI shows a rise in revenue concentration and, therefore, implies less diversification.
Cost (OCTA)	It is defined as the ratio of operating expenses to total assets (OCTA). Efforts by a bank to cut costs through rationalization of its labour force and branches and back office operations get reflected in this ratio. The ratio is also used to represent the intermediation cost of the banking system, as banks use these operating costs to generate assets (loans) from their available funds (deposits). A reduction in operating costs is expected to decrease lending rates and net interest margin (NIM).
Size (SIZE)	Size helps in taking into account the scale of operations that improve banks' efficiency. It is measured by the log of total assets of a bank.

Source: Based on the literature.

Table 2. Variables Employed for DEA Analysis

Approach	Input Variables	Output Variables
Intermediation Approach	x1 = Demand Deposits x2 = Savings Deposits x3 = Term Deposits x4 = Capital-related Operating Expenses x5 = Employee Expenses	y1 = Investments y2 = Advances
Operating Approach	x1 = Interest Expenses x2 = Capital-related Operating Expenses x3 = Employee Expenses	y1 = Interest Income y2 = Non-interest/ Other Income

Source: Das and Ghosh (2006).

Charnes–Cooper–Rhodes (CCR—CRS) and Banker–Charnes–Cooper (BCC—variable returns to scale [VRS]) DEA models used to calculate TE and PTE scores respectively are elaborated in the Appendix.

Table 3. Number of Reporting Scheduled Commercial Banks in India: 1999–2000 to 2012–2013

Year	Number of Reporting Banks
1999–2000	100
2000–2001	98
2001–2002	91
2002–2003	88
2003–2004	88
2004–2005	78
2005–2006	82
2006–2007	80
2007–2008	76
2008–2009	75
2009–2010	76
2010–2011	74
2011–2012	73
2012–2013	75

Source: Computed from various issues of RBI's *Statistical Tables Related to Banks in India.*

Descriptive Statistics

Table 4 reports the means and standard deviations of efficiency variables for four bank groups—diversified, specialized, domestic and foreign. We find that in the case of specialized vs diversified banks, the latter have significantly higher average scores with respect to IAPTE, OATE and OAPTE. There is a marginal difference in average

Table 4. Descriptive Statistics

	Specialized Banks		Diversified Banks		Domestic Banks		Foreign Banks	
Variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
IATE	0.630	0.271	0.631	0.238	0.609	0.193	0.670	0.093
OATE	0.760	0.203	0.783	0.173	0.775	0.146	0.742	0.101
IAPTE	0.775	0.249	0.811	0.266	0.764	0.240	0.849	0.102
OAPTE	0.835	0.183	0.921	0.121	0.908	0.060	0.851	0.100

Source: Author's calculations.

Table 5. *t*-test of Significance of Means

Variables	Diversified vs Specialized Banks	Foreign vs Domestic Banks
IATE	–0.002	–3.165***
OATE	2.087**	–3.603***
IAPTE	2.392***	2.930***
OAPTE	9.439***	4.849***

Source: Author's calculations.
Note: *** $p < 0.01$, ** $p < 0.05$.

IATE scores for both the categories. When we consider domestic vs foreign banks, the results suggest that under the intermediation approach, foreign banks have both higher average TE and PTE, while under the operating approach, domestic banks report the same. Table 5 reports the *t*-test statistic of significance of means between the same bank groups and confirms these results.

We check for differences in mean efficiency scores between diversified and specialized banks during the pre- and post-crisis periods in Table 6. We find that in the pre-crisis period, diversified banks have higher TE and PTE scores under both the intermediation and operating approaches. In the post-crisis period, we find that specialized banks have higher IATE, IAPTE and OATE scores, but diversified banks report a higher OAPTE scores. This means that in the light of risks prevalent in the post-crisis period, being conservative in terms of engaging in non-traditional business activities has paid off banks with higher efficiency, while diversified banks have reported lower scores.

