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Branch expansion and banking efficiency in Sri Lanka's post-conflict era

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Branch Expansion and Banking Efficiency in Sri Lanka's Post-Conflict Era

Abstract

This study assesses changes in the technical efficiency of commercial banks in Sri Lanka following the end of armed conflict in 2009. The weighted aggregate-efficiency technique, based on a group-wise heterogeneous subsampling bootstrap approach, is employed to compare efficiency levels during the periods 2007–2009 and 2010–2013. This technique allows for heterogeneity in environmental and regulatory conditions between the two periods while assuming homogeneity within each period. Our results reveal that the banking sector experienced a significant efficiency improvement post-conflict even with unprecedented branch expansion. The findings, therefore, controvert the mainstream view that bank efficiency declined with rapid industry expansion. Further, we conclude that geographical expansion of the banking sector is a viable and effective policy tool to achieve broad-based and inclusive growth for emerging economies like Sri Lanka, particularly in a period of post-conflict recovery.

Keywords: aggregate-efficiency technique; bank ownership; bootstrap; financial intermediation; Sri Lanka

JEL Codes: G21, E55, D24, D22.

1. Introduction

At the end of the 26-year armed conflict between the government and the ethnic Tamil rebels in 2009, Sri Lanka's banking sector recorded a significant expansion in terms of geographical dispersion and number of branches. There were three main reasons for this development: 1) an overall expansion in the economy arising from the peaceful post-conflict domestic environment; 2) the pent-up demand for banking services with the expansion of agricultural land and revival of economic activities in conflict-affected areas; and 3) policies implemented by the Central Bank of Sri Lanka (CBSL) for geographical dispersion of bank branches aimed at improving broad based and inclusive access to finance. Banking sector expansion is generally encouraged by policy makers in developing countries since improvements in geographical coverage of banking services and greater access to finance are vital for

achieving broad-based and inclusive economic growth. However, a growing body of literature raises the possibility of a decline in bank efficiency due to “over-branching”. Increased banking costs, particularly with respect to employees and fixed assets, have been identified by some studies as contributing to a decline in banking efficiency subsequent to branch expansion (Berger *et al.* 1997; Battese *et al.* 2000; Berger & De Young 2006; Vu & Turnell 2010). In addition, informational asymmetries, lack of knowledge of new market conditions, and insufficient assessment of socio-economic conditions have been identified as additional factors dampening banking efficiency with branch expansion (Bhattacharyya *et al.* 1997; Buch 2003; Das & Ghosh 2006; Bhattacharyya & Pal 2013). Therefore, an assessment of the efficiency of Sri Lankan banks, particularly the commercial banks which dominate the financial sector, is both timely and pertinent.

From a macroeconomic point of view, it is also crucial for Sri Lanka to achieve the highest possible level of banking efficiency to ensure the sustainability of the high economic growth achieved in the post-conflict era. Policy makers, at the same time, aim to ensure access to finance for people living in regional areas with the objective of eliminating economic disparities, generally identified as a root cause of armed conflict. Typically, there are tensions between policy objectives of achieving broad-based economic growth and raising efficiency in the banking sector. Hence, this study investigates the technical efficiency of the commercial banking sector in Sri Lanka between the period immediately before the end of the armed conflict (2007–2009) and after the end of the conflict (2010–2013), to determine if there is any significant evidence of decreasing banking efficiency caused by the expansion of bank branch networks after 2009.¹

This study employs a weighted aggregate-efficiency framework based on data envelopment analysis (DEA) as introduced by Simar and Zelenyuk (2007). Weighted aggregate-efficiencies are calculated based on the proportional contribution of each bank to output. This technique assumes homogeneity in environmental and regulatory conditions within each period while allowing for heterogeneity between periods (Simar & Zelenyuk 2007). DEA does not require a presumed functional form between inputs and output which makes it prone to errors, particularly with small samples. Consequently, a bootstrapping simulation

¹ Foreign banks in Sri Lanka were not required to publish their detailed financial accounts before 2007. Therefore, the data available for analysis pertain to the period 2007–2013.

technique is utilised as a remedial measure to alleviate bias in the technical efficiency scores derived from DEA (Simar & Wilson 1998; 2000).

This study contributes to the literature in two major respects. First, it provides an assessment of banking sector efficiency changes in a post-conflict emerging nation that has experienced both high economic growth and rapid branch expansion. Second, it implements the weighted aggregate-efficiency technique, rather than simply averaging performance across banks, which is new to the banking efficiency literature.

The remainder of the paper is structured as follows. Section 2 briefly reviews the literature on banking efficiency and branch expansion. Section 3 presents an overview of the banking sector in Sri Lanka. An explanation of the weighted aggregate-efficiency technique and the methodological framework adopted for the empirical analysis is provided in section 4. Specification of inputs and outputs as well as a discussion of the data are presented in section 5. The empirical analysis and findings are presented in section 6, followed by concluding remarks and policy recommendations in section 7.

2. A Brief Review of the Literature

The geographical coverage of financial institutions has been growing globally due to economic developments and expansions in trade and information technology (Berger & DeYoung 2006; Berger 2007; Claessens & Van Horen 2014; Niepmann 2015). Such an expansion in the banking sector, along with methodological developments in efficiency analysis, has provided the basis for several studies investigating the relationship between branch expansions and banking efficiency. A majority of studies have identified branch expansion as a negative factor for bank efficiency as it can lead to cost increases particularly with respect to employees and fixed assets (Berger *et al.* 1997; Battese *et al.* 2000; Berger & De Young 2006; Vu & Turnell 2010). While accepting this negative impact, some studies have still proposed branch expansion along with an improvement in geographical dispersion as a strategy to improve output generation and reduce bank risk through economic diversification (Hughes *et al.* 1996; 1999; Shiers 2002).² When branch expansion takes place across territorial borders a low level of bank efficiency can occur mainly due to the so-called

² Shiers (2002) explains the impact of geographic diversity on commercial bank risk measures.

