Bank Productivity And Sources Of Efficiency Change: A Case Of The Four Largest Banks In South Africa

Gerhardus van der Westhuizen, North-West University, South Africa

ABSTRACT

The Malmquist productivity index was utilised to estimate the total factor productivity and productivity change of the four largest banks in South Africa for the period 1994 to 2010. Total factor productivity change can be decomposed into efficiency change and technological change, which allow for determining the sources of total factor productivity change. Various changes in the South African banking scene impacted on the average productivity of the banks. The four banks experienced, on average, regress in total factor productivity as well as regress in technological change, the latter indicating a lack of innovation. The four banks operated, on average, in the proximity of fully technical efficiency. For various reasons, South Africa still has a large 'unbanked' community.

Keywords: Total Factor Productivity; Malmquist Index; Data Envelopment Analysis; Bank Performance; Efficiency Change; Technological Change

INTRODUCTION

Over the last two decades, the banking scene in South Africa experienced considerable change. During this time, banks saw the first substantial rewrite of the Banks Act and Regulations since 1990, following the adoption of the international guidelines called Basel II which took effect on 1 January, 2008 (Booysen, 2008:6). Banks also saw the introduction of the National Credit Act, as well as the financial sector charter. All these changes had the effect that banks experienced pressure on their lending activities and thus on their profitability. Additonal reasons include increased competition because of, *inter alia*, foreign banks entering the South African banking scene, financial services delivered by various companies, and the introduction of new banking products. There have been a number of changes in respect of the regulatory environment, product offerings, and number of participants resulting in a greater level of competition on the market from smaller banks, such as Capitec Bank and African Bank, which have targeted the low income and the previously unbanked market. The SA banking industry is currently made up of 19 registered banks, two mutual banks, 13 local branches of foreign banks, and 43 foreign banks with approved local representative offices (Anon, 2010).

These changes forced banks to adjust their management strategies in order to manage the changing environment and retain or increase their market share and thus protect profitability. In order to do this, banks, e.g., introduced new banking products and services which contributed toward an increase in non-interest income (service fees). Increasing income (and profitability) does not always mean that the bank is able to improve efficiency. This means that a bank may be profitable while it is relatively inefficient. When evaluating the performance of a bank, it is important to look at profitability as well as efficiency.

A large number of summary measures of bank performance are calculated as financial ratios. Financial ratio measures that are used both within and outside the banking industry include the rate of return on assets (ROA), the rate of return on equity (ROE), the ratio of bad debts to assets, the ratio of staff costs to assets plus liabilities, and total costs per employee. Financial ratio measures peculiar to the banking and finance industry include the ratio of non-interest income to interest income, and ratios that measure liquidity and credit risk associated with loan portfolios. Rates of growth (e.g., in deposits and advances), net interest income (NII) and the net interest margin (NIM) are also used as summary measures of performance in the banking industry (O'Donnell and van der Westhuizen, 2002:485).

According to Yeh (1996: 980), there are at least two problems associated with performance measures of this type. First, they are only meaningful when compared to a benchmark, and finding a suitable benchmark (e.g., the exact ROE that must be obtained before a bank is regarded as performing well) may be difficult. Second, each performance measure is partial in the sense that it is calculated using only a subset of the data available on the firm. The problem with partial measures is that a bank may perform well using one measure (e.g., ratio of bad debts to assets) but badly using another (e.g., total costs per employee). What is needed is a single measure of total performance that is calculated using all the input and output data available on the firm.

Data Envelopment Analysis (DEA) is a widely used quantitative technique for measuring relative productivity. DEA combines all the input and output data on the firm into a single measure of productive efficiency which lies between zero (meaning the firm is totally inefficient) and one (which signals that the firm is fully efficient). Various studies have previously used DEA to study the performance of banks at both the firm/corporate level (e.g., Drake, 2001; Devaney and Weber, 2000; Berger and Humphrey, 1997; Halkos and Salamouris, 2004; Mendes and Rebello, 1999; Luo, 2003; Resti, 1997; van der Westhuizen, 2008; van der Westhuizen and Oberholzer, 2009; Matthews and Zhang, 2010; Chang *et al*., 2012) and at the branch level (e.g., Sherman and Ladino, 1995; Sherman and Gold, 1985; Vassiloglou and Giokas, 1990; Oral and Yolalan, 1990; O'Donnell and van der Westhuizen, 2002; van der Westhuizen and Oberholzer, 2003; Oberholzer and van der Westhuizen, 2004; van der Westhuizen, 2005; van der Westhuizen, 2010; and van der Westhuizen, 2012).

