“Efficiency and productivity change in the banking industry: empirical evidence from New Zealand banks”

AUTHORS	Kofi Adjei-Frimpong Christopher Gan https://orcid.org/0000-0002-5618-1651 Liu Ying Baiding Hu David Cohen

ARTICLE INFO	Kofi Adjei-Frimpong, Christopher Gan, Liu Ying, Baiding Hu and David Cohen (2015). Efficiency and productivity change in the banking industry: empirical evidence from New Zealand banks. *Investment Management and Financial Innovations*, *12*(1), 19-25
RELEASED ON	Thursday, 26 February 2015
JOURNAL	"Investment Management and Financial Innovations"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
0	0	0

© The author(s) 2026. This publication is an open access article.

Kofi Adjei-Frimpong (New Zealand), Christopher Gan (New Zealand), Liu Ying (New Zealand), Baiding Hu (New Zealand), David Cohen (New Zealand)

Efficiency and productivity change in the banking industry: empirical evidence from New Zealand banks

Abstract

This paper examines the New Zealand banking industry's efficiency and productivity changes during the period of 2007-2011, a period dominated by the US subprime mortgage crisis. Data envelopment analysis (DEA) is used to identify the technical efficiency frontier (static in nature). The DEA-based Malmquist productivity index is used to further analyze the Malmquist components to account for dynamic shifts in the efficiency frontier. Findings indicate that New Zealand retail banks generally have high levels of efficiency. This suggests that the banks wasted relatively less of their input resources over the period under study. In addition, the results suggest that a large part of overall technical inefficiency of retail banks could be attributed to scale inefficiency rather than pure technical inefficiency. Furthermore, the results indicate that New Zealand banks experienced a modest productivity growth rate over the 2007 to 2011 period. This increase is mainly attributed to technological progress, since the average efficiency change declined, thus generating a negative impact on the total productivity growth. This decline appeared to be a result of the decreasing rate in both scale efficiency change and pure technical efficiency change.

Keywords: efficiency, productivity, banks, New Zealand.
JEL Classification: E44, E50, G21.

Introduction

New Zealand's banking industry held up well through the 2006 global financial crisis. This significant event weakened credit markets in many global economies, in spite of wide-spread government bailout schemes. The international financial system came under extreme pressure that lead to a decrease in asset values and increases in funding costs for the major US investment and European banks (Reserve Bank of New Zealand, 2008). Major Australian-owned banks in New Zealand were able to withstand some deterioration in asset quality. Among the registered retail banks in New Zealand, only two have domestic ownership (Kiwibank Limited and TSB Bank Limited). Such foreign ownership not only benefits New Zealand's consumers through offering a wider range of services (Singleton & Verhoef, 2010), but also benefits the New Zealand banking system by allowing access to larger and cheaper international funds (Reserve Bank of New Zealand, 2010). It is usually considered that foreign parents have greater access to capital along with their large international resources (see Kenichiro and Lawrence, 2014). For example, in 2008 about 55 percent of total bank funding came from foreign sources with retail funding contributing the remaining 45 percent (Reserve Bank of New Zealand, 2008). However, in recent years, New Zealand's banking industry has tended to rely on retail deposits. This has reduced its reliance on foreign funding, at least partly because of a recovery in private savings rates (Reserve Bank of New Zealand, 2013). The banking industry plays an increasingly important role in New Zealand's economy owing to its growing contribution to economic growth and development.

To some extent, the global financial crisis generated little significant impact on New Zealand banking system. This is likely because New Zealand's banking system had very little securitization relative to banking systems in those crisis affected countries (Reserve Bank of New Zealand, 2007). More importantly, New Zealand's dominant trading partner Australia owns over 90 percent of retail banks' assets in New Zealand, and was also not directly affected by the US subprime mortgage crisis. In fact, the Australian economy performed well, in spite of the weak recovery of the major developed economies. New Zealand's is an export-oriented economy, and thus heavily depends on the global economy. The economic health of its trading partners is therefore of critical importance. In addition, New Zealand's banking industry quickly incorporates technological changes and has an evolving regulatory climate. In addition, profit expansion has strengthened New Zealand banks' levels of capital. However, like any other highly internationalized economy, New Zealand's financial system must respond to variations in international economic and financial environments.