“home field advantage” hypothesis, which identifies low efficiencies caused by: lack of knowledge of the local market and socio-economic conditions; informational asymmetries; and difficulties in establishing networks (Bhattacharyya *et al.* 1997; Buch 2003; Das & Ghosh 2006; Bhattacharyya & Pal 2013). These factors can contribute to lower efficiency by pushing up bank costs. Further, geographical distance between branches and head office is also identified in the literature as a negative factor for the efficiency of banks due to higher informational and agency costs (Mian 2006). On the other hand, advancements in information technology are identified as a factor which eases the monitoring of branch operations. Some studies have argued that the impact of technological advancement with geographical expansion negates the efficiency decline to some extent (Berger & DeYoung 2006; Havrylchyk 2006; Berger 2007; Lensink *et al.* 2008).

Studies in support of improvements in efficiency due to branch expansion highlight the following arguments: 1) parent banks can use their superior skills, policies, controls and practices to improve the efficiency of regional level branches to offset the negative impact of distance (Grabowski *et al.* 1993; Berger & De Young 2001)³; and 2) a possible increase in the volume of banking business consequent to branch expansion is identified as a positive factor for improvement in banking efficiency (Berger & De Young 2001; Bos & Kolari 2005; Mahathanaseth & Tauer 2014). This literature on banking efficiency has investigated branch expansion and bank performance arising from acquisitions, mergers, liberalisation and other reforms (Berger *et al.* 1997; Iimi 2004; Bos & Kolari 2005; Das & Ghosh 2006; Vu & Turnell 2010; Bhattacharyya & Pal 2013). However, empirical evidence on the impact of branch expansion on bank efficiency when an economy is moving to a higher growth path, particularly in the context of emerging Asian nations, remains limited.

The existing literature on countries afflicted by internal conflict is quite limited, with efficiency studies mainly focusing on the post-conflict period. For instance, studies on countries such as Lebanon, Nigeria and Nepal showed an overall improvement in banking sector performance after the ending of armed conflict (Turk-Ariss 2008; Hui *et al.* 2013; Odeleye 2014). These studies generally argue that a more rapid revival of economic activities occurs where there is a more conducive economic, social and political environment which

³ The US banking system has commonly been used to test the impact of branch networks on efficiency in the literature due to the deregulation of branch expansion with the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994, which encouraged interstate branching from mid-1997.

provides more opportunities for banks to enhance their services in the post-conflict era (Chen *et al.* 2008). None of the above-mentioned studies, however, has compared banking performance between the periods before and after the end of conflicts. This study fills this gap in the literature by investigating Sri Lanka's banking industry performance in both of these periods. Sri Lanka provides a unique case study for such analysis as it has also experienced a significant expansion with respect to branches and geographical dispersion in the post-conflict era, which, as mentioned earlier, can result in either an improvement or deterioration in banking sector performance.

Previous studies have mostly used average efficiency scores or dummy variables in regression models in comparing industry level banking efficiency between two periods or two groups of banks in the absence of a point estimate for a group comparison (Havrylchyk 2006; Vu & Turnell 2010; Manlagñit 2011; Mahathanaseth & Tauer 2012; Bhattacharyya & Pal 2013; Mahathanaseth & Tauer 2014). Deviating from these conventional methods in comparing banking sector efficiency, this study has adapted a weighted aggregate-efficiency measure which is a more logical and representative point estimator for comparing efficiency between two periods and across different bank groups. This study also contributes to the limited literature on branch expansion and bank efficiency for Asian economies by focusing on the Sri Lankan economy. Although policy makers see expansion in banking sector activity in terms of geographical dispersion and number of branches as an important and necessary move for broad-based and inclusive growth, little is known about the effect of this expansion on the efficiency of the banking system. The post-conflict development era of Sri Lanka provides an interesting case in which to assess changes in banking efficiency during a period of rapid economic and branch network growth. Therefore, this study provides strong empirical evidence for the efficiency dynamics of the banking sector when the expansion is focused on achieving broad-based and inclusive growth. In addition, it is the first study to evaluate changes in banking efficiency in an era of post-conflict economic expansion.

3. The Banking Sector in Sri Lanka

With the regaining of the country's independence in 1948 the domestic banking sector primarily catered to the plantation industry developed by the British rulers who occupied the entire island from 1815. There were 9 foreign banks and 2 domestic banks operating in Sri Lanka, with a few finance companies and savings institutions in operation based mostly in

the capital of Colombo. The banking sector was dominated by the foreign banks whose services were limited to Colombo and other major cities that had strong links to the plantation industry. Banking sector expansion in the post-independence period was initiated by the establishment of the CBSL in 1950, which replaced the previous Currency Board System. Banking penetration increased gradually with the establishment of two state-owned commercial banks in 1959 and 1961, along with the establishment of several state-owned savings banks.⁴ The bank branch network was further expanded after 1977 with improvements in foreign and private sector participation in the banking industry due to the adoption of financial sector liberalisation policies (CBSL 1998). After an array of reforms introduced to the banking sector and the economy as whole, the Banking Act 1988 empowered the CBSL to provide more regulations and controls over the banking sector.⁵

Despite the continuous expansion in branch networking for most of the banks in Sri Lanka, differences in banking penetration between the Western Province and other provinces prevailed for a long period of time. Bank branches were highly concentrated in urban areas, particularly in the Western Province, with all the commercial banks and specialised savings banks tending to expand their branch networks in urban areas. This reflected the greater demand for banking services in urban areas and contributed to increased regional economic disparities across the provinces. As a policy measure to minimise disparities in banking services, and encourage broad based growth, the CBSL issued a directive in 2008 to all commercial and specialised savings banks in Sri Lanka to open two bank branches in other provinces when they opened one bank branch in the Western Province (CBSL 2011a; CBSL 2011b). This policy directive effectively influenced the geographical expansion in bank branch networks in Sri Lanka, particularly after the end of the armed conflict.

The economy progressed to a higher growth path with an improved business climate after the ending of the conflict in 2009, and the banking sector also expanded in terms of service volumes and branch networks.⁶ Policy directives of the CBSL for improving geographical

⁴ Bank penetration is commonly defined as the number of bank branches per 100,000 people.