DEA can also be applied to measure Total Factor Productivity (TFP). The Malmquist index is an index number approach that can be calculated without any information on the prices of inputs and outputs. Provided that panel data is available, the Malmquist index provides a decomposition of productivity change into technical and efficiency changes and thereby offers an insight into the potential sources of change in TFP (Howcroft and Ataullah, 2006:193).

The purpose of this paper is to estimate and compare the total factor productivity (TFP) as well as the sources of efficiency change of the four largest banks in South Africa. The South African financial sector is dominated by four large banks; namely; ABSA, First National Bank, Nedbank and Standard Bank. According to the BA 900 reports (Department of Bank Supervision, 2009), these four banks control over 84% of total deposits and assets in South Africa. The contribution of this paper is that this will be the first attempt to estimate the total factor productivity (TFP) of the four largest South African banks.

TOTAL FACTOR PRODUCTIVITY

According to Coelli *et al*. (2005:6), TFP indices are applied to aggregate time-series data and provide measures of technical change and/or TFP and it assumes that all firms are technically efficient. DEA, on the other hand, is most often applied to cross-section data and provides measures of relative efficiency among the firms included in the sample. DEA does not assume that all firms are technically efficient and can be applied to measure both technical and efficiency changes in the case of panel data. Multilateral TFP indices can also be used to compare the relative productivity of a group of firms at one point in time (Coelli *et al.*, 2005:6).

For single-input single-output firms, TFP is almost always defined as the output-input ratio. The TFP of a multiple-output multiple-input firm is commonly defined as the ratio of an aggregate output to an aggregate input (O'Donnell, 2008:7). If Q_{nt} denotes the aggregate output and X_{nt} denotes the aggregate input of firm n in period t, then the TFP of the firm in that period is:

$$TFP_{nt} = \frac{Q_{nt}}{X_{nt}} \qquad (1)$$

The associated index number that measures the TFP of firm n in period t relative to its TFP in period 0 is:

$$TFP_{n0/nt} = \frac{TFP_{nt}}{TFP_{n0}} = \frac{Q_{nt} / X_{nt}}{Q_{n0} / X_{n0}} = \frac{Q_{n0,nt}}{X_{n0,nt}} \quad (2)$$

where $Q_{n0,nt} = Q_{nt}/Q_{n0}$ is an output quantity index and $X_{n0,nt} = X_{nt}/X_{n0}$ is an input quantity index. Thus, TFP growth can be viewed as a measure of output growth divided by a measure of input growth (O'Donnell, 2010:1).

According to Lawrence (2003:9-10), growth rates for individual outputs and inputs are weighted together using revenue and cost shares, respectively. This means that the TFP index is essentially a weighted average of changes in output quantities relative to a weighted average of changes in input quantities. This is necessary because most banks have a diverse range of outputs (e.g., loans, investments, interest income, non-interest income) and an equally diverse range of inputs (e.g., deposits, operating expense, fixed assets). Calculating TFP requires a means of adding together these diverse output and input quantities into measures of total output and total input quantity. Changes in the TFP index give an indication of how the amount of total output that can be produced from a unit of total input changes over time.

TFP indexes are a relatively simple and robust technique for measuring changes in relative efficiency over time (Lawrence, 2003:10). They can be formed from a small number of observations whereas econometric cost and profit functions, on the other hand, require much longer time series to allow sufficient degrees of freedom to facilitate estimation. TFP indexes also provide maximum detail on year–to–year changes in performance but allow the flexibility to form smoothed trend rates of change over time.

According to Lawrence (2003:11), the main advantage of the index number approach to the measurement of TFP is its reproducibility; i.e., different investigators will obtain the same productivity estimates (provided that they use the same data and use a 'superlative' or flexible index number formula to aggregate up the data). On the other hand, econometric estimates of TFP change will be much more open to challenge. Different econometricians will choose different functional forms for the production function or the dual unit profit function or the dual unit cost function; different econometricians will choose different break points for splines (differential time trend variables), and different econometricians will choose alternative stochastic specifications and methods of estimation. These differences will lead to different estimates of TFP.

TFP indexes have a rigorous grounding in economic theory. According to Diewert and Lawrence (1999:9), the two most commonly used approaches to the problem of finding the 'best' functional forms for the TFP index are the economic and the axiomatic approaches. The economic approach selects index number formulations on the basis of an assumed underlying production function and assuming price taking, profit maximising behaviour on the part of producers. The axiomatic approach to the selection of an appropriate index formulation specifies a number of desirable properties an index formulation should possess. Potential indexes are then evaluated against four specified properties and the index that passes the most tests would be preferred for the analysis, and only the Fisher index method passes all four tests.