Next, we analyze whether foreign or domestic banks diversify more into non-interest income generating activities in the pre- and post-crisis periods. This is shown through Table 7. The results suggest that in both the pre- and post-crisis periods, foreign banks have reported to higher income diversification. Lastly, trends in efficiency of foreign and domestic banks in the two sub-periods have been exhibited through Table 8. The results suggest that in the pre-crisis period, domestic banks report higher IAPTE, OATE and OAPTE scores, whereas foreign banks have higher IATE score. In the post-crisis period, while foreign banks exhibit higher IATE, IAPTE and OATE scores, domestic banks report higher OAPTE scores. Therefore, we can presume that due to vulnerabilities in the system in the post-crisis period, domestic banks' efficiency has been negatively affected.

Results of Empirical Analysis

This section reviews the results of our empirical panel data regression analysis based on our four regression specifications outlined in the third section. We run both FE and random effects (RE) models, and the choice between the two is based on the results generated by the Hausman test.

Table 6. Differences in Mean Efficiency Scores under Intermediation and Operating Approaches—Diversified vs Specialized Banks in Pre- and Post-crisis Periods

	Specialized Banks				Diversified Banks			
Period	IATE	OATE	IAPTE	OAPTE	IATE	OATE	IAPTE	OAPTE
2000–2006	0.694	0.790	0.799	0.841	0.727	0.852	0.871	0.949
2007–2013	0.550	0.727	0.740	0.829	0.507	0.701	0.729	0.887

Source: Author's calculations.

Table 7. Mean Revenue Diversification Scores Based on Bank Ownership in Pre- and Post-crisis Periods

Period	Mean Revd DBs	Mean Revd FBs
2000–2006	0.417	0.451
2007–2013	0.316	0.377

Source: Author's calculations.

Table 8. Mean Efficiency Scores under Intermediation and Operating according to Bank Ownership in Pre- and Post-crisis

	Domestic Banks				Foreign Banks			
Period	IATE	OATE	IAPTE	OAPTE	IATE	OATE	IAPTE	OAPTE
2000–2006	0.724	0.852	0.848	0.927	0.727	0.767	0.844	0.857
2007–2013	0.495	0.699	0.680	0.888	0.612	0.767	0.854	0.844

Source: Author's calculations.

Table 9. Regression Results (Specification 1)

Particulars	Intermediation Approach Technical Efficiency (IATE)	Intermediation Approach Pure Technical Efficiency (IAPTE)	Operating Approach Technical Efficiency (OATE)	Operating Approach Pure Technical Efficiency (OAPTE)
Revenue Diversification (Revd)	0.061 (0.035)*	0.089 (0.40)**	–0.121 (0.028)***	–0.100 (0.023)***
Interaction Term Oship*Prd*Revd	0.252 (0.036)***	0.166 (0.041)***	0.274 (0.029)***	0.145 (0.024)***
Control Variables				
OCTA	–0.013** (0.005)	–0.019 (0.006)***	–0.010 (0.004)**	–0.000 (0.003)
SIZE	–0.116 (0.013)***	–0.094 (0.015)***	–0.053 (0.010)***	–0.010 (0.008)
FE/RE	FE	FE	FE	FE
F-Stat	64.06***	29.44***	41.25***	12.23***
R^2 (within)	0.198	0.102	0.137	0.045
Intercept	1.252 (0.080)	1.288 (0.091)	1.095 (0.065)	0.955 (0.053)

Source: Author's calculations.
Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

When the results of the test are in favour of the FE model, we report the corresponding estimates along with the *F*-test statistic to signify goodness of fit of the model. Contrarily, if the test evidence supports the RE model, then we present the relevant estimates and the Wald-test statistic to assess the model fit. We structure our discussion as per results under the intermediation and operating approaches.

Table 9 reports the estimation results of how Revd affects banks' efficiency as per our regression specification —equation (1).