⁵ The reforms occurred in the period 1977–1998 and included: introducing a managed floating exchange rate regime; opening the banking sector to more private and foreign banks; relaxing restrictions on the branch expansion of existing banks; controlling the money supply through statutory reserve requirements and open market operations; allowing banks to open foreign currency banking units; removing credit ceilings on non-priority sectors; and establishing a secondary market for treasury bills.

⁶ A peacetime dividend.

dispersion of the banks, the overall economic growth and the pent-up demand for banking services with the revival of economic activities in conflict-affected areas provided the necessary ingredients for this expansion.

There are currently 25 licensed commercial banks, 7 licenced specialised savings banks and 46 registered finance companies operating in the country (CBSL 2015). The commercial banks dominate the financial sector controlling and possessing more than 67% of banking sector assets and 48.7% of the country's total financial sector assets (see Table 1). As depicted in Table 2, one foreign commercial bank and one domestic commercial bank entered the banking industry while one foreign bank exited during the period from 2007 to 2013. During this period the total number of commercial bank branches and outlets increased by 46% from 1,792 to 2,616, as well as their geographical coverage.

<TABLES 1 AND 2 ABOUT HERE>

Since an efficient banking sector stimulates the economy by minimising the cost of funds and improving investment, maintenance of a higher efficiency level in the banking sector is important in sustaining the country's high economic growth achieved in the post-conflict era (Lucchetti *et al.* 2001; Koetter & Wedow 2010). Therefore, the findings of this study will be useful for policy makers in order to formulate effective financial policies for eliminating disparities in banking services in the country to achieve broad-based economic growth while still maintaining the highest possible level of banking efficiency.

4. Methodology

Parametric stochastic frontier analysis (SFA) and non-parametric DEA are the two most commonly adopted methods used for estimating banking sector efficiency (Coelli *et al.* 2005; Margono & Sharma 2006; Bhattacharyya & Pal 2013; Hou *et al.* 2014; Manlagnit 2015). Both methods derive the efficiency of a firm (or a bank in this instance) against an estimated efficiency frontier. SFA derives efficiency by disentangling an inefficiency term from a composite error term. Then, the purely random error is assumed to be due to the impact of factors beyond the control of the production process (Aigner *et al.* 1977; Kalirajan & Shand 1994; Coelli *et al.* 2005). In contrast, DEA estimates efficiency based on deviations of firms from an estimated efficiency frontier assuming that random errors average out to zero over time (Seiford & Thrall 1990; Henderson & Zelenyuk 2007). Since SFA and DEA have their

own weaknesses and strengths, the researchers' choice of using one method over the other for measuring efficiency is mainly dependent on aspects such as the characteristics of the dataset and industry, the research question and the sample size.⁷ This study employs DEA for the empirical analysis for two main reasons. First, DEA does not require a specific functional form to be followed by the data. This avoids the risk of contaminating efficiency measures due to misspecification of the functional form of bank production (Havrylchyk 2006). In general, the production processes of the services sector, particularly banking services, are more complex than the production sector and it is challenging to accurately specify the functional form. Second, DEA works well with small samples relative to SFA. Unlike SFA, which needs a relatively large sample to estimate a substantial number of parameters, more consistent coefficients can be derived from DEA using a small sample (Seiford & Thrall 1990; Sathye 2001; Coelli *et al.* 2005; Wilson 2008).

DEA was first introduced and formalized in linear programming by Seitz (1971) for multi-inputs and single output cases. Later, Charnes *et al.* (1978) proposed a multi-inputs and multi-outputs DEA model based on the assumption of constant returns to scale implying that firms are operating at optimal scale. However, financial sector institutions, particularly banks, are not operating at an optimum scale most of the time due to imperfect competition, regulations and other limitations. Therefore, DEA under the variable returns to scale (VRS) assumption, as introduced by Afriat (1972), Färe *et al.* (1983) and Banker *et al.* (1984), is used in this study. The output-orientation approach, which measures the technical efficiency of firms by evaluating maximum possible output from given inputs, is also used in this study which assumes that banks are trying to maximise their intermediation services from given inputs (Banker *et al.* 1984). Since maximisation of intermediation services provided by the banks is important for stimulating the economy, the output-orientation approach is more appropriate for deriving policy directions.

Technical efficiency

In compiling technical efficiency based on the above approaches, DEA uses a set of mathematical formulations incorporating a number of assumptions of the production process to mimic the technology set, using data gathered from banks in the real world. It is assumed

⁷ According to Fried *et al.* (2008) a similar conclusion can be expected from both DEA and SFA for good quality data, and choosing one method for an efficiency analysis does not discount usage of the other method. See Matousek and Taci (2004) for a review of the DEA and SFA approaches.

that all banks have access to the same technology and that this technology set, T , satisfies the regulatory axioms.⁸ Although this assumption is required to establish one efficiency frontier for all firms, some may deviate from the technological frontier due to factors such as management strategies, principal-agent problems and changes in the regulatory or business environment (Zelenyuk & Zheka 2006).⁹ Simar and Zelenyuk (2007) introduced a comprehensive framework to compare the efficiency of two groups based on their output weights, assuming heterogeneity between the groups and allowing for homogeneity within the groups. To evaluate differences in technical efficiency between groups of banks based on different periods this study employs weighted aggregate-efficiency introduced by Simar and Zelenyuk (2007).