This paper is motivated by the growing interest of bank management, investors, customers and policy makers to understand efficiency and productivity changes in New Zealand banks that appear to have resulted from the global financial crises. This study may help policy makers and bank regulator to initiate policy measures designed to ensure efficient bank supervision and responses to regulatory

© Kofi Adjei-Frimpong, Christopher Gan, Liu Ying, Baiding Hu, David Cohen, 2015.

changes. It may be of use to depositors and investors when making investment decisions, and assist bank managers in their efforts to identify sources of efficiency, thus leading to productivity improvements. The study contributes to the banking literature by examining bank productivity and efficiency that may have resulted from the global financial crisis. This is the first study of the New Zealand banking sector that examines efficiency and productivity changes during the uncertain period surrounding the US subprime mortgage crisis.

The study employs the Data Envelopment Analysis (DEA) approach and the Malmquist productivity index to examine efficiency and productivity change. The technique involves decomposition of technical efficiency into two components: pure technical efficiency and scale efficiency. Productivity change is broken down into four components; technical efficiency change, technological change, pure technical efficiency change and scale efficiency change. Separating out these components provides a means for finding out whether productivity in the New Zealand banking industry has improved or deteriorated. It also allows for examination of the sources of productivity change.

The rest of this paper is organized as follows: Section 1 provides the literature review on the analysis of efficiency and productivity changes. Section 2 briefly discusses data and the methodology. Section 3 presents the results of technical efficiency and productivity and their components. The paper provides some concluding remarks in final section.

1. Literature review

Several studies have been devoted to the examination of bank efficiency and productivity. In terms of efficiency, Ataullah and Le (2004) provided a comparative analysis of the evolution of the technical efficiency of commercial banks in India and Pakistan for the decade of 1988 through 1998. The authors use the DEA approach to estimate technical efficiency, decomposing technical efficiency into pure technical efficiency and scale efficiency. They report evidence of very low overall technical efficiency in the Indian and Pakistani banking sectors over the study period and document little improvement in efficiency until 1995. In both countries, the low overall technical efficiency is mainly attributed to low scale efficiency. Pasiouras (2008) employed the DEA approach to assess the efficiency of the Greek commercial banking industry over the period of 2000-2004, including Greek banks operating abroad. Analysis showed that banks operating abroad are more technically efficient than those operating at the national level. More recently, Sufian and Habibullah (2010) investigated the efficiency of the Thai banking sector from 1999 to 2008. Their results show that inefficiency in the Thai banking sector emerges predominantly from scale efficiency. In another study, Staub et al. (2010) estimate cost, technical and allocative efficiencies for Brazilian banks for the period of 2000-2007. The authors apply the DEA approach and argue that banks in Brazil are inefficient. The inefficiency in Brazilian banks is assigned mostly to technical inefficiency rather than allocative inefficiency. The authors explain that the higher level of technical inefficiency is evidence that the Brazilian banks' managers selected the appropriate input mix given prices, but use fewer of them. In New Zealand, Tripe (2003) studied trends in bank efficiency over the period of 1996-2002 using the DEA method. The author found improvement in the efficiency of New Zealand banks, attributing these gains to the fall in interest rates and improvements in management effort and technological progress.

One of the earliest studies examining productivity change in the banking industry was provided by Berg et al. (1992), who focussed on Norway's banks during the 1980-1989 decade. The authors used the Malmquist index to measure productivity growth and found that the source of productivity growth was efficiency change (improvements) in Norway's banks. Similarly, using a DEA-based Malmquist productivity change index, Isik and Hassan (2003) examined the influence of financial reforms on the productivity of Turkish commercial banks embarked upon in the 1980s. Their findings indicate that banks in Turkey recorded significant productivity growth. These gains were also assigned to improvements in efficiency rather than technological progress. In contrast, some previous studies have found that productivity growth is mainly driven by technological change for US banks (Mukherjee et al., 2001), European banks (Casu et al., 2004; Koutsomanoli-Filippaki et al., 2009), and Chinese banks (Matthews et al., 2009; Matthews & Zhang, 2010). Casu et al. (2004) employed both parametric and nonparametric methods to evaluate productivity change in the banking systems in France, Germany, Italy, Spain and United Kingdom banks between 1994 and 2000. Their results reveal productivity growth in the Italian and Spanish banking sectors. The findings also attribute growth in productivity to improvements in technological change. In addition, Koutsomanoli-Filippaki, Margaritis and Staikouras (2009) used the directional technology distance function to provide estimates of bank efficiency and productivity change across Central and Eastern European countries for the period of 1998-2003. Their findings show that productivity change in Central and Eastern European is driven by technological change rather than efficiency change.