If applied properly, TFP indexes place a discipline on the analyst to ensure that the data used balances; i.e., that price times quantity equals the dollar value for each output and input and the sum of input costs equals total cost and the sum of output revenues equals total revenue. This discipline is absent with other techniques, such as data envelopment analysis, that only use quantity information. Like any quantitative method, TFP indexes have limitations as well as advantages. These include the fact that they are a non–parametric technique and hence cannot produce confidence intervals and other statistical information, the need to aggregate heterogeneous outputs and inputs, and the need to estimate the annual physical input and cost of capital goods.

Aggregation is an inevitable part of making any modelling exercise tractable and TFP indexes provide a consistent framework within which this can be done. Also, to make sure that businesses' decisions are being accurately modelled, it is necessary to calculate the annual physical input and cost of capital as these key input variables are a fundamental component of producers' decision-making processes, particularly in a capital intensive network industry.

While statistical methods provide useful information, they are best suited to larger data sets where the data errors and inconsistencies have largely been eliminated. In the early stages of developing performance measurement databases and frameworks, particularly where there are a limited number of observations available, there is a strong case for using a non–parametric technique that enables the ready identification of likely data problems while not distorting the results for other observations. Plotting TFP index results provides a ready way of identifying unexpected results that may be less easy to identify in econometric approaches. Where only a limited number of observations are available, the use of statistical methods may be problematic or limited to restrictive functional forms.

SOURCES OF EFFICIENCY CHANGE

Changes in efficiency can, inter alia, be the result of a change in technical efficiency, technical change, or a change in total factor productivity. One way to estimate these changes is with the aid of the Malmquist index; according to Coelli (2005:67), the Malmquist TFP index. In this section, these concepts are briefly reviewed. For a more detailed treatment, see, for example, Coelli *et al*. (2005).

The Malmquist index can be explained in terms of distance functions. Distance functions are function representations of multiple-output, multiple-input technology, which require data only on input and output quantities (Färe *et al.*, 1994:68). It is thus not necessary to specify a behavioural objective, like cost minimisation or profit maximisation. Distance functions may be defined in terms of input distance functions, which means that the output vector is a given and the input vector should be proportionally contracted, given the production technology. Output distance functions means that the input vector is given and the output vector should be proportionally expanded, given the production technology.

The Malmquist index is a 'primal' index of productivity change that does not require cost or revenue shares to aggregate inputs and outputs yet is capable of measuring total factor productivity in a multiple-output setting (Färe *et al.*, 1994:68). The Malmquist TFP index measures the TFP change between two data points. This is done by calculating the ratio of the distances of each data point relative to a common technology. According to Coelli, (1998:223), the Malmquist (output-orientated) TFP change index between period s (the base period) and period t is given by

$$m_0(y_s, x_s, y_t, x_t) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)} \text{ x } \frac{d_0^t(y_t, x_t)}{d_0^t(y_s, x_s)} \right]^{1/2} \tag{3}$$

where the notation $d_0^s(x_t, y_t)$ represents the distance from the period t observation to the period s technology. A value of M_0 greater than one will indicate positive TFP growth from period s to period t, while a value less than one, indicates a TFP decline. Note that equation (3) is, in fact, the geometric mean of two TFP indices. The first is evaluated with respect to period s technology and the second with respect to period t technology.

According to Färe *et al*. (1994:71) and Coelli (1998:223), an equivalent way of writing this productivity index is:

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \text{ x } \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)} \right]^{1/2} \tag{4}$$

where the ratio outside the square brackets measures the change in relative efficiency (i.e., the change in how far observed production is from maximum potential output) between years t and s. The remaining part of the index in equation (4) is a measure of technical change. The geometric mean of the two ratios inside the brackets captures the shift in technology between the two periods t and s (Färe *et al.*, 1994:71, and Coelli, 1998:224). This means that the two terms in equation (4) are a measure of:

$$\text{Efficiency change} = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_x)} \tag{5}$$

and

$$\text{Technical change} = \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \, x \, \frac{d_0^s(y_s, x_x)}{d_0^t(y_s, x_s)}\right]^{1/2} \tag{6}$$

Färe *et al*. (1994:72) define productivity growth as the product of efficiency change and technical change. Improvements in the efficiency-change component are considered to be evidence of catching up (to the frontier), while improvements in the technical-change component are considered to be evidence of innovation.

The required distances can be calculated, using DEA-like linear programs, provided that suitable panel data are available. Färe *et al*. (1994:74) assume constant returns to scale (CRS) technology in their analysis.

DATA AND MODEL

Financial statement data, at year-end from 1994 to 2010, were obtained from the McGregor BFA (2012) database of listed companies' financial statements. The aggregate descriptive statistics (values in thousands of rand, the South African currency) for the four largest South African banks are presented in Table 1.