The methodology of comparing groups using aggregate-efficiency can be explained in the context of the banking industry by considering a sample of n banks. For bank k ($k = 1, \dots, n$) an inputs vector comprised of N inputs, $x^k = (x_1^k, \dots, x_N^k)' \in \mathfrak{R}_+^N$, is used for the production of M outputs, $y^k = (y_1^k, \dots, y_M^k)' \in \mathfrak{R}_+^M$. Each bank is free to use technology that can be characterised by the technology set T^k :

$$T^k = \{(x^k, y^k) : x^k \text{ can produce } y^k\} \quad (1)$$

Equivalently, the technology can be characterised by the following output set P^k :

$$P^k(x^k) \equiv \{y^k : x^k \text{ can produce } y^k\}, \quad x^k \in \mathfrak{R}_+^N \quad (2)$$

Assuming the regularity axiom of production theory, the output oriented Shepherd (1970) distance function can be defined as:

$$D_0^k(x^k, y^k) \equiv \inf \{\theta : y^k / \theta \in P^k(x^k)\} \text{ where } D_0^k : \mathfrak{R}_+^N \times \mathfrak{R}_+^M \rightarrow \mathfrak{R}_+^1 \cup \{\infty\} \quad (3)$$

The complete characterisation of the technology of bank k proves that:

$$D_0^k(x^k, y^k) \leq 1 \Leftrightarrow y^k \in P^k(x^k). \quad (4)$$

⁸ See Färe *et al.* (1994) and Färe and Primont (1995) for axioms of technology characterisation.

⁹ The influences of exogenous factors are not equal among the banks due to issues such as differences in product portfolios, business scope, geographical coverage and customer base.

Accordingly, Farrell's output oriented technical efficiency can be defined for all outputs y^k as:

$$TE^k(x^k, y^k) \equiv \max\{\theta : \theta y^k \in p^k(x^k)\} = 1/D_0^k(x^k, y^k). \quad (5)$$

When the bank is “fully” efficient, $TE^k = 1$. If $TE^k > 1$ the bank is considered as technically inefficient.

Since output sets are unknown due to the unobserved true technology, DEA is employed to estimate the technical efficiency of individual banks. The DEA estimate of the output set $p^k(x^k)$ is defined as:

$$\hat{p}^k(x^k) \equiv \left\{ y : \sum_{k=1}^n z^k y^k \leq y, \sum_{k=1}^n z^k x^k \geq x, \sum_{k=1}^n z^k = 1, z^k \geq 1, k=1, \dots, n \right\} \quad (6)$$

where z^k is an intensity variable.

The output set is estimated based on VRS assuming that banks are not operating at optimal scale due to the exogenous and endogenous factors mentioned above. Accordingly, individual bank efficiency scores based on DEA at a fixed point (x^k, y^k) can be derived by solving the following linear programming problem:

$$TE_{VRS}^k \left\{ x, y : p^k(x^k) \right\} \equiv \max_{\theta, z^1, z^2, \dots, z^k} \left\{ y : \theta y \in p^k(x^k) \right\} \quad (7)$$

Since DEA assumes the nonexistence of random errors, $TE_{VRS}^k \left\{ x, y : p^k(x^k) \right\}$ is a downward biased estimator of $TE^k \left\{ x, y : p^k(x^k) \right\}$ for the finite sample of banks. Therefore, DEA could rate banks as more efficient than they truly are. Although the bias could be avoided asymptotically with large samples, efficiency studies in banking mostly do not deal with large samples.¹⁰ Since the efficiency scores are estimated in the absence of a true frontier, a bootstrap simulation procedure, introduced by Simar (1992) and Simar and Wilson (1998; 2000), has been employed in this study to correct the bias of non-weighted efficiency scores. The bootstrap procedure of Simar and Wilson is specifically designed to compute bias-corrected efficiency scores as a development of the bootstrapping technique introduced by

¹⁰ The consistency of DEA estimates improves with increased sample size for given input and output dimensions (Banker 1993).

Efron (1979). The large number of pseudo samples derived from the given data with replacement is used in the bootstrap technique to construct an approximation for the true frontier asymptotically. Then, the distribution of the difference between the estimated and true frontier is derived while treating the bootstrap frontier as the true frontier. Consistent individual efficiency scores and confidence intervals can be estimated through these techniques. The procedures and algorithms for generating DEA estimates based on the bootstrap technique are given in Simar and Wilson (1998; 2000).

Aggregate technical efficiency

When all the banks are treated similarly, the relative importance of each bank to the industry's efficiency is ignored. Hence, non-weighted average efficiency may not be an appropriate representative measure of the industry's performance (Färe & Zelenyuk 2003). Therefore, in order to account for the contribution of individual firms the weighted aggregate-efficiency of an industry can be estimated. In this study, in addition to the conventional non-weighted technical efficiency means, the (weighted) aggregate-efficiencies introduced by Färe and Zelenyuk (2003) and Simar and Zelenyuk (2007) are also estimated. The weights are calculated based on the output share of individual banks. The following time-period groups are considered in calculating both weighted and non-weighted measures of the industry's overall efficiency: before the end of the conflict (2007–2009); the post-conflict period (2010–2013). The same banks are used in both time-period groups.

It should be noted that the Färe and Zelenyuk (2003) aggregation procedure defines a common technology frontier which inherits its properties from those of the firms' technologies where each firm may have a different technology. Simar and Zelenyuk (2007) extended their result to aggregation within subgroups in a given group. In other words, they defined group efficiencies based on the aggregate-efficiency of all firms within each distinct group under the common technology where groups are distinguished by the heterogeneity of the operating environment in which production takes place. As defined in Färe and Zelenyuk (2003), Simar and Zelenyuk (2007) also used the common technology frontier for both groups in compiling weighted aggregate-efficiency and unweighted efficiency for each firm as well as for each group.

Following Simar and Zelenyuk (2007), this study defines two time-period groups (before the end of the conflict and the post-conflict period) by assuming homogeneity within each period

and heterogeneity between the two periods. In the case of Sri Lanka this grouping can be seen as highly appropriate due to changes in the business environment after the end of the conflict. Since the two time-period groups considered in this study cover the period 2007–2013, the technology set is combined from all of the years. For similar studies on aggregate-efficiency analyses see Zelenyuk and Zheka (2006), Henderson and Zelenyuk (2007) and Curi *et al.* (2013).