2. Data and methodology

This study applies a DEA-based Malmquist index to measure New Zealand banks productivity. The use of the Malmquist index allows total factor productivity changes to be decomposed into two components; technological change and technical efficiency change (Färe et al., 1989). The technical efficiency changes component consists of pure technical efficiency change and scale efficiency change. This helps to provide insight into the sources of productivity change for New Zealand's banking industry. The efficiency measured using DEA is static in nature. However, efficiency frontiers are not static over time because production technology may change, causing shifts in best practice. The shift of the frontier over time cannot be obtained from DEA. To account for dynamic shifts in the production frontier, we use Malmquist Total Factor Productivity Change Index.

2.1. Data. This study examines six New Zealand retail banks. These include four large foreign-owned banks: ANZ national (ANZ), Bank of New Zealand (BNZ), ASB bank (ASB) and Westpac Banking Corporation (Westpac). Two small domestic banks are also included: Kiwi Bank (Kiwi) and TSB bank (TSB). This study uses quarterly data which are extracted from the banks' General Disclosure Statements from March, 2007 to December, 2011, a period influenced by the US subprime mortgage crisis. Quarterly data are used because the end of the financial year differs among the six banks under study.

2.2. Method. Below are the brief descriptions of the procedures used to measure bank efficiency and productivity change in New Zealand over the period of 2007-2011.

2.2.1. Specification of input and output variables. The production and intermediation approaches are the two most widely used methods for selecting input and output variables when measuring efficiency and productivity. Under the production approach, a bank is considered to be a firm that uses various inputs such as labor and capital to generate outputs such as deposits and loans. Outputs are measured by the number of accounts or transactions (see Tripe, 2003; Avkiran, 2006). In contrast, with the intermediation approach a bank acts as an intermediary, raising funds from savers and lending to investors to generate profit. Here, input and output variables are measured in monetary units (Mostafa, 2009; Chen & Yeh, 1998). In this study, the data required for utilizing the production approach are limited; therefore a variation of intermediation approach is used. The intermediation approach was originally developed by Sealey and Lindley (1977) and posits that total loans and securities are outputs, while deposits, labor and capital are inputs. Berger and Humphrey (1997) later suggested that the intermediation approach is best suited for analyzing bank level efficiency, where as the production approach is better suited to measuring bank efficiency at the branch level. Following Avkiran (1999, 2000) Su and Tripe (2001) and Tripe (2003), this study uses interest expense and non-interest expense as inputs and net-interest income and non-interest income as outputs. Table 1 shows the input and output variables used in the model measured in millions of NZ dollars.

Table 1. Inputs and outputs in the model

Symbol	Category	Definition
X1	input	Interest expense
X2	input	Non-interest expense
Y1	output	Interest income
Y2	output	Non-interest income

Descriptive statistics of the relevant variables are presented in Table 2. The descriptive statistics are calculated for the total sample.

Table 2. Descriptive statistics of input and output variables (millions of NZD)

Variable	Minimum	Maximum	Mean	Standard deviation
X1	29.858	1969	589.7076	41.967
X2	14.037	959	257.8813	18.705
Y1	19.742	735	262.348	18.081
Y2	-58	324	96.650	7.650