Table 1: Descriptive Statistics – Aggregate of the Four Largest South African Banks (R,000)

Variable	Mean	Std dev	Minimum	Maximum
Loans and Investments	246,892,110	197,473,065	9,475,000	710,523,000
Deposits and current accounts	256,443,356	193,776,375	3,567,576	843,815,000
Labour costs	6,245,776	4,430,003	1,242,000	19,542,000
User cost of capital	2,645,281	2,057,451	77,292	9,499,205
Operating costs	5,446,451	4,072,597	759,871	18,093,000

For more than two decades, there has been an ongoing debate about the definition of bank inputs and bank outputs. Berger and Humphrey (1992:246) analyse three alternative methods of choosing bank outputs - the asset, user cost, and value-added approaches. Another two approaches have been suggested; namely, the production approach and the intermediation approach (or variations of it) which are most commonly used. According to Berger *et al*. (1987: 508), under the production approach, banks produce accounts of various sizes by processing deposits and loans, incurring capital and labour costs. Under this approach, operating costs are specified in the cost function and the number of accounts is used as the output metric, while average account sizes are specified to control for other account characteristics. Under the intermediation approach, banks use deposits and purchased funds and convert them into loans and other assets. Under this approach, total operating cost plus interest cost are specified and the output is specified in dollars.

A pivotal issue throughout the literature on stock measures of banking products is the role of deposits. On the one hand, it is argued that they are an input in the production of loans (intermediation or asset approach). Yet, other lines of reasoning (the value-added approach, or the user cost approach) suggest that deposits themselves are an output, involving the creation of value added, and for which the customers bear an opportunity cost (Resti, 1997: 224).

In this study, the intermediation approach is followed and all the data were converted into 2000 prices using the GDP deflator. The outputs, loans and investments (y_1), and deposits (y_2) are, in some ways, similar to the outputs applied by Rangan *et al*. (1988), Aly *et al*. (1990), Berger and Humphrey (1991), Olivei (1992), English *et al*. (1993), Berg *et al*. (1993), Favero and Papi (1995), Golany and Storbeck (1999), Howcroft and Ataullah (2006), Sufian (2008), and Matthews and Zhang (2010). The inputs, capital (x_1), operating expenditure (x_2), excluding labour costs and labour (x_3), are, in various combinations, similar to the inputs applied by Sherman and Gold (1985), Rangan *et al*. (1988), Aly *et al*. (1990), Elyasiani and Mehdian (1990), Berger and Humphrey (1991), Berg *et al*. (1993), Sufian (2008), Matthews and Zhang (2010), and Kamau (2011).

RESULTS

The software package DEAP Version 2.1 by Coelli (1996) is purpose-built to solve the Malmquist index (DEA) problem and has been used in this paper to generate measures of total factor productivity change (tfpch), efficiency change (effch) and technological change (techch) for each observation in the data set (i.e., for each bank in each year). Efficiency change reveals whether a firm is moving closer to or further away from the best practice frontier in a particular industry and technical change shows whether the best practice frontier (or technology) to which a firm is being compared is either improving, static or deteriorating (Howcroft and Ataullah, 2006:193). The Malmquist total factor productivity indices are calculated using the technology of the previous year. These estimates have been calculated under the assumption of variable returns to scale (VRS), mainly because it is less restrictive (in an economic sense) than the assumption of constant returns to scale (CRS).

The Malmquist index summary of annual means for the four largest banks is reported in Table 2. From the results, it is evident that on seven occasions during the sample period, the banks experienced deterioration in average total factor productivity ranging between -13.7 percent and -2.1 percent. It is clear that the duration of each deterioration phase was only one year and each deterioration phase was followed by an improvement phase in average total factor productivity. On two occasions, the duration of the improvement phase lasted three years. On nine occasions the banks experienced improvement in average total factor productivity ranging between 1.10 percent and 73.3 percent.

The worst deterioration in average total factor productivity (2009) was caused by regress in average efficiency (-6.1 percent) and a regress in average technology (-8.1 percent). The regress in average efficiency is evident of the decline in loans and investments and a decline in deposits, while this decline in output was not accompanied by a decline in inputs. During this year, the banks also experienced negative average technological change (-8.1 percent), indicating that the global financial crisis was not conducive to expanding investment in technology, but rather the introduction of new and additional banking services.

Table 2: Malmquist Index Summary Of Annual Means

Year	effch	techch	tfpch
1995	0.9840	0.9950	0.9790
1996	0.9340	1.2090	1.1300
1997	1.0660	0.9210	0.9820
1998	1.1060	1.5670	1.7330
1999	0.9500	1.0640	1.0110
2000	0.9380	0.9410	0.8820
2001	0.9700	1.0970	1.0640
2002	1.0290	1.1850	1.2190
2003	1.1270	0.9310	1.0500
2004	1.0020	0.9360	0.9380
2005	1.0150	1.0450	1.0600
2006	0.9270	1.1810	1.0940
2007	0.9840	1.1910	1.1720
2008	0.9950	0.9290	0.9250
2009	0.9390	0.9190	0.8630
2010	1.0770	0.8030	0.8650

Note: All Malmquist index averages are geometric means.