Accordingly, the aggregate technical efficiency of group l ($\overline{TE}^l$) could be disaggregated into the weighted average of technical efficiency of all the individual banks where group l is comprised of n_l observations and technical efficiency of the individual bank k is $\overline{TE}^{l,k}$:

$$\overline{TE}^l \equiv \sum_{k=1}^{n_l} \overline{TE}^{l,k} . S^{l,k} \quad (8)$$

where $y^{l,k}$ is bank k 's output, $S^{l,k}$ represents the output weight of the bank k in group l , $S^{l,k} = p y^{l,k} / p \bar{Y}^l$, p is the vector of output prices, and the output vector of all firms in the l^{th} group is $\bar{Y}^l = \sum_{k=1}^{n_l} y^k, k=1, \dots, n_l$.

Similarly, when the sample consists of L non-overlapping groups, the sample's aggregate technical efficiency of ($\overline{TE}$) can be disaggregated into the weighted averages of technical efficiency of all L groups as follows:

$$\overline{TE} \equiv \sum_{l=1}^L \overline{TE}^l . S^l$$

where $S^l = p \bar{Y}^l / p \sum_{l=1}^L \bar{Y}^l$ and $\bar{Y}^l = \sum_{k=1}^{n_l} y^k, k=1, \dots, n_l$.

When the price information is not available, price independent weights can be used instead of S^l as detailed in Simar and Zelenyuk (2007).

A bootstrap simulation technique, introduced by Kneip *et al.* (2003), is employed to construct confidence intervals and remove possible bias in the aggregate-efficiency estimates. This procedure is in line with Simar and Wilson (1998; 2000) and more appropriate for comparing efficiency across the groups (Henderson & Zelenyuk 2007; Simar & Zelenyuk 2007).

Although the overlapping of confidence intervals derived through bootstrap simulation is generally used to compare the two groups of banks, relatively strong conclusions can be derived through a hypothesis test based on a point estimate. Therefore, this study employs the RD statistic, as proposed by Simar and Zelenyuk (2007), to compare the efficiency of the banking sector before and after the end of the armed conflict. The RD statistic in this study is the ratio of the aggregate-efficiency of the banks between two periods. It approaches unity when the aggregate-efficiencies of the two periods are equal. Therefore, the null hypothesis is defined as “equal aggregate-efficiency” of the banks between the periods before and after the end of the conflict. The null hypothesis can be rejected when the confidence interval of the RD statistic does not include unity.¹¹

In addition to this measure, following the recommendation of Simar and Zelenyuk (2006), the Li (1996) test is also used to compare the unweighted efficiency scores of the two groups.¹² The Li test compares the densities of banking efficiency scores for the period 2007–2009 against that of the period 2010–2013 in this study.¹³

5. Specification of inputs and outputs, and data

The core service of the banking sector has been identified in the literature as the provision of financial intermediation services by matching short-term liabilities with long-term assets (Diamond & Rajan 2001; Song & Thakor 2007). The ability of banks to produce intermediation services was used by Sealey and Lindley (1977) to introduce the intermediation approach which provides a benchmark by which to identify the inputs and outputs for DEA. Accordingly, most previous studies have identified the facilities granted by banking institutions, particularly credit, as an output and the resources utilised for the production of banking services, such as labour, fixed assets and funds, as the inputs (Altunbas *et al.* 2001; Maudos *et al.* 2002; Bos & Kolari 2005; Ray & Das 2010; Arjomandi *et al.* 2012; 2014; Hou *et al.* 2014).

¹¹ Algorithms for computation and comparison of bootstrap aggregate-efficiency are detailed in Simar and Zelenyuk (2007)..

¹² The procedures and algorithms for comparing the distribution of efficiency scores between two groups using the Li test are presented in detail in Simar and Zelenyuk (2006). For a description of the Li test see Li (1996).

¹³ This study used the MATLAB software and the codes were developed for group-wise heterogeneous subsampling procedures for DEA and the Li test by Simar and Zelenyuk (2006; 2007).

This study also adopts the intermediation approach in identifying the inputs and outputs of the banks. The total number of permanent employees (x_1), total value of fixed assets (x_2) and cumulative deposits balance (x_3) are taken as the inputs, while output is defined as the cumulative balance of advances (y_1). Due to the unavailability of annual financial flows of the relevant inputs and outputs, cumulative figures (stock of financial flows) are commonly used as proxies assuming flows are proportional to the stock of the financial value (Berger & Humphrey 1991; 1997). Table 3 shows the descriptive statistics of the above inputs and outputs. The data used in this study has been extracted from the annual published accounts of the respective banks and relevant CBSL publications. The sample consists of 2 state-owned banks, 9 private domestic banks and 4 foreign banks for the period 2007–2013. Out of the 24 banks operated in Sri Lanka during the period 2007–2013, one recently-established domestic private bank and 8 foreign banks are excluded from the analysis due to lack of reliable data. Each of these banks maintains a single branch in the country or accounts for less than 0.5% of market share. The total market share of the excluded banks is only 3.5%. The period 2010–2013 is considered as the post conflict era while 2007–2009 is the period before the end of the conflict. The published financial accounts of the domestic and foreign banks are available from 2007. Until the CBSL issued directives to banks to publish financial statements in 2006 it was not compulsory for foreign banks to publish their financial accounts in Sri Lanka. The distribution of banking assets, branch networks and market share among the selected 15 banks are presented in Table A.1 and Table A.2 in Appendix A.

< TABLE 3 ABOUT HERE >

6. Empirical Results

This section is structured into three main parts. First, the efficiency scores of banks are derived based on DEA with bootstrap simulations. The performance of the banking sector is analysed over the period 2007–2013 based on average efficiency scores. In the second part the obtained efficiency scores are divided into two groups based on observations for the periods 2007–2009 and 2010–2013, and equality between the two distributions is tested using the Li test and kernel densities. The third part incorporates the aggregate-efficiency technique to compare efficiency between the groups based on the two time periods 2007–2009 and

2010–2013. In all these subsections, the technology set is combined from all of the individual years to estimate the various efficiency measures.