Under the intermediation approach, we find that Revd affects both TE and PTE positively, thus providing evidence in support of the conglomeration hypothesis. This shows that banks that diversify into non-interest income-generating activities have greater efficiency than banks that focus on traditional sources of only interest income. While with respect to TE, it has a coefficient of 0.061, significant at the 10 per cent level, with regard to PTE, it displays a coefficient of 0.089 at the 5 per cent significance level. This shows that if banks operate under VRS rather than simply CRS, then they have a better chance of increasing their efficiency due to higher income diversification.

Furthermore, we find that the interaction term of ownership, crisis period and Revd is positively related to both types of efficiencies. While with regard to TE, it has a coefficient of 0.252, significant at the 1 per cent level, in terms of PTE, it displays a coefficient of 0.166, also significant at the 1 per cent level. From this, we can say that foreign banks resort to higher income diversification in the post-crisis period as compared with their domestic counterparts. This can be considered as a strategy to mitigate risks by concentrating solely on interest income. As loans are the main source of interest, digressing into non-interest generating sources can help reduce vulnerabilities faced due to customers defaulting on their payments.

Moreover, we find that the control variables cost and size are negatively and significantly related to banks' efficiency. For TE, cost has a coefficient of –0.013, significant at the 5 per cent level, while it reports a coefficient of –0.019 for PTE, significant at the 1 per cent level. Similarly, for the former, size displays a coefficient of –0.116 at the 1 per cent significance level, while with respect to the latter, it has a coefficient of –0.094, also significant at the 1 per cent level. This shows that both higher costs and a larger bank size are detrimental to efficiency. Banks should try to lower their day-to-day overhead expenses and maintain an optimum scale of operations in order to avoid lower efficiency in their operations.

Under the operating approach, we find that Revd affects both TE and PTE negatively and significantly, thus providing evidence in support of the strategic focus hypothesis. This shows that banks that do not enter into non-interest income-generating activities report lower efficiency scores than banks that diversify their income portfolios. While with respect to TE, Revd has a coefficient of –0.121, with regard to PTE, it reports a coefficient of –0.100. Both these coefficients are statistically significant at the level of 1 per cent.

Furthermore, we find that the interaction term relating to ownership, crisis period and Revd is positively related to both types of efficiencies. While with TE, it displays a coefficient of 0.274, with respect to PTE, it displays a

coefficient of 0.145. Both of them are significant at the 1 per cent level. It follows from this observation that foreign banks resort to higher income diversification in the post-crisis period as compared with domestic ones. The global financial crisis has asserted that banks that rely excessively on traditional interest income sources have lower efficiency. Foreign banks in developing countries also face the roadblock of insufficient knowledge in local markets and, hence, prefer to specialize in non-interest income-generating activities rather than traditional bank activities.

However, unlike the intermediation approach, with respect to control variables cost and size, we find that they are negatively and significantly related only to banks' TE and not PTE. Cost reports a coefficient of –0.010, significant at the 5 per cent level, while size has a coefficient of –0.053, which is statistically significant at the 1 per cent level. This shows that greater overhead costs and a more than optimum bank size harm efficiency. Banks can face greater bureaucratic and managerial problems, thus resulting in lower efficiency.

Table 10 presents the regression results of our specification—equation (2)—wherein we use HHI_{Rev} as our alternate measure of revenue diversification.

Following the intermediation approach, our results suggest that HHI_{Rev} is negatively and significantly related to banks' TE and PTE scores. With respect to TE, it has a coefficient of –0.227, while with regard to PTE, it displays a coefficient of –0.271. Both these coefficients are statistically significant at the 1 per cent level. This shows that the lower the HHI_{Rev}, the lower is concentration of revenue. This leads to banks diversifying more into non-interest income-generating activities, which unfortunately reduces their efficiency. Moreover, our earlier result of the interaction term is further corroborated herein, as we see that foreign banks digress more than domestic ones into non-interest sources of income in the post-crisis period. With respect to TE, the positive coefficient is 0.261, while with respect to PTE, the coefficient displayed is 0.236.