During the sample period, the banks, on nine occasions, experienced average efficiency regress ranging between -6.6 percent and -0.5 percent. The worst deterioration in average efficiency occurred during 1996, but during this year, the banks experienced average technological progress (20.9 percent) that drove the banks to a 13.0

percent average total factor productivity change. This is evident that technological change was the driver behind the improvement in total factor productivity. On seven occasions, during the sample period, the banks experienced average efficiency progress ranging between 0.2 percent and 12.6 percent. Unfortunately, the highest average efficiency progress was offset by average technological regress (-6.6 percent) and the result was a 5.0 percent improvement in average total factor productivity.

For an equal number of years, the banks experienced average efficiency regress (ranging between -19.7 percent and -5.9 percent) and average technological progress (ranging between 0.5 percent and 56.7 percent). The highest average technological progress occurred during 1998 and supported by an average efficiency progress (10.6 percent), the result was a 73.3 percent improvement in average total factor productivity. It is evident that technological progress was the main driver in total factor productivity. During this year, two of the four largest banks merged with smaller financial institutions. This resulted inter alia, in an increase in loans and investments and deposits, while the banks also gained access to additional technology.

On three more occasions, the banks experienced substantial improvement in total factor productivity; namely, in 1996, 2002 and 2007. On all three occasions, the driver behind this improvement in total factor productivity was technological progress. In 1996 and 2007, it happened despite efficiency regress (-6.6 percent in 1996 and -1.6 percent in 2007); but in 2002, the technological progress was supported by efficiency progress (2.9 percent). During 1996, all four banks experienced substantial growth in loans and investments and deposits, while they were able to control expenses. In 2001, a merger took place between one of the four large banks and a foreign bank to establish an Offshore Banking Unit. An analysis of the performance of the four large banks reveals that during 2007, three of the banks experienced technological progress ranging between 20.9 percent and 62.8 percent. It is clear that technological progress is the driver in total factor productivity gains.

The influence of the global financial crisis, commencing in 2007/2008, on the banking industry is clearly evident in the results depicted in Table 2. Already, since 2006, the banks experienced average efficiency regress, except for a 7.70 percent progress in average efficiency during 2010. Since 2008, the banks also experienced average technological regress which resulted in deterioration in average total factor productivity (ranging between -7.5 percent and 13.7 percent). Despite progress in average efficiency, the average technological regress in 2010 resulted in regress in average total factor productivity (-1.2 percent).

The results for the Malmquist index summary of bank means are presented in Table 3. During the sample period 1994 to 2010, Bank A and Bank C were, on average, fully efficient, while Bank B experienced average efficiency progress (1.8 percent) and Bank D average efficiency regress (-1.5 percent).

Table 3: Malmquist Index Summary Of Bank Means

	Effch	**techch**	**tfpch**
Bank A	1.0000	0.9880	0.9880
Bank B	1.0180	1.0590	1.0780
Bank C	1.0000	1.0630	1.0630
Bank D	0.9850	1.0680	1.0520

Note: All Malmquist index averages are geometric means.

Except for Bank A, the other three banks experienced average technological progress, ranging between 5.9 percent and 6.8 percent. The average fully efficiency experienced by Bank A, combined with the average technological regress, resulted in -1.2 percent regress in average total factor productivity. Bank C is in a similar situation, where the total factor productivity progress (6.3 percent) was similar to the average technological progress. In the case of Bank B, the average efficiency progress (1.8 percent) supported by an average technological progress (5.9 percent) resulted in average total factor productivity progress (7.8 percent). Bank D was the only bank where, despite average efficiency regress (-1.5 percent), the average technological progress (6.8 percent) was the driver to a resultant average total factor productivity progress (5.2 percent).

The annual means of the Malmquist index are presented in Figure 1.