Bootstrap DEA Efficiency Measurement

The results presented in Table 4 are derived based on DEA along with the bootstrap simulation technique explained previously for the period 2007–2013. Table 4 provides a summary of the averages of the output-oriented original efficiencies, bias-corrected efficiencies and the respective confidence intervals for the banks in this period. As discussed earlier a technical efficiency score equal to unity means that the bank is “fully” efficient and efficiency values are higher than unity when the bank is relatively inefficient. Thus, the higher the value the more *inefficient* the bank is. Table 4 shows that although (bias-corrected) *inefficiency* increased to some extent from 2007 to 2009 a decreasing trend is observed from 2010. Consequently, the sector’s inefficiency in 2013 is considerably lower than that in 2009. This provides evidence for an overall improvement in the banking sector’s efficiency which coincided with post-conflict banking sector expansion and greater economic growth after 2009. However, these results may not provide strong evidence of industry level banking performance since every bank is treated equally without considering their size in compiling the average of conventional non-weighted efficiency scores.

<TABLE 4 ABOUT HERE>

A comparison of conventional DEA efficiency estimates across periods

In addition to the simple averages of the bias-corrected efficiencies, banking performance between the periods 2007–2009 and 2010–2013 is also compared using densities of efficiency distributions by two statistical methods: first, equality in banking efficiency between the two periods is evaluated using the Li test which enables us to estimate densities of efficiency scores for each period. The test statistics and the p -values of this test for non-weighted efficiency scores are presented in Table 5. The null hypothesis is not rejected indicating possible equality in the distribution of banking efficiency estimates between the time periods. This might be seen as evidence of similarity in the performance levels of the banks in the period before the end of the conflict and the post-conflict period. Second, we use kernel density estimates to approximate the distributions of efficiency scores for the periods 2007–2009 and 2010–2013. A graphical presentation of the densities of banking efficiency

estimates are provided in Figure 1. Unlike the Li test results, which showed similar densities of efficiency scores between the periods, this equality is not reflected in Figure 1. This highlights the challenge of deriving conclusions about changes in overall efficiency based on conventional non-weighted averages of efficiency. As stated earlier, non-weighted efficiency scores may result in unreliable findings at the industry level (Simar & Zelenyuk 2007). Therefore, this study now utilises one of the latest comprehensive weighted aggregate-efficiency methods introduced by Färe and Zelenyuk (2003) to assess efficiency differences between the two periods under consideration.

<TABLE 5 AND FIGURE 1 ABOUT HERE>

A comparison of aggregate-efficiencies across periods

As discussed earlier, aggregate-efficiencies incorporate banks' output weights and enable us to compare two groups of firms in a DEA context. This provides a more comprehensive framework to compare the efficiency of the groups based on their weights in output (in comparison with traditional efficiency values) by assuming between-group heterogeneity and within-group homogeneity. Therefore, the statistics derived based on the weighted aggregate-efficiencies can be considered as more representative and comprehensive than that of the non-weighted means. Table 6 presents the DEA efficiency scores, bias-corrected efficiencies and respective confidence intervals for each group when the sample is divided into two groups for the periods 2007–2009 and 2010–2013. In addition to the confidence intervals the RD point estimates which are calculated based on the ratios of the efficiencies of the two groups are also used to measure the significance of the differences in efficiency. If the confidence interval of the RD statistic includes “1”, we do not reject the null hypothesis of equality in aggregate-efficiency between the two groups.

<TABLE 6 ABOUT HERE>

While confirming the non-weighted mean efficiency results in Table 4, an improvement in banking sector efficiency after the end of the conflict, the weighted aggregate-efficiency scores in Table 6 suggest significant efficiency differences between these periods with the existence of non-overlapping confidence intervals. The result is further confirmed by the confidence interval of the RD statistics which does not include unity. The bootstrap

confidence intervals and bootstrap RD statistics of the weighted aggregate-efficiency scores also indicate an improvement in banking efficiency in the period 2010–2013 against that in the period 2007–2009. Therefore, our results provide evidence of an improvement in the performance level of the banking industry in the post-conflict period relative to the period 2007–2009 when the relative size of bank output is considered for the analysis.

7. Discussion and Conclusion

Deviating from common ways of comparing the performance of bank groups, this paper has extended the established literature to compare banking efficiency during the period before the end of the conflict (2007–2009) and after the end of the armed conflict in Sri Lanka (2010–2013). We employed weighted aggregate-efficiency measures derived from bootstrap simulations in order to provide comprehensive and informative technical efficiency measures of banking industry performance in Sri Lanka. To demonstrate the effectiveness of our model the results were also compared with those of non-weighted efficiency. The empirical findings of this study are pertinent for the CBSL and policy makers as they facilitate a better evaluation of banking efficiency and provide evidence of changes in banking efficiency dynamics during the post-conflict era.

An upward trend in efficiency is observed in the annual average banking efficiency scores for the period 2007–2013. The aggregate-efficiency statistics also showed a significant post-conflict banking efficiency improvement. This could be considered as a wealth creating move as an improved performance in the banking sector minimises the underutilisation of limited financial resources in the banking system and improves any sub-optimal allocation of funds. We may also argue that our analysis provides evidence that an expansion of the banking sector was well positioned with economic expansion in the post-conflict era, with the findings not supporting the view of a decline in efficiency subsequent to branch expansion as asserted in previous literature (Berger *et al.* 1997; Battese *et al.* 2000; Berger & De Young 2001; Vu & Turnell 2010).

Despite substantial branch expansion across the country the aggregate-efficiency level of the banks showed significant improvements over time which could be due to the high credit demand in parallel with branch expansion in the post-conflict era. Private sector credit expanded by 25.1%, 34.5%, and 17.6% in 2010, 2011 and 2012, respectively, and this

coincided with post-conflict economic expansion in the country (CBSL 2012; 2013a). The high credit disbursement of the banking sector is a combined outcome of satisfying latent demand in line with post-conflict economic expansion and supporting development strategies targeting inclusive growth. In fact this improvement in efficiency, by exploiting advantages arising from high demand for credit along with economic expansion, can be considered as a peacetime dividend of the post-conflict era. Policy direction for further expansion in the banking sector while maintaining a high level of banking efficiency is vital for the Sri Lankan banking sector since the continuation of economic expansion is dependent on maintaining the level of banking efficiency achieved in the post-conflict era.