Turning to the control variables cost and size, we find that both affect TE and PTE negatively and significantly. Cost has a coefficient of –0.009 with TE, which is statistically significant at the 10 per cent level, while with PTE, it displays a coefficient of –0.013, which is significant at the 5 per cent level. From this, we can assume that banks that follow VRS in their method of operations incur greater costs, thereby compromising on their efficiency. Size reports a negative coefficient of –0.095 with TE, while with PTE, the coefficient is –0.066. Both these coefficients are statistically significant at the 1 per cent level. Thus, banks should avoid growing too big in scale, as it can lead to problems in achieving higher efficiency.

Under the operating approach, we observe that HHI_{Rev} affects both TE and PTE of banks negatively and significantly. It has a coefficient of –0.150 with TE and a coefficient of –0.101 with PTE, both of which are statistically significant at the 1 per cent level. This shows that lower HHI_{Rev} leads to lesser revenue concentration and, therefore, higher income diversification by banks, thus reducing efficiency. Moreover, we again find that foreign banks

Table 10. Regression Results (Specification 2)

Particulars	Intermediation Approach Technical Efficiency (IATE)	Intermediation Approach Pure Technical Efficiency (IAPTE)	Operating Approach Technical Efficiency (OATE)	Operating Approach Pure Technical Efficiency (OAPTE)
HHI Revenue Diversification (HHI_{Rev})	–0.227 (0.035)***	–0.271 (0.039)***	–0.150 (0.028)***	–0.101 (0.023)***
Interaction Term Oship*Prd* HHI_{Rev}	0.261 (0.025)***	0.236 (0.028)***	0.199 (0.020)***	0.109 (0.017)***
Control Variables				
OCTA	–0.009 (0.005)*	–0.013 (0.006)**	–0.009 (0.004)**	0.000 (0.003)
SIZE	–0.095 (0.013)***	–0.066 (0.015)***	–0.043 (0.011)***	–0.002 (0.009)
FE/RE	FE	FE	FE	FE
F-Stat	68.79***	37.99***	42.66***	13.22***
R^2 (within)	0.210	0.128	0.141	0.048
Intercept	1.273 (0.080)	1.299 (0.090)	1.077 (0.065)	

Source: Author's calculations.
Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

Table 11. Regression Results (Specification 3)

Particulars	Intermediation Approach Technical Efficiency (IATE)	Intermediation Approach Pure Technical Efficiency (IAPTE)	Operating Approach Technical Efficiency (OATE)	Operating Approach Pure Technical Efficiency (OAPTE)
Revenue Diversification (Revd)	0.039 (0.036)	0.066 (0.040)*	–0.133 (0.028)***	–0.099 (0.022)***
Interaction Term Oship*Prd*Revd	0.356 (0.035)***	0.253 (0.039)***	0.323 (0.027)***	0.142 (0.021)***
FE/RE	FE	FE	FE	RE
F-Stat	77.61***	37.96***	68.19***	
Wald Test				45.55****
R^2 (within)	0.130	0.068	0.116	0.043
Intercept	0.563 (0.013)	0.731 (0.015)	0.776 (0.010)	0.882 (0.013)

Source: Author's calculations.
Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

digress more than domestic ones into non-interest sources of income in the post-crisis period. With respect to TE, it shows a positive coefficient of 0.199, while with PTE, it displays a positive coefficient of 0.109. Both these coefficients are statistically significant at the level of 1 per cent.

In the context of control variables cost and size, we find that they affect only TE negatively and significantly. Cost has a coefficient of –0.009, significant at the 5 per cent level, while size reports a negative coefficient of –0.043, which is statistically significant at the 1 per cent level. Thus, banks should avoid incurring high overhead costs and growing beyond the most productive scale size, as it can lead to problems in achieving higher efficiency.

Next, we report our results of regression specification—equation (3) in Table 11, that is, to test if results of Revd are altered when we drop control variables cost and size.