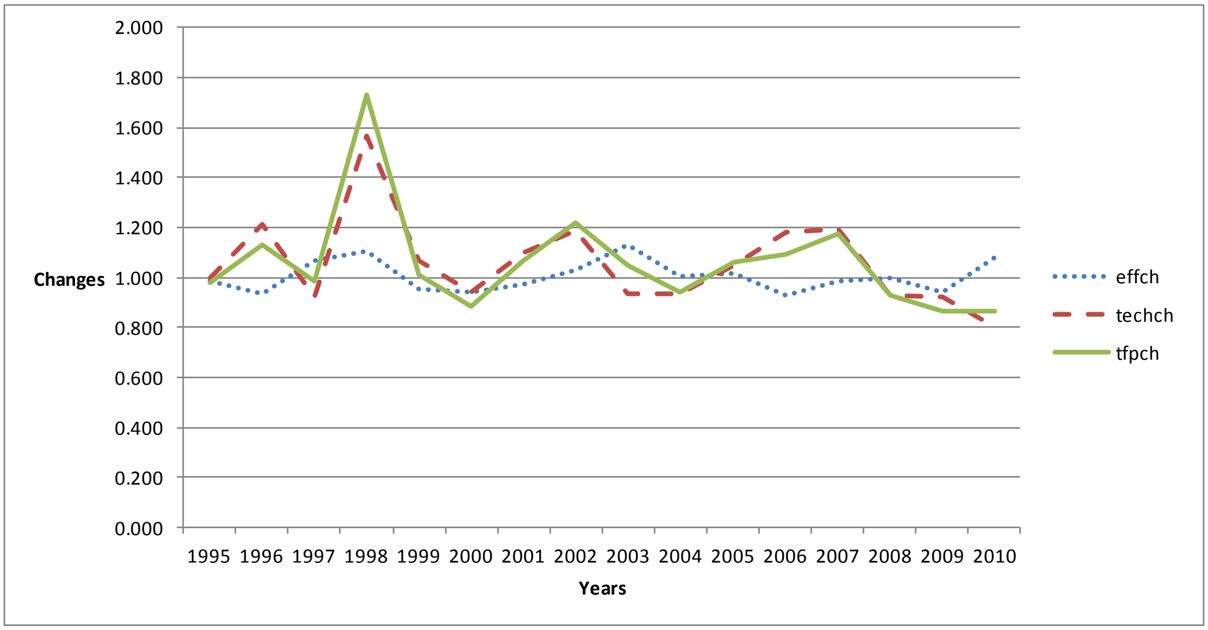

Figure 1: Annual Means of Malmquist Index

From Figure 1, it is clear that, over the sample period, the four largest banks experienced average total factor productivity regress. Average technological change followed a similar pattern with technological regress. When a linear trend line is inserted to display the trend in average total factor productivity change and a linear trend line is inserted to display the trend in average technological change, the trend lines display a similar pattern and are actually the same line. A linear trend line inserted to display average efficiency change display a horizontal pattern, indicating that there is no regress or progress in average efficiency change. It thus indicates that the banks operated, on average, in the close proximity of being fully efficient over the sample period. It appears that average total factor productivity was driven by average technological change.

CONCLUSIONS

This paper applied the Malmquist productivity index to estimate the productivity growth of the four largest banks in South Africa. The Malmquist method enables productivity changes to be decomposed into changes in efficiency (catch-up) and to changes in technology (innovation).

During the sample period, the South African banking scene experienced considerable changes which include various mergers, acquisitions, rights issues, as well as new legislation regulating credit and international changes in bank regulation. All these changes had an effect on the average productivity of the four largest banks in South Africa.

Empirical results suggest that, during the period under investigation, the four largest banks in South Africa exhibited a decline in average total factor productivity. It is also evident that the banks experienced negative technology change. The linear trend line for average total factor productivity and average technology change exhibits a similar trend; it is, in fact, the same line. The average efficiency change follows a horizontal line, indicating that the banks, on average, operated in the proximity of being fully technical efficient. This means that the banks were able to use their inputs in an efficient way (catch-up effect).

The negative technology change may be the result of South Africa still having a large 'unbanked' community and another part of the community still preferring the personal contact way of doing banking business rather than electronically. Many bank clients also do not have access to or own computers which can assist them in doing banking business. As the banking community becomes more computer literate and is able to afford computers, as well as know what is necessary to be involved in electronic banking, more can be invested in technology. The empirical results suggest that technology progress is the driver behind total factor productivity improvement.

AUTHOR INFORMATION

Professor Gerhardus van der Westhuizen is a contract employee in the School of Economics and Management Sciences at the Vaal Triangle Campus of the North-West University (South Africa) and holds a D.Com in Economics. He has taught extensively in the Economics programs at North-West University, the Honors and Masters Program at the Rand Afrikaans University and University of Johannesburg in the Department of Business Management. His academic research output includes more than 60 peer-reviewed articles and conference presentations. His current research focuses on DEA modeling in the context of bank efficiency and the efficiency of local governments. E-mail: profgertvdwesthuizen@gmail.com