Our study finds no evidence to suggest that the efficiency of the banking sector has been adversely affected by policy directions for branch expansion issued by the CBSL. According to the CBSL the main aim of the policy direction is to accelerate economic development in areas of the country outside the Western Province in order to achieve balanced regional growth (CBSL 2011a; 2011b). This study has revealed that bank efficiency can be maintained with branch expansion while aiming for broad-based, inclusive and sustainable growth which has interesting and favourable policy implications. Accordingly, this study suggests that geographical expansion of the banking sector is a viable and effective policy tool to achieve broad-based and inclusive growth in emerging economies such as that of Sri Lanka.

Overall, the empirical evidence presented in this study supports improvements in the efficiency performance of Sri Lankan banks occurring after the end of the armed conflict. Therefore, one may argue that banking sector expansion can be encouraged even further but, at the same time, an emerging challenge for policy makers and regulators is to maintain the higher efficiency level achieved in the post-conflict era.

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Appendix A

Table A.1 Distribution of assets among the commercial banks in Sri Lanka (2007–2009)

Name of the bank	Ownership category	2007			2008			2009		
		Total branches	Total assets (US\$ Million)	Market share (%)	Total branches	Total assets (US\$ Million)	Market share (%)	Total branches	Total assets (US\$ Million)	Market share (%)
1. Bank of Ceylon	SOB	408	3,958.6	21.0	478	4,471.3	21.1	496	4,682.8	21.5
2. People's Bank	SOB	637	3,443.5	18.3	648	3,669.8	17.3	667	4,143.3	19.0
3. Commercial Bank	PDB	169	2,422.2	12.8	177	2,595.9	12.2	179	2,804.2	12.9
4. Hatton National Bank	PDB	169	2,105.5	11.2	173	2,356.4	11.1	182	2,441.2	11.2
5. Sampath Bank	PDB	106	1,204.1	6.4	111	1,278.9	6.0	136	1,358.6	6.2
6. HSBC	FB	14	1,151.9	6.1	14	1,378.4	6.5	14	1,417.8	6.5
7. Seylan Bank	PDB	114	1,304.0	6.9	114	1,442.7	6.8	114	1,155.2	5.3
8. National Development Bank	PDB	41	661.8	3.5	41	760.1	3.6	45	842.6	3.9
9. Nations Trust Bank	PDB	36	450.1	2.4	41	597.9	2.8	41	608.8	2.8
10. Standard Chartered Bank	FB	10	675.2	3.6	10	859.0	4.1	10	728.7	3.3
11. DFCC Vardhana Bank	PDB	32	152.7	0.8	38	229.0	1.1	73	272.6	1.3
12. Pan Asia Bank	PDB	29	140.4	0.7	34	175.2	0.8	39	187.6	0.9
13. Indian Bank	FB	1	83.7	0.4	1	118.5	0.6	1	90.5	0.4
14. Union Bank	PDB	12	98.2	0.5	13	115.4	0.5	15	122.8	0.6
15. State Bank of India	FB	3	135.5	0.7	3	172.7	0.8	3	248.6	1.1
Other Commercial Banks	PDB/FB	11	880.9	4.7	11	970.2	4.6	11	673.9	3.1
All Commercial Banks		1,792	18,868.2	100	1,907	21,191.2	100	2,026	21,779.1	100

Source: Annual reports of the respective commercial banks and publications of the Central Bank of Sri Lanka.

Notes: SOB-State-owned Bank; PDB-Private Domestic Bank; FB-Foreign Bank. All the domestic banks except the two state-owned banks are categorised as private domestic banks based on their management practices. These private domestic banks are listed on the Colombo Stock Exchange and some government institutions acquired significant percentages of shares in some of these banks recently. The reported banks are ordered by total assets. The Other Commercial Banks includes one private domestic bank: Amana Bank and eight foreign banks: Axis Bank; City Bank; Deutsche Bank AG; Habib Bank; ICICI Bank; Indian Overseas Bank; MCB Bank; and Public Bank Berhad. The number of branches includes all banking outlets except student savings and post office units.

Table A.2 Distribution of assets among the commercial banks in Sri Lanka (2010–2013)

Name of the bank	Ownership category	2010			2011			2012			2013		
		Total branches	Total assets (US\$ Million)	Market share (%)	Total branches	Total assets (US\$ Million)	Market share (%)	Total branches	Total assets (US\$ Million)	Market share (%)	Total branches	Total assets (US\$ Million)	Market share (%)
1. Bank of Ceylon	SOB	520	6,323.7	24.1	557	7,556.7	23.5	602	8,214.9	24.1	622	9,128.7	23.8
2. People's Bank	SOB	679	4,843.6	18.5	705	5,987.9	18.6	726	6,842.5	20.0	732	7,117.3	18.5
3. Commercial Bank	PDB	190	3,273.1	12.5	210	3,989.3	12.4	222	4,010.5	11.7	230	4,643.9	12.1
4. Hatton National Bank	PDB	192	2,776.5	10.6	207	3,420.0	10.6	237	3,473.8	10.2	244	3,902.9	10.1
5. Sampath Bank	PDB	148	1,637.0	6.2	200	2,213.5	6.9	204	2,401.3	7.0	209	2,921.9	7.6
6. HSBC	FB	15	1,906.3	7.3	16	2,179.9	6.8	16	2,219.3	6.5	16	2,412.4	6.3
7. Seylan Bank	PDB	114	1,325.9	5.1	126	1,502.2	4.7	147	1,439.4	4.2	152	1,645.6	4.3
8. National Development Bank	PDB	49	928.0	3.5	52	1,246.7	3.9	61	1,267.8	3.7	62	1,539.3	4.0
9. Nations Trust Bank	PDB	43	729.0	2.8	53	911.8	2.8	59	951.6	2.8	65	1,077.8	2.8
10. Standard Chartered Bank	FB	10	705.4	2.7	10	877.9	2.7	10	827.0	2.4	10	989.9	2.6
11. DFCC Vardhana Bank	PDB	119	261.1	1.0	127	313.1	1.0	128	465.6	1.4	133	611.4	1.6
12. Pan Asia Bank	PDB	45	275.8	1.1	62	424.7	1.3	66	439.2	1.3	67	496.5	1.3
13. Indian Bank	FB	1	119.3	0.5	2	152.7	0.5	2	241.0	0.7	2	335.6	0.9
14. Union Bank	PDB	18	165.0	0.6	19	235.6	0.7	21	240.8	0.7	25	267.8	0.7
15. State Bank of India	FB	3	236.8	0.9	3	240.0	0.7	5	151.5	0.4	6	105.1	0.3
Other Commercial Banks	PDB/FB	12	690.0	2.6	27	948.4	2.9	29	951.1	2.8	41	1,214.1	3.1
All Commercial Banks		2,158	26,196.6	100	2,376	32,200.4	100	2,535	34,137.2	100	2,616	38,410.3	100.0