2.2.2. DEA model. For this study the DEA model is used to estimate efficiency and productivity and is particularly suited to working with small sample sizes (Evanoff & Israilevich, 1991; Tripe, 2003). New Zealand's banking market is relatively small. Consequently, the DEA model is appropriate. Alternative parametric techniques require large numbers of observations to ensure reasonably accurate estimations (as these specify large numbers of parameters). DEA is a linear programing-based technique for measuring the relative efficiency of a fairly homogeneous set of decision making units (Charnes et al., 1978). In addition, DEA does not specify a particular functional form of the underlying production relationship or require any assumption about the distribution of ineffficiency. However, DEA does not take into account random error in the data. DEA constructs the frontier as a discrete piecewise linear combination of the most efficient units (actual inputs and outputs). This provides a convex production possibilities set that envelops all observations in the sample. DEA can be implemented by assuming either constant returns to scale (Charnes et al., 1978) or variable returns to scale (VRS) (Banker et al., 1984). The constant

return-to-scale (CRS) means that a proportionate increase in input leads to a proportionate increase in output while variable return-to-scale (VRS) implies that a proportionate increase in input potentially leads to a disproportionate change in output. In this study, we use the input-oriented DEA model to measure the efficiency based on the notion that managers have more control over inputs than over outputs.

Consider the situation with K number of inputs, M number of outputs and N number of banks. For the *i*-th bank, x_i represents a vector of inputs and y_i represents a vector of outputs. The (K×N) input matrix *X*, and the (M×N) output matrix *Y*, represent the data of all *N* banks. The input oriented measure of a particular DMU under constant returns to scale is calculated as:

$$\begin{aligned} &Minimize_{\theta,\lambda}\theta, \text{subject to } -y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0,\ \lambda \geq 0, \end{aligned} \tag{1}$$

where θ is a scalar and is the (technical) efficiency score and λ is a ($N \times 1$) vector of constants or weights attached to each of the efficient banks. The efficiency score ranges between 0 and 1. An efficiency score of one ($\theta = 1$) indicates a technically efficient bank, as it lies on the frontier. However, if $\theta < 1$, then the bank is inefficient and needs a $1 - \theta$ reduction in the input level to reach the efficiency frontier.

Banker et al. (1984) introduce the VRS DEA model by including an additional convexity constraint, $N1'\lambda = 1$, to account for VRS. VRS offers a measure of pure technical efficiency. Thus, the linear programming model CRS can be modified to VRS by adding a constraint $N1'\lambda = 1$ as follows:

$$\begin{aligned} &Minimize_{\theta,\lambda}\theta, \text{subject to } -y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0,\ NI'\lambda = 1,\ \lambda \geq 0, \end{aligned} \tag{2}$$

where *N*1 is a (N×1) vector of ones. Banker et al. (1984) suggested the use of a VRS that decomposes overall technical efficiency into pure technical efficiency (which relates to the ability of managers to use given resources), and scale efficiency (which refers to exploiting scale economies by operating at a point where the production frontier depicts CRS). Scale efficiency is measured as the ratio of technical efficiency to pure technical efficiency.

2.2.3. The Malmquist index. This study uses the Malmquist Index, a DEA-based programing method suggested by Fare et al. (1994). The Malmquist total factor productivity change index depends on the constant returns to scale and output-based approach. However, a Malmquist index computed under the assumption of constant returns to scale implies that the results of the output-oriented approach would not differ from that of the input-oriented approach (Coelli, 1996; Thanassoulis, 2001; Yao, Han & Feng, 2008). The Malmquist index is applied to evaluate the bank's productivity change over time, the most widely used method to measure productivity change. It measures the total factor productivity (TFP) change between two data points by calculating the ratio of the distances of each data relative to a commom technology. The output-oriented Malmquist index follows the Fare et al. (1994) structure under the constant return to scale, and can be expressed as follows:

$$M_0 = \left[\frac{d_0^t(x_0^t, y_0^t)}{d_0^t(x_0^{t+1}, y_0^{t+1})} \frac{d_0^{t+1}(x_0^t, y_0^t)}{d_0^{t+1}(x_0^{t+1}, y_0^{t+1})} \right]^{\frac{1}{2}}. \tag{3}$$