With regard to the intermediation approach, we find that we lose significance of Revd with respect to TE, but with respect to PTE, our earlier finding of Table 9 in support of the conglomeration hypothesis holds. Revd has a positive effect on PTE with a coefficient of 0.066, statistically significant at the 10 per cent level. Also, in sync with Table 9, we find that foreign banks display both higher TE and PTE due to magnified income diversification in the post-financial crisis period as compared with domestic banks. The interaction term has a positive coefficient of 0.356 with TE and a positive coefficient of 0.253 with PTE. Both these coefficients are statistically significant at the 1 per cent level.

Under the operating approach, we find support for the strategic focus hypothesis, which is in sync with our results presented in Table 9. Revd affects both TE and PTE negatively and significantly, thus indicating that banks that confine themselves to only interest streams of income are prone to lower efficiency scores. With the former, it displays a coefficient of –0.133, while with the latter, it exhibits a coefficient of –0.099, both being statistically significant at the 1 per cent level. Also, further corroborating the results of Table 9, we find that foreign banks display both higher TE and PTE due to magnified income diversification in the post-financial crisis period as compared with domestic banks. The interaction term has a positive coefficient of 0.323 with TE and a positive coefficient of 0.142 with PTE. Both these coefficients are statistically significant at the 1 per cent level.

Based on our regression equation (4), Table 12 reports whether results of HHI_{Rev} are altered when control variables cost and size are excluded.

In the context of the intermediation approach, we see that our results remain unchanged, as HHI_{Rev} continues to affect both types of efficiencies negatively and significantly, thus indicating that lower revenue concentration triggers higher income diversification, leading to lower efficiency levels of banks. It has a negative coefficient of –0.300 with TE and a coefficient of –0.318 with PTE. Both of them are significant at the level of 1 per cent. Moreover, the interaction term also implies the same evidence as shown in Table 11. Its coefficient with TE is 0.339, while with PTE it is 0.290, both being statistically significant the level of 1 per cent.

Regarding the operating approach, we find that our results and the corresponding implications for efficiency remain unchanged. HHI_{Rev} affects banks' TE and PTE negatively and significantly. It has a coefficient of –0.180 with TE, and with PTE, it displays a coefficient of –0.100, both of them being statistically significant at the level of 1 per cent. Also, the interaction term highlights that foreign banks shift their income model more towards non-interest

Table 12. Regression Results (Specification 4)

Particulars	Intermediation Approach Technical Efficiency (IATE)	Intermediation Approach Pure Technical Efficiency (IAPTE)	Operating Approach Technical Efficiency (OATE)	Operating Approach Pure Technical Efficiency (OAPTE)
HHI Revenue Diversification (HHI_{Rev})	–0.300 (0.035)***	–0.318 (0.038)***	–0.180 (0.027)***	–0.100 (0.022)***
Interaction Term Oship*Prd* HHI_{Rev}	0.339 (0.023)***	0.290 (0.026)***	0.234 (0.018)***	0.105 (0.014)***
FE/RE	FE	FE	FE	RE
F-Stat	102.64***	65.63***	76.81***	
Wald Test				52.31***
R^2 (within)	0.165	0.112	0.129	0.048
Intercept	0.743 (0.020)	0.928 (0.022)	0.833 (0.016)	0.904 (0.016)

Source: Author's calculations.
Note: *** p < 0.01, ** p < 0.05, * p < 0.1.

income sources in relation to domestic banks in the post-crisis period. Its coefficient with TE is 0.234 and with PTE, it is 0.105, both being statistically significant the 1 per cent level.

Conclusions and Recommendations

In the context of the Indian banking sector, this article attempts to understand how digressing into unconventional non-interest sources of income affects efficiency of banks in the light of two competing hypotheses prevalent in the literature—the strategic focus hypothesis and the conglomeration hypothesis. We supplement this aspect by further studying how ownership differences between banks, that is, domestic and foreign, as well as crisis cycles faced by the economy, that is, pre- and post-crisis periods, affect such income diversification and, therefore, banks' efficiency.