REFERENCES

1. Aly, H.Y., Grabowsky, R., Pasurka, C. and Rangan, N., 1990. "Technical, scale and allocative efficiencies in US banking: an empirical investigation", *The Review of Economics and Statistics.* May, pp. 211-218.
2. Anon. 2010. *South African Banking Sector Overview*. Park Town: The Banking Association South Africa.
3. Berg, S.A., Førsund, F.R., Hjalmarsson, L. and Souminen, M. 1993. "Banking efficiency in the Nordic countries", *Journal of Banking and Finance*, 17, pp. 371-388.
4. Berger, A.N., Hanweck, G.A. and Humphrey, D.B. 1987. "Competitive Viability in Banking: Scale, scope and product mix economies", *Journal of Monetary Economics*, Issue 20, pp. 501-520.
5. Berger, A.N. and Humphrey, D.B. (1991). "The dominance of inefficiencies over scale and product mix economies in banking", *Journal of Monetary Economics*, 28, pp. 117-148.
6. Berger, A.N. and Humphrey, D.B. 1992. "Measurement and efficiency issues in commercial banks". In Z. Griliches (ed), *Output Measurement in the Service Sectors, National Bureau of Economic Research Studies in Income and Wealth*, 56, Chicago: The University of Chicago Press, pp. 245-279.
7. Berger, A.N. and Humphrey, D.B. 1997. "Efficiency of Financial Institutions: International Survey and Directions for Further Research", *European Journal of Operational Research*, 98, pp. 175-212.
8. Booysen, S. 2008: *Annual Review 2008*. Park Town: The Banking Association South Africa.
9. Chang, T-P., Hu, J-L., Chou, R.Y., and Sun, L. 2012. "The sources of bank productivity growth in China during 2002 – 2009: A disaggregation view", *Journal of Banking and Finance,* http://dx.doi.org/10.1016/j.jbankfin.2012.03.003 (Accessed 6 August 2012.)
10. Coelli, T.J. 1996. TFPIP Version 1.0: Total Factor Productivity Index (Computer) Program, available at www.uq.edu.au/economics/cepa/
11. Coelli T. J., Rao D.S.P., and Battese G.E. 1998. *An Introduction to Efficiency and Productivity Analysis,* Kluwer Academic Publishers: Norwell.
12. Coelli T. J., Rao D.S.P., O'Donnell C.J., and Battese G.E. 2005. *An Introduction to Efficiency and Productivity Analysis,* Springer: New York
13. Department of Bank Supervision. (Various years): "DI 200 Reports and BA 120 Reports", wwwapp.resbank.co.za/sarbdata/ifdata/periods.asp?type=DI200 (Accessed 16 August 2012.)
14. Devaney, M. and Weber, W.L. 2000. "Productivity growth, market structure, and technological change: evidence from the rural banking sector", *Applied Financial Economics*, 10, pp. 587-595.
15. Diewert, W.E. and Lawrence, D. 1999. *Measuring New Zealand's Productivity*, The Treasury Working Paper 99/5, Wellington.
16. Diewert, W.E., and Nakamura, A.O. 2003. "Index number concepts, measures and decompositions of productivity growth", *Journal of Productivity Analysis*, 19, pp. 127-159.
17. Drake, L. 2001. "Efficiency and productivity change in UK banking", *Applied Financial Economics,* 11, pp. 557-571
18. Elyasiani, E. and Mehdian, S.M. 1990. "A non-parametric approach to measurement of efficiency and technological change: The case of large US commercial banks", *Journal of Financial Services Research,* July, pp. 157-168.