M_0 in equation (3) measures the productivity of the production points (x^{t+1}, y^{t+1}) relative to production point (x^t, y^t). The index uses period *t* technology and the next period *t*+1 technology. These two mixed period technical efficiency scores are used to calculate the index. The Malmquist productivity index makes use of distance functions to measure productivity change. The Malmquist total productivity change index can be decomposed into technical change and technical efficiency change. Thus, equation (3) can be modified to measure the technical efficiency change and the movement of the production frontier of the specific decision making unit (DMUo). This is defined as follows:

$$\begin{aligned} \overline{M}_0 &= \frac{d_0^t(x_0^t, y_0^t)}{d_0^t(x_0^{t+1}, y_0^{t+1})} \times \\ &\times \left[\frac{d_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{d_0^t(x_0^{t+1}, y_0^{t+1})} \times \frac{d_0^{t+1}(x_0^t, y_0^t)}{d_0^t(x_0^t, y_0^t)} \right]^{\frac{1}{2}}, \end{aligned} \tag{4}$$

where the ratio outside the square brackets measures the change in the output oriented measure of Farrell technical efficiency for the period *t* to *t*+1. The geometric average of the two ratios in square brackets defines the change in technology for the period between *t* and *t*+1. The two terms in the square bracket in equation (4) are:

$$Efficiency\ change = \frac{d_0^t(x_0^t, y_0^t)}{d_0^{t+1}(x_0^{t+1}, y_0^{t+1})}, \tag{5}$$

and

$$\begin{aligned} &Technical\ change = \\ &= \left[\frac{d_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{d_0^t(x_0^{t+1}, y_0^{t+1})} \times \frac{d_0^{t+1}(x_0^t, y_0^t)}{d_0^t(x_0^t, y_0^t)} \right]^{\frac{1}{2}}. \end{aligned} \tag{6}$$

Thus, the multiplication of the change in technical efficiency and technological change yields the total factor productivity change. Similarly, technical efficiency change is the product of pure technical efficiency change (due to the VRS assumption) and scale efficiency change. It should be noted that the changes in total factor productivity and components are also measured as the geometrical average of Malmquist productivity indices (Fare et al., 1994).

Table 3 shows the state of the Malmquist productivity index. When $\bar{M} > 1$, it indicates that a positive productivity growth rate from period t to period $t + 1$. In contrast, $\bar{M} < 1$ implies a decline in productivity from period t to period $t + 1$, while $\bar{M} = 1$ signifies no change in productivity for the interval.

Table 3. Productivity index $\bar{M}$

Malmquist Productivity Index	Productivity level
$\bar{M} > 1$	Improvement in productivity
$\bar{M} = 1$	No change in productivity
$\bar{M} < 1$	Productivity loss

3. Empirical results

Table 4 presents the results of the New Zealand banks' technical efficiency analysis. These show that New Zealand retail banks exhibit a mean overall efficiency score of 0.955, signifying a high level of efficiency. This suggests that banks in New Zealand wasted 4.5 percent of input usage relative to the "best-practice" bank. In other words, on average, banks could have produced the same amount of outputs with 4.5 percent fewer input resources. There is relatively less waste of valuable resources in the New Zealand banking industry over the period under study. The decomposition of overall technical efficiency into pure technical efficiency and scale efficiency shows that pure technical efficiency and scale efficiency are on average about 0.985 and 0.969 respectively, over the study period. The results also suggest that scale inefficiency (3.1 percent) dominates pure technical inefficiency (1.5 percent). This implies 3.1 percent of the 4.5 percent of overall technical inefficiency could be due to the banks operating at the wrong scale (either too large or too small) and 1.5 percent of the overall technical inefficiency can be attributed to managerial errors such as selecting incorrect input combinations. The finding of higher level of bank efficiency in New Zealand is in contrast to the results of the studies by Sufian and Habibullah (2010) and Staub et al. (2010) on Thai and Brazilian banking sectors respectively. Both studies found higher levels of technical inefficiency.

Table 4. Average efficiency scores of the New Zealand Banking industry

Summary	Overall Efficiency	Pure Technical Efficiency	Scale Efficiency
2007:Q1	0.990	1.000	0.990
2007:Q2	0.967	1.000	0.967
2007:Q3	0.969	0.998	0.971
2007:Q4	0.989	1.000	0.989
2008:Q1	0.982	1.000	0.982
2008:Q2	0.953	0.979	0.972
2008:Q3	0.847	1.000	0.947
2008:Q4	0.950	0.985	0.965
2009:Q1	1.000	1.000	1.000
2009:Q2	0.867	1.000	0.867
2009:Q3	0.874	0.973	0.895
2009:Q4	0.891	0.905	0.980
2010:Q1	0.968	0.979	0.989
2010:Q2	0.988	1.000	0.988
2010:Q3	0.954	0.967	0.987
2010:Q4	0.976	0.987	0.988
2011:Q1	0.990	0.991	0.999
2011:Q2	0.978	0.981	0.997
2011:Q3	0.944	0.979	0.962
2011:Q4	0.933	0.981	0.950
Overall	0.955	0.985	0.969