Source: Annual reports of the respective commercial banks and publications of the Central Bank of Sri Lanka.

Notes: SOB-State-owned Bank; PDB-Private Domestic Bank; FB-Foreign Bank. All the domestic banks except the two state-owned banks are categorised as private domestic banks based on their management practices. These private domestic banks are listed on the Colombo Stock Exchange and some government institutions acquired significant percentages of shares in some of these banks recently. The reported banks are ordered by total assets. Other Commercial Banks includes one private domestic bank: Amana Bank and eight foreign banks: Axis Bank; City Bank; Deutsche Bank AG; Habib Bank; ICICI Bank; Indian Overseas Bank; MCB Bank; and Public Bank Berhad. The number of branches includes all banking outlets except student savings and post office units.

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Table 1 Asset Composition of the Sri Lankan financial sector, 2007-2013, in percent

Institutions	2007	2008	2009	2010	2011	2012	2013
Central Bank of Sri Lanka	13.5	12.5	11.4	14.8	14.6	14.1	12.1
Institutions regulated by the Central Bank:							
Deposit-taking institutions:							
licensed commercial banks	49.0	47.5	47.0	45.2	46.4	48.1	48.7
licensed specialised banks	9.2	9.1	9.3	8.8	8.7	8.2	8.9
licensed finance companies	3.1	3.7	3.5	3.6	4.5	5.9	6.3
Other financial institutions:							
primary dealers	1.3	1.8	1.9	1.9	1.8	1.8	2.1
specialised leasing companies	2.1	2.3	2.1	2.3	1.8	0.6	0.6
Institutions not regulated by the Central Bank	21.8	23.1	24.8	23.4	22.2	21.3	21.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: CBSL (2013b).

Note: Institutions not regulated by the Central Bank of Sri Lanka include rural banks, thrift and credit co-operative societies, employee provident funds, insurance companies, stockbroking companies, unit trusts/unit trust management companies, and market intermediaries such as underwriters, margin providers, investment managers, credit rating agencies, and venture capital companies.

Table 2 Size of banking sector, 2007-2013

Category	2007	2008	2009	2010	2011	2012	2013
Number of licensed commercial banks	23	22	22	22	24	24	24
Domestic banks	11	11	11	11	12	12	12
Foreign banks	12	11	11	11	12	12	12
Number of licensed commercial bank branches	1,792	1,907	2,026	2,158	2,376	2,535	2,616
Domestic bank branches	1,753	1,868	1,987	2,117	2,332	2,487	2,565
Foreign bank branches	39	39	39	41	44	48	51
Student savings units	2,397	2,684	2,788	2,789	2,792	2,856	2,864
Automated teller machines	1,370	1,654	1,757	1,862	2,079	2,235	2,364

Source: CBSL and annual reports of commercial banks.

Note: The number of licensed commercial bank branches includes all banking outlets except student savings and post office units.

Table 3 Descriptive statistics for input and output variables

Input/output	Mean	S.D.	Min.	Max.
Employees (x_1)	2,560	258	25	8,883
Fixed assets (x_2)	2,918	325	3.6	14,706
Deposits (x_3)	151,866	17,694	2,113	842,070
Advances (y_1)	137,389	16,297	4,069	854,441

Source: Annual reports and published financial accounts of commercial banks.

Note: Employees is in persons; other values are in million Sri Lankan rupees.

Table 4 Output-oriented average technical efficiency measures, 2007–2013

Year	Efficiency	Bias-corr. efficiency	95% C.I. lower bound.	95% C.I. upper bound.
2007	1.599	1.683	1.522	1.766
2008	1.547	1.619	1.477	1.692
2009	1.801	1.882	1.718	1.962
2010	1.552	1.628	1.477	1.704
2011	1.398	1.467	1.333	1.536
2012	1.339	1.411	1.277	1.484
2013	1.342	1.448	1.282	1.555

Table 5 Li test for change in technical efficiency, 2007–2009 vs 2010–2013

H_0 (where f is the density function)	Li Test Statistic	P -value	Decision on H_0
$f_1(2010-2013) = f_2(2007-2009)$	0.0458	0.9478	Do not reject H_0

Table 6 Aggregate banking efficiency statistics, 2007–2013

Statistic	DEA estimation	Standard error	Bias-corr. estimation	95% C.I.	
				lower bound.	upper bound.
Aggregate efficiency					
2007–2009	1.34	0.08	1.45	1.29	1.59
2010–2013	1.17	0.03	1.25	1.18	1.30
2007–2013	1.22	0.04	1.30	1.23	1.37
$RD_{Aggregate}$	1.14	0.07	1.16	1.03	1.30
Mean efficiency					
2007–2009	1.65	0.18	1.86	1.42	2.15
2010–2013	1.41	0.09	1.56	1.36	1.71
2007–2013	1.51	0.11	1.69	1.45	1.88
RD_{Mean}	1.17	0.15	1.19	0.81	1.43

Figure 1 Kernel-estimated densities of efficiency scores, 2007–2009 vs 2010–2013