With respect to revenue diversification as a measure of the share of non-interest income of a bank in its total income portfolio, under the intermediation approach, for both TE and PTE, our results in the context of the Indian banking sector favour the conglomeration hypothesis which asserts that banks that diversify their income portfolios more during periods of crisis are in a stronger position to be able to reap the benefits of higher efficiency gains as compared with those that focus on a single stream of income (Calomiris, 1998; Gallo, Apilado, & Kolari, 1996; Gambacorta & Marques-Ibanez, 2011; Meador, Ryan, & Schellhorn, 2000; RBI, 2008;). In line with the studies of Gamra and Plihon (2011) and Meslier, Tacneng and Tarazi (2014), we find support in favour of the fact that greater competition in financial markets leads to increasing need for banks to diversify. Banks with multiple diversification strategies can produce information that enhances their loan-making by activities such as securities underwriting, brokerage and other trading services. Foreign banks reap more advantages from a shift towards non-interest activities than domestic banks. However, under the operating approach, with respect to both types of efficiencies, we find support for the strategic focus hypothesis, which states that lower income diversification by banks helps in improving their efficiency. This finding is in line with studies such as Jensen (1986) and Denis, Denis and Sarin (1997).

When we consider the Herfindahl–Hirschman index (HHI_{Rev}) as an alternate measure of income digression, we find that under both the intermediation and operating approaches, it displays a negative relationship with efficiency calculated under both CRS and VRS. This propagates the view that a decrease in revenue concentration by banks increases their level of income diversification, thus probably increasing their risk exposure and, therefore, reducing their efficiency. Also, foreign banks irrespective of challenges faced in the post-crisis period, tend to undertake greater diversification of their income portfolios. This is probably due to their better risk management and technological capabilities.

These differences in results based on both the approaches illustrate that when banks have to judiciously and effectively channel funds from savers to borrowers, revenue diversification in terms of multiple business segments actually helps in achieving higher efficiency. Banks can generate various types of loans and other assets to earn greater fees, commissions, brokerage and trading income. On the contrary, if banks' main objective is to minimize costs and maximize revenues, then it's better to focus on a particular line of business. This can help in achieving greater efficiency.

Moreover, following in the footsteps of foreign banks, we suggest that irrespective of being susceptible to changes

in the economic environment in the light of the global financial crisis, domestic banks should try to strengthen their risk management and technological strategies so that they can not only diversify their revenue sources, but also target greater efficiency in their operations.

Appendix

Charnes–Cooper–Rhodes (CCR; 1978) Model

The input-oriented CCR model considers a set of DMUs $j = 1,2,...,n$, utilizing quantities of inputs $X \in R_+^s$ to produce quantities of outputs $Y \in R_+^s$. The objective is to utilize minimum level of inputs with the same level of production.

x_{ij} denotes the amount of the *i*th input used by the DMU j, and y_{rj} is the amount of the *r*th output produced by DMU j. Assuming CRS, strong disposability of inputs and outputs and convexity of the production possibility set, the TE score for the DMU k (denoted by TE^k) can be obtained by solving the following set of equations:

$$1.\ \min_{\theta_k, \lambda, s_i^-, s_r^+} \quad TE^k{}_{CRS} = \theta_k - \epsilon\left(\sum_{i=1} s_i^- + \sum_{r=1} s_r^+\right)$$

subject to

$$2.\ \sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{rk} \qquad r = 1, 2, \ldots s$$

$$3.\ \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_k x_{ik} \qquad i = 1, 2, \ldots m$$