However, in terms of trends, the overall technical efficiency of the New Zealand banking industry falls from 0.99 in 2007:Q1 to 0.933 in 2011:Q4, a decline of 5.7 percent. This was by no means a consistent decay, as overall efficiency was quite variable across the five years. In addition, pure technical efficiency declined from 1.000 in 2007:Q1 to 0.981 in 2011:Q4, though the range of variation over the five years was narrower than for overall efficiency. Similarly, scale efficiency deteriorated from 0.990 in 2007:Q1 to 0.950 in 2011:Q4. Focusing on the individual quarters, there are only a few, i.e., 2009:Q4, 2010:Q1 and from 2010:Q3 to 2011:Q2, where pure technical inefficiency is greater than scale inefficiency. This implies that retail banks in these periods should have focused on improving their managerial efficiency.

Table 5 summarizes productivity change results that consist of the Malmquist index and its components. Five indices of New Zealand banking industry performance are calculated for each quarter. These are technical efficiency change (EFFCH), technological change (TECHCH), pure technical efficiency change (PECH), scale efficiency change (SECH) and total factor productivity change (TFPCH). An index value greater than one signifies an increase in productivity, while a value less than one indicates productivity loss. When the index is equal to one, productivity remained constant.

Table 5. Malmquist productivity index
(New Zealand banking industry)

Period	EFFCH	TECHCH	PECH	SECH	TFPCH
2007:Q1	0.976	0.927	1.000	0.976	0.904
2007:Q2	1.003	1.026	0.998	1.005	1.029
2007:Q3	1.021	0.967	1.002	1.019	0.987
2007:Q4	0.992	1.011	1.000	0.992	1.003
2008:Q1	0.968	0.936	0.978	0.990	0.906
2008:Q2	0.994	0.995	1.023	0.972	0.989
2008:Q3	1.004	1.113	0.985	1.019	1.117
2008:Q4	1.056	0.978	1.015	1.040	1.033
2009:Q1	0.862	1.174	1.000	0.862	1.013
2009:Q2	1.001	0.935	0.98	1.021	0.936
2009:Q3	1.014	1.233	0.932	1.088	1.250
2009:Q4	1.103	0.795	1.073	1.028	0.877
2010:Q1	1.023	0.984	1.020	1.002	1.006
2010:Q2	0.962	0.980	0.964	0.998	0.943
2010:Q3	1.026	0.997	1.024	1.001	1.023
2010:Q4	1.015	0.974	1.004	1.011	0.989
2011:Q1	0.987	1.065	0.989	0.998	1.051
2011:Q2	0.960	1.157	0.991	0.969	1.111
2011:Q3	0.990	1.033	1.009	0.981	1.023
Mean	0.997	1.010	0.999	0.998	1.007

Notes: All indices are geometric averages.

The results in Table 5 show a higher Malmquist productivity index ($\bar{M}$ = 1.007), that is, an increase of 0.007 per quarter during the period of 2007-2011. This suggests that New Zealand banks experienced an average quarterly productivity growth rate of 0.7 percent during the period of 2007-2011. Productivity increase is mainly the result of a 1 percent per quarter improvement in technological progress (technological change index = 1.010, an increase of 0.010 per quarter), since the average technical efficiency change (efficiency change index = 0.997, a decrease of 0.003 per quarter) declines at the rate of 0.3 percent per quarter. This implies that total productivity change is mainly the result of technological progress rather than efficiency change. Thus, New Zealand banks experienced high technological change but achieved only modest productivity growth over the study period. This result is consistent with the Koutsomanoli-Filippaki, Margaritis, and Staikouras (2009) finding that productivity change in Central and Eastern European banks was driven by technological change rather than efficiency change. Similar results were obtained by Geeta et al. (2004) in their study of banks in Malaysia, and the Matthews et al. (2009) and Matthews and Zhang (2010) studies of the Chinese banking industry. Technical efficiency change has a negative influence on total productivity change and could mainly be attributed to the decreasing rate of 0.2 percent and 0.1 percent per quarter in average scale efficiency change and pure technical efficiency change, respectively. In addition, productivity changes for New Zealand banks achieve the highest increasing rate of 25 percent over the study period at 2009:Q3. At the same time, New Zealand banks exhibit the highest level of technological change (23.3 percent) and experience highest level of scale efficiency change (8.8 percent). However, the highest decreasing rate of 6.8 percent in pure technical efficiency change is recorded at that time (2009:Q3). A year later, that is, 2010:Q3/Q4 efficiency change achieves the highest level at the rate 2.6 percent.