19. English, M., Grosskopf, S., Hayes, K. and Yaisawarng, S. 1993. "Output, allocative and technical efficiency of banks'', *Journal of Banking and Finance*, 17, pp. 349-366.
20. Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. 1994, "Productivity growth, technical progress, and efficiency change in industrialised countries", *The American Economic Review*, 84(1), pp. 66-83.
21. Favero, C.A. and Papi, L. 1995. "Technical Efficiency and Scale Efficiency in the Italian Banking Sector: a non-parametric approach", *Applied Economics*, 27, pp. 385-395.
22. Golany, B. & Storbeck, J.E. 1999. "A data envelopment analysis of the operational efficiency of bank branches", *Interfaces*, 29(3), pp. 14-27.
23. Halkos G.E., and Salamouris D.S. 2004. "Efficiency measurement of the Greek commercial banks with the use of financial ratios: a data envelopment analysis approach", *Management Accounting Research*, 15(2), pp. 201-224.
24. Howcroft, B. and Ataullah, A. 2006. "Total factor productivity change: An examination of the commercial banking industry in India and Pakistan", *The Service Industries Journal*, 26(2), pp. 189-202.
25. Kamau, A.W. 2011. "Intermediation efficiency and productivity of the Banking Sector in Kenya", *Interdisciplinary Journal of Research in Business*, 1(9), pp. 2-26.
26. Lawrence, D.A. 2003. Regulation of Electricity Lines Businesses, Analysis of Lines Business Performance: 1996 – 2003. Report prepared for Commerce Commission, Wellington, New Zealand, 19 December.
27. Luo X. 2003. "Evaluating the profitability and marketability efficiency of large banks: An application of data envelopment analysis", *Journal of Business research*, 56(8), pp. 627-635.
28. Matthews, K. and Zhang, N. 2010. "Bank productivity in China, 1997 – 2007: Measurement and convergence", *China Economic Review*, 21, pp.617-628.
29. McGregor. 2012. BFA database. (Information available at www.mcgregorbfa.com/pages/researchdomain.aspx)
30. Mendes, V. and Rebelo, J. 1999. "Productive Efficiency, technological change and Productivity in Portuguese Banking", *Applied Financial Economics*, 9(5), pp. 513-521.
31. Oberholzer, M. and Van der Westhuizen, G. 2004. "An empirical study on measuring profitability and efficiency of bank regions", *Meditari (Accounting Research)*, 12, pp. 165-178.
32. O'Donnell, C. J. (2010). DPIN Version 1.0: A Program for Decomposing Productivity Index Numbers. Centre for Efficiency and Productivity Analysis Working Papers WP01/2010, University of Queensland.
33. O'Donnell, C. J. 2008. "An Aggregate Quantity-Price Framework for Measuring and Decomposing Productivity and Profitability Change." Centre for Efficiency and Productivity Analysis Working Papers WP07/2008. University of Queensland. http://www.uq.edu.au/economics/cepa/docs/WP/WP072008.pdf
34. O'Donnell, C.J. and van der Westhuizen, G. 2002. "Regional comparisons of banking performance in South Africa", *The South African Journal of Economics*, 70(3), pp. 485-518.
35. Olivei G. 1992. "Efficienca tecnica ed efficienca di scala nel settore Italiano: un approccio non-parametrico", *Quaderni del Centro Baffi di Economia Monetaria e Finanziaria*, pp. 67.
36. Oral, M. and Yolalan, R. 1990. "An Empirical Study on Measuring Operating Efficiency and Profitability of Bank Branches", *European Journal of Operational Research*, 46, pp. 282-294.
37. Rangan, N., Grabowsky,R., Aly, H.Y. and Pasurka, C. 1988. "The technical efficiency of US banks", *Economics letters*, 28, pp. 169-175.
38. Resti, A. 1997. "Evaluating the cost-efficiency of the Italian Banking System: What can be learned from joint application of parametric and non-parametric techniques", *Journal of Banking and Finance*, 21, pp. 221-250.
39. Sherman, H.D. and Gold, F. 1985. "Bank Branch Operating Efficiency. Evaluation with Data Envelopment Analysis", *Journal of Banking and Finance*, 9, pp. 297-315.
40. Sherman, H.D. and Ladino, G. 1995. "Managing Bank Productivity Using Data Envelopment Analysis (DEA)", *Interfaces*, 25, pp. 60-73.
41. Sufian, F. 2008. "Sources of total factor productivity change: Empirical evidence from the Chinese banking sector", *Margin-The journal of Applied Economic Research* 2(4), pp. 351-368.
42. Van der Westhuizen, G. and Oberholzer, M. 2003. "A model to compare bank size and the performance of banks by using financial statement analysis and data envelopment analysis", *Management Dynamics: Contemporary Research*, 12(4), pp. 18-26.

43. Van der Westhuizen, G. 2005. The relative efficiency of bank branches in lending and borrowing: An application of Data Envelopment Analysis. *South African Journal of Economic and Management Sciences*, 8(3), pp. 363-376.
44. Van der Westhuizen, G. 2008. "Estimating technical and scale efficiency and sources of efficiency change in banks using balance sheet data: A South African study", *Journal for studies in Economics and Econometrics*, 32(1), pp. 23-45.
45. Van der Westhuizen, G. and Oberholzer, M. 2009. "The role of interest income and non-interest income on the performance of four large South African banks", *Studia Universitatis Babes Bolyai Oeconomica*, 54(2), pp. 100 -114.
46. van der Westhuizen, G. 2010. The role of interest income and non-interest income on the relative efficiency of bank regions: The case of a large South African bank. *Studia Universitas Babes-Bolyai, Oeconomica*, 55(2), pp. 3-23.
47. Van der Westhuizen, G. 2012. "Change in the composition of bank income and its effect on the changes in the efficiency of bank regions", *International Business and Economics Research Journal*, 11(6), pp. 631-646.
48. Vassiloglou, M. and Giokas, D. 1990. "A Study of the Relative Efficiency of Bank Branches: An Application of Data Envelopment Analysis", *Journal of the Operational Research Society*, 41(7), pp. 591-597.
49. Yeh, Q. 1996. The Application of Data Envelopment Analysis in Conjunction with Financial Ratios for Bank Performance Evaluation. *Journal of the Operational Research Society*, 47, pp. 980-988.

NOTES