$$4.\ s_i^-, s_r^+ \geq 0$$

$$5.\ \lambda_j \geq 0 \qquad j = 1, 2, \ldots n$$

The solution to the model is interpreted as the largest contraction in inputs of bank *k* that can be carried out, given that bank *k* will stay within the reference technology. The restrictions (2) and (3) form the convex reference technology. The restriction (4) restricts the input slack (s_i^-) and output slack (s_r^+) variables to be non-negative. The restriction (5) limits the intensity variables to be non-negative. Parameter ε is a non-Archimedean infinitesimal. Since the model measures the TE of a single bank *k*, it needs to be solved *n* times to obtain the TE score of each bank in the sample. The optimal value θ_k^* reflects the TE score of bank k. TE measures inefficiencies due to the input or output configuration as well as size of operations. TE has a range of 0 to 1, that is, $0 < \theta_k^* \leq 1$, with a high score implying a higher efficiency. If $\theta_k^* = 1$ and $s_i^{-*} = s_r^{+*} = 0$, then bank k is Pareto-efficient.

As stated by Coelli et al. (2005), the piece-wise linear form of the non-parametric frontier in DEA can lead to an efficiency measurement problem. This problem arises because sections of the piece-wise linear frontier run parallel to the axes. Thus, a number of the efficient DMUs/banks can reduce their amount of inputs and still produce the same output. This is known as input slack. For the same reason, in a case involving multiple inputs and outputs, the possibility of output slack also arises. Therefore, besides the measure of TE, any non-zero input or output slack should be reported to accurately measure the TE of a firm in DEA analysis.

Thus, to identify efficiency slacks, Ali and Seiford (1993) have proposed a second-stage linear programming problem which is defined as follows:

$$\min_{\lambda OSIS} -(M1'OS + N1'IS)$$

$$\text{Subject to} \quad -q_i + Q\lambda - OS = 0$$
$$\theta x_i - X\lambda - IS = 0$$
$$\lambda \geq 0, OS \geq 0, IS \geq 0,$$

where *M1* is an $M \times 1$ vector of one and *N1* is an $N \times 1$ vector of 1. *OS* is an $M \times 1$ vector of outputs slacks and *IS* is an $N \times 1$ vector of input slacks. ϑ in this second-stage linear programming is not a variable, and the value of ϑ is taken from the first-stage result of DEA. Also, this stage must be solved for all i DMUs involved. If *OS* and *IS* are both equal to zero, then the DMU is efficient. But, positive *OS* or *IS* at the optimal solution means that the corresponding input or output of the DMU can improve further.

Banker–Charnes–Cooper (BCC; 1984) Model

The CCR model elaborated above provides the input-oriented CRS envelopment surface and a measure of TE (ϑ_k). Under the assumption of CRS, any scaled-up or scaled-down versions of the input combinations are also included in the production possibility set. However, the constraint over returns to scale may be relaxed to allow units to be compared, given their scale of operations. To allow returns to scale to be variable (i.e., constant, increasing or decreasing), Banker, Charnes and Cooper (1984) added the convexity constraint $\Sigma\lambda_j = 1$ to the CRS model. This convexity constraint essentially ensures that an inefficient DMU is only 'benchmarked' against DMUs of a similar size. The mathematical form of the BCC model in model 2 is as follows:

$$1.\ \min_{\theta_k, \lambda, s_i^-, s_r^+} \quad TE^k{}_{VRS} = \prod_k - \epsilon\left(\sum_{i=1} s_i^- + \sum_{r=1} s_r^+\right)$$

subject to

2. $\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{rk} \qquad r = 1, 2, \ldots s$

3. $\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_k x_{ik} \qquad i = 1, 2, \ldots m$

4. $\sum_{j=1}^{n} \lambda_j = 1$

5. $s_I^-, s_r^+ \geq 0$

6. $\lambda_j \geq 0 \qquad j = 1, 2, \ldots n$

The optimal value of $\prod_k$ (i.e., $\prod_k$*) represents PTE of bank k, which is a measure of efficiency without scale efficiency. Furthermore, if a bank is characterized as efficient in the CCR model, then it will also be characterized as efficient with the BCC model. However, the converse is not necessarily true.

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