Conclusions

In this study we estimate the efficiency of retail banks in New Zealand and productivity over the period of 2007-2011. This period encapsulated the US subprime mortgage crisis. The findings indicate that New Zealand retail banks exhibited high levels of efficiency. This suggests that banks wasted relatively fewer input resources over the study period. Further, the findings suggest that scale inefficiency dominates pure technical inefficiency over the interval. This indicates that a large part of the overall technical inefficiency of New Zealand retail banks was due to scale inefficiency instead of pure technical inefficiency.

In terms of productivity, the results suggest that New Zealand banks experienced positive productivity growth during the period of 2007-2011. This increase is mainly attribute able to technological progress, but it still achieved modest productivity growth over the study period. In contrast, the average efficiency rate change declines. The technical efficiency change has a negative influence on the total productivity change and could be mainly attributed to the decreasing rates in both scale efficiency change and pure technical efficiency change.

References

1. Ataullah, A., Cockerill, T. and Le, H. (2004). Financial liberalization and bank efficiency: a comparative analysis of India and Pakistan, *Applied Economic*s, 36 (17), pp. 1915-1924.
2. Avkiran, N.K. (1999). The evidence on efficiency gains: the role of mergers and the benefits to the public, *Journal of Banking and Finance*, 23 (7), pp. 991-1013.
3. Avkiran, N.K. (2000). Rising productivity of Australian tradingbanks under deregulation 1986-1995, *Journal of Economics and Finance*, 24 (2), pp. 122-140.
4. Banker, R.D., Charnes, A., and Cooper, W.W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis, *Management Science*, 30 (9), pp. 1078-1092.

5. Berg S.A., Forsund, F.R, Hjalmarsson, L. and Suominen, M. (1993). Banking Efficiency in the Nordic Countries, *Journal of Banking and Finance*, 17 (2-3), pp. 371-388.
6. Berg, S.A., Førsund, F.R., and Jansen, E.S. (1992). Malmquist indices of productivity growth during the deregulation of Norwegian banking, 1980-89, *Scandinavian Journal of Economics*, 94(Supplement), pp. 211-228.
7. Berger, A.N. and Humphrey, D.B. (1997). Efficiency of financial institutions: International survey and directions for future research, *European Journal of Operational Research*, 98 (2), pp. 175-212.
8. Casu, B., Girardone, C. and Molyneux, P. (2004). Productivity change in European banking: A comparison of parametric and non-parametric approaches, *Journal of Banking and Finance*, 28 (10), pp. 2521-2540.
9. Charnes, A., Cooper, W.W. and Rhodes, E. (1978). Measuring the efficiency of decision making units, *European Journal of Operational Research*, 2 (6), pp. 429-444.
10. Chen, T. and Yeh, T.L. (1998). A Study of efficiency evaluation in Taiwan's banks, *International Journal of Service Industry Management*, 9 (5), pp. 402-415.
11. Coelli, T., Prasada Rao, D.S. and Battese, G.E. (1998). *An Introduction to Efficiency and Productivity Analysis*, Boston: Kluwer Academic Publishers.
12. Coelli, T. (1996). A guide to DEAP version 2.1: A data envelopment analysis (computer) program, *Working Paper 96/08*, Centre for Efficiency and Productivity Analysis.
13. Evanoff, D.D. and Israilevich, P.R. (1991). Productive efficiency in banking.Economic Perspectives, Federal Reserve Bank of Chicago, pp. 11-32.
14. Fare, R., Grosskopf, S., Norris, M. and. Zhang, Z. (1994). Productivity growth, technical progress and efficiency changes in industrialized countries, *The American Economic Review*, 84 (1), pp. 66-83.
15. Krishnasamy, G., Ridzwa, A.H. and Perumal, V. (2004). Malaysian post merger banks' productivity: application of Malmquist productivity index, *Managerial Finance*, 30 (4), pp. 63-74.
16. Isik, I. and Hassan, M.K. (2002). Technical, scale and allocative efficiencies of Turkish banking industry, *Journal of Banking & Finance*, 26 (4), pp. 719-766.
17. Isik, I. and Hassan, M.K. (2003). Efficiency, ownership and market structure, corporate control and governance in the Turkish banking industry, *Journal of Business Finance & Accounting*, 30 (9-10), pp. 1363-1421.
18. Kenichiro, M. and Lawrence, E.C. (2014). The impact of the financial crisis on foreign banks in U.S., *Banks and Bank Systems*, 9 (2), pp. 29-50.
19. Koutsomanoli-Filippaki, A., Margaritis., M. and Staikouras, C. (2009). Efficiency and productivity growth in the banking industry of Central and Eastern Europe, *Journal of Banking & Finance*, 33 (3), pp. 557-567.
20. Matthews, K. and Zhang, N. (2010). Bank productivity in China 1997-2007: measurement and convergence, *China Economic Review*, 21 (4), pp. 617-628.
21. Matthews, K., Zhang, X. and Guo, J. (2009). Nonperforming loans and productivity in Chinese Banks, 1997-2006. *Chinese Economy*, 42 (2), pp. 30-47.
22. Mukherjee, K., Ray, S.C. and Miller, S.M. (2001). Productivity growth inlarge US commercial banks: The initial post-deregulation experience, *Journal of Bankingand Finance*, 25 (5), pp. 913-939.
23. Mostafa, M.M. (2009). Modeling the efficiency of top Arab banks: A DEA–neural network approach, *Expert Systems with Applications*, 36 (1), pp. 309-320.
24. Pasiouras, F. (2008). Estimating the technical and scale efficiency of Greek commercial banks: the impact of credit risk, off-balance sheet activities, and international operations, *Research in International Business Finance*, 22 (3), pp. 301-318.
25. Reserve Bank of New Zealand (2007). *Financial Stability Report.*
26. Reserve Bank of New Zealand (2008). *Financial Stability Report.*
27. Reserve Bank of New Zealand (2010). *Financial Stability Report.*
28. Reserve Bank of New Zealand (2013). *Financial Stability Report.*
29. Sealey, C. and Lindley, J. (1977). Inputs, outputs and a theory of production and cost of depository financial institutions, *Journal of Finance*, 32 (4), pp. 1251-1266.
30. Singleton, J. and Verhoef, G. (2010). Regulation, deregulation, and internationalisation in South African and New Zealand banking, *Business History*, 52 (4), pp. 536-563.
31. Staub, R.B., da Silva Souza, G. and Tabak, B.M. (2010). Evolution of bank efficiency in Brazil: A DEA approach, *European Journal of Operational Research*, 202 (1), pp. 204-213.
32. Su, B. and Tripe, D.W.L. (2001, December). New Zealand bank mergers and efficiency gains. A paper presented to the 14 Annual Australasian Finance and Banking Conference, Sydney.
33. Sufian, F. and Habibullah, M.S. (2010). Bank-specific, industry-specific and macroeconomic determinants of bank efficiency: Empirical evidence from the Thai banking sector, *Margin: The Journal of Applied Economic Research*, 4 (4), pp. 427-461.
34. Thanassoulis, E. (2001). Introduction to the theory and application of Data Envelopment Analysis, (Kluwer Academic Publishers, Boston).
35. Tripe, D. (2003). Trends in New Zealand Bank Efficiency over Time, *Applied Econometrics and International Development*, 3 (1), pp. 55-80.
36. Yao, S., Han, Z. and Feng, G. (2008). Ownership Reform, Foreign Competition and Efficiency of Chinese Commercial Banks: A Non-parametric Approach, *The World Economy*, 31 (10), pp. 1310-1326.